Characterization and Classification of IP Traffic

- Complete specification of IP traffic is difficult due to;
    - **Most of the applications adapt to the network capabilities**
    - **IS it appropriate to design a future network using traffic from current applications; possibility of new and radically different applications in the future.**

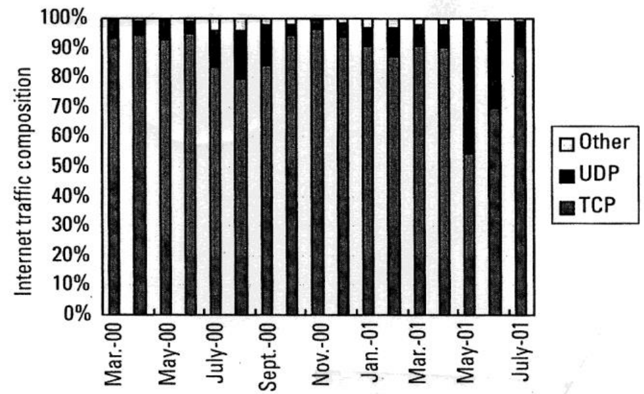
However, these applications posses certain **generic inherent properties** resulting from **human behavior and interaction**; i.e. independent of network infrastructure

- On the Internet exist *heterogeneous services with different traffic and QoS demands*.

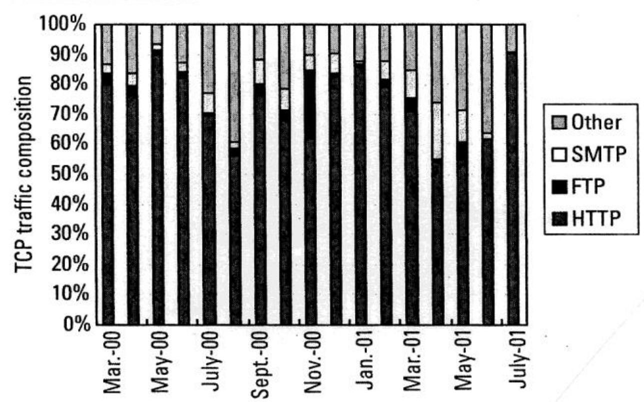
Characterization of IP Traffic

- **Aggregate Internet Traffic;** **Best-effort service is the dominant type of services (equal bandwidth is shared among all traffic flows).**
  - **Web traffic dominates as the single largest Internet application with TCP accounting for most of the traffic: 95% or more of the bytes.**

- **Internet Traffic Components; Web traffic (WWW) accounts for 55% to 90% of TCP traffic. UDP is convenient for real-time services (RTP over UDP for video)**



Internet traffic analysis on a protocol basis.



TCP traffic analysis.

QoS Classification of IP Traffic

- **Service requirements are based on; packet loss, packet delay, delay variation (jitter), and throughput**
- **Classification based on users' perspective;**

1. **Interactive applications (e.g., IP telephony), have stringent requirements for packet delay and delay jitter. Few 100 msec impact the perceived quality of communications.**

Example, VoIP; 0 to 150 msec, acceptable

150 to 400 ms, barely acceptable

> 400 ms, n't acceptable

Total acceptable delay must be divided into an acceptable delay budget for each node on the path between sender and receiver.

It's necessary for these applications to enter almost empty buffer.

Better not to mix them with other traffic in the buffer, or sometimes allocate higher priority to VoIP packets. Tolerant to losses.

IP Traffic Classification(continued)

2. **Distribution Services** such as audio and video streaming & Web TV. Tolerant to delay and delay variations (several seconds which depends on the playback buffers in the receiver).

   Loss toleration varies depending on the application; video distribution requires lower losses than video conferencing.

