# Recent Advances in Networking Including ATM and Its Traffic Management

**Raj Jain**

Raj Jain is now at
Washington University in Saint Louis
Jain@cse.wustl.edu
http://www.cse.wustl.edu/~jain/


- Networking Trends
- Impact of Networking
- ATM Networks
- Competing technologies
- ATM Traffic Management

# Trends

- Communication is more critical than computing
  - Greeting cards contain more computing power than all computers before 1950.
  - Genesis's game has more processing than 1976 Cray supercomputer.
- Internet: 0.3 M hosts in Jan 91 to 9.5 M by Jan 96 $\Rightarrow$ More than 5 billion (world population) in 2003

# Stone Age to Networking Age

- Microwave ovens, stereo, VCRs, had some effect. But, Stone, iron, …, automotive, electricity, telephone, jet plane,…, networks caused a fundamental change in our life style
- In 1994, 9% of households with PC had Internet link. By 1997, 26%. Soon 98% … like TV and telephone.
- URL is more important than a company's phone number. (54 URLs in first 20 pages of March'97 Good Housekeeping.)
- Better communication $\Rightarrow$ Distance not important

# Social Impact of Networking

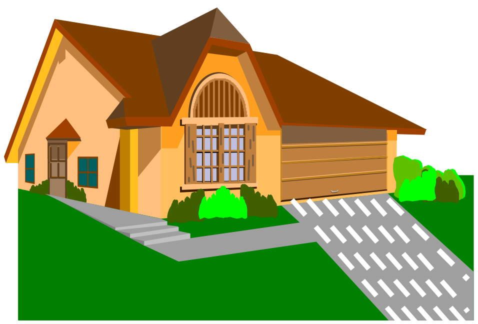
- No need to get out for
  - Office
  - Shopping
  - Entertainment
  - Education
- Virtual Schools
- Virtual Cash
- Virtual Workplace

(55 Million US workers will work remotely by 2000)

# Cave Persons of 2050

# Garden Path to I-Way

- Plain Old Telephone System (POTS)
  = 64 kbps = 3 ft garden path
- ISDN = 128 kbps = 6 ft sidewalk
- T1 Links to Businesses = 1.544 Mbps
  = 72 ft = 4 Lane roadway
- Cable Modem Service to Homes:
  = 10 Mbps = 470 ft = 26 Lane Driveway
- OC3 = 155 Mbps = 1 Mile wide superhighway
- OC48 = 2.4 Gbps = 16 Mile wide superhighway



# Impact on Education

- Email is faster than telegram
  ⇒ Fast pace of life
- Shorter product life cycles.
  Distance between research and products has narrowed
- Technology is changing faster than our ability to learn
  ⇒ A person's value (salary) decreases with experience (years out of college)
- Recent graduates know C++, HTML, Java, TCP/IP, ...
- New Opportunities/Challenges for educators
- New challenges for learners

# Impact on R&D

- Too much growth in one year
  ⇒ Can't plan too much into long term
- Long term = $1_2$ years at most
  year or $10_2$

oducts have life span of 1 year, 1 month, …

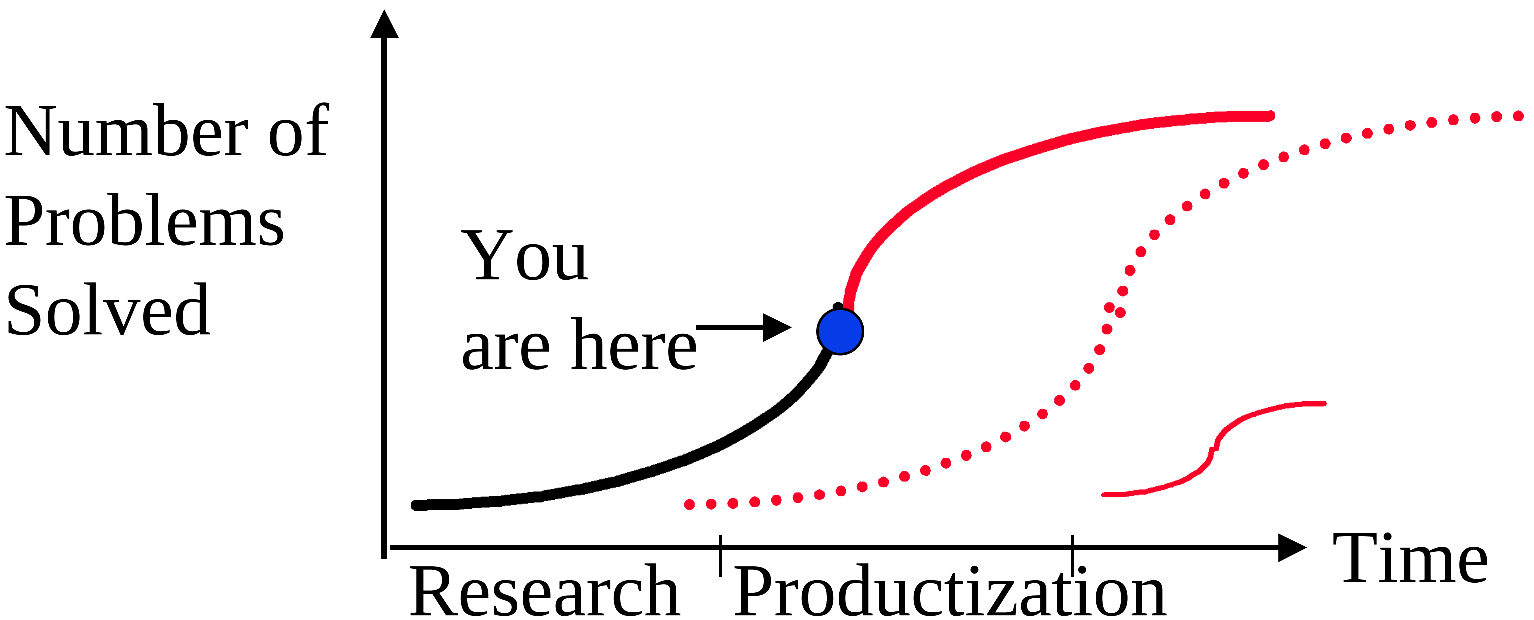
ort product development cycles.

