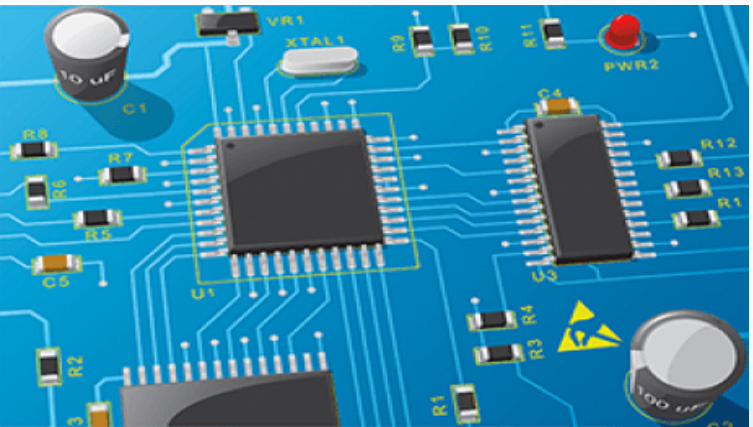
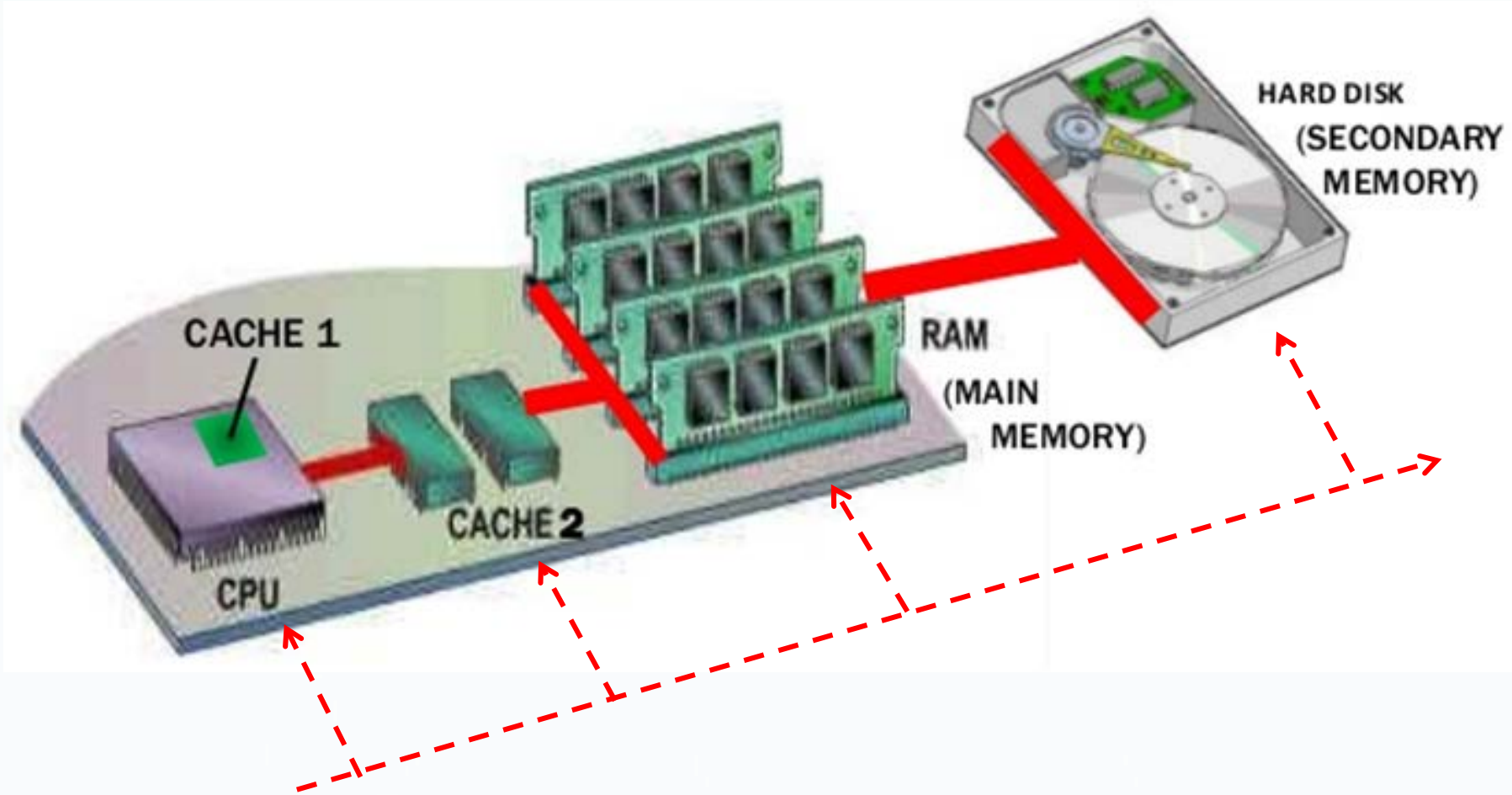
External Memory

