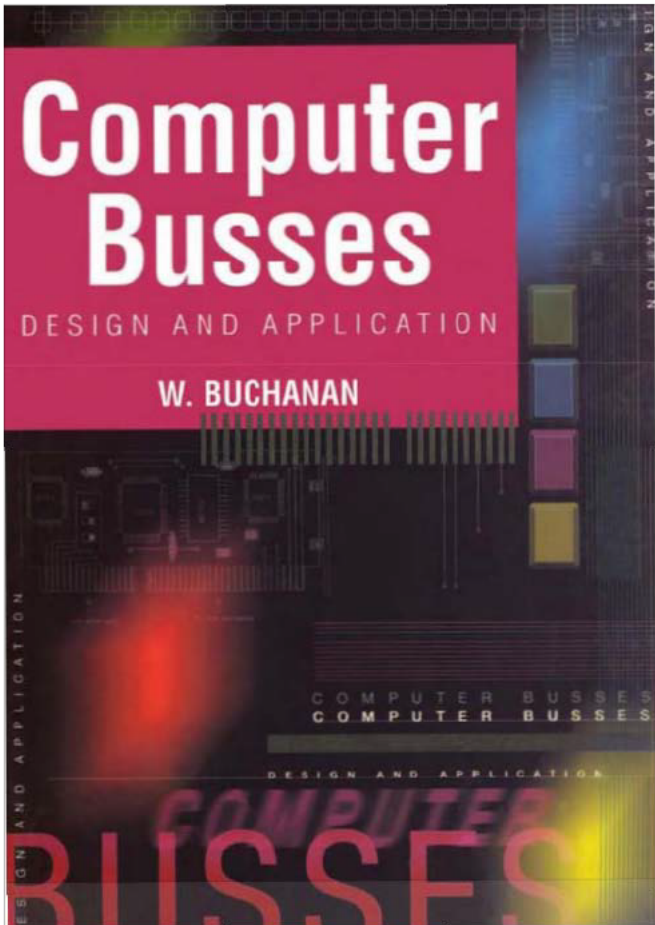




Computer Busses

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IDE and Mass Storage

6.1 Introduction

This chapter and the next chapter discuss IDE and SCSI interfaces which are used to interface to disk drives and mass storage devices. Disks are used to store data reliably in the long term. Typical disk drives either store binary information as magnetic fields on a fixed disk (as in a hard disk drive), a plastic disk (as in a floppy disk or tape drive), or as optical representation (on optical disks).

The main sources of permanent read/writeable storage are:

- Magnetic tape – where the digital bits are stored with varying magnetic fields. Typical devices are tape cartridges, DAT and 8 mm video tape.
- Magnetic disk – as with the magnetic tape the bits are stored as varying magnetic fields on a magnetic disk. This disk can either be permanent (such as a hard disk) or flexible (such as a floppy disk). Large capacity hard disks allow storage of several gigabytes of data. Normally fixed disks are designed to a much higher specification than floppy disks and can thus store much more information.
- Optical disk – where the digital bits are stored as pits on an optical disk. A laser then reads these bits. This information can either be read only (CD-ROM), write once read many (WORM) or can be reprogrammable. A standard CD-ROM stores up to 650 MB of data. Their main disadvantage in the past has been their relative slowness as compared with Winchester hard disks; this is now much less of a problem as speeds have steadily increased over the years.

6.2 Tracks and sectors

A disk must be formatted before it is used, which allows data to be stored in a logical manner. The format of the disk is defined by a series of tracks and sectors on either one or two sides. A track is a concentric circle around the disk where the outermost track is track 40 and the innermost track is 0. The next track is track 1 and so on, as shown in Figure 6.1. Each of these tracks is divided into a number of sectors. The first sector is named sector 1, the second is sector 2, and so on. Most disks also have two sides: the first side of the disk is called side 0 and the other is side 1.