3. **Service on Demand** (e-mail, video or audio on demand, and data transfers). MPEG-4 for video adapts to the available bandwidth

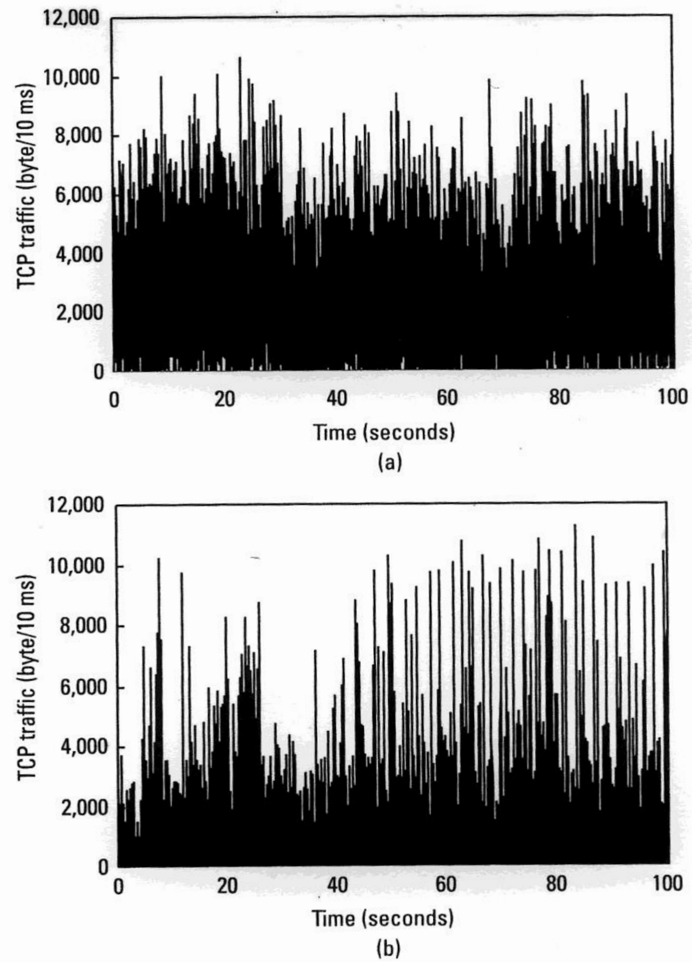
   e-mails; retransmission of lost packets achieves reliable transmission.

Classifications

Class	Subclass	Flow Type	Application
A	**A1**	**Highest priority**	**IP Telephony, videoconference, e-commerce**
	A2	**VBR real-time**	**Video/audio streaming, on demand service**
	A3	**Best Effort- minimal QoS guarantees**	**WWW, multimedia mail, file downloads**
B		**BE (Best-effort)**	**E-mail, scheduled file downloads**

Statistical Characterization

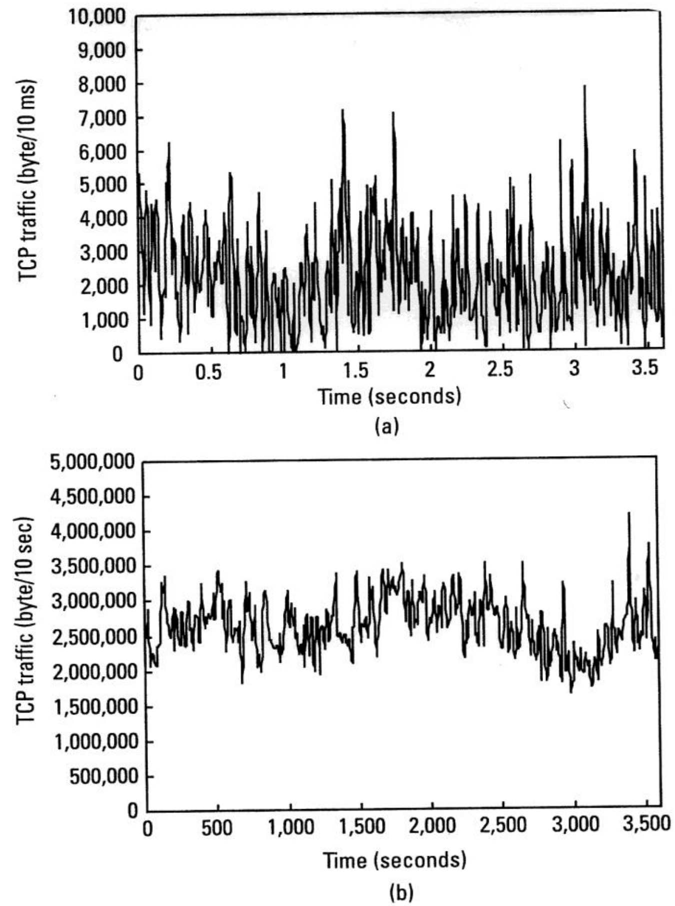
- **Nature of IP Traffic**; The figures show that traffic is **bursty** and show the time dependence of traffic at different time scales (e.g., bytes per 10 ms and byte per 1 second



TCP traces at time scale 10 ms: (a) *tcptrace1*; and (b) *tcptrace2*.

