COPAN SYSTEMS

MAID (Massive Array of Idle Disks)

Meeting the Long-Term Data Challenge

Dr. Aloke Guha

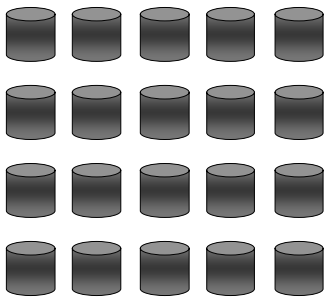
CTO, COPAN Systems
2605 Trade Center Drive, Ste D
Longmont, CO 80503
Email: aloke.guha@copansys.com
Phone: (303) 827 2500 FAX: (303) 827 2504

Presented at the THIC Meeting at the National Center for Atmospheric Research
1850 Table Mesa Drive, Boulder CO 80305-5602
June 29, 2004

The Premier Advanced Recording Technology Forum

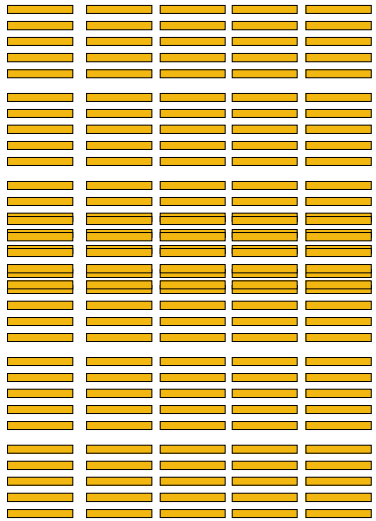
THIC Inc.

Traditional Storage Hierarchy



Backup/Migrate

Recover/Restore



Offline Tape

Primary Disk

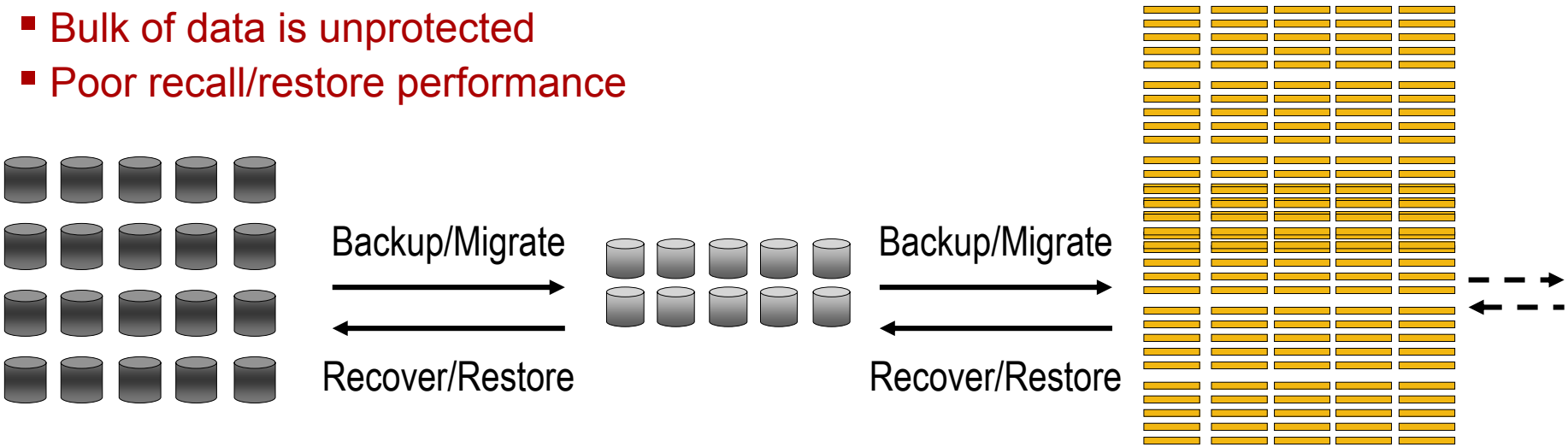
- Fibre Channel
- $30-$100/GB
- 15%
- ms
- RAID

