Voice/IP

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Voice and Data

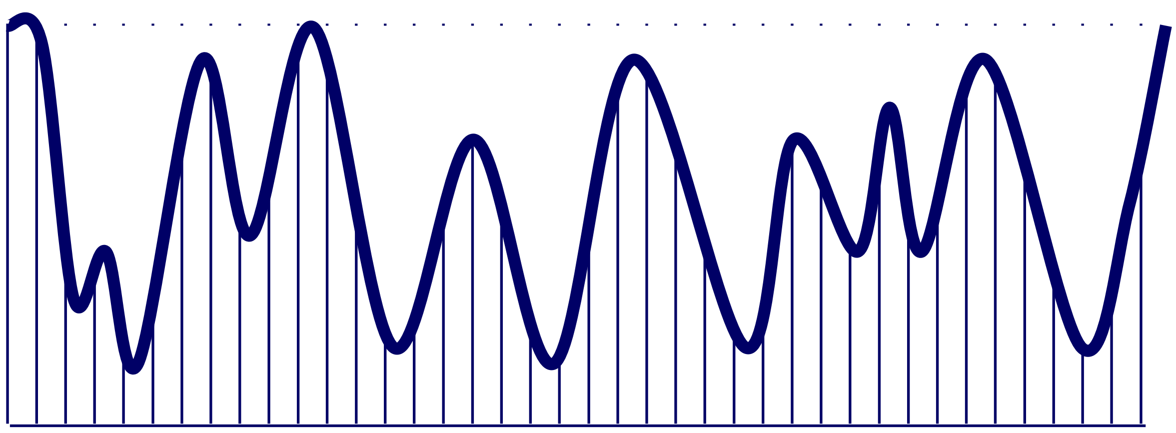
- Analog voice transmission has dominated the communications industry for the past 100 years
- The entrance of multi-service digital networks is placing a new set of demands on the service profile of communications networks
- Will we see convergence to a single network platform?

Voice Networks

- Voice transmissions have an number of characteristics:
  - 3Khz bandwidth
  - limited amplitude (<25db)
  - time synchronization
  - limited average duration (200 seconds)
  - High localization (80:20 rule)
  - Strong traffic peaking characteristics

Digitizing Voice

- 8000 samples per second (Nyquist Theorem)
  - 125 μsecond timebase
- 256 discrete amplitude levels
  - 8 bits per sample
- 64Kbps PCM data stream



