Recent Trends in Networking Including ATM and Its Traffic Management

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- 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.)
- Email is faster than telegrams

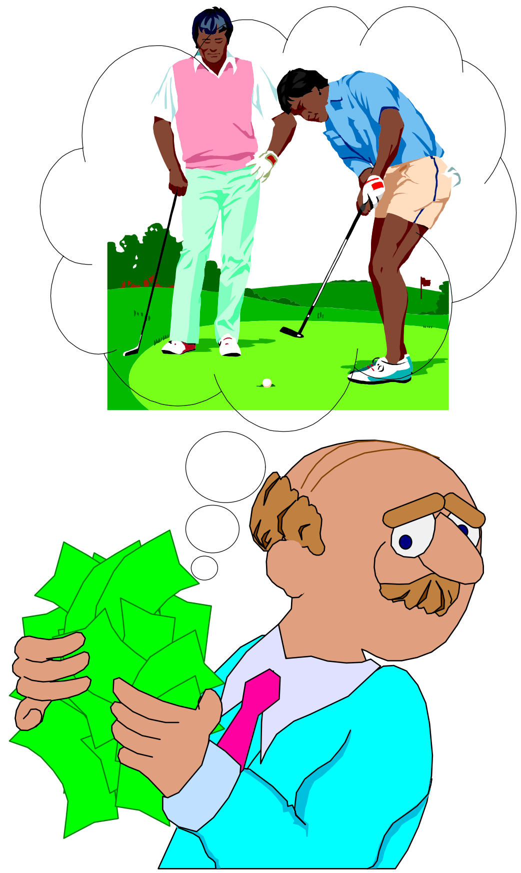
Social Impact of Networking

- 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

High Technology
≠ More vacation



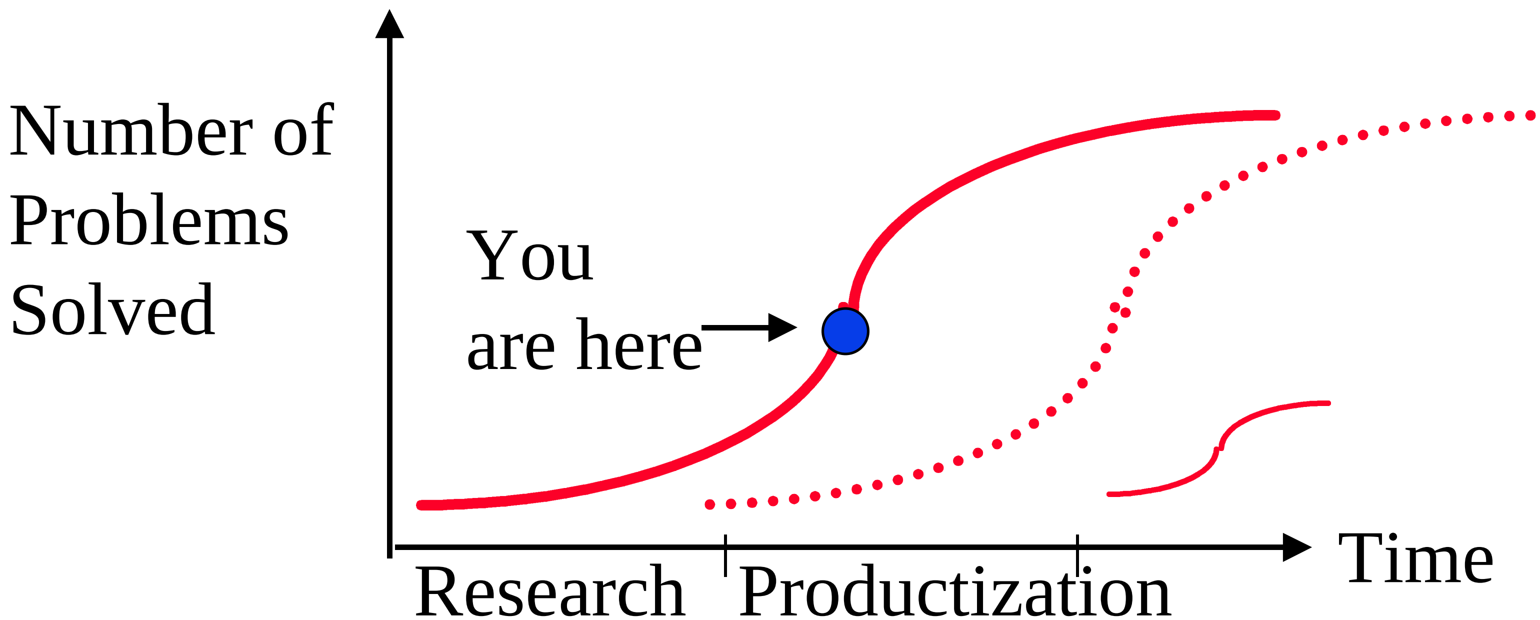
Impact on R&D

- Too much growth in one year
  ⇒ Can't plan too much into long term
- Long term = 1_2 year or 10_2 years at most
- Products have life span of 1 year, 1 month, …
- Short product development cycles.
  Chrysler reduced new car design time
  from 6 years to 2.
- Distance between research and products has narrowed
  ⇒ Collaboration between researchers and developers
  ⇒ Academics need to participate in industry consortia

