



ALBERT-LUDWIGS-
UNIVERSITÄT FREIBURG

Algorithms and Methods for Distributed Storage Networks

1. Motivation, Organization, Overview

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Rechnernetze und Telematik
Wintersemester 2007/08



Organization

▶ **Lecture**

- Thursday 11 am - 1pm, room 101/SR 01-009/13
- Friday 11 am - 12 pm, room 101/SR 01-009/13

▶ **Exercise (Stefan Rührup)**

- starts Oct 29, 2008
- Friday 12 - 1 pm, room 101/SR 01-009/13
- appear every Friday on the web-pages
- solved voluntarily by students
- are the bases for the oral exam
- solutions of the exercises are discussed in the following week

Web

▶ Web page

- <http://cone.informatik.uni-freiburg.de/teaching/vorlesung/distributed-storage-w08>
- Slides, exercises, link to forum

▶ Forum

- for discussion, links, funnies etc.
- <http://cone.informatik.uni-freiburg.de/forum/viewforum.php?f=28>

Exam

▶ Dates by appointment

- possible dates
 - Monday, 23.02.2009
 - Thursday, 05.03.2009
 - Tuesday, 07.04.2009
- Contact me during the lecture or send an E-Mail to
schindel@informatik.uni-freiburg.de

▶ Oral exam

- based on the lecture and the exercises

▶ Mandatory registration

- Students of computer science register at the secretary of exams (*Prüfungssekretariat*)

Algorithms and Methods for
Distributed Storage Networks

Motivation
Evolution of Disks

Fall in Storage Prices

Technological impact of magnetic hard disk drives on storage systems,
Grochowski, R. D. Halem
IBM SYSTEMS JOURNAL, VOL 42, NO 2, 2003

