Networking and Telecommunications Research at OSU

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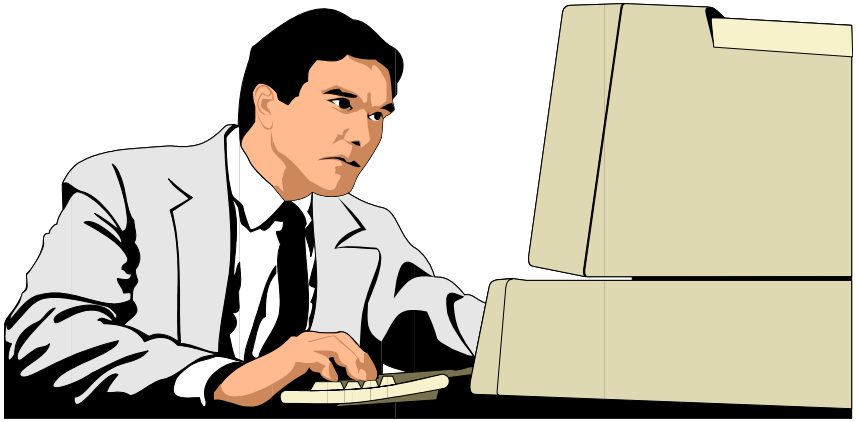
Overview

- Research Personnel
- Networking Trends
- Past Accomplishments
- Current Research and Research Facilities
- Networking and Telecommunications Education

Research Personnel

- Telecommunications Networks
  - Raj Jain, Gojko Babic, Arjan Durresi
- Wireless Networks
  - Steve Lai and Raj Jain
- Multimedia Networking
  - Wu-Chi Feng and Raj Jain
- Protocol Engineering - Mike Liu
- Other CIS Collaborators: D.K. Panda, Anish Arora, Mukesh Singhal,
- EE Dept Collaborators: Mike Fitz, Jennifer Hou, Yuan Zhang, and Stan Ahalt

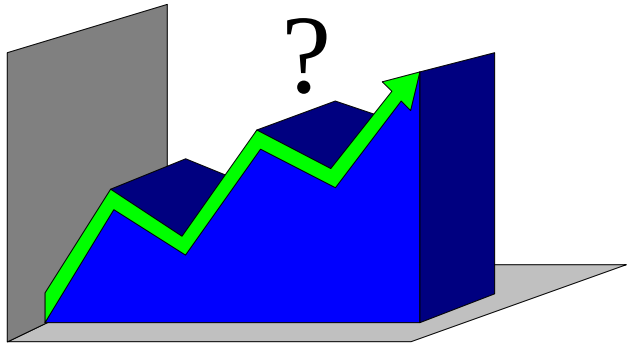
Social Impact of Networking



- No need to get out for
  - Office
  - Shopping
  - Entertainment
  - Education
- Virtual Schools
- Virtual Cash
- Virtual Workplace

(55 Million US workers will work remotely by 2000)

