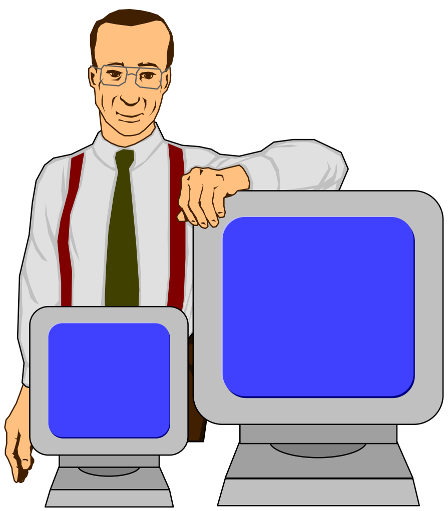
# Performance and Traffic Management of Internet Protocols over ATM

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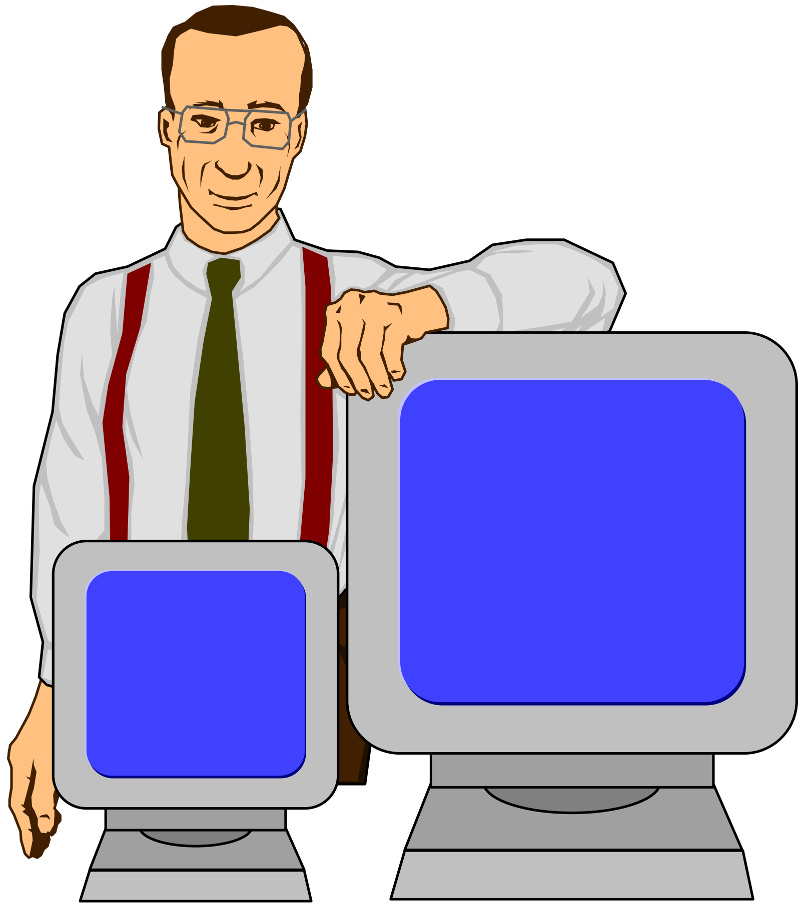
# Dime Sale



One Megabit memory, One Megabyte disk, One Mbps link, One MIP processor, 10 cents each.....


- Why worry about traffic management?
- ATM Traffic Management
- TCP/IP over ATM
- How to improve TCP/IP over ATM?
- Our Contributions to ATM Research

# Trends

- Communication is more critical than computing.Greeting cards contain more computing power than all computers before 1950.
- Last 10 years: Personal computing
  Next 10 years: Collaborative computing
- Past: Corporate networks (Intranets)
  Future: Intercorporate networks (Extranets)
- Internet: 0.3 M hosts in Jan 91 to 9.5 M by Jan 96
  $\Rightarrow$ More than 5 billion (world population) in 2003
- URL is more important than a company's phone number

# Future

Year

1980

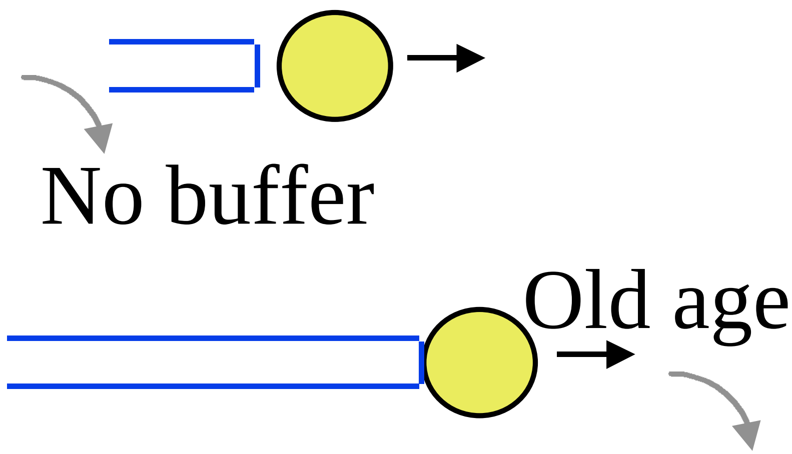
In 1990, the memory will be so cheap that you will not have to worry about paging, swapping, virtual memory, memory hierarchy, and....