National College of Ireland

Dublin, Ireland.



Edited by Dr Muhammad Iqbal

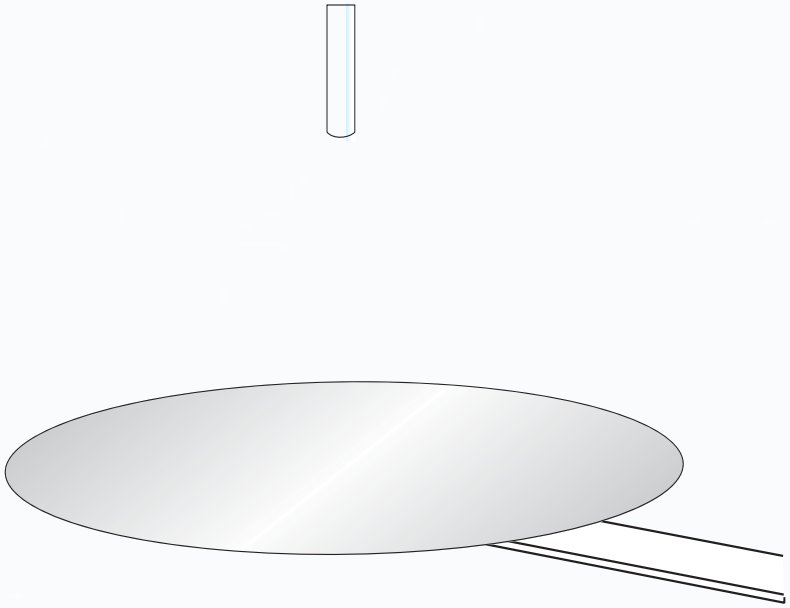


https://www.youtube.com/watch?v=TvkIi6NVnqY

Magnetic Disk

- **A disk is a circular *platter* constructed of nonmagnetic material, called the *substrate*, coated with a magnetizable material.**
  - **Traditionally the substrate has been an aluminium or aluminium alloy material**
  - **Recently the glass substrates have been introduced**
- **Benefits of the glass substrate:**
  - **Improvement in the uniformity of the magnetic film surface to increase disk reliability**
  - **A significant reduction in overall surface defects to help to reduce read-write errors**
  - **Ability to support lower fly heights**
  - **Better stiffness to reduce disk dynamics**
  - **Greater ability to withstand shock and damage**