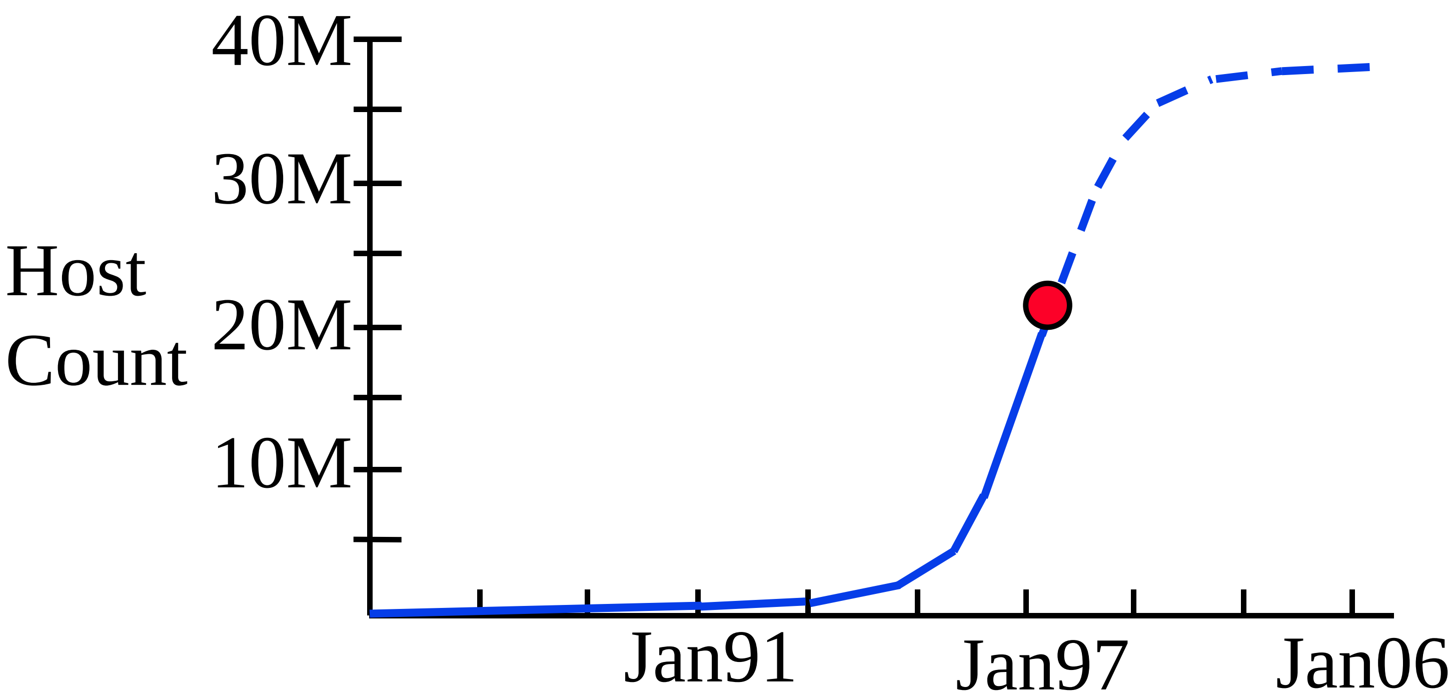
Garden Path to I-Way

- 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

Life Cycles of Technologies



Internet Technology

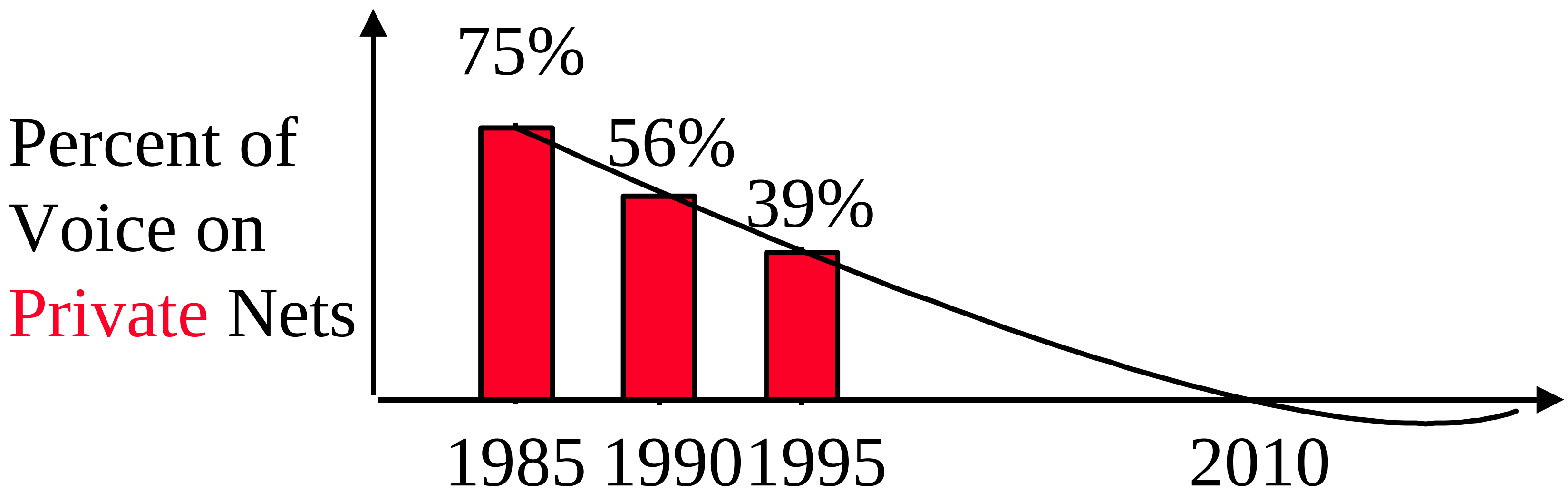


New Challenges

- Networking is moving from specialists to masses ⇒ Usability (plug & play), security
- Exponential growth in number of users + Exponential growth in bandwidth per user ⇒ Traffic management
- Standards based networking for reduced cost
  ⇒ Important to participate in standardization forums
  ATM Forum, Frame Relay Forum, …
  Internet Engineering Task Force (IETF),
  Institute of Electrical and Electronic Engineers (IEEE)
  International Telecommunications Union (ITU), …