64K Networks

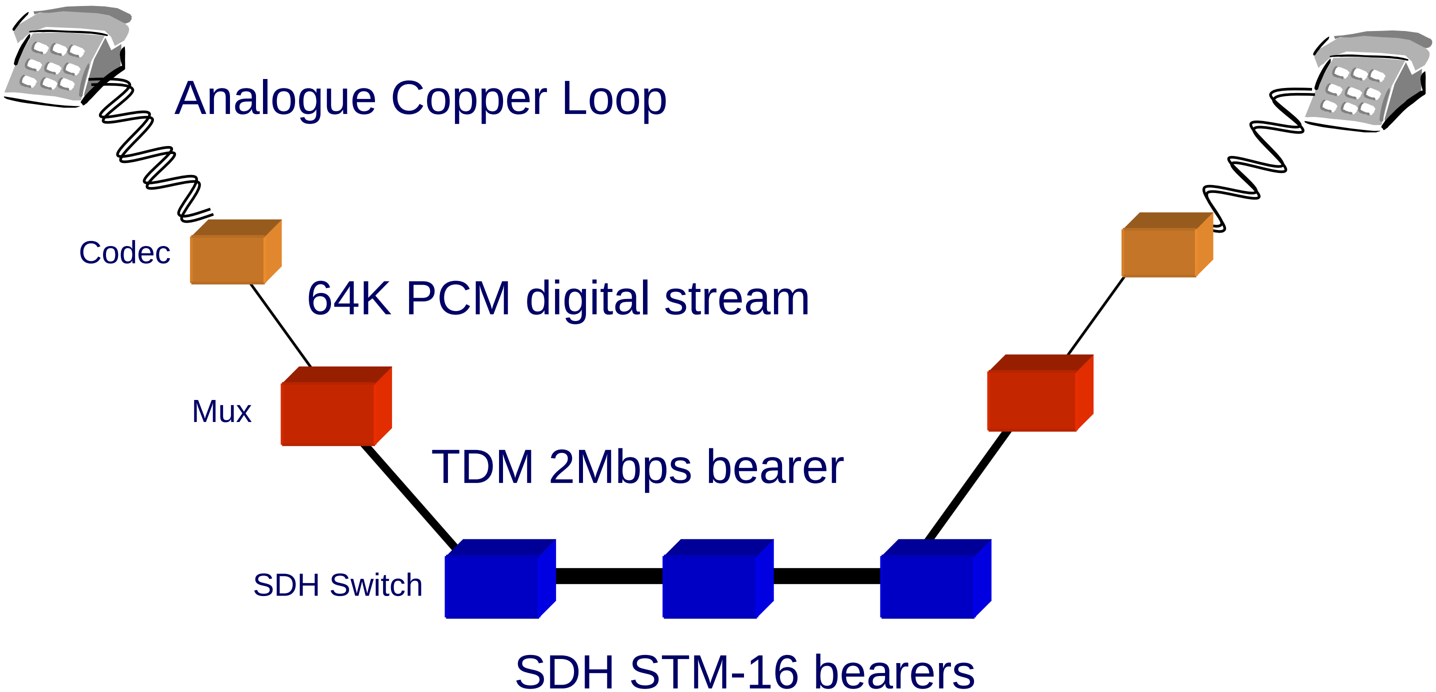
- Voice networks are built by multiplexing and switching synchronous 64K data streams
- Time division multiplexing
  - 125 μsecond time base
  - 8 bit symbols per time slot per voice channel
- 2Mbps bearer is 32 x 64K slots
  - 30 data slots
  - 1 channel signaling slot
  - 1 frame sync slot

  = 2048Mbps

Circuit-switched Networks

- Time division switches
  - reorder the timeslots of a TDM data stream
  - impose 1 slot time constant delay
- Space Switches
  - crossbar switching
  - 2 slot time delay due to muxing overhead
- Supports dynamically switchable end-to-end synchronously clocked circuits

A Voice Network



A Data Network

- Switches *Packets*, not *circuits*
- Each packet may be independently forwarded, delayed or dropped by each router
- Each packet is independently switched to its addressed destination
- There is no time synchronization between sender and receiver

Data Networks

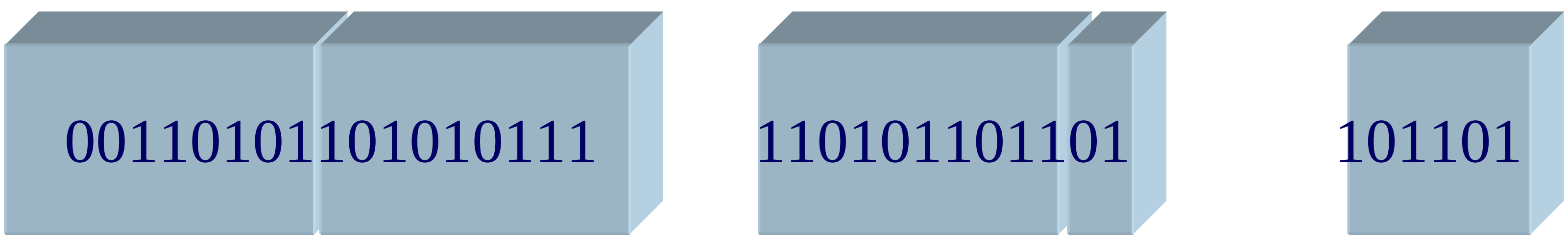
- Highly cost effective infrastructure
  - low levels of network functionality
  - high potential carriage efficiency
- Functionality pushed beyond the network edge
- Assumption of adaptive data flow control by end hosts
- No guarantees of service level by the network.

