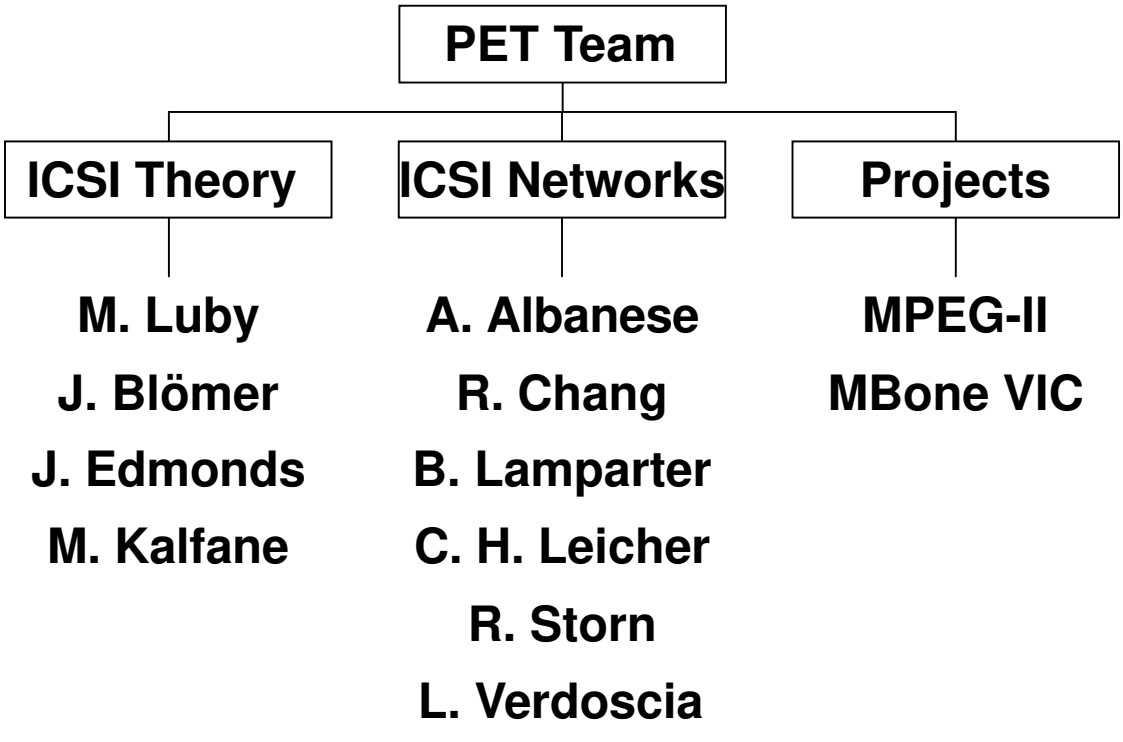
# Priority Encoding Transmission

**Andres Albanese**
**http://www.ICSI.berkeley.edu/~aa**

# Coping with Variable Loss in Bursty Packet Networks

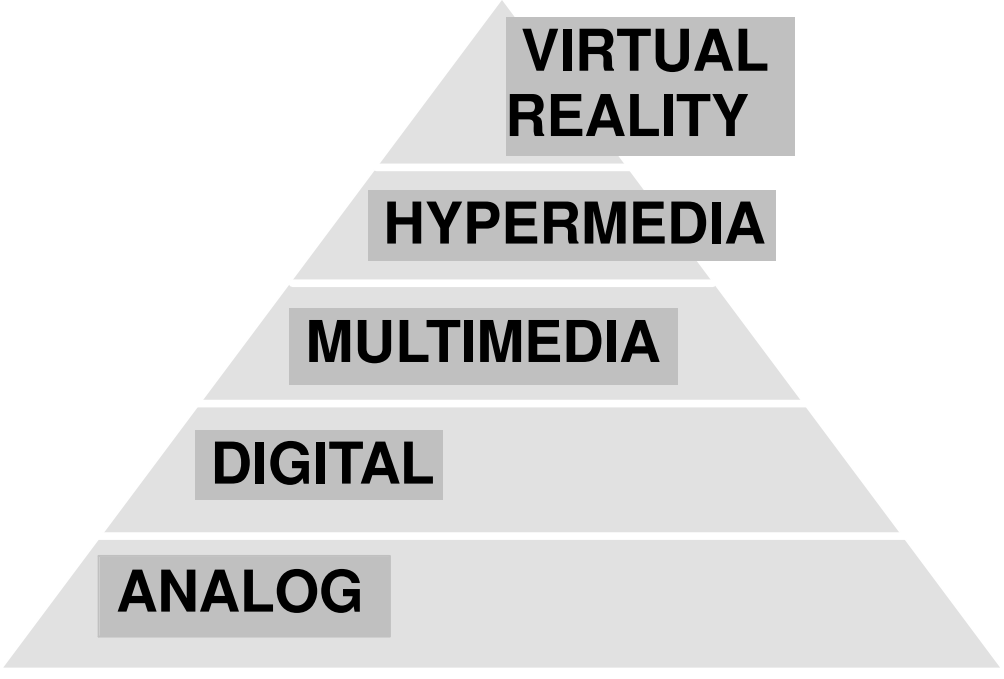


# Outline

- Network Evolution Trend
- Packet Loss
- Priority Encoding
- Feasibility Demonstration
- Conclusions

