Recent Trends in Networking Including ATM and Its Traffic Management and QoS

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Future

White House Astrologer

Joan Quigly

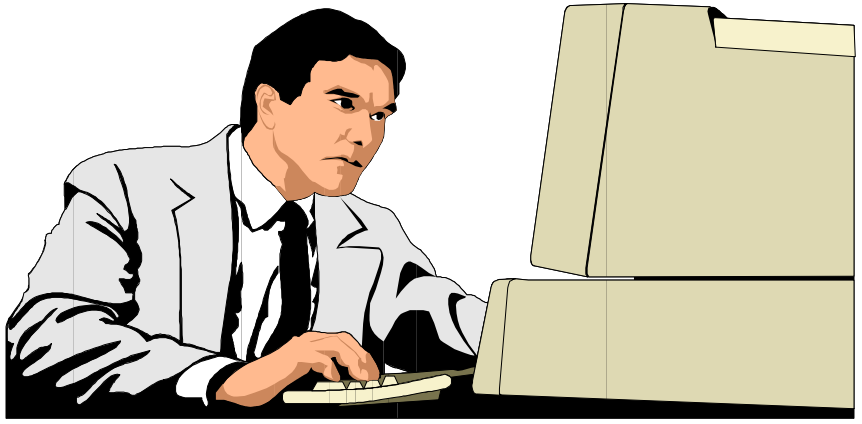
All I want you to tell me is what will be the networking technology in the year 1999.

- Networking and Telecommunications Trends
- Why ATM?
- Traffic Management in ATM: ABR Vs UBR
- Quality of Service in IP: Integrated services/RSVP/Differentiated Services/MPLS

Computing vs Communication

- 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.
- Network is the bottleneck. Productivity of people, companies and countries depends upon the speed of their network.

Social Impact of Networking

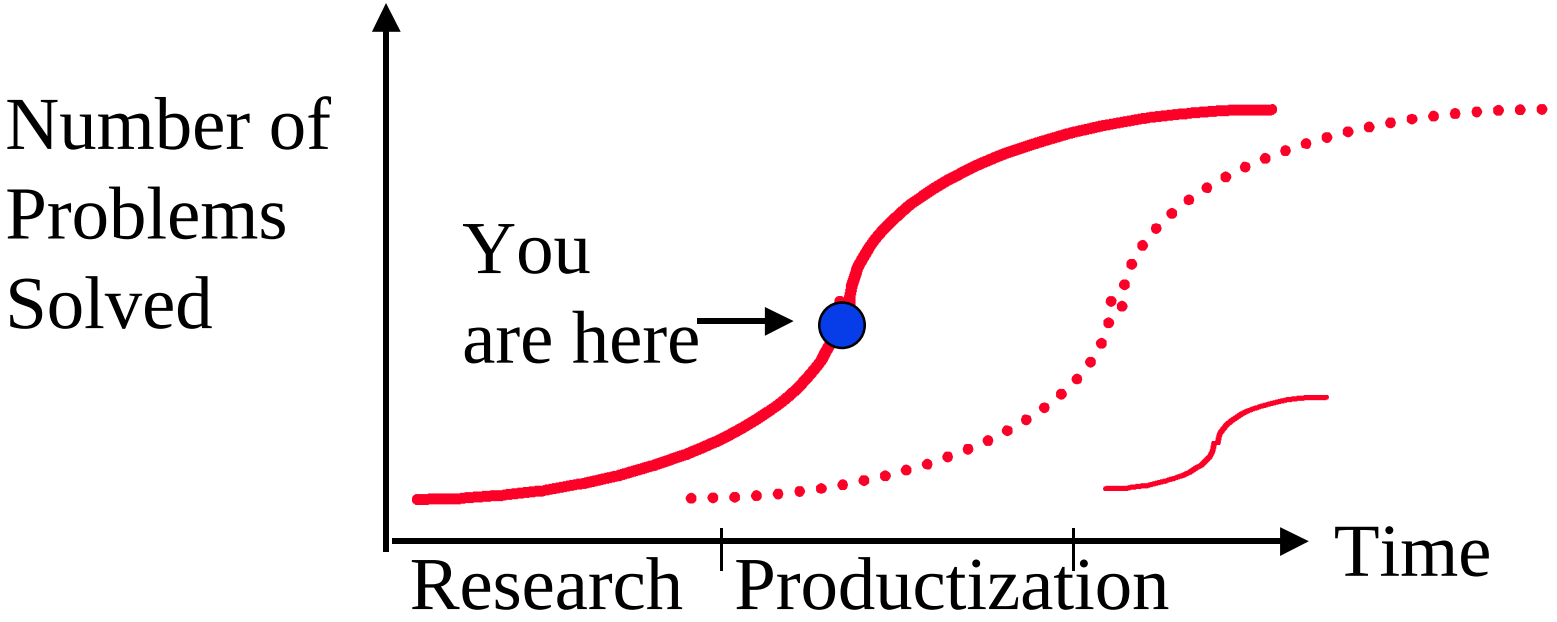


- No need to get out for
  - Office
  - Shopping
  - Entertainment
  - Education
- Virtual Schools
- Virtual Cash
- Virtual Workplace

