Can the Internet That Got Us Here Take Us There?

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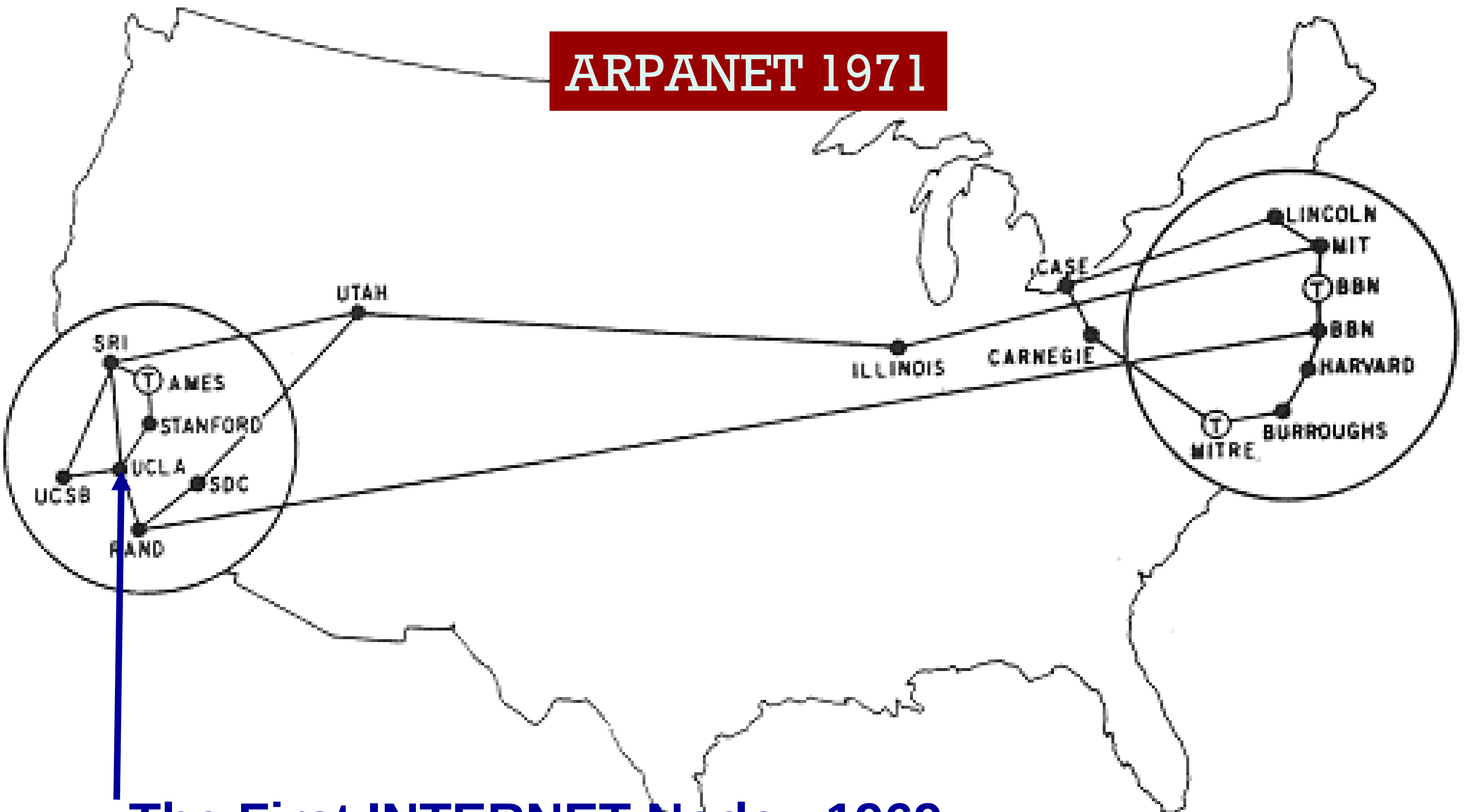
Internet Chronology

