Priority Encoding Transmission

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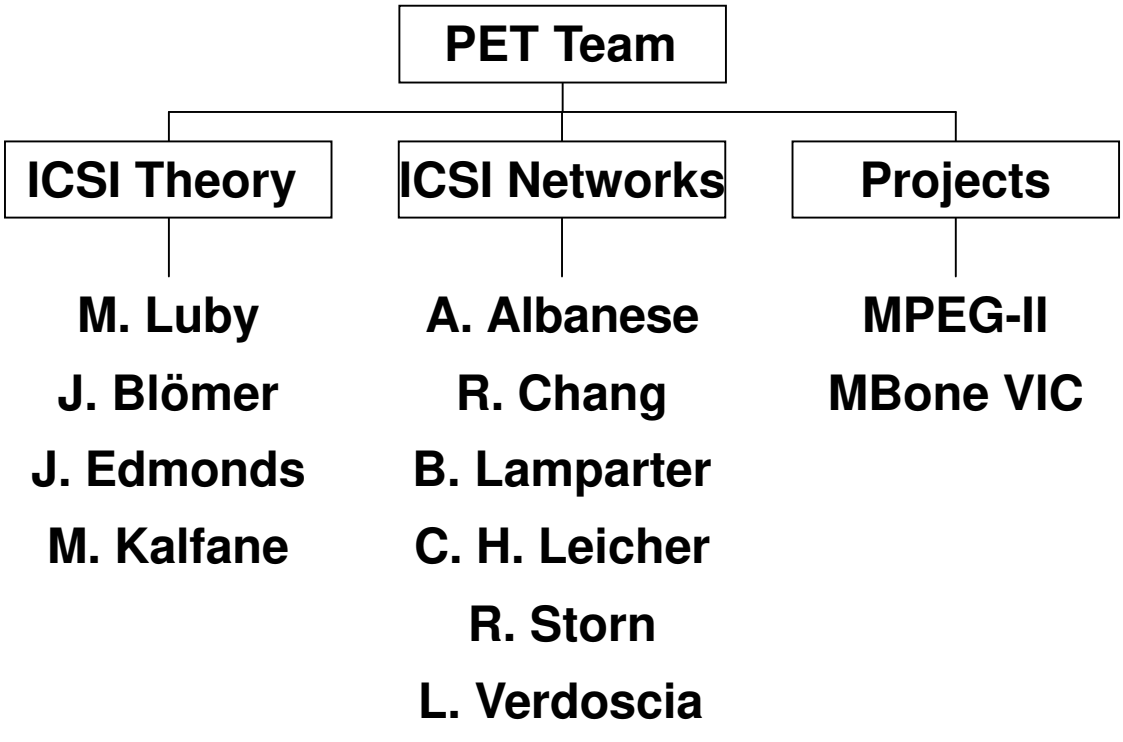
Coping with Variable Loss in Bursty Packet Networks