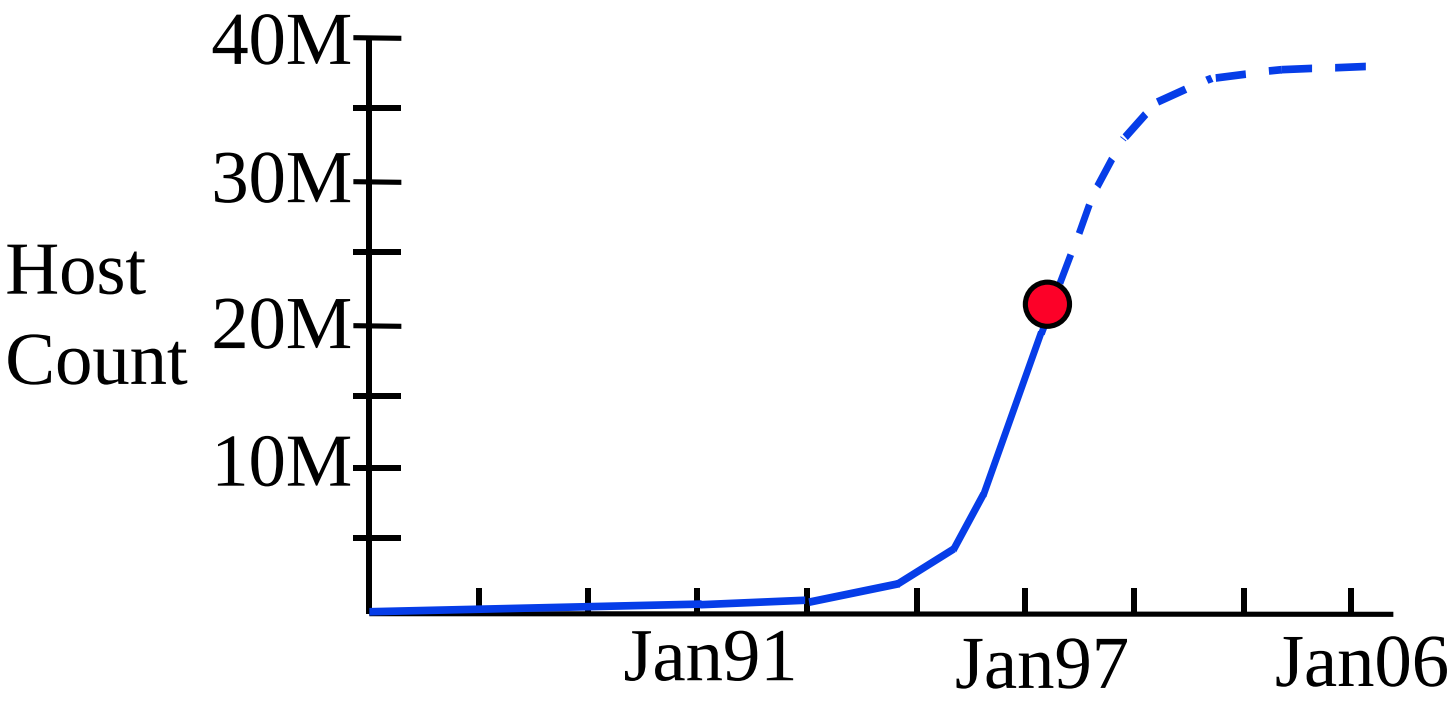
(55 Million US workers will work remotely by 2000)