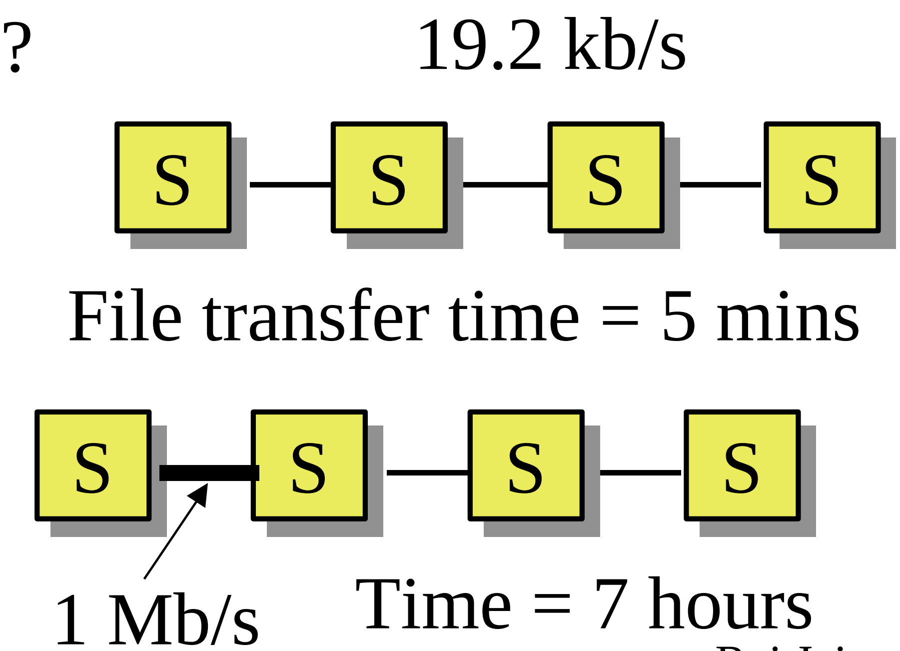
# Why Worry About Congestion?

Q: Congestion problem be solved when?:

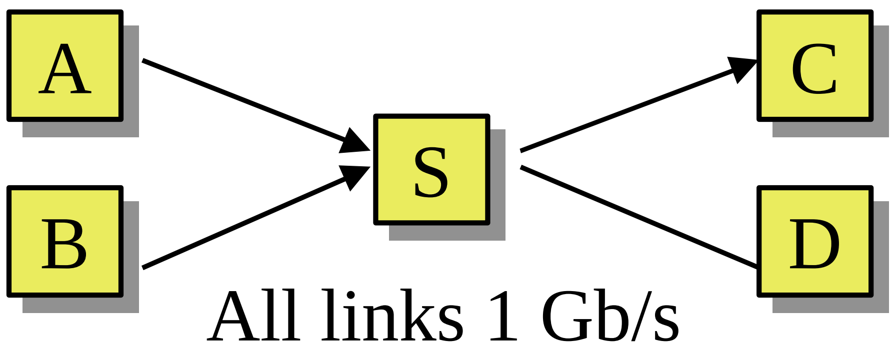
- Memory becomes cheap (infinite memory)?
- Links become cheap (very high speed links)?
- Processors become cheap?

A: None of the above.