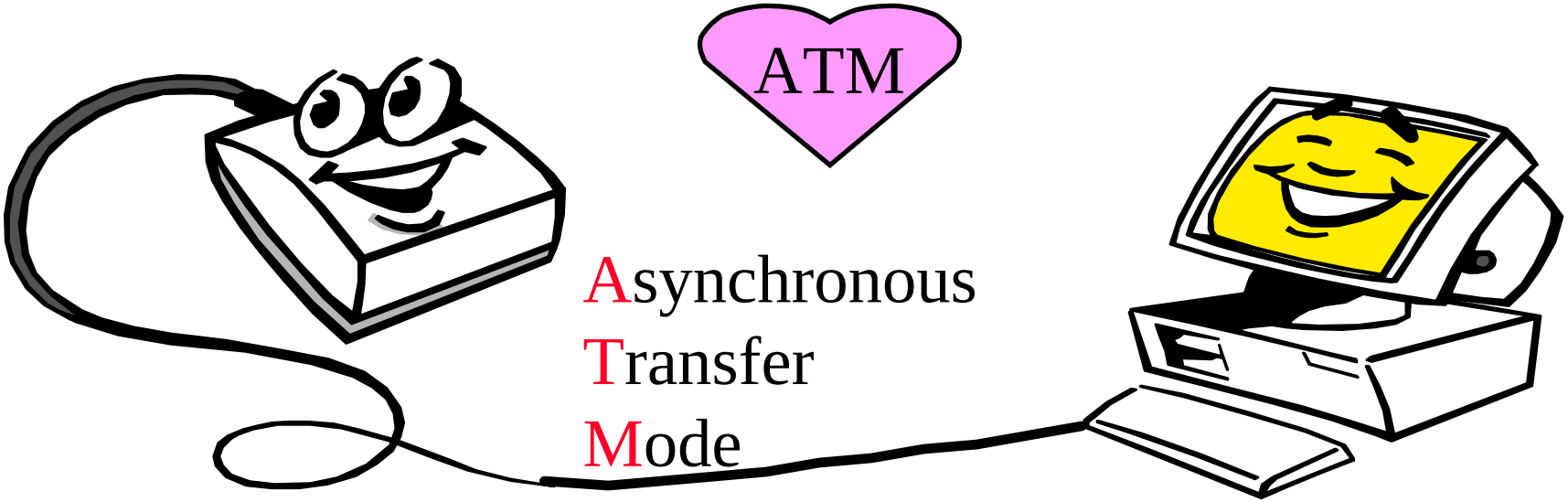
Networking Trends



- Networking Bottleneck
- Networking Age
- Internet-based Economy
- Super-exponential Internet Growth
- Data > Voice ⇒ Networking and Telecom Merger

ATM

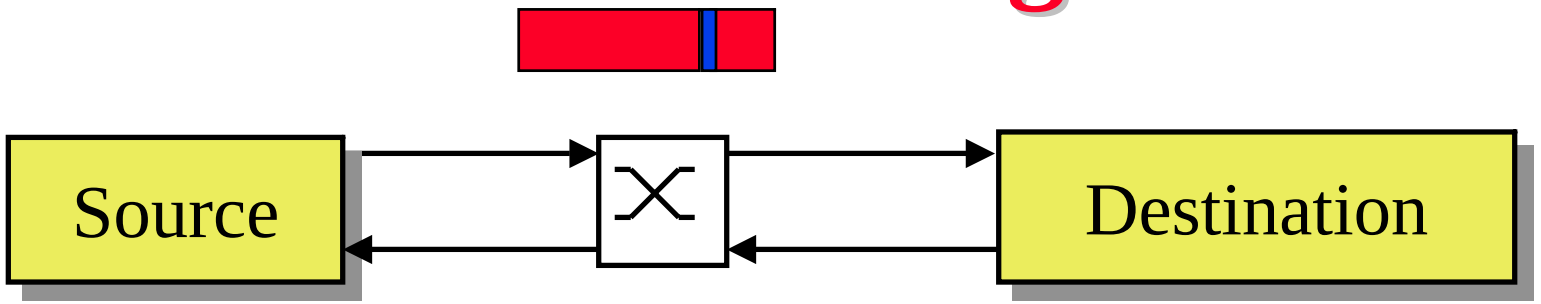
- ATM = Asynchronous Transfer Mode
- ATM Net = Data Net + Phone Net
- Combination of Internet method of communication (packet switching) and phone companies' method (circuit switching)



Recent Research Accomplishments

- ATM Traffic Management
- OCARnet: State-wide ATM Testbed
- OSU National ATM Performance Testing Lab
- Voice over Data Networks