Cave Persons of 2050

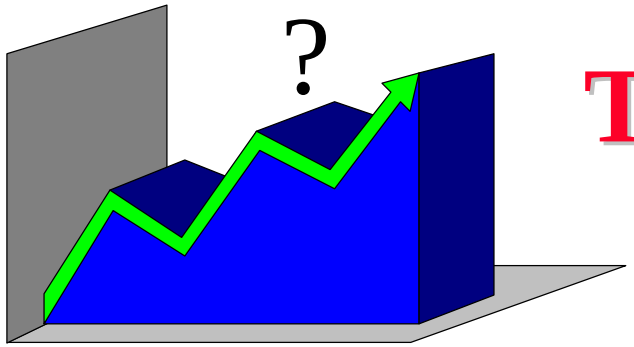
Life Cycles of Technologies



Internet Technology



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



Trend: Standards Based Networking

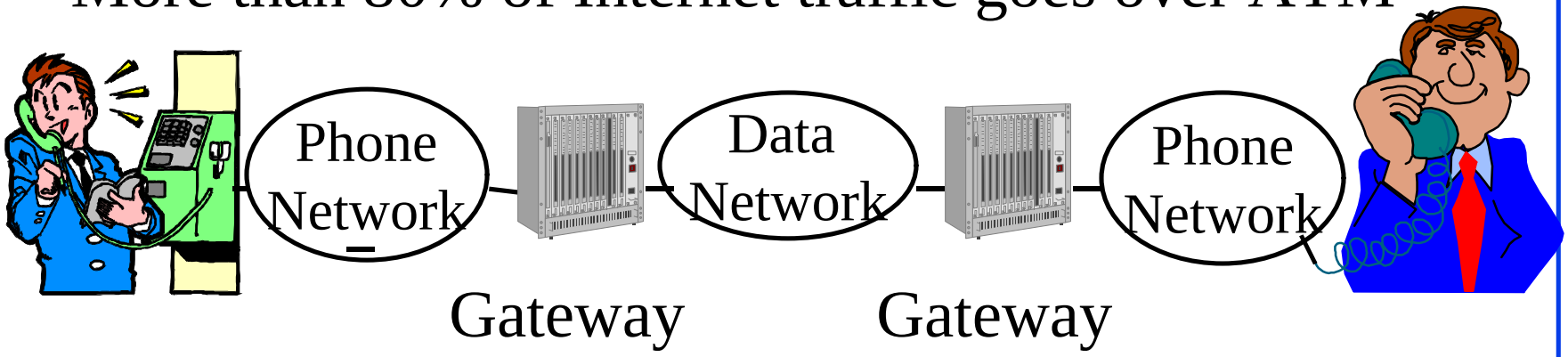
- Too much growth in one year
  ⇒ Long term = 1_2 year or 10_2 years at most
- Distance between research and products has narrowed
  ⇒ Collaboration between researchers and developers
  ⇒ Academics need to participate in industry consortia
- Standards based networking for reduced cost
  ⇒ Important to participate in standardization forums
  ATM Forum, Frame Relay Forum, ITU …
  Internet Engineering Task Force (IETF),
  Institute of Electrical and Electronic Engineers (IEEE)

Networking Trends

1. Inter-Planetary Networks ⇒ Distances are increasing
2. WDM OC-768 Networks = 39.8 Gb/s
   ⇒ Bandwidth is increasing
   ⇒ Large Bandwidth-Delay Product Networks
3. Copper is still in. Fiber is being postponed.
   6-27 Mbps on phone wire.
   1999: Gigabit Ethernet on UTP-5 w 200m net dia.
4. Routing to Switching. Distinction is disappearing

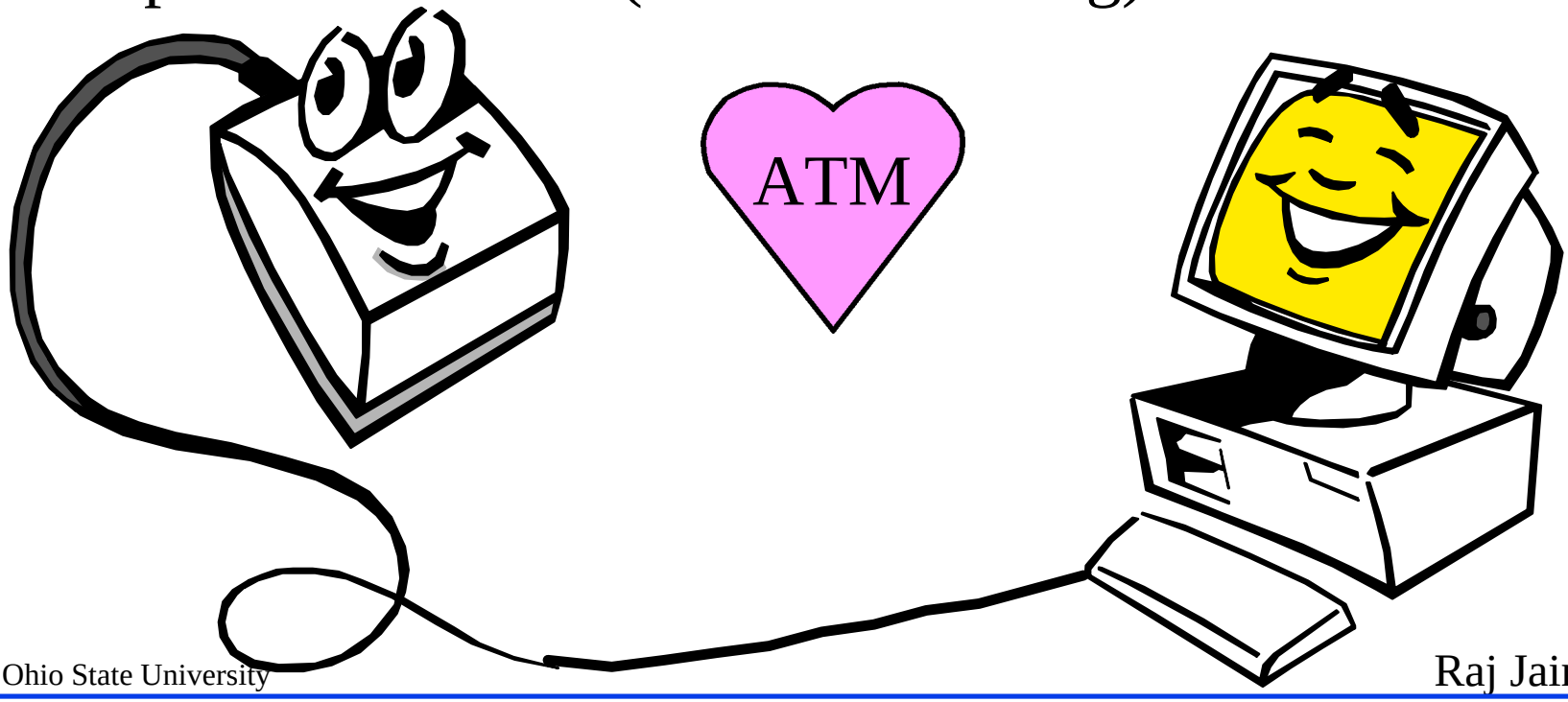
Telecommunication Trends

1. Voice traffic is growing linearly
   Data traffic is growing exponentially
   Bandwidth requirements are doubling every 4 months
   Data Volume > Voice Volume (1998)
2. Voice over data ⇒ Quality of Service issues
3. Carriers are converting to ATM
   More than 80% of Internet traffic goes over ATM