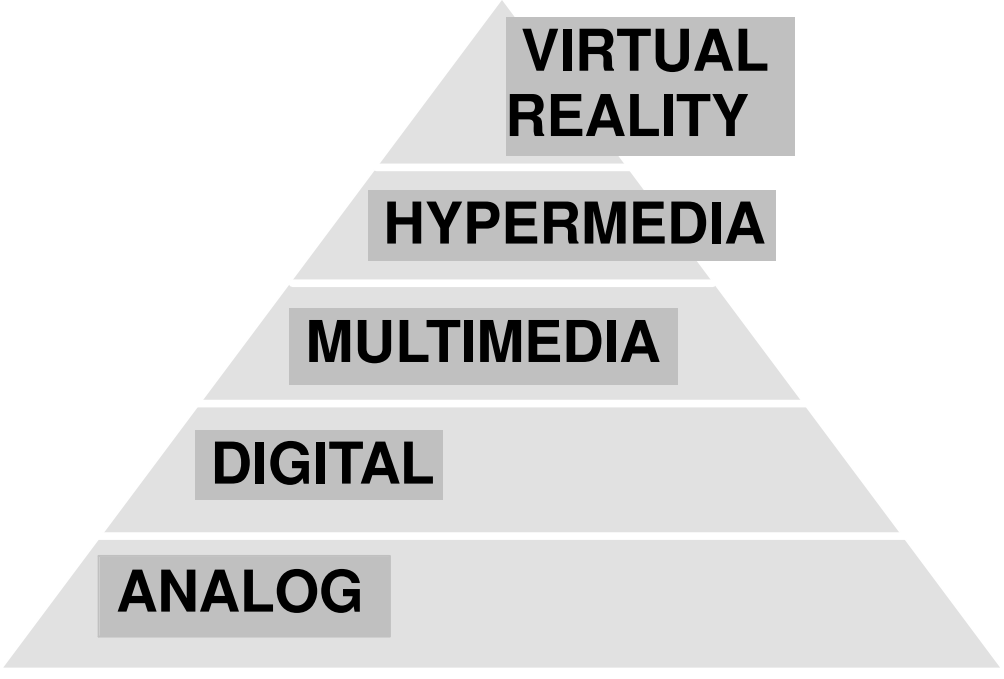


Outline

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

Network Evolution Trend

Information Media Evolution



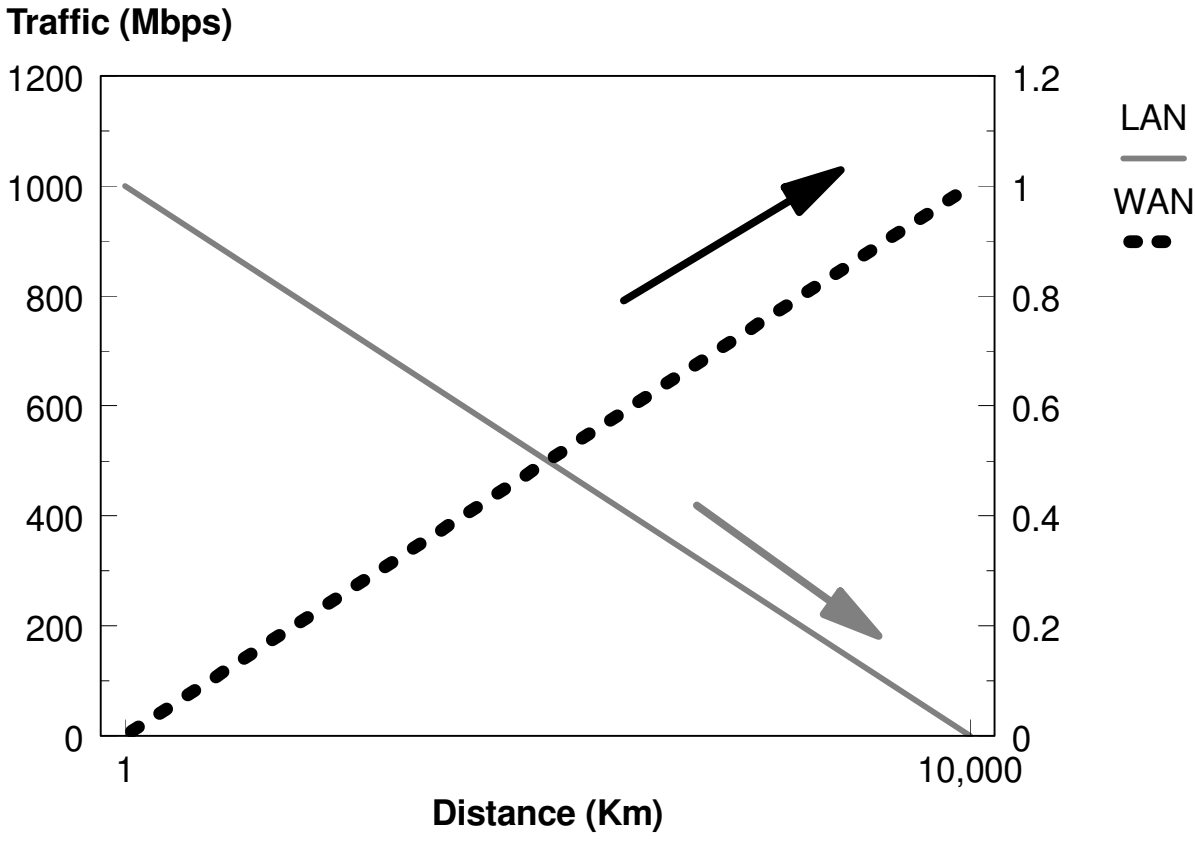
Computer Mediated Communication Applications