# Network Evolution Trend

# Information Media Evolution



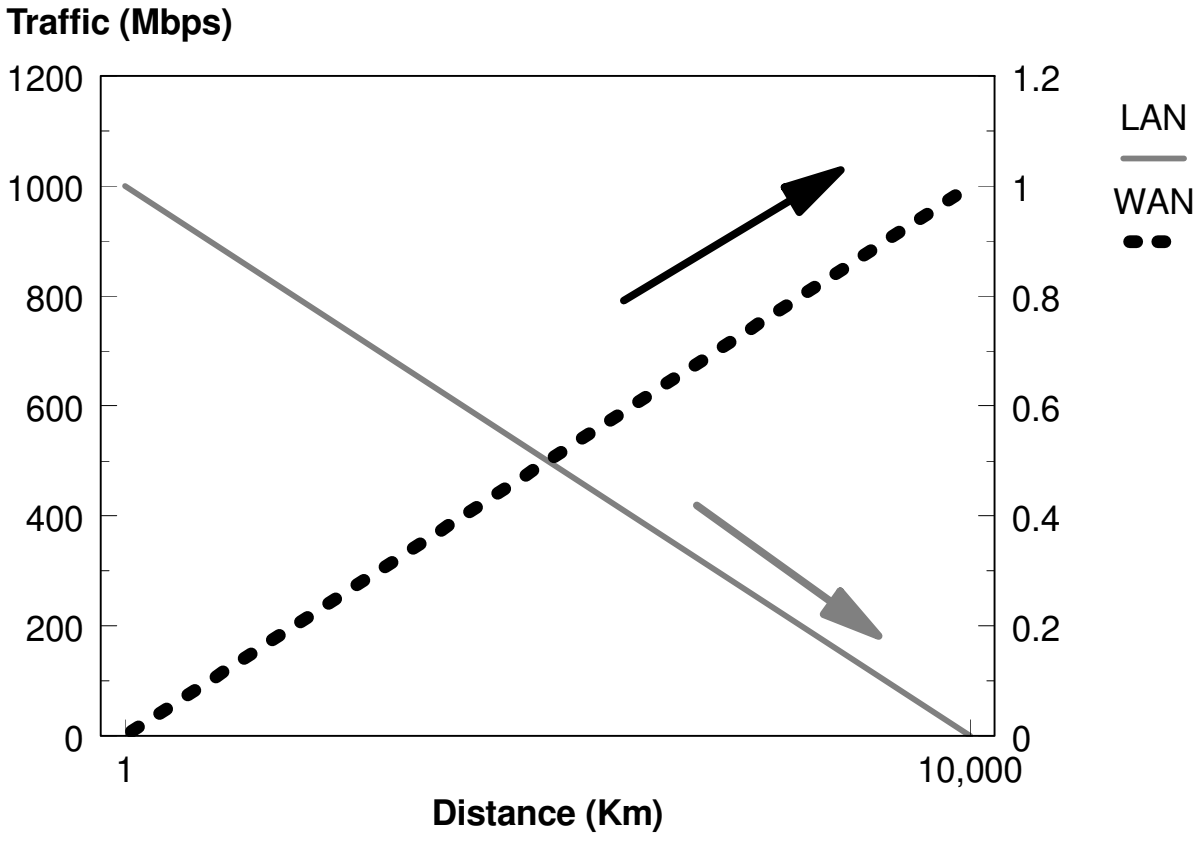
# Computer Mediated Communication Applications

- Virtual Communities
- Browsing
- Navigation
- Collaboration
- Distance learning
- Telemedicine
- Telecommuting
- Commerce

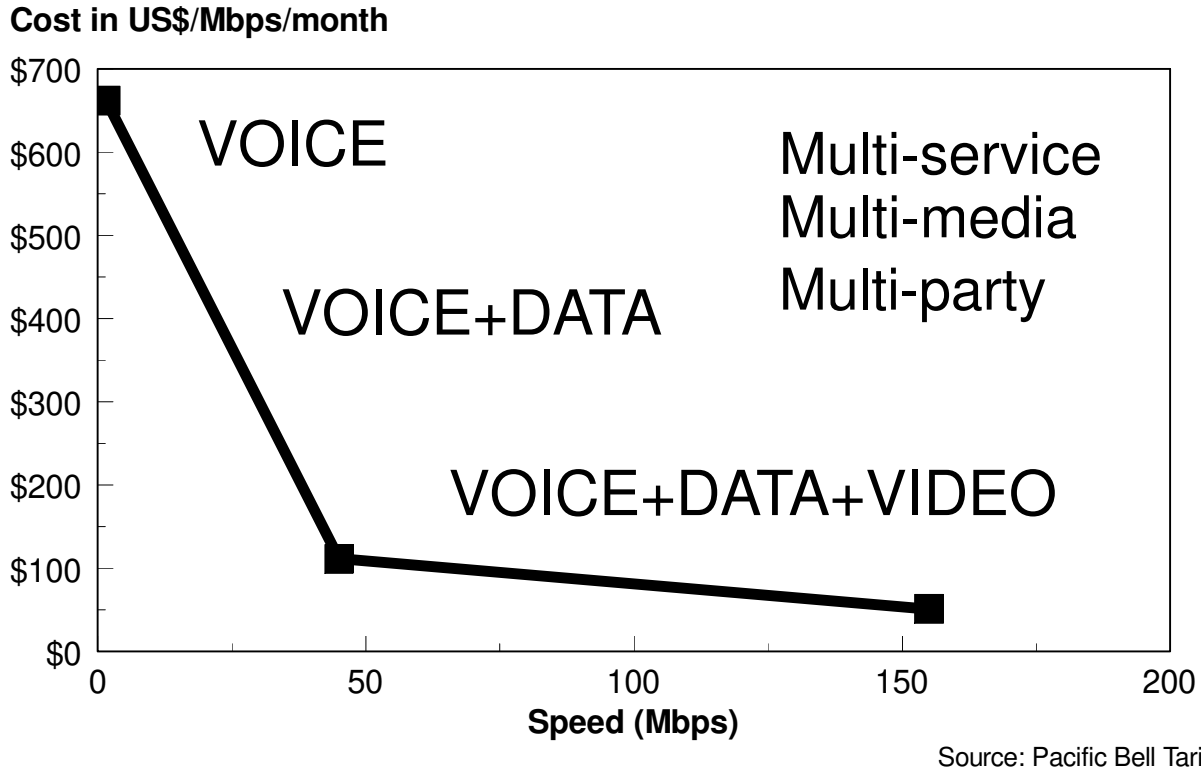
# Application Requirements

- **Wide Area Network Interfaces (Global Interoperability)**
- **Scaleability (Heterogeneity)**
- **Multicast (Groups)**
- **Realtime (Interactive)**