Figure 6 Cost of storage at the disk drive and system level

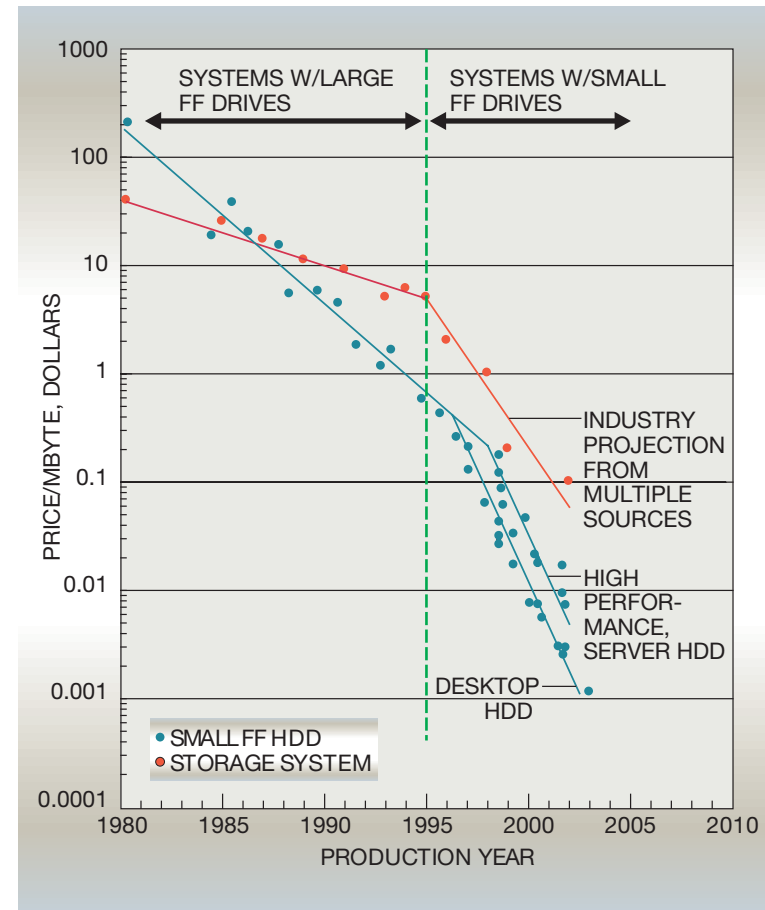
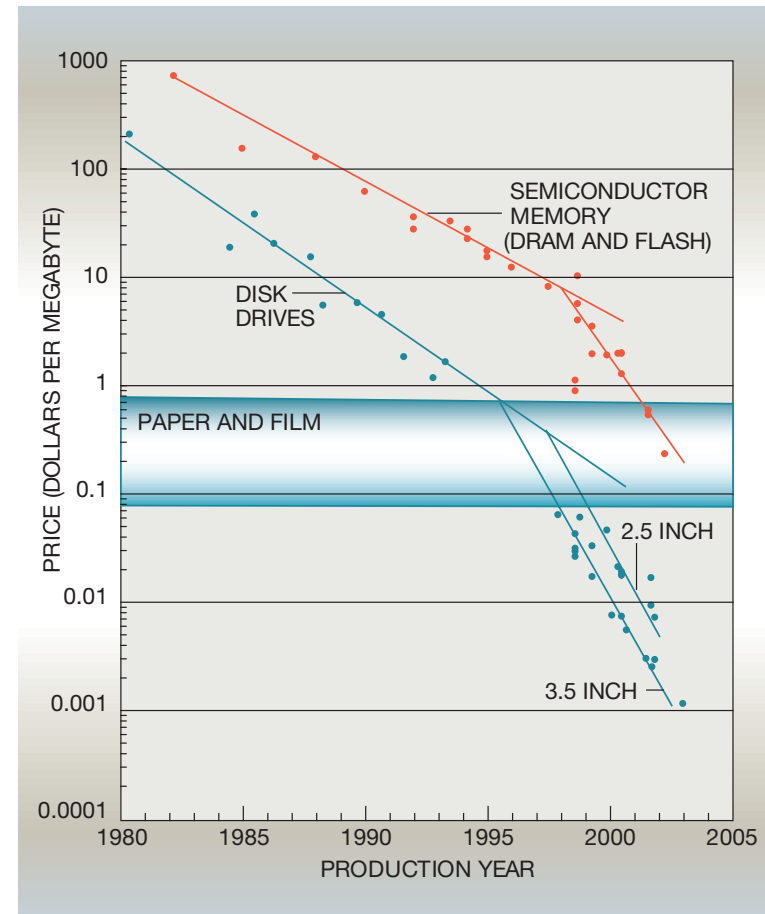


Figure 7 Cost of storage for disk drive, paper, film, and semiconductor memory

Price Fall of RAM and Disk Storage

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hard disk drives on storage systems,
Grochowski, R. D. Halem
IBM SYSTEMS JOURNAL, VOL 42, NO 2, 2003

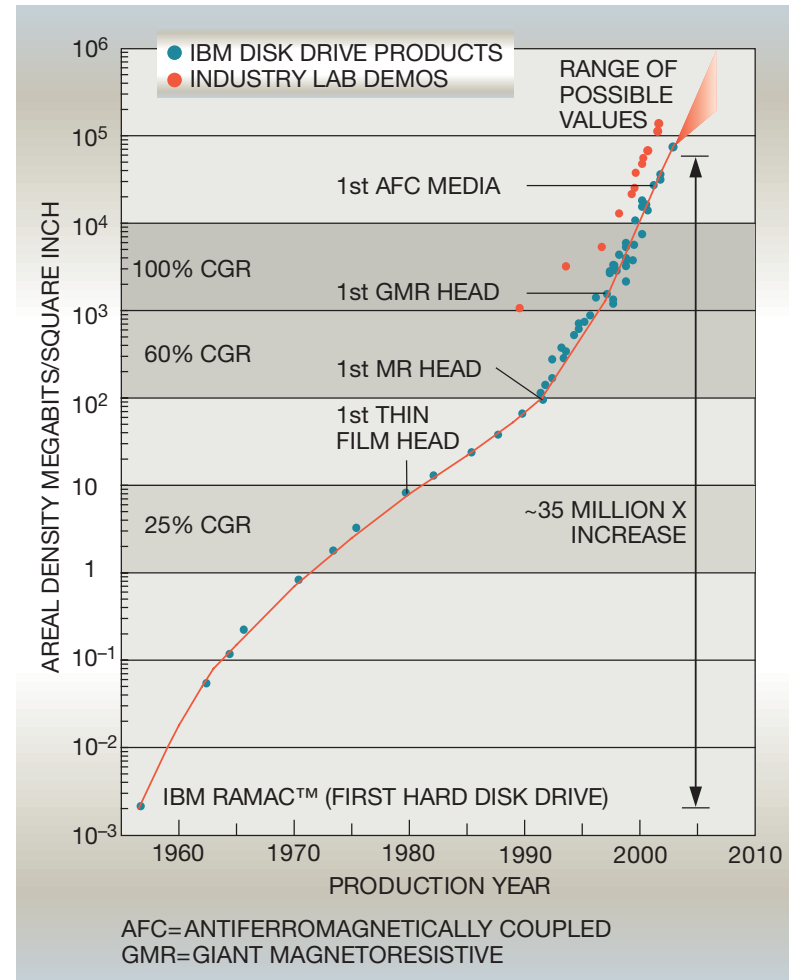
Figure 7 Cost of storage for disk drive, paper, film, and semiconductor memory



