The Past, Present and Future of Magnetic Hard Disk Technology

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Introduction:

Since the early days of civilization, mankind has been consumed with the desire to record its history and culture. With the dawn of the computer age, society truly entered into a new era of information sharing and mass communication. The invention of magnetic media helped facilitate this need and provided a means for systematically recording data and information that could be retrieved or re-written at any point in time. For many years however, magnetic media was limited to the format of reel-to-reel tape. Although successful, tape media was cumbersome and required constant maintenance and supervision. Society needed a more reliable and rigid technology to store information. This need was met by the creation of the hard disk drive. Hard disk technology has endured a long and successful history; however, the same basic fundamentals from early designs remain even in the most advanced magnetic storage technology today.

Early Drive Technology:

One of the earliest and most influential companies to develop magnetic media disk storage technology was IBM. For almost three decades, IBM dominated the industry with innovative advancements on an almost annual basis. Framing on much of the original concept of digital tape storage by the ERA Corporation and other previous tape innovations, IBM went to work on a new type of magnetic storage. IBM had amassed an elite team of engineers in the early 1950's known to be true pioneers in their field. It was no surprise then that in 1956, IBM released a newly developed piece of hardware known as the 305 RAMAC. The RAMAC, short for Random Access Method of Accounting and Control, was the world's first computer with a disk storage system.

Fig. 1 – The IBM 350 Disk Storage System
(IBM Archives)

The RAMAC 305 was included with the IBM 350 DSS that would eventually become the precursor to the modern computer hard disk. Consisting of fifty 24" magnetic platters, these discs maintained a total storage capacity of about 4.4 megabytes. Although the capacity is significantly small by today's standards, this was considered to be absolutely enormous in 1956. Data on the RAMAC was stored in a similar fashion to how it was on

the older tape technology. Through the use of disk “heads”, data could be read or written by manipulating a magnetic coating on the surface of the platters. Similarly to tape media, data could be re-written almost an indefinite number of times. Because of the complexity and support required of the new hardware, IBM decided the best solution was to lease the hardware rather than sell it outright. The initial “going rate” for the 350 was about $3,200 per month.

Shortly after the 350’s inception, IBM went immediately back to work on improving the basic design. They quickly released the 355 just days later. When used with the 650 series of computer, the 355 storage units could be daisy-chained to double, triple, and even quadruple the amount of total storage. In the initial release of the 350 and 355 however, data was stored on only one side of the platter. Additionally, only one head was being utilized to read this data. Although perfectly functional, IBM engineers knew this technology could be easily improved. Future advancements included the inclusion of multiple heads, utilization of both sides of the disc platters, and additional storage unit chaining. This not only increased capacity and the speed of data retrieval, but offered both upgradability and expandability (“Our History of”).

As computers began to seep more and more into the typical business infrastructure, corporations realized the enormous potential for these machines in both financial and record-keeping capacities. IBM continued to release newer and more revised versions of the 350 disk technology. In the years following the 350 and 355 data unit, was the release of the IBM 1301 data storage unit. This offered increased storage, speed, and the use of air bearing-cushioned heads (Dayes, & Trader, 1999). The 1302 and 1311 followed shortly thereafter with the 1311 model being the first to introduce removable disc packs.

Improved speed and storage capacity continued with the subsequent release of models such as the 1405, 2305, 2314 and 2321. As desk and office dumb-terminals began to hit the market, IBM focused their hardware development on supporting mainframe storage systems. In the early 1970's, they released several new data storage units starting with the IBM 3330 direct access subsystem. These new units began to take shape into the type of equipment more commonly seen throughout the 1980's and 1990's. The 3330 was followed in order by the 3340, 3350, 3858, 3310, 3370, 3380 and finally the 3390. Each new unit significantly increased capacity with a considerably reduced physical size.

Fig. 2 – The IBM 3390 Expandable Direct Access Storage Device
(IBM Archives)

As computer technology advanced, and the cost associated with distribution and manufacturing decreased, technology in the home also improved. An entirely new industry was being formed for the home consumer. To support this growing market trend, new hardware corporations began springing up throughout the United States during the 1970's. These companies offered competition and technological improvements to much of the newly available data technology. One large group of engineers from IBM, known internally as "the dirty dozen", left the company to form a new corporation known as Memorex. Several of them later left to form another corporation known as Seagate. Seagate would quickly become one of the foremost leaders in home computer storage technology (Snyder, 2006).

