CSE/EE 461 – Lecture 16
Bandwidth Allocation

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Reading: Peterson 6.1 – 6.2

Midterm Feedback:
What’s working well

• Fishnet projects
• Engaging lectures – thanks, I’m trying! 😊
  – Presenter/Tablet PC
  – Lecture notes
• End-of-class feedback

Midterm Feedback:
Suggestions

• Homework
  – Too vague, too divorced from lecture, too time-consuming, too harshly graded
  • We’ll try to grade HW2 more graciously
  • I’ll try to do better at designing the next homework
  • I’ll take this into account for final grades
  • Let’s do more examples in quiz section
• Lecture is too fast, too much to write
  – I’m working on a more relaxed pace – Stop me!
• Jumping around text is confusing
  – Sorry, too late to avoid this! Any strategies?

Last time...

• Medium Access Control
  – How can senders share access to a single network?
  – Token Ring networks
    • Taking turns is efficient but complex!
  – Wireless networks
    • Hidden and exposed terminals
    • Collision avoidance with RTS/CTS
This time…

- Bandwidth Allocation
  - How can many senders share bandwidth across the Internet?
  - Issues: Congestion and Fairness
  - What’s inside a router?

HTTP

- How fast should the web server send packets?

Bandwidth Allocation

- Congestion:
  - sending too fast swamps the network

- Fairness:
  - Different users should get their fair share of the bandwidth

- Often treated together (e.g. TCP) but can be considered separately

Congestion

- Buffer intended to absorb bursts when input rate > output
- But if sending rate is persistently > drain rate, queue builds
- Dropped packets represent wasted work
**Fairness**

- Each flow from a source to a destination should get an equal share of the bottleneck link.

**Bandwidth Allocation Taxonomy**

- Router-centric vs Host-centric
  - Whose responsibility is it to learn and act on network conditions?
- Reservation-based vs Feedback-based
  - Are allocations guaranteed at the beginning of the flow, or adjusted based on feedback?
- Rate-based vs Window-based
  - Is allocation in terms of sending rate or buffer space in routers?

**Design Choices**

- Two positions: What are advantages and disadvantages of each?
  - Router-centric, reservation-based, rate-based
  - Host-centric, feedback-based, window-based

**Evaluating Congestion Management**

- How efficient is the bandwidth allocation?
Evaluating Fairness

• How do we compute the fairness of an allocation?
  – If all flows have an equal share on a link it’s “fair”
    • e.g., min-max fairness
      \[ f_1 \]
      \[ f_2 \]
      \[ f_3 \]
      \[ f_4 \]
  – But how unfair are unequal allocations?

Jain’s Fairness Index

• Jain’s fairness index:
  – For \( n \) flows each receiving a fraction \( f_i \) of the bandwidth
  – Always between 0 and 1
  – What is fairness if all flows get the same bandwidth?
  – What if only \( k \) out of \( n \) flows get bandwidth?

What’s in a Router?

“Router”
  routing forwarding

From routers or hosts

To routers or hosts

Model of a Router

Input Ports
  Data Link and PHY

Queue

Switching Fabric

“Switch”

Output Ports
  Data Link and PHY

Queue

Routing Processor

Scheduling and Buffering this side

Forwarding this side
Scheduling and Buffer Management

• Two different functions implemented at the output queue

• A scheduling discipline
  – Order in which to send packets
  – e.g.,

• A buffer management policy
  – Which packets get dropped
  – e.g.,

Key Concepts

• Issues for bandwidth allocation: congestion and fairness

• Congestion occurs when buffers inside the network fill with excess traffic.

• Fairness means that competing traffic flows gain a “fair share” of the available bandwidth.

• Packets are queued at router outputs.

FIFO with Tail Drop

Next time…

• Host-based congestion control in TCP