ATM Traffic Management



Change rate to 12.3 Mbps

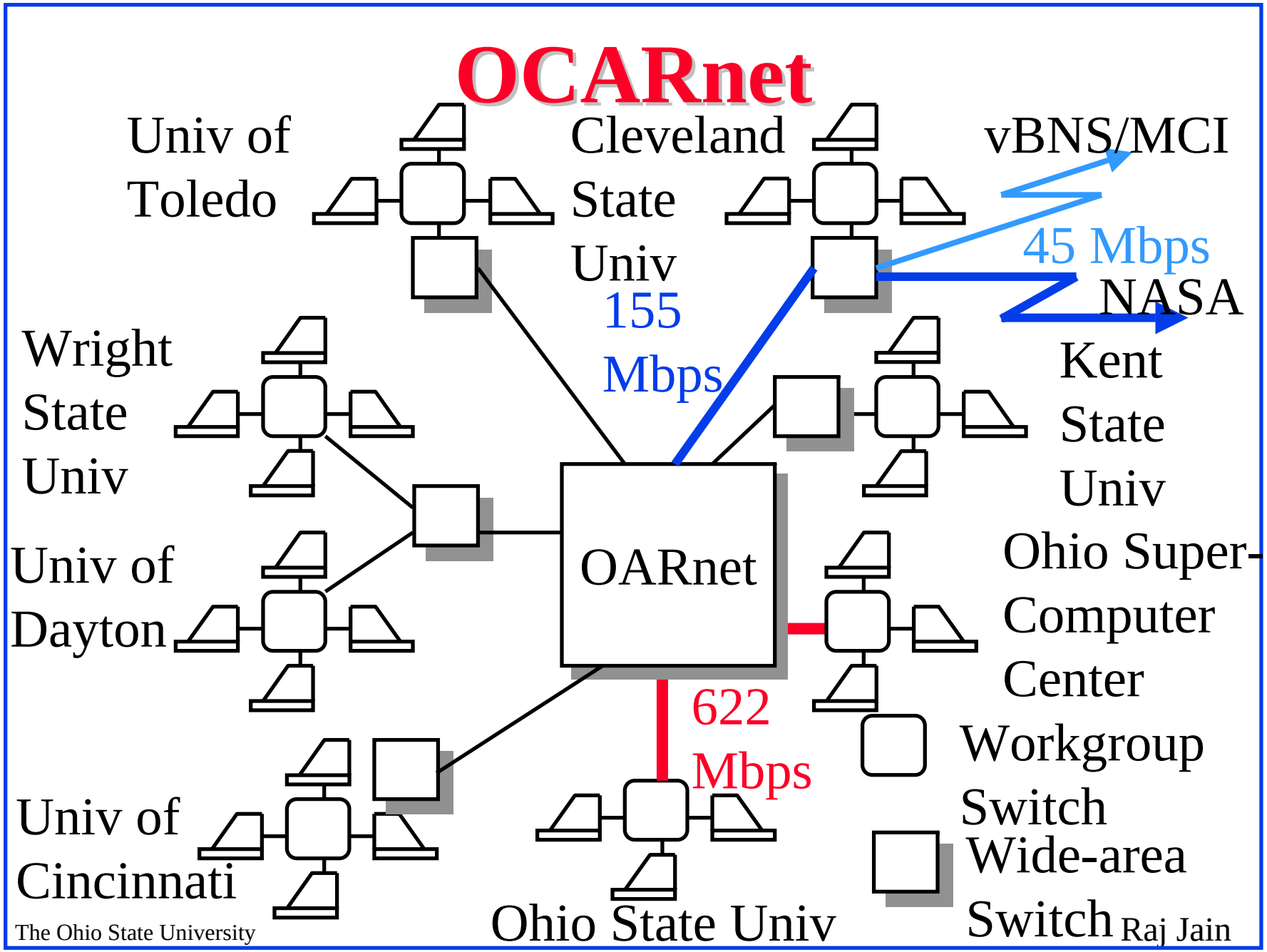
- We invented DECbit scheme in 1986:
  One Bit in the header ⇒ Go up/Down
  - Used now in Frame Relay (FECN)
  - Used in ATM (EFCI)
- In July 1994, we proposed Explicit Rate Approach.
  Current standard.
- Two patents. Collaboration with industry.

Traffic Management: Research

- Explicit Feedback Algorithm [Shiv Kalayanaraman]
  - Explicit Rate Indication for Congestion Avoidance
  - ERICA is the industry baseline
- TCP/IP over ATM [Rohit Goyal]
  - How to improve TCP/IP performance over ABR/UBR
  - ATM over Satellite
- Multicasting [Sonia Fahmy]
  - 1 to n, n to 1, n to n communication with Feedback
  - Feedback aggregation, Extension of ERICA
- Real-Time ABR [Bobby Vandalore]
  - Best effort video and voice

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


OCARnet
Univ of Toledo
Cleveland State Univ
vBNS/MCI
45 Mbps
NASA
155 Mbps
Wright State Univ
Kent State Univ
Univ of Dayton
OARnet
Ohio Super-Computer Center
622 Mbps
Workgroup Switch
Wide-area Switch
Univ of Cincinnati
Ohio State Univ

OSU National ATM Benchmarking Lab

- Started a new effort at ATM Forum in October 1995
- Defined a new standard for frame based performance metrics and measurement methodologies
- OSU benchmarking lab has 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
- Standard was sent for ballot July 1999.

Voice over Data Networks

- Voice compression and silence suppression reduce the required bandwidth, but cause longer delay.
- Analysis of new ATM Adaptation Layer (AAL2):
  - allows multiplexing inside a cell,
  - shorter delay and higher utilization.
- Analysis of submultiplexing schemes in IP:
  - to allow multiple voice sources use the same packet,
  - to reduce delay and transmission overhead.

