CS 457 – Lecture 22
Congestion

Fall 2011
Extended Project 3 Discussion
Topics

- Principles of congestion control
  - How to detect congestion?
  - How to adapt and alleviate congestion?
- TCP congestion control
  - Additive-increase, multiplicative-decrease
  - Slow start and slow-start restart
- Related TCP mechanisms
  - Nagle’s algorithm and delayed acknowledgments
- TCP Throughput and Fairness
- Active Queue Management (AQM)
  - Random Early Detection (RED)
  - Explicit Congestion Notification (ECN)
Resource Allocation vs. Congestion Control

• Resource allocation (connection-oriented networks)
  – How routers meet competing demands for resources
  – Reservations: allocate link bandwidth and buffer space to a flow
  – Admission control: when to say no, and to whom

• Congestion control (Internet)
  – How nodes prevent or respond to overload conditions
  – E.g., persuade hosts to stop sending, or slow down
  – Typically, much less exact
  – Have some notion of fairness (i.e., sharing the pain)
Flow Control vs. Congestion Control

- **Flow control**
  - Keeping *one fast sender* from overwhelming *a slow receiver*

- **Congestion control**
  - Keep a *set of senders* from overloading the *network*

- **Different concepts but similar mechanisms**
  - TCP flow control: receiver window
  - TCP congestion control: congestion window
  - TCP actual window: \( \text{min}\{\text{congestion window, receiver window}\} \)
Internet Congestion is Unavoidable

- Two packets arrive at the same time
  - The router can only transmit one
  - ... and either buffer or drop the other

- If many packets arrive in a short period of time
  - The router cannot keep up with the arriving traffic
  - ... and the buffer may eventually overflow
Metrics: Throughput vs. Delay

- High throughput
  - Throughput: measured performance of a system
  - E.g., number of bits/second of data that get through

- Low delay
  - Delay: time required to deliver a packet or message
  - E.g., number of ms to deliver a packet

- These two metrics are sometimes at odds
  - E.g., suppose you drive a link as hard as possible
  - … then, throughput will be high, but delay will be, too
Load, Delay, and Power

Typical behavior of queuing systems with random arrivals:

A simple metric of how well the network is performing:

\[ \text{Power} = \frac{\text{Load}}{\text{Delay}} \]

Goal: maximize power
Fairness

- Effective utilization is not the only goal
  - We also want to be *fair* to the various flows
  - … but what does *that* mean?
- Simple definition: equal shares of the bandwidth
  - N flows that each get 1/N of the bandwidth?
  - But, what if the flows traverse different paths?
  - Still a **hard and open problem** in the Internet
Simple Queuing Mechanism

- Simplest approach: FIFO queue and drop-tail
- Link bandwidth allocation: first-in first-out queue
  - Packets transmitted in the order they arrive
  
  ![Diagram of FIFO queue](image)

- Buffer space allocation: drop-tail queuing
  - If the queue is full, drop the incoming packet
  
  ![Diagram of drop-tail queuing](image)
Limitations of FIFO/Drop Tail

- Packets served on first come, first served basis
- Aggressive sender can still capture most bandwidth
- Seek a solution that is “fair” to all flows
Defining Fairness: Flows

• First ask “fair” to whom?
  – Should be Fair to a Flow

• What is a flow?
  – Source address?
  – Destination address?
  – Process pair?

• Possible definition:
  <Src IP, Src Port, Dst IP, Dst Port> tuple
Defining Fairness: MaxMin

• Given a resource $u_{\text{total}}$ and several requests $p_i$
• Assign allocations of $u_i$ to node $i$.
• Allocation is fair if
  – No one receives more than they requested: $u_i \leq p_i$ for all $i$
  – No other allocation has higher minimum allocation (for allocations meeting requirement above)
  – Recursive true after removal of minimum node:
    let $j = \text{user with minimum allocation}$
    let $u_{\text{total}} = u_{\text{total}} - u_j$
    remove user $j$
    above conditions should still hold
What’s Next

• Read Chapter 1, 2, 3, 4.1-4.3, and 5.1-5.2
• Next Lecture Topics from Chapter 6.4 and 6.5
  – Congestion Control
• Homework
  – Due *Friday* in recitation
• Project 3
  – Posted on the course webiste