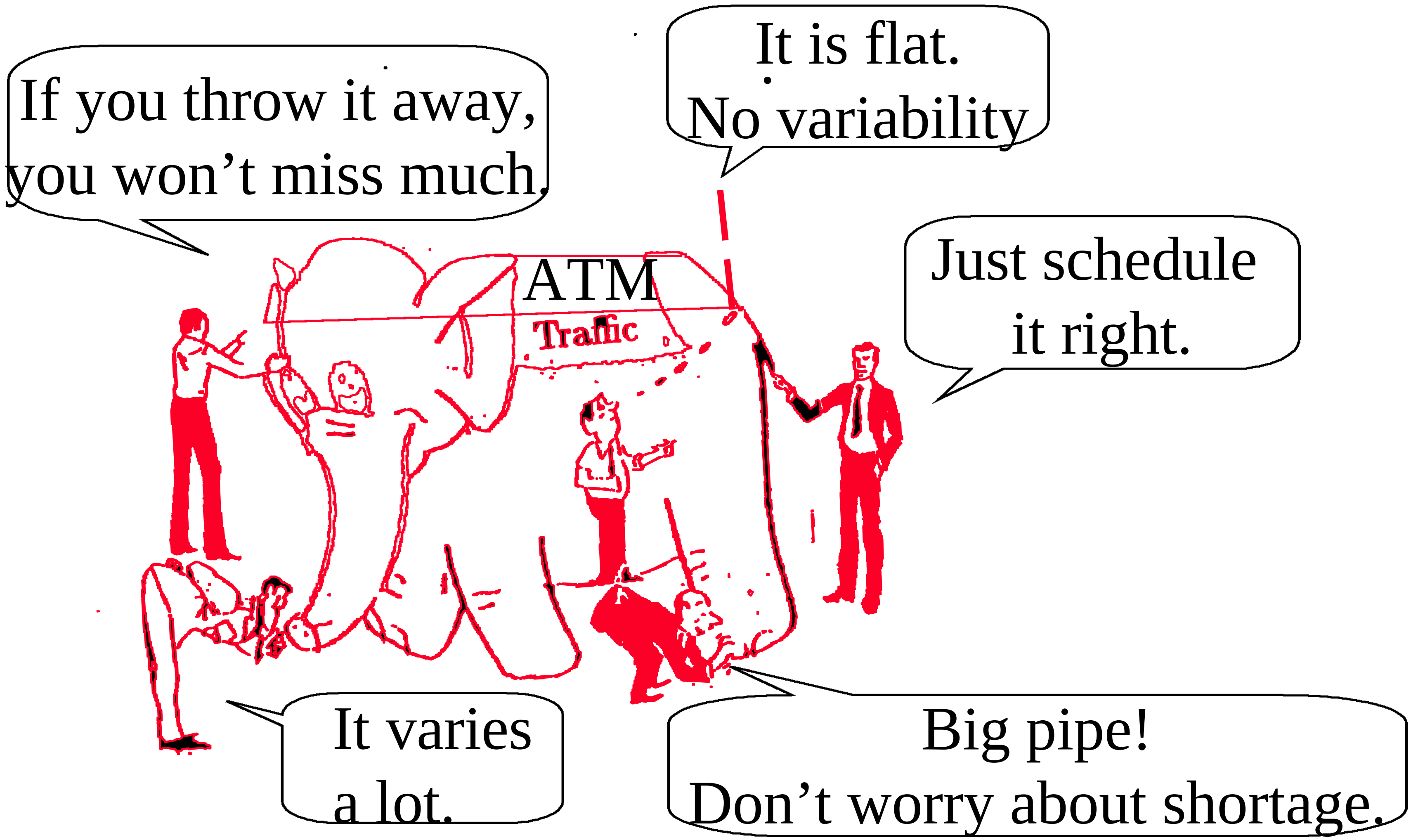



# Congestion (Cont)

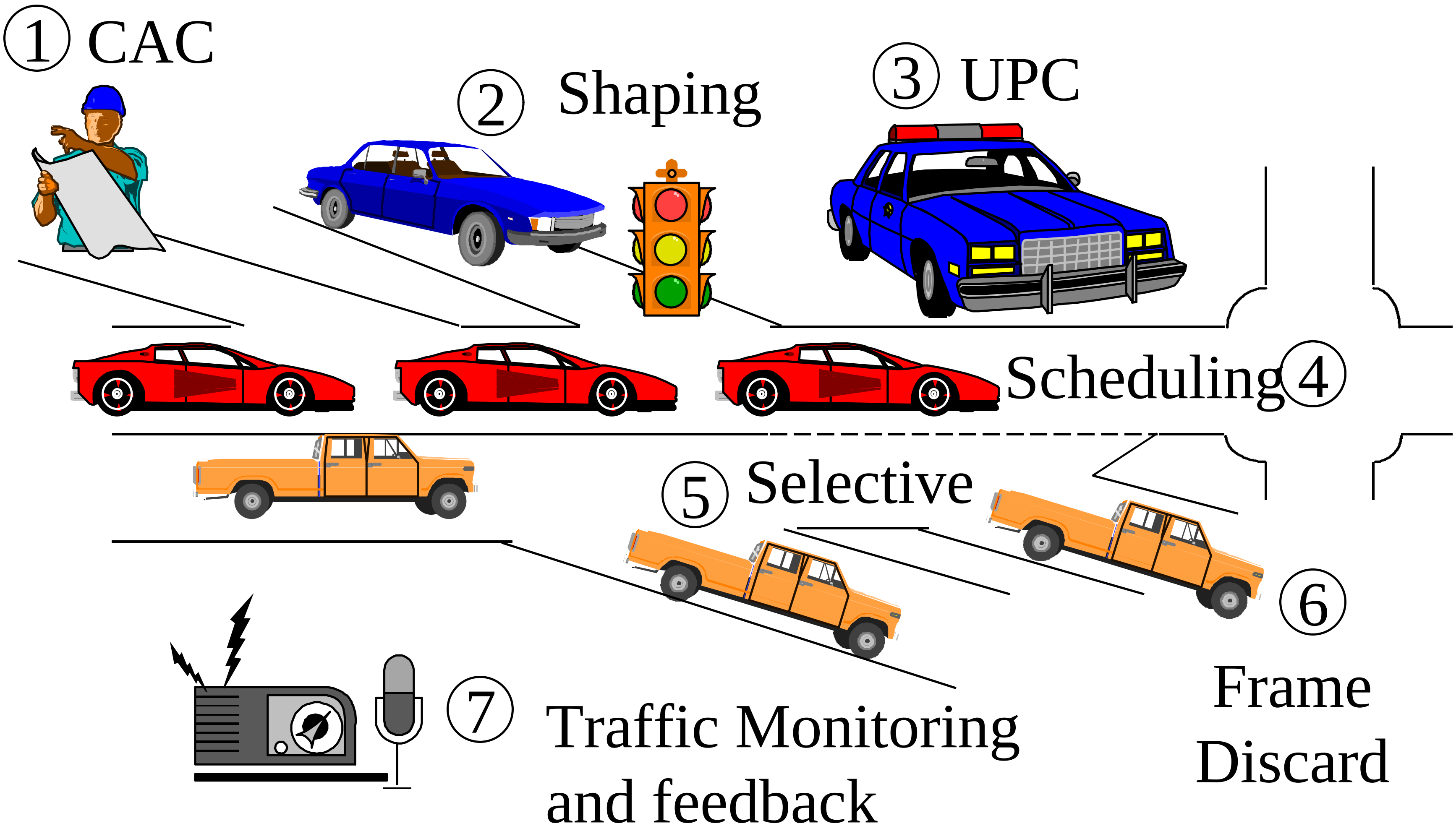



- Congestion is a dynamic problem. Static solutions are not sufficient
- Traffic management is required even during underload
- Traffic management is important for continuous media

# ATM Traffic


If you throw it away, you won't miss much.
It is flat. No variability
ATM
Traffic
Just schedule it right.
It varies a lot.
Big pipe! Don't worry about shortage.

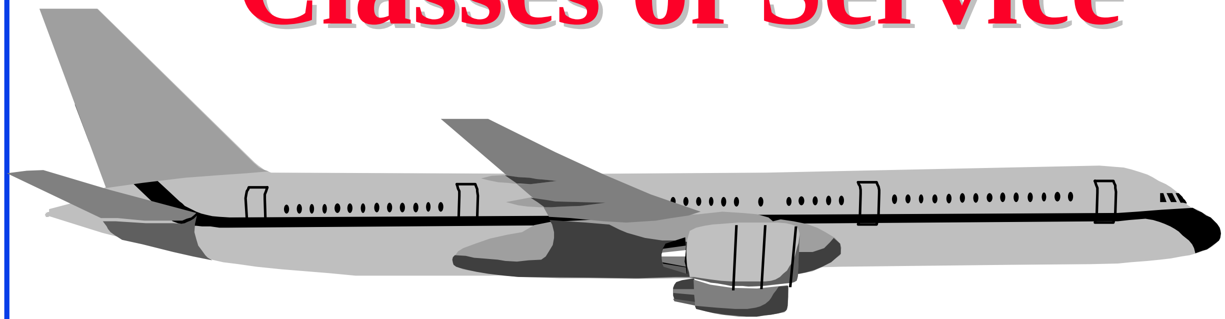
# Traffic Management on the Info Superhighway



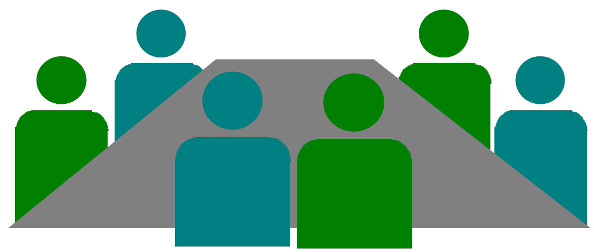
# Traffic Mgmt Functions

- Connection Admission Control (CAC):
  Can quality of service be supported?
- Traffic Shaping: Limit burst length. Space-out cells.
- Usage Parameter Control (UPC):
  Monitor and control traffic at the network entrance.
- Network Resource Management:
  Scheduling, Queueing, resource reservation
- Priority Control: Cell Loss Priority (CLP)
- Selective Cell Discarding: Frame Discard
- Feedback Controls: Network tells the source to increase or decrease its load.