Voice over IP

- packetize the digital voice stream
- add timing information
- add IP headers
- send across the network
- strip IP headers
- feed into playback buffer using timing information
- playback analogue signal

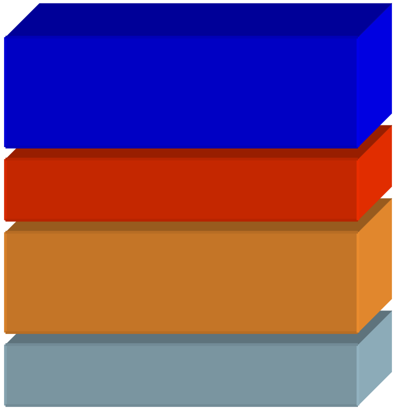
Packetizing Voice

- Compress the digital stream
  - differential PCM
  - Linear Predictive Encoding
  - silence suppression
- packetize the stream into fixed length payloads

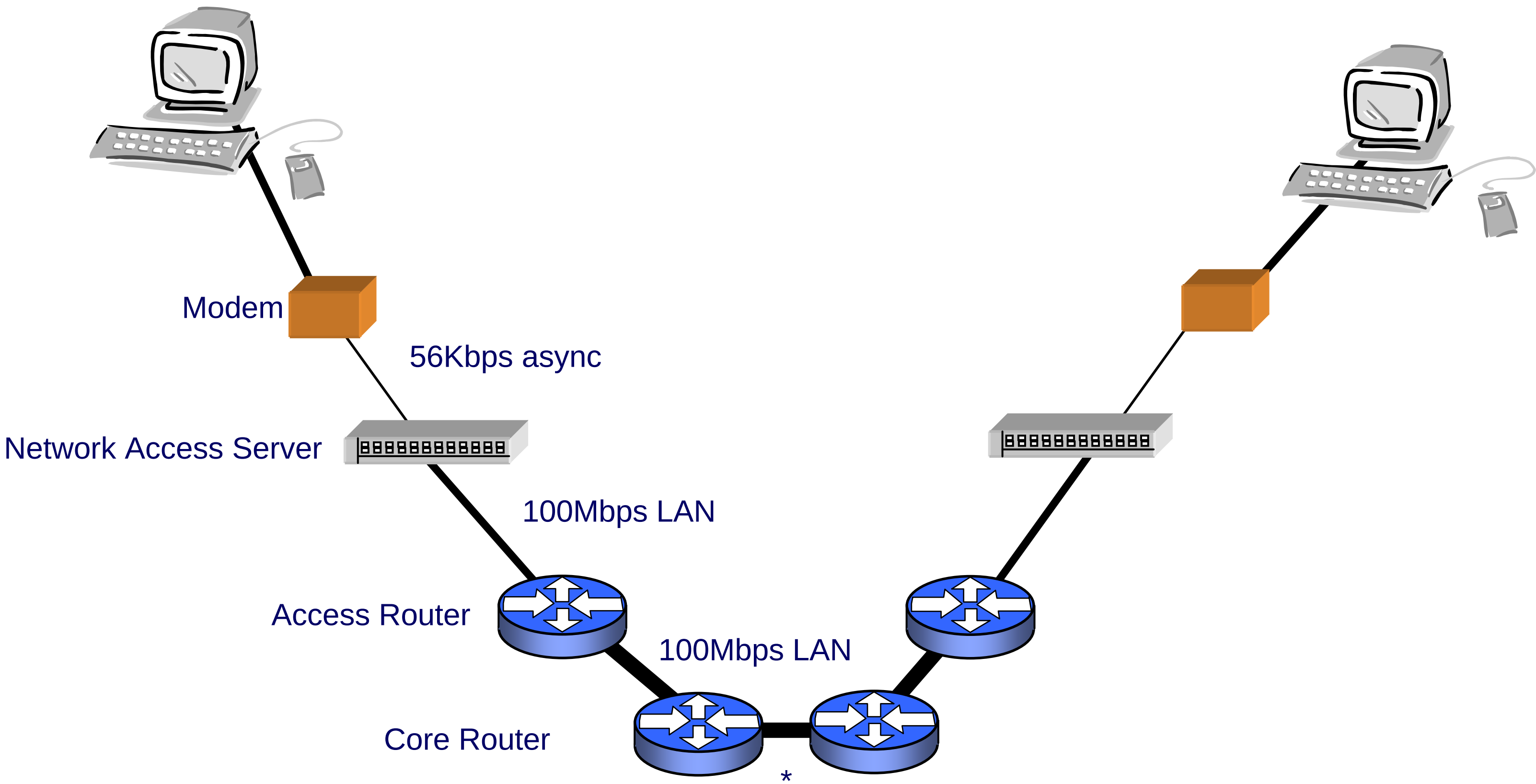


Voice over IP

- Insert RTP header
  - 12 bytes or more
- Insert UDP header
  - 8 bytes
- Insert IP header
  - 20 bytes or more
- Payload size (packet rate) is a compromise between packet overhead and latency and jitter