Increase of Density

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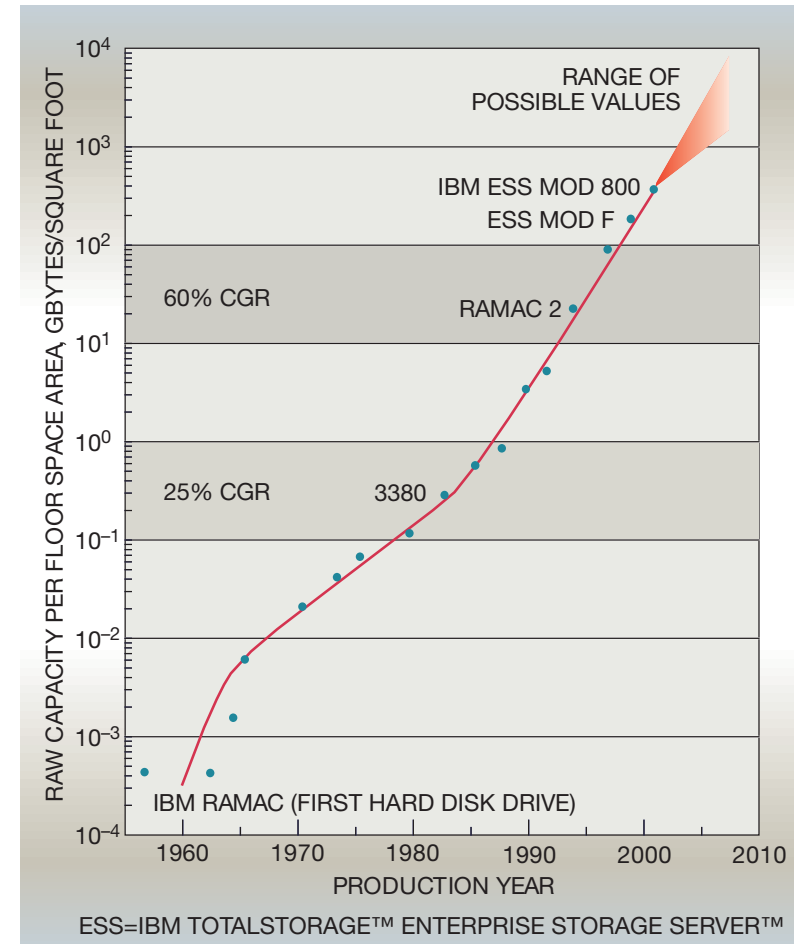
Figure 1 Hard disk drive areal density trend



Increase of Density (Floor Space)