# Classes of Service

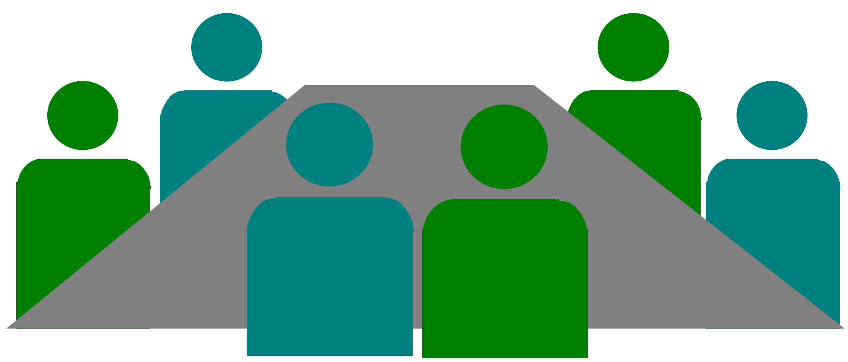


Standby



Guaranteed

Joy Riders

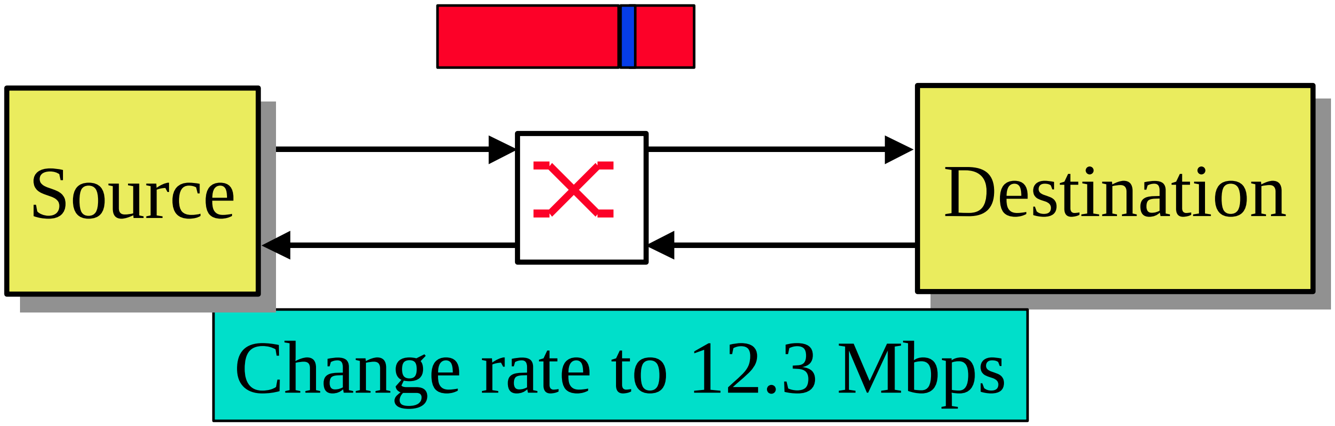


Confirmed

# Classes of Service

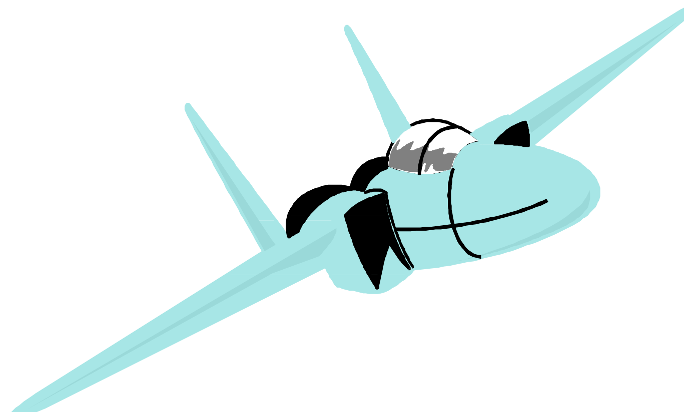
- ABR (Available bit rate):
  Source follows network feedback.
  Max throughput with minimum loss.
- UBR (Unspecified bit rate):
  User sends whenever it wants. No feedback. No guarantee. Cells may be dropped during congestion.
- CBR (Constant bit rate): User declares required rate. Throughput, delay and delay variation guaranteed.
- VBR (Variable bit rate): Declare avg and max rate.
  - rt-VBR (Real-time): Conferencing.
    Max delay guaranteed.
  - nrt-VBR (non-real time): Stored video.

