Redundant Arrays

of IDE Drives

David Sanders, Lucien M. Cremaldi, Vance Eschenburg, Christopher N. Lawrence, Chris Riley, and Donald J. Summers

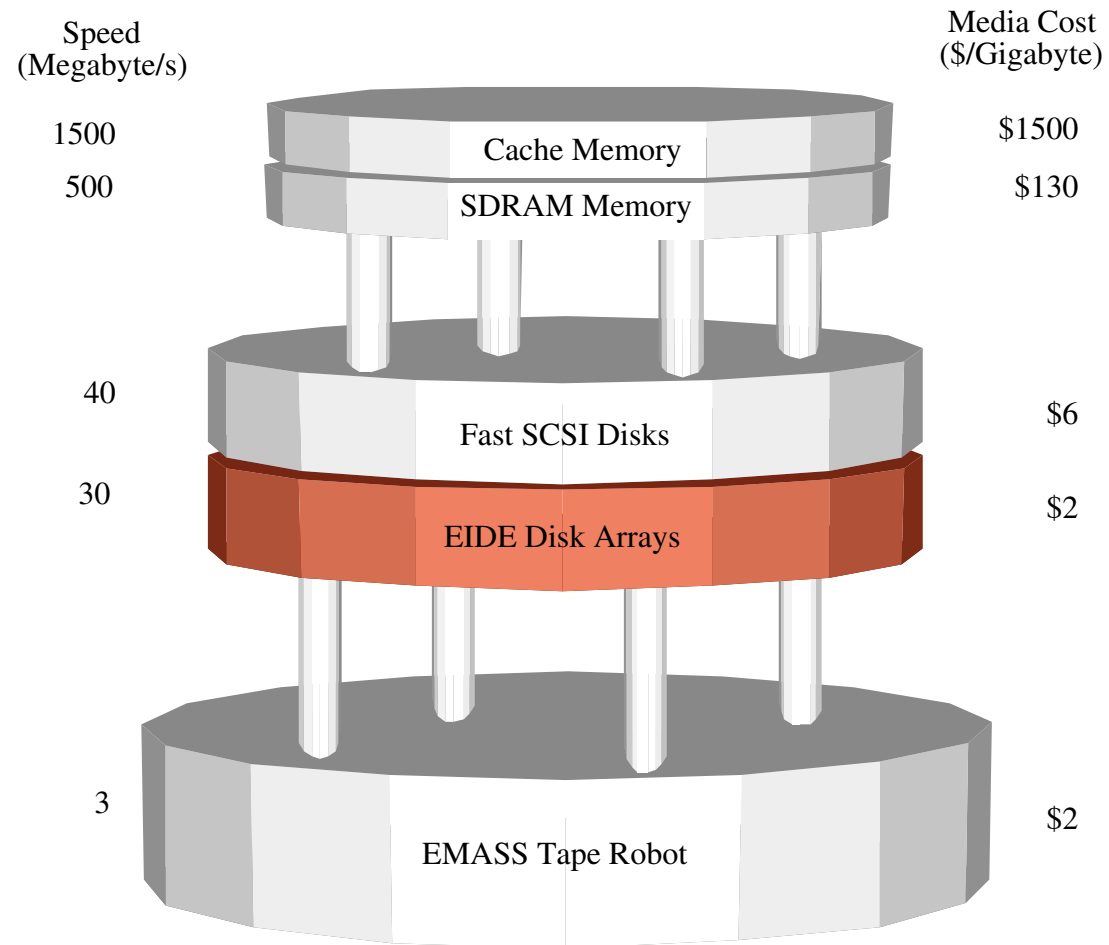## University of Mississippi

Donald L. Petravick

Fermilab

Introduction

- $4000 per Terabyte Storage is Available

- Scalable for use at both Small and Large Institutions — From 1 TB to 250 TB, the same as a $ Million tape silo.

