RAID-II: Providing Network Video Service to Mobile Clients

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10 March 1993

Motivation

- **Providing video to wireless Infopads**
  - Video storage
  - Real-time playback across network
- **RAID-II**
  - High speed file server (~25 MB/s)
  - Large storage capacity (~40 GBytes)
- **Tenet Network Protocols**
  - Real-time guarantees

Outline

- **RAID-II (S. Seshan)**
  - Design
  - Status/Video Demo
  - Performance
- **Tenet Real-Time Protocols (B. Mah)**
  - Protocol Stack
  - Implementation
  - Performance
- **Network Video Service (K. Keeton)**
  - Enhancements to RAID-II and Tenet Protocols
  - Status

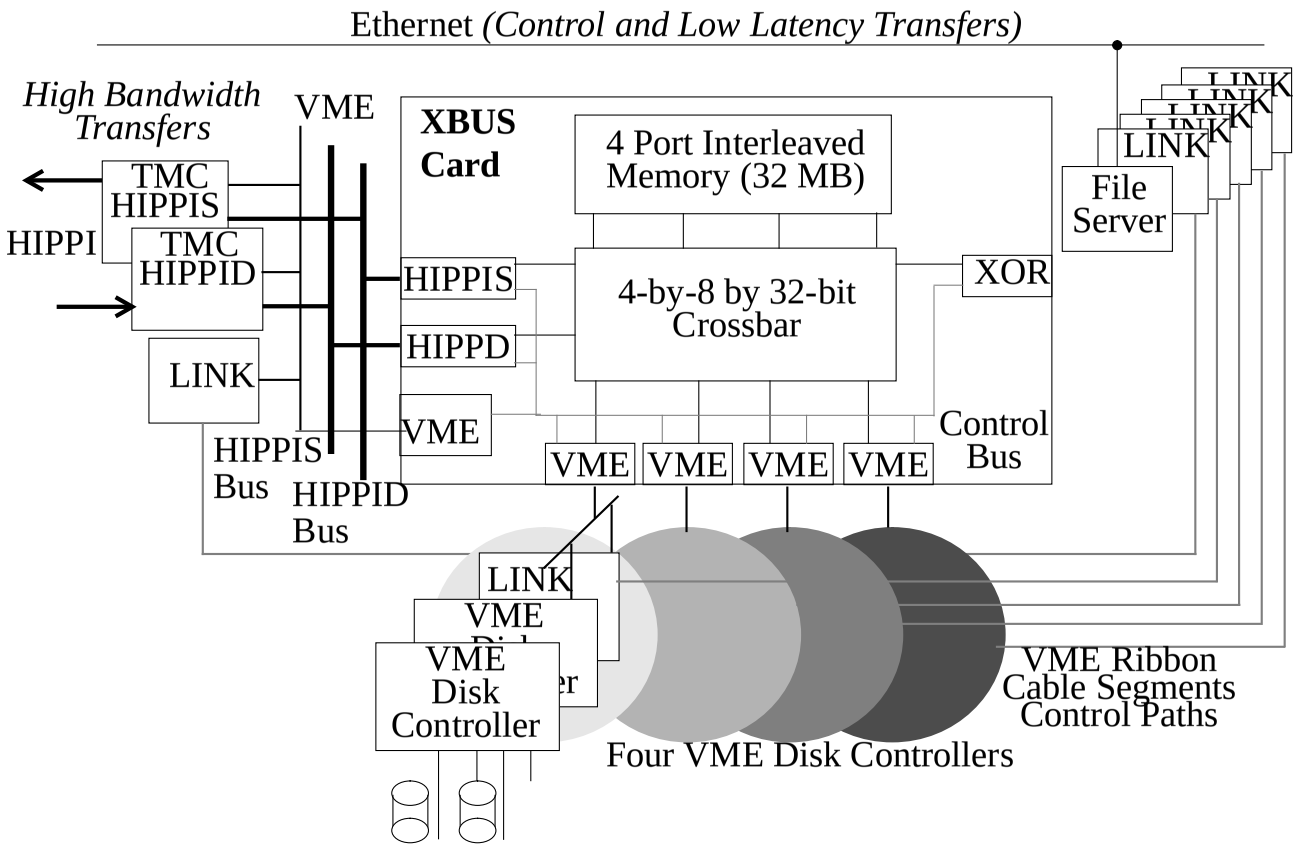
RAID-I Lessons

- **Constructed from stock file server and disk controller hardware**
- **Testbed for RAID striping, parity calculation and reconstruction algorithms**
- **Bandwidth bottlenecks**
  - Memory optimized for processor access
  - Slow speed access to network, disk controllers
  - Too many memory-to-memory copies
- **Basic idea: high bandwidth path from network to memory to disk**

