Storage Trends Disk, Optical, Tape

Theodore Johnson AT&T Labs - Research

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Technology Drivers

- Application pull
 - What do current markets demand?
 - Especially relevant to removable media.
 - Entertainment market
 - Backwards compatibility
- Technology push
 - Crossover technology
- \$\$\$
 - Magnetic Disk: \$30 billion (1996)
 - Optical disk: \$6 billion (1996) (\$4.6 billion for CDROM)
 - Tape: \$4.6 billion (1996)

Storage Trends

- Disk is rapidly getting cheaper.
- Trend line : soon will be cheaper than tape.
- Which trend line
 - Are we comparing apples to oranges?
- Predicting the future
 - Will magnetic disk continue on its trend line?
 - Will optical disk or tape start moving faster?

Trends: Magnetic Disk vs. Semiconductor Memory



Trends: Magnetic Disk vs. Tape

Storage Subsystem Cost Trends



Trends: magnetic disk vs. tape



Magnetic Disk Trends

- Short term
 - 60% per year improvement will continue
- Long term
 - Fundamental limitations on bit density to be overcome.
 - Expert opinion is that improvement will continue.
- Fundamental advantages:
 - \$\$\$
 - No need for backwards compatibility
 - Not limited by need for data interchange.

Magnetic disk trends



Magnetic Disk Technology Trends



Optical disk trends

- Need for compatibility limits rate of change.
 - Use for data interchange limits adoption of new technology.
- The driver is the application, not the technology.
- MO is already considered obsolete by many.
 - But is considered more reliable than other technology.
- New technology to the rescue?



Optical Disk Technology Trends



Optical Disk Trends

Product Roadmap

LD4000	5.6 GB 1024 E	lytes	SCSI F/N
	Sustained Data-rate Write 0.3 Ml Compatibility: None	B/s - Read 0.7 MB/s Recording Technology:	Transfer rate: 4 MB/s Ablative WORM
LD6000	12 GB 1024 B	ytes	SCSI F/N
	Sustained Data-rate Write 1.1 MB Compatibility: read LM4000	/s - Read 2.7 MB/s Recording Technology:	Transfer rate: 10 MB/s Ablative WORM
LD8000	30 GB 2048 B	ytes SCSI F	/W FIBRE Bridge
	Sustained Data-rate Write 2.4 MB Compatibility: read LM4000 & L	/s - Read 6.0 MB/s M6000 Recording Tea	Transfer rate: 20 MB/s chnology: Phase Change WORM
LD10000	60 GB 2048 E	ytes Ultra	SCSI F/W FIBRE
	Sustained Data-rate Write 3 MB/s Compatibility: read LM6000 & L	- Read 7 MB/s M8000 Recording Tech	Transfer rate: 40 MB/s nology: Phase Change WORM Multi-
	Layer (4)	-	No. Plasmon

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New Technologies

- Terastor
 - Solid immersion lens
 - HDD-like flying head
 - Smaller dot size than normal optics allow.
 - 20 Gbyte/side
 - clear path to increased densities.
 - Quantum
- Norsam technologies
 - Electron beam etching
 - IBM

Optical Disk Technology Alternatives



Trends in Tape Storage

- Advantages of tape:
 - Lots more surface area.
 - Automated tape library.
- Disadvantages
 - Need for backwards compatibility.
 - Lower bit density.
 - Tape head abrasion
 - Problems in tracking
 - Lower technology in RW heads.
- Improvements
 - Use magnetic disk technology
 - Laser assisted tracking, thinner tape substrate, etc.
 - Optical tape.