Trends in Applications

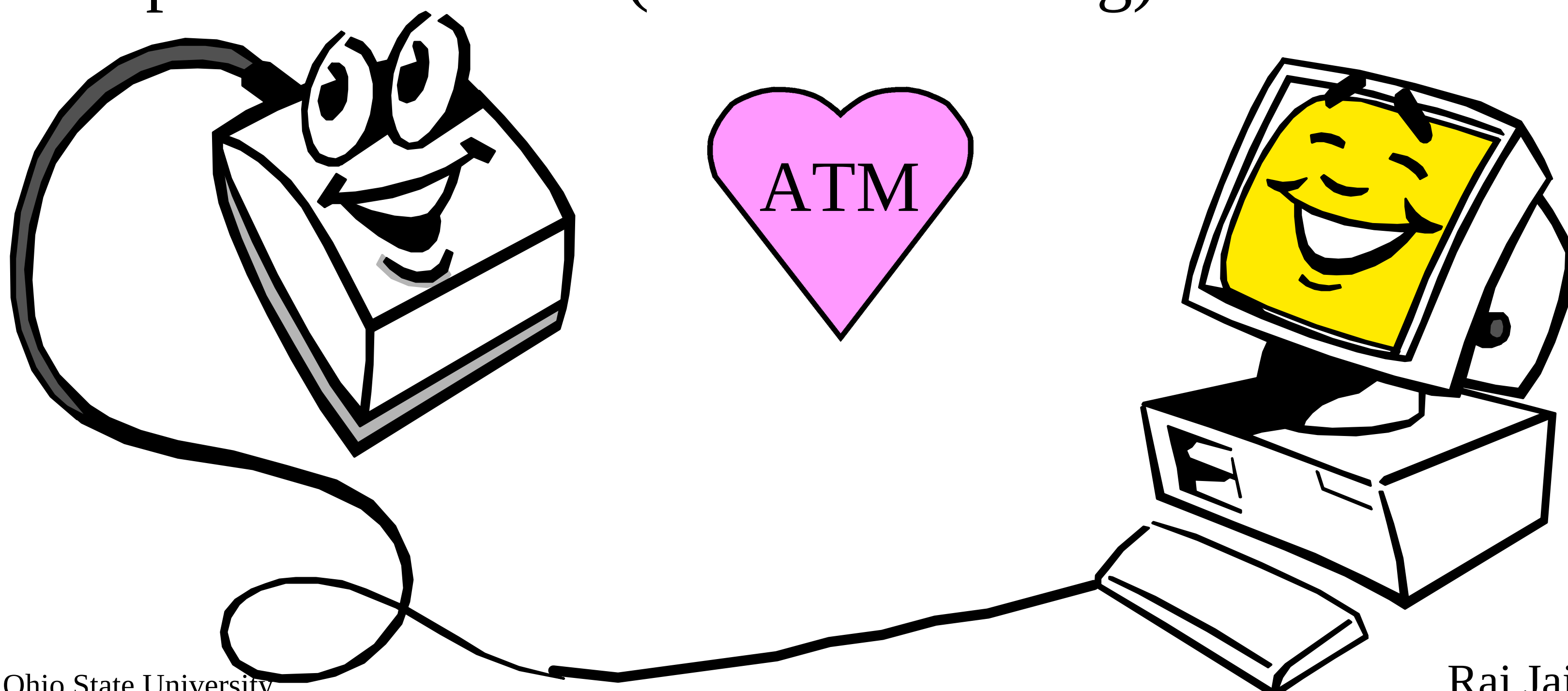
- Little Voice
- AT&T: 125 to 130 M calls/day @ 5 min/call
  64 kbps/call ⇒ 28.8 Gbps = 1/1000 of one fiber
- 200 Million X 24 hr/day X 64 kbps = 12.8 Tbps



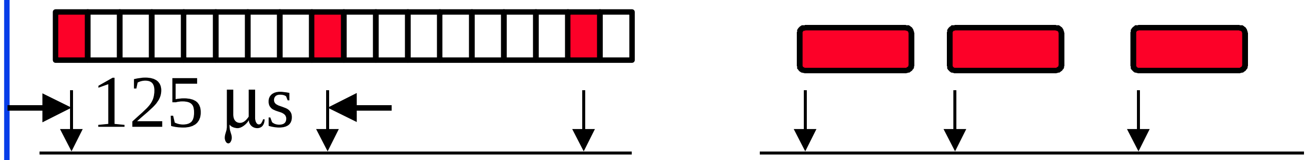
◆Ref: IEEE Spectrum, August 1992, p 19.

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



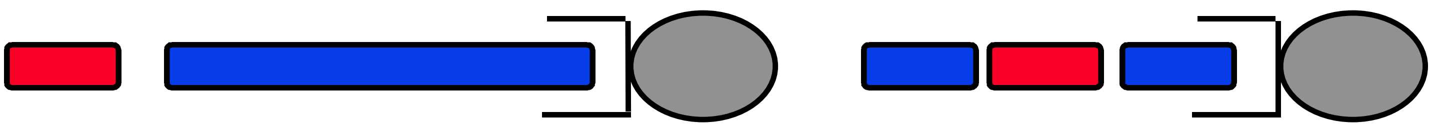
- Current phone networks are synchronous (periodic).
  ATM = Asynchronous Transfer Mode
- Phone networks use circuit switching.
  ATM networks use "Packet" Switching
- In phone networks, all rates are multiple of 8 kbps.
  With ATM service, you can get any rate.
  You can vary your rate with time.
-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

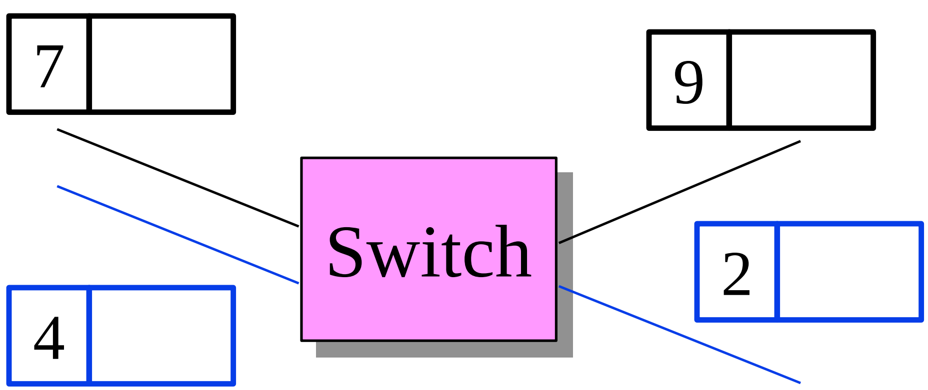
ATM vs Data Nets (Cont)