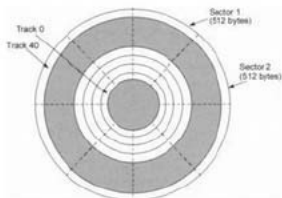


Figure 6.1 Tracks and sectors on a disk

Figure 6.1 also shows how each track is split into a number of sectors, in this case there are eight sectors per track. Typically each sector stores 512 bytes. The total disk space, in bytes, will thus be given by

$$\text{Disk space} = \text{Number of sides} \times \text{tracks} \times \text{sectors per track} \times \text{bytes per sector}$$

For example, a typical floppy disk has two sides, 80 tracks per side, 18 sectors per track and 512 bytes per sector, so

$$\begin{aligned} \text{Disk capacity} &= 2 \times 80 \times 18 \times 512 &&= 1\,474\,560 \text{ B} \\ &= 1\,474\,560 / 1\,024 \text{ KB} &&= 1\,440 \text{ KB} \\ &= 1440 / 1024 \text{ MB} &&= 1.4 \text{ MB} \end{aligned}$$

6.3 Floppy disks

A 3.5-inch DD (double density) disk can be formatted with two sides, nine sectors per track and 40 tracks per side. This gives a total capacity of 720 KB. A 3.5-inch HD (high density) disk has a maximum capacity when formatted with 80 tracks per side.

A 5.25-inch DD disk can be formatted with two sides, nine sectors per disk with either 40 or 80 tracks per side. The maximum capacity of these formats is 360 KB (40 tracks) or 720 KB (80 tracks). A 5.25-inch HD disk can be formatted with 15 sectors per track which gives a total capacity of 1.2 MB. When reading data the disks rotate at 300 rpm. Table 6.1 outlines the differing formats.

Table 6.1 Capacity of different disk types

Size	Tracks per side	Sectors per track	Capacity
5.25-inch	40	9	360 KB
5.25-inch	80	15	1.2 MB
3.5-inch	40	9	720 KB
3.5-inch	80	18	1.44 MB

6.4 Fixed disks

Fixed disks store large amounts of data and vary in their capacity, from several MB to several GB. A fixed disk (or hard disk) consists of one or more platters which spin at around 3000 rpm (10 times faster than a floppy disk). A hard disk with four platters is shown in Figure 6.2. Data is read from the disk by a flying head which sits just above the surface of the platter. This head does not actually touch the surface as the disk is spinning so fast. The distance between the platter and the head is only about 10 μm (which is no larger than the thickness of a human hair or a smoke particle). It must thus be protected from any outer particles by sealing it in an airtight container. A floppy disk is prone to wear as the head touches the disk as it reads but a fixed disk has no wear as its heads never touch the disk.

One problem with a fixed disk is head crashes, typically caused when the power is abruptly interrupted or if the disk drive is jolted. This can cause the head to crash into the disk surface. In most modern disk drives the head is automatically parked when the power is taken away. Older disk drives that do not have automatic head parking require a program to park the heads before the drive is powered down.

There are two sides to each platter and, like floppy disks, each side divides into a number of tracks which are subdivided into sectors. A number of tracks on fixed disks are usually named cylinders. For example a 40 MB hard disk has two platters with 306 cylinders, four tracks per cylinder, 17 sectors per track and 512 bytes per sector, thus each side of a platter stores

$$\begin{aligned} 306 \times 4 \times 17 \times 512 \text{ B} &= 10\,653\,696 \text{ B} \\ &= 10\,653\,696 / 1\,048\,576 \text{ MB} \\ &= 10.2 \text{ MB} \end{aligned}$$

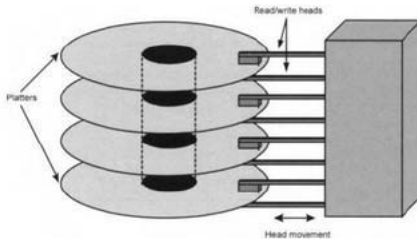


Figure 6.2 Hard disk with four platters

6.5 Drive specifications

Access time is the time taken for a disk to locate data. Typical access times for modern disk drives range from 10 to 30 ms. The average access time is the time for the head to travel half way across the platters. Once the head has located the correct sector then there may be another wait until it locates the start of the data within the sector. If it is positioned at a point after the start of the data, it requires another rotation of the disk to locate the data. This average wait, or latency time, is usually taken as half of a revolution of the disk. If the disk spins at 3600 rpm then the latency is 8.33 ms.