Bit Density

Tape Has the Capability to Maintain Its Storage Capacity Advantage



Current Drives

Today's Users Have a Choice of Many Different Tape Technologies

Tape	<u>Media</u>	<u>Drive</u>	Native <u>Capacity</u>	Native Data Rate	Drive <u>Maker</u>
DD-2 L					
19mm eliçal	MP	D\$T-312	330 GB	15 MB/s	Ampex
SD⊮3 ″elical	MP	Redwood	50 G B	11 MB/ş	StorageTek
AIT-2					
8mm elical	AME	<u>SD-5000C</u>	50 GB	MB/ş	Sony
DTF-1 ″elical	MP	DTF-1	42 G B	12 MB/s	Sony
DLTtape IV "Linear	MP	DLT-8000	40 GB	MB/s	Quantum, Tandberg
SLR50 ″Linear	MP	SLR50	25 G B	2 MB/ş	Tandberg
Magstar-3590 ″ Linear	MP	3590-E	20 G B	14 MB/ş	IBM
Mammoth-1 8mm elical	AME	Mammoth (8900)	20 G B	3 MB/s	Exabyte
DDS4 150M 4mm elical	MP	DD \$-4	20 GB	2.7 MB/s	Seagate, Sony, P
NCTP "Linear	MP	NCTP	18 G B	10 MB/s	Plasmon LMS

High-Capacity Tape Technologies

15 7/14/99

Next Generation

New Industry Offerings Continue to Expand User's Choices

Net Generation High-Capacity Tape Technologies

Таре	Media	Drive	Native Capacity	Native Data Rate	Drive Maker
DTF-2					
" elical	MP	G -4240	200 GB	24 MB/s	Sony
<i>Super</i> DL T * Linear	АМР	Super DLT-	100 GB	10 - MB/s	Quantum, Tandberg
LTO Ultrium "Linear	АМР	LTO Ultrium-	100 GB	10 - 20 MB/s	Fujitsu, IBM, Seagate, P
Mammoth-2 8mm elical	AME	Mammoth-2	0 GB	12 MB/s	Exabyte
SLR100 "Linear	MP	SLR100	50 GB	5 MB/s	Tandberg
V A 8mm elical	AME	V A-1	45 GB	3 MB/s	Ecrix
Magstar 3590 E " Linear	MP	3590-E	40 GB	14 MB/ş	IBM
ADR70 8mm Linear	Co Fe ₂ O ₃	ADR70	35 GB	2 MB/s	OnStream

Products expected to impact the market within the next one to twelve months.

Ecrix currently shipping 33GB V A On Stream cur

OnStream currently shipping 25GB ADR

16 7/14/99

Some Projections

Technology Futures Comparison

	1998		19	1999		00	
	1 H	2H	1 H	2 H	1H	2 H	
Capacity: AIT	25	35	50	50	50	100	
DLT	35	35	35	100	100	100	
EXB	20	20	20	60	60	60	
LTO	N,	/ A		??	100	100	
Data Xfer: AIT	3.0	3.0	6.0	6.0	6.0	12.0	
DLT	5.0	5.0	5.0	10.0	10.0	10.0	
EXB	3.0	3.0	3.0	12.0	12.0	12.0	
LTO	N,	/ A		??	10.0	10.0	



SONY

Projections

Storagetek 9480

	<u>1998</u>	<u>1999</u>	<u>2000</u>	<u>2001</u>	<u>2002</u>	2003
Mass Storage Tape	e (9480)					
 Capacity GB 			65	100	200	400
•Data Rate MB/s			10	30	30	40
Performance Tape	<u>(9840)</u>					
 Capacity GB 	20	20	20	20	40	120
•Data Rate MB/s	10	10	20	20	20	40

Vendor Projections

- Quantum : Super DLT
 - End of '99: 100 GB/tape, 10 Mbyte/sec
 - Evolve to : 1 TB/tape, 100 Mbyte/sec
 - DLT 7000: 35 Gbyte/tape, 5 Mbyte/sec, 1997.
- Linear Tape Open (IBM, HP, Seagate)
 - '00: 100 Gbyte/tape, 10 Mbyte/sec
 - 4th generation: 800 Gbyte/tape, 80 Mbyte/sec
- Sony AIT
 - Double capacity every 2 years.
- Lots Technologies (Optical tape)
 - End of '00: 1.4 Tbyte/tape, 25 Mbyte/sec
 - Mid '01 : 2.0 Tbyte/tape, 40 Mbyte/sec
- Storagetek 9840
 - 65 Gbyte/cartridge in '00, 400 Gbyte/cartridge '03

Conclusions

- Magnetic disk will continue getting cheaper at 60%/year.
- Optical disk improves at a much slower rate
 - New technology.
- Tape systems are improving.
 - Double capacity every 1-2 years?
 - New technology
 - Optical tape
- Will magnetic disk make optical, tape obsolete?
 - Perhaps
 - But not if vendors live up to their claims.

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