Nearline Tape

- $0.75 - $3.5/GB
- 85%
- 100s TB - PB
- sec – min . . . hrs

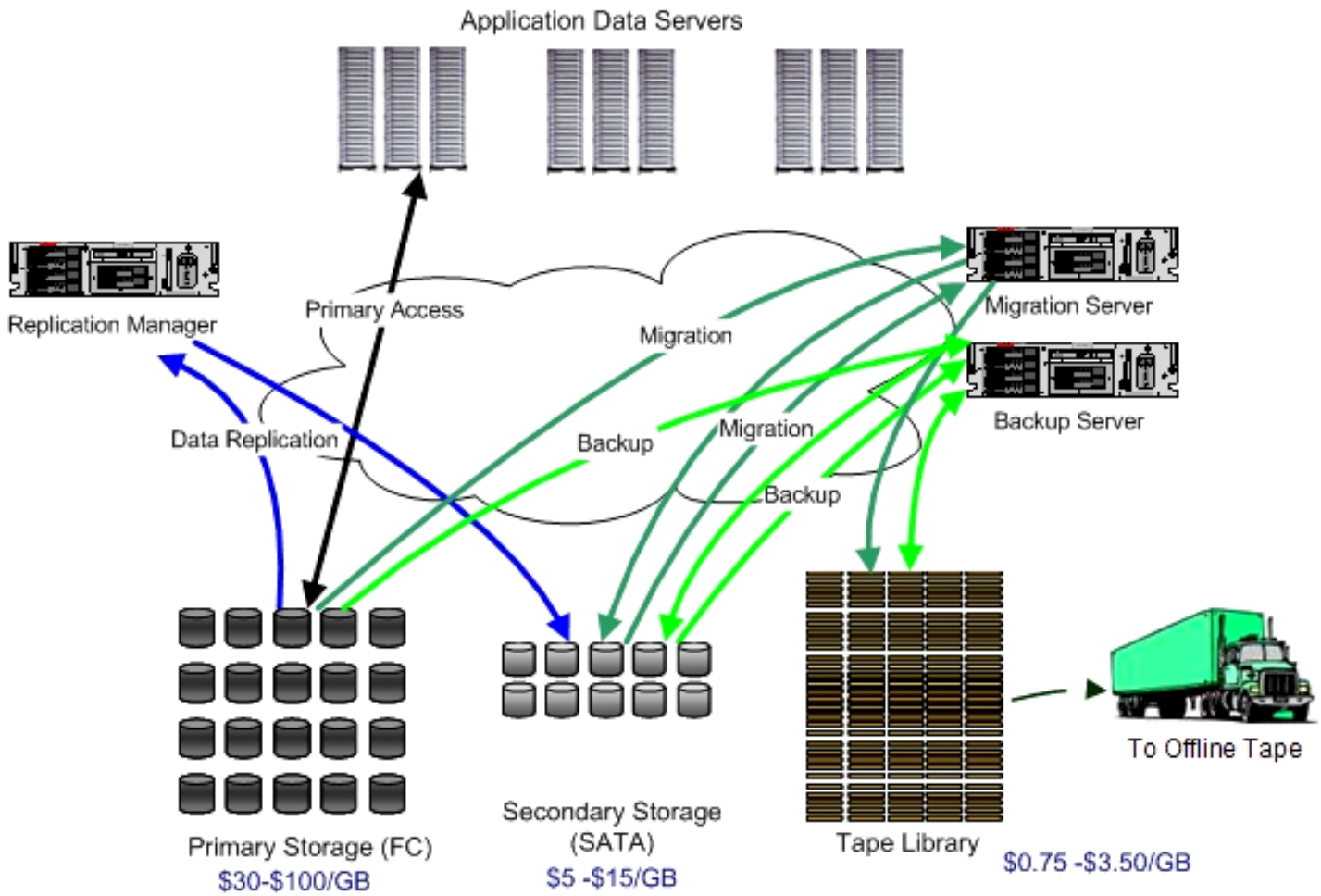
Today's Storage Hierarchy

- Bulk of data stays on tape
- Bulk of data is unprotected
- Poor recall/restore performance



Primary Disk	Secondary Disk	NearlineTape
• Fibre Channel • $30-$100/GB • 10% • ms • RAID	• SATA • $5-$15/GB • 5% • ms • RAID	• $0.75 - $3.5/GB • 100s TB – PB • 80% • sec – min . . . hrs

