Lecture 23: Buffering & Scheduling

CSE 123: Computer Networks
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HW 4 due Wednesday
Lecture 23 Overview

- Buffer Management
  - FIFO
  - RED

- Traffic Policing/Scheduling
  - WFQ
Key Router Challenges

- **Buffer management**: which packet to drop when?
  - We only have finite-length queues
- **Scheduling**: which packet to transmit next?
Basic Buffer Management

- FIFO + drop-tail
  - Simplest choice
  - Used widely in the Internet
- FIFO (first-in-first-out)
  - Implies single class of traffic
- Drop-tail
  - Arriving packets get dropped when queue is full regardless of flow or importance
- Important distinction:
  - FIFO: scheduling discipline
  - Drop-tail: drop policy
FIFO/Drop-Tail Problems

- Leaves responsibility of congestion control completely to the edges (e.g., TCP)
- Does not separate between different flows
- No policing: send more packets → get more service
- Synchronization: end hosts react to same events
Design active router queue management to aid congestion control

Why?
- Router has unified view of queuing behavior
- Routers see actual queue occupancy (distinguish queue delay and propagation delay)
- Routers can decide on transient congestion, based on workload
Design Objectives

- Keep throughput high and delay low
  - High power (throughput/delay)

- Accommodate bursts

- Queue size should reflect ability to accept bursts rather than steady-state queuing

- Improve TCP performance with minimal hardware changes
Random Early Detection

- Detect incipient congestion
- Assume hosts respond to lost packets
- Avoid window synchronization
  - Randomly mark packets
- Avoid bias against bursty traffic
RED Algorithm

- Maintain running average of queue length

- If $\text{avg} < \text{min}_\text{th}$ do nothing
  - Low queuing, send packets through

- If $\text{avg} > \text{max}_\text{th}$, drop packet
  - Protection from misbehaving sources

- Else drop/mark packet in a manner proportional to queue length
  - Notify sources of incipient congestion
RED Operation

Max thresh

Min thresh

Average Queue Length

P(drop)

1.0

max_p

min_{th}  max_{th}  Avg queue length

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Non-responsive Senders

1 UDP (10 Mbps) and 31 TCPs sharing a 10 Mbps line

UDP (#1) - 10 Mbps
TCP (#2)
TCP (#32)

UDP (#1)
TCP (#2)
TCP (#32)
UDP vs. TCP
Token Bucket Basics

- Parameters
  - \( r \) – average rate, i.e., rate at which tokens fill the bucket
  - \( b \) – bucket depth
  - \( R \) – maximum link capacity or peak rate (optional parameter)
- A bit is transmitted only when there is an available token

\[
\text{Maximum # of bits sent} = \frac{b \cdot R}{R - r}
\]
Traffic Policing

- Drop packets that don’t meet **user profile**
- Output limited to average of \( r \) bps and bursts of \( b \)

![Diagram showing traffic policing process](chart)

Packet input leads to testing if token. If token is present, it passes through to Packet output. If no token, it is dropped.

**User Profile (token bucket)**

- \( r \) bps
- \( b \) bits

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Traffic Shaping

- Shape packets according to user profile
- Output limited to average of $r$ bps and bursts of $b$

Packet input → Wait for token → Packet output

Queue, Drop on overflow

User Profile (token bucket)

$r$ bps

$b$ bits
Shaping Example

- \( r = 100 \text{ Kbps}; \ b = 3 \text{ Kb}; \ R = 500 \text{ Kbps} \)

(a) \( 3\text{Kb} \)

\( T = 0 : 1\text{Kb packet arrives} \)

(b) \( 2.2\text{Kb} \)

\( T = 2\text{ms} : \text{packet transmitted} \)

\( b = 3\text{Kb} - 1\text{Kb} + 2\text{ms} \times 100\text{Kbps} = 2.2\text{Kb} \)

(c) \( 2.4\text{Kb} \)

\( T = 4\text{ms} : 3\text{Kb packet arrives} \)

(d) \( 3\text{Kb} \)

\( T = 10\text{ms} : \)

(e) \( 0.6\text{Kb} \)

\( T = 16\text{ms} : \text{packet transmitted} \)
Buffer Management

- Mark packets that exceed user profile
- During congestion, drop marked packets first
For next time...

- Read Ch. 6.5 in P&D
- Good luck on HW 4
- Home stretch on Project 2!