THE LAST BOTTLENECK IN MODERN PC

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ABSTRACT

In the last 10 years CPU speeds have increased by 200 times, hard disk capacities have increased by 100 times, memory speeds have effectively increased by 500 times, motherboard bus data transfer speeds have increased by 400 times and floppy disks have been replaced by flash disks, which are 100 times larger and faster than a 1.44MB floppy. But hard disk access times and transfer rates or IOPS (Inputs and Outputs per Second) have only increased by only 10 times. IOPS is Intel Corporation's measure of how many files a drive can serve (output) and receive (input) per second. So it is obvious to say that hard disk performance is the last bottleneck in the modern PC. In this paper, current hard disk design and architecture will be included in order to find out the Issues, which contribute to current hard disk performance limitation, and recommendations will be suggested to circumvent the long existed hard disk problem.

Keywords: Hard Disk, Speed, Architecture, Performance, Limitations, and Recommendations.

1. Introduction

A hard disk drive (HDD), is a non-volatile storage device which stores digitally encoded data on rapidly rotating platters with magnetic surfaces. It consists of a motor, spindle, platters, read/write heads, actuator, frame, air filter, and electronics. The frame mounts the mechanical parts of the drive and is sealed with a cover. The sealed part of the drive is known as the Hard Disk Assembly or HDA. The drive electronics usually consists of one or more printed circuit boards mounted on the bottom of the HAD [5].

A head and platter can be visualized as being similar to a record and playback head on an old phonograph, except the data structure of a hard disk is arranged into concentric circles instead of in a spiral as it on a phonograph record (and CD-ROM). A hard disk has one or more platters and each platter usually has a head on each of its sides. The platters in modern drives are made from glass or ceramic to avoid the unfavorable thermal characteristics of the aluminum platters found in older drives. A layer of magnetic material is deposited on the surface of the platters and those in most of the drives dissected have shiny, chrome-like surfaces. The platters are mounted on the spindle which is turned by the drive motor. Most current IDE
Hard disk drives spin at 5,400, 7,200, or 10,000 RPM and 15,000 RPM drives are emerging [3].

2. Technology

HDDs record data by magnetizing ferromagnetic material directionally, to represent either a 0 or a 1 binary digit. They read the data back by detecting the magnetization of the material. A typical HDD design consists of a spindle which holds one or more flat circular disks called platters, onto which the data is recorded. The platters are made from a non-magnetic material, usually aluminum alloy or glass, and are coated with a thin layer of magnetic material. The platters are spun at very high speeds. Information is written to a platter as it rotates past devices called read-and-write heads that operate very close over the magnetic surface. The read-and-write head is used to detect and modify the magnetization of the material immediately under it. There is one head for each magnetic platter surface on the spindle, mounted on a common arm. An actuator arm moves the heads on an arc roughly radially across the platters as they spin, allowing each head to access almost the entire surface of the platter as it spins. The arm is moved using a voice coil actuator [1].

Older drives read the data on the platter by sensing the rate of change of the magnetism in the head; these heads had small coils, and worked in principle much like magnetic-tape playback heads, although not in contact with the recording surface. As data density increased, read heads using magnetoresistance came into use; the electrical resistance of the head changed according to the strength of the magnetism from the platter. Later development made use of spintronics; in these heads, the magnetoresistive effect was much greater that in earlier types, and was dubbed "giant" magnetoresistance. This refers to the degree of effect, not the physical size, of the head — the heads themselves are extremely tiny, and are too small to be seen without a microscope [6].

In today's HDDs, each of these magnetic regions is composed of a few hundred magnetic grains. Each magnetic region forms a magnetic dipole which generates a highly localized magnetic field nearby. The write head magnetizes a region by generating a strong local magnetic field. Early HDDs used an electromagnet both to generate this field and to read the data by using electromagnetic induction. Later versions of inductive heads included metal in Gap heads and thin film heads. In today's heads, the read and write elements are separate, but in close proximity, on the head portion of an actuator arm. The read element is typically magneto-resistive while the write element is typically thin-film
inductive [7].