rysler reduced new car design time

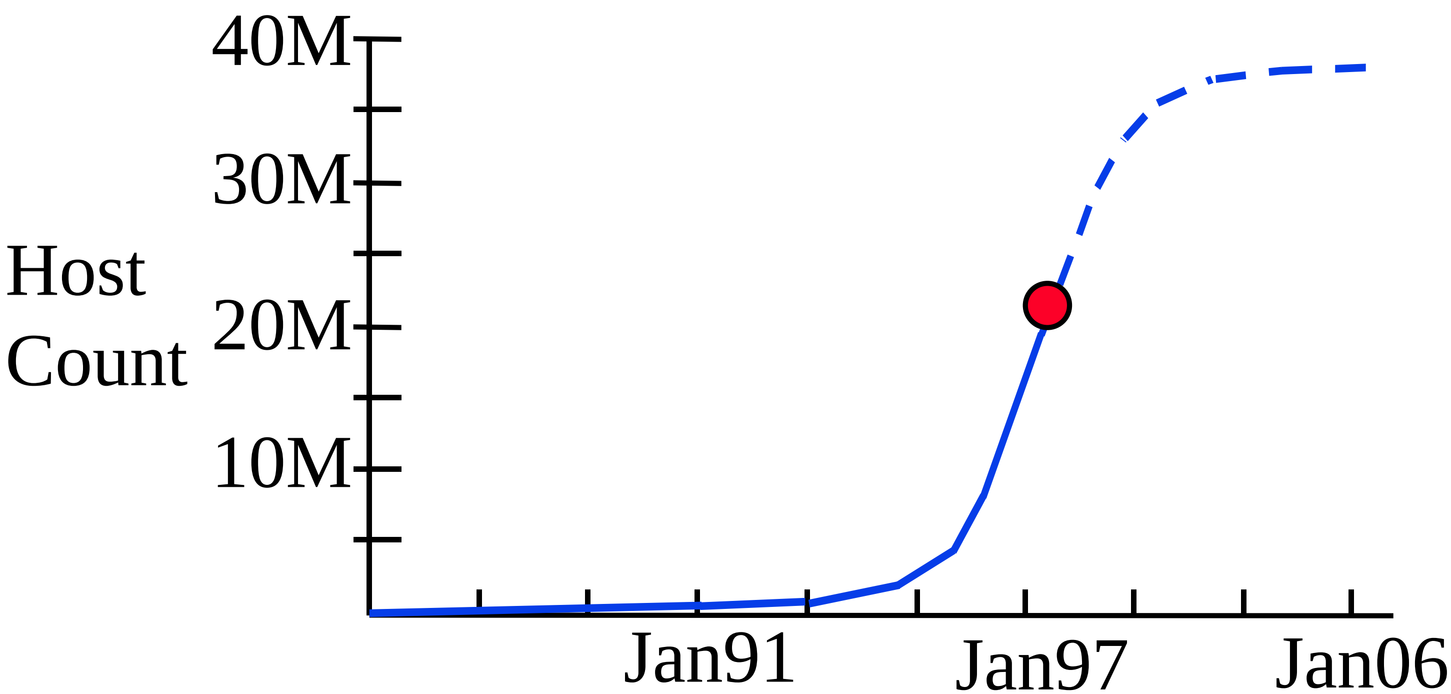
om 6 years to 2.

