Basic Networking Concepts: LANs, WANs, and Multiplexing

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LANs and WANs

- Networks come in many shapes and sizes
- LAN: Local Area Network
  - Limited geographic coverage (e.g., lab, building)
  - Examples: home network, Ethernet LAN, WiFi
- MAN: Metropolitan Area Network
  - Size of a “city” (1-10 km or so)
- WAN: Wide Area Network
  - Large geographic coverage (e.g., country, planet)
  - Examples: CANARIE, cellular networks, Internet
- Technologies differ (capacity, distance, $$)

Some Useful Analogies

- Many of the concepts in computer networks are not really new, but come from other familiar areas…
- Telephone network: (POTS: Plain Old Telephone System)
  - Phone calls, trunk lines, toll offices, circuit-switching
- Postal system: (most similar to Internet packet-switching!)
  - Letters/parcels, addresses, mail carriers, post office
- Highway network:
  - Cars/buses, streets/highways, rush hour, collisions
- Broadcast TV:
  - Channels, stations, TVs, streaming (live/stored)

Communications Networks

- Historically, there have been two different philosophies guiding the design, operation, and evolution of communication networks
  - the “telco” view (i.e., telecommunications networks to support voice telephony and other types of services, such as fax, dialup modems, etc.)
  - the “data networking” view (i.e., the Internet)
- While the two approaches share some similar goals and challenges (e.g., scale, geography, heterogeneity), they have quite different underlying assumptions

Telco Networks (1 of 2)

- Over 100 years old
- Circuit-switched network
- Designed for transmission of human voice
- Twisted pair copper wire for residential access
  - "cheap", adequate bandwidth, easy to handle...
- Aggregation of multiple calls at toll office for multiplexing/demultiplexing using TDM
- Low bandwidth required per call (e.g., 64 kbps)
- Fixed bandwidth required per call

Telco Networks (2 of 2)

- Call routing and circuit allocation decided once per call at time of call arrival
- End-to-end path allocation, with dedicated circuit (reserved bandwidth) per active call
- All bits travel same path; stay in same order
- Call state information crucial in network switches
- Busy signal if no path possible (blocking <= 2%)
- Billing model based on time used (in minutes)
- Single class of service; high reliability (99.99%)
- Additional services: faxes, modems, mobility, ...

The Internet (1 of 2)

- About 50 years old
- Packet-switched network
- Designed for transmission of data
- Variable-size packets permitted
- Wide range of access technologies
- Wide range of user and application behaviour
- Bursty, variable bandwidth required by apps
- Aggregation of traffic at routers/switches
- Transmission links shared on stat mux basis

The Internet (2 of 2)

- Connection-less network layer protocol (IP)
- “Best effort” datagram delivery model
- Packet routing decided on a per-packet basis
- No end-to-end path allocation; no reserved bandwidth per active call
- Packets can travel any path; packets can be delayed, lost, duplicated, re-ordered
- Minimal state info in network switches
- Single class of service
- Billing model? (hours? pkts? bytes? bandwidth?)

Time Division Multiplexing (TDM)

- Static channel allocation mechanism
- Divides a fixed resource among N concurrent users
- Done in the time domain (i.e., turn-taking, time slots)
- Give each user all of the channel part of the time
- Examples:
  - Classroom scheduling; traffic lights; daily TV programs
  - T1 digital transmission standard (1.5 Mbps)
- Very efficient if N is fixed and all N users are active
- Very inefficient for bursty and unpredictable traffic

Frequency Division Multiplexing (FDM)

- Static channel allocation mechanism
- Divides a fixed resource among N concurrent users
- Done in the frequency domain (i.e., Hertz) (Hz)
- Give each user part of the channel all of the time
- Examples:
  - Radio stations; TV channels; WiFi channels
  - CRTC regulation of wireless/cellular technologies
- Very efficient if N is fixed and all N users are active
- Very inefficient for bursty and unpredictable traffic

Statistical Multiplexing (Stat Mux)

- Flexible (dynamic) channel allocation mechanism
- Shares a fixed resource among N concurrent users
- Done dynamically on a packet-by-packet basis
- Give each user the channel when they need it
- Hope they don't all need it at exactly same time!
- Examples:
  - Cars on city streets; letters sent via Canada Post
  - Internet packets on ISP link
- Very efficient for bursty and unpredictable traffic, even if N is unknown or highly dynamic

Summary

- There are several key concepts that underly many of the computer networks that we will talk about:
  - Network edge: end system devices, access links, LAN
  - Network core: aggregation, switching, multiplexing, WAN
- Many of the design principles will be familiar to you from other human “communication systems”
- An “internetwork” is a “network of networks”
- “The Internet” is a massive global internetwork
- Protocols are the glue for putting these together