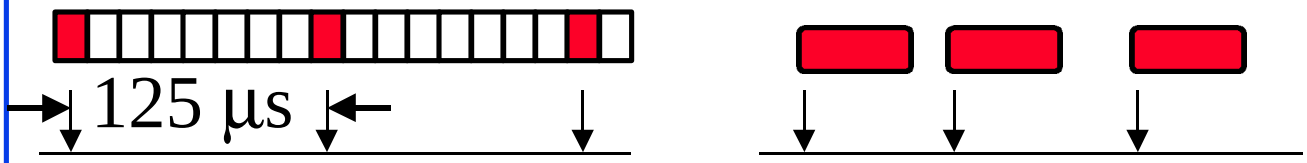


ATM

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



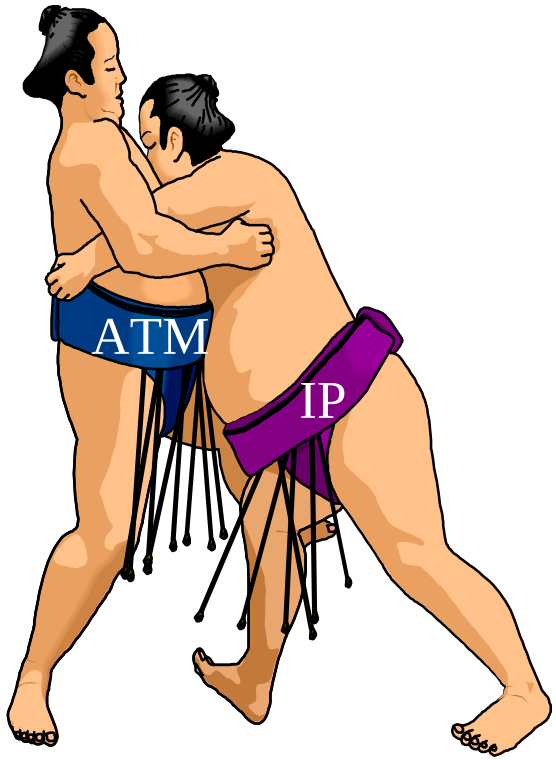
ATM vs Phone Networks



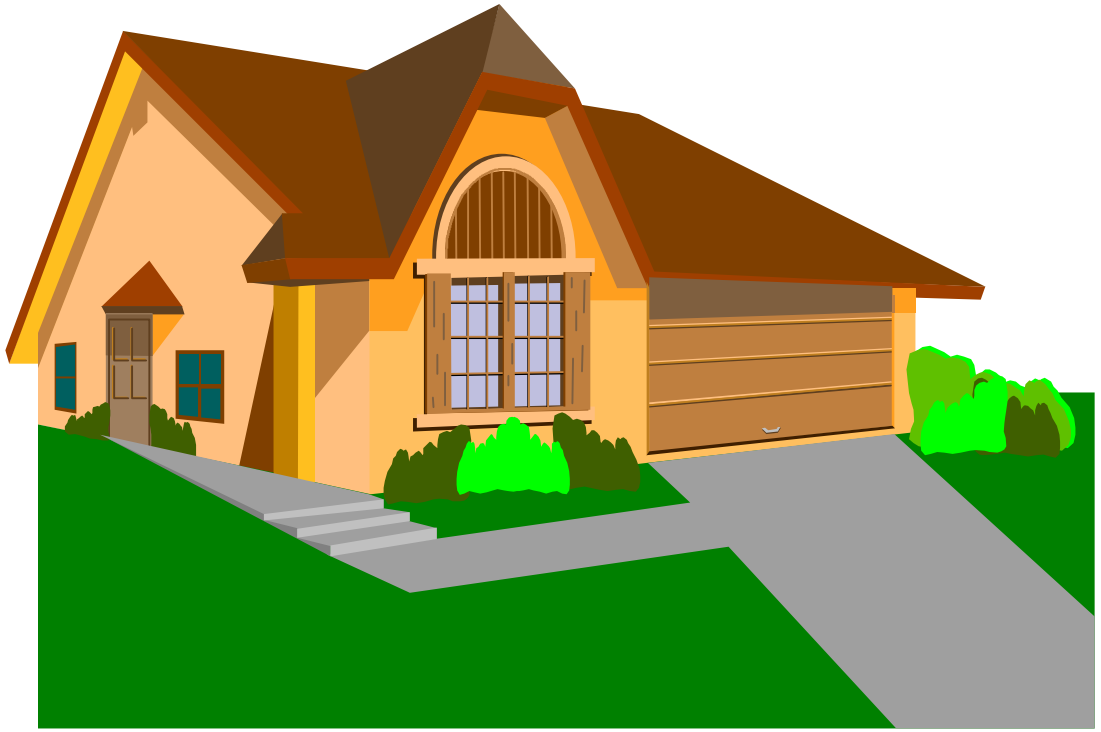
- Current phone networks are synchronous (periodic).
  ATM = Asynchronous Transfer Mode
- Phone networks use circuit switching.
  ATM networks use "Packet" Switching
- In phone networks, all rates are multiple of 8 kbps.
  With ATM service, you can get any rate.
  You can vary your rate with time.
-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

