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Hard Disks

The x86 PC

assembly language, design, and interfacing

fifth edition

Prentice Hall

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OBJECTIVES

this chapter enables the student to:

- Contrast and compare the terms primary storage and secondary storage.
- Discuss hard disk organization in terms of the boot record, FAT, and the directory.
- Analyze the capacity of hard disks in terms of sectors, tracks, clusters, cylinders, and platters.
- Define hard disk terminology: partitioning, interleaving, low-level and high-level formatting, parking the head, and MTBF.
- Define the components of hard disk access time: seek time, settling time, and latency time .

19.1: HARD DISK ORGANIZATION/PERFORMANCE

- The hard disk, or fixed disk, is judged according to three major criteria:
  - Capacity.
  - Access time. (speed of accessing data)
  - Interfacing standard.
- The term hard disk comes from the fact that it uses hard solid metal platters to store information.
  - Called fixed because it is mounted (fixed) at a place on the computer and is not portable like the floppy disk.
  - In order to store data on the disk, both sides are coated with magnetic materials.

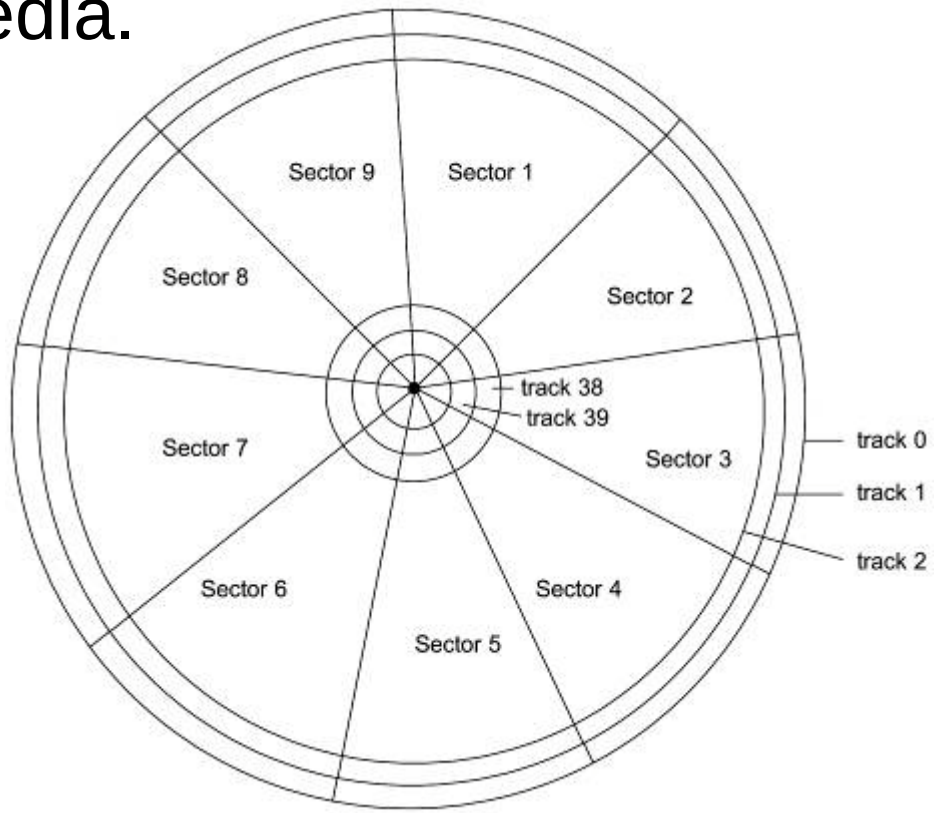
19.1: HARD DISK ORGANIZATION/PERFORMANCE
capacity of the disk

- The principles behind the process of reading and writing (storing) digital data on disks is the same as used in any magnetic media.

  Each disk side is organized into tracks & sectors.

  Tracks are organized as circles, & number per disk varies depending on the size and technology.

  Each track is divided into a number of sectors, which varies, depending on the density of the disk.