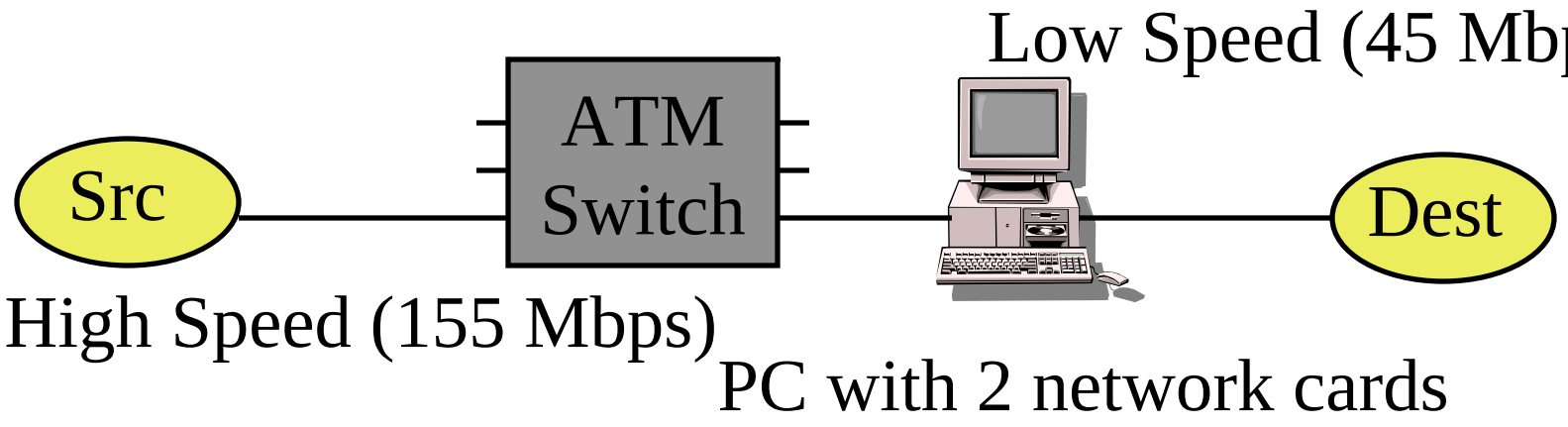
Current Research Projects

- Real-Time ATM ABR and Software Switch
- Internet Protocol (IP) Congestion Management
- Quality of Service (QoS) over Internet Protocol
- Wireless QoS
- Scalable Real-time Video
- Internet-2 Technology Evaluation Center

Real-Time ABR

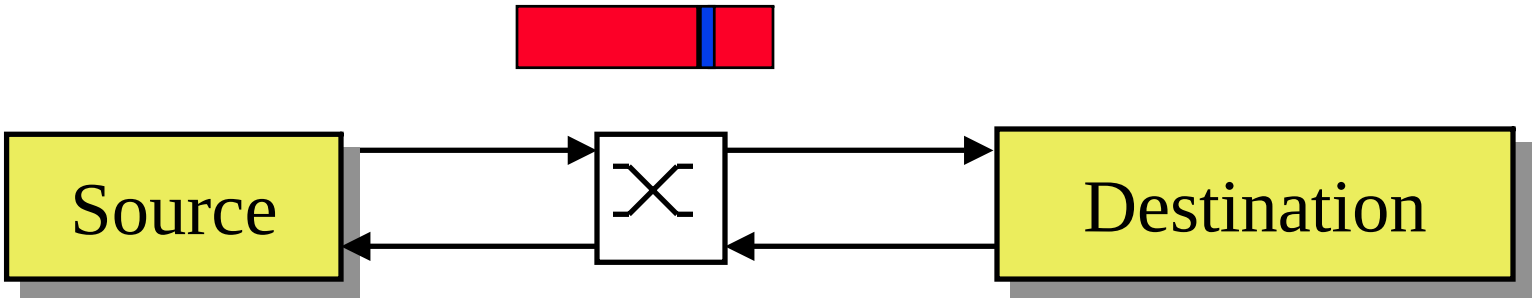
- Compressed video produces variable bit rate (VBR) stream. VBR service is subject to connection denial.
- In situations where reduced service is preferable over connection denial, such as in tactical environments, Video over ABR is preferable over no Video.
- ABR divides the available bandwidth fairly among contending connections
- By proper control, ABR can be designed to reduce delay
- Compression parameters can be adjusted dynamically based on network feedback

Software Switch



- A 1 x 1 software switch runs on a PC with two network interface cards. It is connected to one output port of an actual ATM switch. PC runs Linux OS.
- Software switch will provide flexible testbed for developing new schemes and testing them.