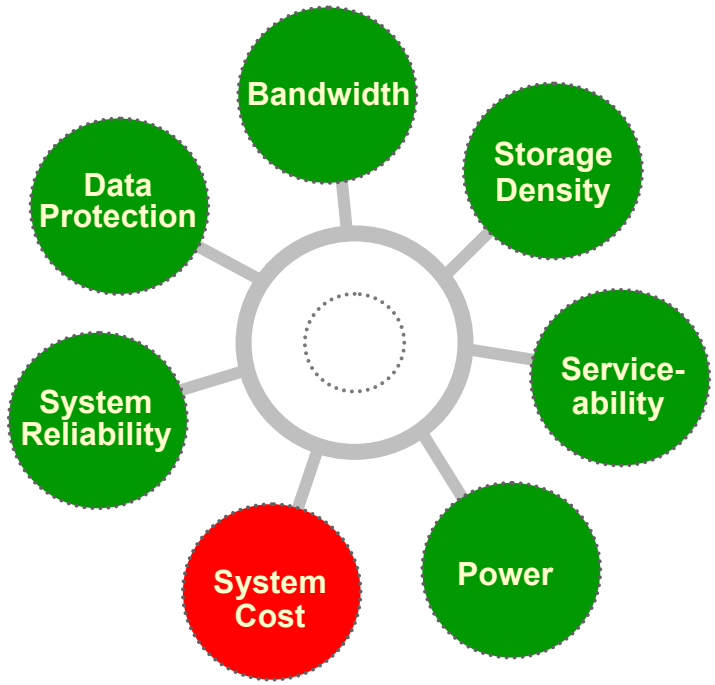
Information Management Complexity



- Frequent Data Movement
- Physical tape handling
- Network, Server Utilization
- CAPEX, Labor Cost

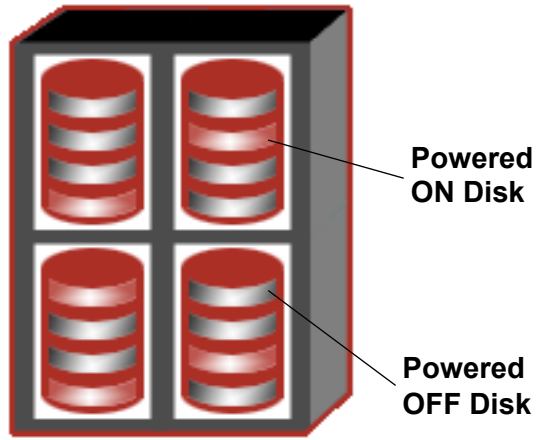
Application-Driven Approach to Storage

- Secondary Storage Needs
  - I/O: Sequential or Predictable Access
  - Performance: Mbytes/sec, not IOPs
  - Latency: msecs - secs
- Design Guidelines
  - No need for large RAM cache
  - No need to access all data at all time
  - No need for non-blocking interconnect
  - High Capacity/Bandwidth ratio
  - Data Availability/Integrity
  - Data Retention
  - Serviceability



MAID: Power-Managed Disks

- Large # power-managed disks
  - > 50% drives powered OFF*
  - Power-cycling by policy
  - Defined in SNIA
- Scale, Cost, Service Life
- Lower Cost/Drive
  - 1/4 - 1/3 of typical RAID systems
  - Lower management cost
- Extending MAID
  - Performance and scale
  - Reliability
  - Cost

