C. NEW HARDWARE

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NEW DEVELOPMENTS IN DATA STORAGE.

P. J. Grosbøl
European Southern Observatory
Karl-Schwarzschildstr. 2, D-8046 Garching, FRG.

ABSTRACT

It is estimated that up to 100 Gbytes of primary data from digital detectors have to be stored each year. The amount of reduced data is at least one order of magnitude smaller. Although the storage density for magnetic recording can be made higher, only the optical technic can provide a substantial denser medium than the photographic emulsion. It seems likely that optical read-only devices will be developed for archival storage of data in this decade. Magnetic recording of data will still be preferred whenever changing of the information is important.

1. INTRODUCTION

The largest source of astronomical data has until now been photographic plates. This seems also to be the case in the next decade although several new detector systems have been developed recently. These detectors have a much higher quantum efficiency than a photographic emulsion , however , their total data acquisition rate is at least one order of magnitude smaller than that of a Schmidt plate due to the size difference. Whereas the photographic emulsion also has been very good for data storage, new technics in magnetic and optical recording of digital data have made it possible to achieve significantly higher bit densities and smaller access times. Although there is a strong development in data storage for small systems this paper will mainly deal with the new technics for storage of large amount of data.

2. STORAGE REQUIREMENTS

To evaluate modern data storage technics the storage requirements in astronomy must be estimated. In Table 1 the amount and rate of data for different detectors are given. These values may vary considerably

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depending on the type of observations being done.

Table 1 : Data rates in astronomy

Source	Mbytes/frame	frame/night	Mbytes/night
Schmidt plates	1000	5	5000
9 cm McMullan E. Camera	100	20	2000
Prime focus plates	500	10	5000
CCD camera	1	50	50
TAURUS	5	20	100

The total amount of data per year is obtained by multiplying these values with the number of telescopes and usable nights (i.e. between 100 and 1000). The largest single source of data in astronomy is photographic plates. Since they already provide the archival storage themselves the immediate problem is storage of between 10 and 100 Gbytes per year from digital detectors (i.e. CCD cameras). An equivalent amount of data is expected from the Space Telescope. The main problem is primary data since after final reduction they become orders of magnitude smaller.

3. COST, SPEED AND CAPACITY

There is a strong correlation between cost, access time and capacity of storage devices which can be seen in Figure 1. When the bit density is made higher the cost and access time will normally decrease while the total capacity of the device becomes larger. Therefore, it is interesting to look on the development of bit density as a function of production year as seen in Figure 2 (Rodriguez 1981).

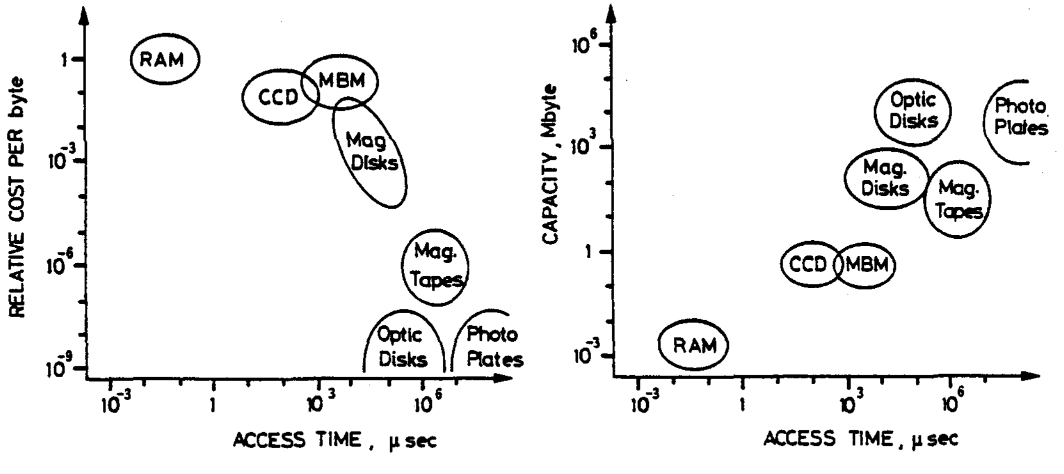

Figure 1 : Cost and capacity of storage as function of access time.

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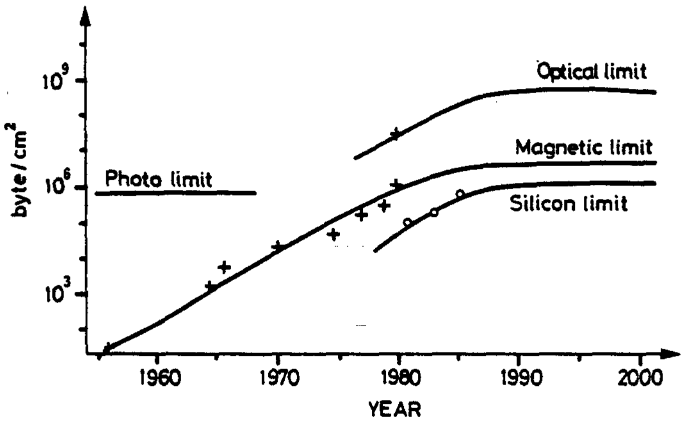

Figure 2 : Bit density as function of production year.