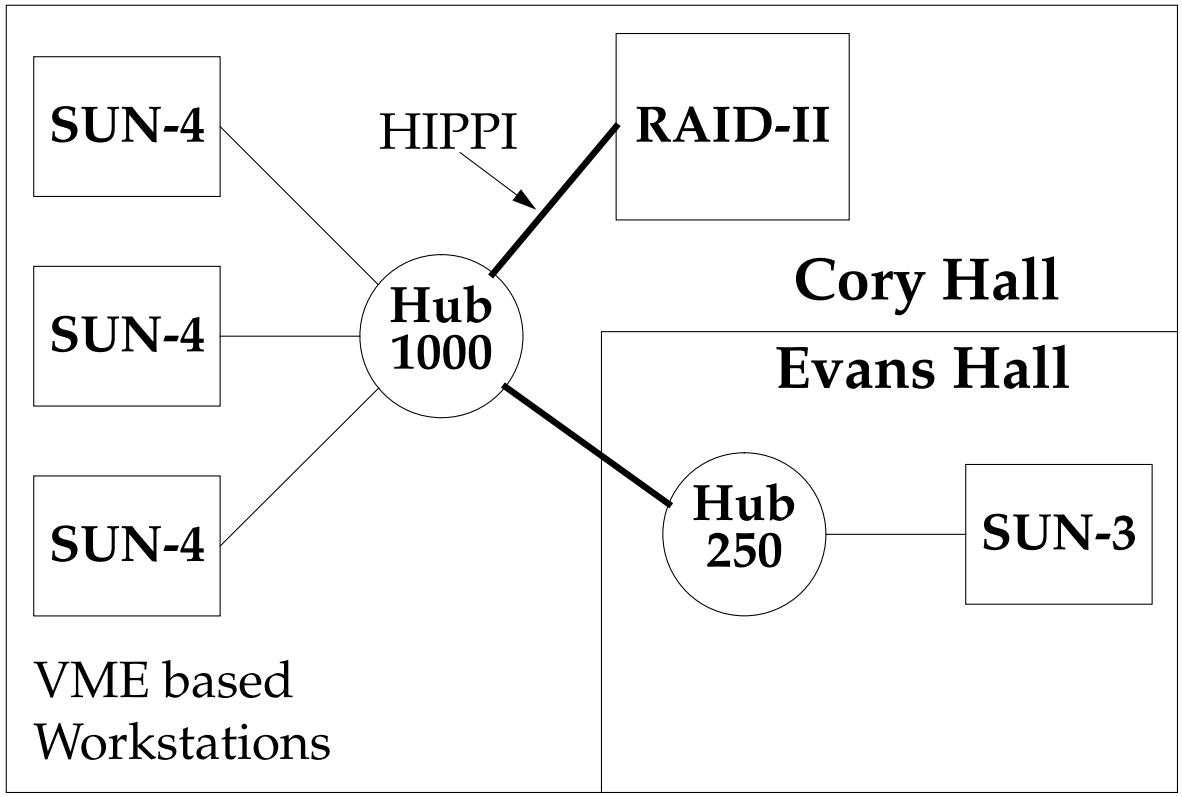
RAID-II Design

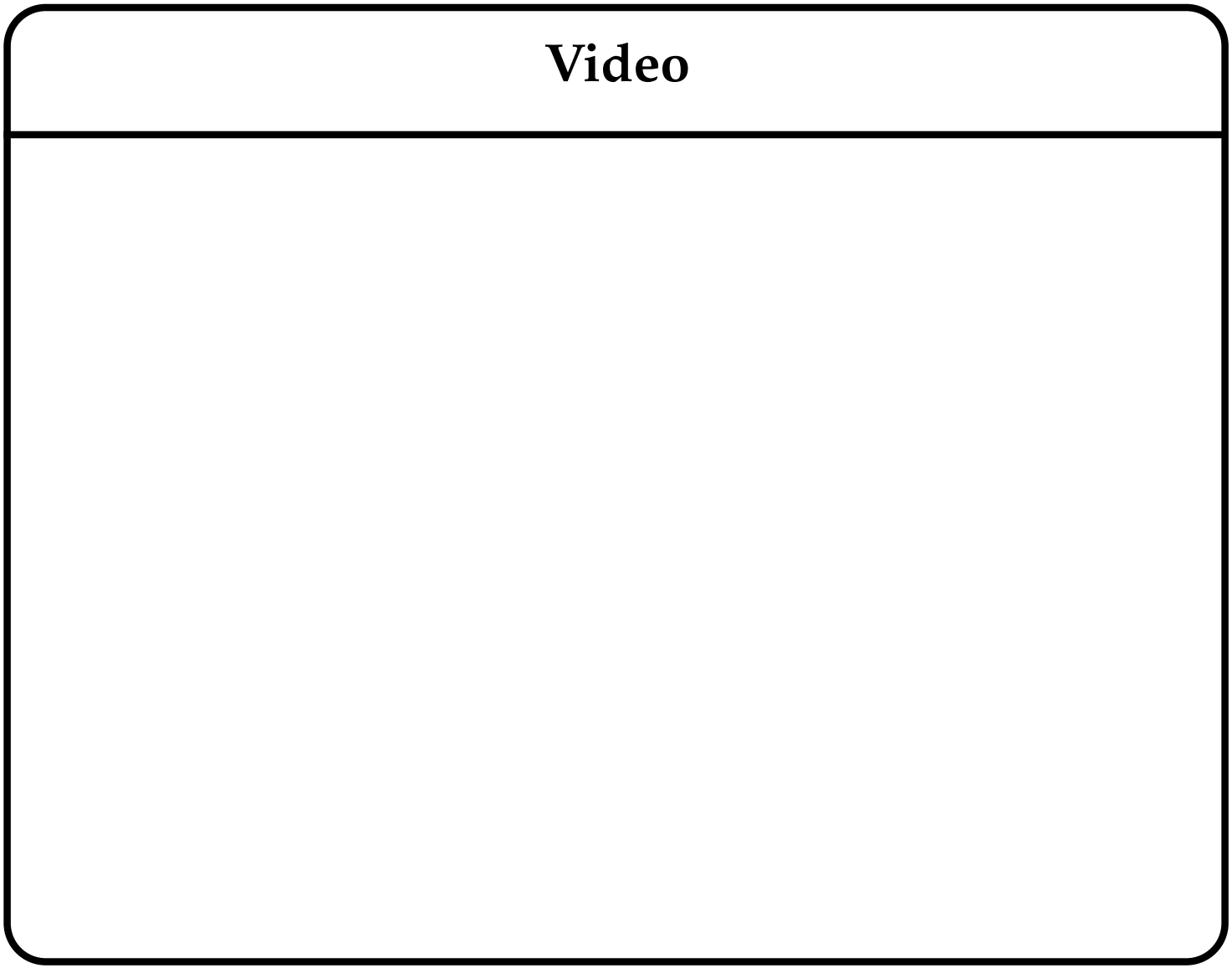
- **Build an experimental high capacity, high performance file server based on RAID and Log-Structured File System (LFS) concepts**
  - 40 MB/s goal
  - Include 100+ 3.5” disk drives
  - SCSI disk interfaces, HIPPI to Ultranet
  - Leverage existing hardware where possible
- **HIPPI board set from TMC**
- **Interphase SCSI controllers**
- **Custom crossbar interconnect board**

RAID-II Block Diagram



Testbed


SUN-4
SUN-4
SUN-4
HIPPI
RAID-II
Hub
1000
Cory Hall
Evans Hall
Hub
250
SUN-3
VME based
Workstations