Nature of IP Traffic (continued)

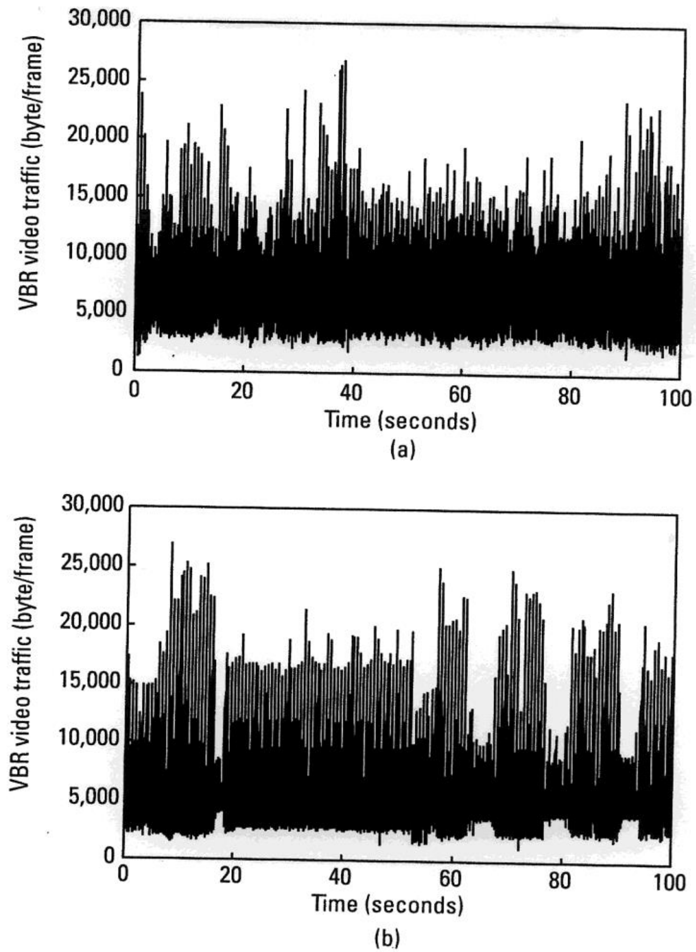
- **Traffic is bursty, also 2nd Fig, Time-scale is 1,000 times longer, but we notice the same traffic behavior**
- **This multiscale burstiness doesn't fit the traditional *Poisson process which fails to capture the burstiness*.**
- **TCP traffic looks the same (similar) over time scales ranging from msec to hours. This is a self-similar process (fractals)**
- **Similar observations are obatined for WWW traffic**



TCP traffic at different time scales, *tcptrace1*: (a) 10-ms aggregation periods; and (b) 10-second aggregation periods.

Nature of IP Traffic (continued)

- **Notice a bursty nature of video traffic similar to those observed at TCP and WWW traces, for <u>aggregate traffic</u> as well as <u>individual connections</u>.**
- **The burstiness of video stream is the result of the content changing, from one frame to another.**
- **Analyses of traces show that TCP, WWW, and VBR video are statistically self-similar by nature.**



VBR video traces: (a) *vbrvideo1*; and (b) *vbrvideo2*.

Self-Similar Processes

- **Traffic processes are said to be self-similar if they look qualitatively the same irrespective of the time scale from which we look at them.**
- **Fundamental properties of self-similar stochastic process are;**
  1. **Long range dependence (LRD) and long-tailed distribution**
  2. **Slowly decaying variance**

Self-Similarity (continued)

X is a stationary process in the discrete time domain with mean value, variance, and auto-correlation function given by

$$X = \{x_t; t = o,1,2..... \}$$