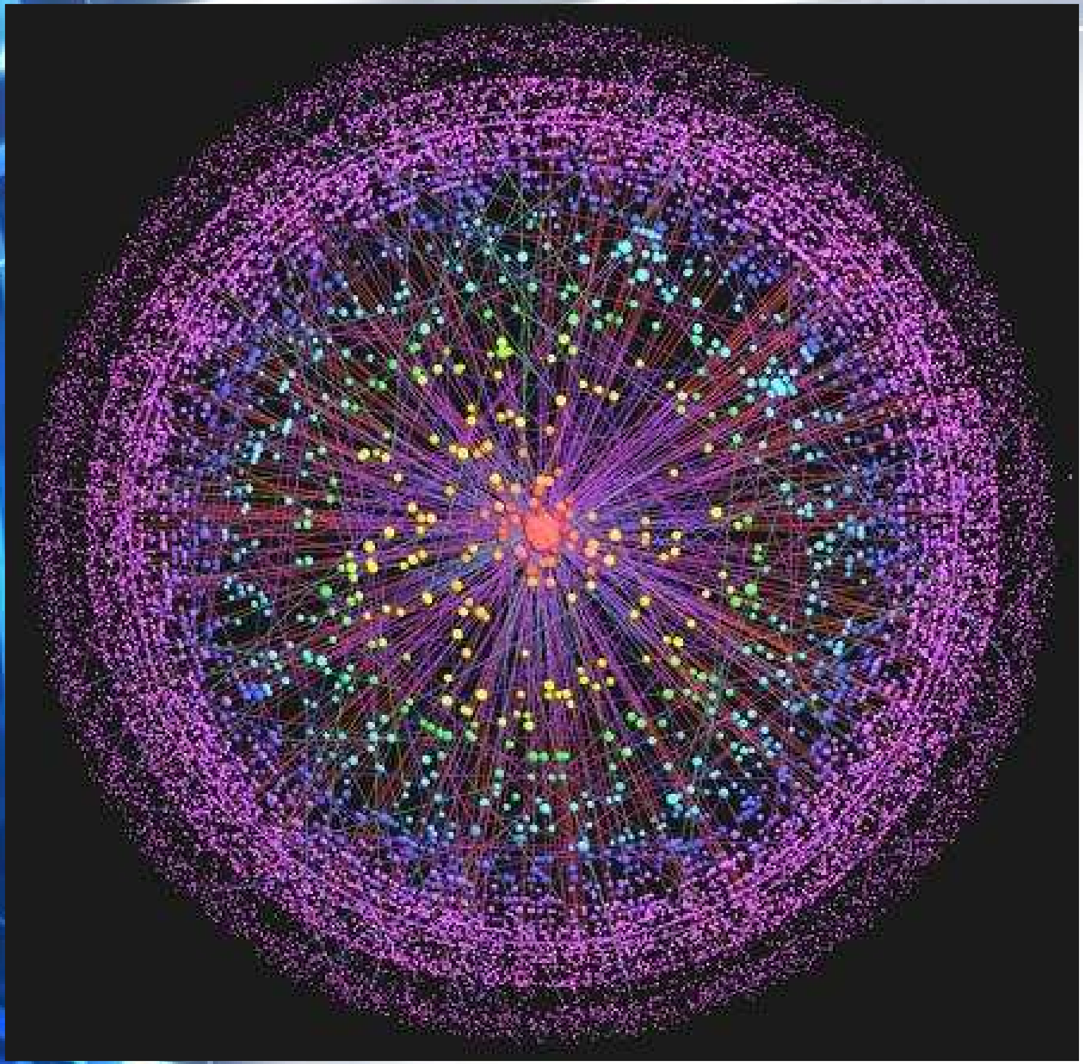
- **1969** First major packet network-ARPANET designed
- **1974** First Internetworking Protocol, TCP outlined in a paper by Robert Kahn and Vinton Cerf
- **1980** NSF Organizes CSNET increasing it to 70 sites and integrating most computer science sites by 1986
- **1983** TCP/IPv4 introduced into Internet
- **1989** Internet opened to commercial mail through MCI Mail
- **1991** NSF Opens Internet to commercial use
- **1993** Introduction of Mosaic Web Browser
- **1998** Google Founded
- **2007** 18% of World population using Internet. Internet is also used for Real Time Applications such as Video, Voice, Gaming

The Internet in 1971



The First INTERNET Node - 1969

Internet Today



- 80 critical high density core nodes
- 5,000 outer shell sparsely connected nodes
- 15,000 peer-connected and self-sufficient nodes

Research Project Bar Ilan University, Israel

Business Drivers

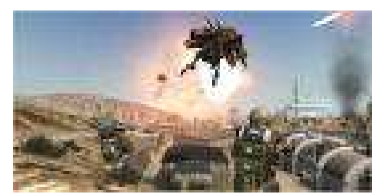
- New Broadband Applications drive Internet traffic Growth
- Real-time applications challenging Service Provider to enforce and monitor QoS policies end-to-end
  - Interactive (Delay Sensitive)
  - Loss Sensitive
  - High Bandwidth Usage
- P2P traffic represents a substantial part of non-revenue burden on current networks
- Integration of mobile, wireless, and wireline networks demands better security