IP Congestion Management

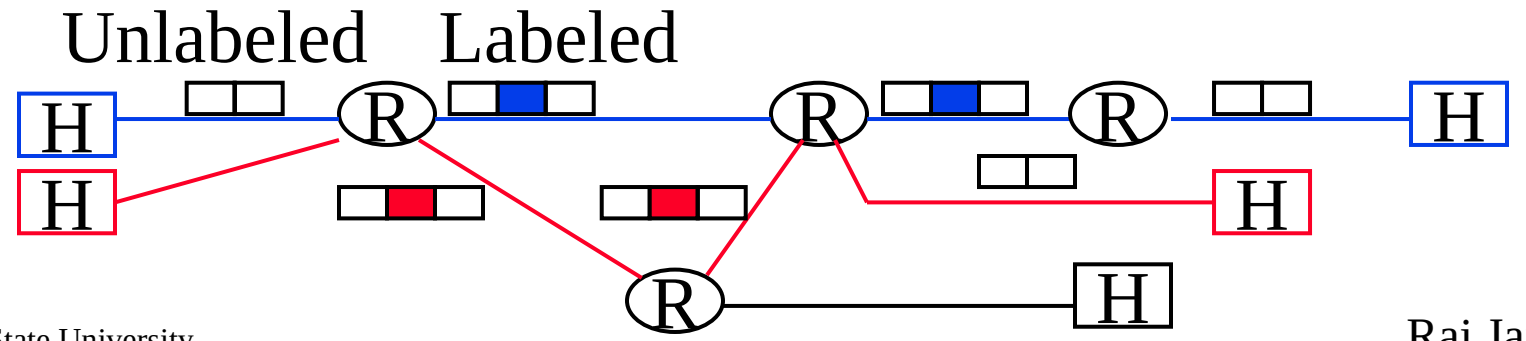


- Explicit Congestion Notification (ECN) bit in IP header (1999)
- What is the correct way for routers to set ECN?
- What is the correct way for end systems to respond to ECN?

Quality of Service over IP

Ver	Hdr Len	Type of Service (ToS)		Tot Len

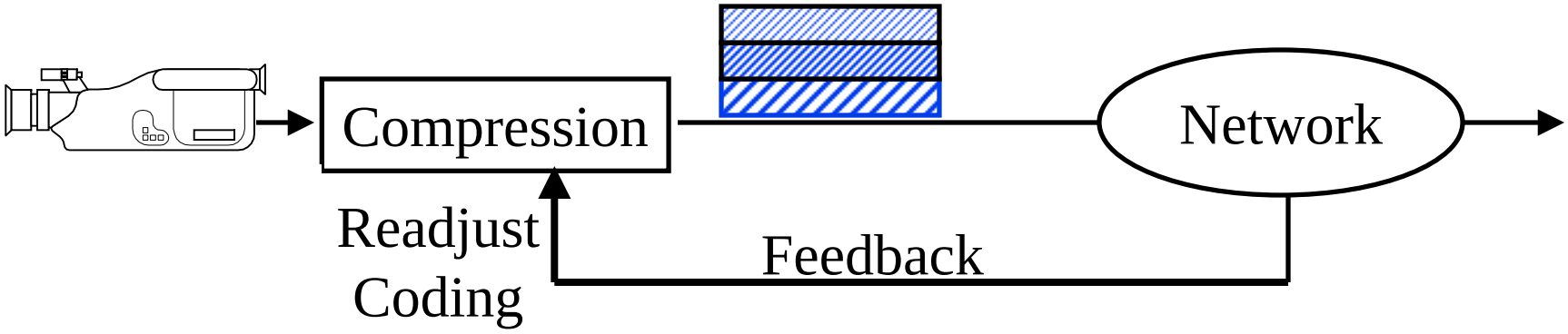
- **Differentiated Services**:
  - IP Packets get treatment depends upon ToS byte
  - Internet Draft on effectiveness of multiple drop preferences
- **Multiprotocol Label Switching (MPLS):**
  - Internet Draft on effectiveness of MPLS



