Lecture 26: Input/Output—Beyond Disk Arrays: Automated Data Libraries

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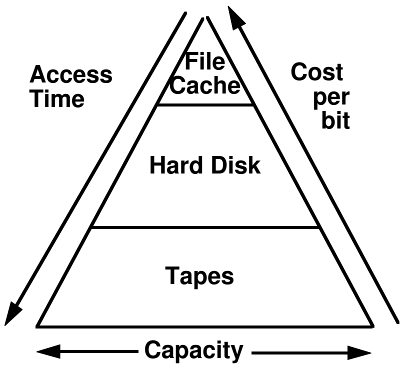
Computer Science 252

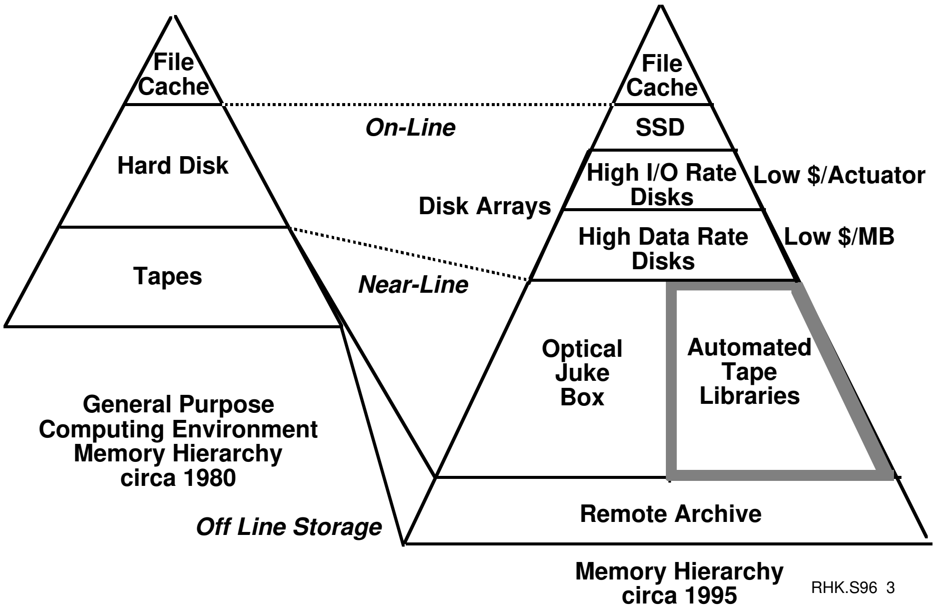
Spring 1996

Memory Hierarchies



General Purpose Computing Environment Memory Hierarchy circa 1980

Memory Hierarchies



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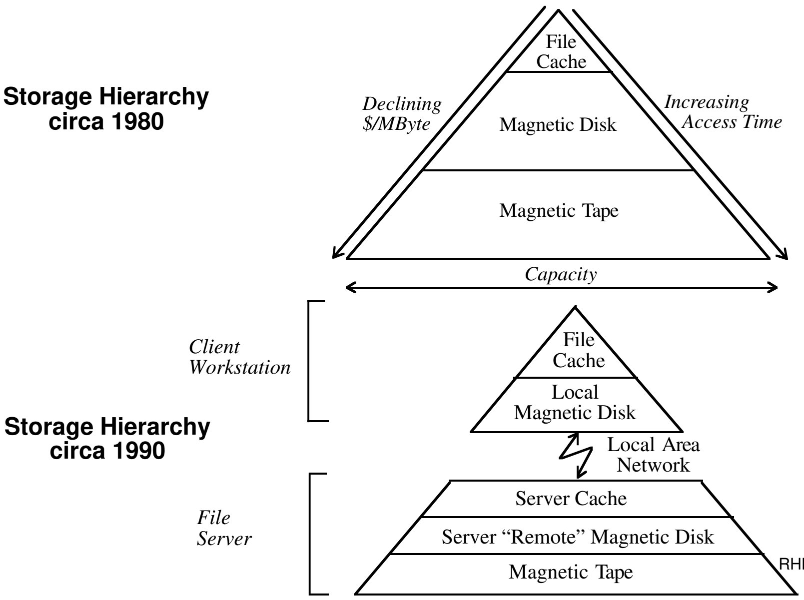
Storage Trends: Distributed Storage