The main parameters which affect the drive specification are the data transfer rate and the average access time. The transfer rate is dependent upon the interface for the controller/disk drive and system/controller and the access time is dependent upon the disk design.

6.6 Hard disk and CD-ROM interfaces

There are two main interfaces involved with a hard disks (and CD-ROMs). One connects the disk controller to the system (system-controller interface) and the other connects the disk controller to the disk drive (disk-controller interface).

The controller can be interfaced by standards such as ISA, EISA, MCA, VL-Local bus or PCI bus. For the interface between the disk drive and the controller then standards such as ST-506, ESDI, SCSI or IDE can be used. ST-506 was developed by Seagate Technologies and is used in many older machines with hard disks of a capacity less than 40 MB. The enhanced small disk interface (ESDI) is capable of transferring data between itself and the processor at rates approaching 10 MB/s.

The small computer system interface (SCSI) allows up to seven different disk drives or other interfaces to be connected to the system through the same interface controller. SCSI is a common interface for large capacity disk drives and is illustrated in Figure 6.3.

The most popular type of PC disk interface is the integrated drive electronics (IDE) standard. It has the advantage of incorporating the disk controller in the disk drive, and attaches directly to the motherboard through an interface cable. This cable allows many disk drives to be connected to a system without worrying about bus or controller conflicts. The IDE interface is also capable of driving other I/O devices besides a hard disk. It also normally contains at least 32K of disk cache memory. Common access times for an IDE are often less than 16 ms, whereas access times for a floppy disk are about 200 ms. With a good disk cache system the access time can reduce to less than 1 ms. A comparison of the maximum data rates is given in Table 6.2.

Table 6.2 Capacity of different disk types

<i>Interface</i>	<i>Maximum data rate (MB/s)</i>	<i>Interface</i>	<i>Maximum data rate (MB/s)</i>
ST-506	0.6	E-IDE	16.6
ESDI	1.25	SCSI	4.0
IDE	8.3	SCSI-II	10.0

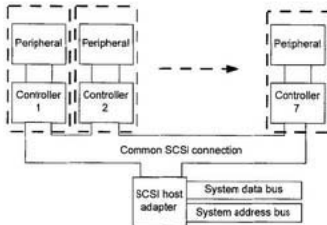


Figure 6.3 SCSI interface

A typical modern PC contains two IDE connections on the motherboard, named IDE0 and IDE1. The IDE0 connection connects to the master drive (C:) and IDE1 to the slave drive (D:). These could connect either to two hard disks or, possibly, to one hard disk and a CD-ROM drive (or even a tape backup system). Unfortunately, the IDE standard only allows disk access up to 528MB. A new standard called Enhanced-IDE (E-IDE) allows for disk capacities of over this limit. The connector used is the same as IDE but the computers' BIOS must be able to recognise the new standard. Most computers manufactured since 1993 are able to fully access E-IDE disk drives.

The specifications for the IDE and EIDE are

IDE

- Maximum of two devices (hard disks).
- Maximum capacity for each disk of 528 MB.
- Maximum cable length of 18 inches.
- Data transfer rates of 3.3, 5.2 and 8.3 MB/s.

EIDE

- Maximum of four devices (hard disks, CD-ROM and tape).
- Uses two ports (for master and slave).
- Maximum capacity for each disk is 8.4 GB.
- Maximum cable length of 18 inches.
- Data transfer rates of 3.3, 5.2, 8.3, 11.1 and 16.6 MB/s.

6.7 IDE interface

The most popular interface for hard disk drives is the Integrated Drive Electronics (IDE) interface. Its main advantage is that the hard disk controller is built into the disk drive and the interface to the motherboard simply consists of a stripped-down version of the ISA bus. The most common standard is the ANSI-defined ATA-IDE standard. It uses a 40-way ribbon cable to connect to 40-pin header connectors. Table 6.3 lists the pin connections. It has a 16-bit data bus (D0-D15) and the only available interrupt line used is IRQ14 (the hard disk uses