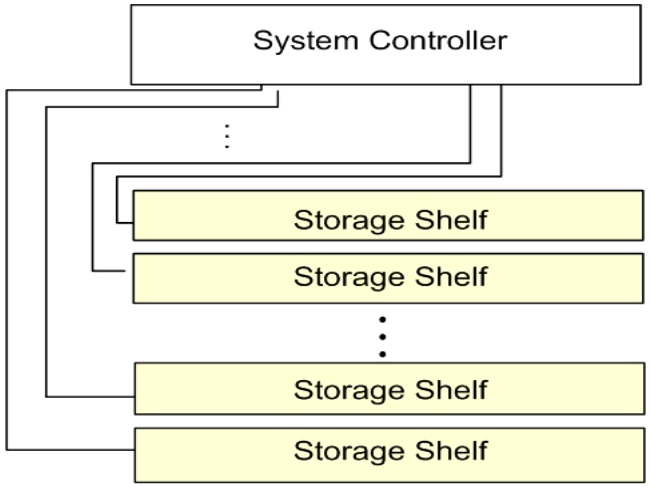


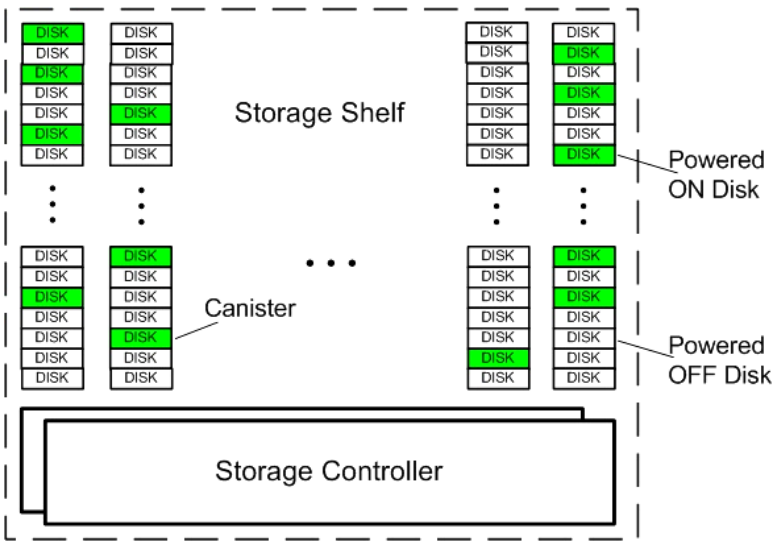
***SNIA ILM TWG Definition**

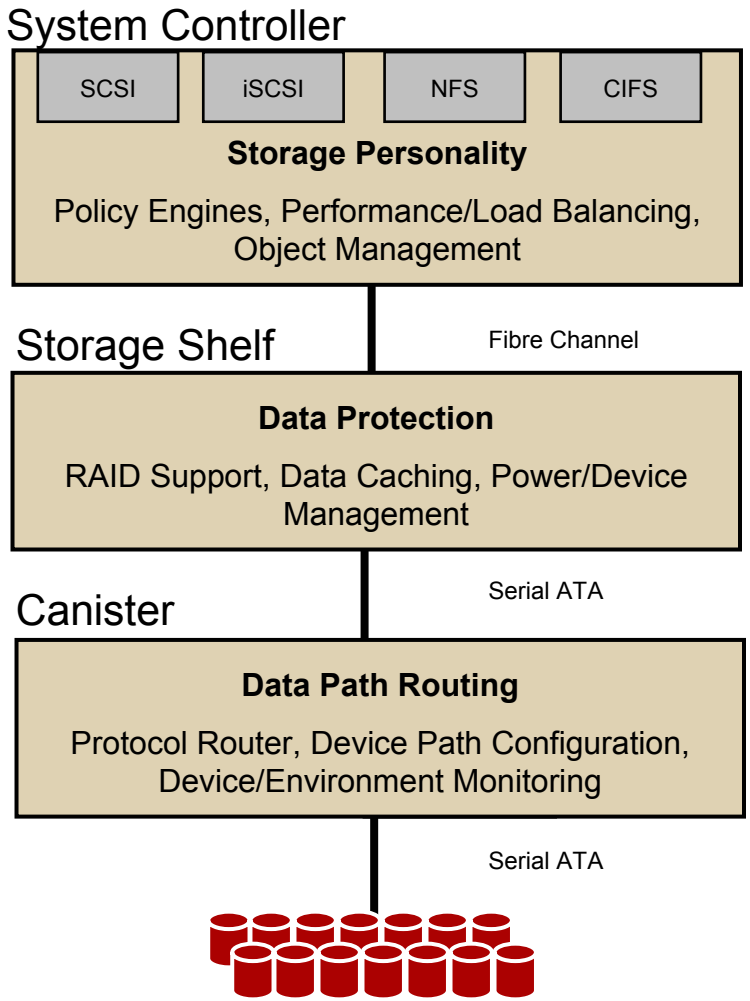
Refers to a storage system comprising a very large array of disk drives where a majority of the drives are powered off. The goal of a MAID storage system is to reduce the energy consumed by a large-scale storage array while increasing storage density and maintaining performance similar to conventional disk arrays or tape libraries.