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hard disk drives on storage systems,
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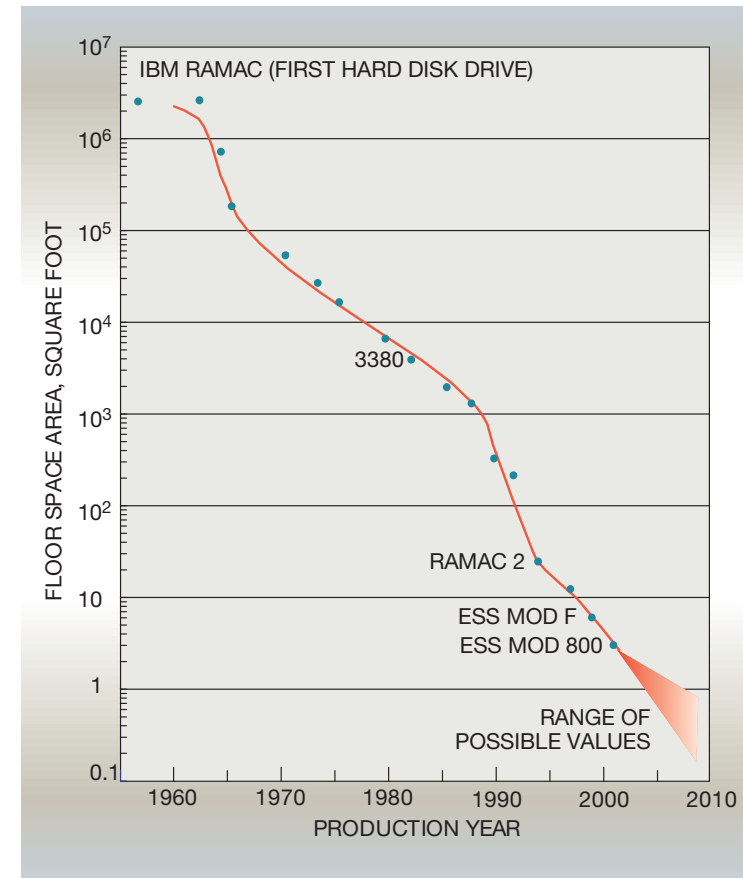
Figure 2 Storage floor space utilization trend – IBM storage systems



Increase of Density (Floor Space)

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hard disk drives on storage systems,
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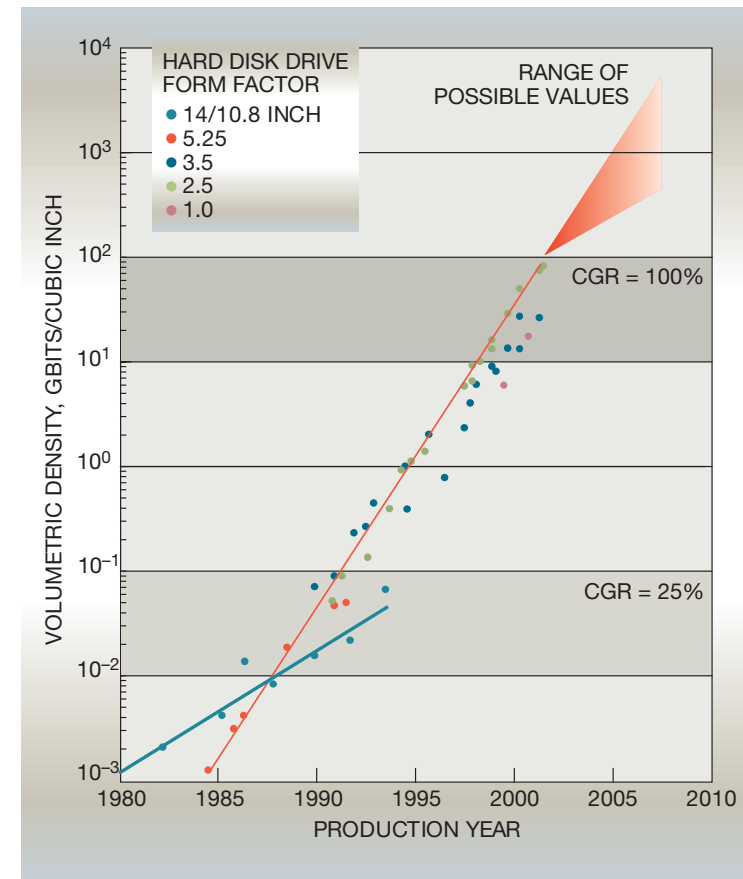
Figure 3 Floor space required to store 1 terabyte



