CSC2209
Computer Networks

Congestion Control (in-the-middle view)

Stefan Saroiu
Computer Science
University of Toronto

Today's Questions

- Why do in-the-middle congestion control?
- What are techniques to control congestion in middle?

Why in-the-middle congestion control?

Why in-the-middle congestion control?

- Congestion occurs "in the middle"
  - Can be directly measured, manipulated, …
  - Resources are local (buffers, queues, link bandwidths)
- Control more tightly integrated
  - No need to wait-and-see if packet was lost, RTT varied, etc..
- Much more attack resilient!

Ways to Control Congestion in the Middle

Ways to Control Congestion in the Middle

- Scheduling
  - Decide order in which packets are forwarded
  - FIFO, fair queuing, priority queuing
- Queue management
  - Decide how to “manage” buffer resources
  - Drop-tail, random-drop, RED

Scheduling

- FIFO has problems…

Scheduling

- FIFO does not guarantee fairness
  - Flows interference
  - Hosts might pro-actively blast packets

- Alternatives:
  - Priority scheduling
  - Fair queuing

Fair Queuing (FQ)

- Maintain one queue per flow
  - Round-robin service each queue
  - Provides each flow with its "fair share" of bandwidth
    - Packets have different sizes!

- Problem:
  - What is a "flow"?

FQ Description

- Bit-level round robin doesn't work in practice
- Approximate using packet "finish" times
  - Finish time depends on number of flows
  - Send in order of finish times
  - Lower delay if flow underutilizes bandwidth
    - VoIP

FQ Problems

FQ Problems

- Implementation complexity
  - Need as many queues as flows
  - Per-flow state
  - O(log(#flows)) processing per packet <-- ouch!
- Delay increases for low-bandwidth & bursty flows
  - Speak monotonically when you use VoIP + FQ :-)

Ways to Control Congestion in the Middle

- Scheduling
  - Decide order in which packets are forwarded
  - FIFO, fair queuing, priority queuing
- Queue management
  - Decide how to “manage” buffer resources
  - Drop-tail, random-drop, RED

Drop-Tail Queuing Policy

- Pros:
  - Simple and efficient to implement
- Cons:
  - Bias against bursty connections
  - Creates global synchronization
  - unfair

Active Queue Management

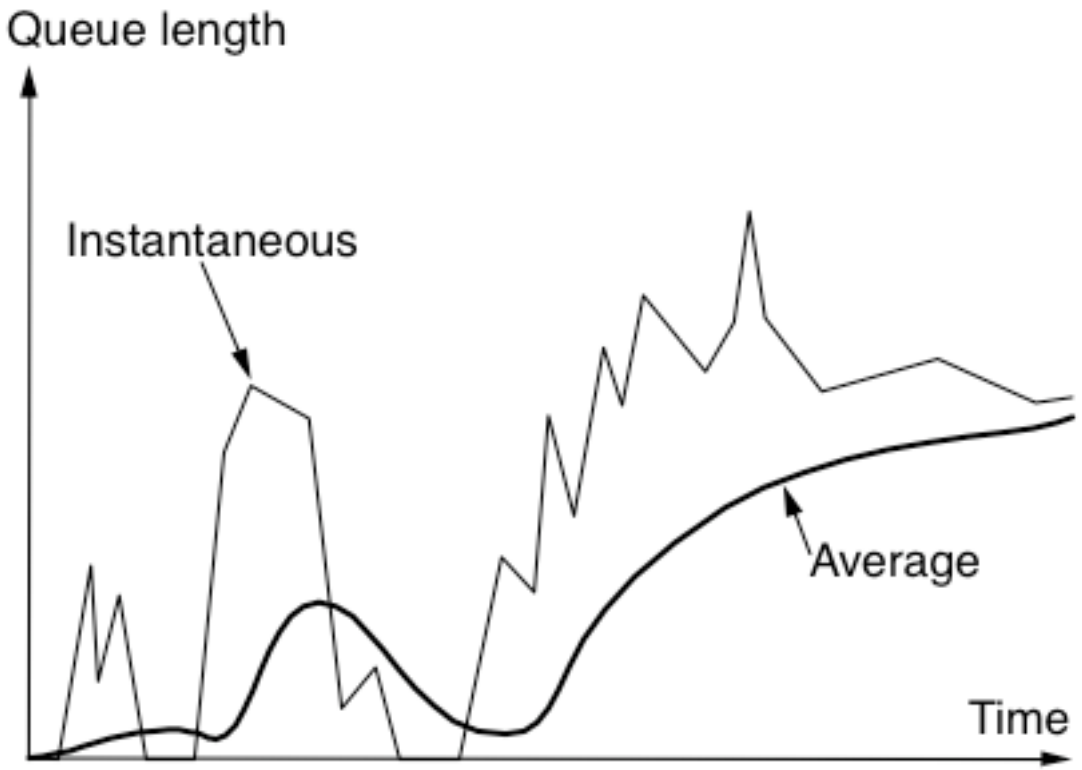
- Let's avoid congestion rather than control it

