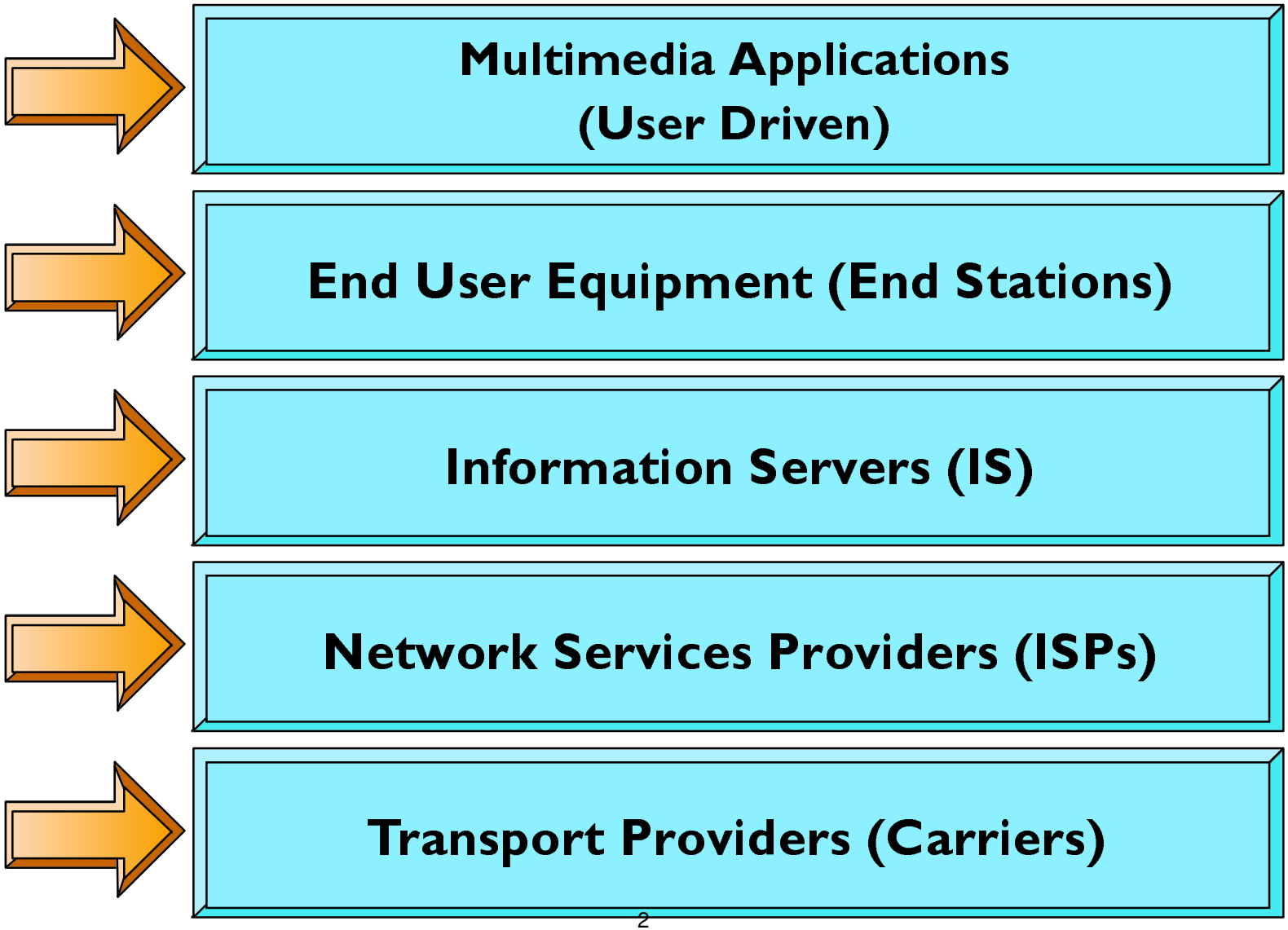