ATM vs IP: Key Distinctions

1. Traffic Management:
   Explicit Rate vs Loss based
2. Signaling: Coming to IP in the form of RSVP
3. QoS: PNNI routing,
   Service categories.
   Integrated/Differentiated services
4. Switching: Coming to IP as MPLS
5. Cells: Fixed size or small size is not important



Old House vs New House

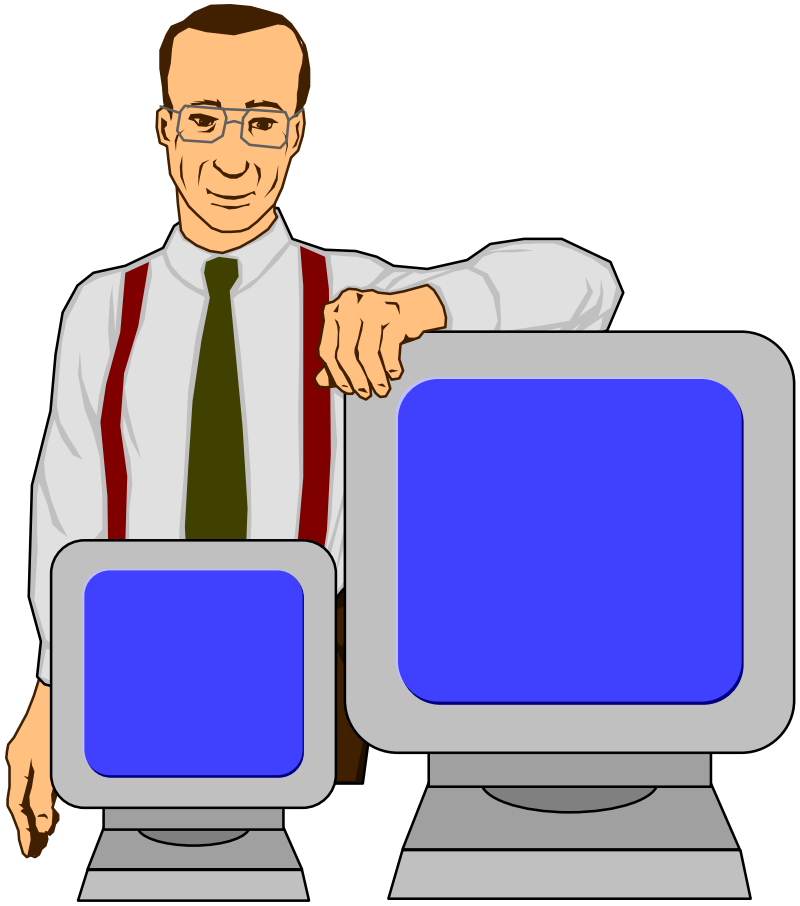


- New needs:

  Solution 1: Fix the old house (cheaper initially)

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

Dime Sale



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

Future

Year

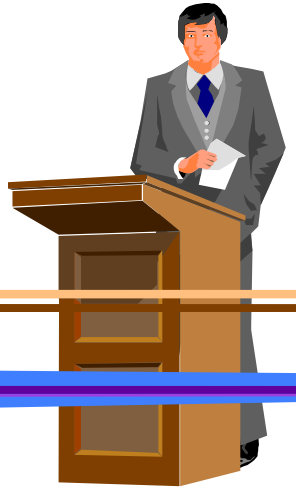
1980

In 1990, the memory will be so cheap that you will not have to worry about paging, swapping, virtual memory, memory hierarchy, and....

