Professor office hours changed: 2-230pm T-Th

Download new version of project 1

Homework 1: #18c is optional.

Home network is connected to DSL or Cable.

Access network (Home Network): computer, laptop, smartphone.

Enterprise(ethernet) - msu network.

* Host: send packets of data. A large message is split into smaller packets.
* Transmission rate: R -
* Capacity - bandwith. Transmission rate of a packet
* Transmission delay:
* Physical media
  + Bit: propagates between transmitter/receiver pairs
  + Physical link what lies between transmitter and receiver
  + Copper wire - twisted pair
  + Coaxial cable
    - Copper conductors. Bidirectional
  + Fiber optic cable
  + Radio: signal carried in electromagnetic spectrum.
    - No physical wire. Broadcast and :half-duplex. (sender to receiver)
    - Radio link types
      * Terrestrial microwave
        + Up to 45 Mbps channels
      * LAN
        + Up to 100mbps
      * wide-area(Cellular)
        + 4g - 10mbps
      * Satellite
        + (kbps to 45mbps)
    - Propagation environment effects:
      * Reflection
      * Obstruction by objects
      * Interference
* Packet-switching: hosts break application-layer messages into packets.
  + Forward packets from one router to the next, across links on path from source to destination.
  + Each packet transmitted at full ink capacity.
  + Store and forward:
    - Entire packet must arrive at the router before it can be transmitted on the next link.
  + L bits per packet. R bps
  + Takes L/R seconds to transmit L-bit packet into link at R bps
  + End-end delay = 2L/R assuming zero propagation delay.
  + Queuing and Loss:
    - If arrival rate(in bits) to link exceeds transmission rate of link for a period of time:
      * Packets will queue, wait to be transmitted on link
      * Packets can be dropped(lost) if memory (buffer) fills up.
    - If input is faster than output rate. The queue can fill up(finite).
* Routing (global): determines source-destination route taken by packets.
* Forwarding(local): move packets from router’s input to appropriate router output.
* Circuit-switching: end-end resources to, reserved for call” between source and destination.
  + Dedicated resources: no shared
    - circuit-like(Guaranteed) performance.
  + Circuit segment idle if not used by call (No sharing)
  + Commonly used in traditional telephone networks.
  + Link from A to B has to be reserved before data can be sent.
  + Advantage: guaranteed performance
  + Disadvantage: wasted resources. Limited connections. Only so many pairs are possible, other connections have to wait.
* Packet switching allows more users to use the network than Circuit switching
* Packet switching is great for bursty and simpler to set up
  + No need to set up path
* Packet switching is susceptible to congestion and packet loss.
  + Protocols for reliable data transfer and congestion control and needed.
* Internet structure: network of networks
  + End systems connect to the internet via access ISPs.
  + Possible structures:
    - Connect each access ISP to every ISP. (bad).
    - Several major ISPs with peer links to connect users of different ISPs.
      * Use regional nets
    - Tier 1 ISP
* How do loss and delay occur?
  + Packet arrives in queue. If the queue has space, the packet stays in queue and waits for its turn. However, if the queue is full at the router, the packet is dropped.
* 4 Sources of Packet Delay
  + Nodal processing
    - Check bit errors
    - Determine output link
    - Typically <msec
  + Queuing delay
    - Time waiting at output link for transmission
      * Depends on router congestion
    - Transmission delay
      * L: packet length(bits)
      * R:link bandwidth (bps)
      * Dtrans = L/R
    - Propagation delay:
      * D: length of physical link
      * S: propagation speed (-2x10^8 m/sec)
      * Dprop = d/s
      * Varies by length and how many bits and be received at once.
* Traceroute: program - provides delay measurement from source to router along end-end internet path towards destination.
* Packet loss
  + Lost packet may be retransmitted by previous node, by source end system, or not at all.
    - Varies depending upon the important of the packet.
* Throughput: rate (bits.time unit) at which bits transferred between sender/receiver
  + Instantaneous: rate a given point in time
  + Average: rate over longer period of time
  + Bottleneck-link: link on end-end path that constrains end-end throughput.