# Evolution Toward a WAN

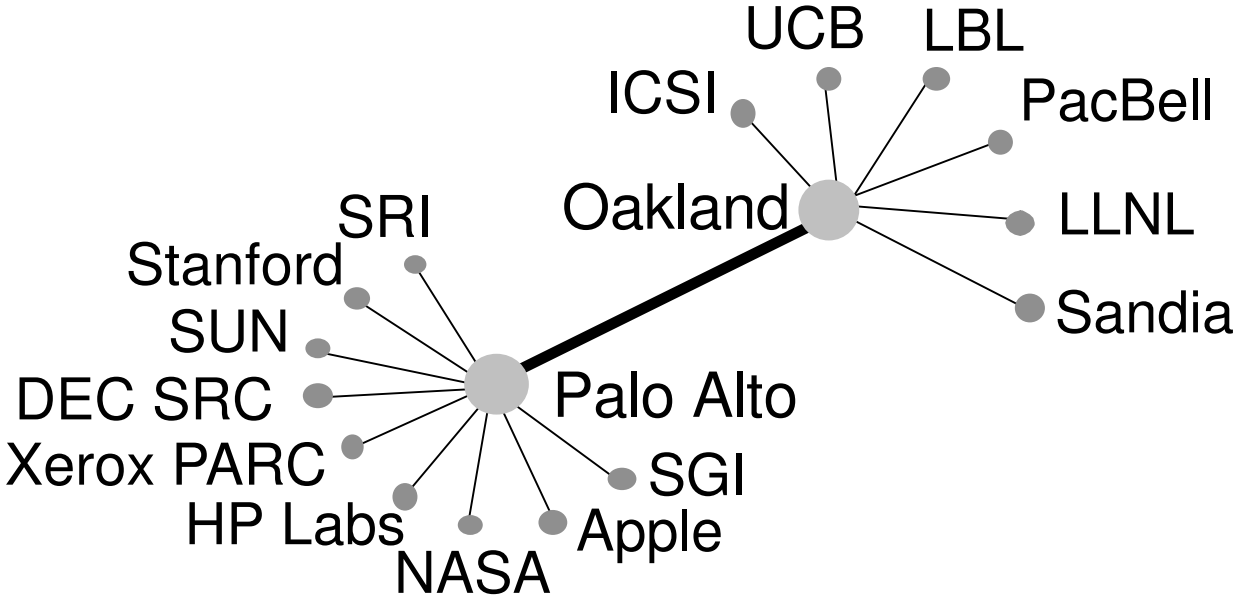


# Economy of Scale
# Customer Access Cost




Source: Pacific Bell Tariff

# Service Trial: BAGNet




- ATM service 155 Mbps (SDH)
- Applications: multi-party collaborations (initially teleseminar)