- 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)

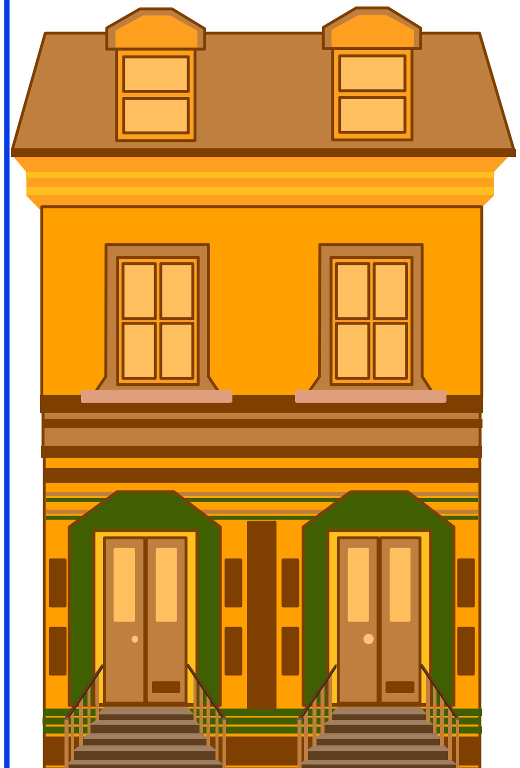
- Current IP uses 4-byte addresses.
  (e.g., 123.45.65.89)
  Not enough IP addresses for global communication.
  (Next Generation of IP will use 16-byte addresses)
  ATM uses 20-byte addresses.
- IP has to match addresses for routing each packet.
  ATM indexes circuit numbers for switching ⇒ Fast.

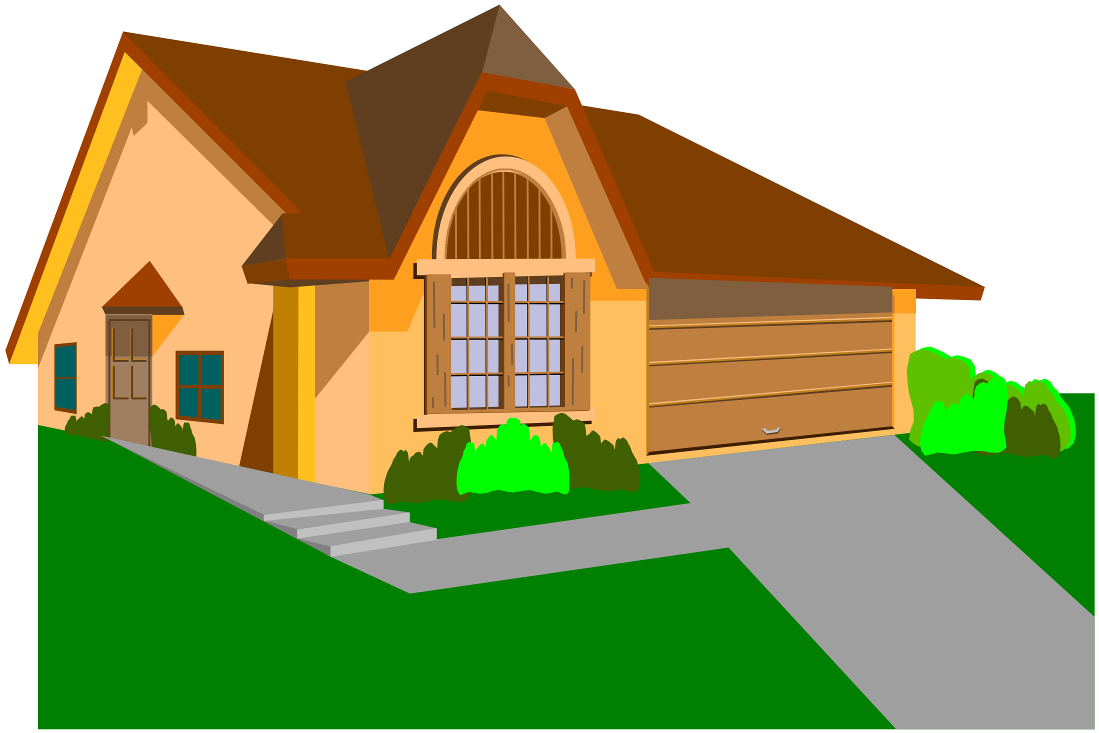


Why ATM?

- 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

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)

Competing Technologies

- Fast Ethernet to the desktop
  Gigabit Ethernet for the campus backbone
  - No traffic management. No priority. (Being added)
- Frame-Relay for Wide-area networking
  - Lower speed only (1.5 Mbps - 10 Mbps)
  - No support for quality of service (for video/voice)
- IP over SONET
  - No signaling $\Rightarrow$ Fixed bandwidth. Can't dial in.
  - No traffic management $\Rightarrow$ Unused bandwidth wasted.

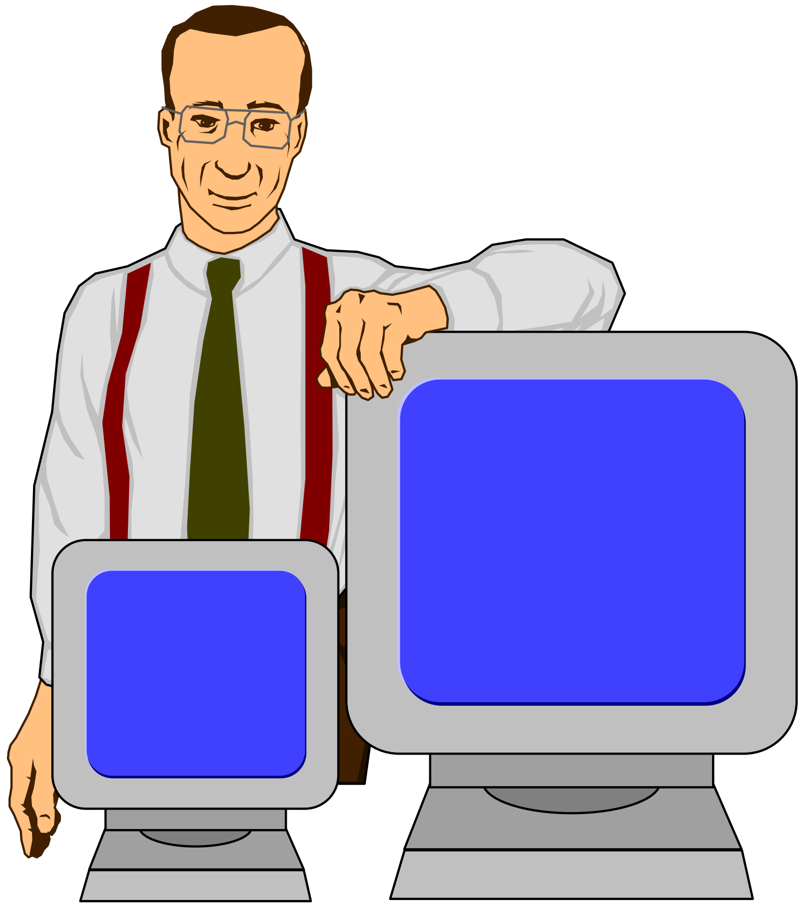
Who Can Benefit from ATM?