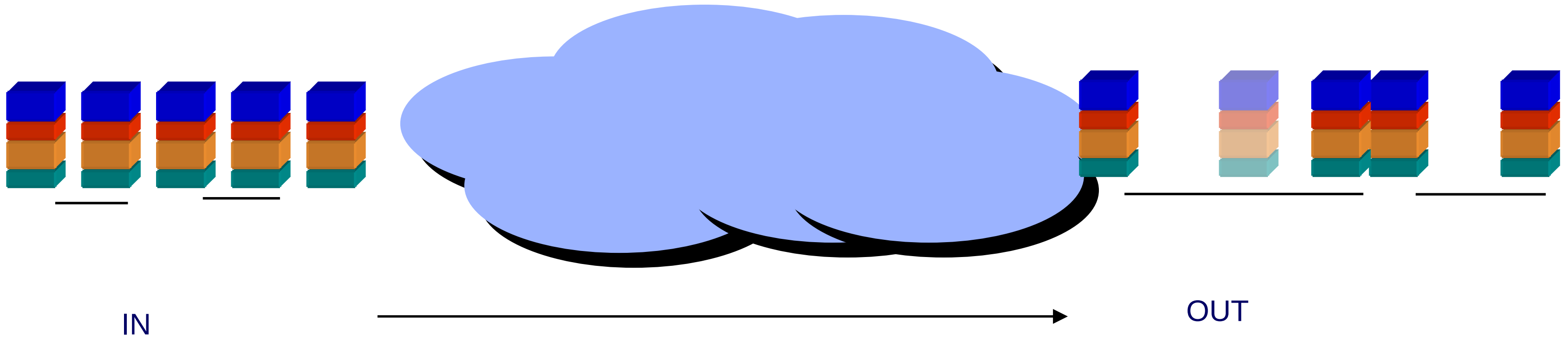


Voice over IP



VoIP Service Requirements

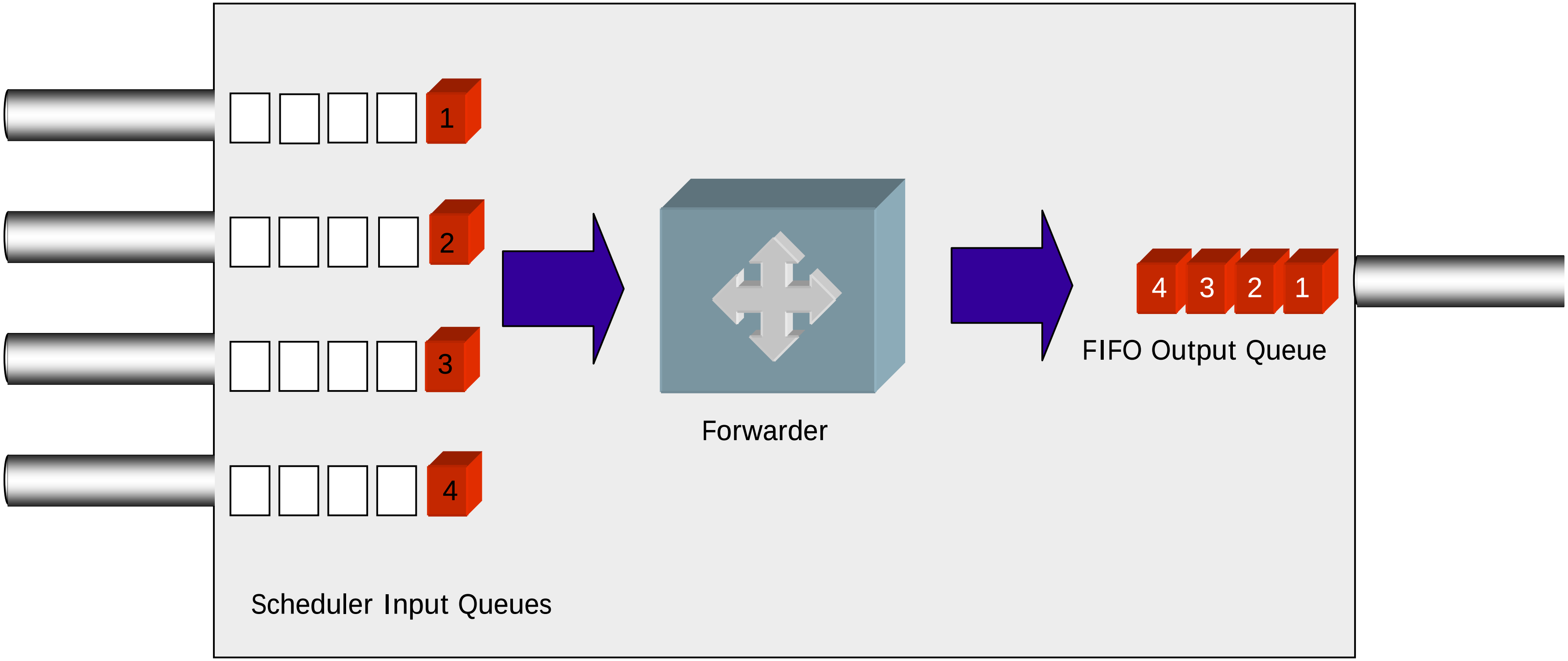
- Bounded End-to-End
  - Delay - interaction requires delay to be under 500ms
  - Jitter - high jitter causes large playback buffers
  - Drop - signal quality



Why do Routers have queues?

- Delay, Jitter and Drop are all outcomes of router queue behaviour
- Queues are used to:
  - resolve contention for a resource
  - buffer speed differences within the network