Increase of Density (Cubic Space)

Technological impact of magnetic hard disk drives on storage systems,
Grochowski, R. D. Halem
IBM SYSTEMS JOURNAL, VOL 42, NO 2, 2003

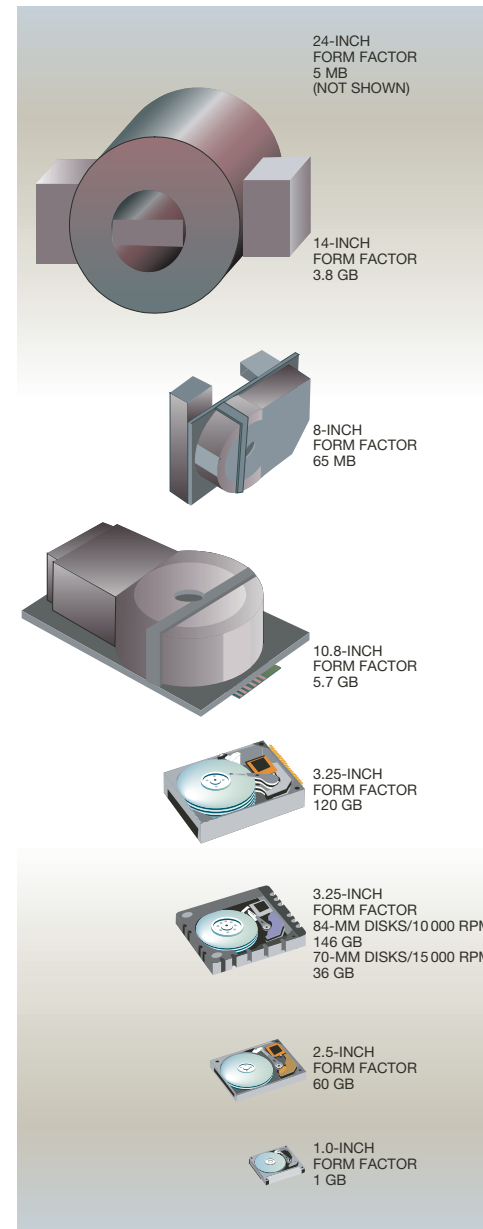
Figure 4 Hard disk drive volumetric density trend



Evolution of Disk Form Factors

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Grochowski, R. D. Halem
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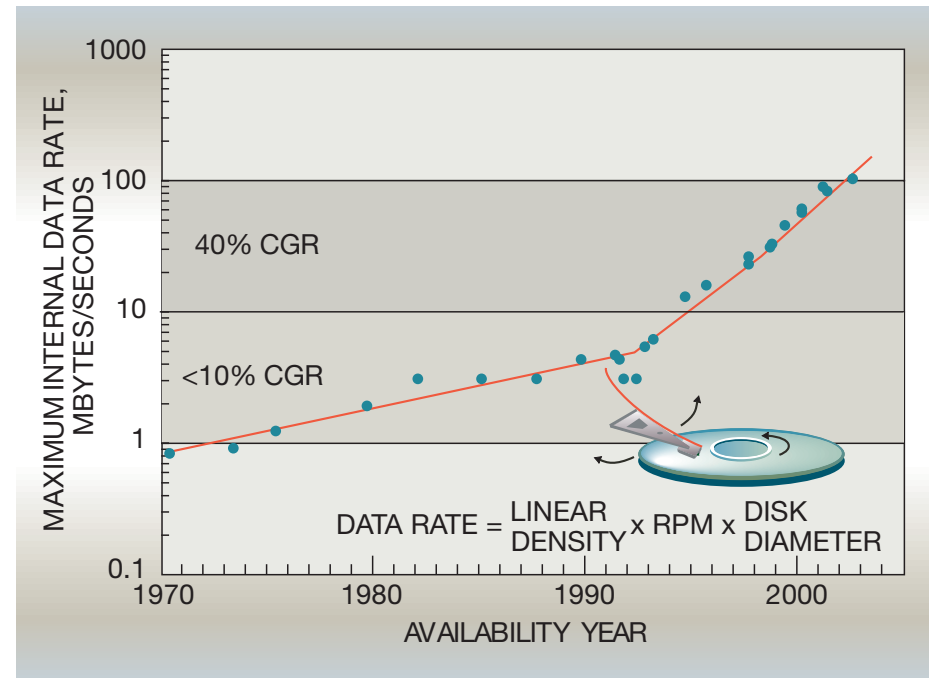
Figure 8 The evolution of disk drive form factors
1956–2002