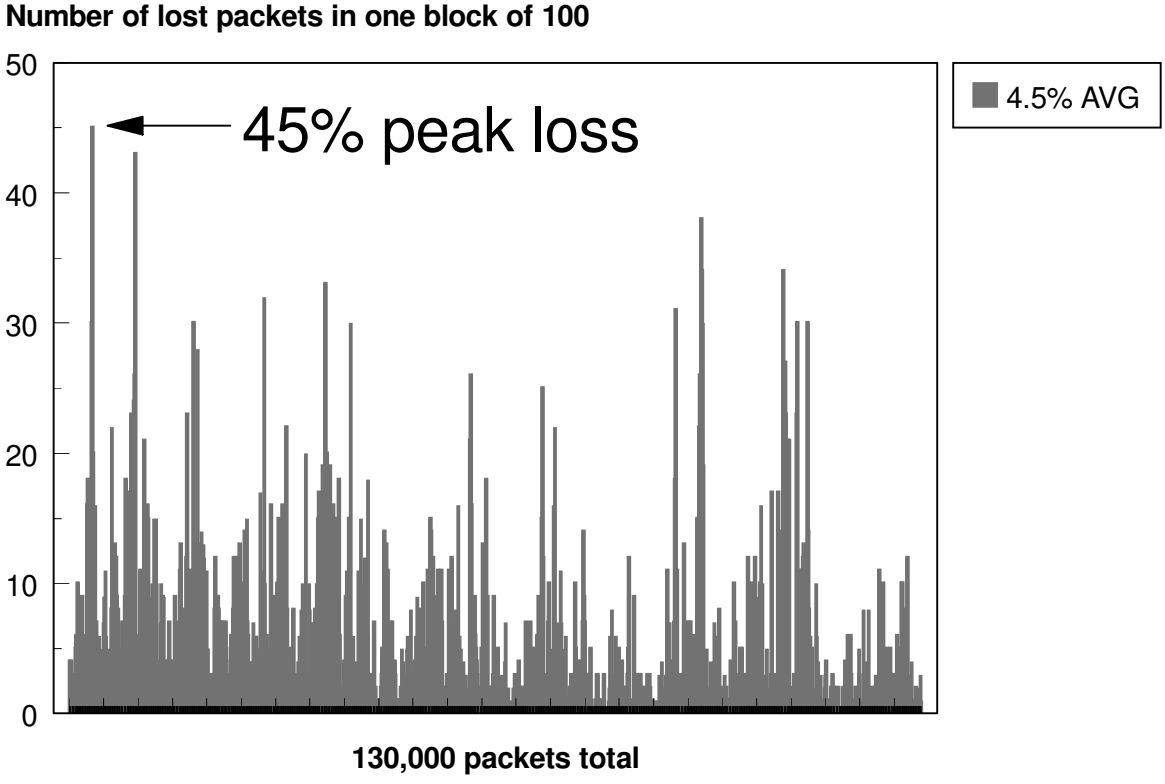
# Applications

- TeleSeminar
- Remote Laboratories
- Distance Learning
- Distributed Storage
- Collaborative Work
- Video on Demand

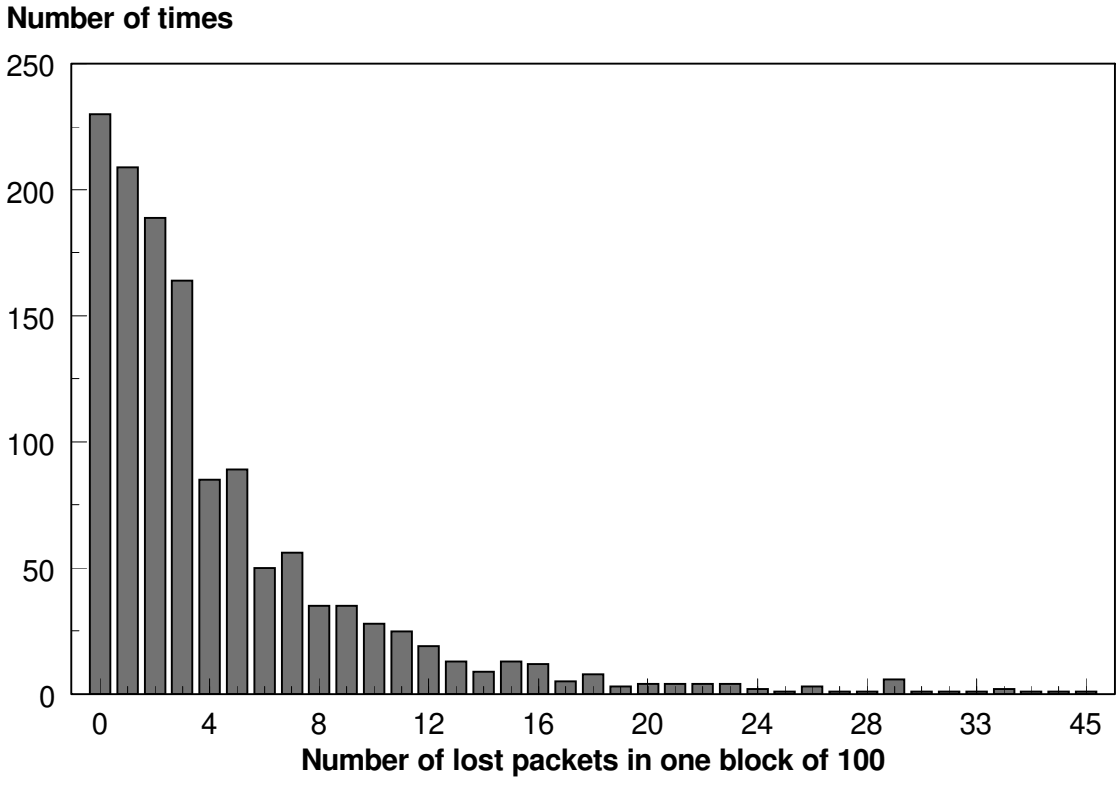
# Packet Loss is Inevitable !!!

Xerox PARC Forum (captured)

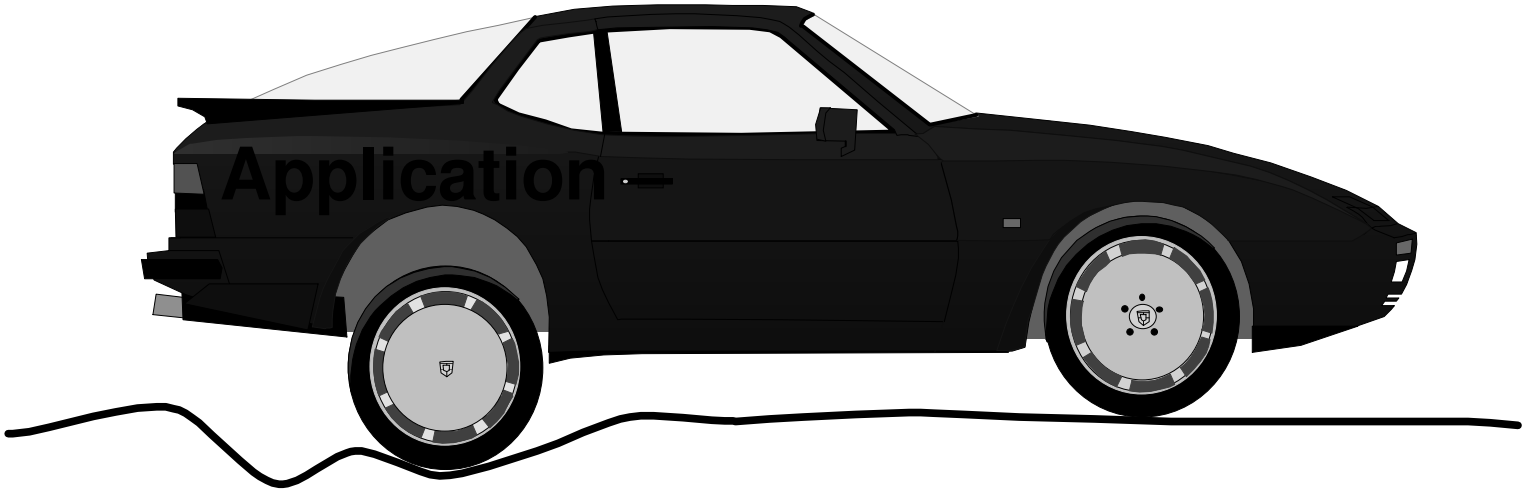
# Packet Loss per 100 from Palo Alto to Berkeley



