Network performance

In computer networks, speed is at a premium.

Three yardsticks of performance:

- bandwidth: bps (bits-per-second)

  $\longrightarrow$ throughput: includes software processing overhead
- latency: msec (millisecond)

  $\longrightarrow$ signal propagation speed

  $\longrightarrow$ approximately: speed of light

  $\longrightarrow$ delay: includes software processing overhead
- jitter: delay variation

Bandwidth vs. throughput:

bandwidth—maximum data transmission rate achievable at the hardware level; determined by signalling rate of physical link and NIC.

throughput—maximum data transmission rate achievable at the software level; overhead of network protocols inside OS is accounted for.

reliable throughput—maximum reliable data transmission rate achievable at the software level; effect of recovery from transmission errors and packet loss accounted for.

$\longrightarrow$ note: the Internet is "leaky"

Meaning of "high-speed" networks:

- signal propagation speed is bounded by SOL (speed-of-light)

  $\longrightarrow$ $\sim$300K km/s or $\sim$186K miles/s

  $\longrightarrow$ optical fiber, copper: nearly same

- Ex.: latency: Purdue to West Coast

  $\longrightarrow$ around 2000 miles: $\sim$10 msec (= 2000/186000)

  $\longrightarrow$ lower bound

- Ex.: geostationary satellites: $\sim$22.2K miles

  $\longrightarrow$ latency: $\sim$120 msec

  $\longrightarrow$ end-to-end (one-way): $\sim$240 msec

  $\longrightarrow$ round-trip (two-way): $\sim$480 msec

  $\longrightarrow$ typically: $\sim$500 msec

- thus: a single bit cannot go faster

  → for example: digital pulse

  → can only increase "bandwidth"

  → analogous to widening highway, i.e., more lanes

  → simulatenous transmission

- interpretation: "high-speed" ⇔ "many lanes"

  → what does it buy?

  → completion time of large files faster

  → in this sense, "higher" speed

  → more accurate term: broadband networks

Some units:

Tbps, Gbps, Mbps, Kbps:

10^12, 10^9, 10^6, 10^3 bits per second; indicates data transmission rate; influenced by clock rate (MHz/GHz) of signaling hardware

$\longrightarrow$ communication rate: factors of 1000

$\longrightarrow$ data size: 1 KB means 1024 bytes

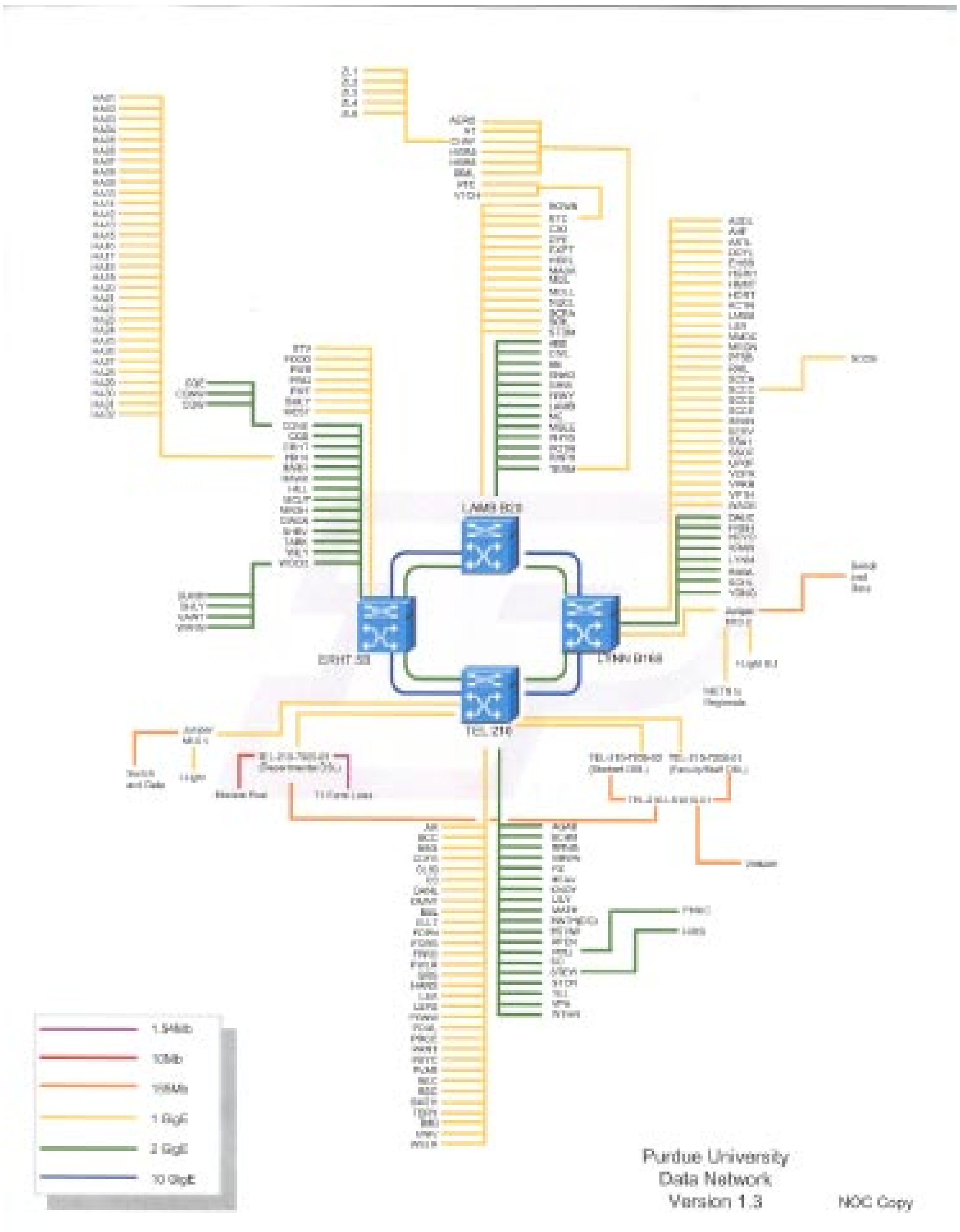
Common bit rates:

- 10, 100, 1000 Mbps (1 Gbps); 10 Gbps Ethernet
- 11 Mbps (and 5, 2, 1 Mbps) for 802.11b WLAN

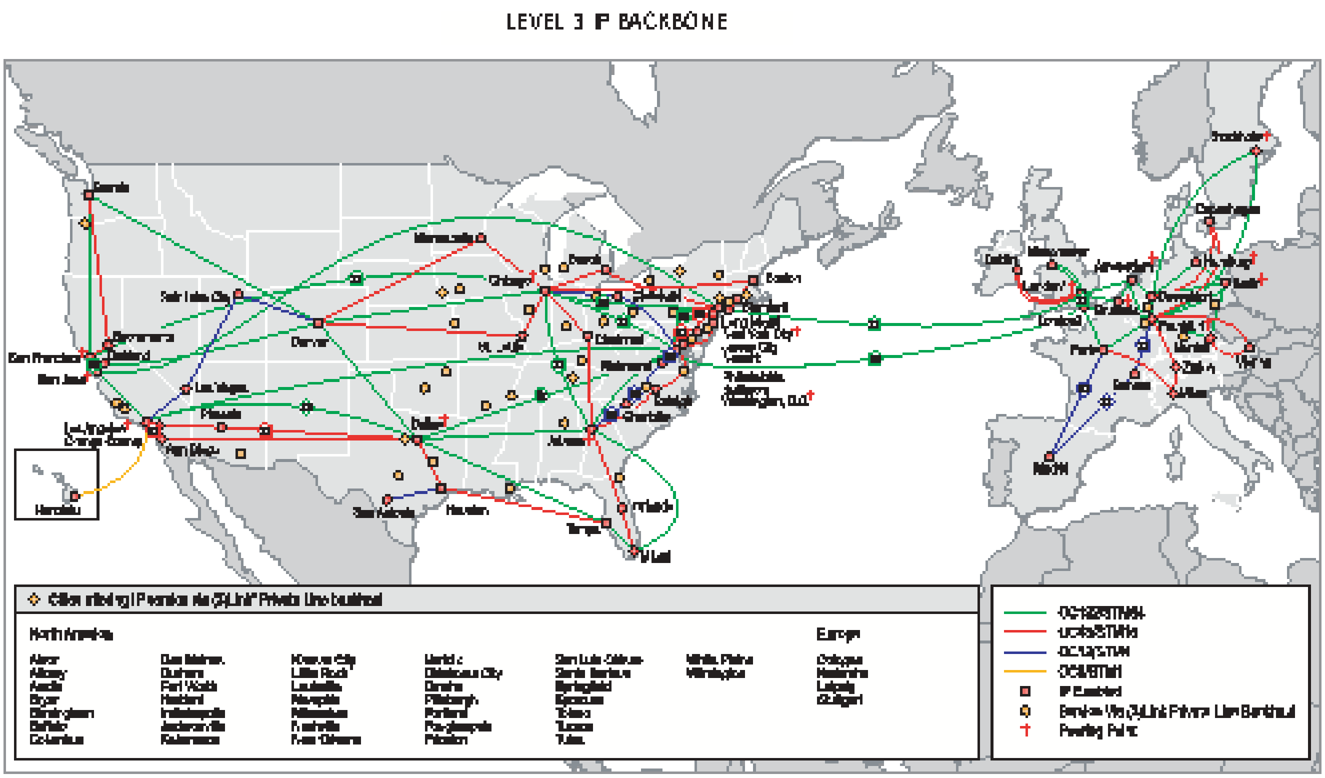
  → 5, 2 and 1 Mbps: fallback rates
- 54 Mbps (and 48, 36, 24, 18, 12, 9, 6 Mbps) for 802.11g/a WLAN
- 540 Mbps for 802.11n WLAN
- 64 Kbps (toll quality digitized voice)