Moving-head Disk Mechanism



Disk platter has a flat circular shape

Disk arm that moves all the heads as a unit

Inductive Write/Magnetoresistive Read Head

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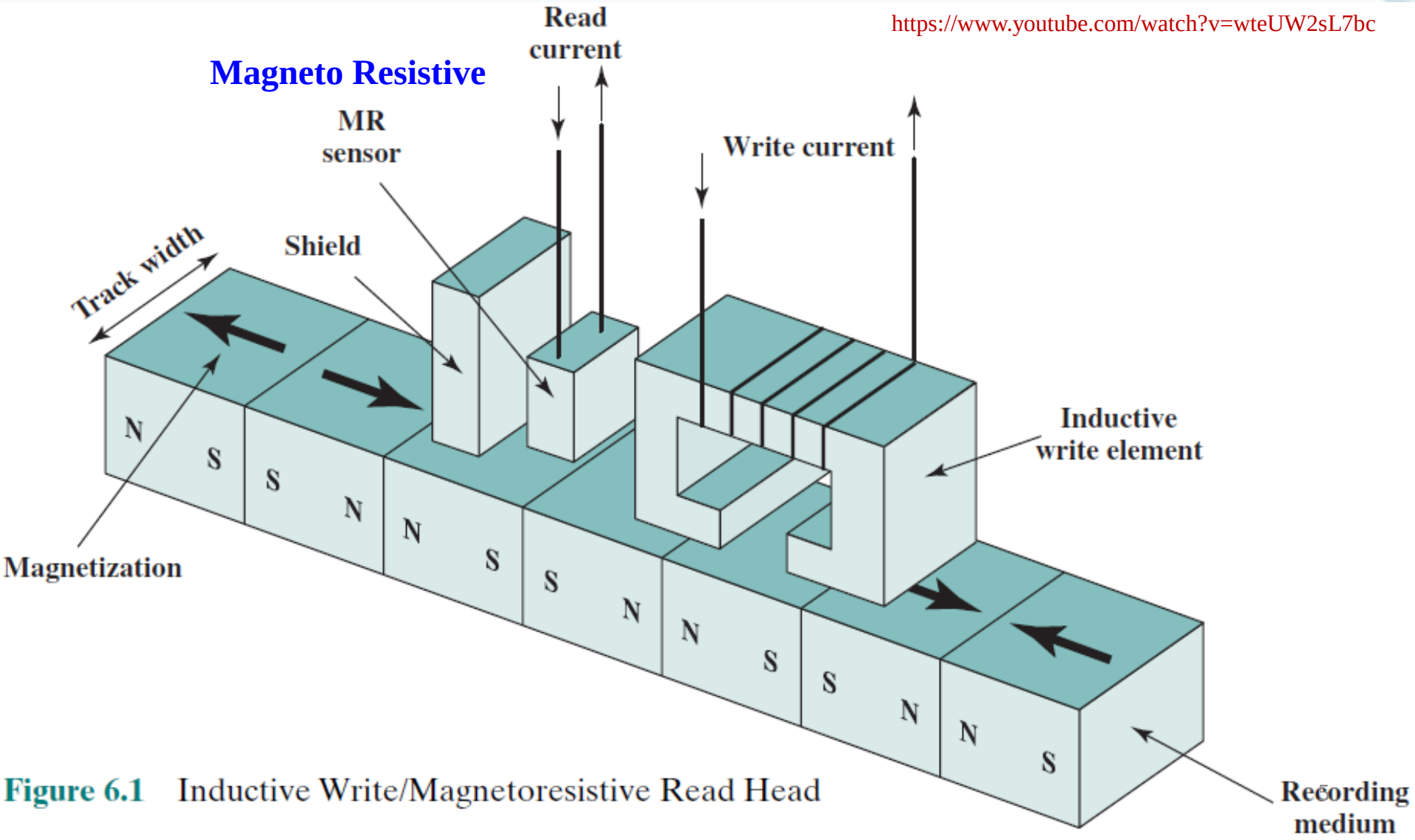


Figure 6.1 Inductive Write/Magnetoresistive Read Head

Magnetic Read and Write Mechanisms

- **Data are recorded on and later retrieved from the disk via a conducting coil named the head.**
- **In many systems there are two heads, a read head and a write head.**
- **During a read or write operation, the head is stationary while the platter rotates beneath it.**
- **Electric pulses are sent to the write head and the resulting magnetic patterns are recorded on the surface below, with different patterns for the positive and negative currents.**
- **The write head is in the shape of a rectangular doughnut with a gap along one side and a few turns of conducting wire along the opposite side.**
- **An electric current in the wire induces a magnetic field across the gap, which in turn magnetizes a small area of the recording medium.**
- **Reversing the direction of the current reverses the direction of the magnetization on the recording medium.**

Inductive Write/ Magnetoresistive Read Head

- The traditional read mechanism exploits the fact that a magnetic field moving relative to a coil produces an electrical current in the coil.
- When the surface of the disk passes under the head, it generates a current of the same polarity as the one already recorded.
- The structure of the head for reading is essentially the same as for writing and therefore the same head can be used for both. Such single heads are used in floppy disk systems and in older rigid disk systems.
- Contemporary rigid disk systems use a different read mechanism, requiring a separate read head, positioned for convenience close to the write head.