Wireless Networking

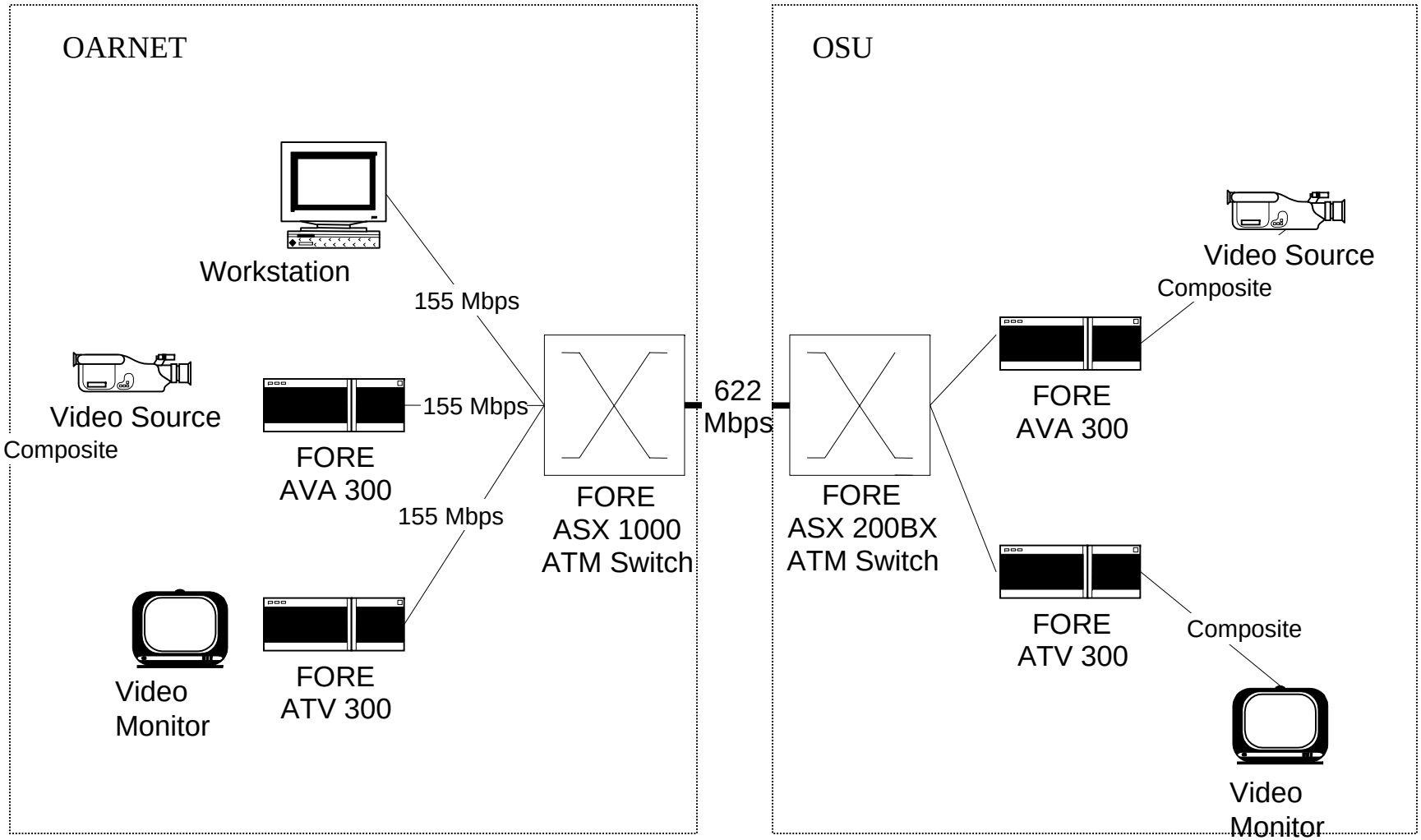
- In collaboration with Electro-science laboratory of EE Dept (Experts in Antenna design and wireless modem communications)
- Dynamically adapt to measured error characteristics:
  - Media Access Protocol
  - Transport protocol (retransmissions)
  - Hand-off strategies
- Modem design for optimal higher-layer performance
- Funded by NSF

Video over Data Networks



- Joint project with Prof. Stan Ahalt, Yuan Zhang, and Patrick Flynn of EE Dept
- Hierarchical compression of video
  Different users can view the same compressed stream at different rates
- Network feedback to adjust levels of compression
- Forwarding adaptive to network feedback