VoIP

skype

IPTV

Mobility



Gaming

Media

Video is the Primary Internet Traffic Driver

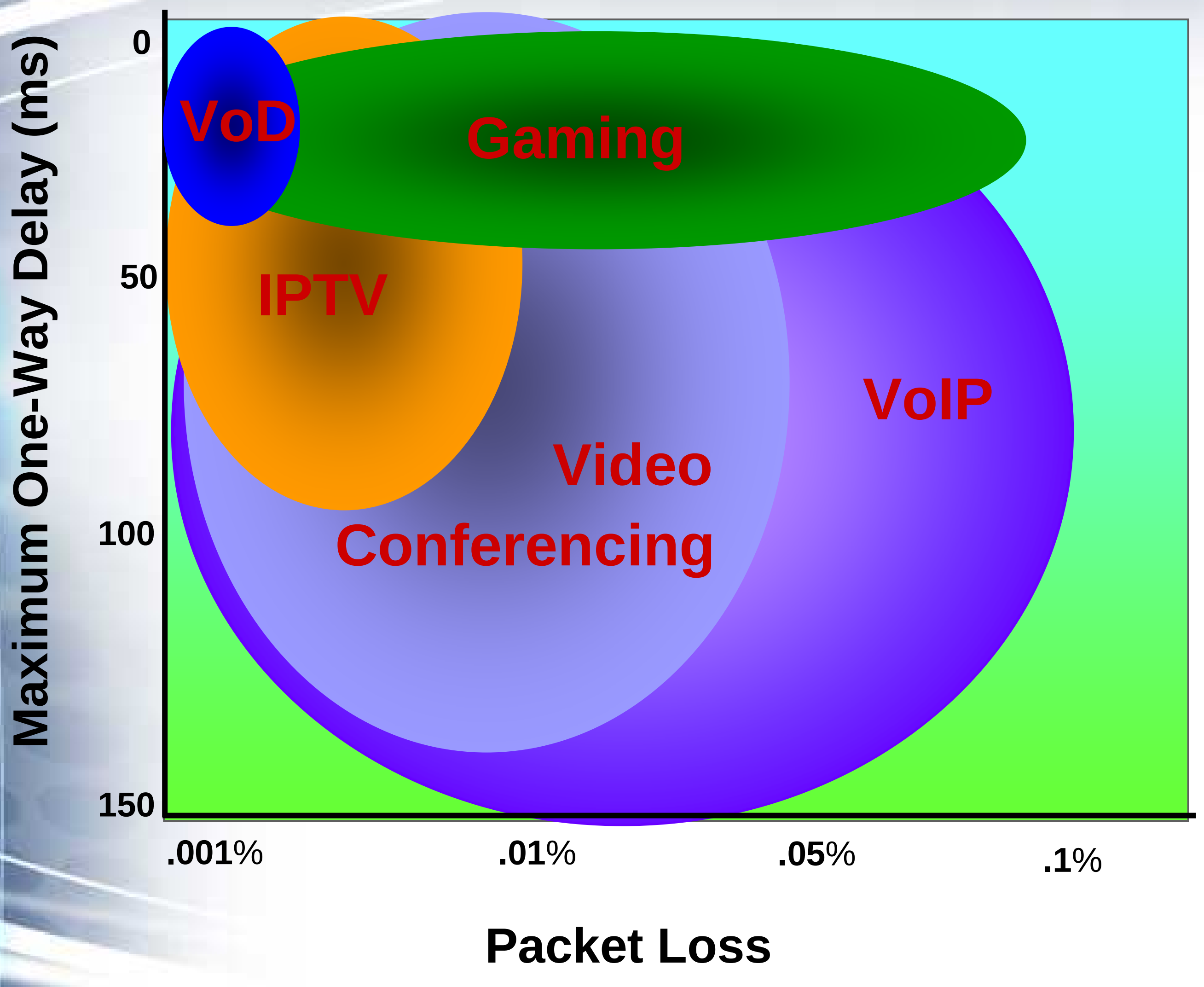
- Peer-to-Peer (P2P)
  - Download of Large Files
  - Over 650 Petabytes a month
- YouTube
  - Short HTTP Video Streams
  - 1-3 Minutes Long over 100M Videos a day
- IPTV (multicast and on-demand)
  - By 2011 is projected to reach 1.2 exabyte a month
- According to Ellacoya Networks because of YouTube, HTTP Traffic now accounts for 46% and P2P for 37% of all Broadband Traffic (down from 53%)

Networks Economics

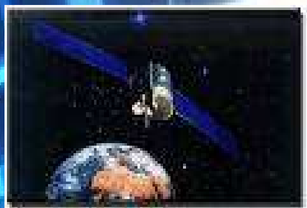
Application	Bandwidth Consumed by Broadband User	Cost to Service Provider
Today Internet	2 Gigabytes/ Month	$1
Download Video (YouTube, P2P)	9 Gigabytes/ Month	$4.50
IPTV	224 Gigabytes/ Month	$112
High Definition VoD	1 Terabyte/ Month	$560