Increase of Speed

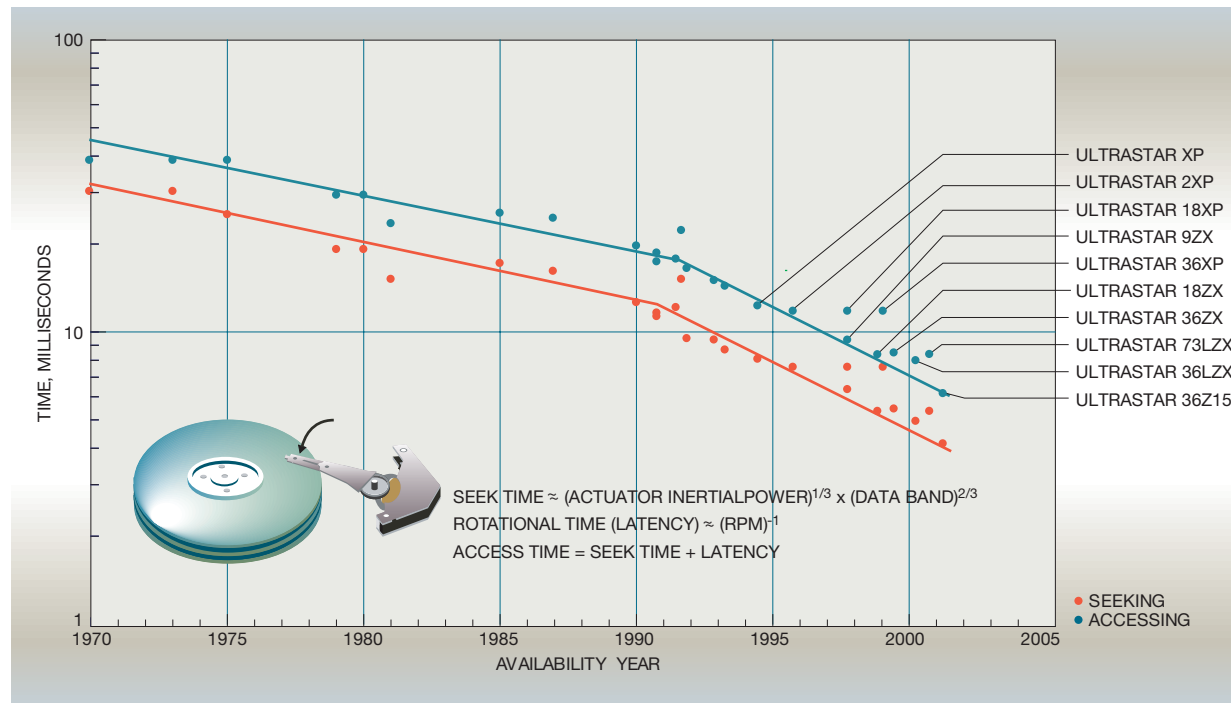
Technological impact of magnetic hard disk drives on storage systems,
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Figure 10 Hard disk drive maximum internal data rate for enterprise/server drives



Increase of Speed

Figure 11 Disk drive access/seek times



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 Distributed Storage Networks
 Winter 2008/09

Algorithms and Methods for Distributed Storage Networks

Motivation Consumer Behavior

Consumer Usage

▶ **Consumer Survey on Digital Storage in Consumer Electronics 2008, Coughlin Associates (Dec. 2007)**