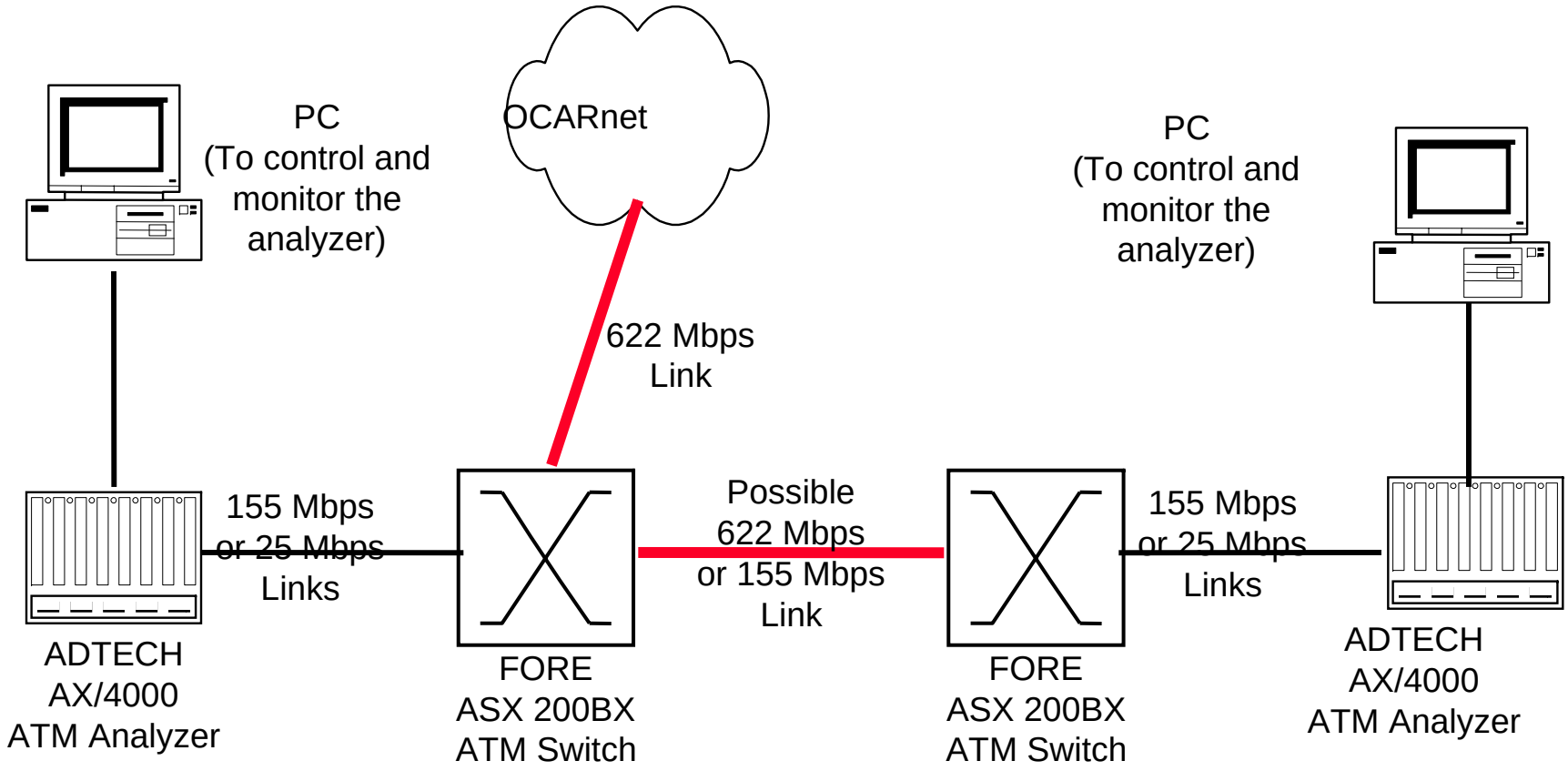
Video Testbed



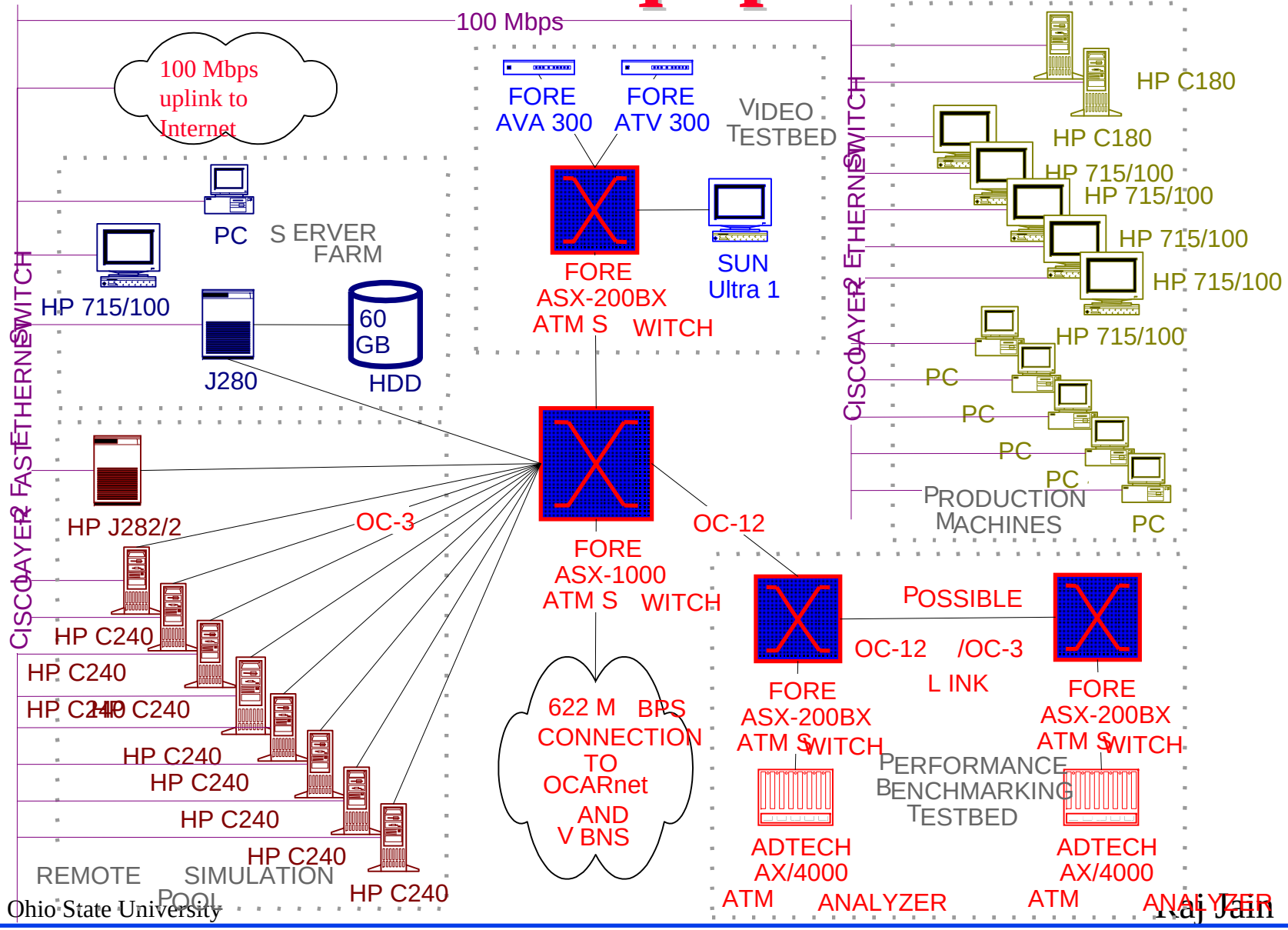
Abilene Technology Evaluation Center

- Jointly with OARnet and Ohio Supercomputer Center
- Abilene = Internet-2 = High-speed (1.2 Gbps academic backbone)
- All new technology to be used in Internet-2 will be tested in Ohio
- OSU/CIS's performance testing laboratory will be used for testing

Performance Testing Facility



Netlab Equipment



Research Facilities

- **Netlab**:
  - Well equipped Lab in DL274
  - 622 Mbps connection to OCARnet
  - 100 GB Storage Server
  - High-end HP compute servers
  - PC workstations/printers/copiers/video equipment
  - Compute power/student = 10 × Avg CIS Faculty
- **Networking Library**: Latest books. Regularly updated.
- **On-line Standards Archive for Internal Use**: ATM Forum, ITU, IEEE

CIS Networking Courses

- CIS 677: Introduction to Networking
  - Offered every quarter
- CIS 678: Internetworking
  - Offered once a year - Winter quarter
- CIS 777: Telecommunication Networks
  - Offered once a year - Spring quarter
- CIS 788: Recent Advances in Networking (Raj Jain)
- CIS 788: Wireless Networking (Steve Lai)
- CIS788: Multimedia Networking (Wu-Chi Feng)
- CIS788: CDMA (Mike Liu)

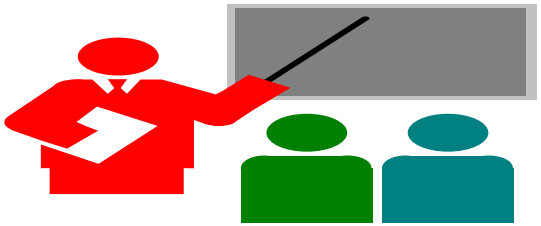
Distance Education

- All our courses are broadcast live over the Internet see http://www.cis.ohio-state.edu/~jain/