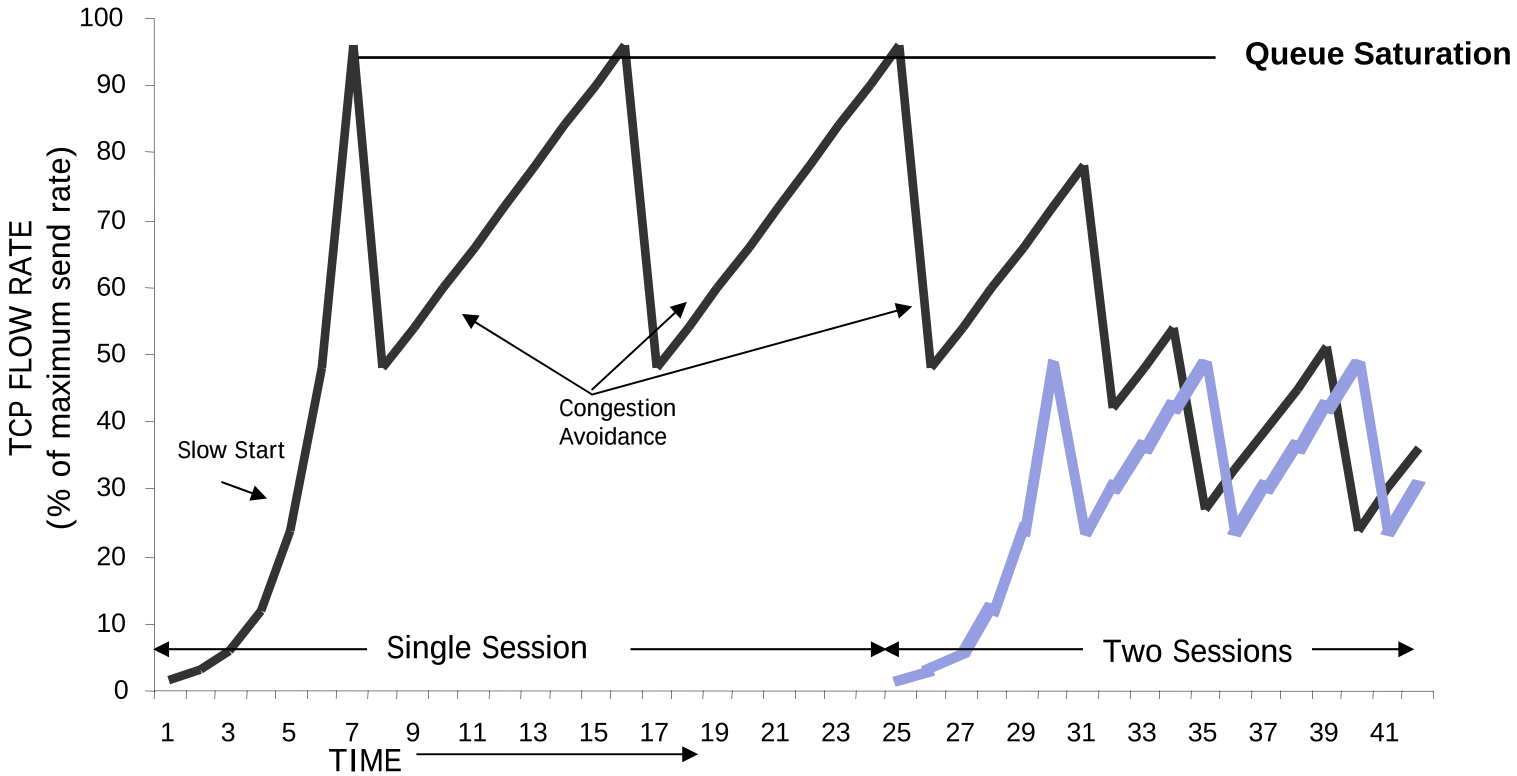
Resource Contention Queues



TCP and Queues

- TCP is an adaptive data protocol
- TCP has no ‘fixed’ data transfer rate.
- Instead, TCP uses an adaptive flow control algorithm
- TCP uses a feedback loop to adjust the sending rate to the available network capacity