- Large enterprises with large WANs
  - Scalable: 1.5 to 622 Mbps
  - Multiple quality of services
  - Integration of voice, data
  - Standard
- Internet Service Providers
- Carriers
- Any one with a need for high-quality multimedia

Case Studies

- AGIS - Forth largest ISP. ISP's ISP.
  Offers three quality of services.
  Store and forward, Interactive, Guaranteed.
- Chrysler installed a 3000 node network in Detroit area
- McDonald has implemented an ATM backbone for 150 subnets
- World Health Organization is installing 2000-desktop ATM network in Geneva.
- Home Depot, Texaco, Amoco, Fuji Bank of Japan, Malaysian Bank, Royal Bank of Canada, Florida Power and Light, Allegheny Hospital, ...

Dime Sale



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

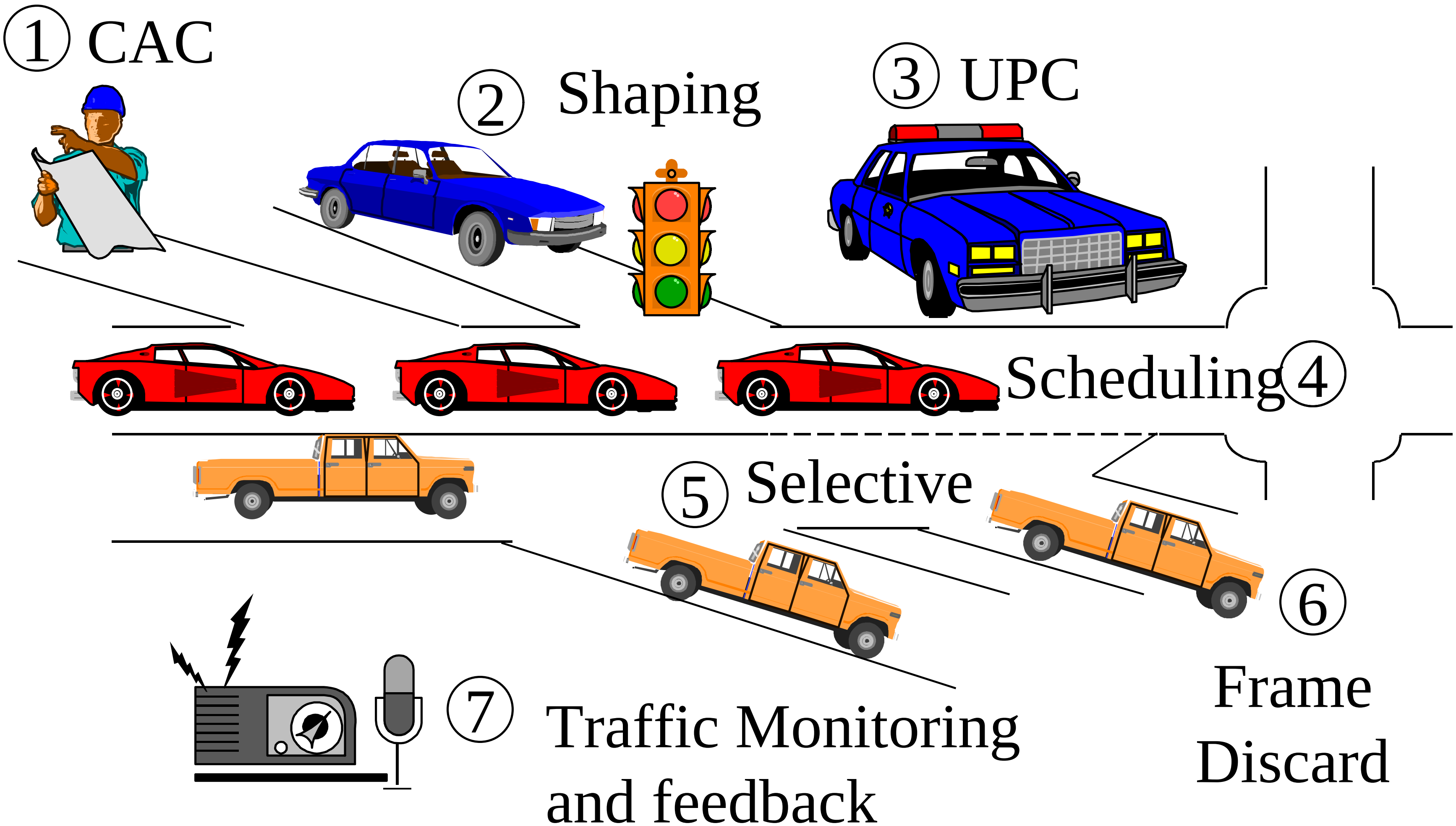
Future

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....