# Packet Loss Histogram

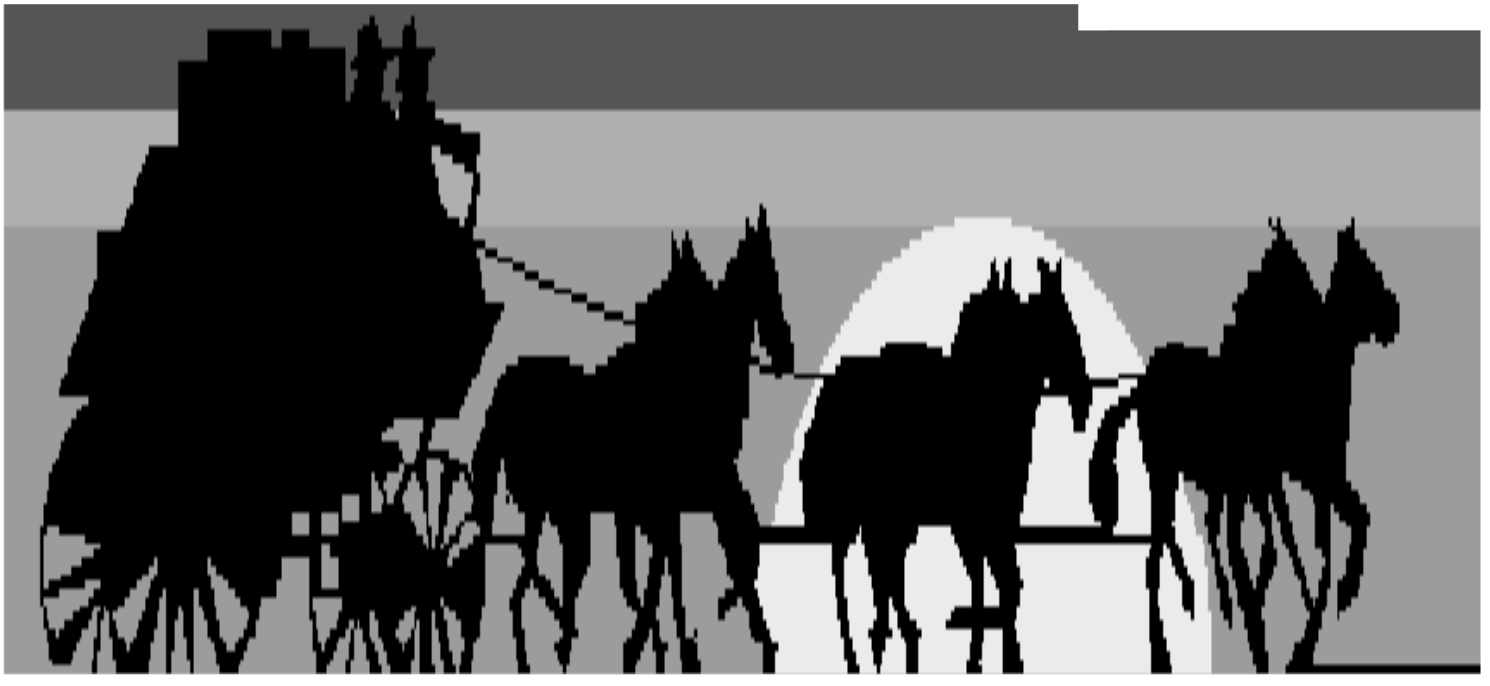


# Information Shock Absorber for the Information Highway



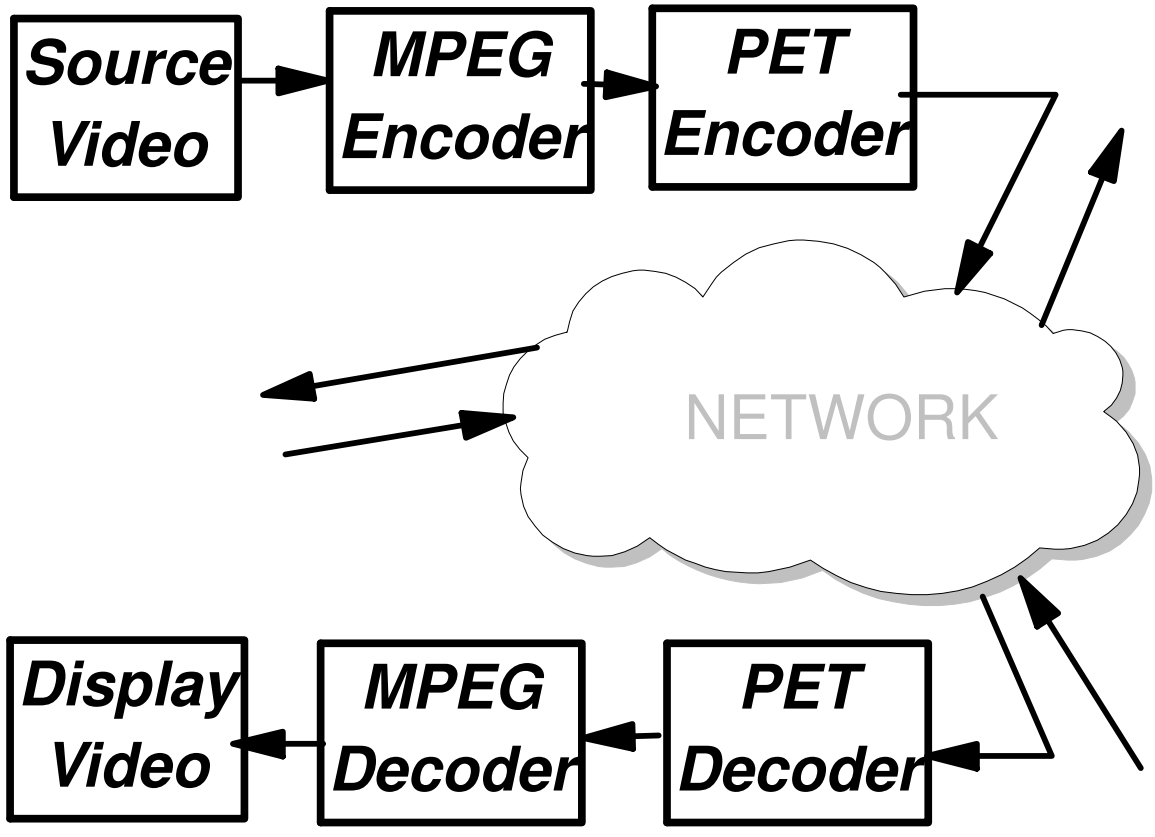

"Bumpy" Information Highway

# "Early Stages" of the Information Highway



# Priority Encoding Transmission PET

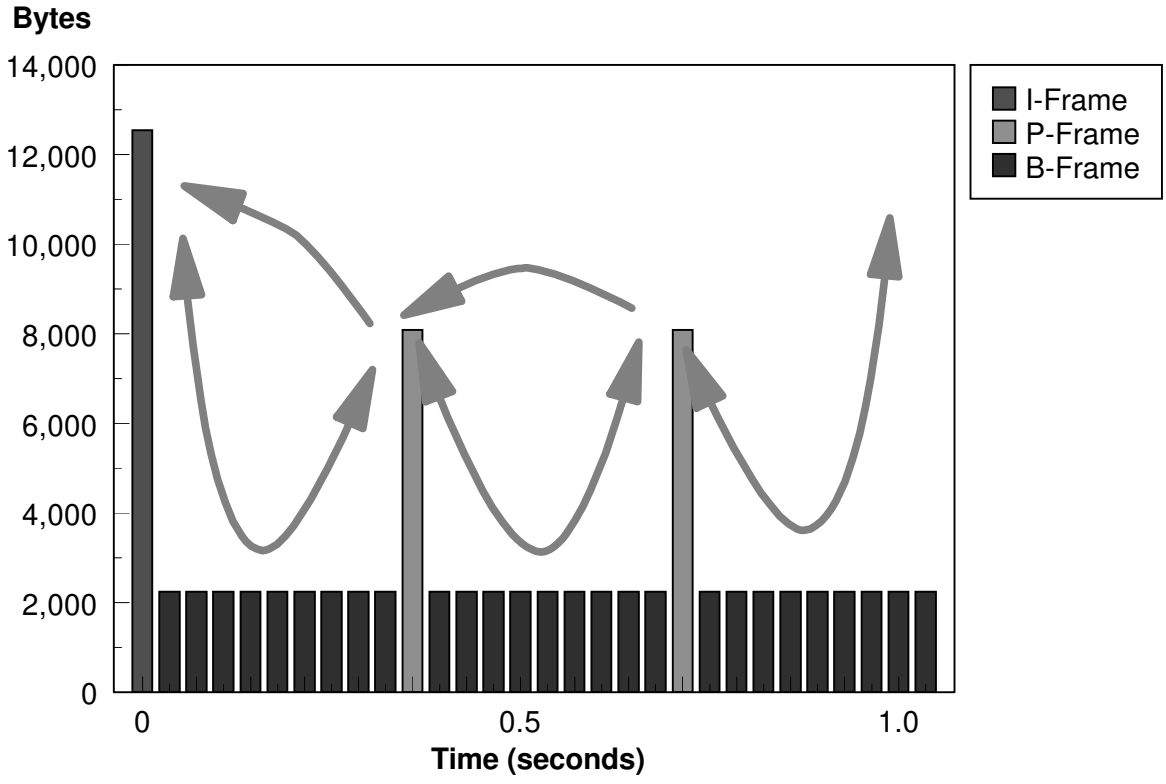
# Multicast Network



# PET algorithm

- sending information over lossy media
- dividing message into priority blocks
- encoding blocks into multiple packets
- packets are lost & delayed in transmission
- decoding blocks in priority order
- gracefully acquisition/degradation

# Example:
# MPEG Group of Pictures



# PET - Mechanism?

| a1 | b1 | a2 | b2 | c2 | a3 | b3 | c3 | d3 |
|---|---|---|---|---|---|---|---|---|

$p1(x) = a1+b1.x$ [mod 2^16+1]

$p2(x) = a2+b2.x+c2.x^2$ "