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

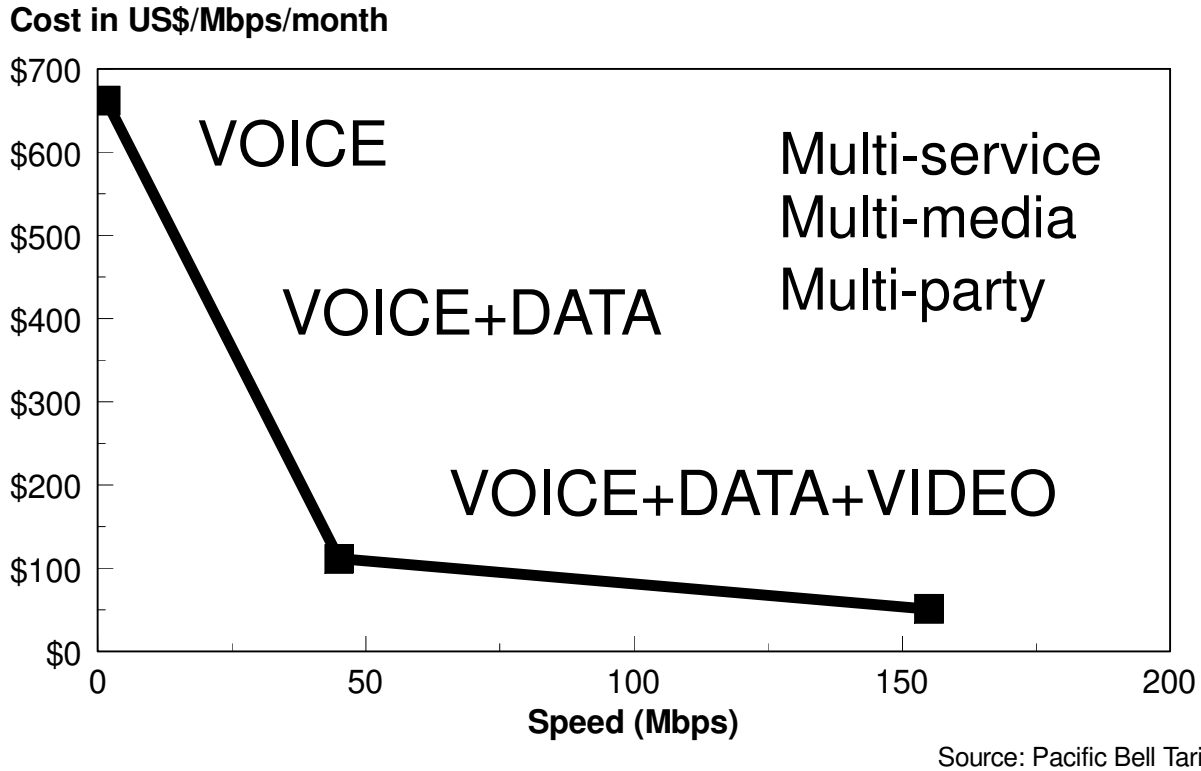
Application Requirements

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

Evolution Toward a WAN

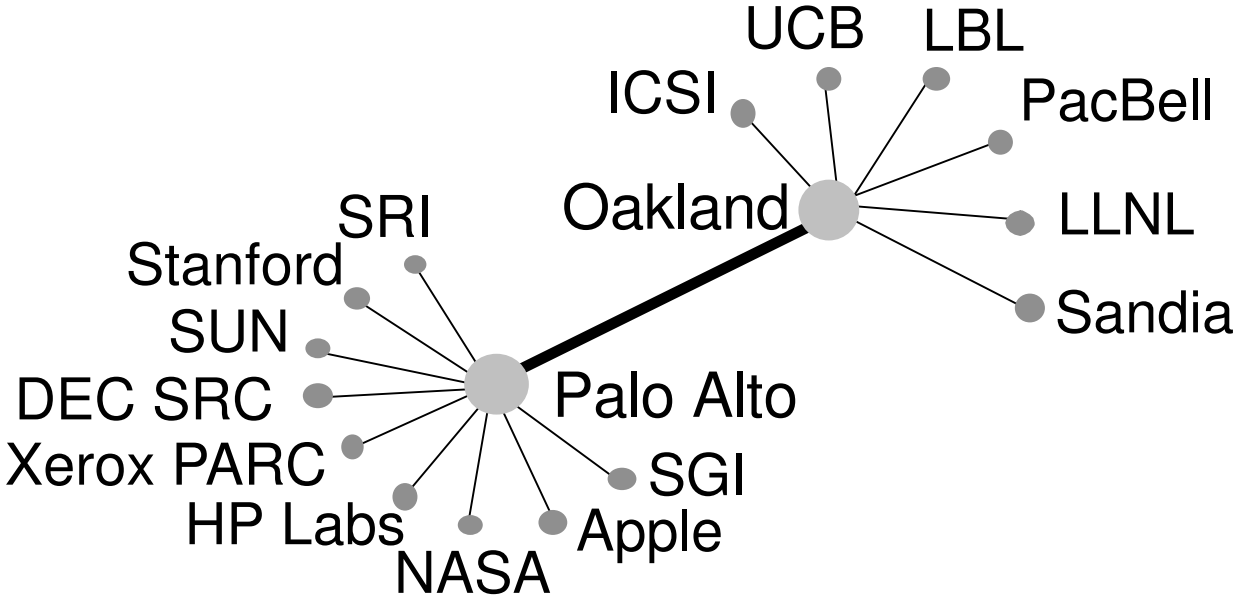


Economy of Scale
Customer Access Cost



Source: Pacific Bell Tariff