- Fast Access to Data

- Redundant — RAID5

- Commodity Hardware

Data Storage Cake

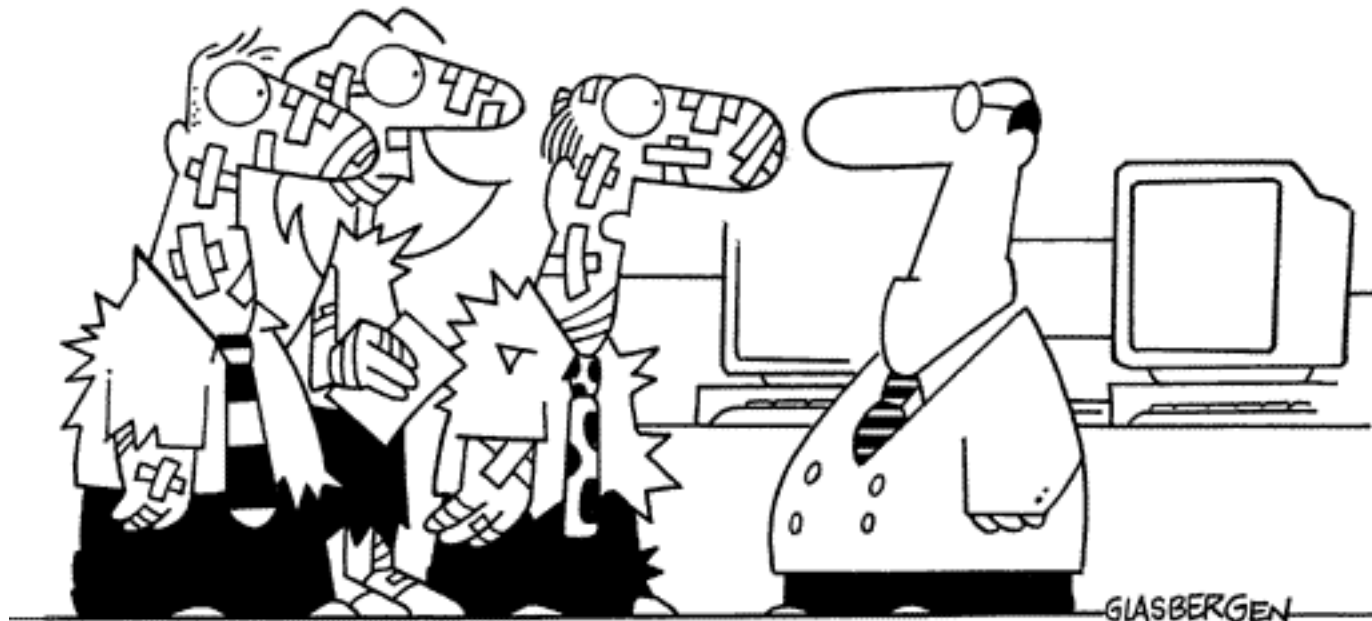| Speed (Megabyte/s)		Media Cost ($/Gigabyte)
1500	Cache Memory	$1500
500	SDRAM Memory	$130
40	Fast SCSI Disks	$6
30	EIDE Disk Arrays	$2
3	EMASS Tape Robot	$2

Definitions

- RAID — Redundant Array of Inexpensive Disks
- RAID level 0 — Concatination
- RAID level 1 — Mirroring
- RAID level 4 — Parity
- RAID level 5 — Striped-Parity
- EIDE — Enhanced Integrated Drive Electronics

Why Use Commodity Hardware?

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"Frankly sir, we're tired of being on the cutting edge of technology."

Hardware

- System Disk — 100 GB Maxtor
- Eight 100 GB Maxtor Disks
- 2 Promise Ultra100 PCI cards
- 24" EIDE Cables
- CPU — 1.4 GHz AMD Athlon
- Motherboard — Asus A7A266
- 512 MB DDR memory
- Second Power Supply (15A at 12V)

RAID5 Box for BABAR

Disks

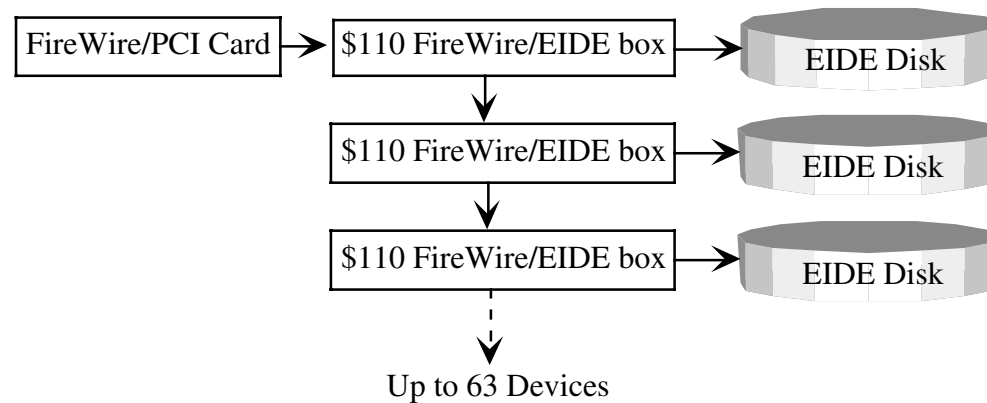| Disk	RPM	$/GB	GB/platter	Amps@12V
80 GB Maxtor	5400	1.88	20	2.000
100 GB Maxtor	5400	2.20	33	0.640
160 GB Maxtor	5400	2.05	40	1.800
75 GB IBM	7200	3.00	15	2.000

