

Traffic Management of Internet Protocols over ATM

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- ❑ Why ATM?
- ❑ ATM Service Categories: ABR and UBR
- ❑ Binary and Explicit Feedback
- ❑ ABR Vs UBR
- ❑ TCP/IP over ABR
- ❑ TCP/IP over UBR

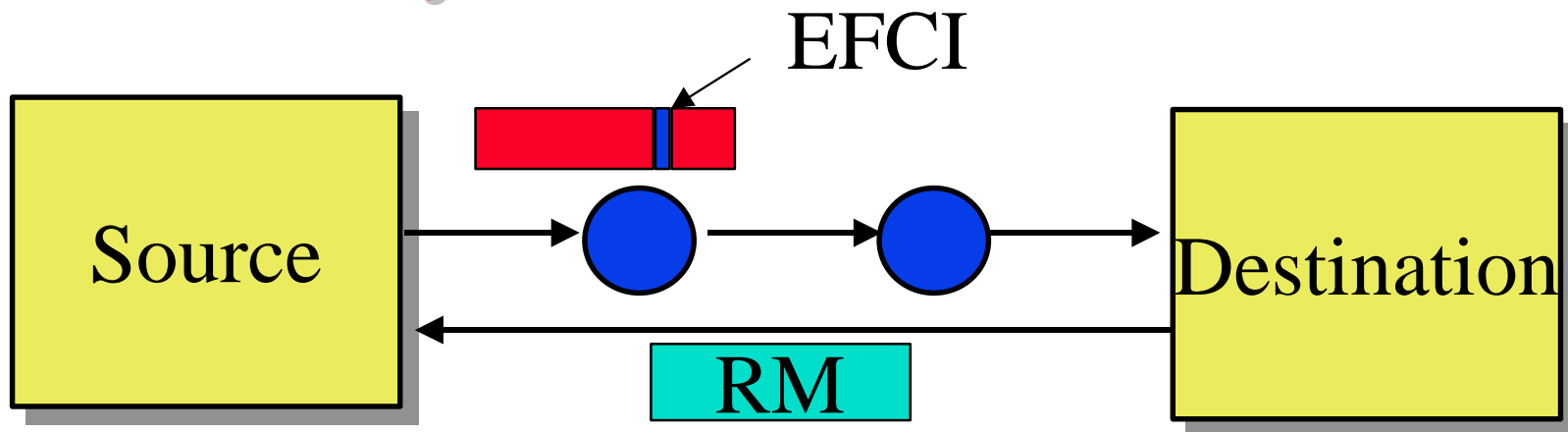
Why ATM?

- ATM vs IP: Key Distinctions
 - Traffic Management:
Explicit Rate vs Loss based
 - Signaling: Coming to IP in the form of RSVP
 - PNNI: QoS based routing
 - Switching: Coming soon to IP
 - Cells: Fixed size or small size is not important