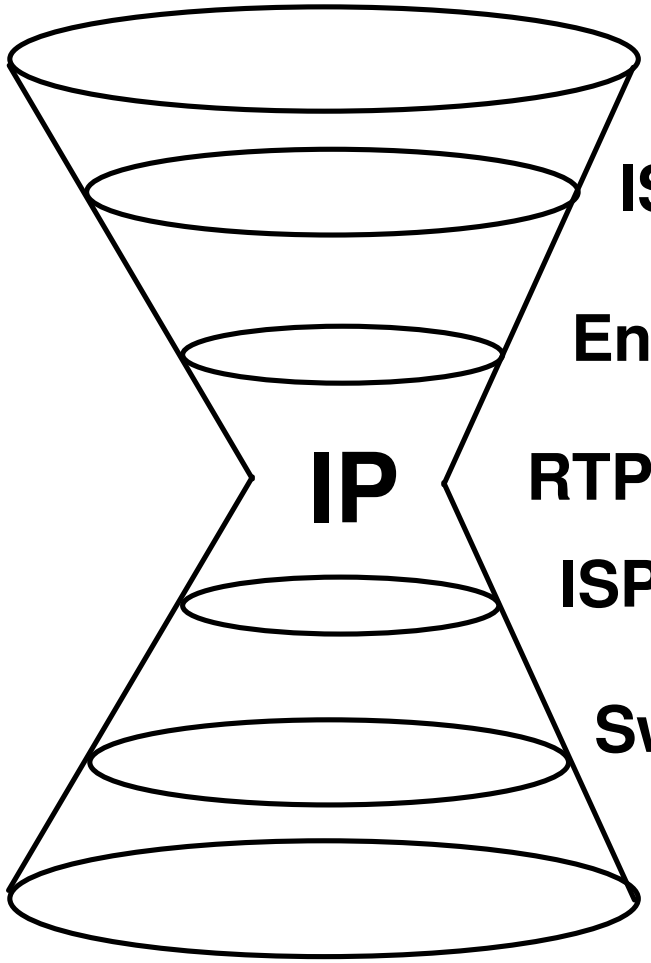
Multicast in Lossy Media