# Explicit Rate Scheme




- Invented DECbit scheme in 1986: Bit ⇒ Go up/Down
  - Used now in Frame Relay (FECN)
  - Used in ATM (EFCI)
- In July 1994, we proposed Explicit Rate Approach. Current standard.
- Feedback via "Resource Management" (RM Cells)

# Bit-based vs Explicit Rate



Go left

Go
30 km East
35 km South

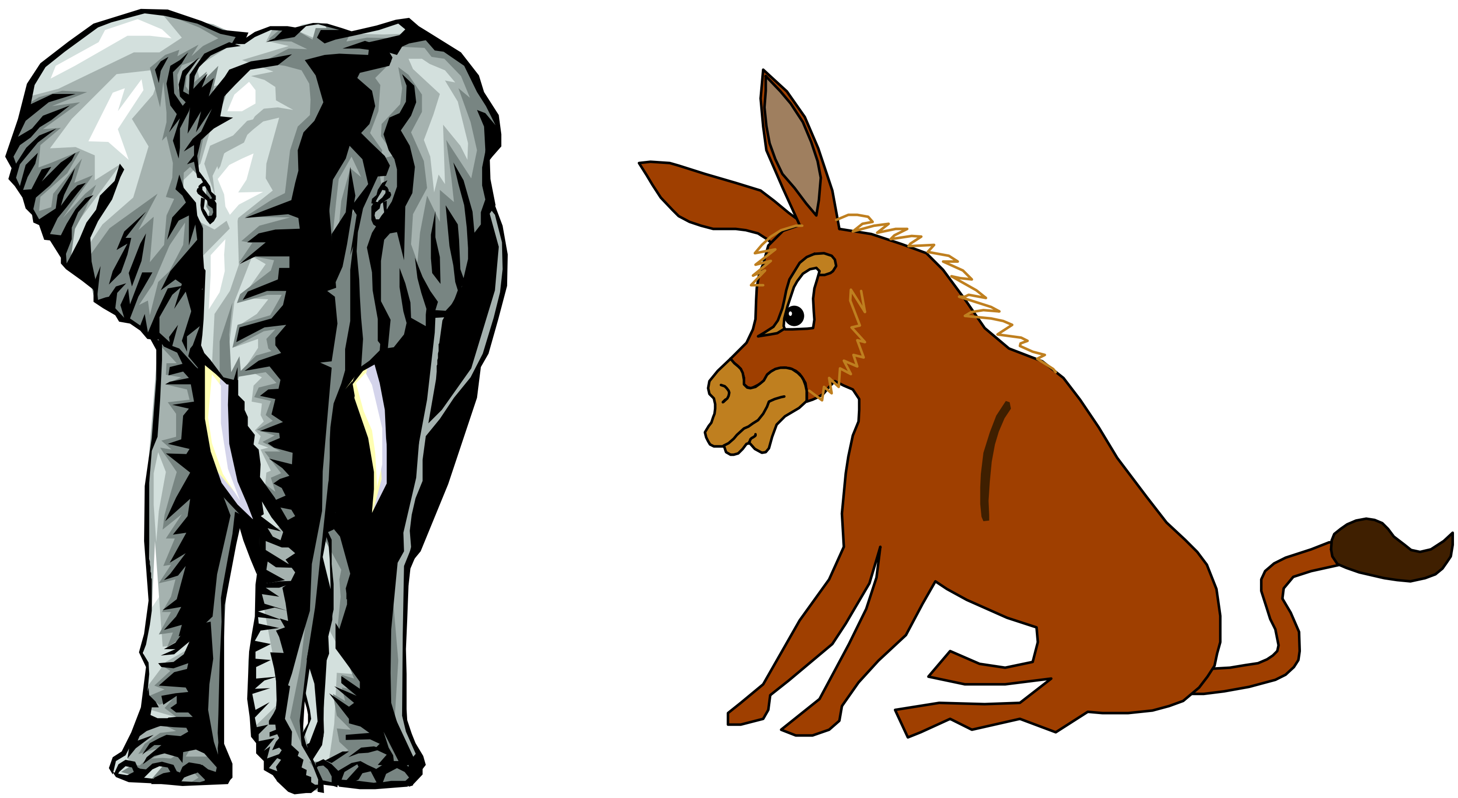
# ERICA Switch Algorithm

- Each manufacturer has its own explicit rate switch algorithm
- Explicit Rate Indication for Congestion Avoidance (ERICA) is the most thoroughly analyzed algorithm
- Shown to be efficient, fair, fast transient response, able to handle bursty TCP traffic
- ERICA+ allows low delay even at 100% utilization and provides stability in the presence of high frequency VBR background traffic
- Being implemented by several vendors. Software implementation feasible.

# Internet Protocols over ATM

- ATM Forum has designed ABR service for data
- UBR service provides no feedback or guarantees
- Internet Engineering Task Force (IETF) prefers UBR for TCP

# ABR or UBR?



- Intelligent transport or not?