stance between research and products has narrowed

# Life Cycles of Technologies



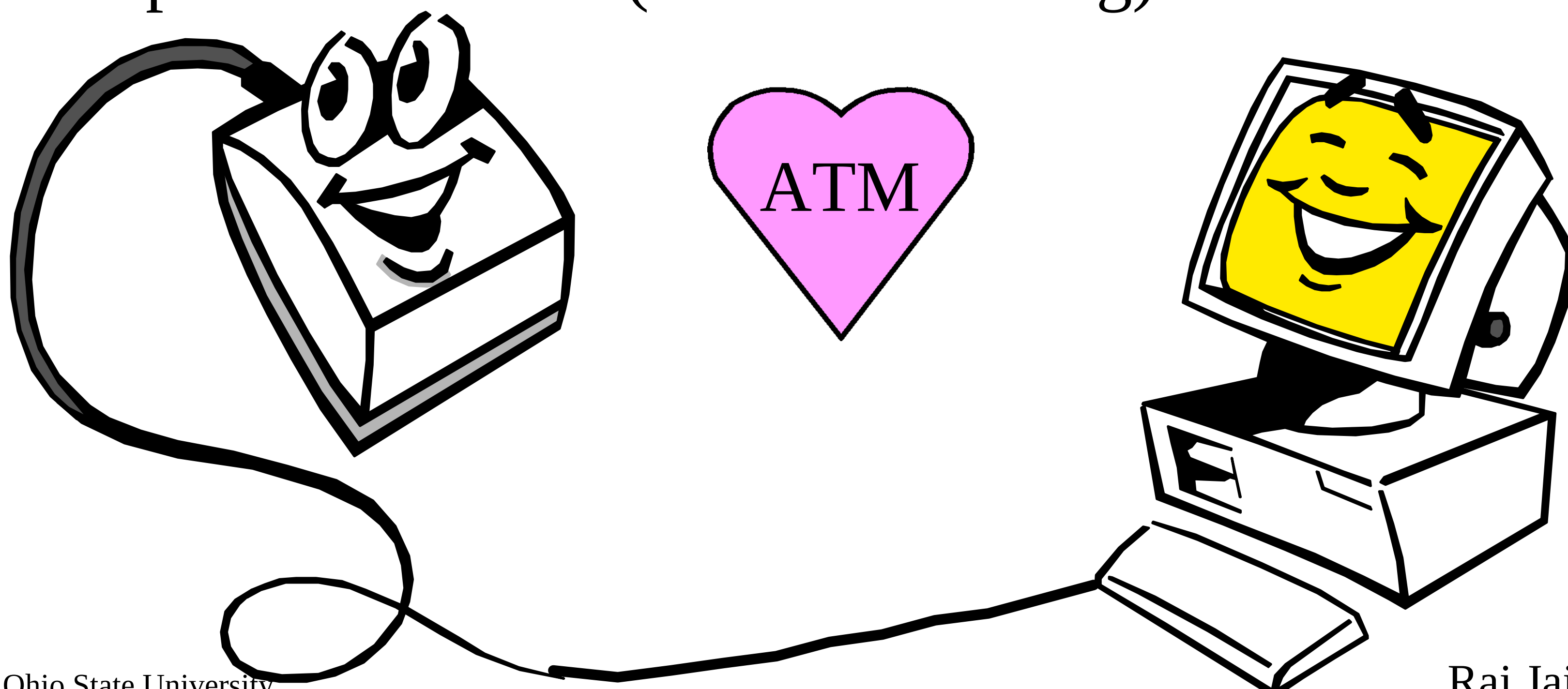
# Internet Technology



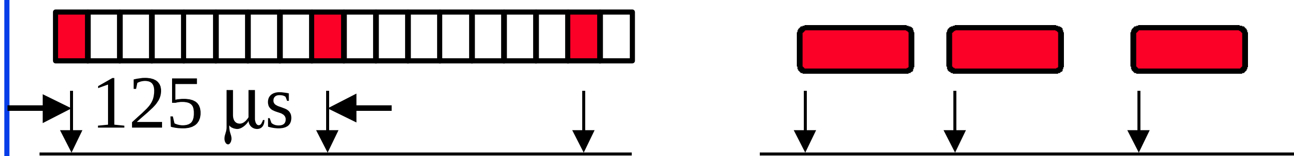

- **New Challenges**: Exponential growth in number of users. Exponential growth in bandwidth per user. Traffic management, Security, Usability, ...

# ATM

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



# ATM vs Phone Networks



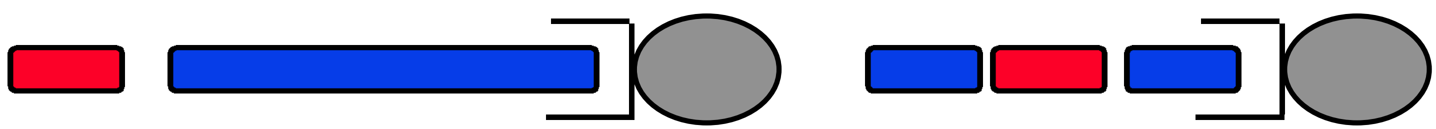

- Current phone networks are synchronous (periodic).
  ATM = Asynchronous Transfer Mode
- Phone networks use circuit switching.
  ATM networks use "Packet" Switching
- In phone networks, all rates are multiple of 8 kbps.
  With ATM service, you can get any rate.
  You can vary your rate with time.
- With current phone networks, all high speed circuits are manually setup. ATM allows dialing any speed.

# ATM vs Data Networks

- Internet Protocol (IP) is connectionless.
  You cannot reserve bandwidth in advance.
  ATM is connection-oriented.
  You declare your needs before using the network.
- Routers cannot guarantee bandwidth or delay.
  ATM networks reserve bandwidth and buffers.
- In IP, each packet is addressed and processed individually. Inefficient for continuous media like voice and video.

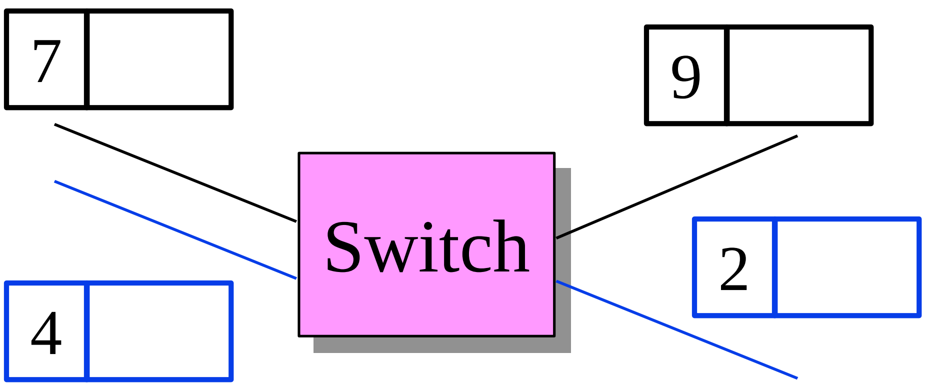
# ATM vs Data Nets (Cont)

- IP has no traffic management.
  (TCP does have traffic management
  but it is 1984 technology.)
  ATM has 1996 traffic management technology.
  Required for high-speed and variable demands.
- IP uses variable size packets.
  ATM uses fixed size cells.
  Less variance in delay $\Rightarrow$ Good for voice.
  (However, at high speeds, variance with variable size
  packets is not significant.)



# ATM vs Data Nets (Cont)

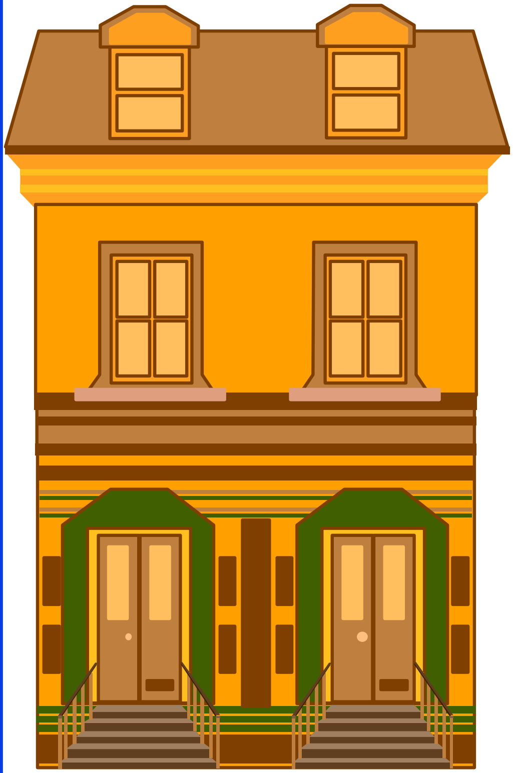
- Current IP uses 4-byte addresses.
  (e.g., 123.45.65.89)
  Not enough IP addresses for global communication.
  (Next Generation of IP will use 16-byte addresses)
  ATM uses 20-byte addresses.
- IP has to match addresses for routing each packet.
  ATM indexes circuit numbers for switching ⇒ Fast.