Software

- Linux 2.4.13 Kernel (2.4.5 Tested)
- raidtools available with most distributions
- Journaling File systems (ReiserFS and ext3)
- NFS to mount on other computers (Linux, Sun Solaris, DEC Ultrix, Mac OSX)
- HDPARM speed test (~28 MB/s)
- Simple write test (22 MB/s)

FireWire™

- 63 Disks per chain

- 10 Terabytes per chain using 160 GB disks

- Hot swapable (Using Firewire™ Hubs)

- We tested RAID5 in Linux
  (Oxford 911 chipset)

```
FireWire/PCI Card ──→ $110 FireWire/EIDE box ──→ [ EIDE Disk ]
                              │
                              ↓
                      $110 FireWire/EIDE box ──→ [ EIDE Disk ]
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                      $110 FireWire/EIDE box ──→ [ EIDE Disk ]
                              ┊
                              ↓
                       Up to 63 Devices
```
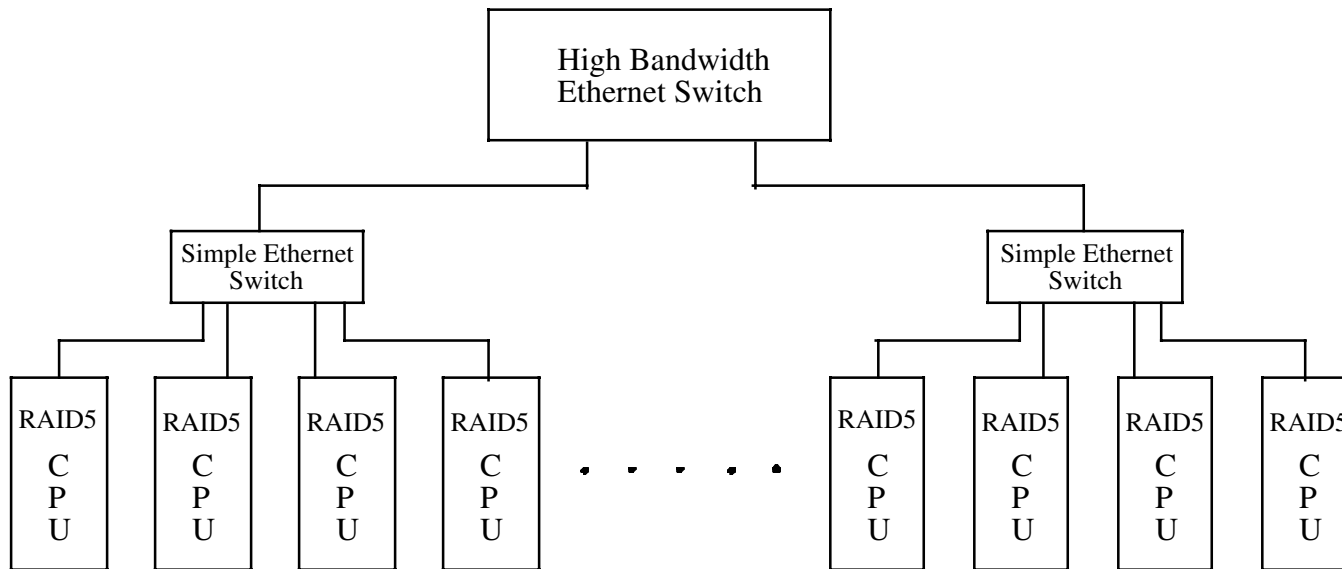
High Energy Physics Data Analysis Strategy

- Use Parallel Processing

- Split data and store on many RAID5 PCs

- Analysis for a subset of data takes place locally on the PC where the data resides

- Network is only used to combine results

- Or use NFS to mount RAID5 array on many PCs (Less efficient due to network overhead)

High Energy Physics Cluster

High Bandwidth
Ethernet Switch

Simple Ethernet
Switch

Simple Ethernet
Switch

RAID5
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Moving Data to Institutions

- Internet transfers

- Hot pluggable EIDE disks in Firewire cases

- DVD-R disks — 4.7 GB DVD-R disks are now $6, the DVD writer is only $500, and the DVD-ROM reader is $60.

Summary

- $4000 per Terabyte RAID5 arrays of EIDE Drives tested, without tape backup.

- They are Scalable —Same cost/TB as a tape silo, but scalable down to 1 TB.

- Uses Commodity Hardware.

- FireWire has been tested in Linux