Traffic Management on the Info Superhighway

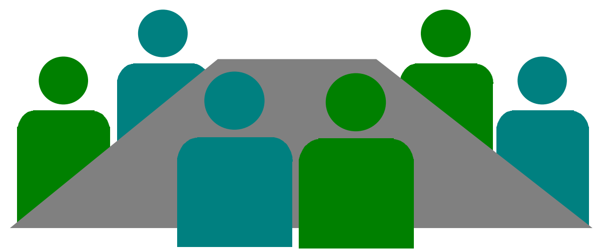


Traffic Mgmt Functions

- 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.

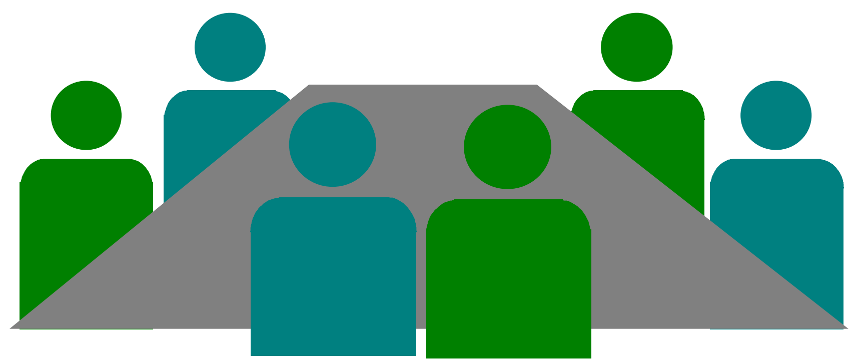
Service Categories

Standby



Guaranteed

Joy Riders

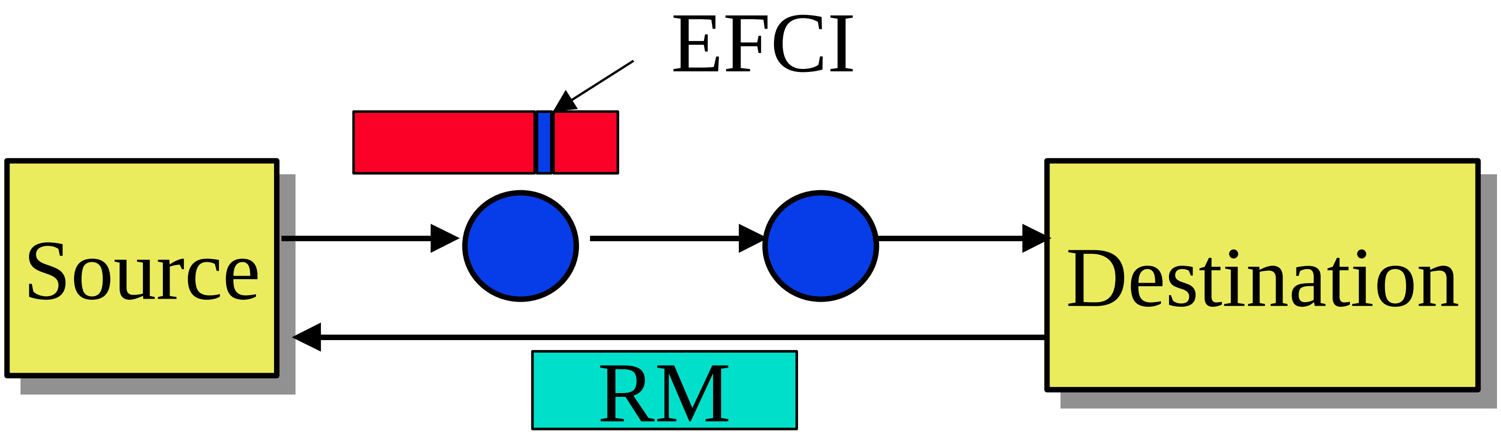


Confirmed

Service Categories

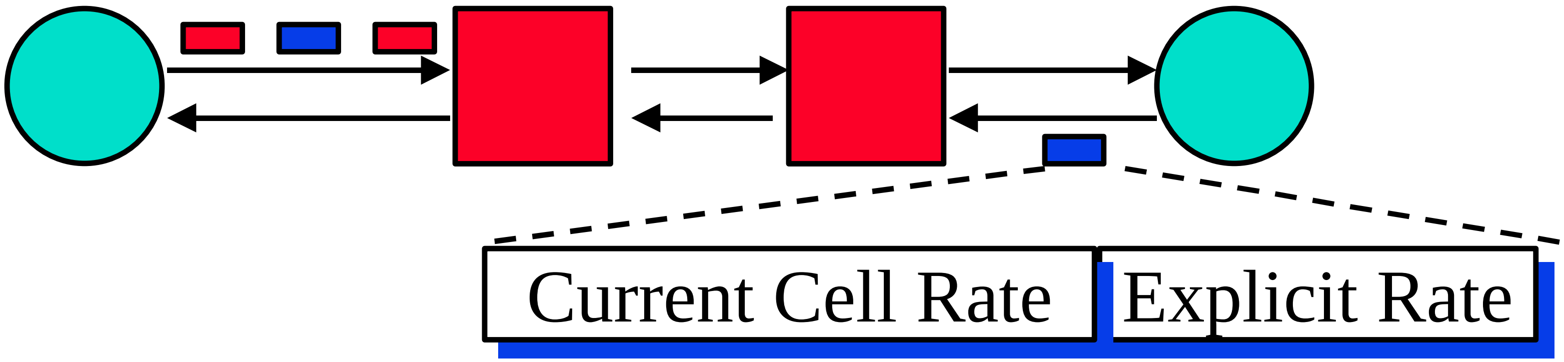
- ABR (Available bit rate):
  Source follows network feedback.
  Max throughput with minimum loss.
- UBR (Unspecified bit rate):
  User sends whenever it wants. No feedback. No guarantee. Cells may be dropped during congestion.
- CBR (Constant bit rate): User declares required rate. Throughput, delay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

