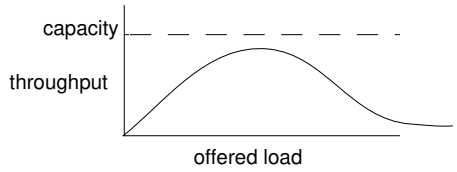
CprE 489
Lecture 19

Fall Semester 1997

Congestion

- Congestion can build up for two reasons
  - routers process packets slowly allowing queues to build up
  - Outgoing lines at routers at capacity causing queues to build up
- Congestion is a network wide problem that needs a network wide solution.
- Under high loads a network can have a decrease in overall throughput
  - Packets are discarded and resent packets fill the network.
  - If queues are to be built up they should be at the hosts not within the network.

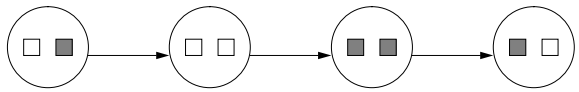


Congestion Control

- Open loop control - preventative - useful for virtual circuit subnets
  - preallocation of buffers to virtual circuit - no buffer overflow.
  - flow control into the network - Less flow requires fewer buffers.
  - traffic shaping - smoother flows have smaller queues at switches
  - refuse connections in a virtual circuit
- Closed loop control - reactive - useful in datagram subnets
  - recompute routing tables
  - good buffer management
  - thottle sources using choke packets
  - load shedding

Preallocation of Buffers

- Virtual circuit network layer - prealloaction of buffer space and bandwidth to circuits can be used effectively. Switch to switch window control will never allow queues to build up nodes.



- Each node including the host has k buffers allocated to a virtual circuit.
  - A node sends a packet to the next node only if it knows there is a free buffer available at the next node. When a buffer becomes free a "request" is sent to the previous node.
  - There may be a waste of buffers if a virtual ciruit underutilizes its buffers.

Buffer Pool Management

- Pure buffer pool

  There are M buffers total. They are allocated on a first come first serve basis to the various virtual circuits. If no buffer is available then the packet is tossed.

- Restricted buffer pool

  There are M buffers total and n virtual ciruits. Virtual circuit i is limited to having at most m(i) buffers allocated to it. The value of m(i) is determined at set-up time. Typically m(i) << M, but m(1)+m(2)+ ... + m(n) > M.

  There is some chance that a virtual circuit will not have a buffer available if the other virtual circuits are using M buffers total.

- Restricting outgoing queues

  There are M buffers total. Each output queue may have no more than m buffers allocated to it. A virtual circuit may not get its fair share.

Flow Control and Traffic Shaping

- A flow problem is an end-to-end problem which the hosts can manage themselves using sliding windows or other mechanisms.
- Flow control can be used to avoid congestion, but not preferred
- Leaky Bucket:

  At the entrance to the network is a "bucket" which passes packets to the network at a steady rate regardless of the rate exhibited by the source.

  Packets that overflow the bucket are thrown away. Alternatively, the tap at the source can be turned off.

  Guaranteed smooth flow.

- Token Bucket:

  Tokens are added to a bucket at a steady rate up to the capacity of the bucket. When the capacity is exceeded tokens are thrown away.

  Packets which have a token can be transmitted immediately.

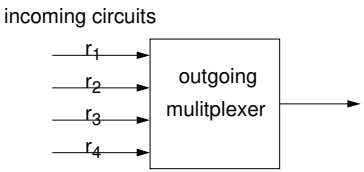
  Flow may be bursty, but never exceeds average rate of token arrivals.

Dealing with Fairness

- This can be done in a virtual circuit network more easily.
- Fair queuing

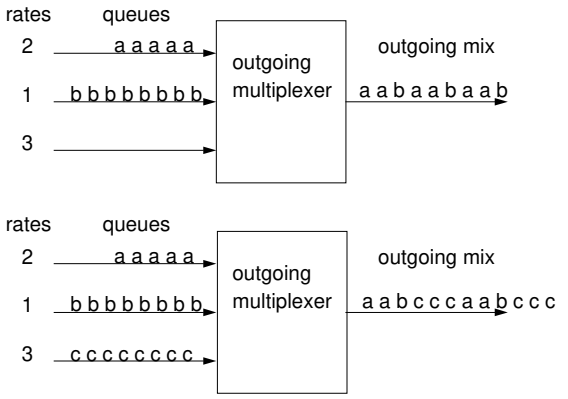
  - each virtual circuit c has an assigned packet rate r(c). At a specific switch packets for c may arrive at a rate different from r(c).

  - Suppose the outgoing line has total assigned rate R from all virtual circuits then c gets a r(c)/R percent share of the outgoing packets when the outgoing line is heavily loaded.



$R = r_1 + r_2 + r_3 + r_4$

Queues build up for each incoming circuit.

The server samples r_i for service r_i/R percent of the samples.

Fair Queing Example