Inductive Write/Magnetoresistive Read Head

- **The read head consists of a partially shielded magnetoresistive (MR) sensor.**
- **The MR material has an electrical resistance that depends on the direction of the magnetization of the medium moving under it.**
- **By passing a current through the MR sensor, the resistance changes are detected as voltage signals.**
- **The MR design allows higher-frequency operation, which equates to greater storage densities and operating speeds.**

Disk Data Layout

- The head is a relatively small device capable of reading from or writing to a portion of the platter rotating beneath it.
- This gives rise to the organization of data on the platter in a concentric set of rings, called tracks.
- Each track has the same width as the head. There are thousands of tracks per surface.
- Adjacent tracks are separated by gaps as shown in the Figure.

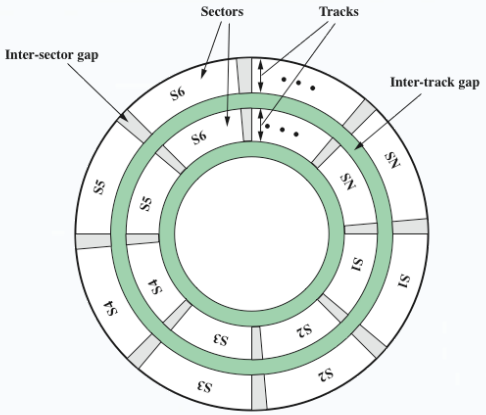


Figure 6.2 Disk Data Layout

https://www.youtube.com/watch?v=kdmLvl1n82U

- Data are transferred to and from the disk in sectors.
- There are typically hundreds of sectors per track, and these may be of either fixed or variable length.
- In most contemporary systems, fixed-length sectors are used, with 512 bytes being the nearly universal sector size.
- To avoid imposing unreasonable precision requirements on the system, adjacent sectors are separated by intratrack (intersector) gaps.

Disk Layout Methods Diagram

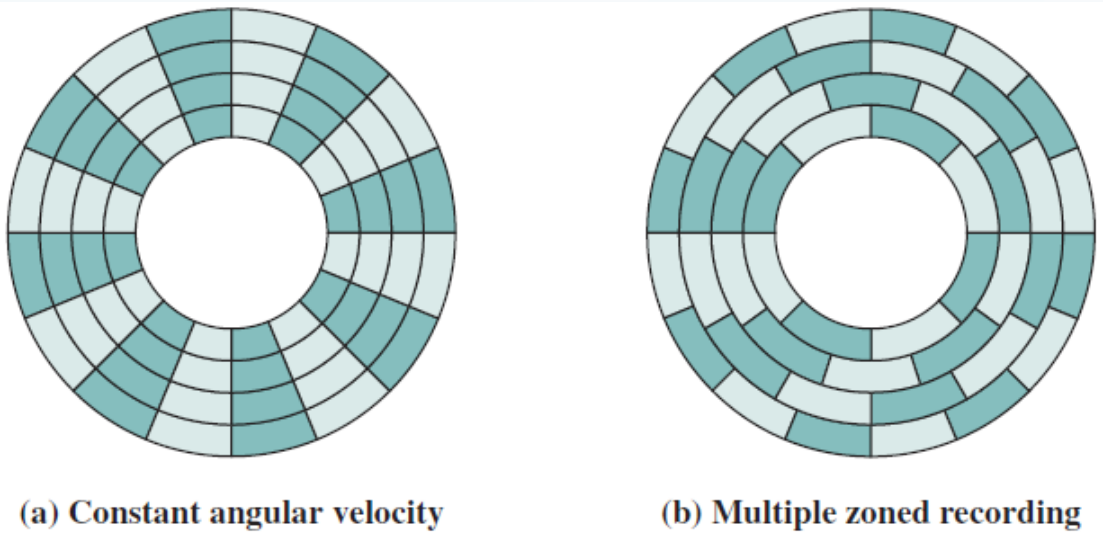
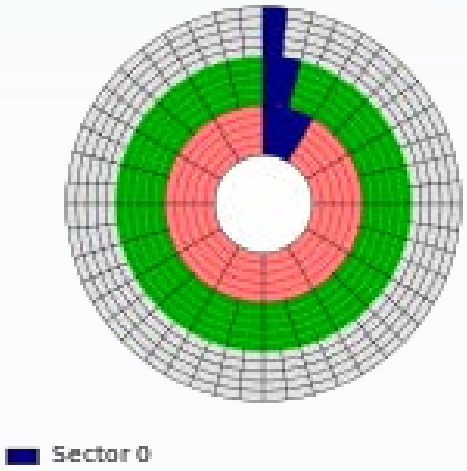