*Colarelli and Grunwald, The Case for Massive Arrays of Idle Disks (MAID), Usenix FAST 2002

Extending MAID: Scalable Architecture

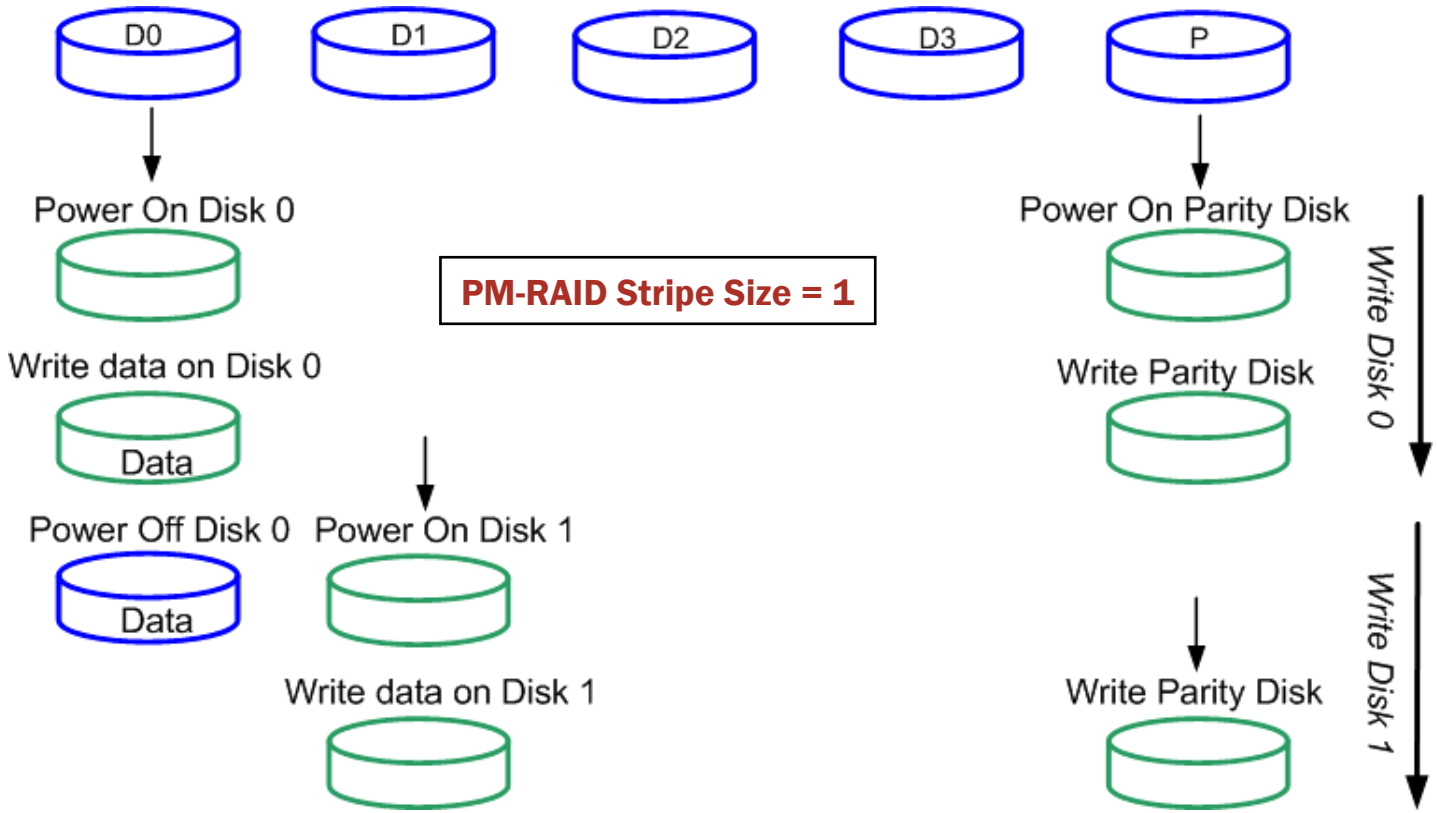






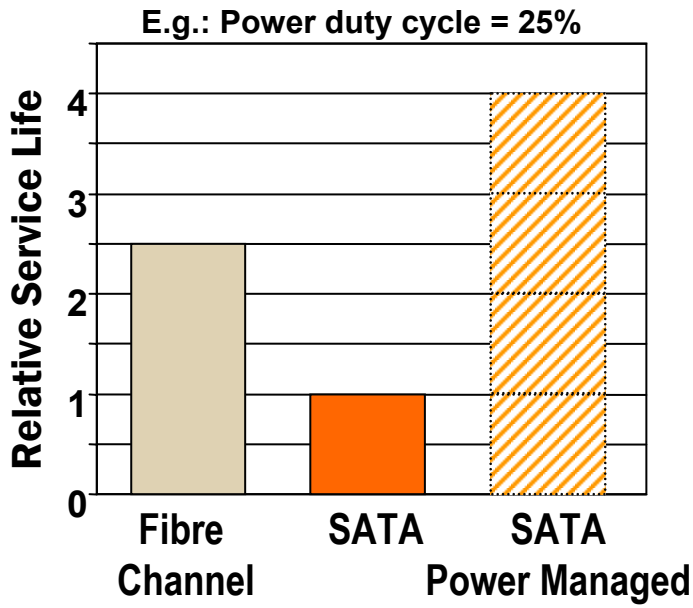
Extending MAID: Power-Managed RAID™

- Data protection with only subset of drives powered in RAID group
- Number of drives powered dictated by application needs
- Multiple options on data organization to support application