Video

RAID-II Performance

- **Hardware limitations**
  - Loopback mode through HIPPI cards
  - 31 MB/s sequential reads from disk
  - 23 MB/s sequential writes to disk
- **Software limitations**
  - Performance to workstation clients on Ultranet
  - Using Ultranet protocol stack
  - Performance limited by client VME backplane bandwidth
  - Estimated maximum bandwidth:

    25 MB/s sequential reads from disk

    23 MB/s sequential writes to disk

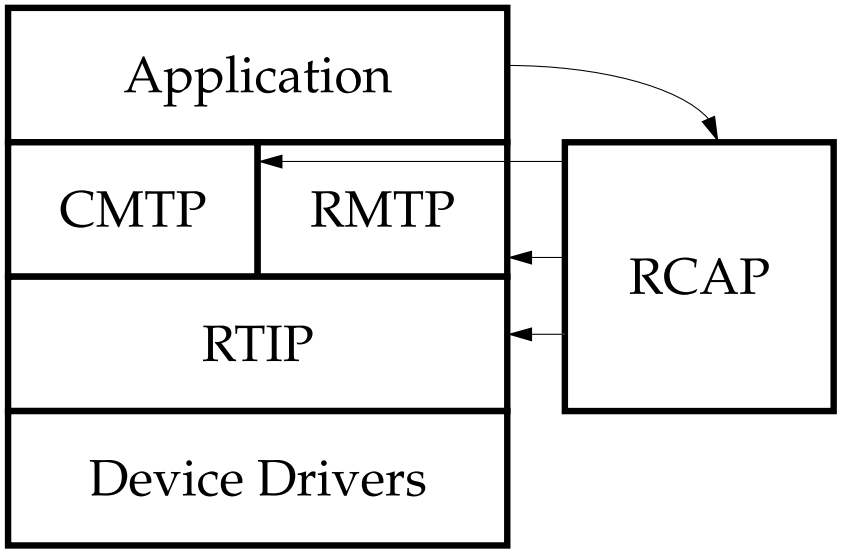
The Tenet Real-Time Networking Scheme

- **Future applications (e.g. video) will require guarantees on network performance**
- **Guarantees**
  - Delay
  - Throughput
  - Delay jitter
  - Packet droppage

"Real-Time" = "Guaranteed Performance"

- **Worst-case analysis**
- **Mathematically rigorous**
- **Connections (virtual circuits)**
  - Accommodate different client requirements
  - Protection between different conversations
- **Admission control**

The Tenet Real-Time Protocol Suite



RCAP: Real-Time Channel Administration Protocol
RTIP: Real-Time Internet Protocol
RMTP: Real-Time Message Transport Protocol
CMTP: Continuous Media Transport Protocol

Tenet Protocol Implementation

- **DECstation 5000 (Ultrix)**
- **Sparcstation/Sun 4 (SunOS)**
- **Performance (DECstation 5000/240 over FDDI, 4 KB packets)**
  - RMTP/RTIP: 35 Mbps
  - UDP/IP: 25 Mbps
  - No performance degradation under increased network load

Tenet Protocol Future Work

- **RAID-II**
  - New operating system environment (Sprite)
  - Not a standard workstation architecture
  - Mixed network types (HIPPI, FDDI, ATM)
- **Infopad network**
  - Host mobility considerations

Video Service to Mobile Clients

RAID-II and the Tenet Real-Time Protocol Suite provide the basis for video service:

- High bandwidth disk system
- Guaranteed network performance

How can these technologies be applied to providing video to mobile clients?