  → landline
- ∼10 Kbps (cell phone quality voice)
- 1.544 Mbps (T1), 44.736 Mbps (T3)
- popular backbone speeds: 1 and 10 Gbps

Purdue's backbone network: ITaP



Level3 backbone network: www.level3.com



→ 10 Gbps backbone (green): same speed as Purdue

→ Purdue CS Dept.: 10 Gbps backbone

What is traveling on the wires?

Mixture of:

bulk data, audio/voice, video/image, real-time interactive data, etc.

$\longrightarrow$ $> 85\%$ of Internet traffic is bulk TCP traffic

$\longrightarrow$ due to Web/HTTP

$\longrightarrow$ share of P2P traffic (TCP) increasing rapidly

Multimedia (voice/audio/video) streaming on the rise but still a minority

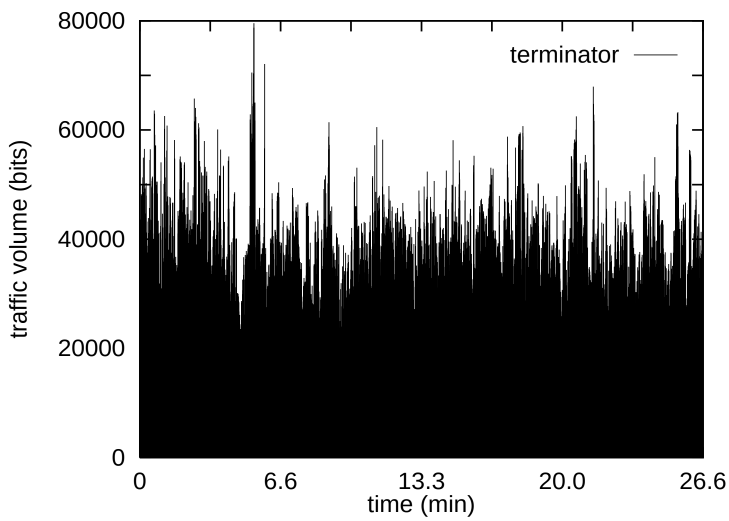
$\longrightarrow$ e.g., Skype (voice)

$\longrightarrow$ e.g., desktop video conferencing (webcams)

$\longrightarrow$ e.g., Internet radio, iTunes snippets (audio)

Internet traffic is "bursty":

⟶ multimedia: MPEG compressed video



Why?

- video compression

  → utilize inter-frame compression

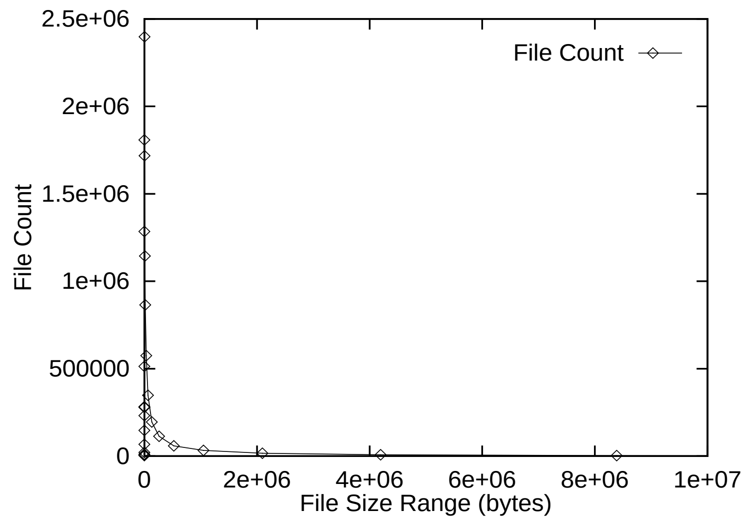
- pattern of scene changes in movies

  → within a scene few changes

- across scenes, significant scenary changes

  → e.g., action movies

⟶ file sizes on file servers



Why?

- bulk data: 80/20 rule-of-thumb
- majority of files are small, a few very large

  → "many mice, a few elephants"

  → the few elephants make up 80% of total traffic

  → same for disk space

Real-world is inherently uneven . . .

How to make sense of all this?

Study of networks has three aspects:

- architecture

  $\longrightarrow$ system design or blueprint

- algorithms

  $\longrightarrow$ how do the components work

- implementation

  $\longrightarrow$ how are the algorithms implemented

Keep in mind when viewing networking material.

Also, importance of performance, i.e., speed.

$\longrightarrow$ slow technologies do not survive in networking world

$\longrightarrow$ e.g., cryptography