Increased Disk and System Reliability

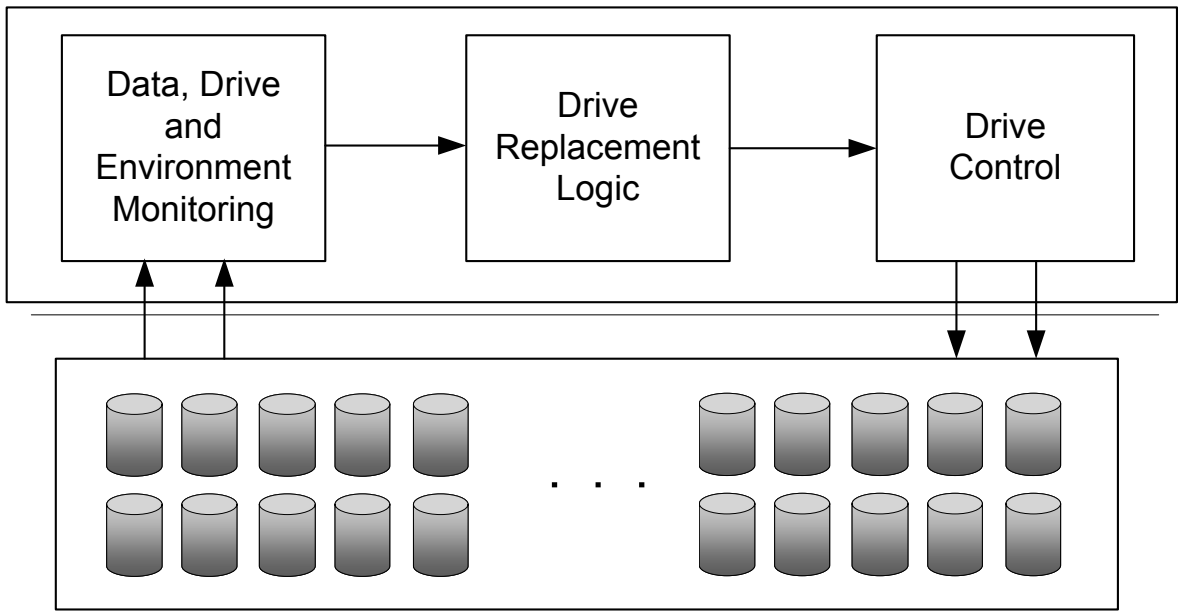
- Effective drive service life
  - Increases with decreasing duty ratio*
- Increases Data Reliability
- Explicitly manage start stops
  - ≤ 50K over service life
  - Match to application need
- Use disk density for availability
  - Spares to replenish failed drives
  - Rebuild data transparently
  - Data Revitalization for Long-Term Data