Service Trial: BAGNet



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

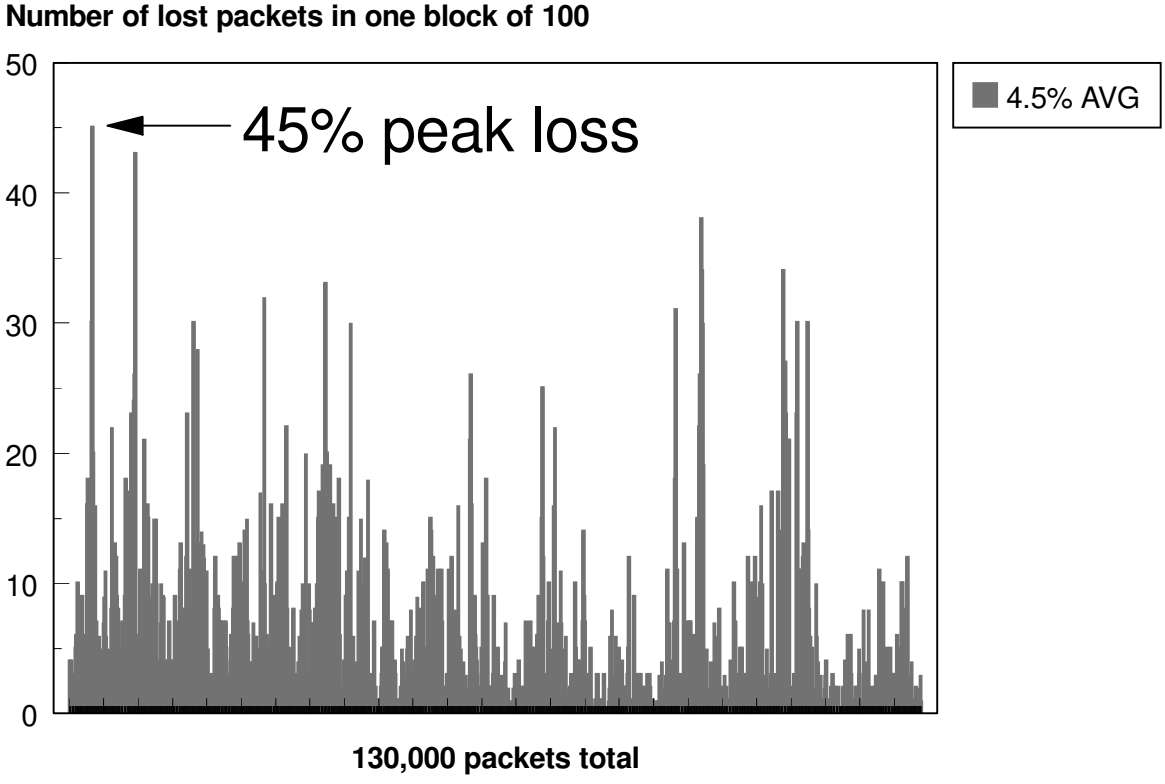
Applications

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

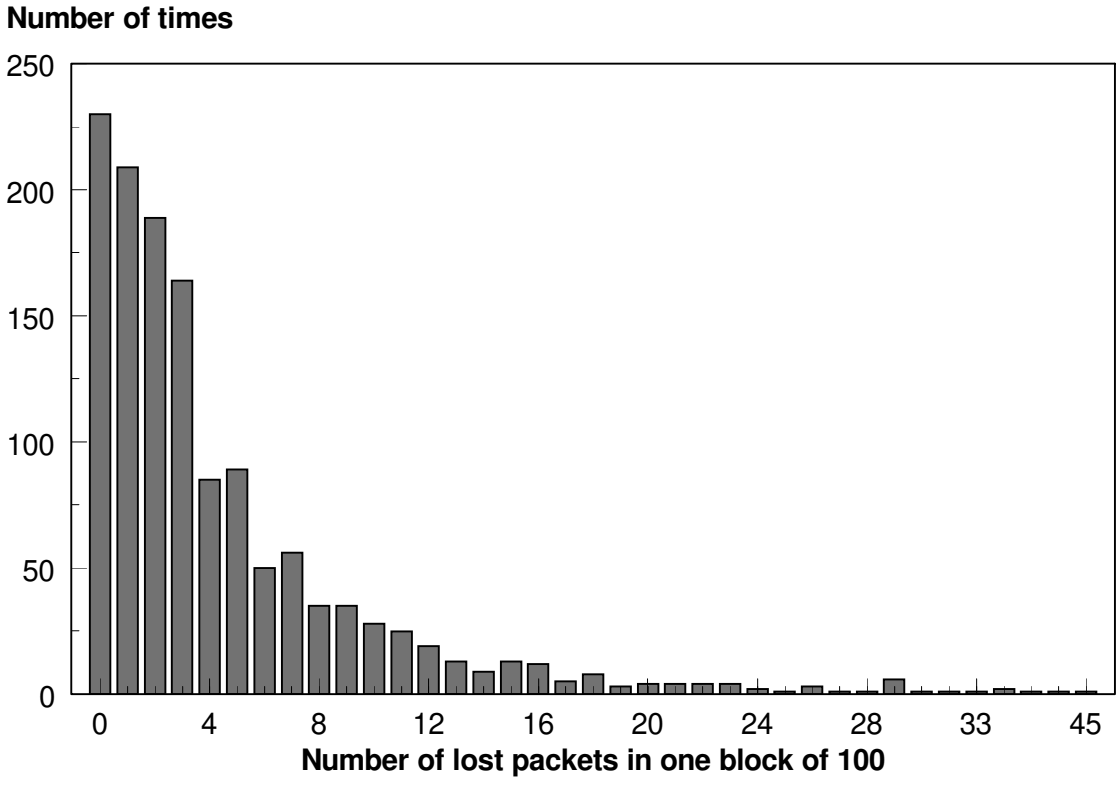
Packet Loss is Inevitable !!!

Xerox PARC Forum (captured)