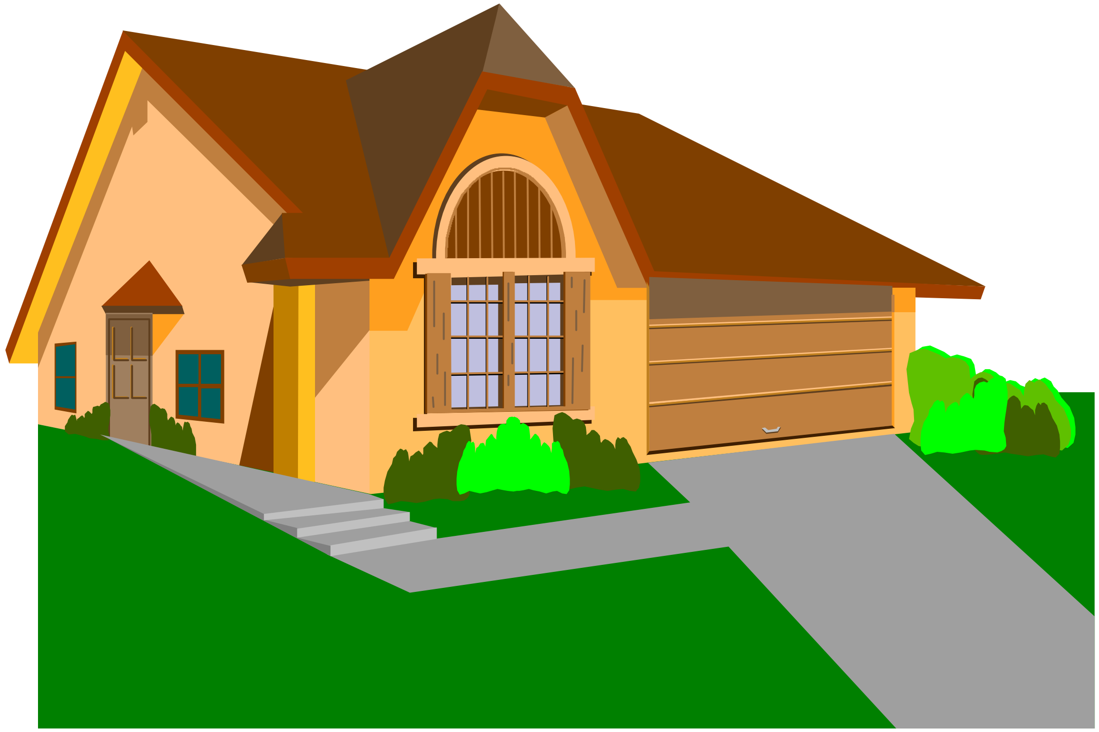


# IP vs ATM

- Traffic management
- Signaling (resource reservation)
- QoS based Routing
- World-wide Addressing
- Connections: Soft vs Hard
- Evolution vs revolution

# Old House vs New House



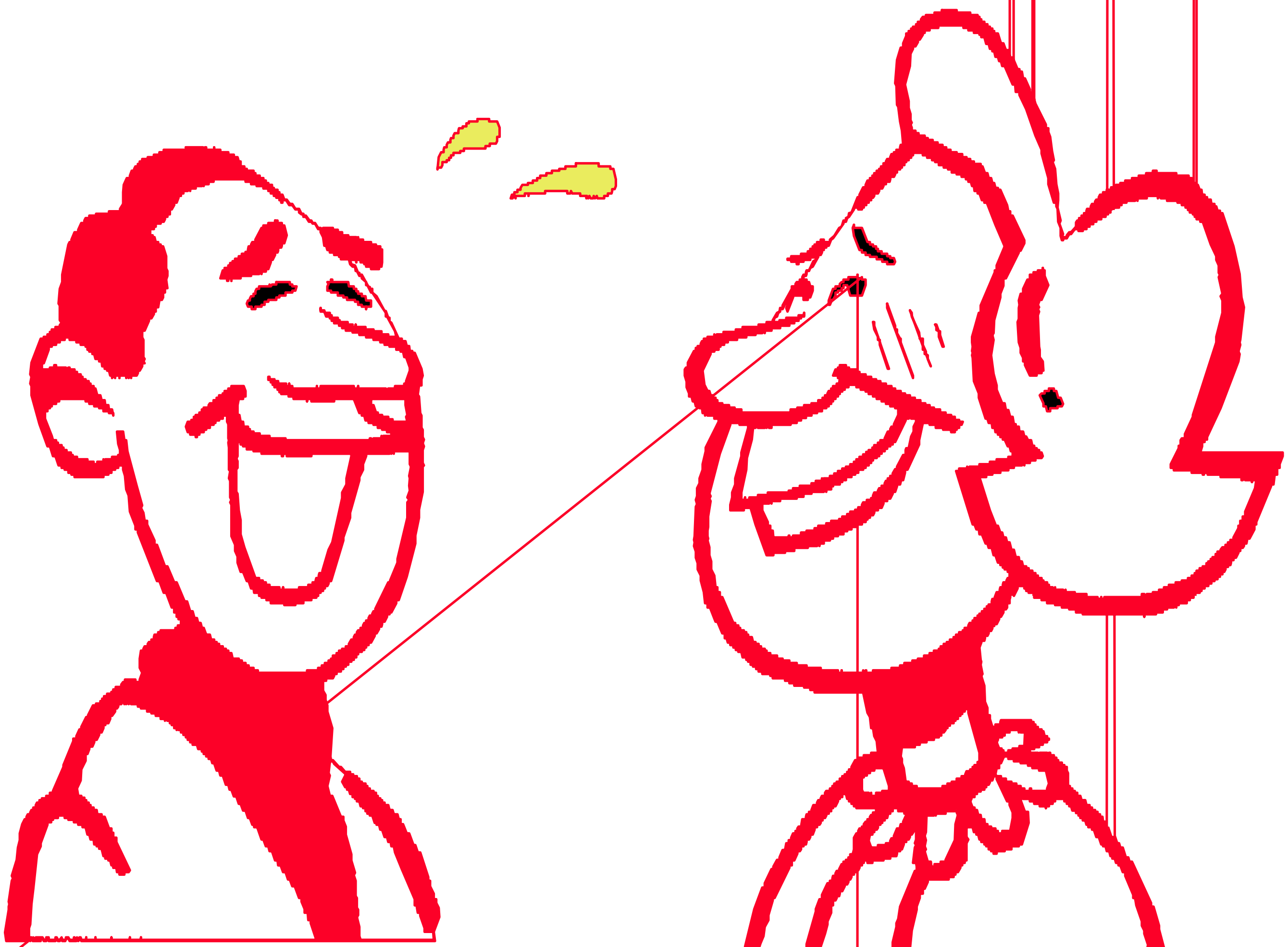


- New needs:

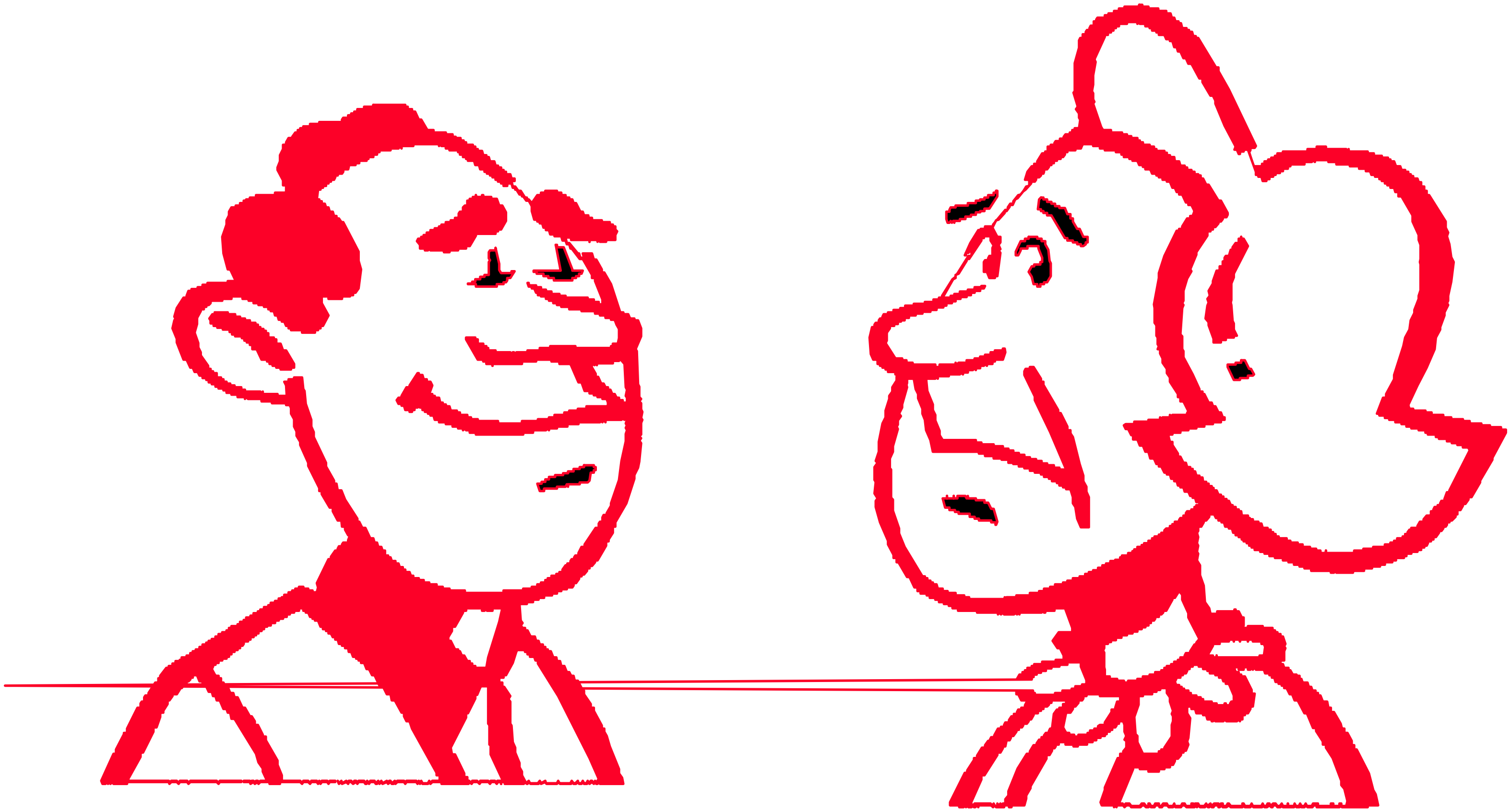
  Solution 1: Fix the old house (cheaper initially)

  Solution 2: Buy a new house (pays off over a long run)