19.1: HARD DISK ORGANIZATION/PERFORMANCE
hard disk capacity and organization

- Capacity of hard disks ranges from a few hundred megabytes to many thousands of gigabytes.
  - A gigabyte is 1024 megabytes.
- Regardless of capacity, all use hard metal platters to store data, with the higher the number of platters, the higher the capacity of the disk.
  - Both sides of each platter in the disk are coated with magnetic material.
- There is one read/write head for each side of every platter, and these heads all move together.
  - Number of read/write heads varies between hard disks.

19.1: HARD DISK ORGANIZATION/PERFORMANCE
hard disk capacity and organization

- Knowing the number of cylinders makes it possible to calculate the total capacity of the hard disk.
  - Total capacity of a disk is calculated as follows:

number of tracks = number of cylinders × tracks per cylinder
HD capacity = number of tracks × sectors per track × sector density

Example 19-1 Verify the capacity of the hard disk using the data in Figure 19-2.

Solution:

As shown in Figure 19-2, the hard disk has 4864 cylinders, 255 tracks per cylinder, 63 sectors per track, and 512 bytes per sector:
Total tracks = 4864 cylinders × 255 tracks per cylinder = 1,240,320 tracks
Total sectors = 1,240,320 tracks × 63 sectors per track = 78,140,160 sectors
Total bytes = 78,140,160 sectors × 512 bytes per sector = 40,007,761,920 bytes

Note that in Figure 19-2 the capacity of the drive is expressed as 37.26 GB, where GB = 2^{30}.

19.1: HARD DISK ORGANIZATION/PERFORMANCE
hard disk capacity and organization

- The sectors of a disk are grouped into clusters.
  - Cluster size varies, but is always a power of 2 (2, 4, 8, 16, 32, ...) sectors per cluster.
  - The file allocation table, or FAT, keeps track of what clusters are used to store which files.