- Distance teaching from remote locations
- All classes also stored on the Web. Extensively viewed all over the world.
- Downloadable for local viewing
- Plans to provide lectures on CD-ROM
- Ohio Distance Education Network (ODEN): Proposal to broadcast classes and seminars among Kent State U, U of Dayton, Cleveland U, OSU, OSC, and OARnet

Collaboration

- **Inter-Faculty**: Joint funding with Wu-Chi, Steve Lai, D. Panda, A. Arora
- **Inter-Department**: Joint funding with EE (Stan Ahalt, Jennifer Hoe, Yuan Zhang, Mike Fitz), OSC (Al Stutz), OARnet (Doug Gale, Eugene Wallis)
- **Inter-University**: OCARnet, ODEN
- **With Industry**:
  - Joint research proposals with Nokia, ...
  - Research Sponsored by: NASA, FORE, Nokia, ...
  - New Technology Seminars at Nortel, Lucent, ...
- **Industry Forums**: IETF, ATM Forum, TIA, IEEE, Networld+Interop

Summary



- Networking Age, Networking Bottleneck ⇒ Opportunities, Demand
- Recognized leader in traffic management and QoS
- Current research in ATM, IP QoS, Wireless QoS, Scalable Video, and Performance testing
- Excellent networking educational program, lab facilities, literature facilities, and world-wide exposure
- Extensive collaboration ⇒ Real-world problems and real-world solution

Our Publications

- 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"