Storage in the Early Consumer Market:

In the early 1980's, computer desktops began hitting the home consumer market. With advancements in computer technology, it became increasingly feasible for families to own and operate a computer. Several companies were already heavily into the home computer market such as Apple, Commodore, and Atari. Because there was no real standard by which to follow however, most of these machines were incompatible with each other. Many of their designs also lacked conformity in terms of look, feel, and usability. Atari, Commodore, and Texas Instruments designed computers which made use of the television for the display and were nothing more than small computers integrated into a large keyboard. Although somewhat successful, these machines were often advertised as gaming machines so they were never really taken seriously in business. Other manufacturers like KayPro, NEC, and Altair either came with built in screens for their portables, or required an expensive external proprietary monitor. It was not until IBM released the 5150 in 1981 that computers as we know them today began to take their familiar shape.

Fig. 3 – The IBM 5150 Personal Computer
(OldComputers.NET)

Known as the *Personal Computer* or PC for short, this early IBM computer literally created an entire foundation of standards for both use and design. The IBM 5150 provided a solid platform that could be configured to meet almost any household budget. Although the IBM PC made use of Basic as well as Microsoft's DOS operating system, what made it especially dominant in the industry was its upgradability. Within two years of its release, IBM began offering the PC with a 10 megabyte hard drive (Wikipedia). Although officially released as the IBM 5160 PC/XT in 1983, all previous 5150 PCs could be upgraded with this hard disk. The design of this new hard-drive coupled with the design layout of the 5150 set the physical standards for all future drive components ("Our History of"). This type of storage technology in the home had never before been available and was well received despite its high cost. As with the 5160 and all other early PC compatibles, there were several dominant hard disc manufacturers. The most notable of these manufacturers was Seagate. Their first personal computer hard disk, including the one found in the IBM 5160 PC made use of a new standard drive technology known as Run Length Limited (RLL) and Modified Frequency Modulation (MFM).

Fig. 4 – The Seagate ST-225 20mb 5.25" HH MFM Hard Disk (exposed)
(Jailbird) Wikipedia, 9/10/2006

MFM and RLL hard disk drives quickly grew in popularity. They were compact, sealed from outside exposure, and exponentially more reliable than hard disk technology of the past. Companies such as Tandon, IBM, Seagate, North Star and Apple were releasing newer and faster hard drives almost monthly. Although common, storage was still fairly expensive. A typical 20 megabyte hard disk would average on the retail market for $1000 dollars in 1985. This created a new marketing yard stick for price comparison with a cost measure of “megabyte per dollar” (Smith, 2008).

Through most of the mid, to late 1980’s, hard disk technology typically took a back seat to other demands in the industry. Without a significant demand for increased storage, hard disk companies instead focused on creating smaller profile hard disk designs. By the end of the 1980’s, the average hard disk’s storage capacity had increased minimally from about 10 megabytes to 40 megabytes but met a new full height (FH) 3.5” form factor.

Fig. 5 – The Seagate ST-125 21mb 3.5” FH MFM Hard Disk
(Seagate Archives)

The Demands of Multimedia:

It was not until the early 1990's that significant demand was again put on disk manufacturers to improve upon the basic hard disk design. Although technology had improved relatively steadily, the biggest improvement was cost. Storage and speed had remained relatively unchanged however. As computers became a staple in the average American household, more demands were being placed on them. The onset of multi-media technology became immediately apparent with the advancement of computer game technology. With graphical word processing and improved computer game graphics, the need for more disk storage and performance grew. Manufacturers immediately stepped up their research and development and introduced two new standards of hard disk control technology. The first, Integrated Drive Electronics, known as IDE for short, provided the most common and standard means for driver control.

Fig. 6 – Integrated Drive Electronics / PATA cable
(NewEgg)

The significant physical difference between IDE and MFM was with respect to the electronics. Almost all of the hard disk control circuitry was now integrated into the drive itself. Originally created by Western Digital, this new controller technology saved considerable space on the computer's internal peripheral card. In some cases it freed up valuable space internally by adding the connections to the motherboard directly. This also meant that manufacturers could better tune their drives. This tuning usually led to higher individual drive performance and better manufacturer competition. Although a generic

hardware was already recognized for this new technology, it quickly became standardized in 1994 by ANSI as the X3.221 standard (“Parallel ATA”).