19.1: HARD DISK ORGANIZATION/PERFORMANCE
formatting disks

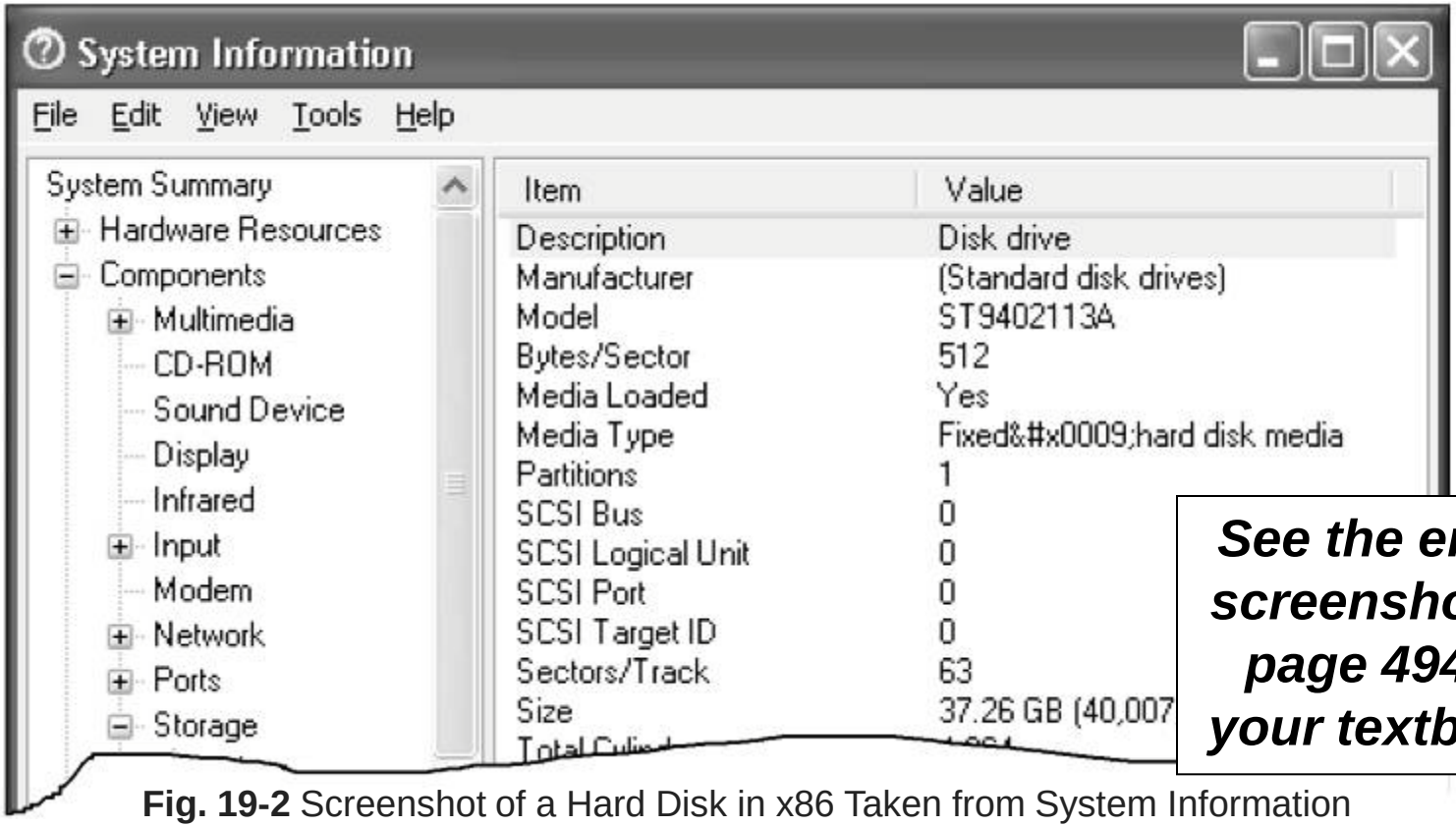
- Formatting organizes the sectors and tracks in a way that makes it possible for the disk controller to access the information on the disk.
  - When a disk is formatted, a number of sectors are set aside for various functions and the remaining sectors are used to store the user's files.
  - Formatting sets aside a specific number of sectors for the boot record, directory & FAT. (file allocation table)
- It also copies some system files onto the disk if it was formatted as a bootable disk.

19.1: HARD DISK ORGANIZATION/PERFORMANCE
disk organization

- Regardless of the type of disk, the first sector of the disk (side 0, track 0, sector 0) is always assigned to hold the boot record.
  - Then some sectors are used for storage of the FAT (file allocation table) copies 1 and 2.
    - The number of sectors set aside for FAT depends upon the disk density.

19.1: HARD DISK ORGANIZATION/PERFORMANCE
disk organization

- After the FAT, the directory is stored in consecutive sectors, depending on disk density.



See the entire screenshot on page 494 of your textbook.

Fig. 19-2 Screenshot of a Hard Disk in x86 Taken from System Information

19.1: HARD DISK ORGANIZATION/PERFORMANCE
looking into the boot record

- When a disk is formatted, the first sector is used for the boot record.
  - It is from the boot record that the computer will know:
    - The disk type.
    - Sector density.
    - Total number of sectors in the disk.
    - Other essential information needed by BIOS & operating system.

19.1: HARD DISK ORGANIZATION/PERFORMANCE
bootable and nonbootable disks

- If the disk is formatted as a system disk (bootable), the first two files are IO.SYS and MSDOS.SYS, and followed by COMMAND.COM.
  - The job of IO.SYS is to provide low-level (hardware) communication (interface) between BIOS and DOS.
  - The high-level (software) interface is provided by the MSDOS.SYS file.
  - If the disk is formatted as a *nonbootable* disk, it will *not* have those three files on it after it is formatted.
- The SYS command can be used to copy these files to a *nonbootable* disk to make it *bootable*.