- 51% said that 1 TB disk would be useful
- Most storage of content was on hard disk
- 46% backup data less than once per year
 - except pictures most of them do not backup
 - but most think it is important to have backups out of their homes
- Most people want to store entire TV series, copies of their entire music collection

▶ **Projection**

- by 2013 average home has 9 Terabyte
- by 2015 user content sums up to 650 Exabyte

Storage Hierarchy

- ▶ **Primary storage**
 - Processors registers
 - Processor cache
 - RAM
- ▶ **Secondary storage**
 - Hard disks
 - Solid state disks
 - CD, DVD
- ▶ **Tertiary storage**
 - tape libraries
 - optical jukeboxes

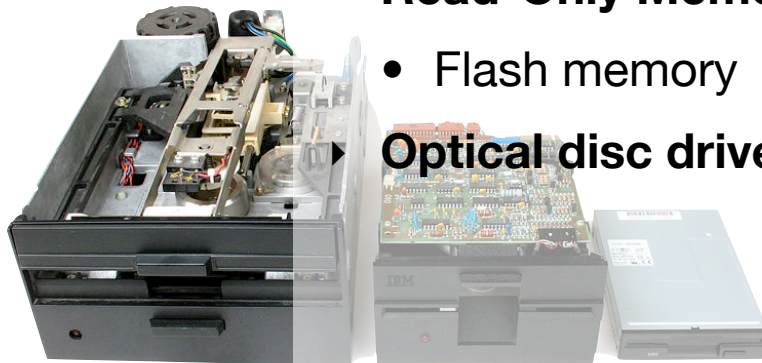
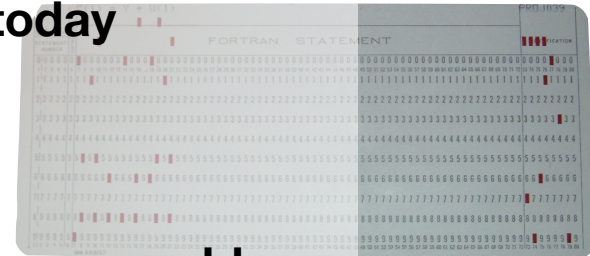
Characteristics of Storage

- ▶ **Volatile – non-volatile memory**
 - non-volatile: dynamic or static
- ▶ **Read & write – Read only – Slow write, fast read**
- ▶ **Random access – Sequential access**
- ▶ **Addressability**
 - location addressable
 - file addressable
 - content addressable
- ▶ **Capacity**
- ▶ **Performance**
 - Latency
 - Throughput

Non-volatile Storage Technologies



- ▶ **Punch cards (Hollerith) 1886-1950s**
- ▶ **Magnetic tape data storage 1951-today**
- ▶ **Hard disk drive 1956-today**
- ▶ **Floppy disks 1970s-1990s**
- ▶ **EEPROM (Electrically Erasable Programmable Read-Only Memory) 1980-today**
 - Flash memory
- ▶ **Optical disc drive (read/write) 1997-today**



Network Storage Types

- ▶ **Direct attached storage (DAS)**
 - traditional storage
- ▶ **Network attached storage (NAS)**
 - storage attached to another computer accessible at file level over LAN or WAN
- ▶ **Storage area network (SAN)**
 - specialized network providing other computers with storage capacity with access on block-addressing level
- ▶ **File area network (FAN)**
 - systematic approach to organize file-related storage systems
 - organization wide high-level storage network

Overview

▶ **Basic Storage Technology**

- Hard disks
- Flash memory, solid state disks
- Storage device design

▶ **File systems**

- Classic file systems
- Network and distributed file systems

▶ **Storage organization**

- SAN, NAS, FAN
- Storage hierarchies, Tiers

▶ **Selected topics of Distributed Algorithms**

- Conflict resolution
- Cache strategies

▶ **Redundancy**

- RAID levels
- Coding techniques

▶ **Internet and storage**

- TCP/IP, FTP, Webdav, etc.

▶ **Distributed Storage Systems**

- Online storage
 - e.g. Amazon S3, Google Shared Storage
- Peer-to-peer network storage
 - e.g. Oceanstore



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