# Before



# After



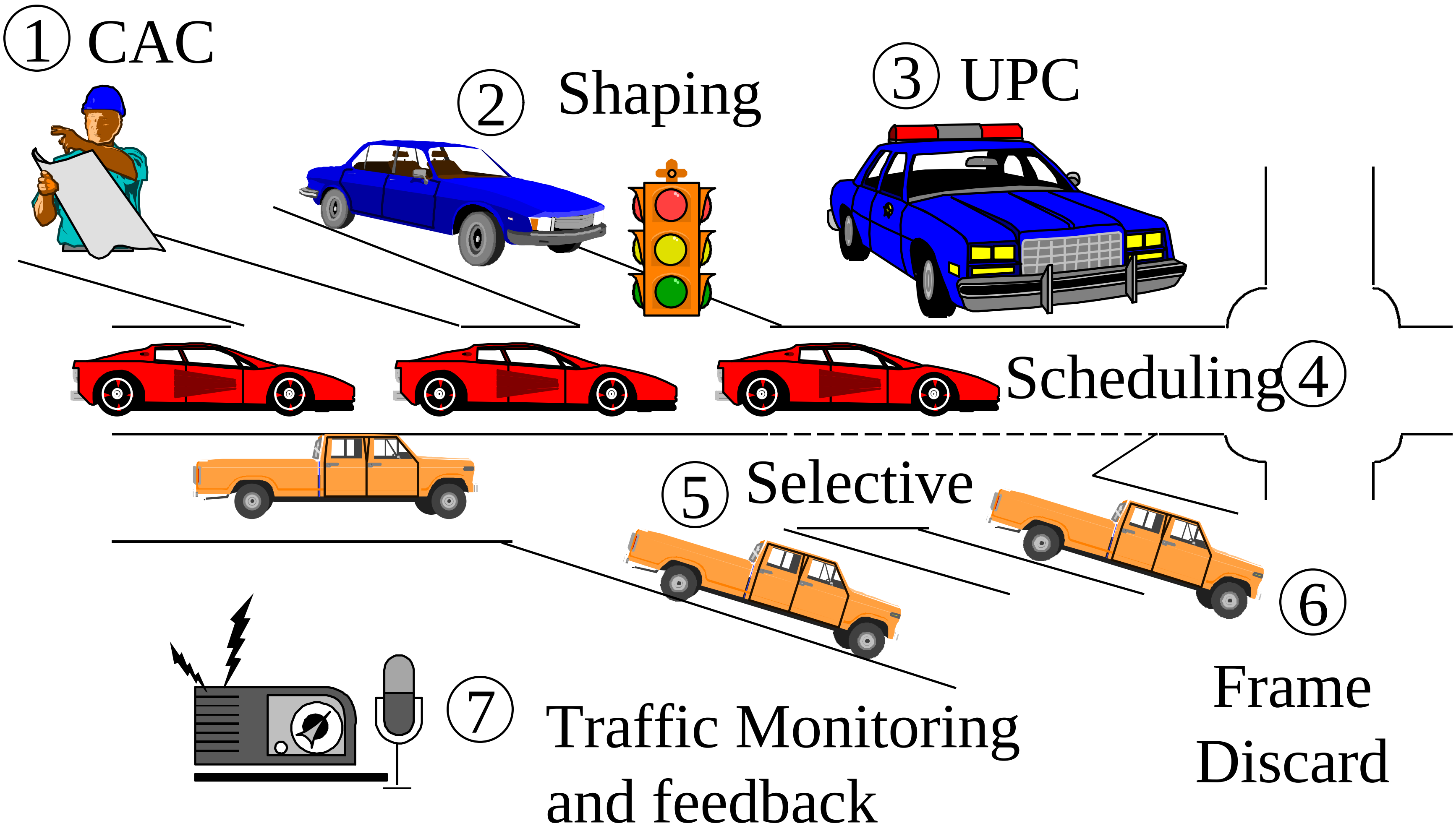
# Key Challenge: Economy of Scale

- Technology is far ahead of the applications. Invention is becoming the mother of necessity. We have high speed fibers, but not enough video traffic.
- Low-cost is the primary motivator. Not necessity. $\Rightarrow$ Buyer's market (Like $99 airline tickets to Bahamas.) Why? vs Why not?
- Parallel computing, not supercomputing
- Ethernet was and still is cheaper than 10 one-Mbps links.

# Challenge: Tariff

- Phone company's goal: How to keep the voice business and get into data too?
- Customer's goal: How to transmit the voice/video/data cheaper?
- Tariff Today:
  - 64 kbps voice line = $300/year
  - 45 Mbps line ($45/mile/month)
    Coast to coast = $180 k-240 k/year
    ⇒ 155 Mbps line = $540 k - $720 k/year
- Tomorrow: 155 Mbps = $1k/month+ $28/G cells
  ⇒ $13k - $45k/year

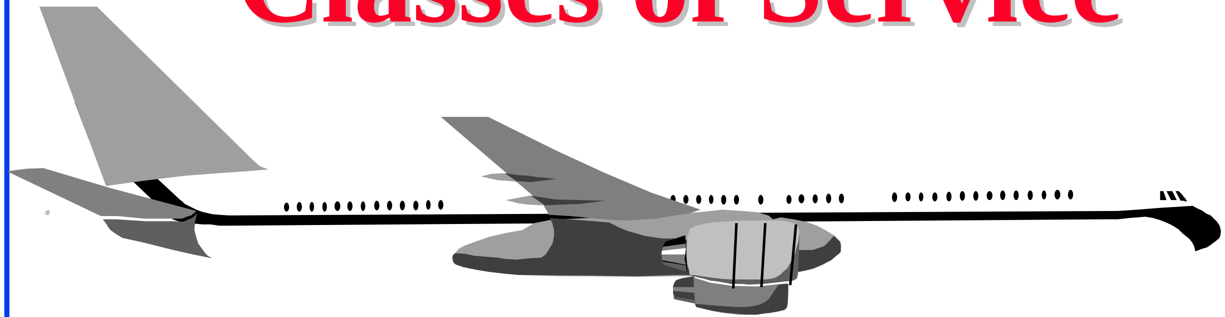
# Traffic Management on the Info Superhighway