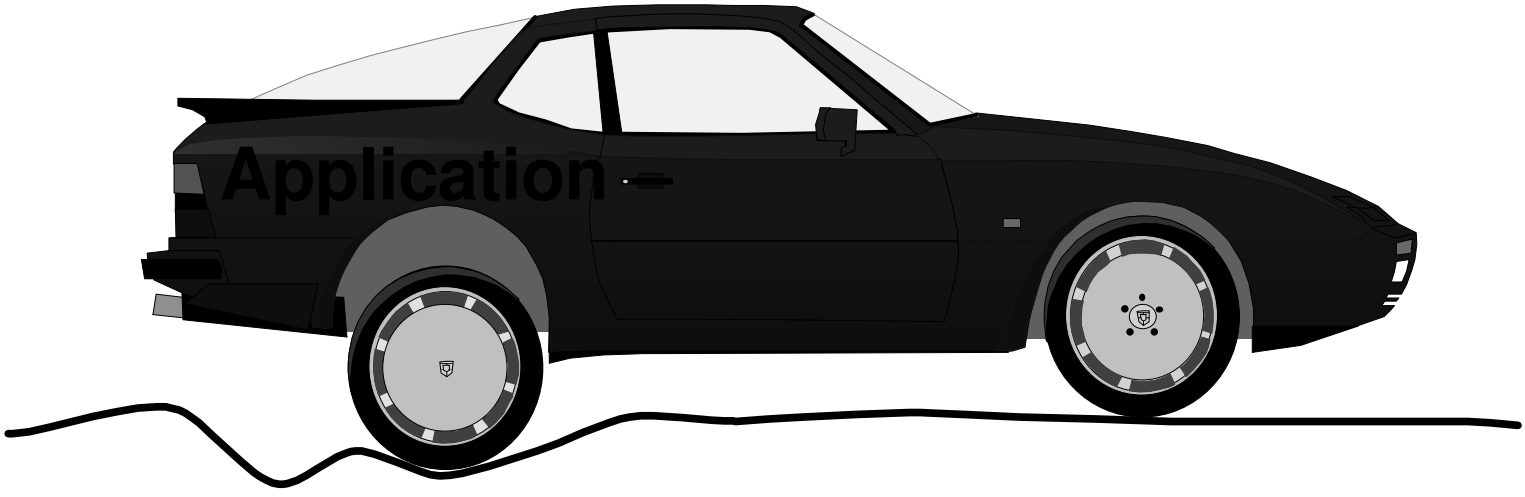
Packet Loss per 100 from Palo Alto to Berkeley