Service Categories

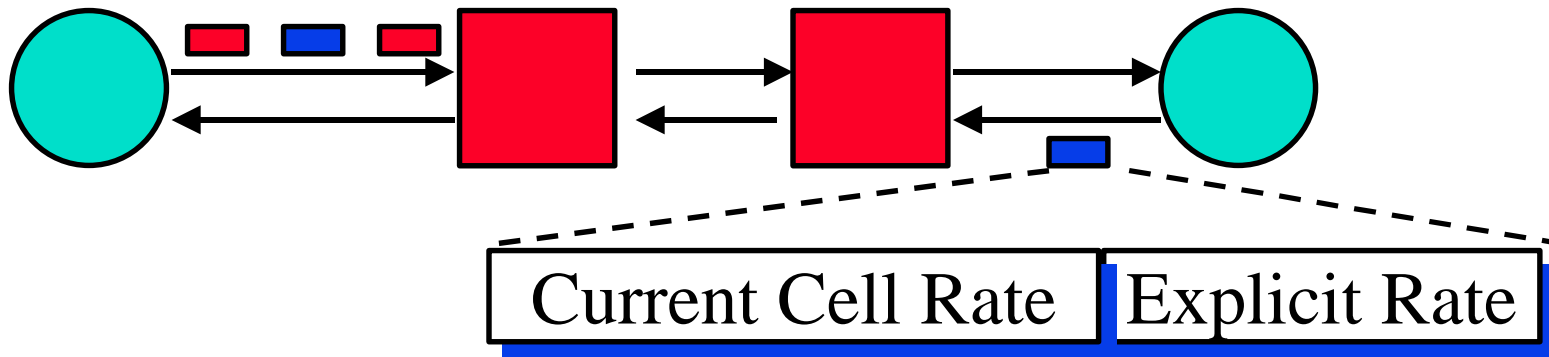
- ❑ **ABR** (Available bit rate):
Source follows network feedback.
Max throughput with minimum loss.
- ❑ **UBR** (Unspecified bit rate):
User sends whenever it wants. No feedback. No guarantee. Cells may be dropped during congestion.
- ❑ **CBR** (Constant bit rate): User declares required rate.
Throughput, 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.

Binary Rate Scheme



- ❑ DECbit scheme in many standards since 1986.
- ❑ Forward explicit congestion notification (FECN) in Frame relay
- ❑ Explicit forward congestion indicator (EFCI) set to 0 at source. Congested switches set EFCI to 1
- ❑ Every n th cell, destination sends an resource management (RM) cell to the source

The Explicit Rate ABR



- ❑ Proposed in July 1994
- ❑ Sources send one **RM cell** every n cells
- ❑ The RM cells contain “**Explicit rate**”
- ❑ Destination returns the RM cell to the source
- ❑ The switches adjust the rate **down**
- ❑ Source adjusts to the specified rate

Why Explicit Rate Indication?

- Longer-distance networks
 - ⇒ Can't afford too many round-trips
 - ⇒ More information is better
- Rate-based control
 - ⇒ Queue length = $\Delta\text{Rate} \times \Delta\text{Time}$
 - ⇒ Time is more critical than with windows

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

Observations About ABR

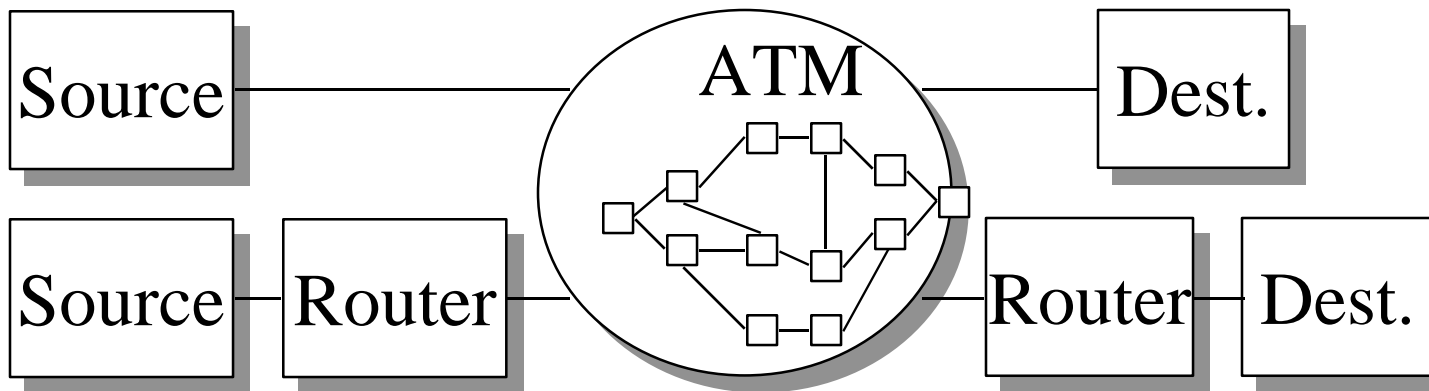
- ❑ ABR performance depends upon the switch algorithm. Assuming *ERICA*.
(Ref: <http://www.cis.ohio-state.edu/~jain/>)
- ❑ No cell loss for *TCP* if switch has buffers $\approx 4 \times \text{RTT}$.
- ❑ No loss for **any** number of TCP sources w $4 \times \text{RTT}$ buffers.
- ❑ No loss even with **VBR** background.
W/o VBR, $3 \times \text{RTT}$ buffers will do.
- ❑ Under many circumstances, $1 \times \text{RTT}$ 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 \geq RTT for full throughput
- ❑ Unfairness in many cases.
- ❑ Fairness can be improved by proper buffer allocation, selective drop policies, and scheduling.
- ❑ No starvation \Rightarrow 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