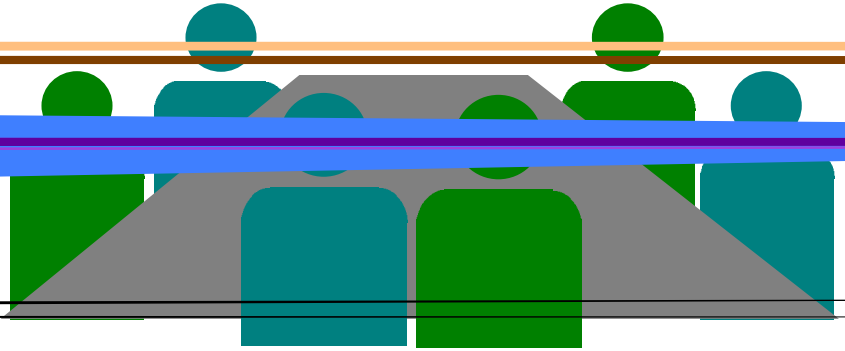
Service Categories

Standby

Guaranteed



Joy Riders

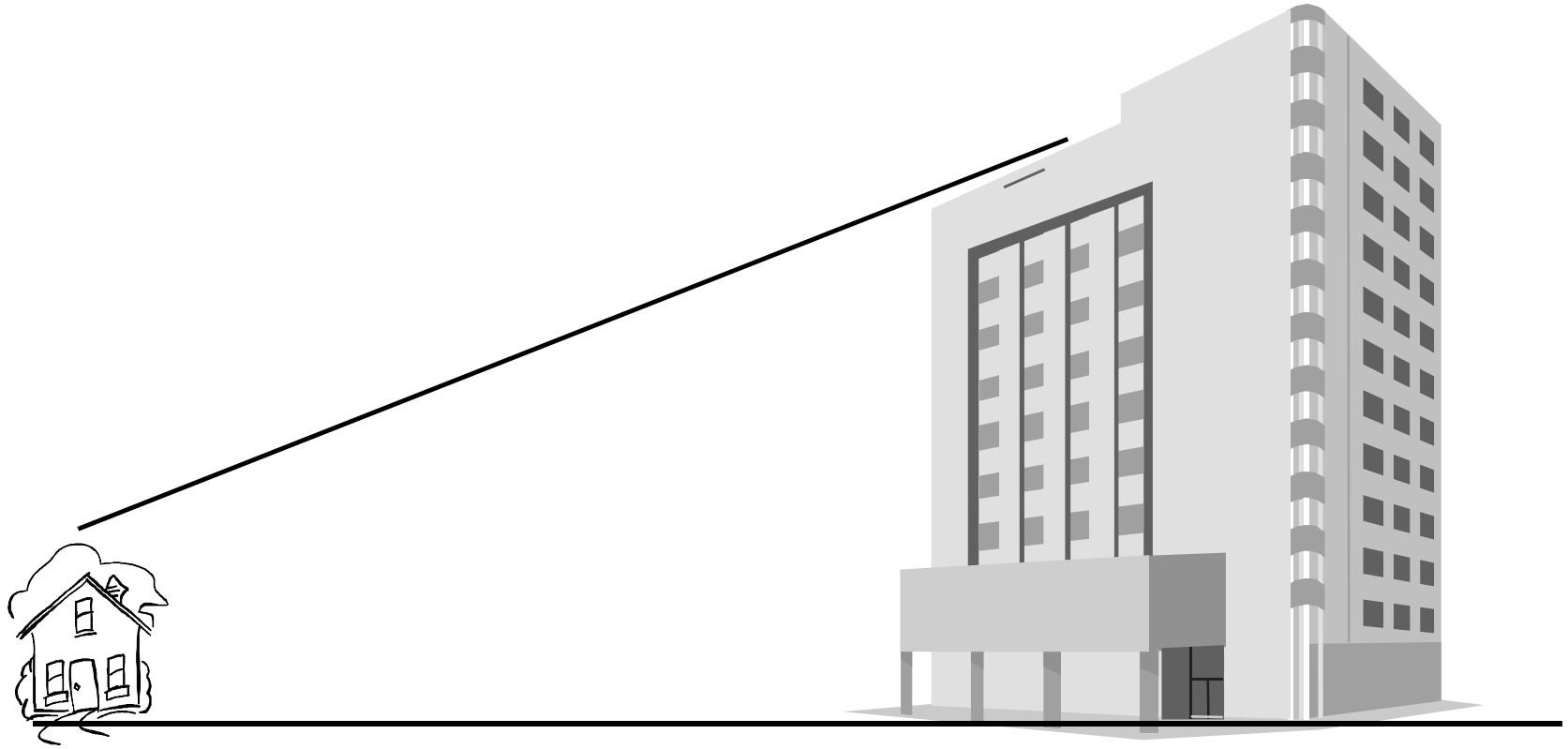


Confirmed

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.

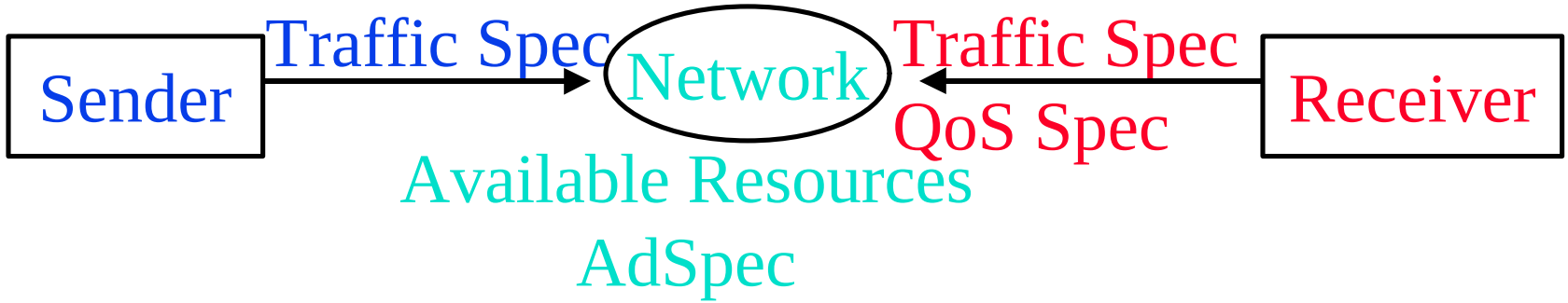
Quality of Service (QoS)



