

TCP/IP over ATM using ABR, UBR, and GFR Services

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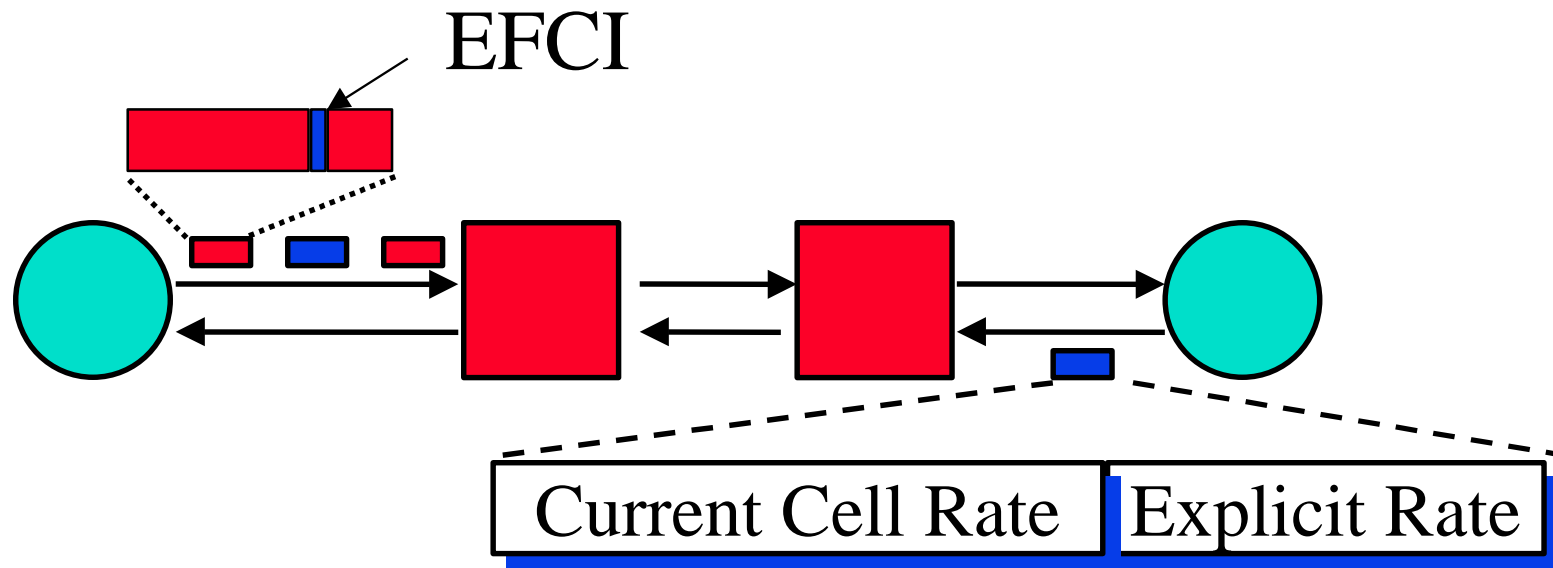


- ❑ Why ATM?
- ❑ ABR: Binary and Explicit Feedback
- ❑ ABR Vs UBR
- ❑ TCP/IP over UBR
- ❑ TCP/IP over GFR
- ❑ ATM Research at OSU

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.
QOSPF, Integrated/Differentiated services
 - Switching: Coming soon to IP in the form of MPLS
 - Cells: Fixed size or small size is not important

ABR: Binary vs Explicit Rate



- ❑ DECbit scheme in 1986: Bit \Rightarrow Go up/Down
 - Used in Frame Relay (FECN) and ATM (EFCI)
- ❑ In July 1994, we proposed Explicit Rate Approach. Sources send one **RM cell** every n cells. The switches adjust the explicit rate field **down**.

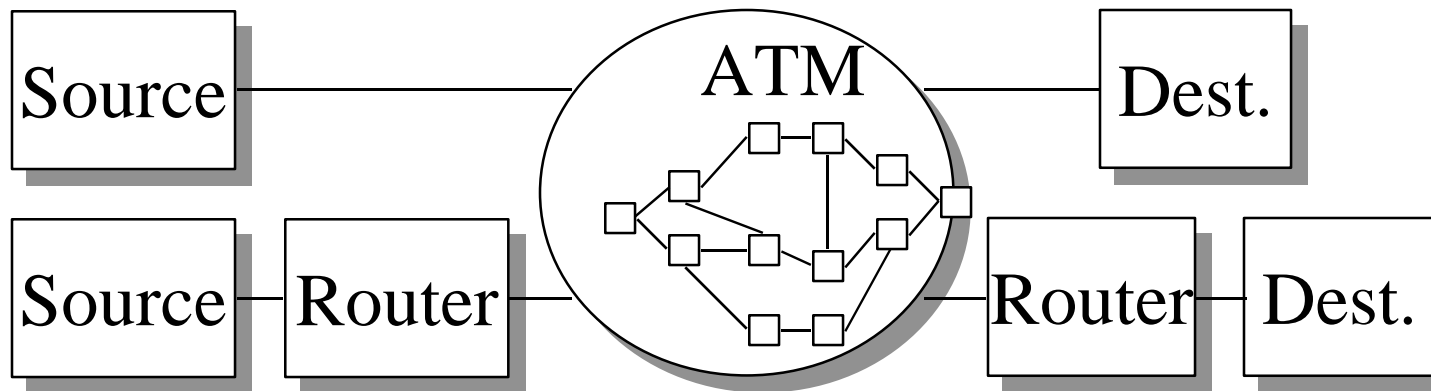
Why Explicit Rate Indication?

