Announcements

- Midterm #1 solutions are on the web
  - last day to submit re-grade requests in Thursday (11AM)
- Term Project proposals
  - due at 6:00 PM in my office
- HW #2 (due 10/28/97):
  - Chapter 5: 1, 5, 6, 7, 8, 15, 16, 21, 30, 35
- Reading
  - Today: 5.3-5.4
  - Thursday: 5.5-5.6

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Congestion

- Too much traffic can destroy performance
  - goal is to permit the network to operate near link capacity
  - can reach a knee in the packets sent vs. delivered curve
- Sources
  - all traffic is destined for a single out link
    - backup in traffic consumes buffers
    - other (cross traffic) will not get through due to lack of buffers
  - slow router CPU
    - can't service all requests at link speed
      - links still backup
- Often feeds on itself
  - queuing delays can cause packets to timeout
    - introduces more traffic due to re-transmissions

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Congestion Control

- Two possible approaches
  - open loop: prevent congestion from every happening
    - tends to be conservative and result in under utilizaion
  - closed loop: detect and correct
    - some congestion will still occur until it is corrected
- Open loop
  - request resources before using them
  - global (or regional) resource allocation
    - responds yes or no to each request for service
- Closed loop
  - monitor network to detect congestion
  - pass information back to location where action can be taken
  - adjust system operation to correct the problem

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Responding to Congestion

- Add more resources
  - dialup network: start making additional connections
  - SMDS: request additional bandwidth from provider
  - split traffic: use all routes not just optimal
- Decrease load
  - deny service to some users: based on priorities
  - degrade service to some or all users
  - require users to schedule their traffic

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Traffic Shaping

- Traffic tends to be bursty
  - great variation between min and max bandwidth used
  - this uncertainty leads to inefficient use of the network
- Flow Specification
  - user proposes a specific probability distribution
    - maximum packet size
    - transmission rate (min, max, or mean)
    - maximum delay
    - maximum delay variation (jitter)
    - quality guarantee (how strong is this agreement)
  - network can
    - agree to request
    - refuse it
    - counter offer

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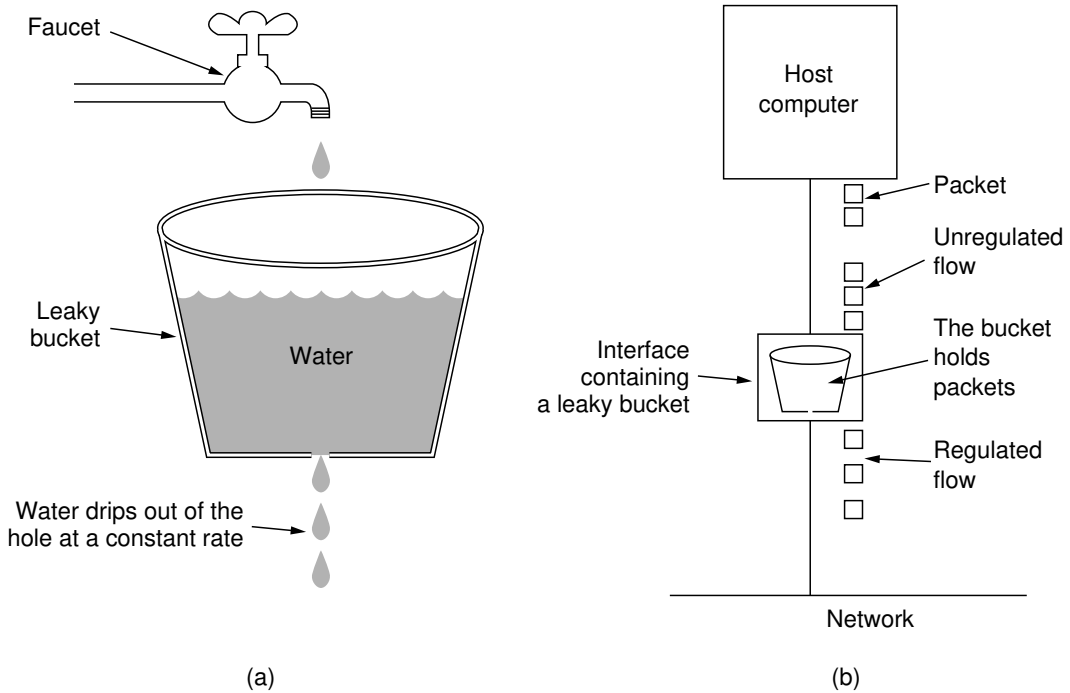
Leaky Bucket

- buffer accepts traffic at link rate
  - buffer has a bounded size (limits burst size that is accepted)
- output is limited to a lower rate
  - traffic is constrained to this rate



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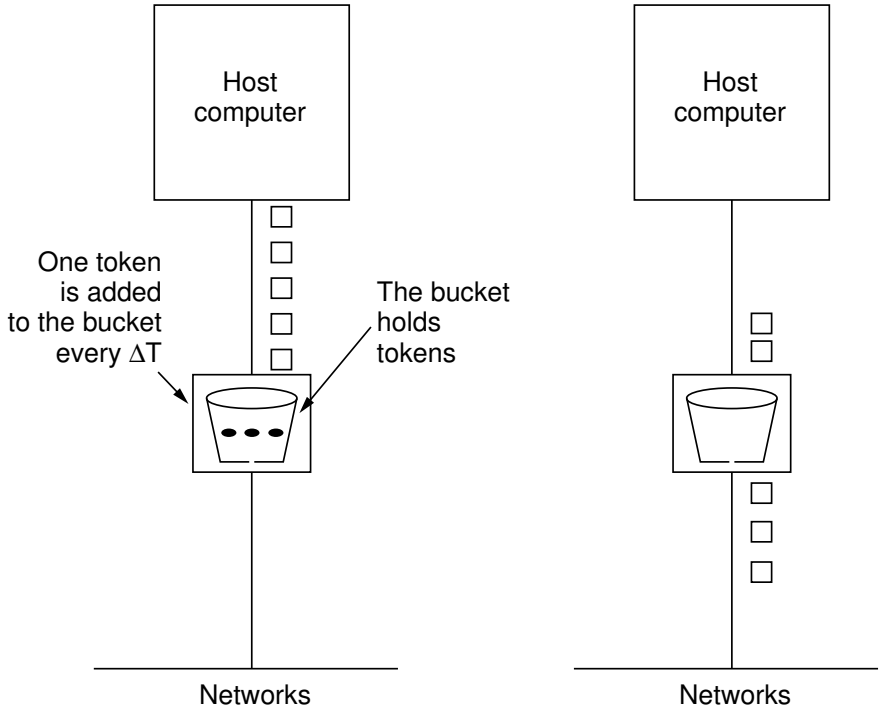
Token Bucket

- Bucket hold tokens (generated one every T seconds)
- Can save up to a fixed limit of n tokens
- When traffic arrives, it must a have token to be sent



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- Max burst rate
  - C – capacity of bucket
  - S – burst length in seconds
  - M – max output rate
  - p – token credit rate
  - $C + pS = MS$

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Congestion Control with Virtual Circuits

- Admission control
  - once traffic reaches a threshold, don't admit more VCs
  - doesn't correct current problem, but prevents additional congestion
- Alter routes
  - admit new connections
  - route them around "trouble" areas
- Negotiate traffic
  - establish parameters for volume and shape of traffic

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