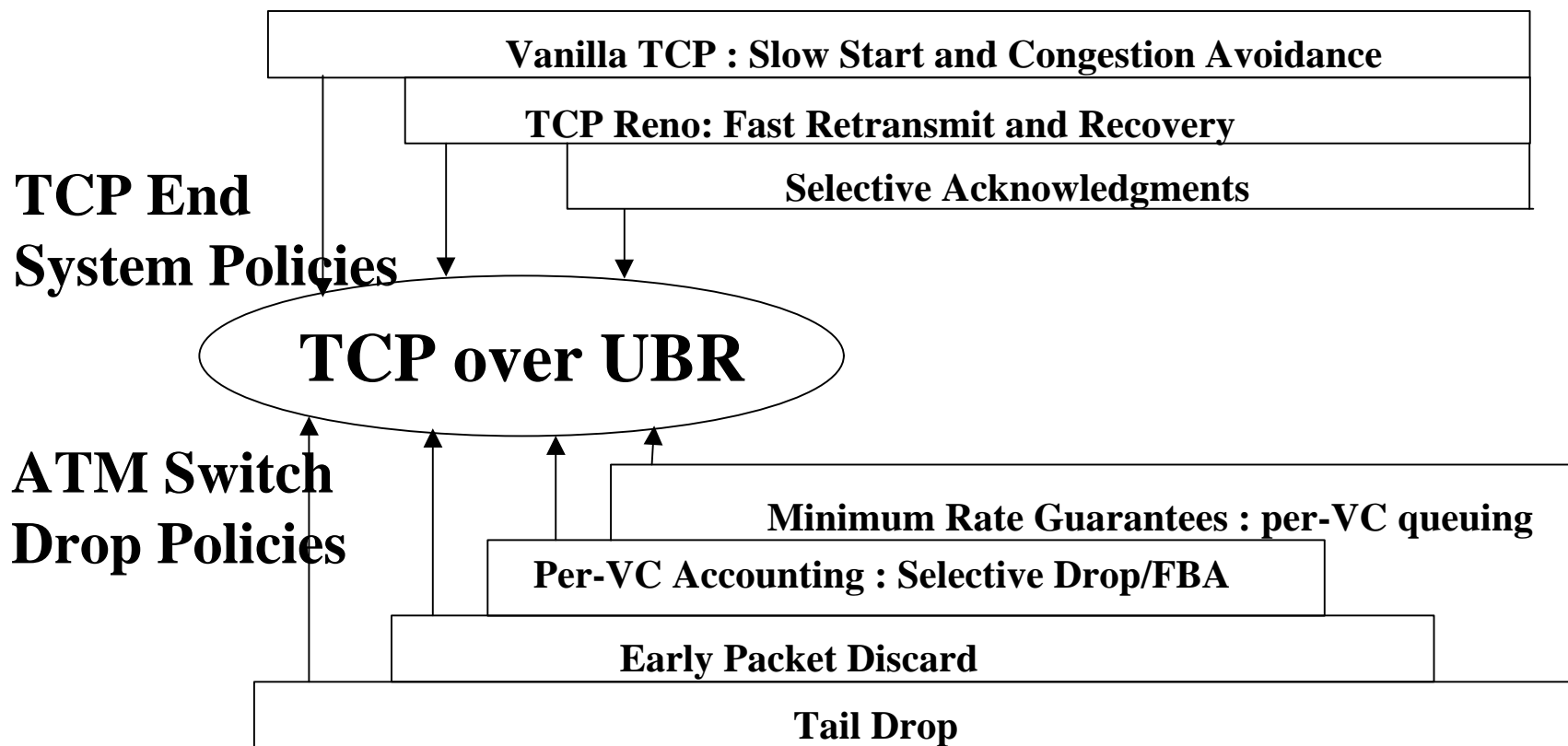
ABR

Queue in the source
Pushes congestion to edges
Good if end-to-end ATM
Fair
Good for the provider

UBR

Queue in the network
No backpressure
Same end-to-end or backbone
Generally unfair
Simple for user

Improving Performance of TCP over UBR



Policies

End-System Policies

		No FRR	FRR	New Reno	SACK + New Reno	
		Switch Policies	No EPD			
Plain EPD						
EPD	Selective Drop					
	Fair Buffer Allocation					

Policies: Results

- ❑ In LANs, switch improvements (PPD, EPD, SD, FBA) have more impact than end-system improvements (Slow start, FRR, New Reno, SACK). Different variations of increase/decrease have little impact due to small window sizes.
- ❑ In large bandwidth-delay networks, end-system improvements have more impact than switch-based improvements
- ❑ FRR hurts in large bandwidth-delay networks.

Policies (Continued)

- ❑ Fairness depends upon the switch drop policies and not on end-system policies
- ❑ In large bandwidth-delay networks:
 - SACK helps significantly
 - Switch-based improvements have relatively less impact than end-system improvements