Andres Albanese, Ph.D.
http://www.icsi.berkeley.edu/~aa

Where should multicast be?



II. Why IP Layer?



Multimedia Applications

IS-Information Servers

End User Equipment

RTP / UDP-TCP / IP Multicast

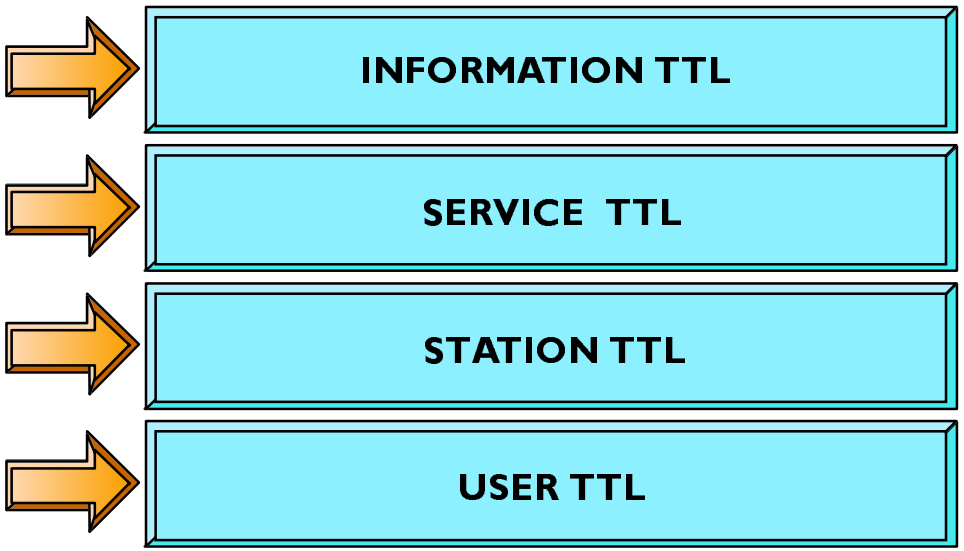
ISP - Network Service Provider

Switches

Trunks & Links

III. Why lossy?

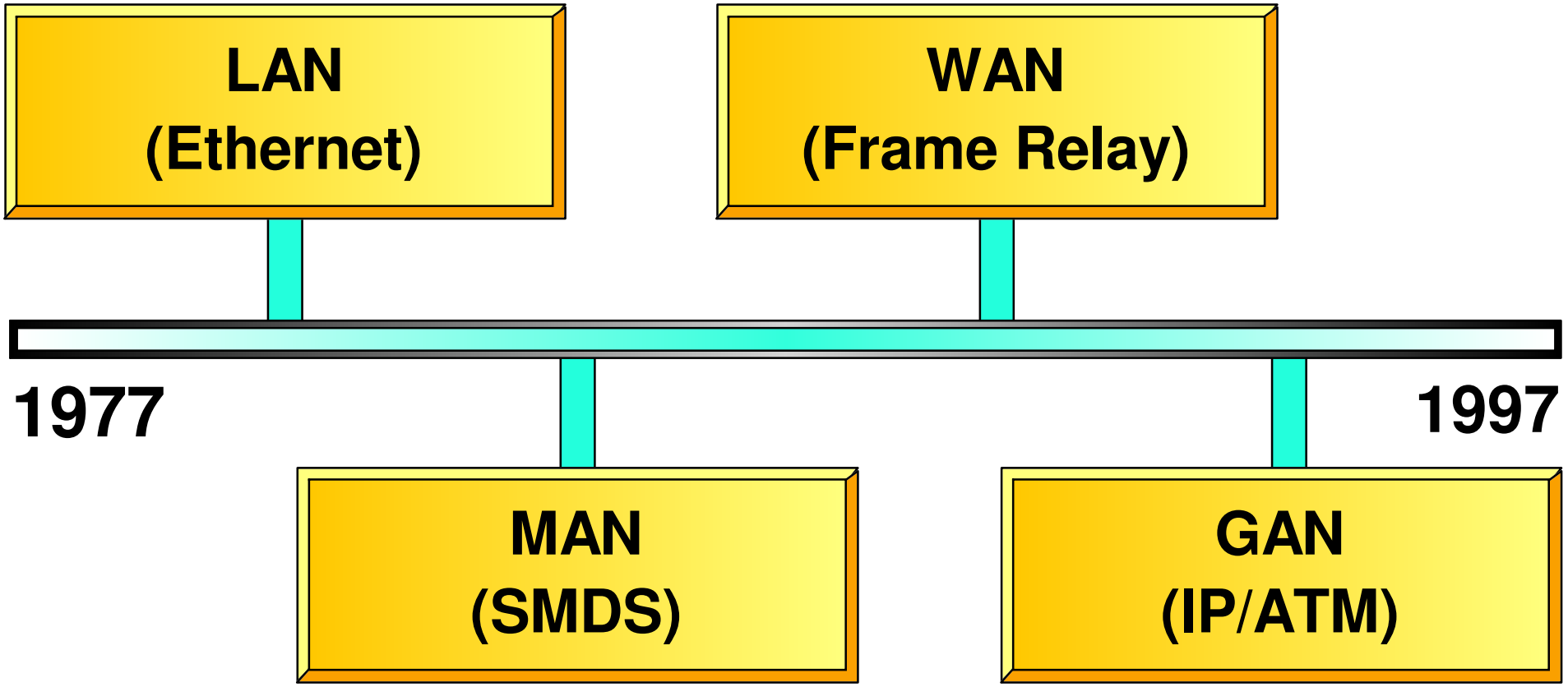
- User-to-user communication is redundant, it degrades gracefully, and involves different sensory systems depending on distance and context:
  - vision (text, graphics & video)
  - audio
  - smell
  - touch
  - taste