Need to Reduce cost/ per Byte

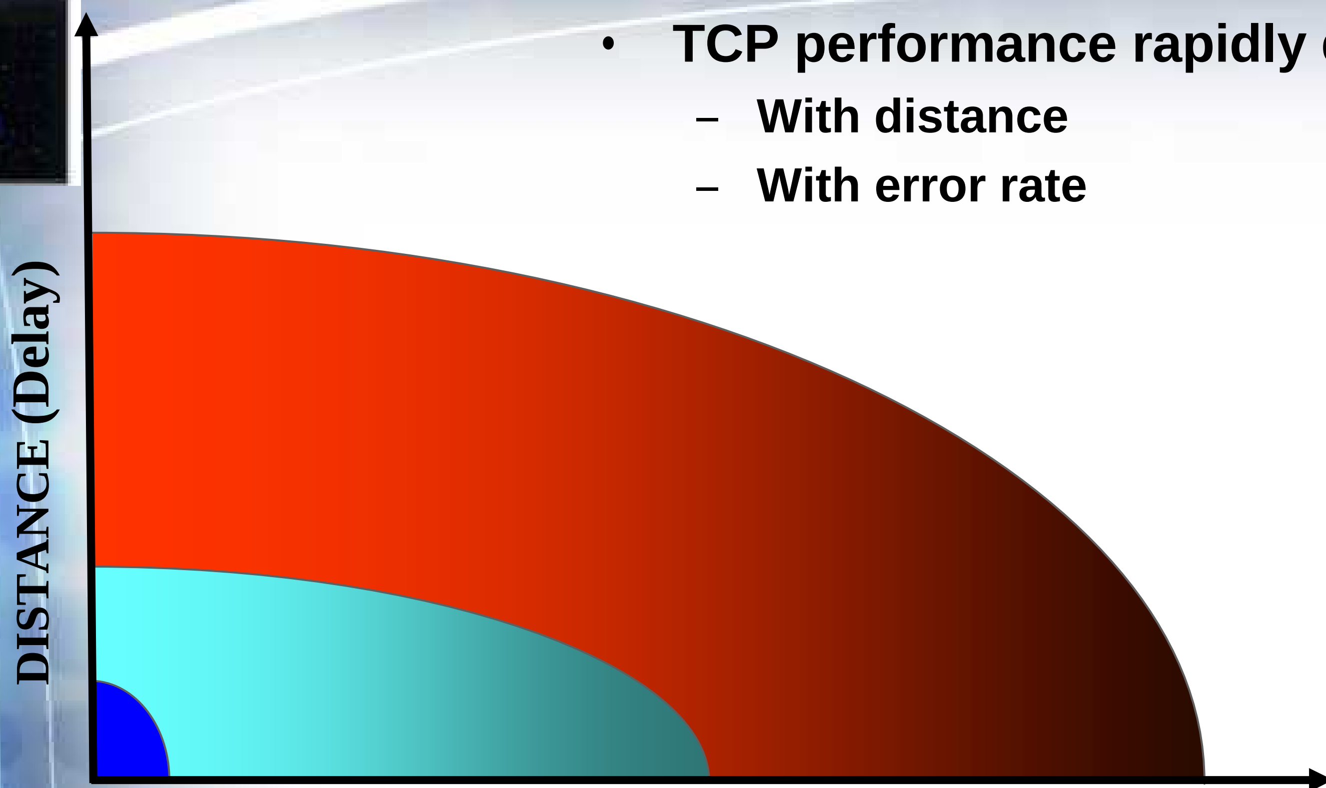
QoS Performance Requirements by Application

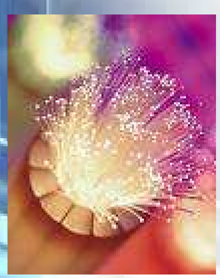


TCP Performance Problem



- TCP performance rapidly degrades
  - With distance
  - With error rate





Fiber

WiFi

Field Radio

Next Generation Networks Requirements

- Need to Reduce Cost per Byte
- Have to Keep up with the Traffic Growth
  - Provide More Bandwidth Capacity if needed
  - Increase Network Utilization
- Provide New Network Management Controls to Deliver Real Time Applications
- Demand for High Security