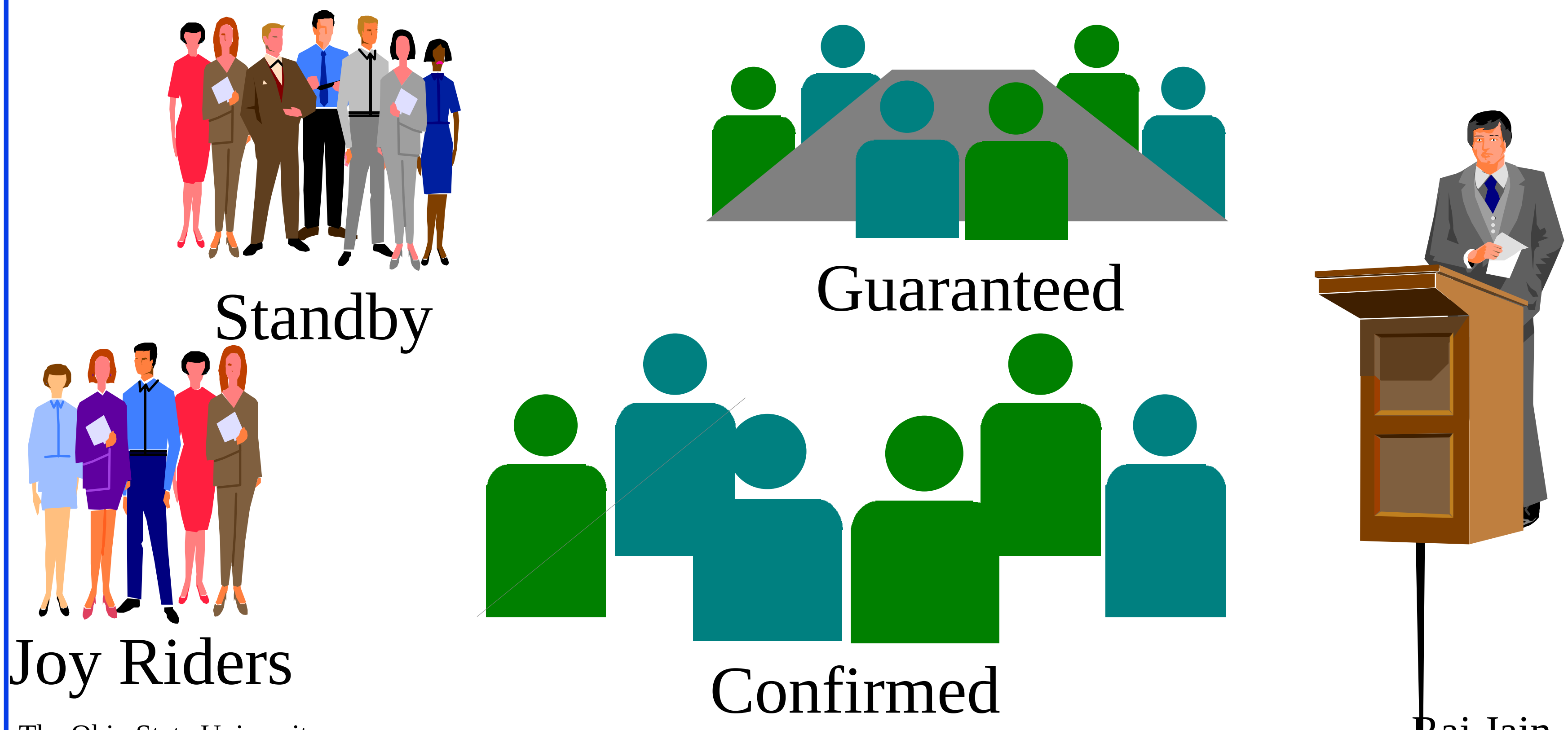


# Traffic Mgmt Functions

- 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

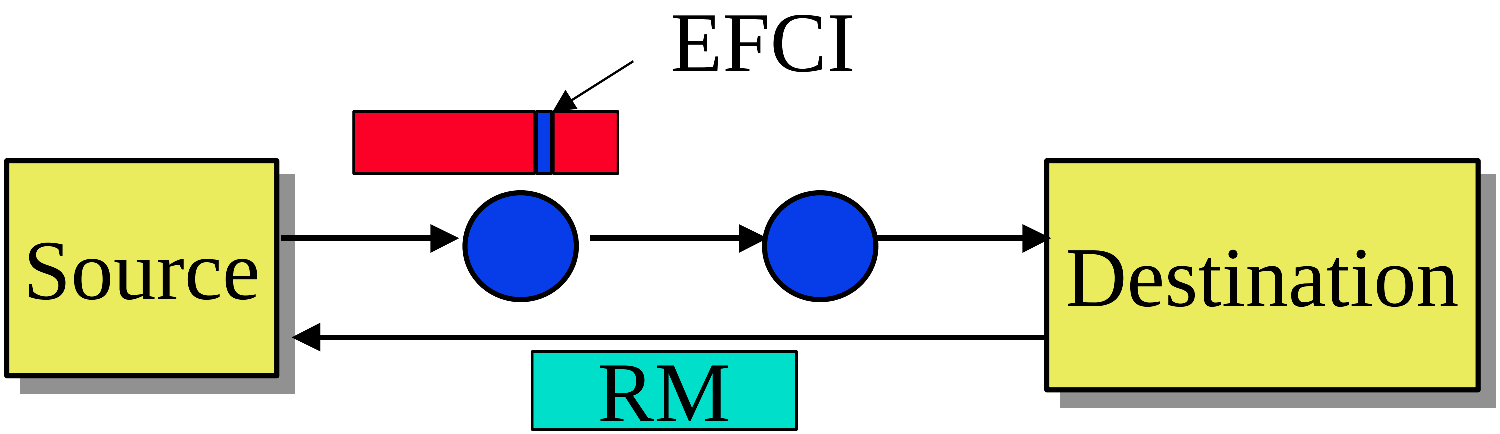




# Classes of Service

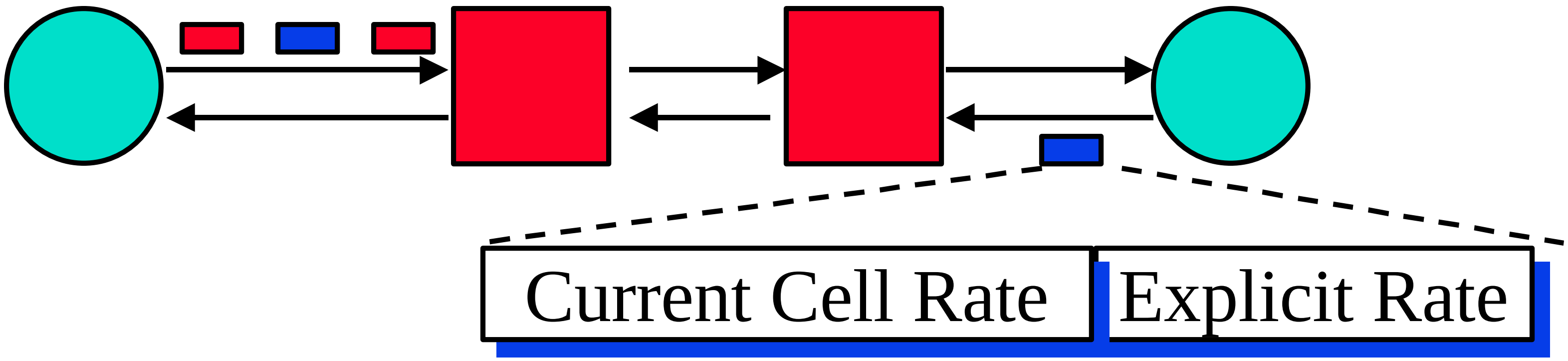
- ABR (Available bit rate):
  Source follows network feedback.
  Max throughput with minimum loss.
- UBR (Unspecified bit rate):
  User sends whenever it wants. No feedback. No guarantee. Cells may be dropped during congestion.
- CBR (Constant bit rate): User declares required rate.
  Throughput, delay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