RAID-II Enhancements

Goals:

- Retrieve video in real-time to satisfy client quality of service (QoS) requirements
- Maximize number of concurrent video streams

Techniques:

- Multiple representations of video sequence
- Video layouts on disk which minimize data retrieval time
- Real-time scheduling

Multiple Representations of Video

- **Supports heterogeneous client display hardware**
  - Compression scheme
  - Color vs. greyscale
  - Frame rate
- **Allows reduction in QoS for existing streams to satisfy additional client requests**
  - Dynamically reallocate server's system bandwidth

Data Layout Policies

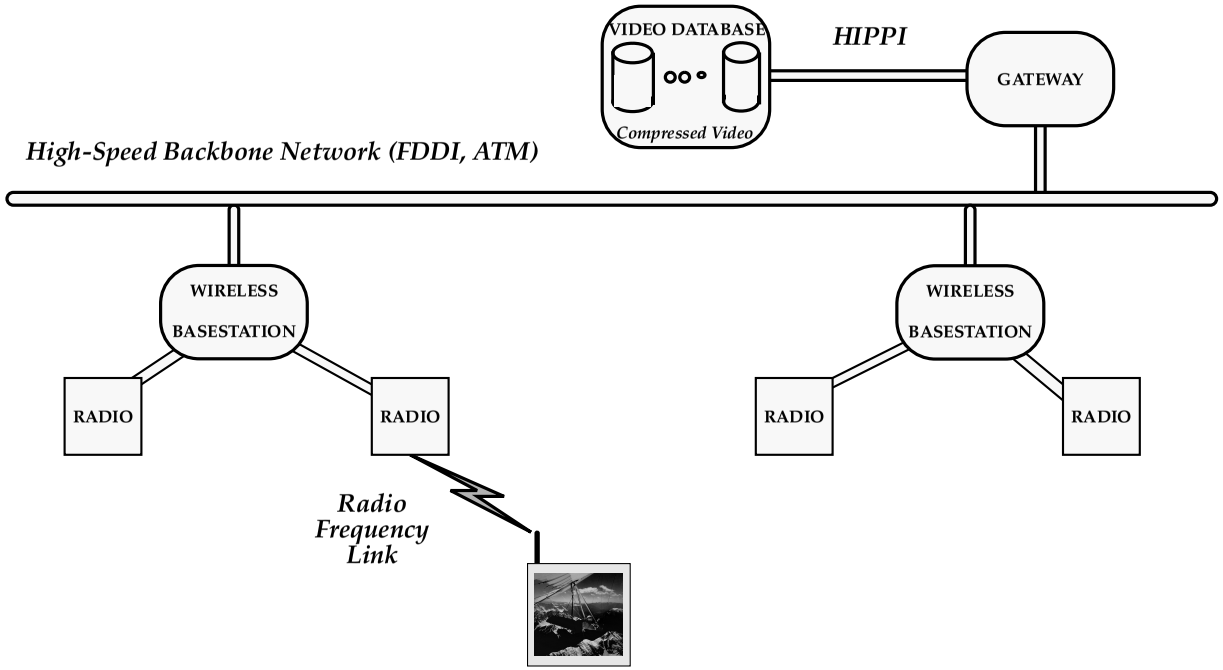
- **Conventional File System (e.g., BSD FFS)**
  - Logically contiguous file blocks not necessarily physically contiguous
- **Log-Structured File System (e.g., Sprite LFS)**
  - Allows efficient reads of data written at same time
- **Multiple Representation File System**
  - Minimizes seek time within data for a single stream
  - Minimizes penalty to switch between representations
  - Minimizes seek time between streams

Tenet Protocol Suite Mobility Extensions

- **Locate mobile hosts and compute routes**
- **Hide mobility from transport layer and above**
  - Fixed host addressing
- **Maintain connections in progress during handoffs**
  - Incremental re-establishment scheme
- **Minimize protocol state and overhead**
  - Ubiquitous computing: scalable to many users
  - Little compute power/hardware required for mobile unit

Incremental Re-establishment

Idea: Modify/re-establish connections as close to site of handoff as possible



Ptolemy Simulations

- **Video server**
  - Evaluate layout policies for multiple video representations
  - Examine Tenet Protocol performance under video server workload
- **Mobile host handoff**
  - Analyze overheads associated with incremental re-establishment scheme
  - Compare with other schemes

Summary

- **RAID-II and Tenet Real-Time Protocol Suite**
  - Provide a solid basis for video service
- **Heterogeneous host environment**
  - Multiple video representations
  - Video layout schemes
- **Host mobility**
- **Simulations in progress**
  - Video layout policies
  - Network protocol algorithms