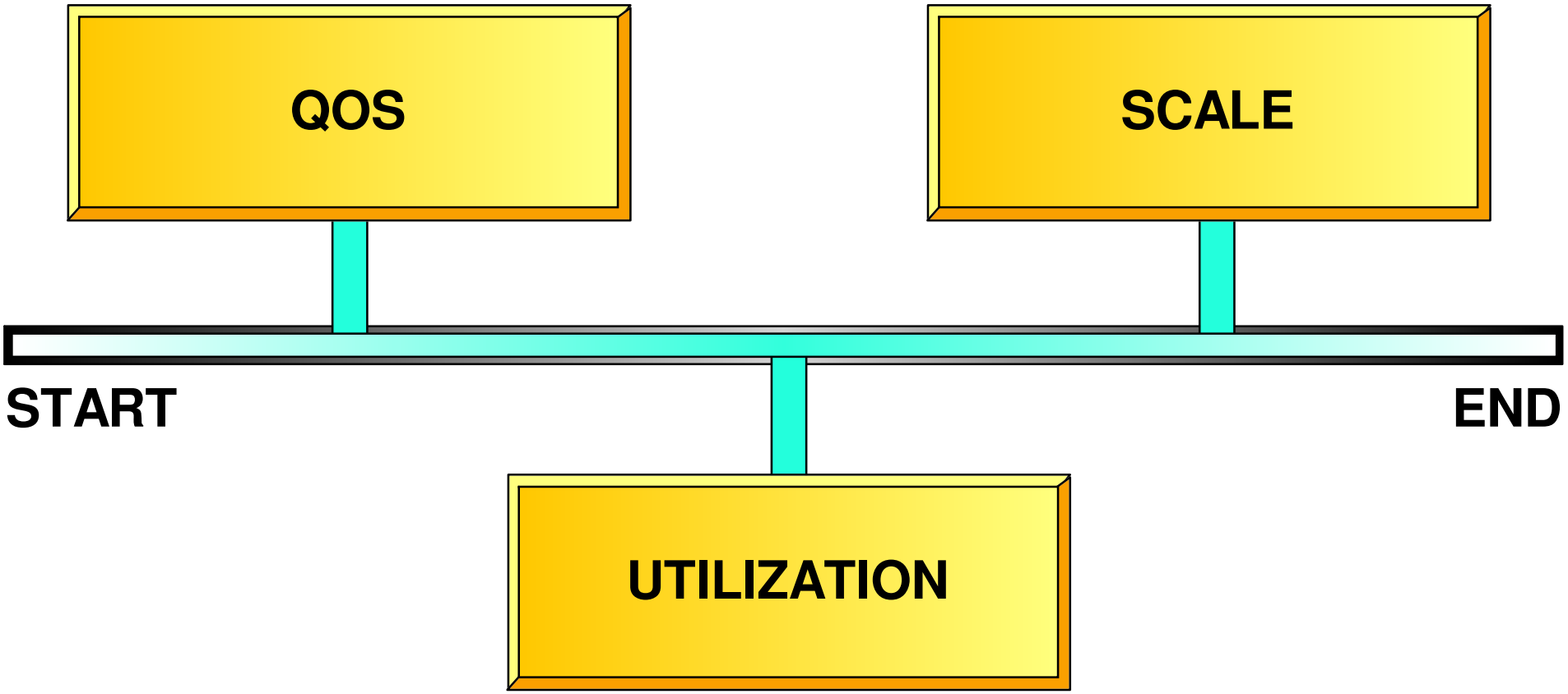
Protocol History

- Bit-rate driven protocols
  - CBR - Continuous Bit Rate
  - ABR - Adaptable Bit Rate
  - VBR - Variable Bit Rate
  - UBR - Unspecified Bit Rate
- IP driven protocols
  - IP-TCP
  - IP-UDP
  - RTP
  - Reservation Protocols (RSVP, ... , ...)

Distributed Systems



Network Trend



Global Area Networks: Technical Issues

- QOS
  - Delay (up to 40,000 km RT or 200 msec)
  - Loss (FEC, PET)
  - Jitter (Buffers, RTP)
- Utilization
  - Different time zones (VCR)
  - Large ratio of (round-trip-time/file-size/bit-rate)
- Scale
  - Multiple network domains
  - Heterogeneity

Key Issues

Key Issues	*Implications*
Delay (200 msec)	**Echo, no re-transmission**
Bandwidth (Kilo-Mega / sec)	**Congestion**
Heterogeneity	**Software solutions (CPU)**
Frequent Information	**Distributed storage (cache)**
Varying QOS	**Load distribution**
Multiple Network Domains	**No Global Management**