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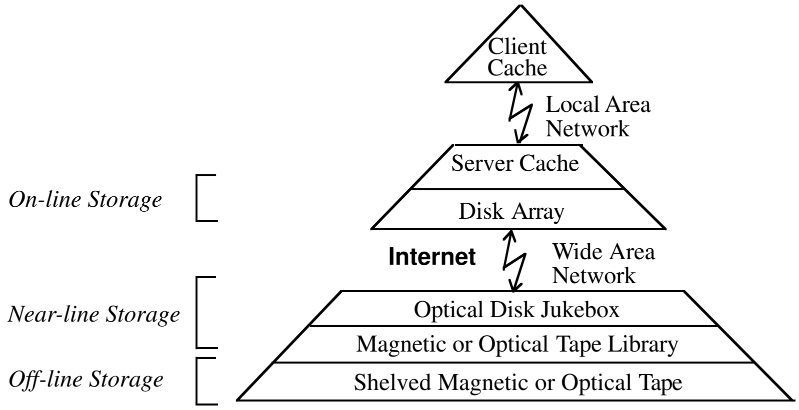
Storage Trends: Wide-Area Storage



Typical Storage Hierarchy, circa 1995

Conventional disks replaced by disk arrays

Near-line storage emerges between disk and tape

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What's All This About Tape?

Tape is used for:

- **Backup Storage for Hard Disk Data**

  Written once, very infrequently (hopefully never!) read

- **Software Distribution**

  Written once, read once

- **Data Interchange**

  Written once, read once

- **File Retrieval**

  Written/Rewritten, files occasionally read

  Near Line Archive

  Electronic Image Management

Relatively New Application For Tape

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Alternative Data Storage Technologies

Cap	BPI	TPI	BPI*TPI	Data Xfer		Access Time	
Technology	(MB)			(Million)	(KByte/s)		
Conventional Tape:							
Reel-to-Reel (.5")		140	6250	18	0.11	549	minutes
Cartridge (.25")	150	12000	104	1.25	92	minutes	
Helical Scan Tape:							
VHS (.5")	2500	17435	650	11.33	120	minutes	
Video (8mm)*	2300	43200	819	35.28	246	minutes	
DAT (4mm)**	1300	61000	1870	114.07	183	20 seconds	
Disk:							
Hard Disk (5.25")		760	30552	1667	50.94	1373	20 ms
Floppy Disk (3.5")		2	17434	135	2.35	92	1 second
CD ROM (3.5")		540	27600	15875	438.15	183	1 second

* Second Generation 8mm: 5000 MB, 500KB/s
** Second Generation 4mm: 10000 GB

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R-DAT Technology

Two Competing Standards

DDS (HP, Sony)

- 22 frames/group
- 1870 tpi
- Optimized for serial writes

DataDAT (Hitachi, Matsushita, Sharp)

- Two modes: streaming (like DDS) and update in place
- Update in place sacrifices xfer rate and capacity

  Spare data groups, intergroup gaps, preformatted tapes

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R-DAT Technology

Advantages:

- Small Formfactor, easy handling/loading
- 200X speed search on index fields (40 sec. max, 20 sec. avg.)
- 1000X physical positioning (8 sec. max, 4 sec. avg.)
- Inexpensive media ($10/GBytes)
- Volumetric Efficiency: 1 GB in 2.5 cu. in; 1 TB in 1 cu. ft.