19.1: HARD DISK ORGANIZATION/PERFORMANCE
FAT file allocation table

- It is the function of the FAT to provide a road map for the operating system to find where each file is located.
- FAT is so critical that two copies of the FAT are kept on the disk.
  - One for use and another one for backup in case something happens to the first one.
- The FAT is always located in the sectors following the boot record sector.
  - The number of sectors used by the FAT varies depending on the size and density of the disk.

19.1: HARD DISK ORGANIZATION/PERFORMANCE partitioning

- Partitioning the disk is the process of dividing the hard disk into many smaller disks.
  - They are called logical disks since it is the same physical disk, but as far as the operating system is concerned, it will be labeled disks C, D, and E.
- After the hard disk has been partitioned, high-level formatting should be performed next.
  - The C:\ drive must be formatted with the system option. (FORMAT C: /S)
    - So the system can boot from drive C:\.

19.1: HARD DISK ORGANIZATION/PERFORMANCE clusters

- In the x86 PC, sector size is always 512 bytes.
  - Cluster size varies among disks of various sizes.
    - Always a power of 2: 2, 4, 8, etc.
- A number of small files on a disk with a large number of sectors per cluster will result in wasted space on the hard disk.
  - Use the WinHex utility to find the cluster size.

19.1: HARD DISK ORGANIZATION/PERFORMANCE
speed of the hard disk

- A most important, widely cited disk performance factors is its speed, or how fast the requested data is available to the user.
  - Hard disk access time ranges 10–80 ms, and dropping.
- Hard disk access time is broken into several smaller times, indicating speed of different components.
  - **Seek time** - the amount of time the read/write head takes to find the desired cylinder or track
  - **Settling time -** is the time it takes the head to stop vibrating before it can begin reading the data
  - **Latency time** - is the time it takes for the head to locate on the specific sector.

19.1: HARD DISK ORGANIZATION/PERFORMANCE
interfacing standards in the hard disk

- To ensure hard disks by different manufacturers are compatible, common standards for interfacing the hard disk and personal computers have been devised.
  - ESDI and SCSI.

19.1: HARD DISK ORGANIZATION/PERFORMANCE
ESDI enhanced small device interface

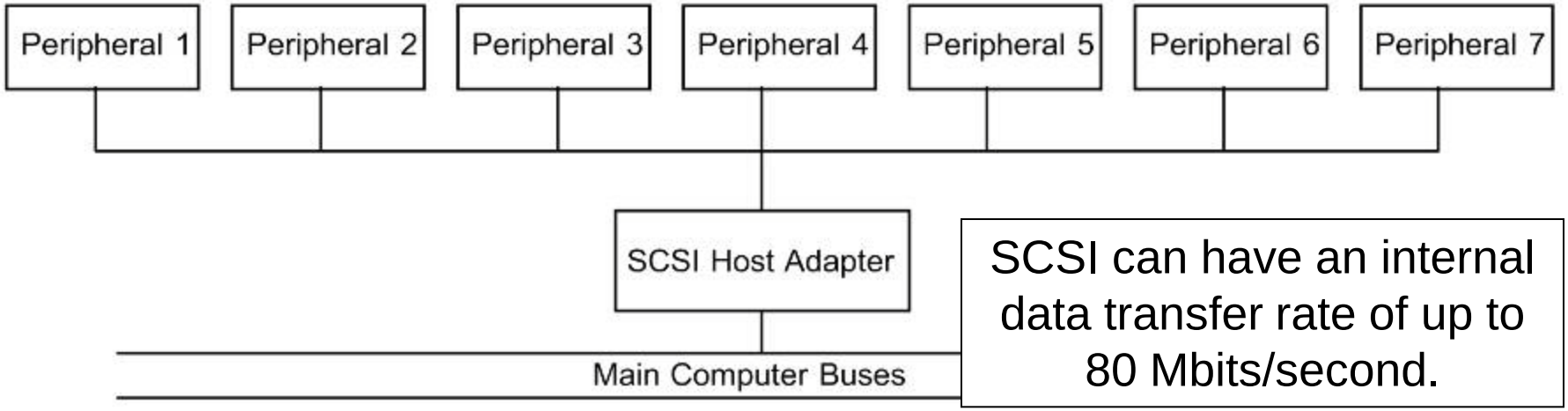
- The ESDI standard was developed by a group of disk drive manufacturers in 1983.
  - 1. ESDI can achieve a data transfer rate of up to 20 Mbits per second in contrast to 7.5 Mbits/second of the ST412.
  - 2. The number of sectors for ESDI can vary between he 20s and the 50s.
  - 3. The ESDI defect map is already stored on the drive.
  - 4. ESDI configuration information is already provided and there is no need to store it externally.
    - In the ST412 standard, the number of cylinders, heads, and sectors is stored either in the CMOS RAM of the system or in the ROM of the hard disk controller,