- ECN
- Random early detection (RED)

Random Early Detection (RED)

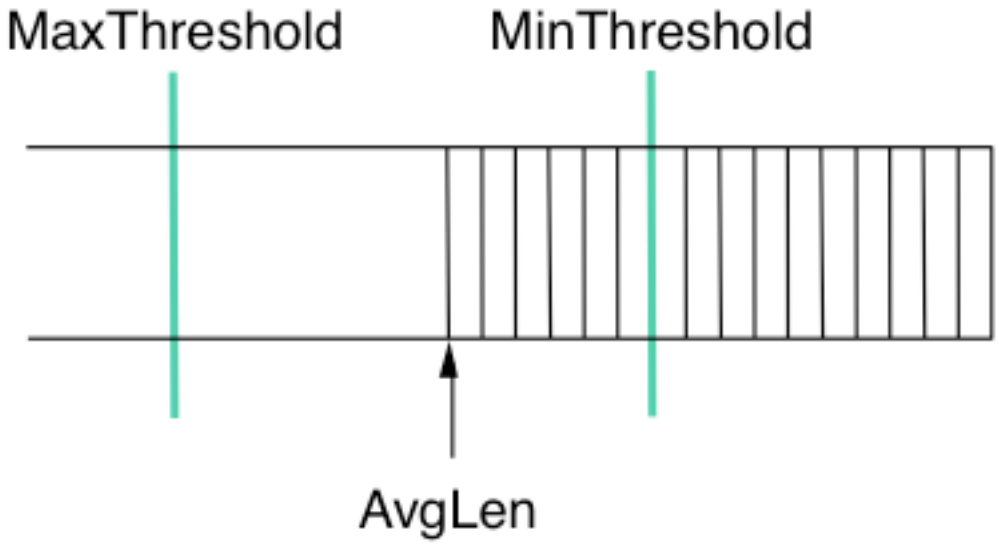
- Congestion avoidance by detection incipient congestion and dropping packets early
- High-level view:
  - Triggered when average queue length exceeds threshold
  - Packets dropped at random (proportional to bandwidth share)
  - No per-flow state
  - Dropping and marking are equivalent in semantics
  - Agnostic to scheduling discipline
  - Incrementally deployable

Queue Dynamics



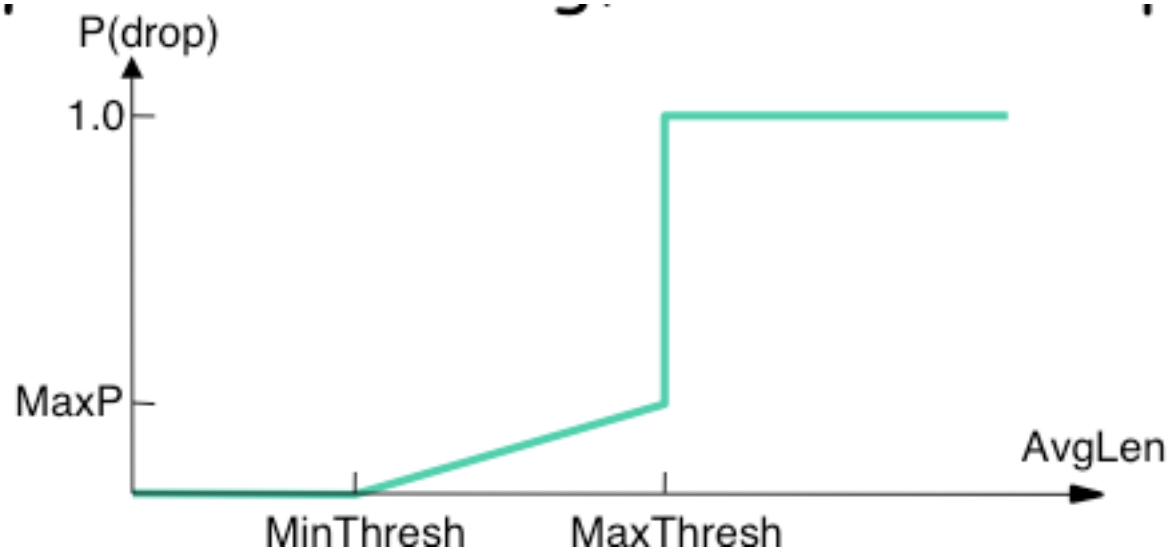
Queue Management in RED

- Send “early” signal by probabilistically dropping packet



Setting the Probability Parameter

- Probabilistically drop as queue builds
- Switch to drop-tail if queue too long



RED vs. ECN

- Which one is better, or are they equivalent?

RED vs. ECN

- Which one is better, or are they equivalent?
- Misbehaving users
  - RED punishes them
  - Could implement sampling mechanisms in ECN as well
- ECN helps short flows

Summary

- Two ways to do congestion control in the middle
  - Scheduling FIFO, fair queuing, priority queuing
  - Queue management: drop-tail, RED, ECN

- RED + ECN have seen little deployment
- Most router queues are drop-tail, FIFO by default

- Still very much an open problem!