Disadvantages:

- Two incompatible standards (DDS, DataDAT)
- Slow XFER rate
- Lower capacity vs. 8mm tape
- Small bit size (13 x 0.4 sq. micron) effect on archive stability

RDAT Technical Challenges

Tape Capacity

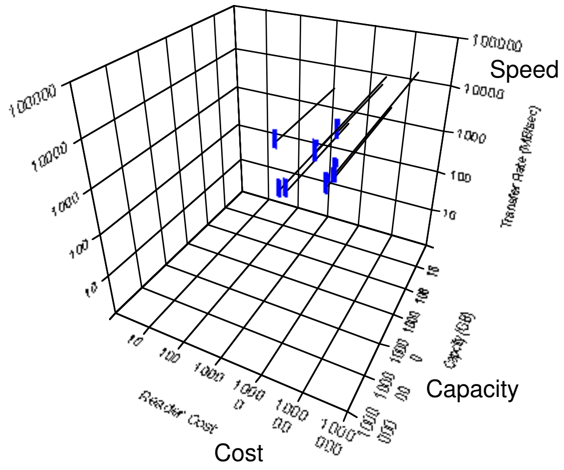
- Data Compression is key

Tape Bandwidth

- Data Compression
- Striped Tape

MSS Tape: No “Perfect” Tape Drive

- **Best 2 out of 3 Cost, Size, Speed**
- **Expensive (Fast & big)**
- **Cheap (Slow & big)**



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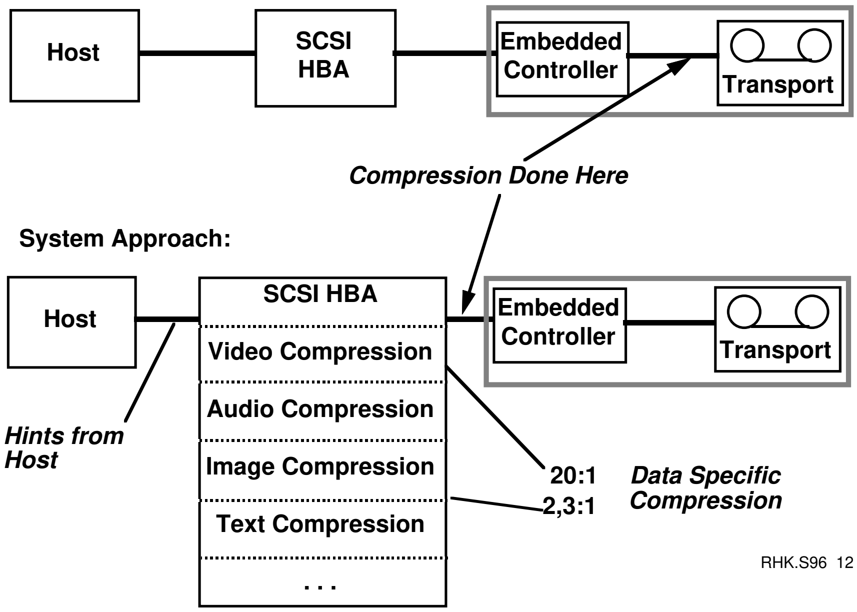
Data Compression Issues

Peripheral Manufacturer Approach:



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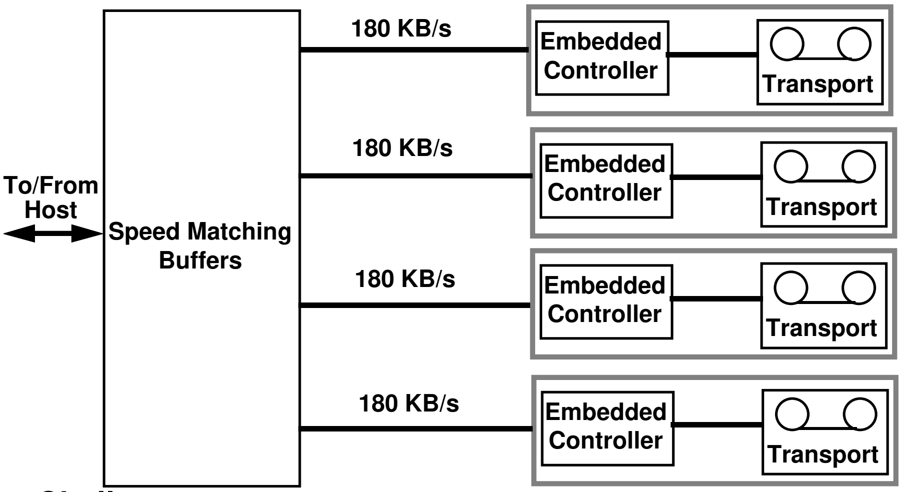
Striped Tape



Challenges:

- **Difficult to logically synchronize tape drives**
- **Unpredictable write times**

R after W verify, Error Correction Schemes, N Group Writing, Etc.

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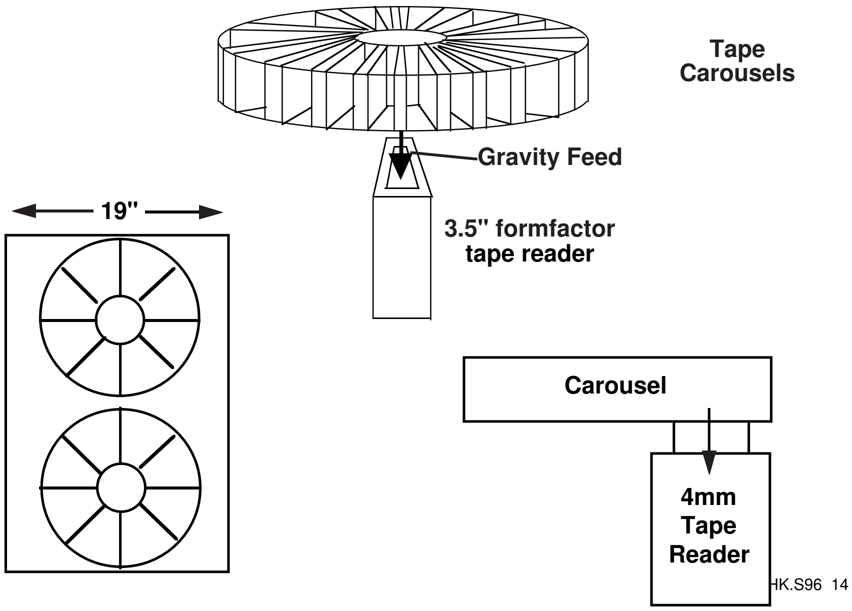
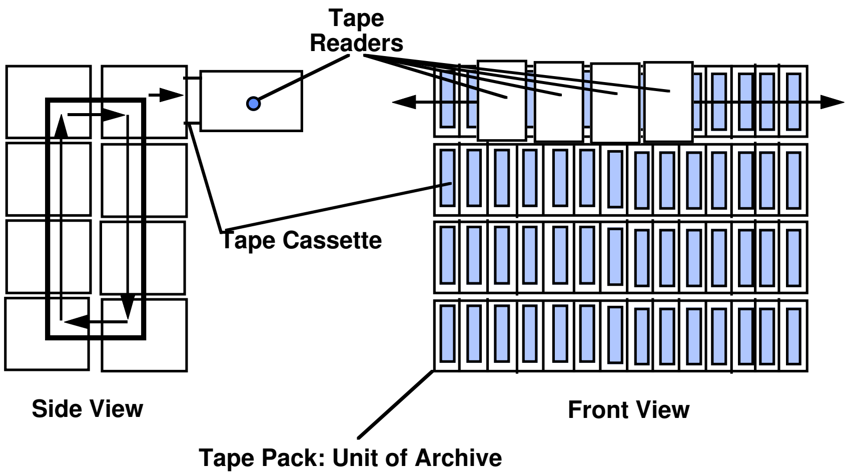
Automated Media Handling