- 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
- NOTE: Explicit congestion notification (ECN) in IP is binary and applies only to TCP.

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 vs UBR



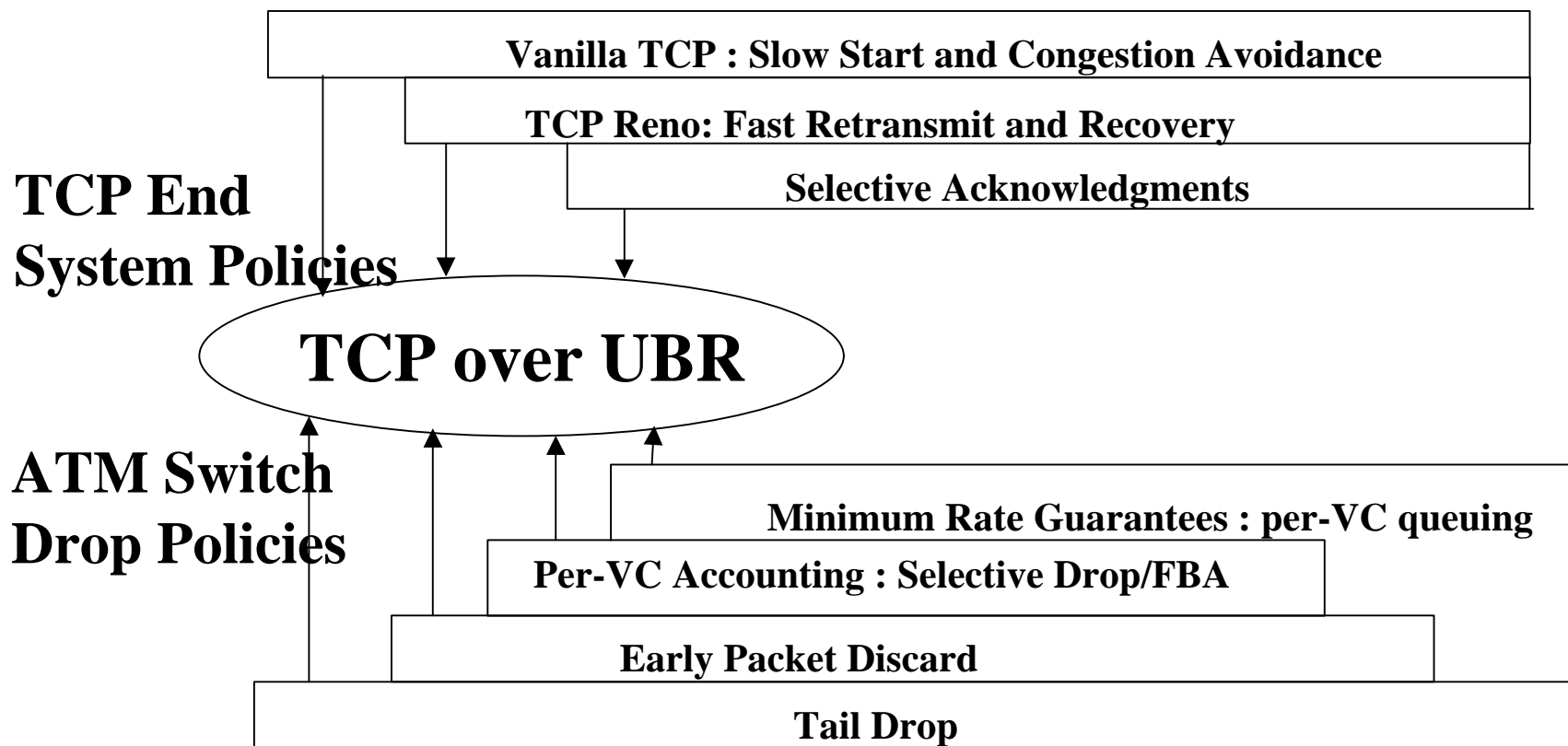
ABR

Queue in the source
Pushes congestion to edges
Good if end-to-end ATM
Fair
Works for all protocols

UBR

Queue in the network
No backpressure
Same end-to-end or backbone
Generally unfair
Works with TCP

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

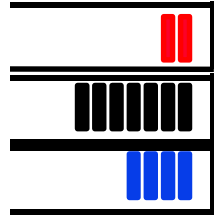
- Guaranteed Rate (GR): Reserve a small fraction of bandwidth for UBR class.

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.