3. Architecture

![Figure 2: Read-and-Write Head](Source: Duxcw.com)

The hard disk read-and-write head are extremely small electromagnets (about 1 mm square). It is located above or below the surface of the platter at a distance measured in micro-inches. The direction of the current and the diverging magnetic field across the gap in the head determine the direction of the magnetic domains on a particular spot on the platter's magnetic coating. Information that stored on the platters is send through the pulses of current to the head. After the head read the data wanted, it will retain their directional bent or position until for the next task or the computer is turn off [1].

![Figure 3: Actuator Arm](Source: Duxcw.com)

The read-and-write heads are bonded to a head arm, which is a small arm that holds the head in position above or beneath a disk. A head and suspension is called a head-gimbal assembly or HGA. The HGAs are stacked together into a head-stack assembly, which is propelled across the disk surface by the actuator.

The actuator on most recent hard disks employs a voice coil mechanism. It functions much like the voice coil in a loud speaker, thus it is how it get its name. It consists of a curved magnet and a spring-loaded coil of fine wire, which is attached to the read/write heads by head arms. The head arms are attached to, and pivot about an actuator shaft. When the drive electronics apply an electric current to the actuator coil, it interacts with the magnet and swings against the actuator spring. The heads rotate around the actuator shaft in the opposite direction of the coil movement, inward and outward from the center to the edges of the platters [4].

4. Issues

- 1998 Ultra ATA/33 at 33.3 MB/s
- 2000 Ultra ATA/66 at 66.6 MB/s
- 2002 Ultra ATA/100 at 100 MB/s
- 2003 Ultra ATA/133 at 133 MB/s
- 2003 SATA at 1.5Gbit/s or 150MB/s
- 2007 SATA at 3.0Gbit/s or 300MB/s

The above points shows over the pass ten year, home user hard disk (IDE and SATA) transfer rate increased merely at 10 times only. The improvement on speed is far below compare to other parts of the computer such as CPU, memory and motherboards bus data transfer rate. One of the reasons that contribute to the hard disk limitation is the current hard disk architecture.

Hard drives typically have several platters and each platter can store up to 200GB capacity. Each platter will have 1 read-and-write head which mount onto the actuator. In a 400GB hard disk will consists of 2 platters, 1 TB hard disk.
will consists of 5 platters and so on. The Capacity of the hard disk is rocketing in these few years is because the manufacturer place several platters in a single hard disk. However, the architecture of the hard disk still remain the same and no enhancement on the way how read-and-write heads operate. To improve this deadly limitation, revolution thinking and creative solution need to figure out in order to catch up with the speed of the other parts of the computer (Meyers, Michael, 2003).

5. Recommendations

1) As I mention earlier, every platter has 1 read-and-write head. But only 1 head will operate at a time in order to read or write data. Multi-core processor can come to rescue the problem. Manufacturer can design in the way that 1 core of the processor control for 1 head. In another words, if the user having dual core processor computer and a hard disk with at least 2 platters, then the HDD transfer rate will be cut off by half. If Quad-core processor is used, then 1 quarter of the original time will be taken only, thus greatly speed up the task.

2) Current HDD technology still having 1 platter and only 1 actuator arm with read-and-write head mount on it, after 30 years of history since it emerged. This old HDD architecture has to be changed. Like processors nowadays, it did encounter its speed bottleneck few years ago, until multiple core processor came and rescue. Quad-core processor can found on the market nowadays. Likewise, HDD can have 2 actuator arms or more on 1 platter to speed things up. Data will split according to arms available and each arm will read or write independently, thus time taken will decrease significantly.

3) HDD platter can divided into inner and outer area. Inner platter can write data up to 70MB/s, whereby outer area is 100MB/s, which is half the speed faster than inner area. Due to this reason, outer platter should be in high priority to fill up first before inner platter will be used. In addition, large data such as operating system file, which only will be write once during OS installation, is recommended to first installed at outer area and move later to inner area. This will free the outer platter space for other data and also faster during OS installation. Thus, inner and outer platter space will be fully utilized.

Conclusion

Hard disks are one of the most important and also one of the most interesting components within the personal computer. Over the last few decades, engineers have improving them in every respect: reliability, capacity, speed, power usage, and more. It is no doubt that HDD speed had been improved a lot from last decade (10x), but if compare with CPU or RAM speed (100x), it is still lagging in HDD history. HDD can catch up with the CPU speed only if it uses multiple actuator arms or other revolution architecture. It is time to design new architecture to make the changes before it is fall too behind to others.

References