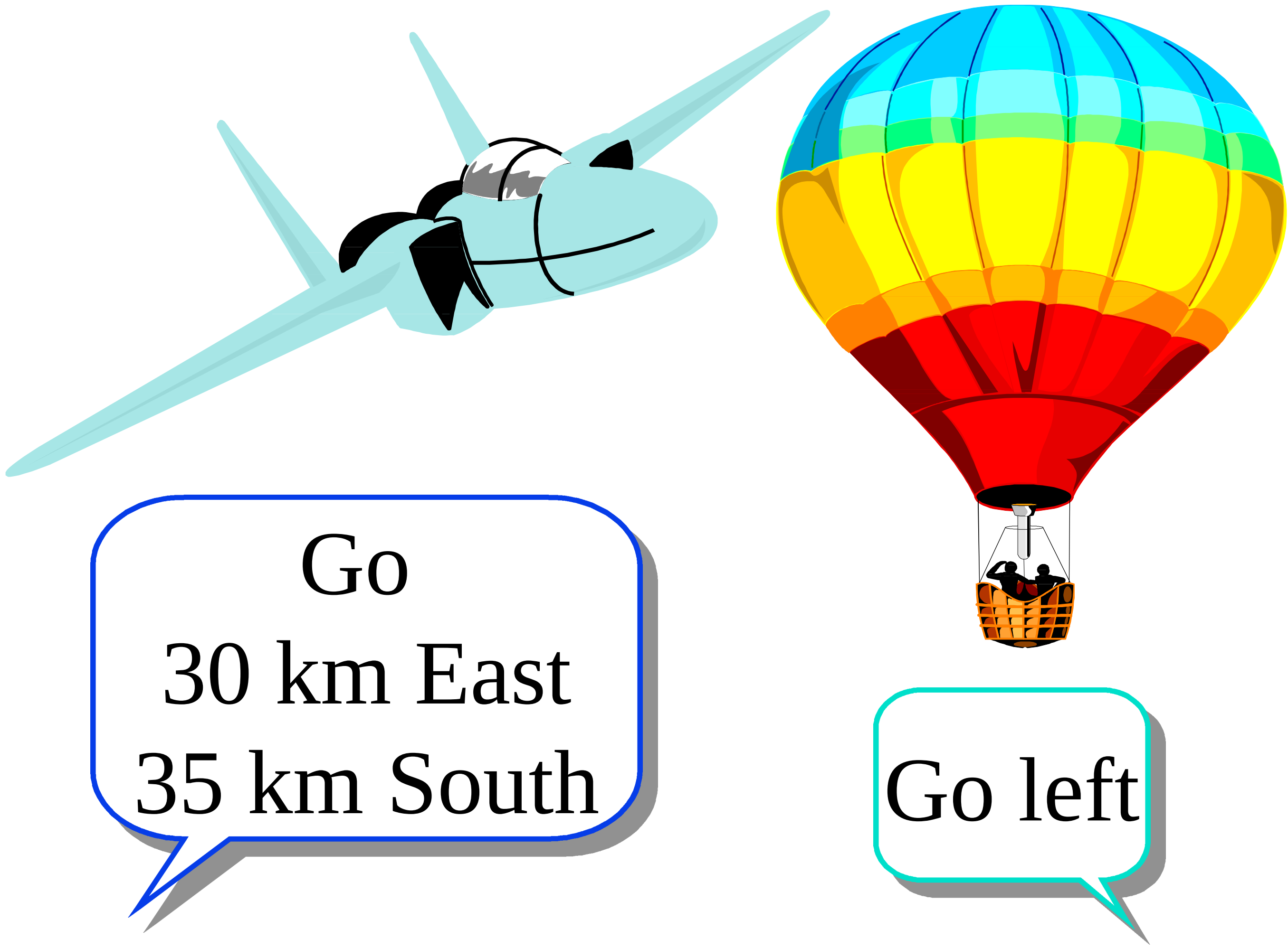


- Explicit forward congestion indicator (EFCI) set to 0 at source
- Congested switches set EFCI to 1
- Every *n*th cell, destination sends an resource management (RM) cell to the source indicating increase amount or decrease factor

The Explicit Rate Scheme



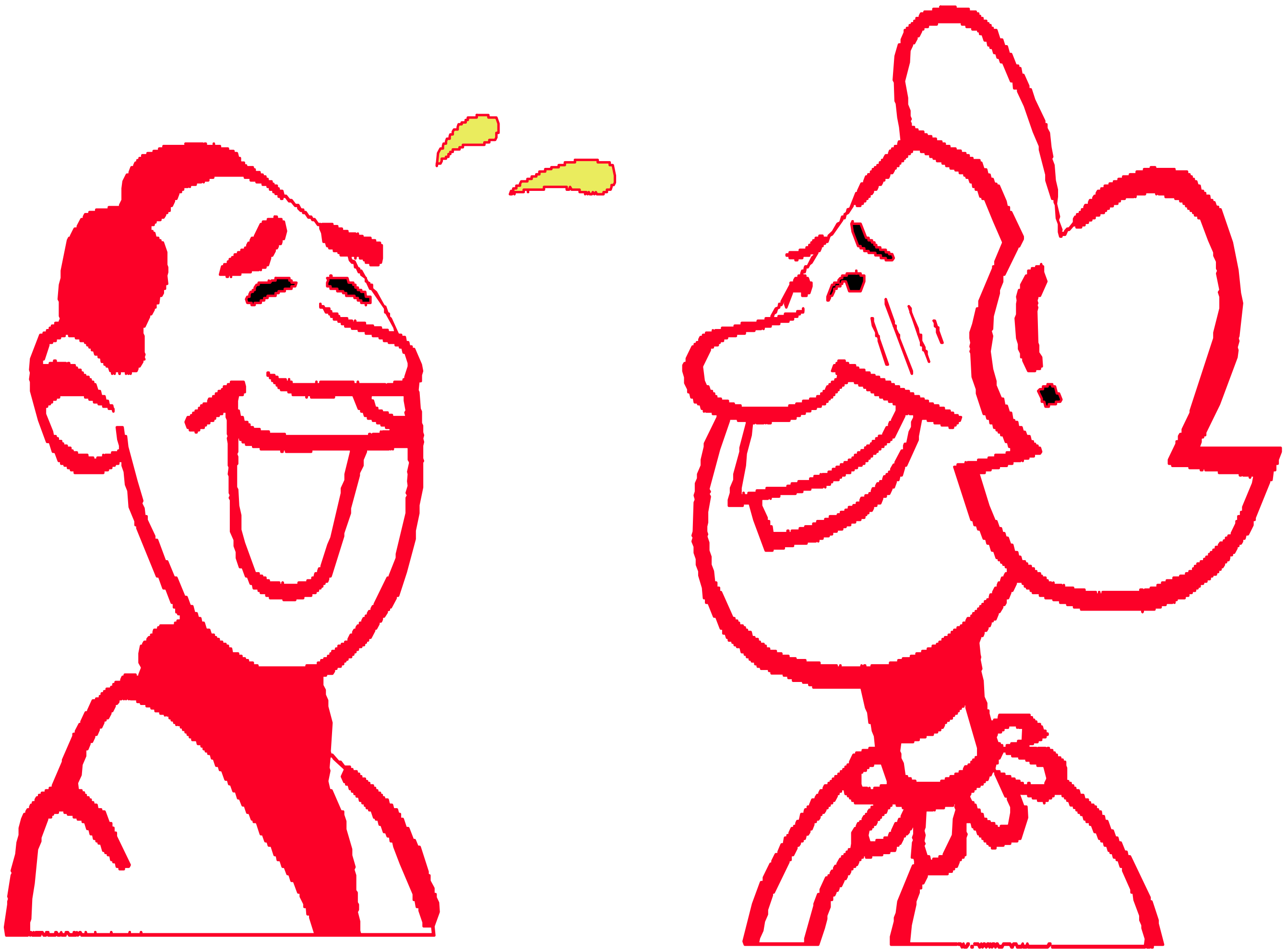
- Sources send one RM cell every n cells
- The RM cells contain "Explicit rate"
- Destination returns the RM cell to the source
- The switches adjust the rate down
- Source adjusts to the specified rate