Automated Media Handling



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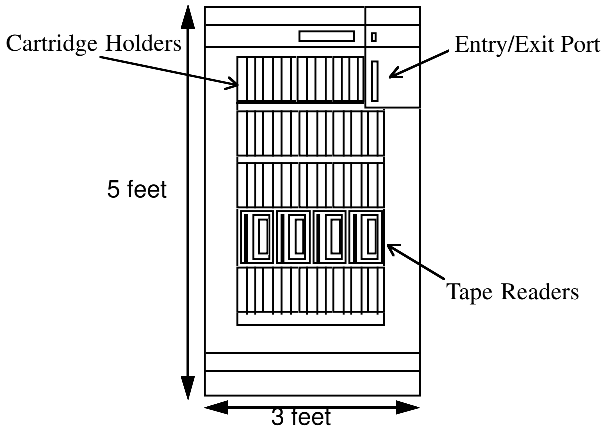
MSS: Automated Tape Library

EXB-120



- **116 x 5 GB 8 mm tapes = 0.6 TBytes (1991)**
- **4 tape readers 1991, 8 half height readers now**
- **4 x .5 MByte/second = 2 MBytes/s**
- **$40,000 O.E.M. Price**
- **Predict 1995: 3 TBytes; 2000: 9 TBytes**

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Open Research Issues

- Hardware/Software attack on very large storage systems
  - File system extensions to handle terabyte sized file systems
  - Storage controllers able to meet bandwidth and capacity demands
- Compression/decompression between secondary and tertiary storage
  - Hardware assist for on-the-fly compression
  - Application hints for data specific compression
  - More effective compression over large buffered data
  - DB indices over compressed data
- Striped tape: is large buffer enough?
- Applications: Where are the Terabytes going to come from?
  - Image Storage Systems
  - Personal Communications Network multimedia file server

MSS: Applications of Technology Robo-Line Library

Books/Bancroft	x Pages/book	x bytes/page	= Bancroft
372,910	400	4000	= 0.54 TB

Full text Bancroft Near Line = 0.5 TB;

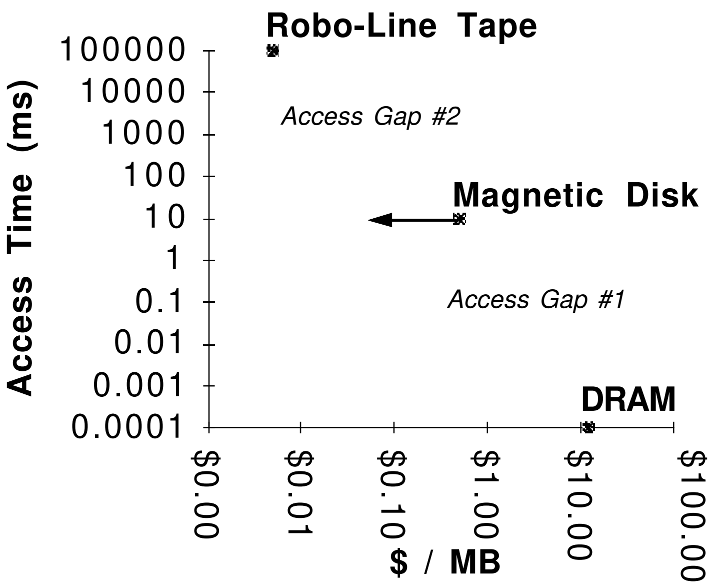
Pages images ≈ 20 TB

Predict: "RLB" (Robo-Line Bancroft) = $250,000

Bancroft costs:

Catalogue a book:	$20 / book
Reshelve a book:	$1/ book
% new books purchased per year never checked out:	20%

MSS: Summary



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