Packet Loss Histogram

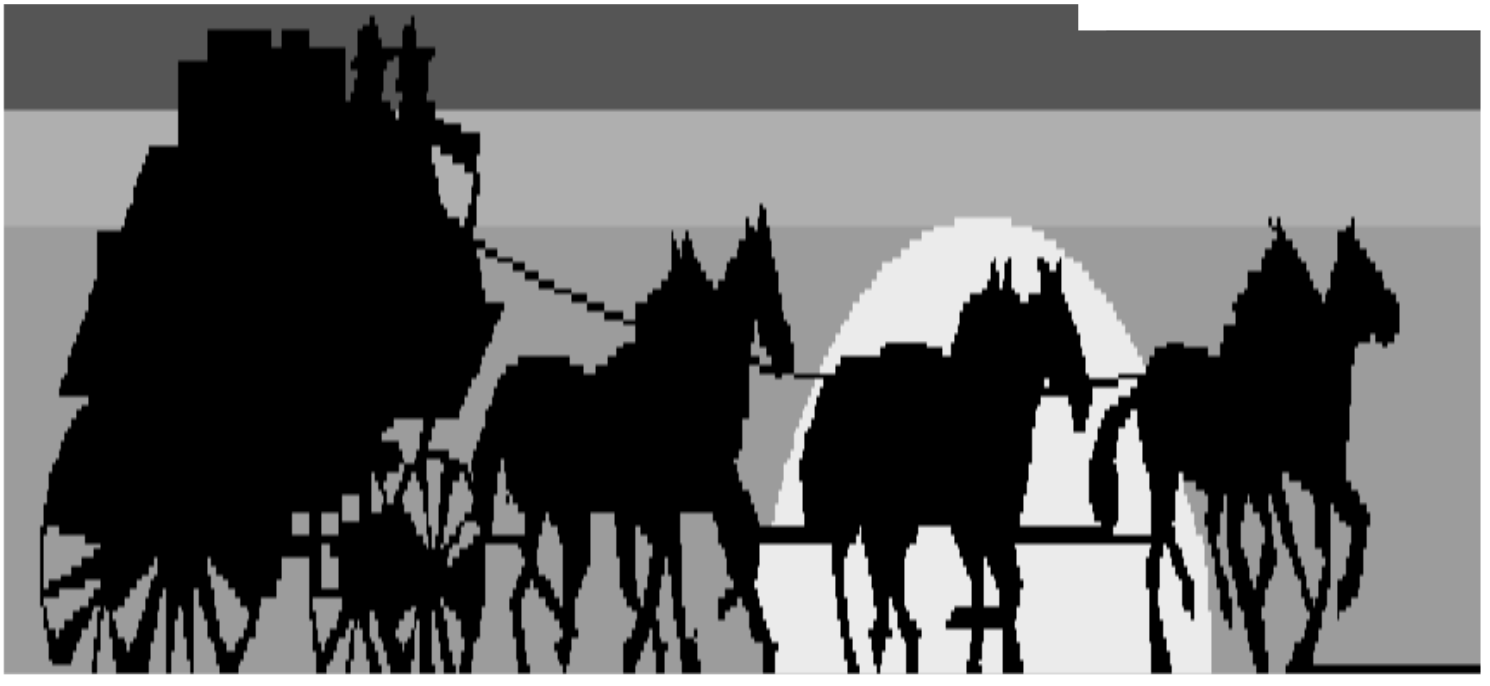


Information Shock Absorber for the Information Highway



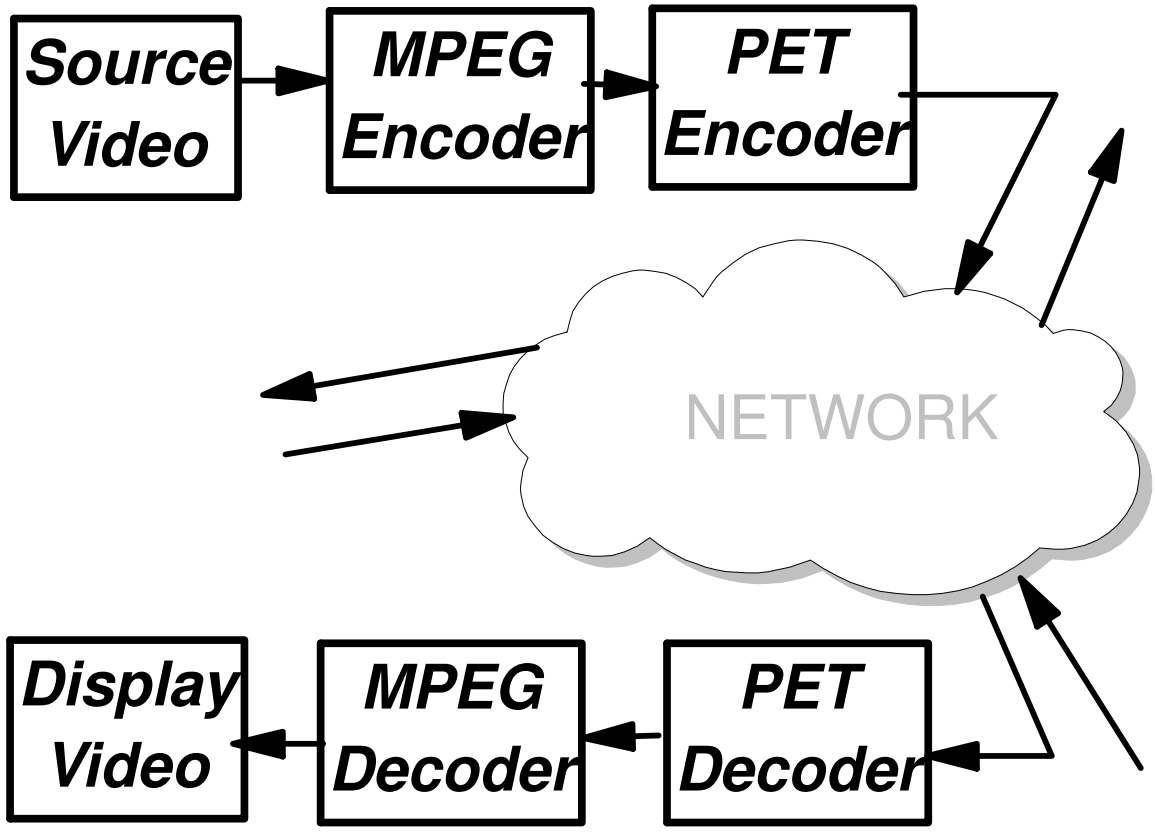
"Bumpy" Information Highway

"Early Stages" of the Information Highway



Priority Encoding Transmission PET