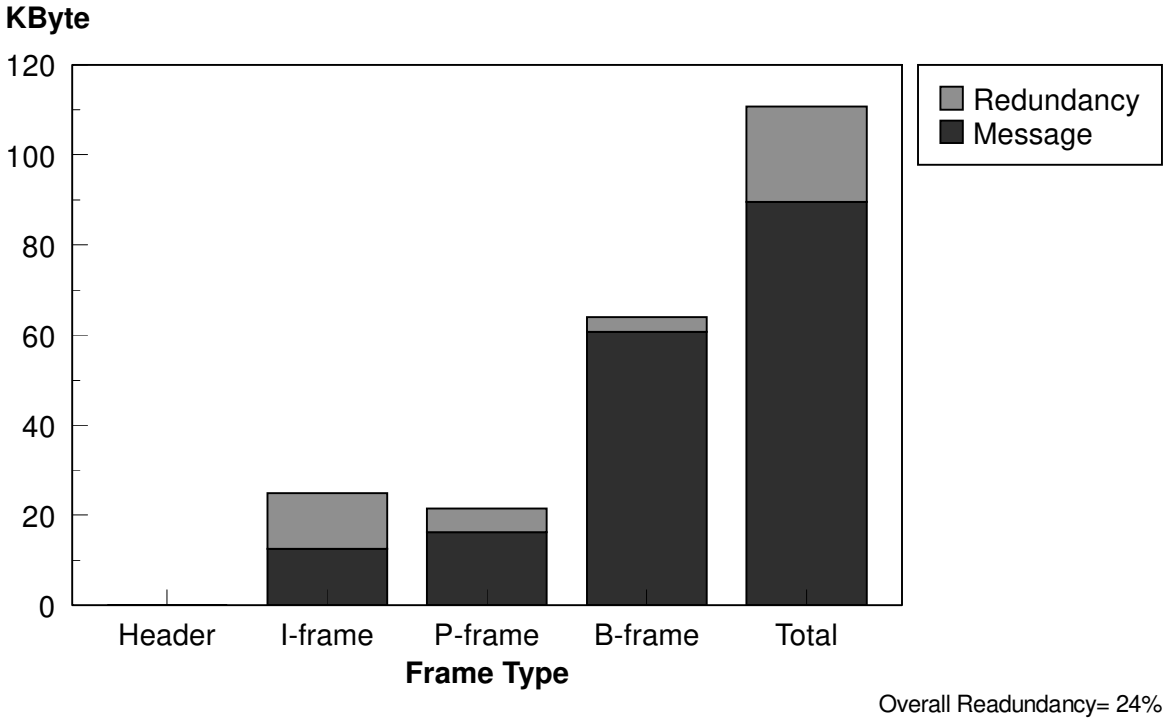
$p3(x) = a3+b3.x+c3.x^2+d3.x^3$ "

| | | | |
|---|---|---|---|
| 0 | p1(0) | p2(0) | p3(0) |
| 1 | p1(1) | p2(1) | p3(1) |
| 2 | p1(2) | p2(2) | p3(2) |
| 3 | p1(3) | p2(3) | p3(3) |
| 4 | p1(4) | p2(4) | p3(4) |

# MPEG: Group of Pictures Information Distribution

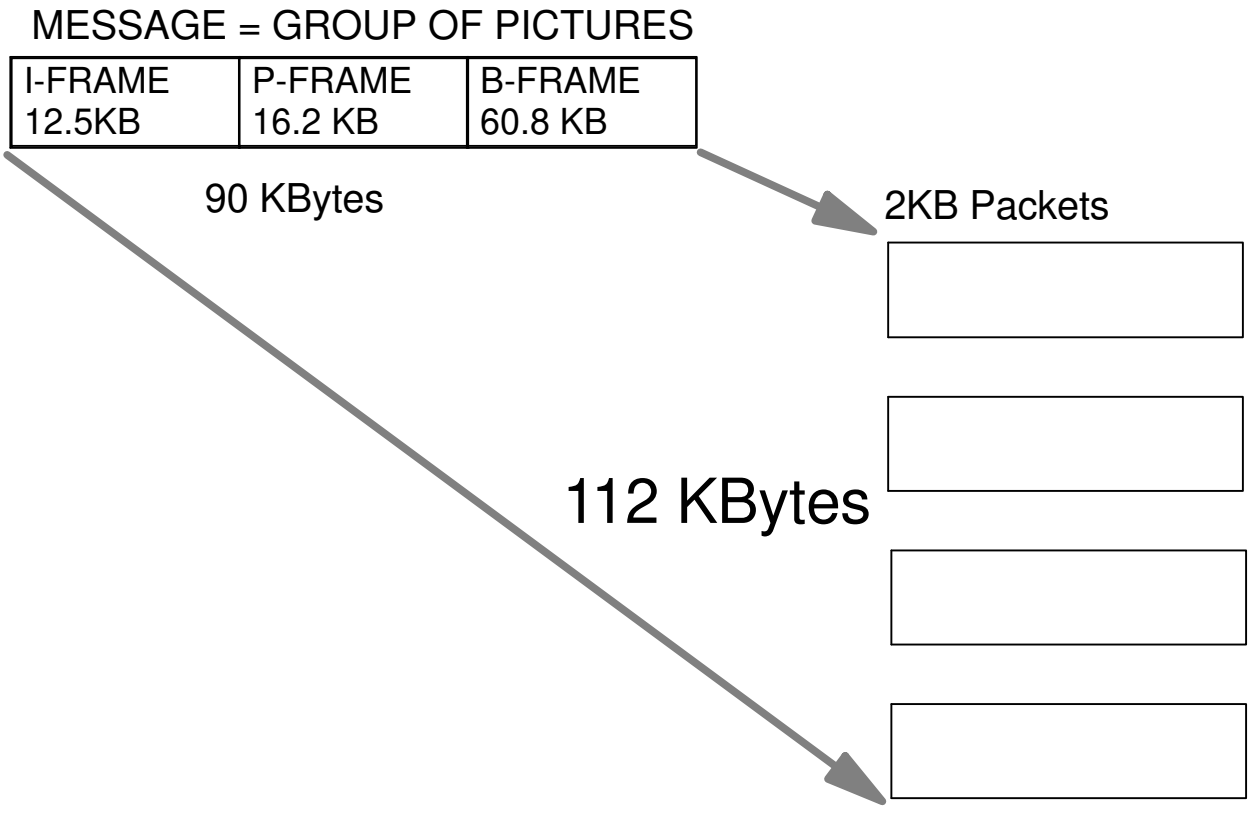
| | Length (KBytes) | Fraction Needed | Encoding (KBytes) |
|---|---|---|---|
| Header | 0.012 | 0.10 | 0.12 |
| I-Frames | 12.5 | 0.50 | 25.00 |
| P-Frames | 16.2 | 0.75 | 21.60 |
| B-Frames | 60.8 | 0.95 | 64.00 |
| Total | 89.5 | | 110.72 |