 - Fairness is not affected by SACK
- ❑ In LANs:
 - Previously retransmitted holes may have to be retransmitted on a timeout
⇒ SACK can hurt under extreme congestion.

Guaranteed Frame Rate (GFR)

- ❑ UBR with minimum cell rate (MCR)
⇒ UBR+
- ❑ Frame based service
 - Complete frames are accepted or discarded in the switch
 - Traffic shaping is frame based.
All cells of the frame have $CLP = 0$ or $CLP = 1$
 - All frames below MCR are given $CLP = 0$ service.
All frames above MCR are given best effort
($CLP = 1$) service.

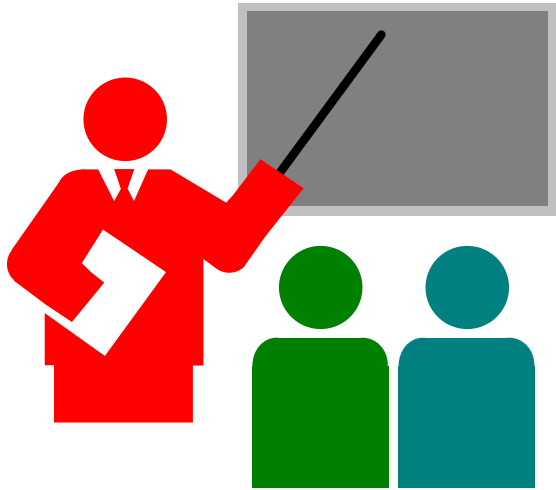
Guaranteed Rate Service

- Guaranteed Rate (GR): Reserve a small fraction of bandwidth for UBR class.

GR	GFR
per-class reservation	per-VC reservation
per-class scheduling	per-VC accounting/scheduling
No new signaling	Need new signaling
Can be done now	In TM4+

Guaranteed Rate: Results

- ❑ Guaranteed rate is helpful in WANs.
- ❑ For WANs, the effect of reserving 10% bandwidth for UBR is more than that obtained by EPD, SD, or FBA
- ❑ For LANs, guaranteed rate is not so helpful. Drop policies are more important.