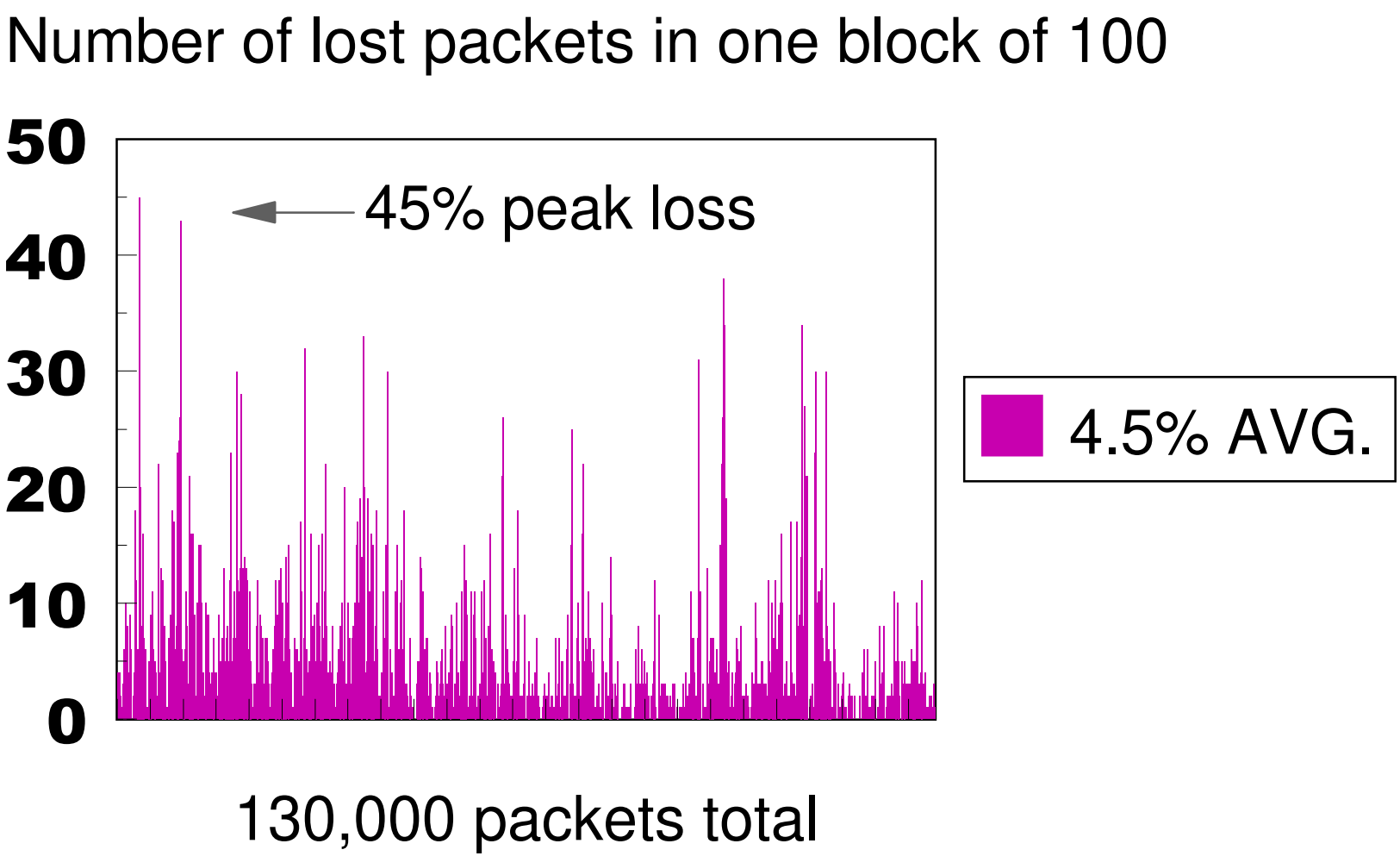
Potential Solutions

- IP multicast
- Forward Error Correction (FEC)
- Priority Encoding Transmission (PET):
  - with selective redundancy based on information priority and link QOS
  - spread in time and space
- Selective distributed storage (cache)
- Selective distributed processing (local processing)
- Collaborative Management Environment (CME)