Figure 6.3 Comparison of Disk Layout Methods

- A bit near the center of a rotating disk travels past a fixed point (such as a read–write head) slower than a bit on the outside.
- This can be done by increasing the spacing between bits of information recorded in segments of the disk.
- The information can then be scanned at the same rate by rotating the disk at a fixed speed, known as the **constant angular velocity** (CAV).

Disk Layout Methods Diagram



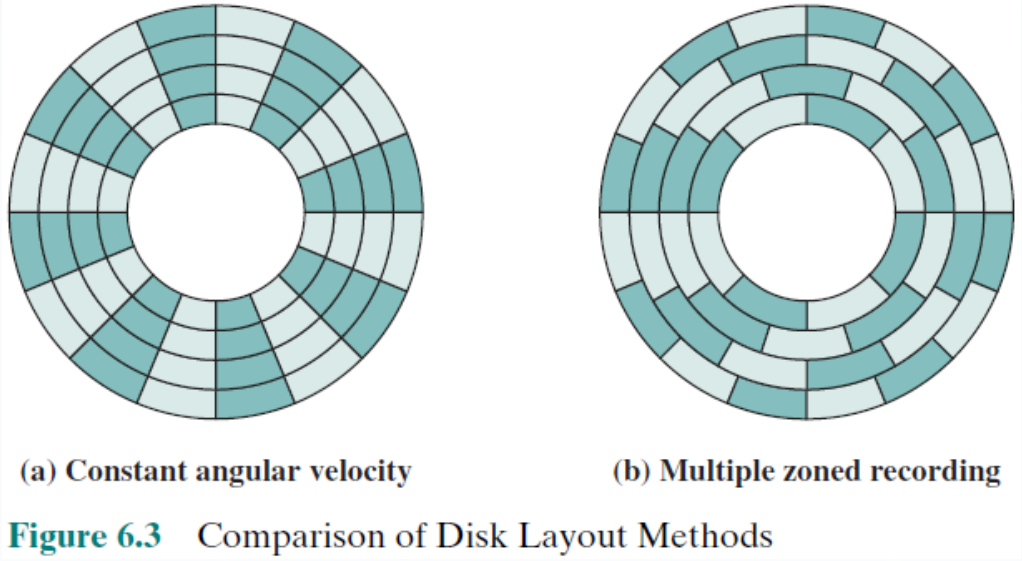


Figure 6.3 Comparison of Disk Layout Methods

- To increase density, modern hard disk systems use a technique known as ***multiple zone recording***, in which the surface is divided into a number of concentric zones (16 is typical).
- Within a zone, the number of bits per track is constant.
- Zones farther from the center contain more bits (more sectors) than zones closer to the center.
- We can accommodate more bits in the outer track as compared to inner track.