# Binary Rate-based Scheme

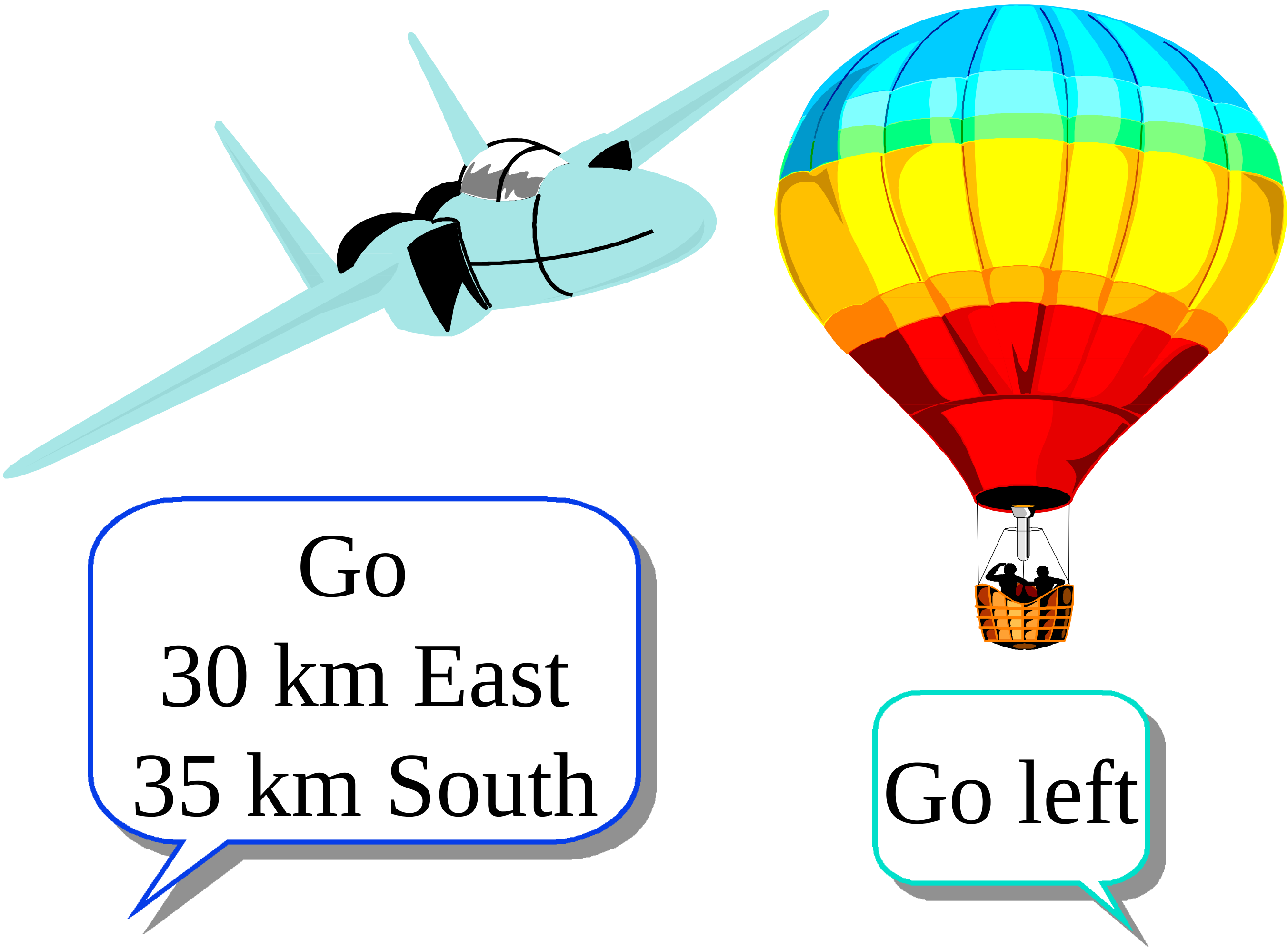



- Explicit forward congestion indicator (EFCI) set to 0 at source
- Congested switches set EFCI to 1
- Every *n*th cell, destination sends an resource management (RM) cell to the source indicating increase amount or decrease factor

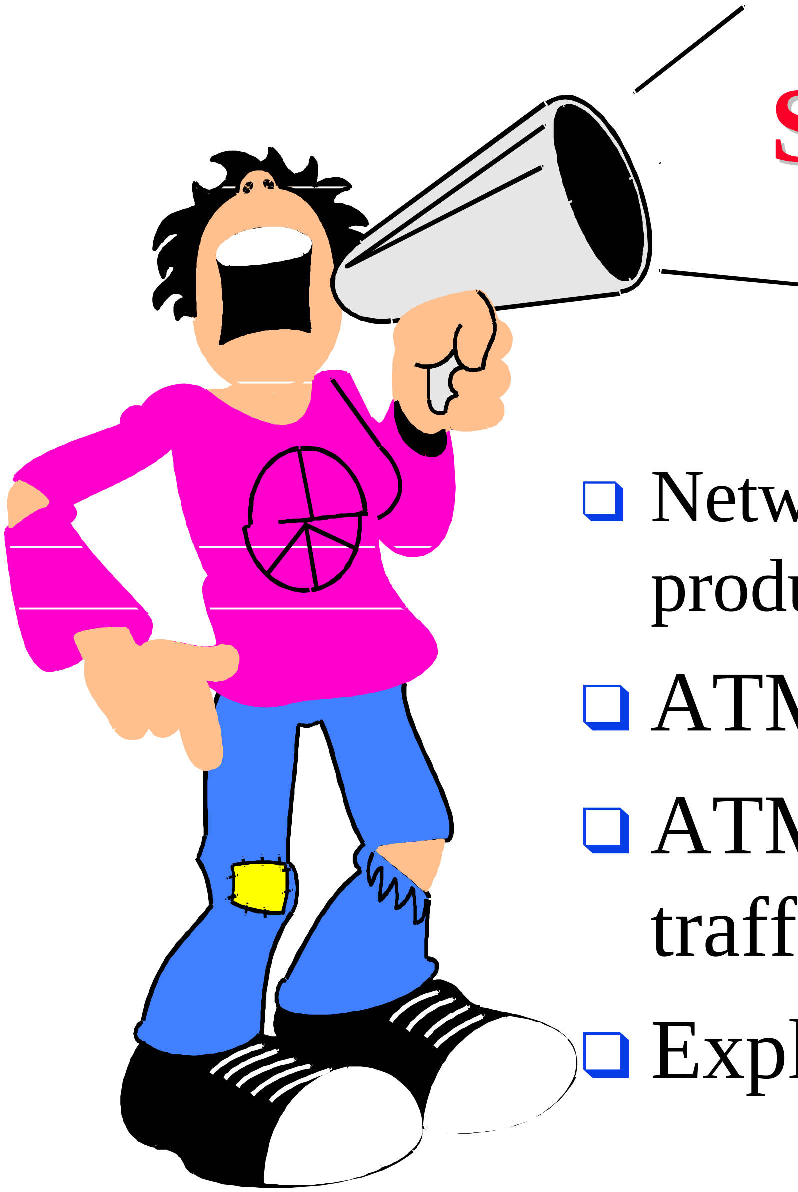
# The Explicit Rate Scheme




- 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


Go
30 km East
35 km South
Go left

# Summary



- Networking is the key to productivity
- ATM Net = Phone + Data
- ATM vs IP: Signaling and traffic management
- Explicit Rate Approach

# 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"
- D. Tapscott, "The Digital Economy: Promise and Peril in the Age of Networked Intelligence," McGraw-Hill, 1995.
- G. Sackett and C. Y. Metz, "ATM and Multiprotocol Networking," McGraw-Hill, 1997 (Technical).

# Thank You!