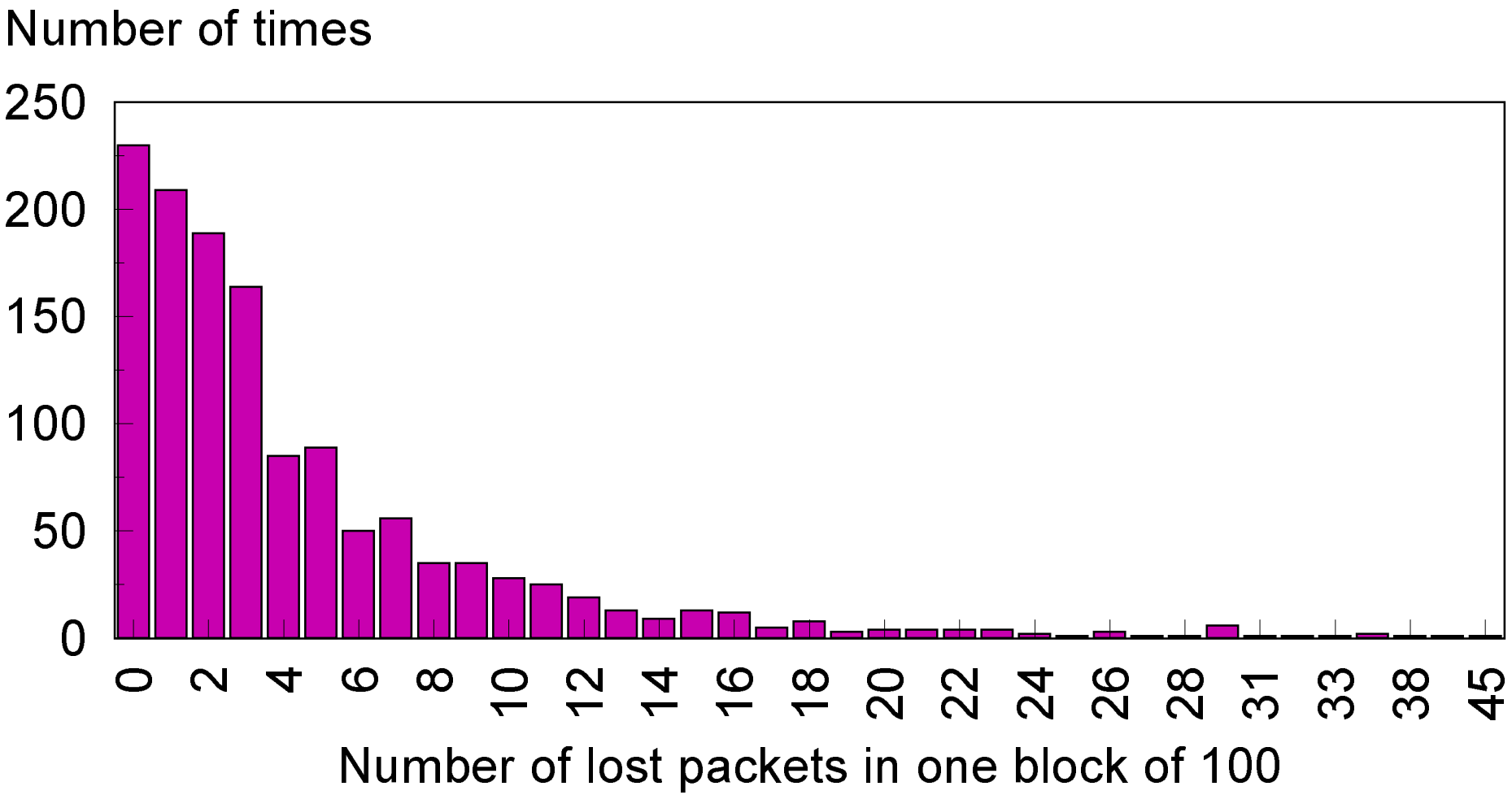
Recommended Strategy

- Evaluate media and increase utilization by:
  - Elimination of redundant information (Coding)
  - Using information push (Multicast)
  - Risk assessment of errors in packets and links
  - Enable selective redundancy over time and space (PET)
- Increase QOS by:
  - Application requiring a larger bit-rate