GFR: Results



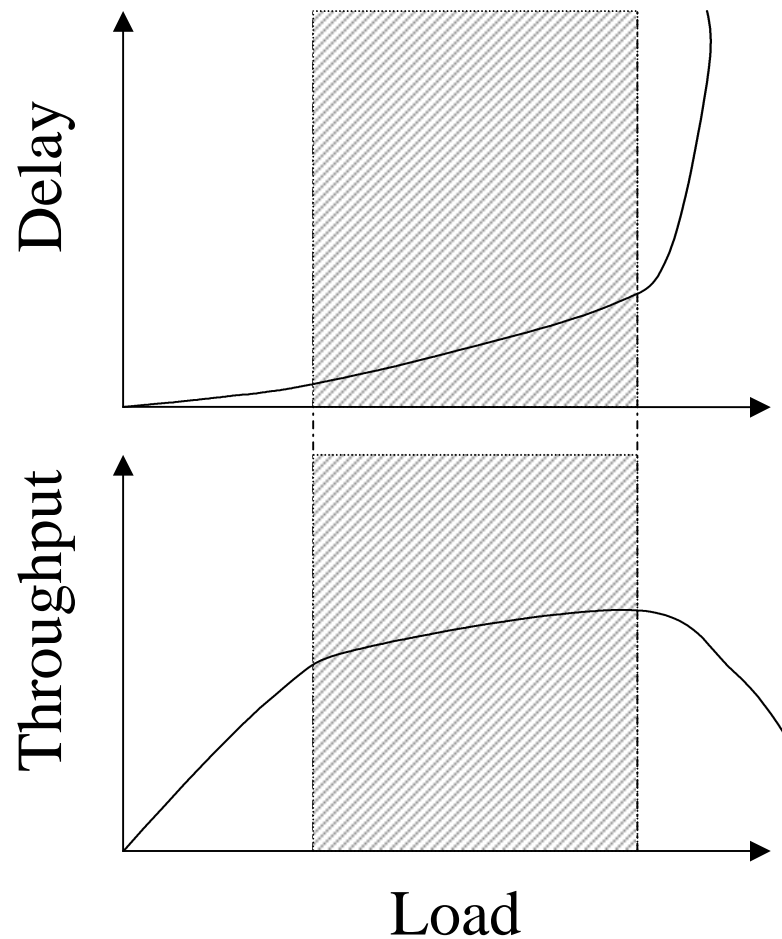
Per-VC Q



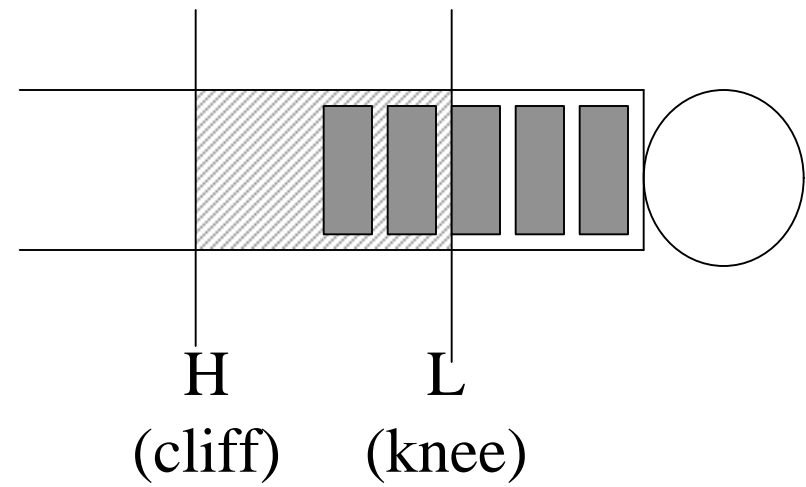
Single FIFO

- ❑ Per-VC queuing and scheduling is sufficient for per-VC MCR.
- ❑ FBA and proper scheduling is sufficient for fair allocation of excess bandwidth
- ❑ Questions:
 - How and when can we provide MCR guarantee with FIFO?
 - What if each VC contains multiple TCP flows?