19.1: HARD DISK ORGANIZATION/PERFORMANCE
IDE integrated device electronics

- In IDE, the standard for current PCs, the controller is part of the hard disk, and there is no longer a separate controller, as is often the case for ST412.
  - IDE drives have a better data transfer rate due to integration of many of the controller's functions into the drive itself with the use of VLSI chips.

19.1: HARD DISK ORGANIZATION/PERFORMANCE
SCSI small computer system interface

- SCSI (*scuzzy*) is one of the most widely used interface standards, for all kinds of peripheral devices, not just hard disks.
  - One can daisy chain up to seven devices, such as CD-ROMs, optical disk, tape drives, floppy drives, networks, and other I/O devices, using SCSI.

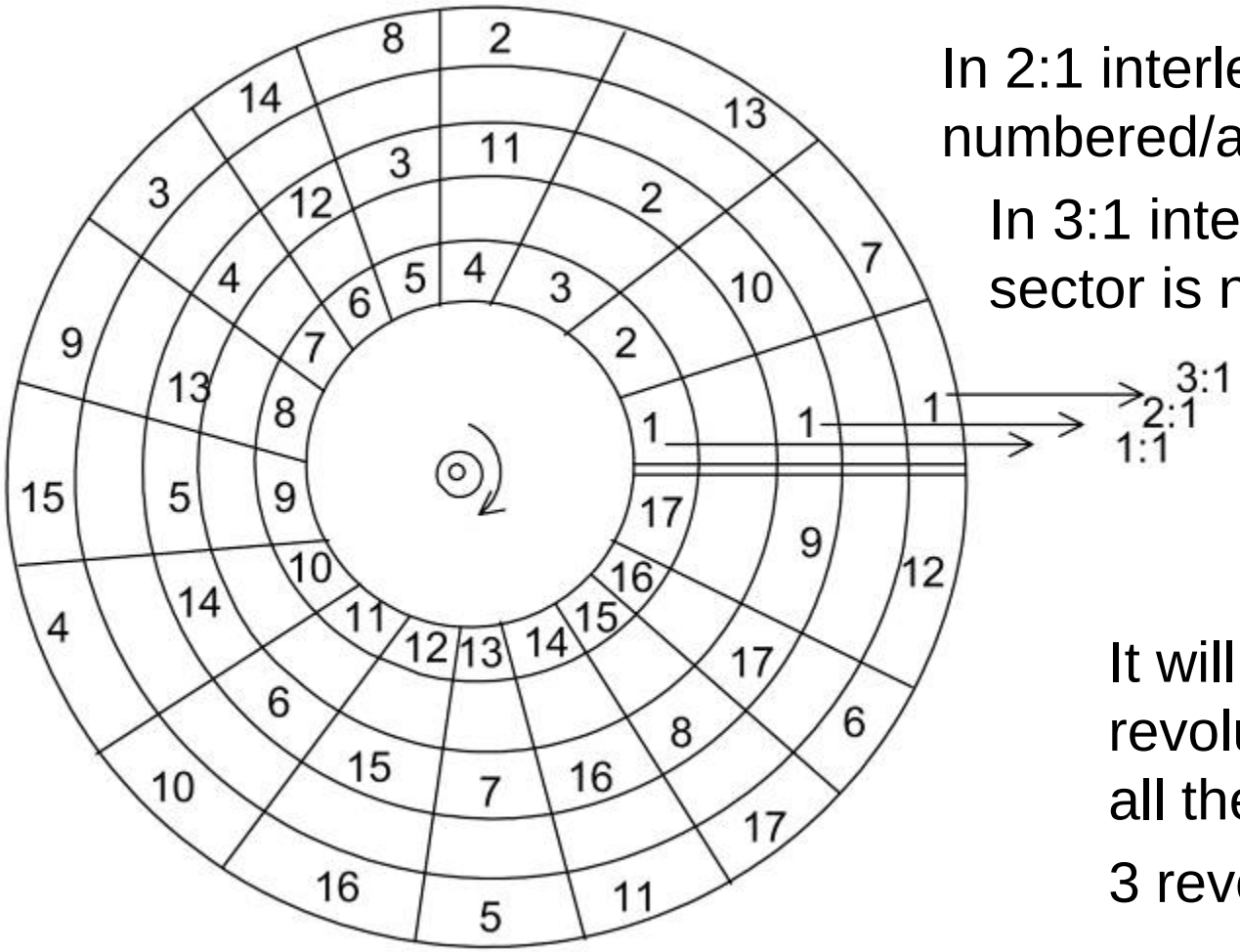


SCSI can have an internal data transfer rate of up to 80 Mbits/second.

19.1: HARD DISK ORGANIZATION/PERFORMANCE
interleaving

- As the read/write head moves along the track, it must read each sector and pass it to the controller.
  - The controller in turn will deliver this data to the host computer through the buses.
- If the head and the controller cannot keep up with the data stream, there are two choices:
  - Rotation should be slower or *interleaving* should be used.

19.1: HARD DISK ORGANIZATION/PERFORMANCE
interleaving



In 2:1 interleaving, sectors are numbered/accessed alternately.

In 3:1 interleaving, every *third* sector is numbered/accessed.

It will take 2 complete revolutions to access all the sectors in 2:1.

3 revolutions for 3:1

Fig. 19-4 Hard Disk Interleaving

19.1: HARD DISK ORGANIZATION/PERFORMANCE