*Power duty cycle ratio = # of powered-ON drives/# of powered-OFF drives

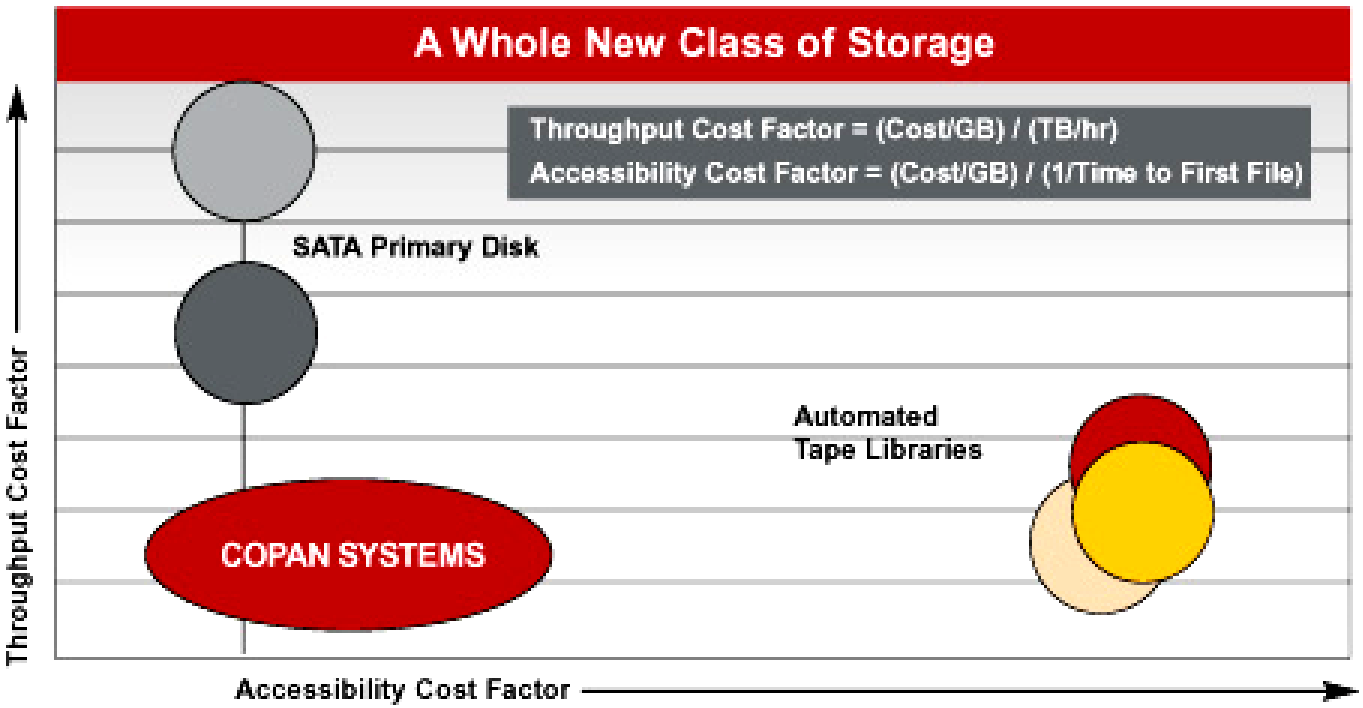
Extending MAID: Data Reliability

- Device health monitoring
- Proactive data management: closed-loop control
- Revitalize data on disk for long-term data retention
- System data integrity mechanisms



Filling the Performance Gap

- Fraction of data on-line: ~10X tape
- Design: RAID processing, Interconnect Bandwidth, Disk Cache



Exploiting Disk Performance: Data Rate

- Disk Drive bandwidth
  - 40 MBs+ media; 150 MBs SATA interface
- Power-managed RAID in shelf
  - Bandwidth increases with stripe size
  - I/O rate increases with block size
- Aggregation Benefits
  - Multiple streams/shelf
  - Multiple shelves
- Results
  - 90 MBs/single stream uncompressed/shelf
  - Over 720 MBs for 8-shelf system
  - Further Improvements: Tuning, Compression

Exploiting Disk Performance: Access Time

- Access Time: 10X better than tape
  - Powered ON Drive: access time is in ms
  - Powered OFF Drive: 6s spin-up time, 10s data access

