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?

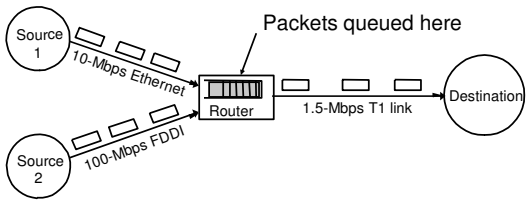
HTTP

- 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

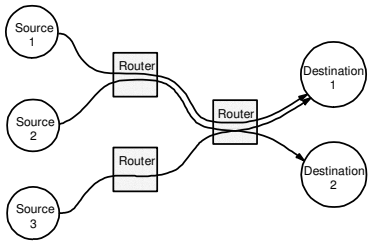
Congestion



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

Chapter 6, Figure 1djw // CSE/EE 461, Autumn 2001

Fairness



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

Chapter 6, Figure 2djw // CSE/EE 461, Autumn 2001

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?

L4.10

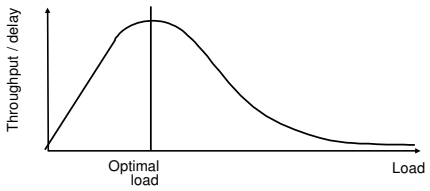
Design Choices

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

L4.11

Evaluating Congestion Management

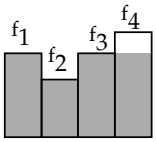
- How efficient is the bandwidth allocation?



Chapter 6, Figure 3djw // CSE/EE 461, Autumn 2001

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



  - But how unfair are unequal allocations?

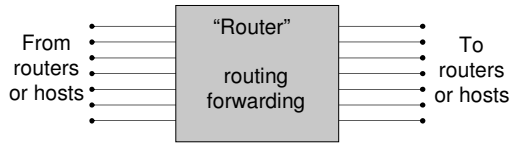
Jain's Fairness Index

- Jain's fairness index:
  - For n flows each receiving a fraction f_i of the bandwidth
  - Always between 0 and 1

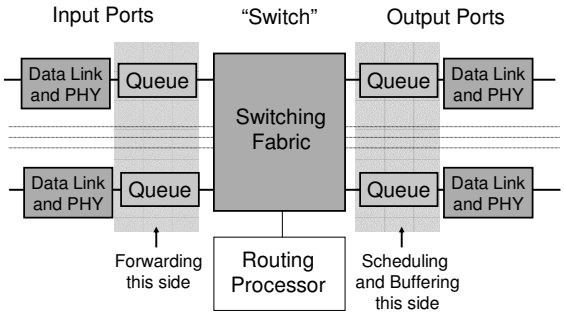
$$fairness = \frac{\left(\sum f_i\right)^2}{n\sum f_i^2}$$

  - 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?



Model of a Router

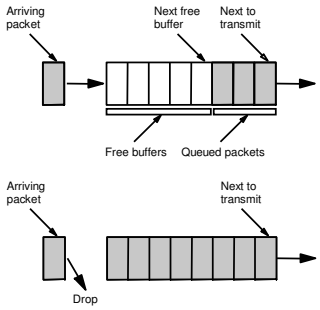


Scheduling and Buffer Management

- 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.,

L4.17

FIFO with Tail Drop



L4.18

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.

L4.19

Next time…

- Host-based congestion control in TCP

L4.20