Only the limit for photographic emulsions is reached while the other storage media still can be improved. It seems likely that optical disks will be the preferred media for archival purposes (i.e. read only applications) when they are fully developed.

4. SILICON TECHNOLOGY

Two new kinds of memories based on semiconductors have been introduced, namely : Charge-Coupled Devices (CCD) and Magnetic Bubble Memories (MBM). Their performance (i.e. access time and storage capacity) places them between Random Access Memories (RAM) and disks. The main difference is that MBMs are nonvolatile because the information is stored as small magnetic domains (see, Snigier 1979 and Haggard 1981) while CCDs are volatile (Bhandarkar et al. 1979). Since their maximum storage capacity is about 1 Mbyte they are mainly used as buffers between the fast memory and on-line mass storage devices.

5. MAGNETIC TECHNOLOGY

The demand for higher densities of magnetic recording of data has created new types of disk and tape drives. Both the size of the recording head and its distance from the magnitic surface have to be decreased in order to achieve higher densities. The technology of thin film heads has reduced their thickness to less than 100 microns. The decrease of the distance between head and recording surface to the order of 50 microns has ,however, made it necessary to protect disk surface from contamination. This development has given rise to the fixed 'Winchester' type disks (see, Keith Plant 1980 and Shershow 1980). Disk drives with a capacity above 500 Mbytes are already available using this technic.

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The fixed disks have created a need for fast, high density tape drives to be used as back-up devices. Although the recording density can be increased the standard inter-block gaps on 1/2" tapes make it less efficient. The new streaming tape drives which record the data continuously (Valiant 1979) have solved this problem while some of the compatibility has been lost. These streaming drivers can offer capacities over 100 Mbytes on a 600 feet 1/4" tape cartridge and data rates of several Mbytes per second. These features make them quite attractive for internal use in data centers.

6. OPTICAL TECHNOLOGY

A major part of astronomical data have been stored optically in the form of photographic plates. This analog storage has two advantages compared to present technics, namely : its high information density and its excellent archival quality. The problems, using glass plates as mass storage, are the very long access time and the difficult handling. The new developments in digital optical data storage seem within this decade to be able to provide a storage medium which both has up to 100 times higher bit density, a much shorter access time, and an archival quality. Although these optical methods are not able to change data already written they are of high interest for archiving astronomical data. The two main technics being holography and spot recording (Redderson and Ralston 1980) are discussed below.

The holographic technic records the standard Fourier transform of an array of bits on a photographic film. Different methods have been used to perform the transform. Most recently the Wideband Holographic Recorder/Reproducer system by Harris Corporation has employed an acousto-optic page composer as signal distributer and generated the Fourier transform interferometrically. This system has demonstrated a recording rate of over 100 Mbytes per second while the bit density is that of photographic emulsions. For astromony a high bit density is much more important than a high transfer rate. Thus, it seems less likely that the holographic recording technic will be of interest.

The other optical storage method is spot recording where the data are stored on a disk by altering its surface using a focused laser. In this way densities higher than 100 Mbytes per square cm (i.e. at least 100 times denser than photographic emulsions) can be reached. The technic developed by Philips laboratory and RCA records the data on a master disk with a thin film of a ablative material such as tellurium or bismuth. Copies in plastic can then be made from this master disk. In the case of digital data storage where only one or a few copies are needed the quality of the master is important. Unfortunately, the abletive materials now used show a significant degradation within a few years even if they are protected with overcoating of glass or plastic. A new technic developed by 3M Corp. may, however, provide the archival quality needed for making optical storage of data usable in astronomy. Instead of changing the reflectivity of the disk surface by removing material, small bubbles are made in the top layer consisting of a material with an extremely high melting point (Robbins 1981). The bubbles are formed by focusing a laser on the underlying material which then outgasses and presses the surface out. If these types of optical disks are used an on-line storage of several Gbytes per drive is possible.

7. CONCLUSION

Magnetic tapes and disks will still be the main data storage media in the coming years. The increased density offered by the thin head technology makes it possible to have all frequently used data on on-line disks while tapes are used for transportation and long term storage of data. The 1/2" tapes will remain important due to the large amount of data already on them and to their standard format which makes them portable. Streaming tape drives may ,however, take over most of the internal storage such as disk back-ups. With the increasing amount of data from digital detectors an archival storage medium with very high bit density is needed. It is likely that optical disks can provide this within the present decade. In that case not only primary data from detectors would be stored on such disks. Also some often used photographic data (e.g. the sky surveys) could be transferred to digital form to decrease the access time for them.

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