disk caching

- Due to the long access time of the hard disk, disk caching is used to speed up the disk access time.
  - In a *hardware disk cache*, the disk manufacturer puts some (several megabytes) fast memory on the disk.

Table 19-1: Seagate LD25 Series Disk Drive Datasheet Data

Specifications	**40 GB** **GB = 1 billion**	**20 GB** **GB = 1 billion**
Model Number	ST9402115AS	ST920217AS
	ST9402115A	ST920217A
Interface Options	SATA/150	SATA/150
	Ultra ATA/100	Ultra ATA/100
Performance		
Spindle Speed (RPM)	5400	5400
Average Latency (mse c)	5.6	5.6
Seek Time		
Average Read/Write (msec)	<16	<16
Transfer Rate		
Maximum Internal (Mbytes/sec)	[illegible]	57.6

See the entire table on page 499 of your textbook.

19.1: HARD DISK ORGANIZATION/PERFORMANCE
disk caching

- In the other cache type, a section of memory on the PC motherboard is set aside for disk caching.
  - The larger the size of this memory, the more files can be stored and accessed by the CPU.
- Using a section of motherboard DRAM for disk caching is done by the operating system.
  - This kind of disk caching is called *software disk cache*.

19.1: HARD DISK ORGANIZATION/PERFORMANCE
disk reliability

- MTBF (mean time between failures) is a measure of reliability/durability of the disk when the power is on.
  - This factor is given in hours.
- The Seagate ST225 has a MTBF of 100,000 hours.
  - Dividing it by 24 hours gives an MTBF value of 4166.6 days or 11.4 years (4116.6/365).
  - Manufacturers use extremely reliable statistical analysis to determine the MTBF.

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