# Observations About ABR

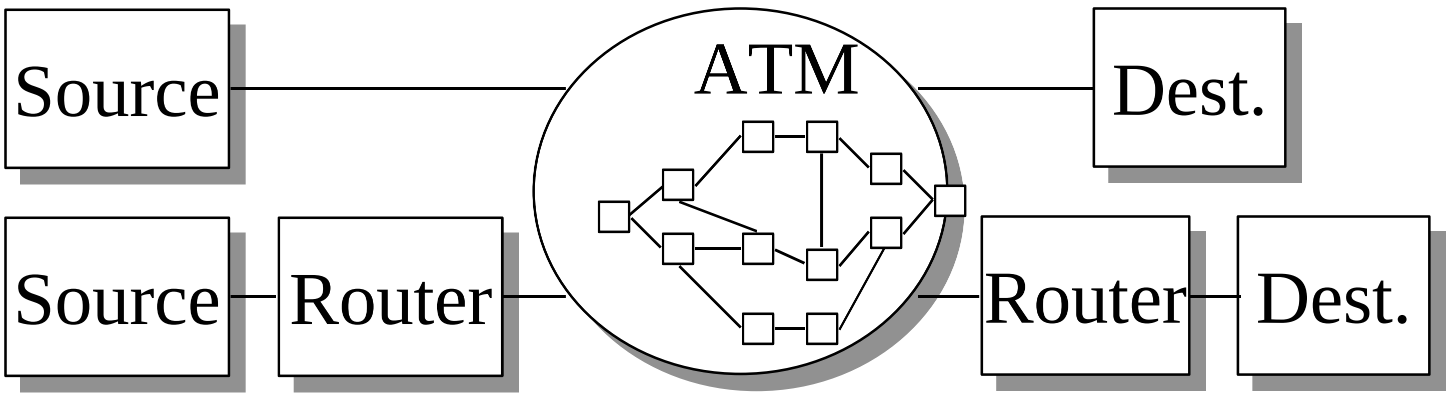
- ABR performance depends upon the switch algorithm. Assuming *ERICA*. (Ref: http://www.cis.ohio-state.edu/~jain/)
- No cell loss for *TCP* if switch has Buffers ≈ 4 × RTT.
- No loss for any number of TCP sources w 4 × RTT buffers.
- No loss even with VBR background. W/o VBR, 3×RTT buffers will do.
- Under many circumstances, 1× RTT buffers may do.
- Required buffers depend upon RTT, feedback delay, switch parameters, and characteristics of VBR.

# Observations about UBR

- No loss for TCP if Buffers
  = Σ TCP receiver window
- Required buffering depends upon number of sources.
- Receiver window ≥ RTT for full throughput
- Unfairness  in many cases.
- Fairness can be improved by proper buffer allocation, selective drop policies, and scheduling.
- No starvation ⇒ Lower throughput shows up as increased file transfer times = Lower capacity

**Conclusion**: UBR may be OK for: LAN, w/o VBR, Small number of sources, AND cheap implementation

# ABR vs UBR




| **ABR** | **UBR** |
|---|---|
| Queue in the source | Queue in the network |
| Pushes congestion to edges | No backpressure |
| Good if end-to-end ATM | Same end-to-end or backbone |
| Fair | Generally unfair |
| Good for the provider | Simple for user |

# TCP: Observations

- With enough buffers in the network,
  TCP can automatically fill any capacity.
- TCP performs best when there is NO packet loss.
  Even a single packet loss can reduce throughput considerably.
- Slow start limits the packet loss but loses considerable time.
- Bursty losses cause more throughput degradation than isolated losses.
- For each packet loss, much time is lost
  due to timer granularity.

# Source Based Mechanisms

- Slow start
- Fast Retransmit and Recovery (FRR): Degrades perf.
- Modified FRR (New Reno)
- Selective Acknowledgement
- CLP Probe: Send packets with CLP=1
- Cell Pacing: Evenly space out cells
- Smaller Segments

# Switch Based Mechanisms

- Partial Packet Discard (PPD):
  Discard when the buffers become full.
- Early Packet Discard (EPD):
  After a threshold, discard full packets.
- Selective Drop:
  After threshold, drop only overloading circuits
- Guaranteed Rate: Reserve bandwidth for UBR
  Per-class scheduling, No new signaling.
- Guaranteed Frame Rate

# ATM Research at OSU

- Traffic Management:
  - ERICA+ Switch Algorithm
  - Internet Protocols over ATM
  - Multi-class Scheduling
- Voice/Video over ATM
- Performance Testing
- ATM Test bed: OCARnet

# Multi-class Scheduling

<table>
<tr><td colspan="3">CBR</td></tr>
<tr><td colspan="3">rt-VBR</td></tr>
<tr><td>nrt-VBR</td><td>ABR</td><td>UBR</td></tr>
</table>

- Ensures *no-starvation* for all classes even under overload.
- Each class has an *allocation* = Guaranteed under overload
- Some classes need minimum delay ⇒ have *priority*.
- Some classes are greedy.
  Left-over capacity is *fairly* allocated.