Differential Fair Buffer Allocation

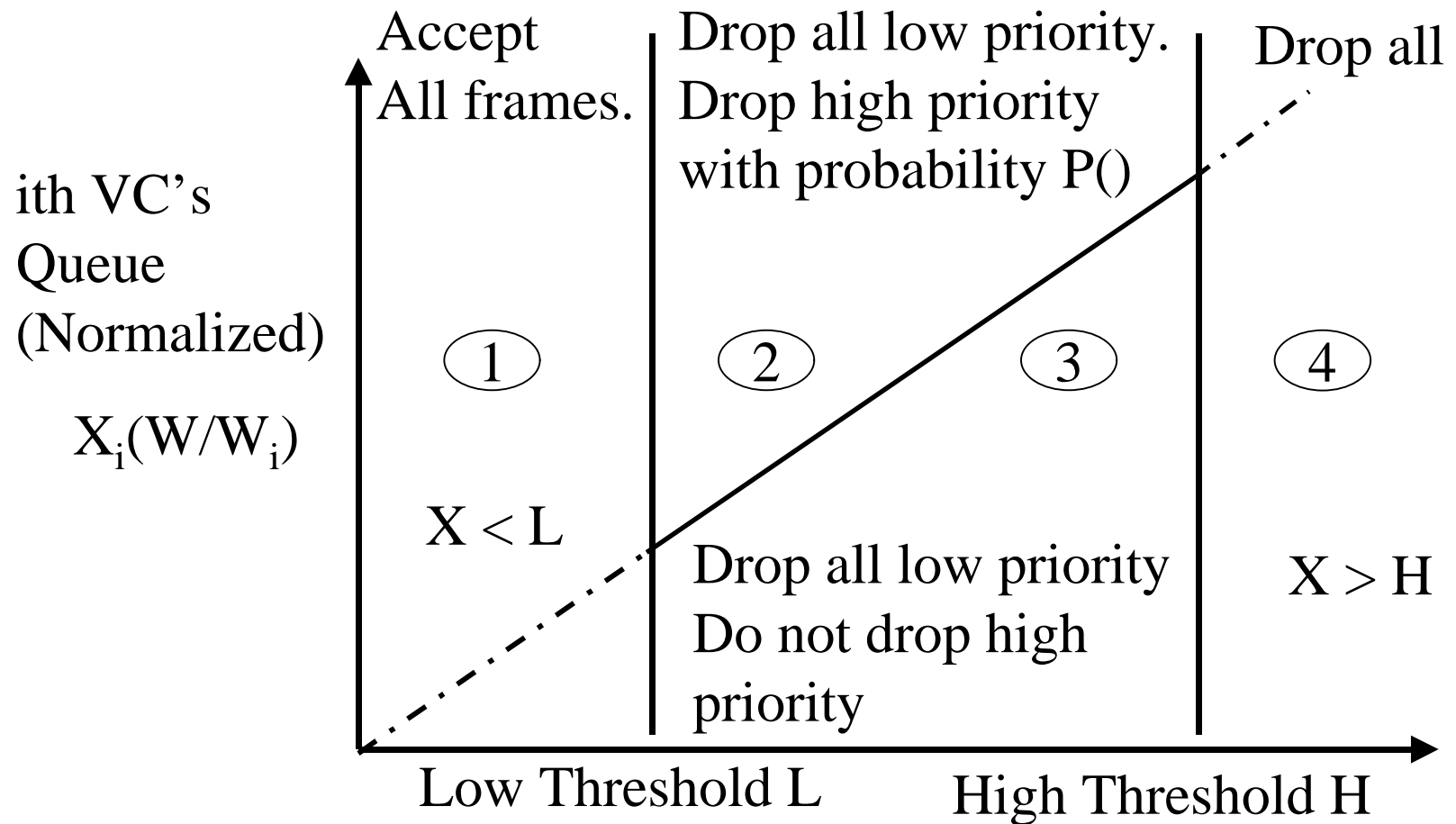


Buffer occupancy (X)



 Desired operating region

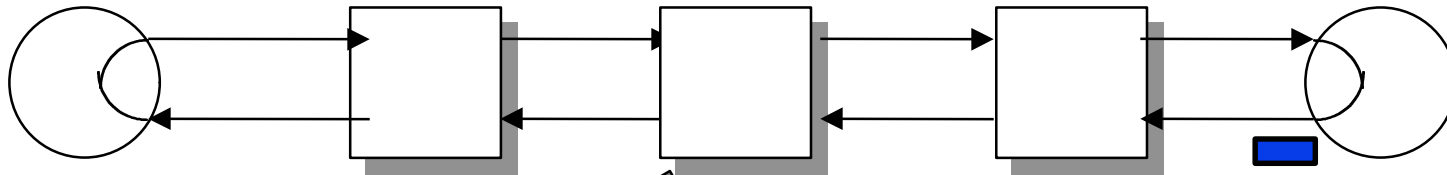
DFBA (contd.)



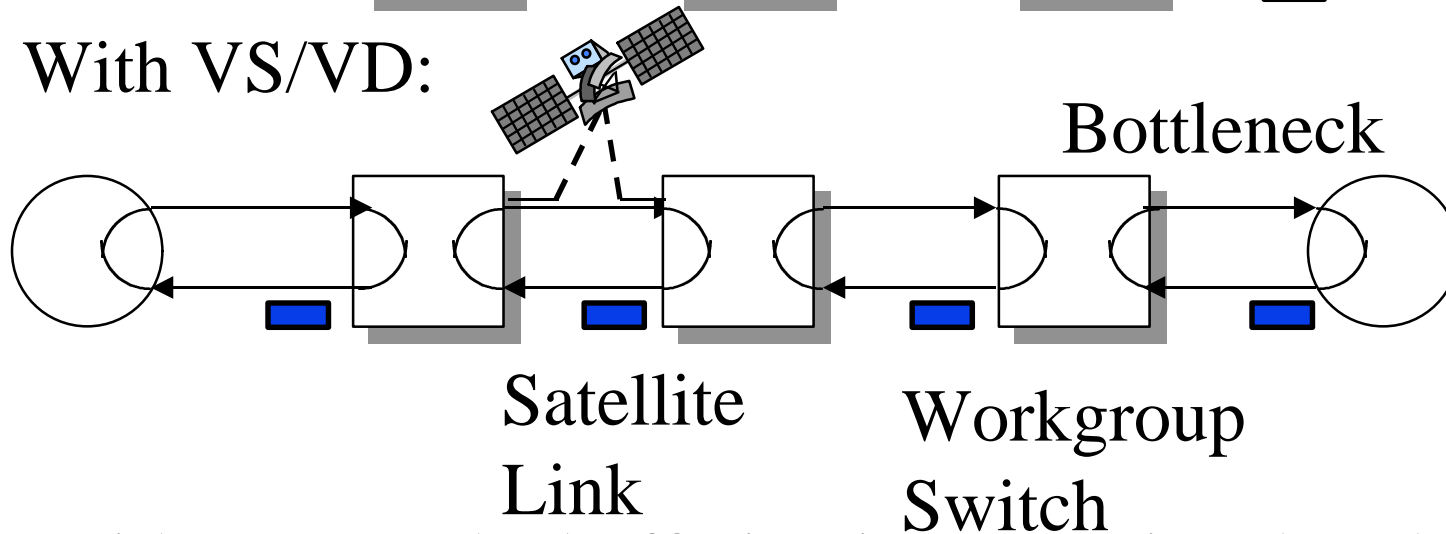
TCP Rate $D \propto \frac{MSS}{RTT \times \sqrt{P(drop)}}$