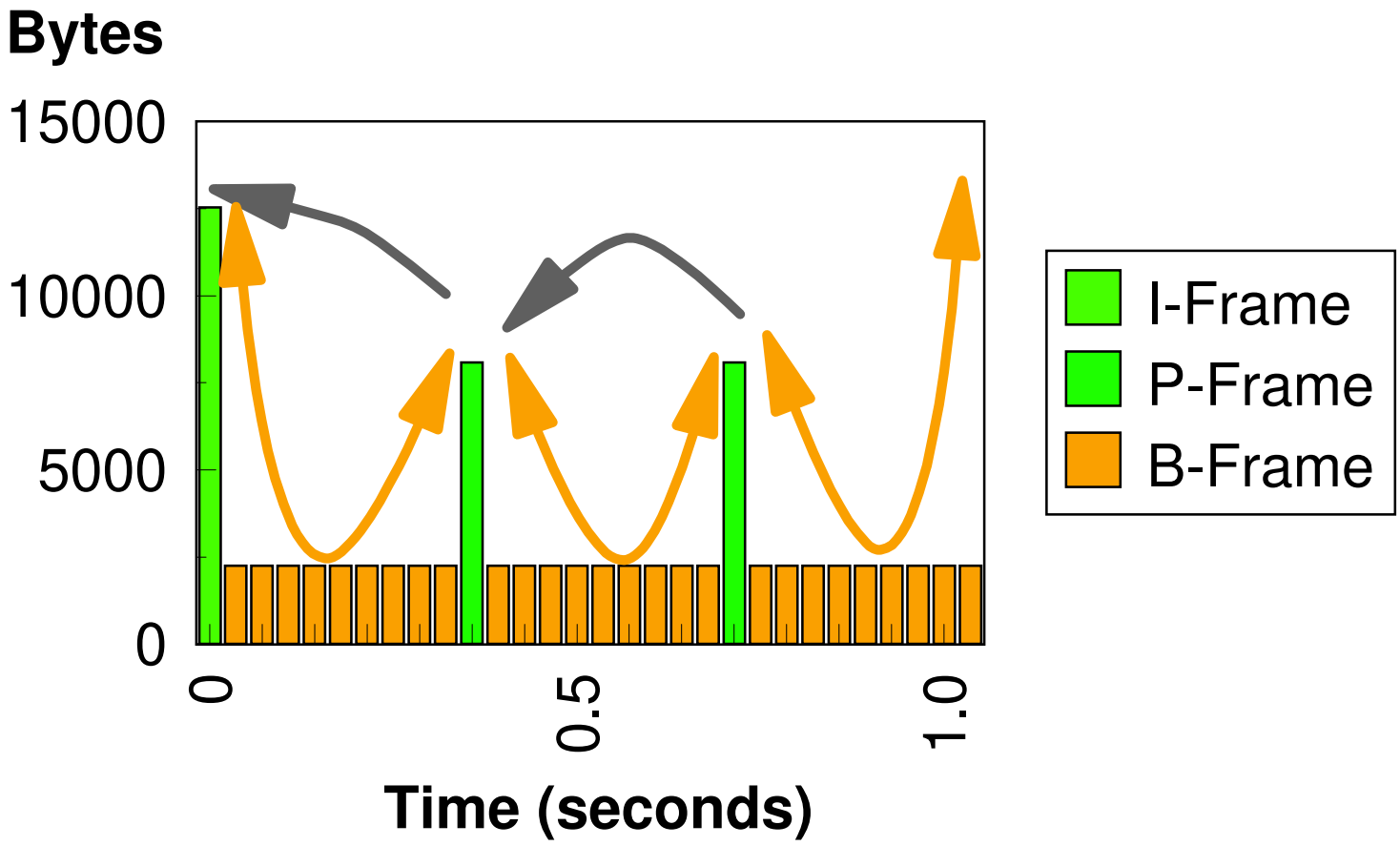
Packet Loss per 100 from Palo Alto to Berkeley