# Voice/Video over ATM

- Speech suppression
  ⇒ Unused bandwidth can be used by data
  Cannot be used by voice.
- Hierarchical compression of Video
  Different users can see different bandwidth video
- Multipoint ABR
- Real-time ABR

# Real-Time ABR

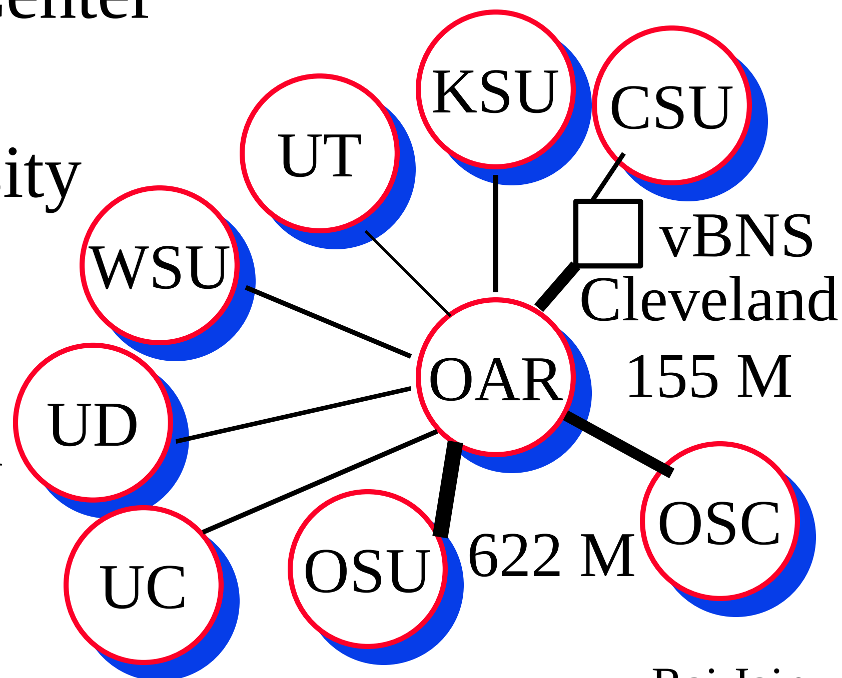
- Compressed video is VBR.
  VBR is subject to connection denial.
- Compression parameters can be adjusted dynamically
- In situations, where reduced service is preferable over connection denial, such as in tactical environments, Video over ABR is preferable over no Video.
- ABR divides the available bandwidth fairly among contending connections
- By proper control, ABR can be designed to reduce delay $\Rightarrow$ Real-time ABR

# OSU National ATM Benchmarking Lab

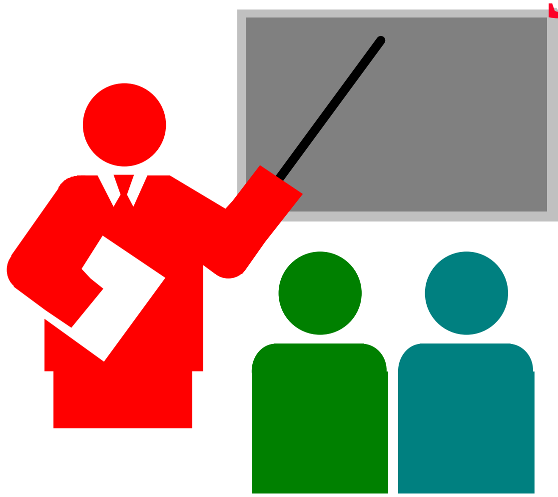
- Started a new effort at ATM Forum in October 1995
- Defining a new standard for frame based performance metrics and measurement methodologies
- We have a measurement lab with the latest ATM testing equipment. Funded by NSF and State of Ohio.
- The benchmark scripts can be run by any manufacturer/user in our lab or theirs.
- Modeled after Harvard benchmarking lab for routers

# OCARnet

- Ohio Computing and Communications ATM Research Network
- Nine-Institution consortium lead by OSU
  - Ohio State University
  - Ohio Super Computer Center
  - OARnet
  - Cleveland State University
  - Kent State University
  - University of Dayton
  - University of Cincinnati
  - Wright State University
  - University of  Toledo



# Summary



- Traffic management is the key for quality of service
- ATM has sophisticated traffic management
- ABR pushes congestion to edges.
  UBR performance can be improved.
- OSU is leading ATM Traffic and performance management research.

# References

- All our ATM Forum contributions and papers are available on-line at *http://www.cis.ohio-state.edu/~jain/*
  Specially see “Recent Hot Papers” and “References on Recent Advances in Networking”
- ATM Forum, http://www.atmforum.com

# Thank You!