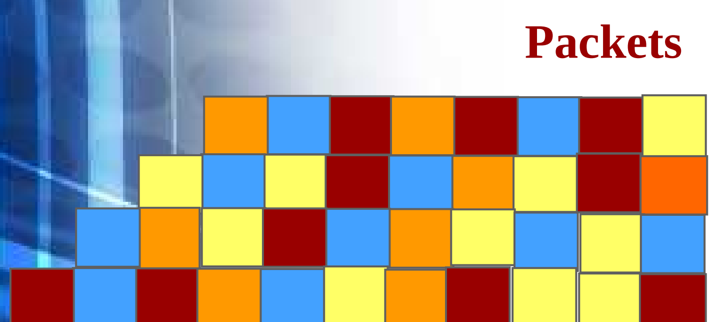
Network Challenges

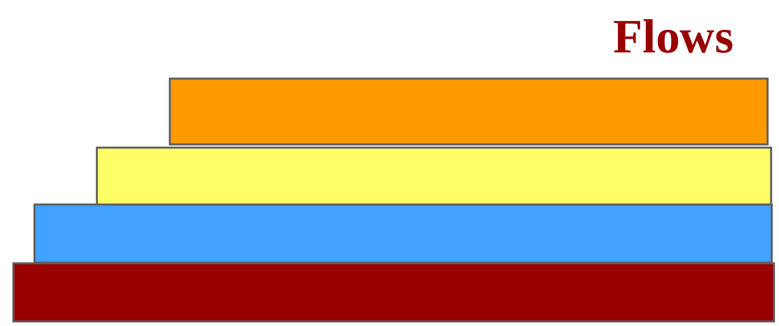
- Today's IP Networks Based on Best Effort Design
  - Low Utilization (less than 27%), network over-provisioned
  - Challenges to Provide hard end-to-end QoS for Broadband Services
    - Rate, Bandwidth, Delay, Discard Control
    - Call Acceptance Control (Video)
- There is no ability of end user to request the rate or QoS
  - New Standards are emerging (TIA 1039), but difficult to implement/ adopt
  - New flow routing technologies are emerging, but require signaling/ QoS request from the edge of the Network
- No preference at home/ business in IP

What is a Flow?

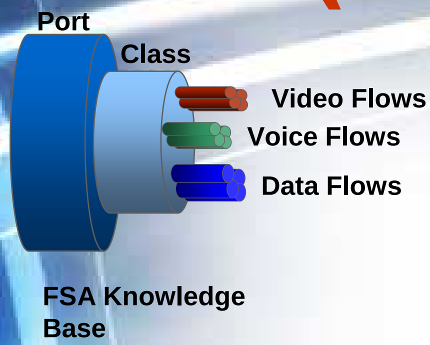
Flow is a stream of packets (data, voice, video) that is defined:

- 5-tupple in IPv4
  - Source Address
  - Destination Address
  - Source Port
  - Destination Port
  - Protocol
- 3-tupple in IPv6
  - Source Address
  - Destination Address
  - Flow Label





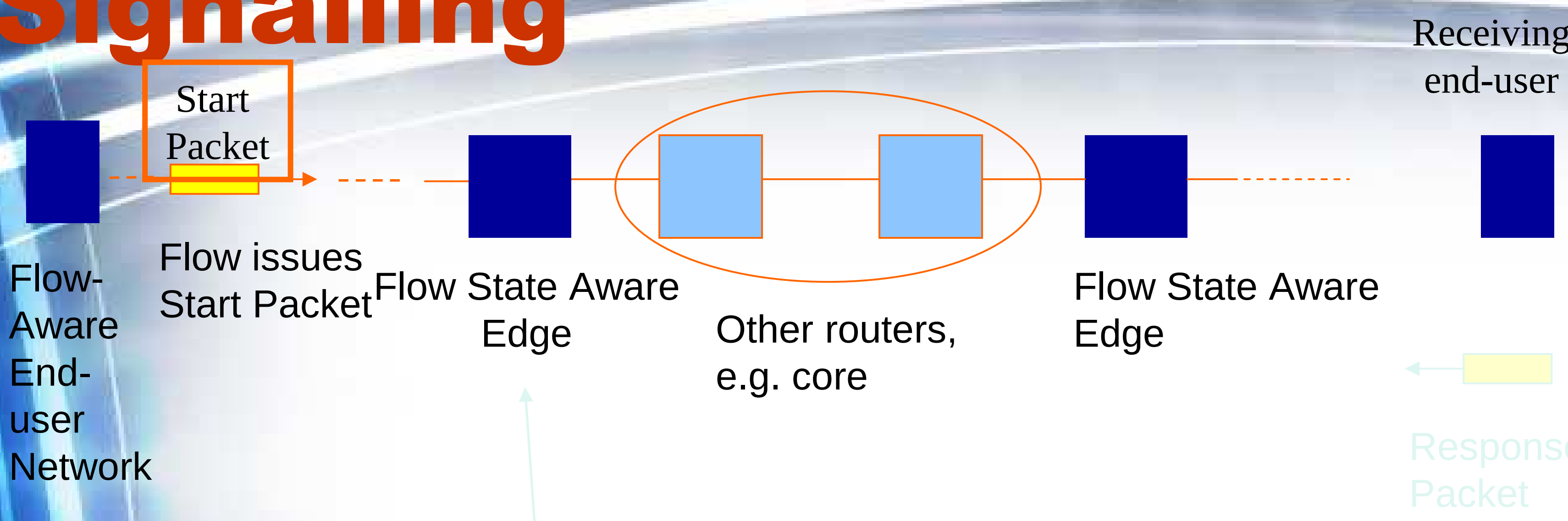
Advantages - Flow State Aware (FSA) Solutions