VS/VD

- Without Virtual Source/Virtual Destination:



- With VS/VD:



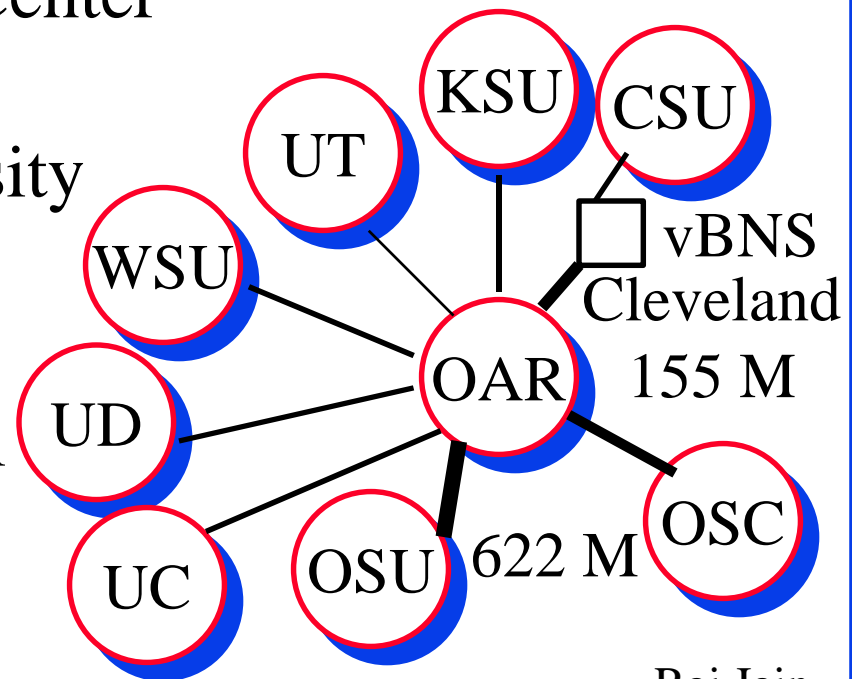
- With VSVD, the buffering is proportional to the delay-bandwidth of the previous loop
⇒ Good for satellite networks