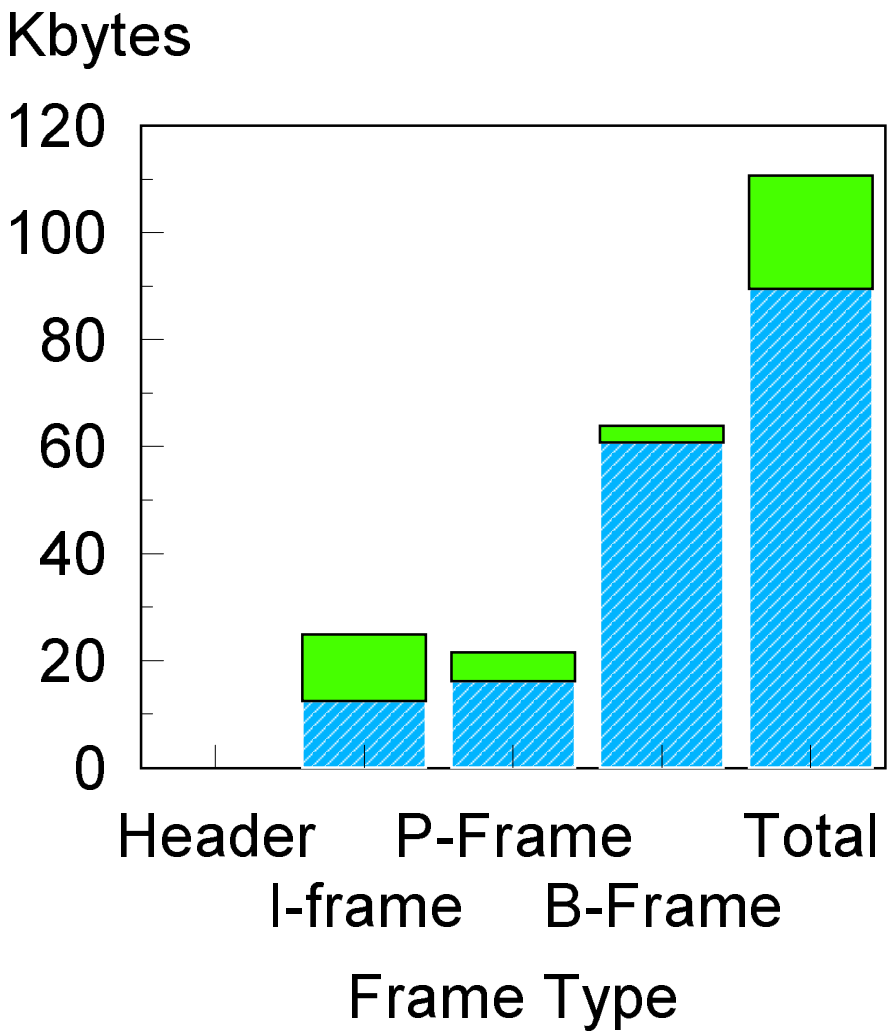
Packet Loss Histogram



Example:
MPEG Group of Pictures



MPEG Example: Byte Distribution by Frame Type



Overall Redundancy = 24%
Header 1000%, I Frame 100%
P-Frame = 33 % , B-Frame 5%

PET - Mechanism?

Message:

$$P_1(x) = A_1 + B_1.x \quad [\text{mod } 2^{16}+1]$$
$$P_2(x) = A_2 + B_2.x + C_2.x^2 \quad "$$
$$P_3(x) = A_3 + B_3.x + C_3.x^2 + D_3.x^3 \quad "$$

Packet_1:	0	$P_1(0)$	$P_2(0)$	$P_3(0)$
Packet_2:	1	$P_1(1)$	$P_2(1)$	$P_3(1)$
Packet_3:	2	$P_1(2)$	$P_2(2)$	$P_3(2)$
Packet_4:	3	$P_1(3)$	$P_2(3)$	$P_3(3)$
Packet_5:	4	$P_1(4)$	$P_2(4)$	$P_3(4)$

Summary

- Applications can be made robust to:
  - Tolerate network congestion, packet loss, and link failures
  - Provide graceful acquisition and degradation of information
- Information can be spread over time and space
- End-station processing work can be proportional to missing packets and quality requirement
- No reordering of packets is necessary
- The network can work as a communication utility

- http: //www.ICSI.Berkeley.edu/PET/

Next Steps

- Study:
  - Performance study
  - Cost analysis
  - Impact on equipment and services
- Research:
  - Faster PET algorithms
  - Packet spreading
  - Packet life
  - Reliable protocols