Added flow state knowledge of the packets, FSA offers unmatched traffic monitoring and management capabilities

- Hard QoS control per flow and per class of traffic to manage the delivery of Broadband services
  - Delay Control
  - Rate Control
  - Burst Tolerance
  - Preference (ITU Standard)
  - Flow Level Discard
- Monitor and report non-revenue traffic (P2P, web surfing)
- Increase Utilization

Flow State Aware (FSA) Signalling



- The Start Packet causes flow identity to be registered at each flow state aware system, together with how that flow is to be treated, as described in the Start Packet fields
- One field of the Start Packet can nominate a (requested) current available rate end-to-end. Routers that implement the standard can mark down this requested rate
- The Response packet confirms the available rate along the end-to-end path

TIA 1039/ITU Y.flowreq QoS Signaling-Start Packet Format

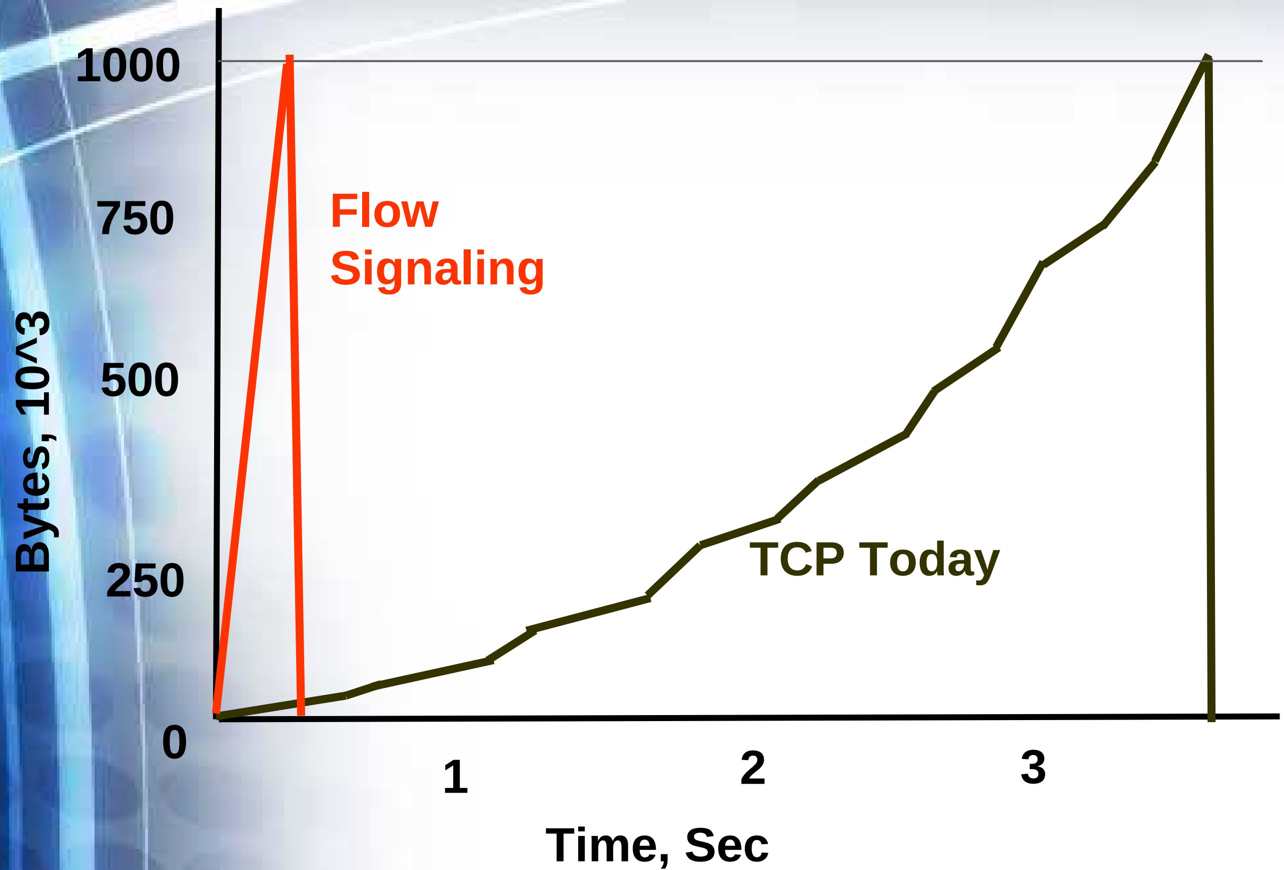
The Start Packet Only Sent in First Packet of Flow or when Rate Changes