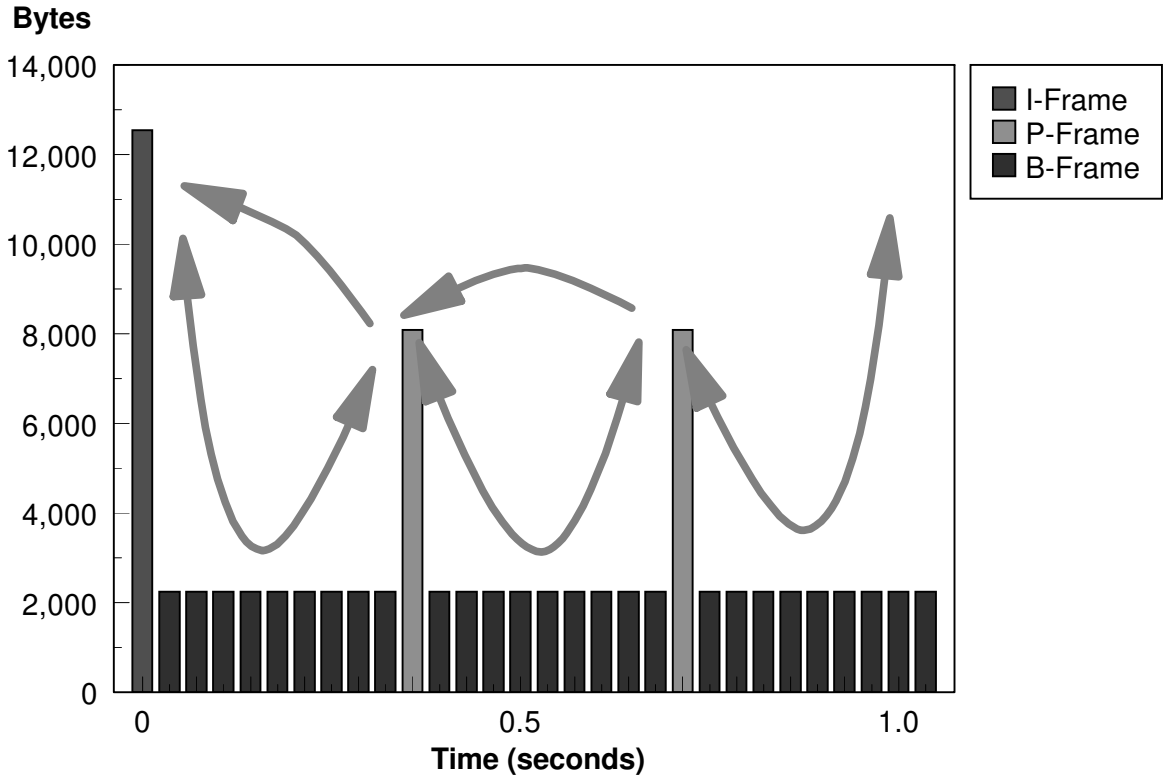
Multicast Network



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]

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

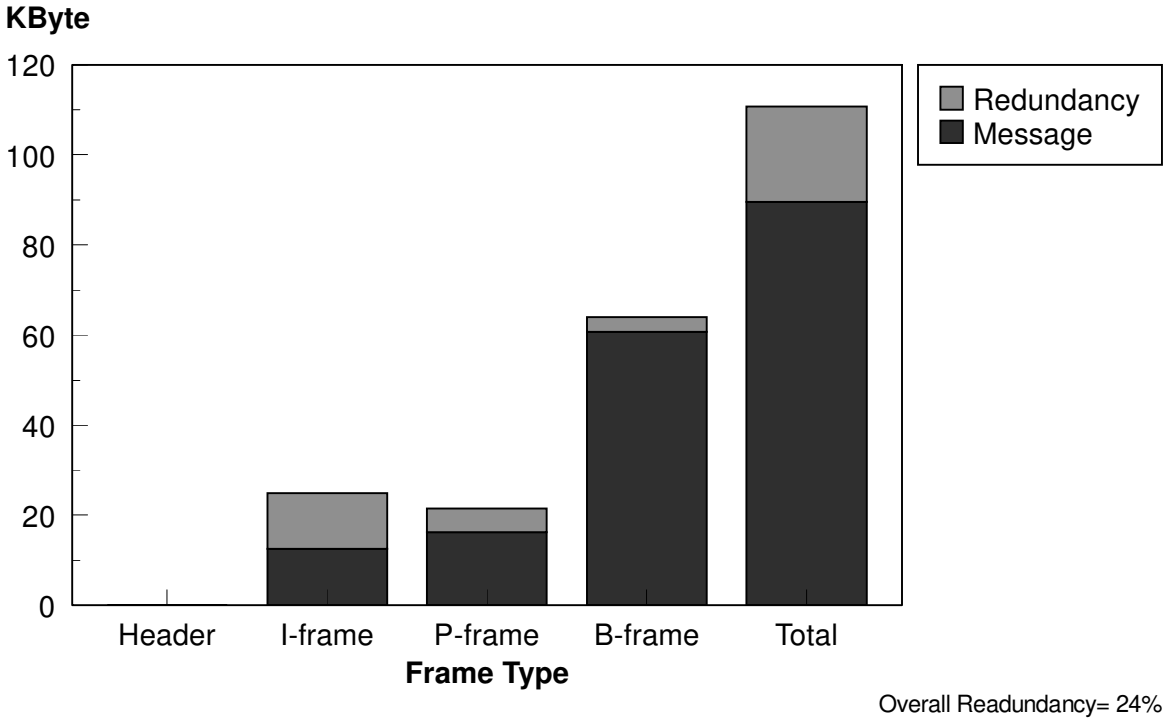
$p3(x) = a3+b3.x+c3.x^2+d3.x^3$ "