Random Access of File/Drive: uncompressed 100 MB

9940B TAPE: streaming @ 30MB/sec

Load	Ave. Time to 1st Byte*	File Xfer	Unload
18 sec	41 sec	3.3 sec	18 sec

Total: 80 sec

SATA 7200 RPM Disk: streaming @ 40 MB/sec – increases with RAID

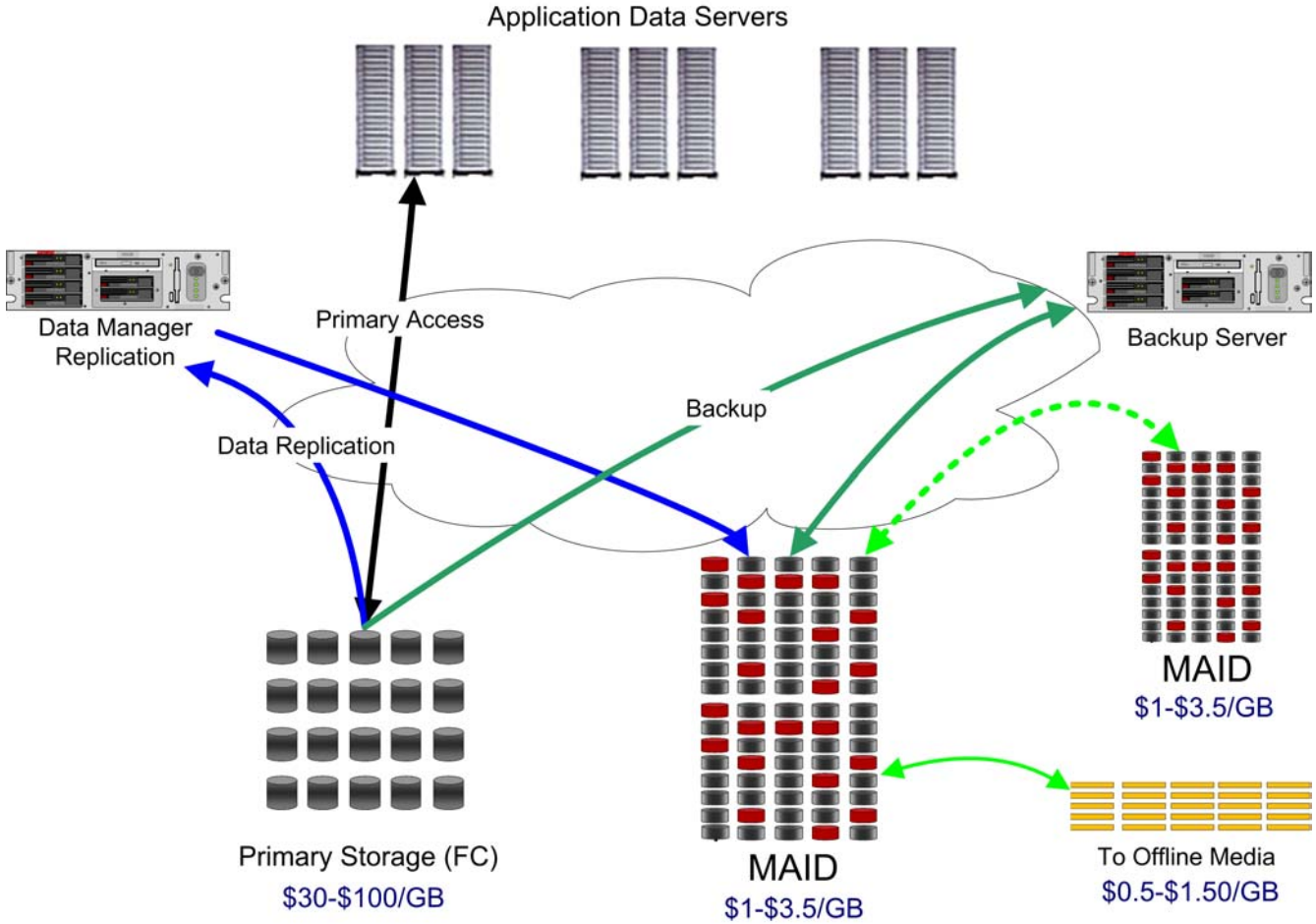
Spin up	Ave. Time to 1st Byte	File Xfer	Spin down
ms-6 sec	0.1 sec	2.5 sec	0.1 sec

Total (power-off AND cache miss): 8.7 sec*

Total (power-on OR disk cache): 2.7 sec

*Ave. time to first byte on tape depends on location of file (0 - 90 s)

Simplifying Information Management



- CAPEX
- Performance
- Data Protection, Longevity

- Minimize Data Movement
- All Data Accessible All Time
- Reduced Management Cost

First Commercial MAID: Revolution 200T

8 shelves,
8 canisters each,
14 drives each

896 drives

224 TB
in a single rack!
(uncompressed)

Performance
2.4TB / HR

~22TB/sq. ft.

Purpose Built Architecture

- Optimized cost, density, performance and reliability
- Spin disks only when necessary
- Performance for bandwidth, not IOPS

Enterprise Reliability

- Long term reliability with SATA
- Validation and revitalization of data
- RAID protected

Conclusions

- MAID: exploits best of disk and tape
- Extensions meet secondary storage needs
  - Capacity and Cost
  - Reliability: Power-Managed RAID
  - Performance: Bandwidth, Access Time
  - Serviceability
  - Retention
- Filling the Gap in the Storage Hierarchy
- Simplifying Long-Term Data Management