

Storage Technology Trends

Three or four technologies:

- Hard disk, magnetic tape, optical disk, (holographic?)

- Consumer markets attract the major investments

 - CD-audio disk, VCR tape brought major advances

 - DVD media currently the cheapest per GB

 - miniDV tape newest development

 - Next consumer outlet – hard disk for settop box

Information sources from the storage industry:

- Thompson and Best article on magnetic recording (IBM JR&D)

 - Note figs. 1, 2, 12

- NSIC studies

 - Optical Disk Roadmap, 2/2000

 - Holographic Storage, 3/1999

 - May displace tape someday, not before 2010

 - Tape Roadmap, 6/1998

 - (As reviewed by “spy tape” users in 2001)

How they work:

- Magnetic storage

 - Writing by inductive (thin film) heads, continuous media

 - Reading is inductive for tape, magnetoresistive for HD

 - Inductive signal proportional to medium speed

 - MR signal is “medium noise limited”

 - Limits are thermal demagnetization

 - Proposed solution – nanopatterned bits

- Optical

 - Has least expensive “printing” technologies

 - Laser to read or write benefits from shorter wavelengths

 - Less delicate than tape or hard disk

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Cost comparisons:

Go to <http://www.pricewatch.com>

Drives range from dirt cheap to limiting in their expense:

Floppy drive	\$3
DVD reader	\$30
CD-RW/DVD	\$70
DVD-RAM	\$300
DLT tape	\$500
Ultrium tape	\$3000

Media prices

DVD-R media	\$1-2 for 4.7/9.4 GB (\$0.1-0.2/GB)
Mini-DV tape	\$5 for 12.5 GB (\$0.4/GB)
DLT, Ultrium	about \$0.75/GB

Laptop and desktop files: (figures from Haystack, Pricewatch)

Magnetic Tape

Has offered best medium information density (3D)

0.5 TB/cm³ by 2010

Currently laptop hard files are passing tape:

miniDV tape cassette 38 cc, 12.5 GB => 330MB/cc

laptop 40GB hardfile 60 cc, 40 GB => 750MB/cc

Analysis:

Heads

Borrow technology from hard files

Media

1000 bpi → 20,000

tpi only 50-500, with 100 typical

Channel, transport, etc...

Worst for access time

Media costs need to be 1% of disk for viability

This was true 10 yr ago, but ratio dropping to 10-20%

Conclusion – tape will be increasingly restricted to high end

Backup systems (increasingly automated)

Personal archive (fits in a car trunk, top of closet...)

Reliability the major issue:

Heads wear, so that reading old tapes is uncertain

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Optical disk (“inferior in every way to magnetic recording” – DAT)
Fundamentally a low end technology for information distribution
Too big for PDA’s or camcorders
unless 2.5” format succeeds
15 yr prevalence of audio CD, now CD-ROM (120 mm)
Red Book, Yellow Book standards make CDDB possible
CD-ROM, -R, -RW 680 MB
DVD family 4.7 – 17 GB (originally stamped)
17 GB requires 2 sides, 2 layers
DVD-R, -RW (1000 writes) and –RAM (100,000 writes)
Still incompatible
TV/Movies drive desired storage size
4 hrs of SDTV = 10-20 GB
4 hrs of HDTV = 40-90 GB
Blue lasers, magneto-optical hybrids make 30 GB possible
(by 2010 ?)
and 2 GB/cm²
Control of copyright slows infrastructure development

Progress in Magnetic Disks

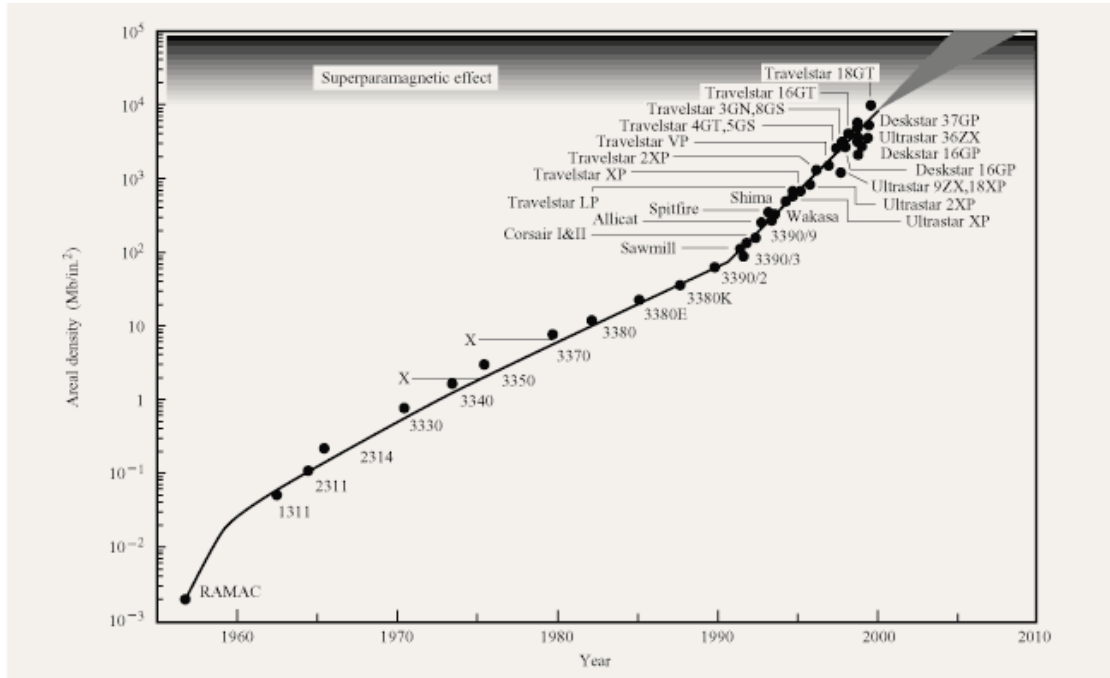


Figure 1

Magnetic disk storage areal density vs. year of IBM product introduction. The Xs mark the ultimate density predictions of References [4] and [5].

Magnetic Storage, ctd.

Magnetic hard disk

Has scaled dimensions 1000x since introduction in 1956

At least 3-10x more is possible without radical change

Currently density/\$ improves 2x per year (an anomaly)

4/2002 Pricewatch → \$1/GB !

historic rate of improvement -- 2X in 2 yrs

expect 30-100X further improvement in decade

\$0.10 - \$0.03/GB (= 1 TB for \$30-100)

MR heads (insensitive to head velocity)

noise a media issue alone

greatly increased sensitivity (GMR...)

Trend to smaller diameter files is driven by vibration, data rate

2x reduction in S/N requirements possible with longer ECC

advantage for video and media (Tivo, music players)

disadvantage for small records

Nano-patterned "grains" could give another 10x in density

after 2010

What to expect in this decade:

Tape → 1-2 GB/cm²

Optical → 2 GB/cm²

Hard disk → 3+ GB/cm²

Capacities depend on useable areas of rotating media

5.25", 3.5", 2.5", 1.25" → 111, 52, 25, 8 cm²

Optical disks

Expect DVD to dominate after 2003

Mainstream products 20-30GB

Hard disks

3.5" disk, 4 surfaces → >640 GB in 2005, 2-5 TB in 2010

2.5" disk, 2 surfaces → 100-200GB in 2005, 0.6-1TB in 2010

Microfile (ultrathin) → 15-30GB in 2005

(6-12 hrs of MPEG2 video!)

(but...is the market there to pull this along?)