IPv4 Header	Ver.	IHL	Type of Ser.	Total Length			
IPv4 Header	Identification	Flg	Fragment Offset				
IPv4 Header	Time to Live	Protocol	Header Checksum				
IPv4 Header	Source Address						
IPv4 Header	Destination Address						
TCP Header	Source Port	Destination Port					
TCP Header	Sequence Number						
TCP Header	Acknowledgment Number						
TCP Header	Offset	Rsv	ECN	Control Bits	Window		
TCP Header	Checksum	Urgent Pointer					
QoS Field	Source Address						
QoS Field	Available Rate (AR)	Guaranteed Rate (GR)					
QoS Field	MLPP	Delay	CD	TP	CH	BT	
QoS Field	QoS Version	M	Source Port				

QoS Features

- New service concepts (in addition to Guaranteed Rate, GR):
  - Available Rate (fast download); Variable Rate (AR + minimum guaranteed rate)
  - Preference Level (flow-level priority)
  - Maximum Rate (soft guarantee without waiting, hard guarantee asap)
- Flow-based packet dropping, tuned to service type and Preference level
- A high Preference Level flow can be established even when network capacity is already fully loaded with flows of lower Precedence Levels

TCP Performance Improvement

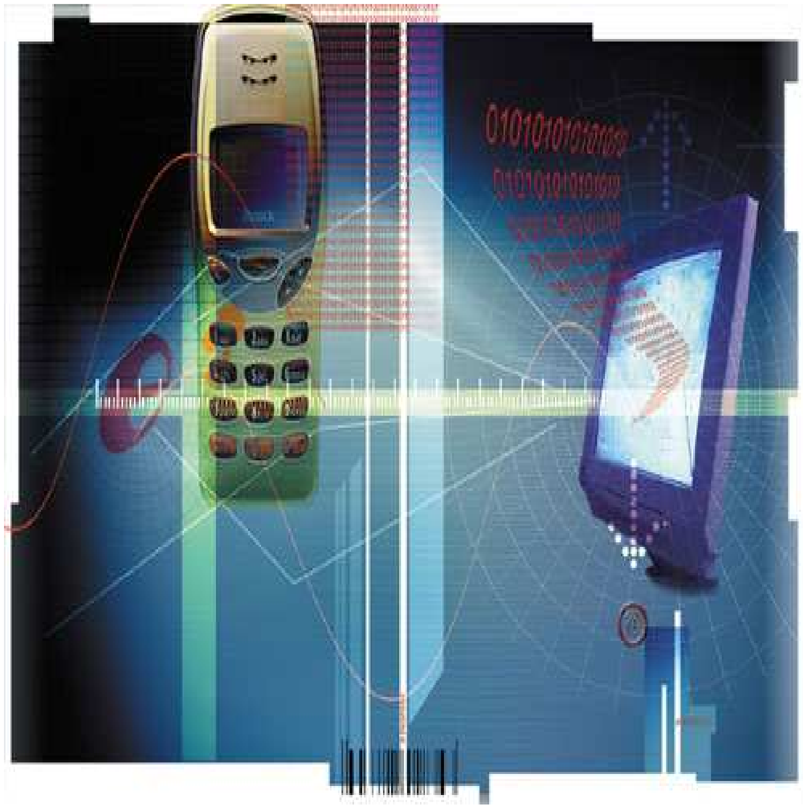


Major Improvement in Performance over Long Delay and High Error rate paths

Interactive Media Services

Case Study: A person talks to a friend on phone (VoIP) and would like to launch the video in the middle of the call

- **Best Effort Network:**
  - **There would be significant delay due to the network negotiating the video call (RSVP, etc.)**
  - **In some cases the phone call will have to be ended before the video is launched**
- **FSA Network:**
  - **The FSA system will request the Maximum Rate and the video call will be launched instantaneously**

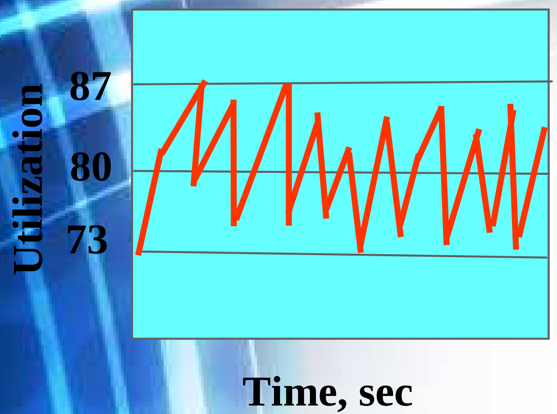


Preference at Home

Case Study: Father and son want to watch Video over IP, however there is not enough available capacity to the home for both video streams:

- **Today:**
  - **Both calls are Video with the same DiffServ priority, the quality for both video calls gets destroyed**
  - **With CAC with First Come/ First Serve whoever is first gets to watch the video**
- **With Flow Control:**
  - **Preference can be enforced automatically; whoever gets the higher Preference will watch the Video**

Trunk Utilization Improvement with FSA

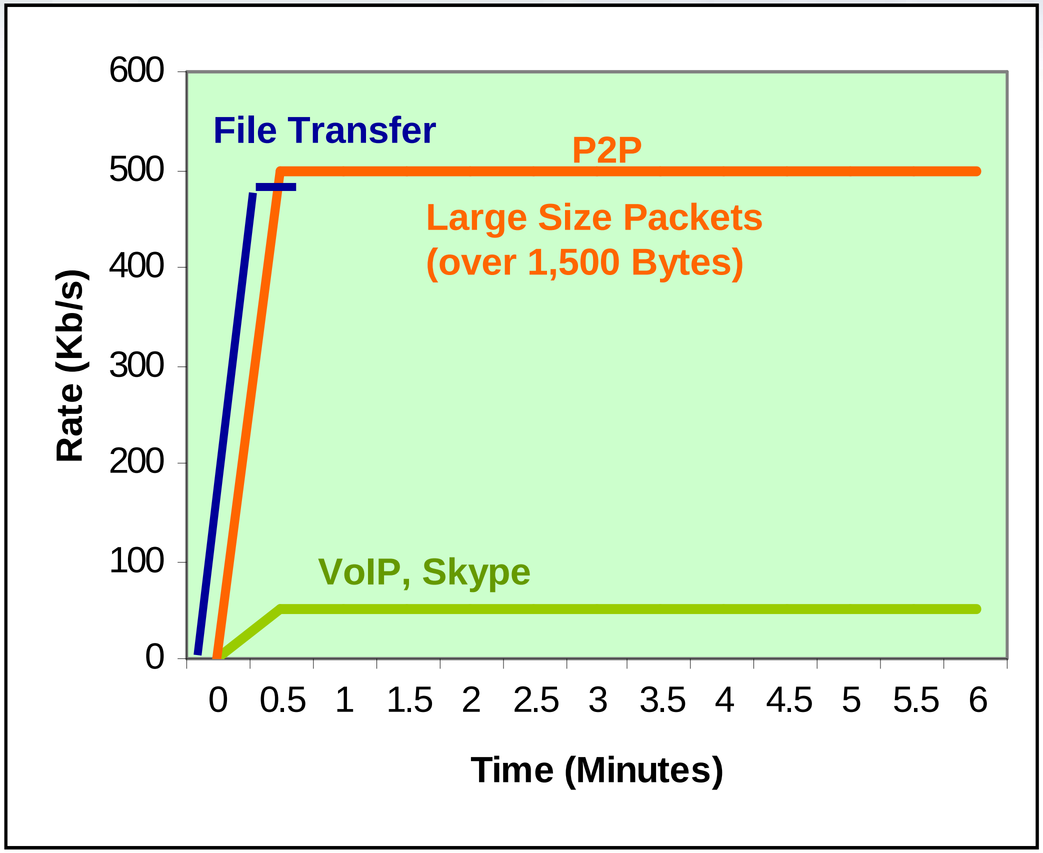


Total utilization averages 80% with FSA vs. a US Internet average of 27% utilization

- Variance is proportional to the square root of the number of controlled flows
  - 10Gbps has 1M flows – variance is reduced by 1000:1 with FSA
  - With WRR DiffServ - 16 queues – variance is reduced by 4:1
  - Variance improvement is 250:1
- Allows a 3:1 improvement in utilization
- With no peaks over 100% - no large queuing delays or packet loss

P2P Traffic Control

- **Flow State provides Information about each flow:**
  - **Rate**
  - **Duration**
  - **Packet Size**
  - **Port**
  - **Priority**
  - **Protocol**
- **This Information allows to identify most traffic types (e.g. file transfer, Voice, Video, etc.), thus enables control over P2P traffic**



Wireless Services

- Strategic Trends: High BW 802.11n ramping in 2009
  AP bandwidth growing from 40 mbps => 200 mbps
- User expectations
  - Wire-line replacement
  - Support for media streaming
  - Support for VoIP flows
- Premium services
  - Voice quality flows
  - Video quality flows
  - FSA preferences will allow premium services
- Registered FSA services requested by client application

Summary

- Flow State Aware Technology reduces cost per byte
  - Increases Utilization
  - Monitors Traffic
- Provides QoS control per flow, per application, and per class of traffic to manage the delivery of Broadband services (especially Video Services)
  - Delay
  - Rate
  - Burst Tolerance
  - Preference
  - Flow Discard
- Monitor and report non-revenue traffic (P2P)
- Improves TCP performance

What's Next?