Networking Research at OSU

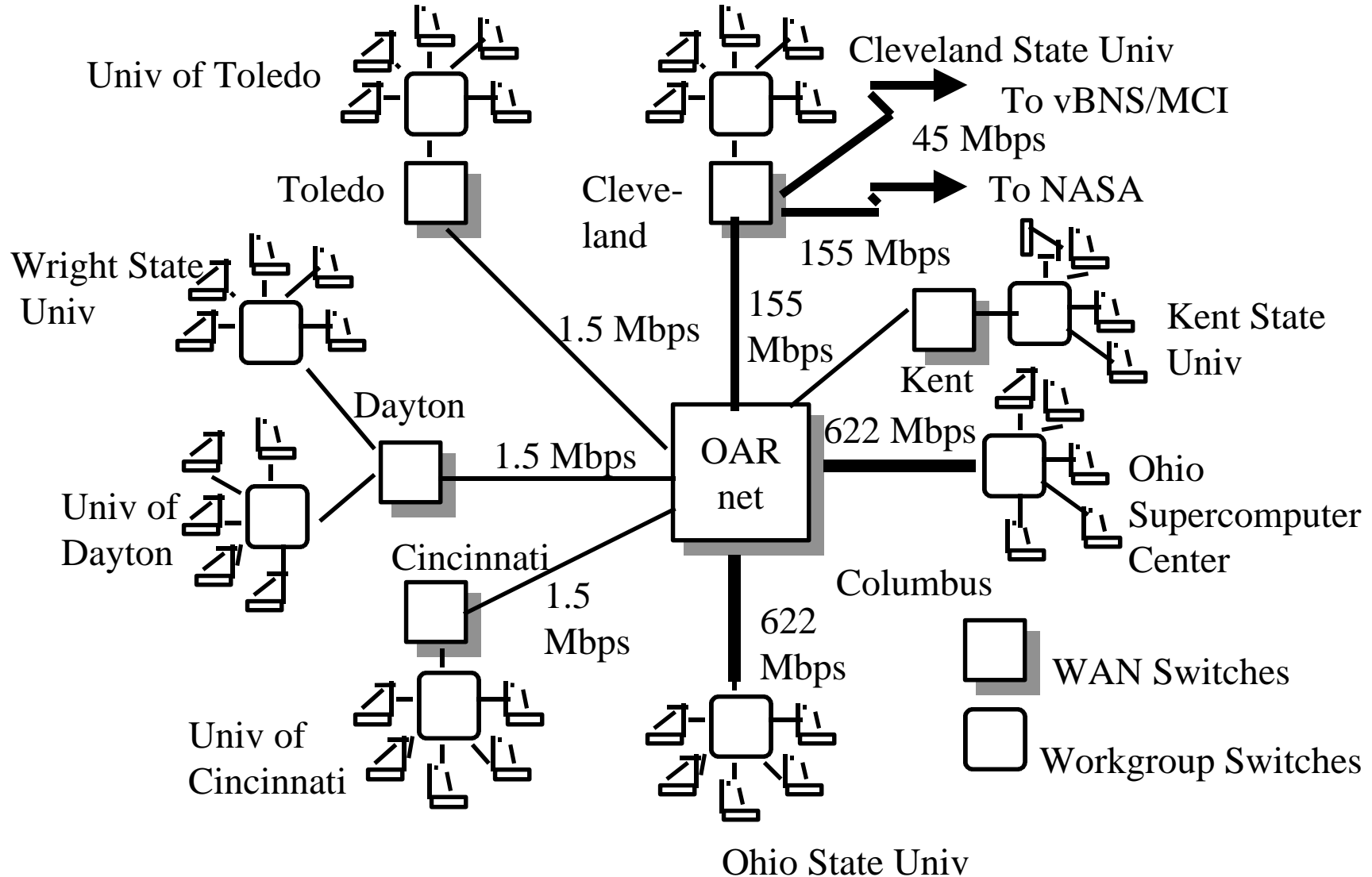
- ❑ Traffic Management:
 - ERICA+ Switch Algorithm
 - Internet Protocols over ATM
 - Multi-class Scheduling
 - Multipoint ABR
- ❑ Performance Testing
- ❑ ATM Test bed: OCARnet
- ❑ Voice/Video over ATM/IP
- ❑ Wireless Networking
- ❑ QoS over IP