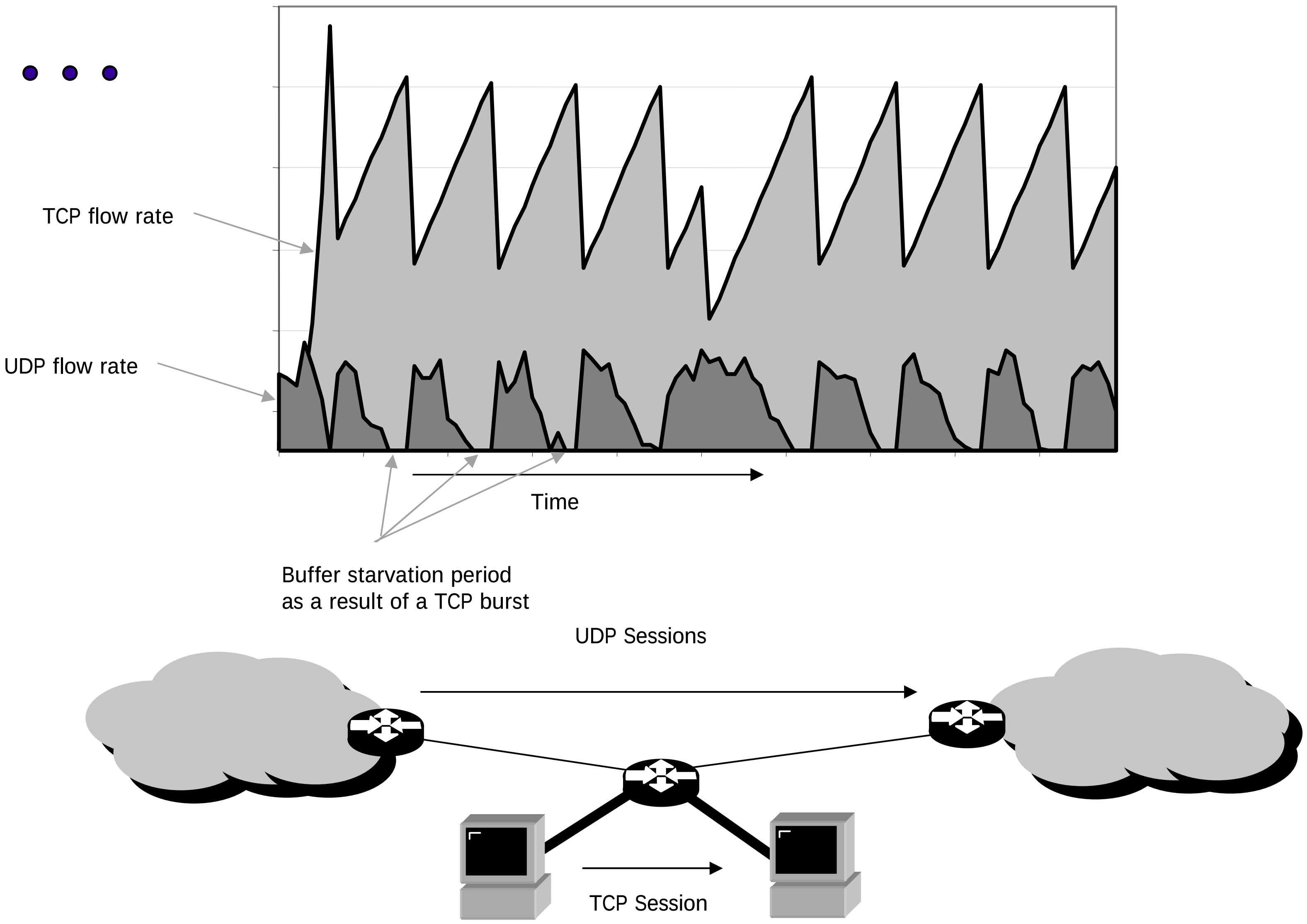
TCP rate control



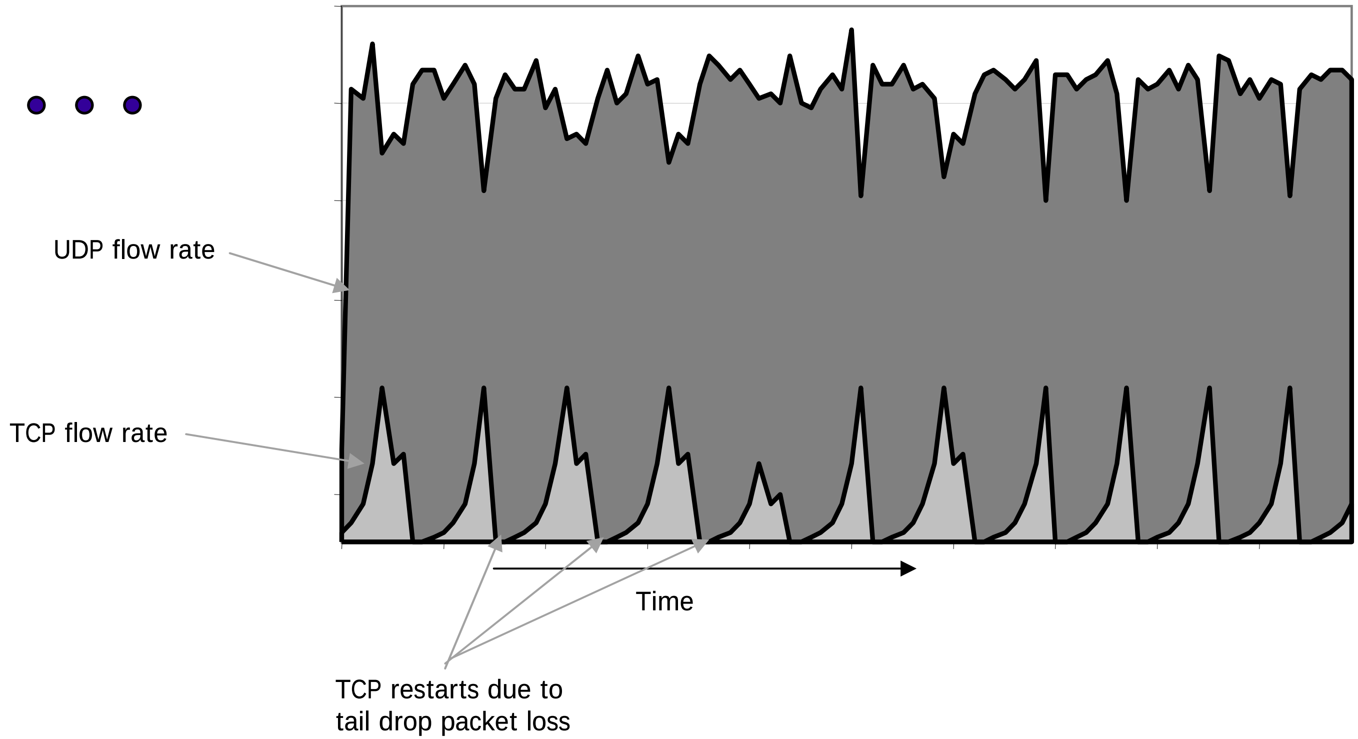
The Multi-Service Problem

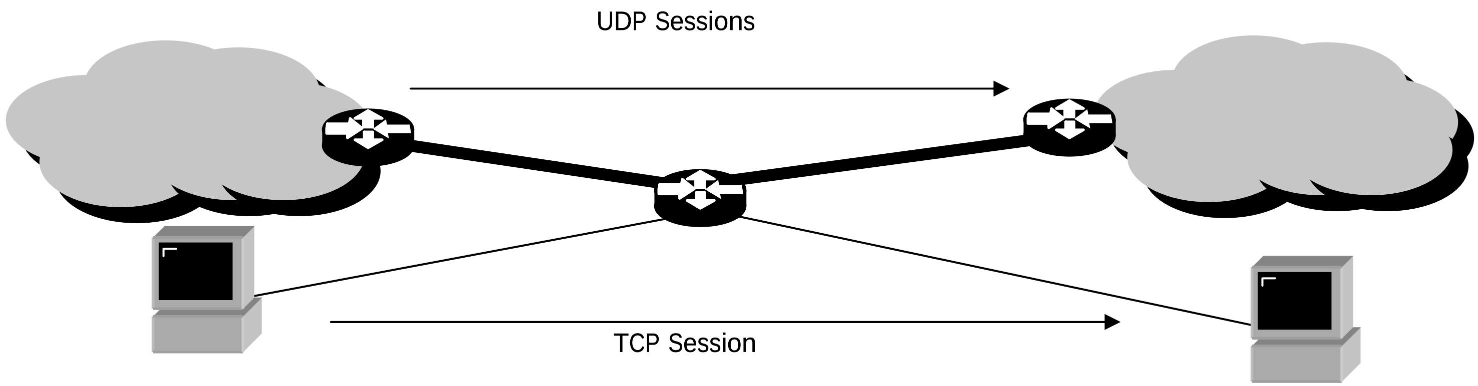
- Real-Time flows require:
  - short queues
  - admission control
  - priority queuing
- Congestion-Managed flows require:
  - large queues
  - no admission control
  - explicit congestion notification

Mixing TCP and UDP



Mixing TCP and UDP





One Network Platform

- Can you mix Voice and Data at the packet level?
- Voice over IP works - as long as:
  - small proportion of total traffic
  - queue lengths are kept short
  - some network inefficiency is tolerated

  - i.e. as long as the proportion of VOIP traffic is low compared to rate-adaptive traffic and the network is generally unloaded

The Multi-Service Network

- Does high quality service require resource reservations?
  - Can resource reservation be provided?
  - Is the cost of simulating time switching in a packet switched network higher or lower than the cost of operating a distinct time-switched network?
  - Where is the cross-over point?
  - Is service convergence and the mother-ship single platform operational model just a perverse throwback fantasy?