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

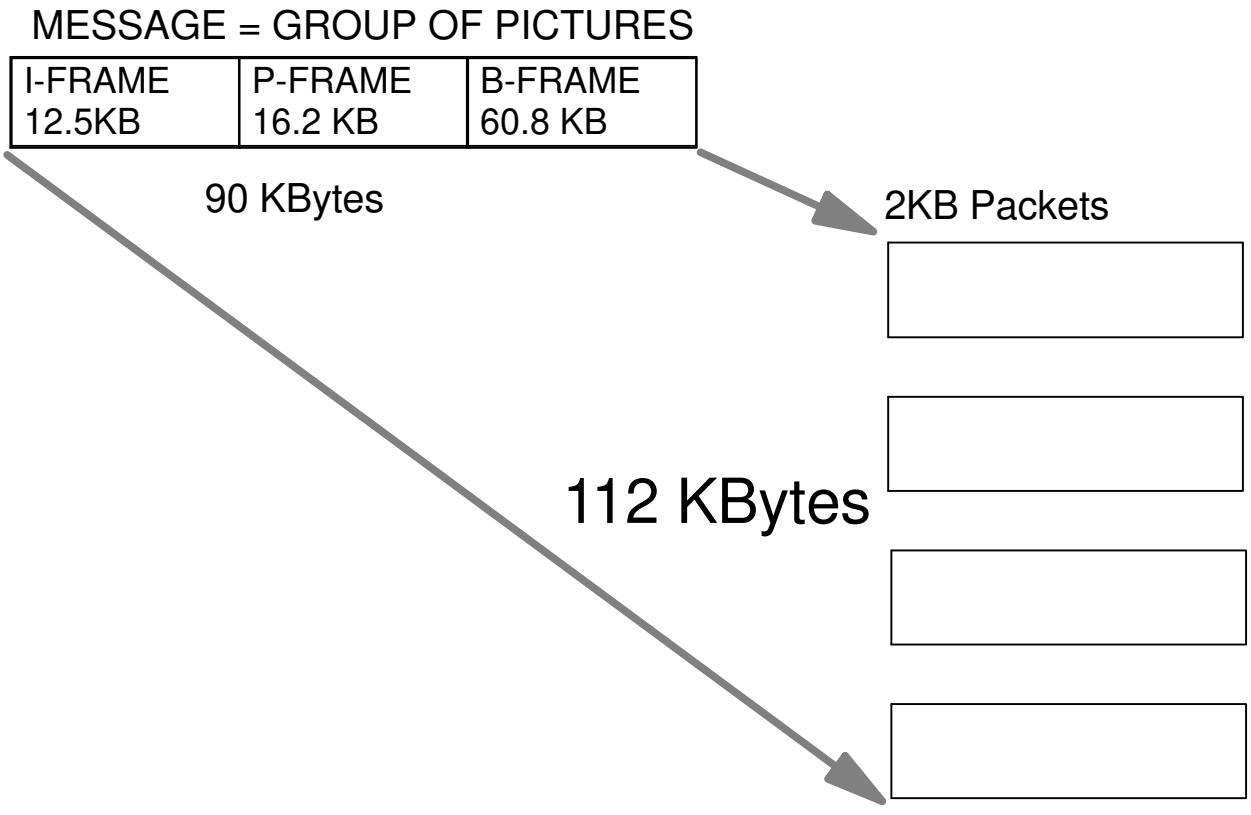
	Length (KBytes)	Fraction Needed	Encoding (KBytes)
Header	0.012	0.10	0.12
I-Frames	12.5	0.50	25.00
P-Frames	16.2	0.75	21.60
B-Frames	60.8	0.95	64.00
Total	89.5		110.72

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:

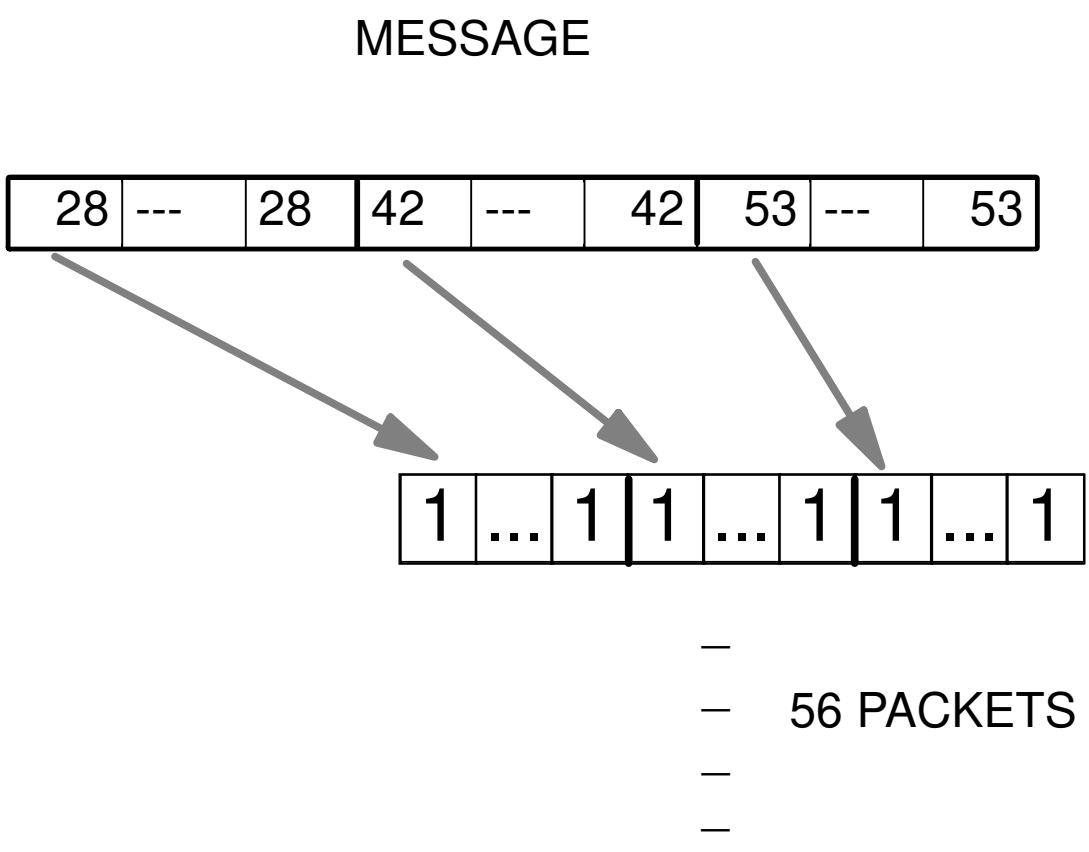
Header = 56x0.10= 6

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