NETWORK TRAFFIC AND QoS Provisioning

Simplest of all: constant bit rate (CBR)

→ flat is good

→ e.g., telephone call, real-time MP3

→ a little bit of wastage

→ half duplex: \( \sim 40\% \) busy

Coin tossing and session arrivals:

→ data traffic is not CBR

→ exponential interarrival time

→ swimming with the fishes: Poisson process

→ e.g., telephone calls, TCP connections, fast food
What does it look like: traffic measurement

logging

traffic time series (at 10ms granularity)
Aggregation (time):

→ analogous to computing sample mean

→ aggregation over multiple time scales

→ what to expect?
Time aggregated traffic becomes flat

→ “flat is good” rule for QoS provisioning
→ buffering or bandwidth dimensioning
→ technically: law of large numbers in action
→ aggregation in time
→ efficient and happy customers

Also aggregation over multiple users

→ statistical multiplexing
→ assuming independence between different users
→ true?
→ approximately
→ most of the time, but not all of the time
Packet trains and on/off process

→ session duration, lifetime, holding time

→ how long does a packet train last?

→ light-tailed vs. heavy-tailed

→ single on/off process

→ multiple on/off processes: backbone traffic
Superposition of multiple on/off sources:

\[ X_1(t) \quad ON \quad OFF \quad ON \quad OFF \quad ON \quad OFF \]

\[ X_2(t) \]

\[ X_3(t) \]

\[ S_3(t) \]

*time*
When on-time is light-tailed

   → similar to Poisson process

When on-time is heavy-tailed

   → multiplexed traffic is fractal
   → self-similar
   → long-range dependent
   → old theorem (late 60s) by B. Mandelbrot
   → burstiness preserved at multiple time scale

Internet traffic: on-time is heavy-tailed

   → empirically established
   → early 90s
Consequences:

- cannot use “flat is good” method anymore
- intrinsic trade-off between QoS and efficiency
- bad news for QoS provisioning
- any good news?

Why are packet trains heavy-tailed?

- causality
- UNIX file sizes are heavy-tailed
- same with web servers (WWW)
- predominance of TCP traffic (∼85%)
- UDP traffic is increasing
- MPEG video . . .
Of mice and elephants:

→ many small ones (mice)
→ a few very large ones (elephants)
Usefulness of log-log plot:

\[ \rightarrow \text{ to ascertain whether indeed heavy-tailed} \]