Go
30 km East
35 km South
Go left

Why Explicit Rate Indication?

- Longer-distance networks
  $\Rightarrow$ Can't afford too many round-trips
  $\Rightarrow$ More information is better
- Rate-based control
  $\Rightarrow$ Queue length = ΔRate $\times$ ΔTime
  $\Rightarrow$ Time is more critical than with windows

Before



After

Networking: Failures vs Successes

- 1980: Broadband (vs baseband)
- 1981: PBX (vs Ethernet)
- 1984: ISDN (vs Modems)
- 1986: MAP/TOP (vs Ethernet)
- 1988: OSI (vs TCP/IP)
- 1991: DQDB
- 1992: XTP (vs TCP)
- 1994: CMIP (vs SNMP)

Requirements for Success

- Low Cost
- High Performance
- Killer Applications
- Timely completion
- Manageability
- Interoperability
- Coexistence with legacy LANs
  Existing infrastructure is more important than new technology

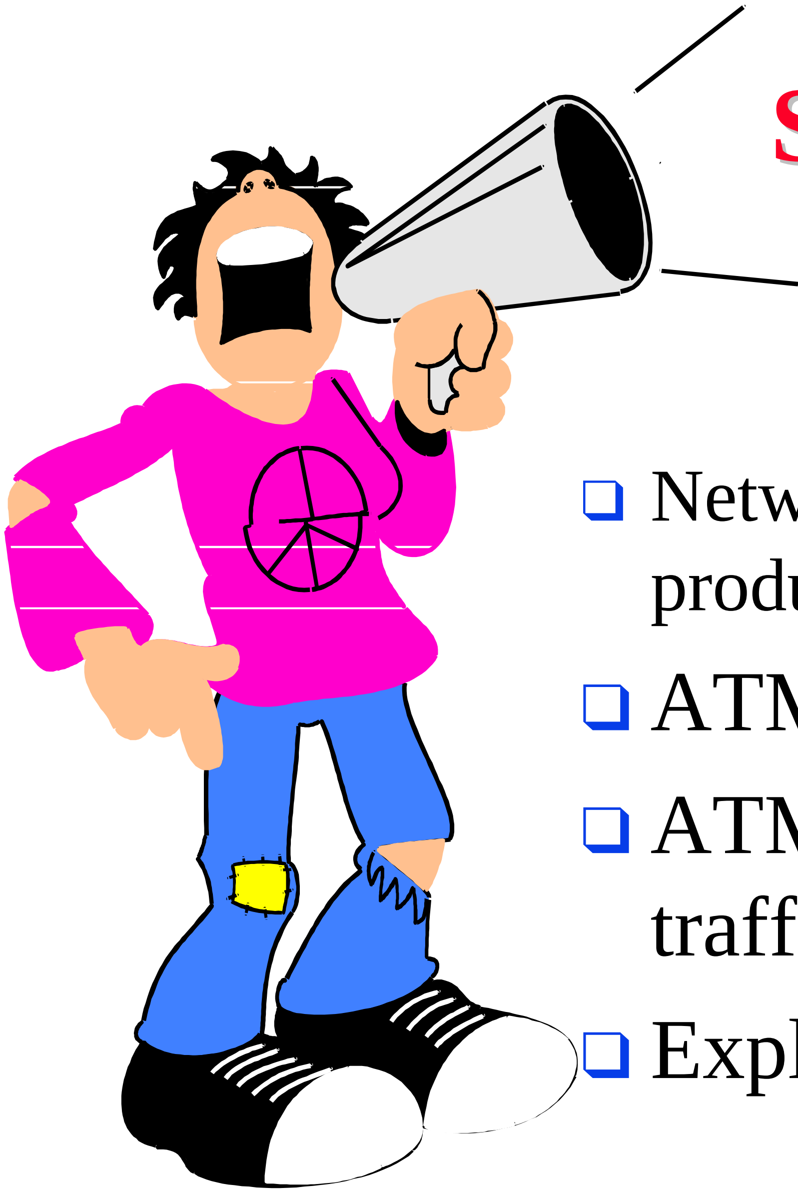
Key Challenge: Economy of Scale

- 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
    $\Rightarrow$ 155 Mbps line = \$540 k - \$720 k/year
- Tomorrow: 155 Mbps = \$1k/month+ \$28/G cells
  $\Rightarrow$ \$13k - \$45k/year

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!