# MPEG: Byte Distribution




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

# Message Striping



# Message Striping (cont.)

$$\text{No. Packets} = \frac{\text{Total Encoding Length}}{\text{Packet Size}}$$

= 112 KB/2KB/packet

= 56 packets

Min. No. of packets for:

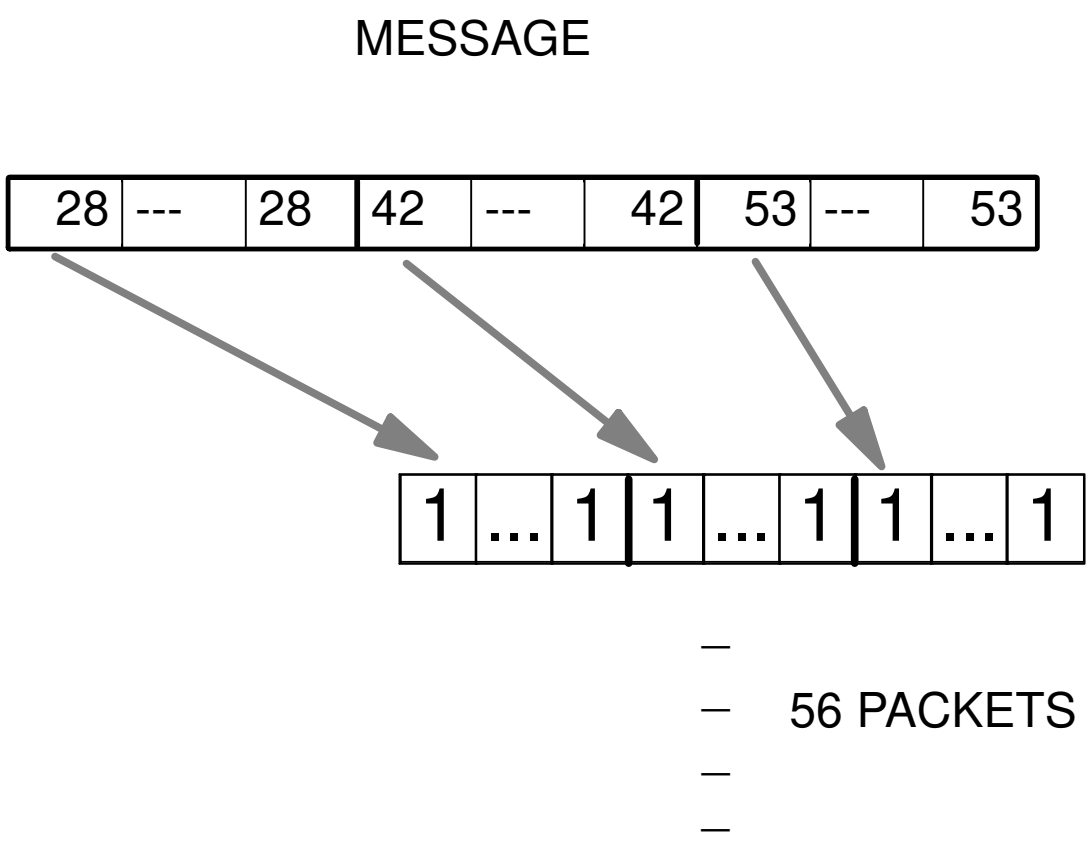
Header = 56x0.10= 6

I-frame = 56x0.50= 28

P-frame = 56x0.75= 42

B-frame = 56x0.95= 53

# Striping Process (cont.)



# PET Results

- Feasible hardware and software solutions
- Sparc-10 can process more than 3 Mbps
- Several algorithms possible:
  - Deterministic
  - Probabilistic
- Exploit arithmetic properties of:
  - Polynomials over finite fields
  - Linear algebra over GF[2]
    (XOR, SHIFT are basic operations)

# Video Transmission Comparisons

| | Bandwidth requirements | Quality degradation with losses |
|---|---|---|
| Full bit map | HIGH | LOW |
| MPEG | LOW | HIGH |
| MPEG + PET | LOW | LOW |

# Information Theory Lower Bound

**b1 ,b2, ... , bm = block sizes**

**p1, p2, ... , pm = fractional priorities**

**Theorem:**

**total encoding length** $\geq \sum_{i=1}^{m}$ **bi/pi**

# Conclusions

- Application Driven Solution
- Low Access Cost
- Graceful Acquisition/Degradation
- Distributed Solutions
- Simple Networks
- Global Coverage