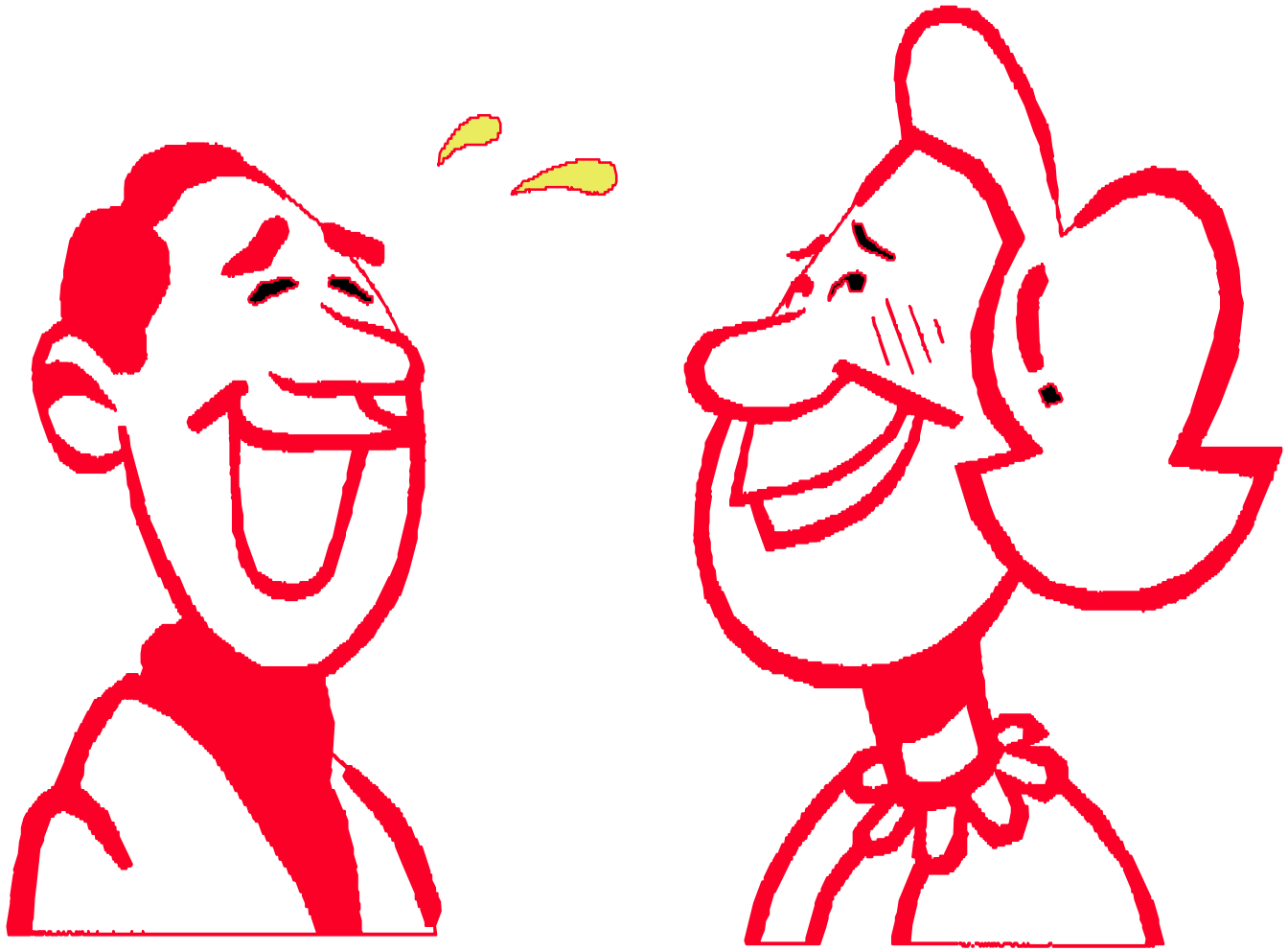
Too much too soon

Integrated Services and RSVP

- Best Effort Service: Like UBR.
- Controlled-Load Service: Performance as good as in an unloaded datagram network. No quantitative assurances. Like nrt-VBR or UBR w MCR
- Guaranteed Service: Like CBR or rt-VBR
  - Firm bound on data throughput and delay.
  - Is not always implementable, e.g., Shared Ethernet.
- Resource ReSerVation Protocol: Signaling protocol



Before

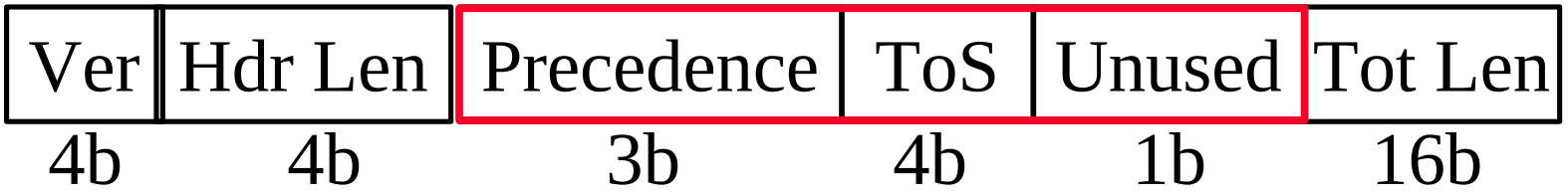


After

Problems with RSVP and Integrated Services

- Complexity: Packet classification, Scheduling
- Scalable in number of receivers per flow but
  Per-Flow State: O(n) $\Rightarrow$ Not scalable with # of flows.
  Number of flows in the backbone may be large.
  $\Rightarrow$ Suitable for small private networks
- Need a concept of "Virtual Paths" or aggregated flow groups for the backbone
- Need policy controls: Who can make reservations? Support for accounting and security.
- RSVP does not have negotiation and backtracking