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



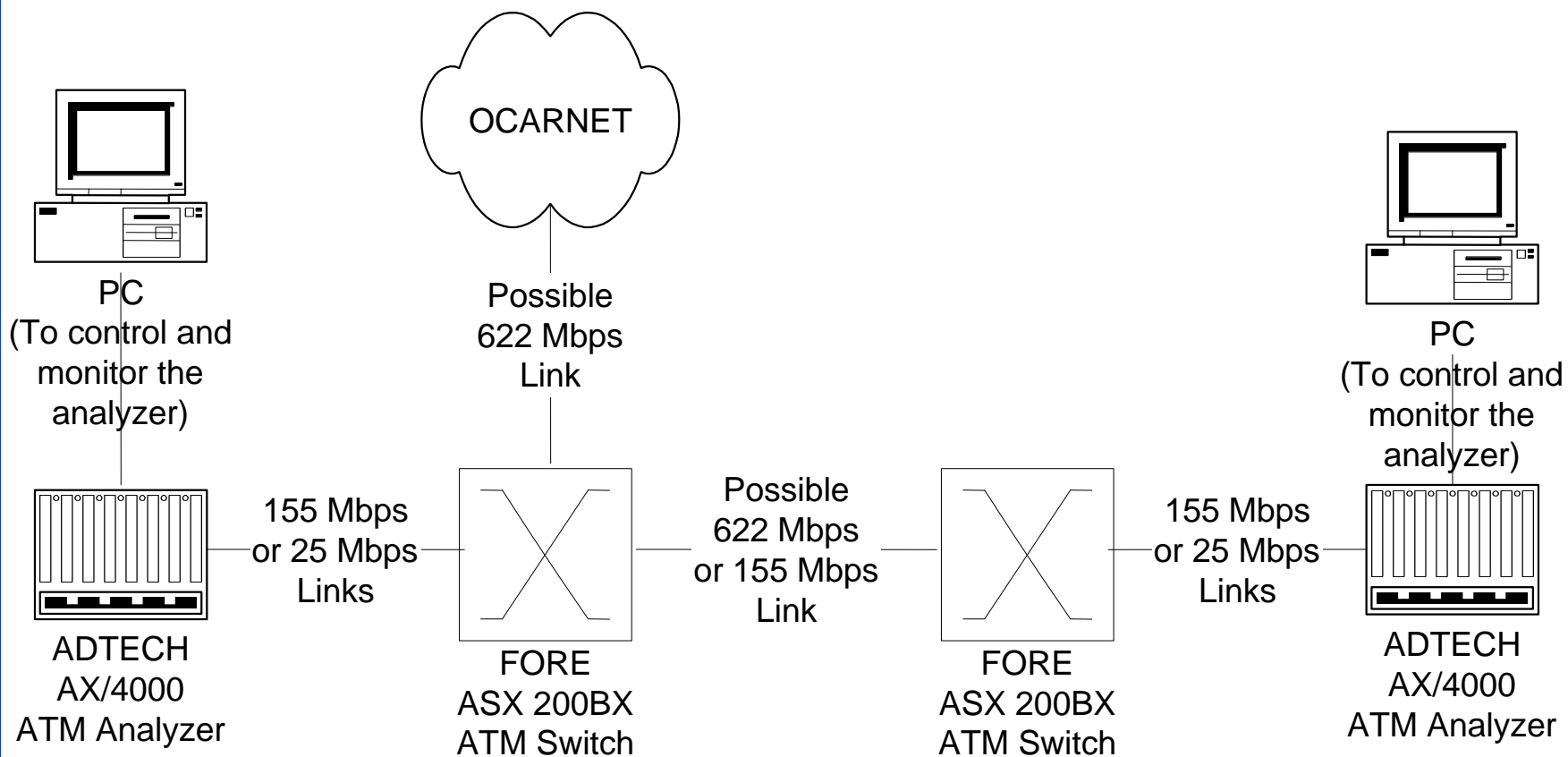
OCARnet



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

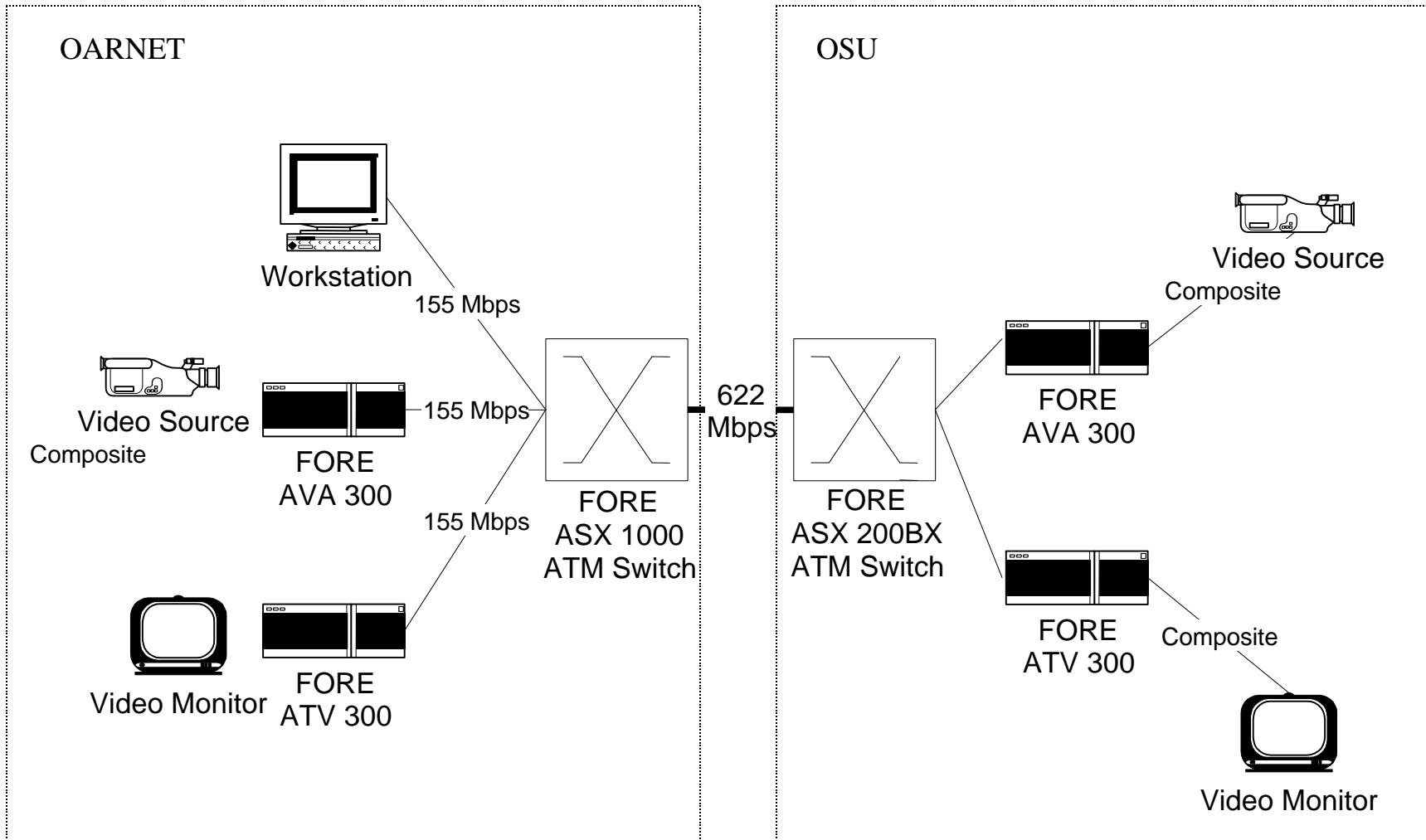
Performance Testing Facility



Voice/Video over ATM and IP

- ❑ VBR Voice 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
Network feedback
- ❑ Multipoint ABR
- ❑ Real-time ABR
- ❑ QoS over IP
- ❑ Distance education