Summary

- ❑ Traffic management distinguishes ATM from its competition
- ❑ Binary feedback too slow for rate control.
ER switches better for high bandwidth-delay paths.
- ❑ ABR pushes congestion to edges.
UBR+ may be OK for LANs but not for large bandwidth-delay paths.

Our Contributions and Papers

- ❑ All our contributions and papers are available on-line at <http://www.cis.ohio-state.edu/~jain/>
- ❑ See Recent Hot Papers for tutorials.

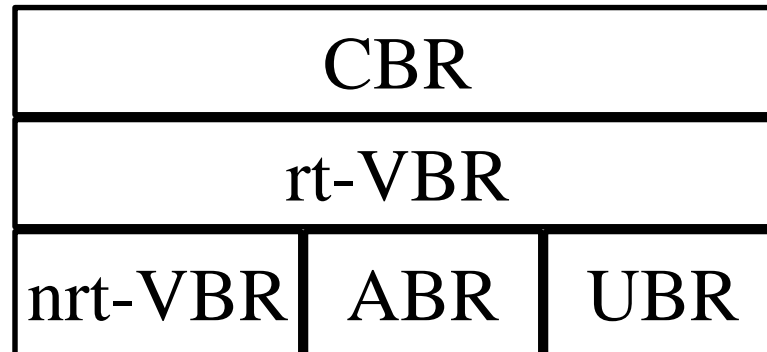
Thank You!



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



- ❑ Ensures *no-starvation* for all classes even under overload.
- ❑ Each class has an *allocation* = Guaranteed under overload
- ❑ Some classes need minimum delay \Rightarrow 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

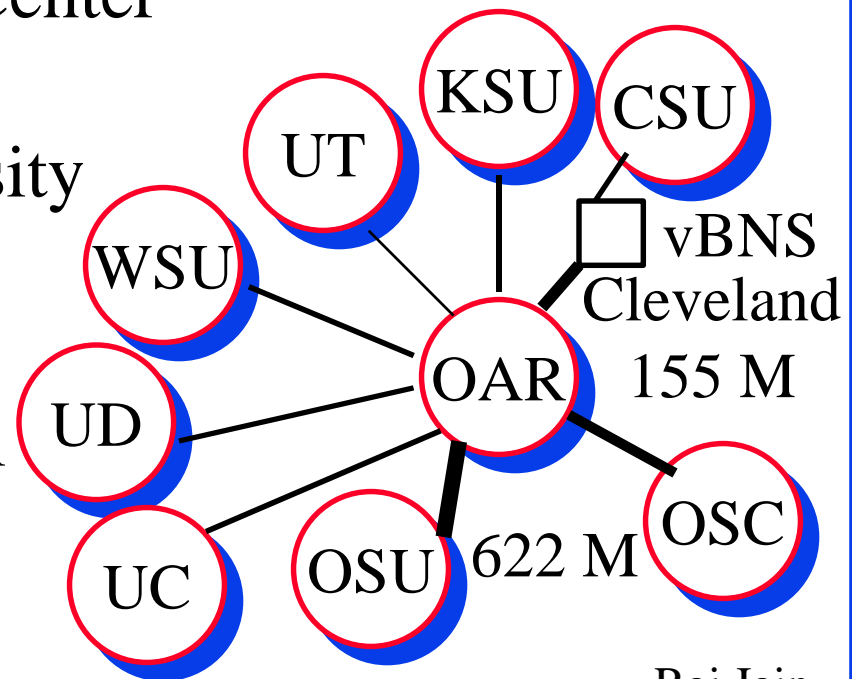
- ❑ Compressed video is VBR.
VBR is subject to connection denial.
- ❑ Compression parameters can be adjusted dynamically
- ❑ In situations, where reduced service is preferable over connection denial, such as in tactical environments, Video over ABR is preferable over no Video.
- ❑ ABR divides the available 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

OARnet

- ❑ 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



OCARnet