Differentiated Services

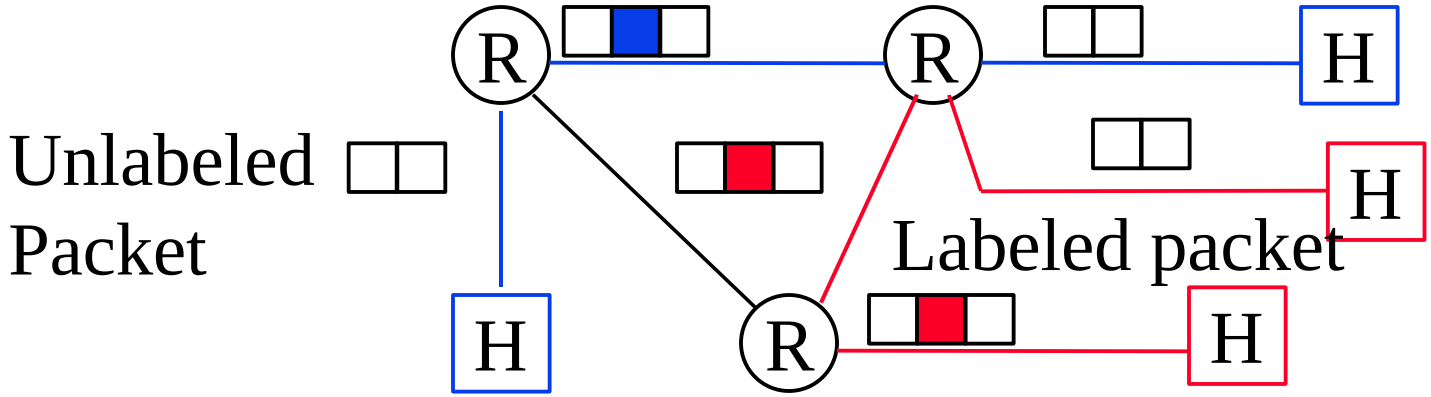


- IPv4: 3-bit precedence + 4-bit ToS
- Many vendors use IP precedence bits but the service varies ⇒ Need a standard ⇒ Differentiated Services
- DS working group formed February 1998
- Charter: Define ds byte (IPv4 ToS field)
- Per-Hop Behavior: Externally Observable Forwarding Behavior, e.g., x% of link bandwidth, or priority

Problems with DiffServ

- End-to-end ≠ Σ per-Hop
  Designing end-to-end services with weighted guarantees at individual hops is difficult.
- QoS is for the aggregate not micro-flows.
  Large number of short flows are better handled by aggregates.
  - Long/high flows (voice and video sessions) need per-flow guarantees.
- All IETF approaches are open loop control ⇒ Drop.
  Closed loop control ⇒ Wait at source
  Data prefers waiting ⇒ Feedback

Multiprotocol Label Switching

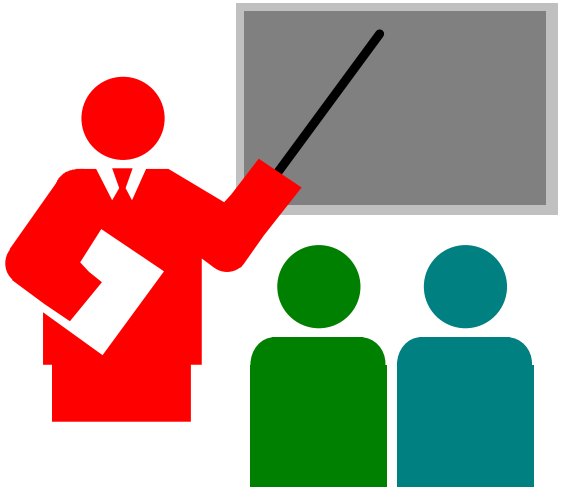


- Entry "label switch router (LSR)" attaches a label to the packet based on the route
- Other LSRs switch packets based on labels.
  Do not need to look inside ⇒ Fast.
- Labels have local significance
  ⇒ Different label at each hop (similar to VC #)
- Exit LSR strips off the label

Traffic Engineering Using MPLS

- Traffic Engineering = Performance Optimization
  = Efficient resource allocation, Path splitting
  $\Rightarrow$ Maximum throughput, Min delay, min loss
  $\Rightarrow$ Quality of service
- In MPLS networks: "Traffic Trunks" = SVCs
  Traffic trunks are routable entities like VCs
- Multiple trunks can be used in parallel to the same egress.
- Each traffic trunk can have a set of associated characteristics, e.g., priority, preemption, policing, overbooking

Summary



- Networking is the key to productivity
- Traffic management distinguishes ATM from its competition
- MPLS is more promising than Integrated Services and Differentiated Services

References

- References on Networking History and Trends: http://www.cis.ohio-state.edu/~jain/refs/ref_trnd.htm
- References on QoS over IP: http://www.cis.ohio-state.edu/~jain/refs/ipqs_ref.htm
- A tutorial talk on "QoS in IP Networks," May 1998, http://www.cis.ohio-state.edu/~jain/talks/ipqos.htm
- A follow up talk on "IP End-to-end Quality of Service: Recent Solutions and Issues," December 1998, http://www.cis.ohio-state.edu/~jain/talks/ipqos2.htm