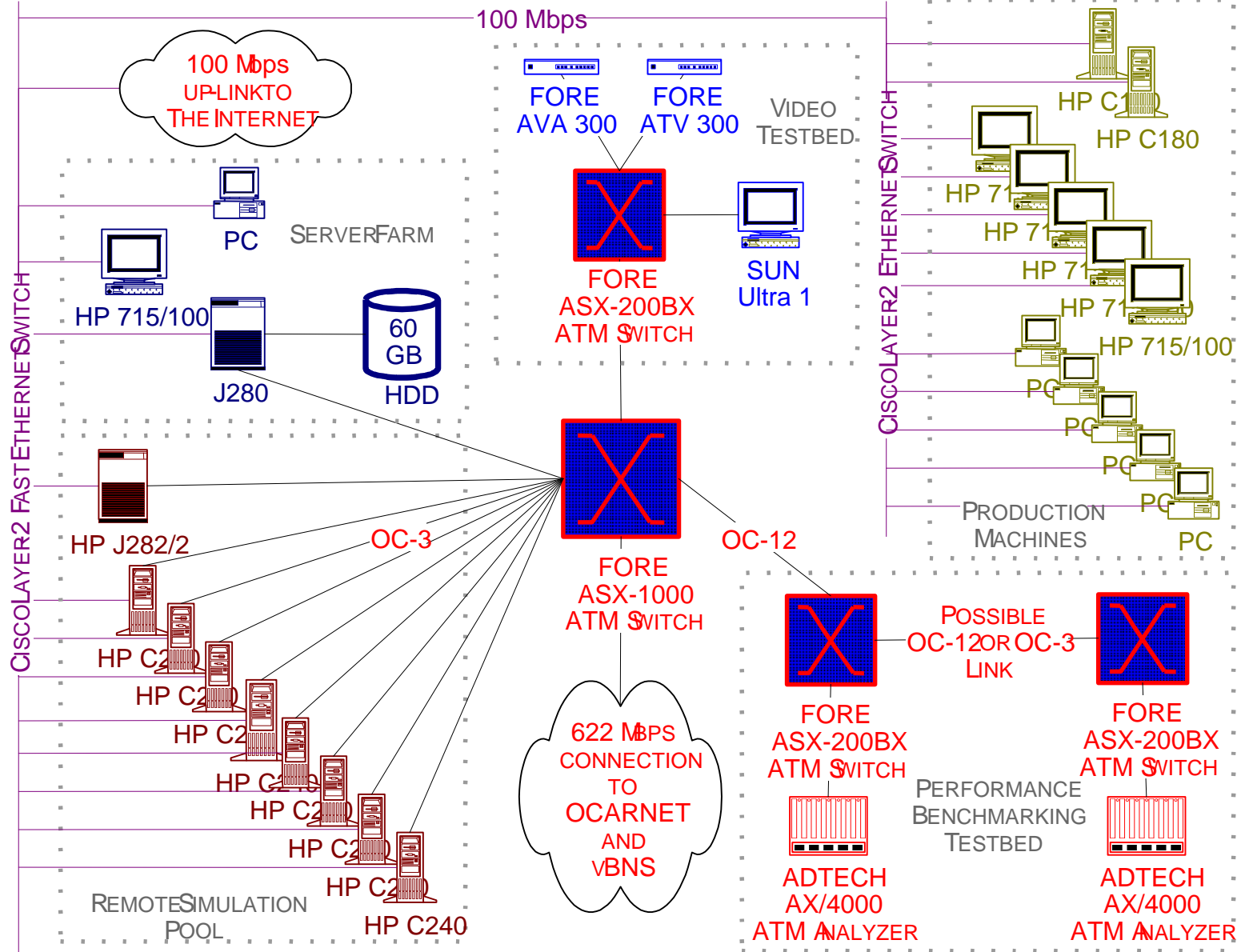
Video Testbed

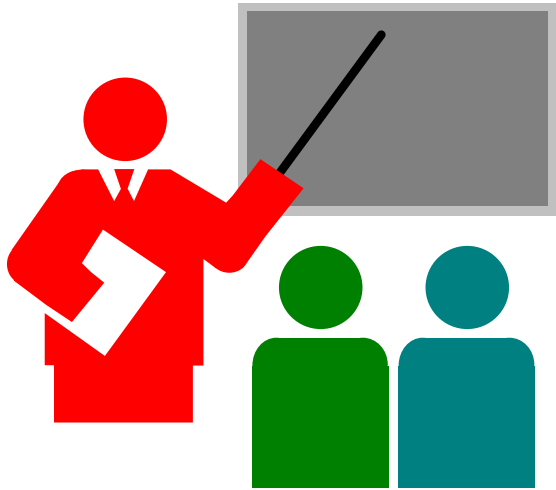


Wireless Networking

- ❑ Antenna design and wireless modem communications in Electro-science laboratory of EE dept
- ❑ High-speed wireless datalink protocols
- ❑ Wireless TCP
- ❑ Access methods and hand-off
(Jennifer Hou/EE and Steve Lai/CIS)

NETLAB Facilities





Summary

- ❑ Traffic management distinguishes ATM from its competition
- ❑ Binary feedback too slow.
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.

Summary (Cont)

- ❑ Reserving a small fraction of bandwidth for the entire UBR class improves its performance considerably.
- ❑ It may be possible to do GFR with FIFO

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!