The second technology, Small Computer System Interface or SCSI for short, was also significantly more advanced than MFM. Although originally standardized in 1986, this technology did not get fully utilized until the mid 1990’s. Like SCSI, the controller hardware was built into the drives themselves, and the connection system served only to transmit actual program data back and forth on the bus.

Fig. 7 – 3.5” HH Hard Drive w/ SCSI 80-Pin Connector
(Computer Circulation Center) USA,

A significant benefit of SCSI over IDE was its ability to “daisy-chain” devices. Depending on the controller card, up to 16 hard drives and other devices could be connected and used simultaneously. Although more advanced than IDE, the technology was cost prohibitive for most home computer configurations. IDE, which was later renamed PATA for Parallel AT Attachment, became the dominant standard for hard drives until the early 2000’s.

In addition to these new controller technologies, the hard drives themselves saw considerable improvement in overall storage capacity. In the span of about five years

from 1990 to 1995, the average hard disk capacity grew from about 40 megabytes to 250 megabytes. This rate of growth grew exponentially with storage capacity exceeding well into the 1 to 2 gigabyte range by the year 2000 for most personal computers. The typical desktop computer hard-drive existed in half-height 3.5” format. With the popularity of laptops quickly growing through the late 1990’s, manufacturers required even smaller drives to combat excessive weight and heat buildup in their machines. Developed originally by PrairieTek, the 2.5” form factor laptop hard disk drive was invented.

Fig. 6 – 2.5” Fujitsu IDE Hard Disk Drive
(Computer Circulation Center) USA,

This new sleeker design of hard disk drives fit perfectly into smaller spaces, helping to create what we now recognize as modern laptop computers. These drives also quickly became popular as external portable removable storage before USB flash drives were overly common. Due to the smaller size however, they typically held about half the storage of an equivalent 3.5” drive. For the most part however, a consumer could still purchase a 2.5” drive with considerable capacity.

Current Hard Disk Technology:

For many of us, the computer encompasses nearly every aspect of our daily lives. With demands such as the internet, movies and music playback, video recording, video and telephony over IP, the demands of data storage and throughput have dramatically increased. To meet these demands, industry leaders sought to create a new standard in 2003 known as SATA. SATA stands for Serial AT Attachment ("Serial ATA").

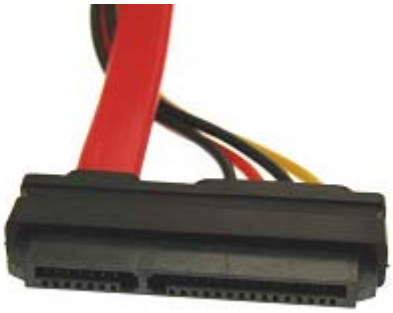

Fig. 7 – Integrated SATA Data & Power Connector
(NewEgg)

This new technology uses direct access bus control and is capable of handling exponentially larger capacity drives with a significantly higher rate of speed. Although the first design of SATA was marginally quicker than Enhanced IDE technology (EIDE), versions two and three of SATA were literally two and three times faster. In its most current form of SATA 3, drives are capable of theoretically transmitting 6 gigabytes of data per second (Wood, 2010). Aside from the throughput advancements in controller technology, the design of hard disk drives changed little through the 2000's. And although capacity did increase significantly, a 250mb hard drive from 1999 is visually nearly identical to that of a 500 gig SATA drive from 2010. Many corporations in fact are still using the same original physical molds for their newer drives.

Conclusion:

Throughout the past sixty years, hard drive technology has improved considerably but theoretically changed very little. The same basic concepts are maintained from the original IBM 350 hard drive storage unit, to the most recent of modern magnetic drives today. Although drives have improved in reliability, performance, and capacity, the same basic principals have remained. Magnetic hard disk storage may be nearing the sunset in its technological life-span however. With the continued advancements in solid state drive technology, it is expected that the typical magnetic hard disk drive that we know today will eventually be phased out. One thing is certain however, magnetic disk storage will likely continue to remain the most viable and cost-effective storage solution for many years to come.

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