Winchester Disk Format
Seagate ST506

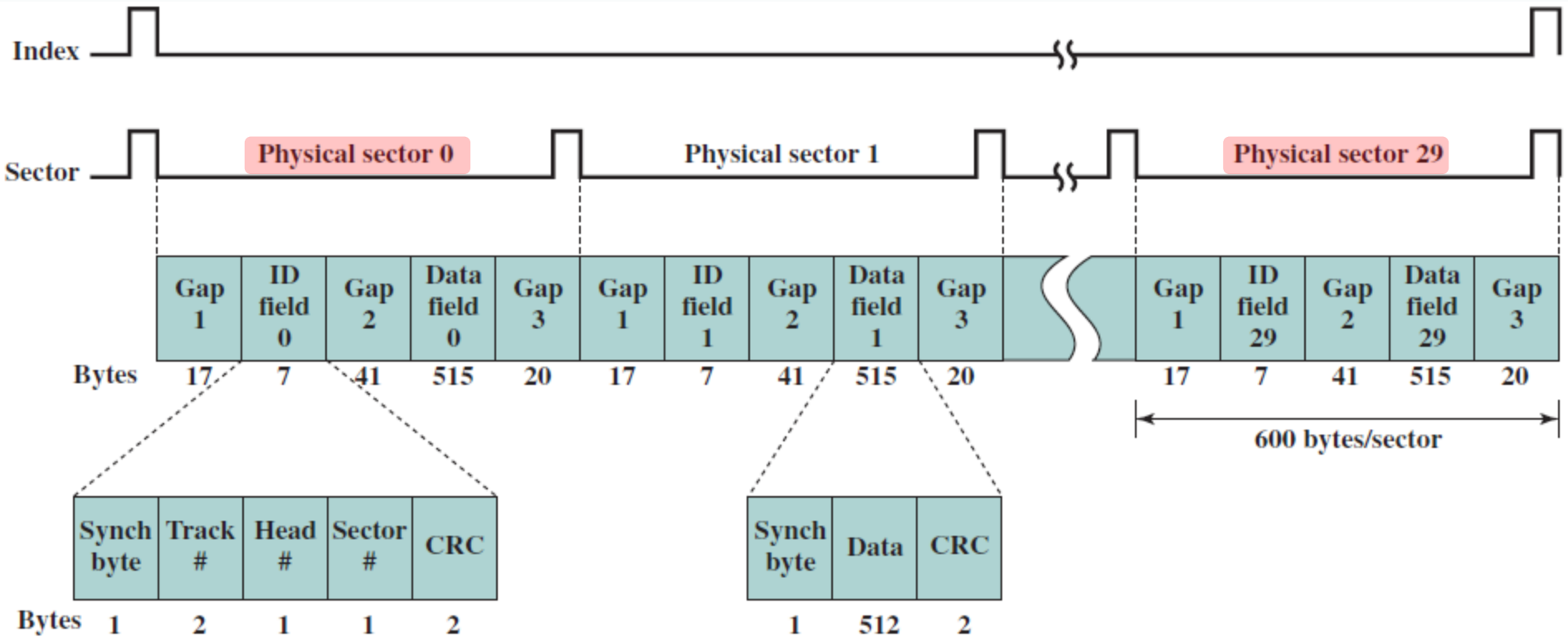


Figure 6.4 Winchester Disk Format (Seagate ST506)

An example of disk formatting is shown in Figure 6.4.

Winchester Disk Format
Seagate ST506

- **In this case, each track contains 30 fixed-length sectors of 600 bytes each.**
- **Each sector holds 512 bytes of data plus control information useful to the disk controller.**
- **The ID field is a unique identifier or address used to locate a particular sector.**
- **The SYNCH byte is a special bit pattern that delimits the beginning of the field.**
- **The track number identifies a track on a surface.**
- **The head number identifies a head, because this disk has the multiple surfaces.**
- **The ID and data fields each contain an error detecting code.**

Multiple Platters

- Some **disk drives** accommodate multiple platters stacked vertically a fraction of an inch apart.
- **Multiple arms** are provided as shown in the Figure 6.5.
- Multiple–platter disks employ a movable head, with one read-write head per platter surface.
- All of the heads are mechanically fixed so that all are at the same distance from the center of the disk and move together.
- Thus all of the heads are positioned over tracks that are of equal distance from the center of the disk at any time.

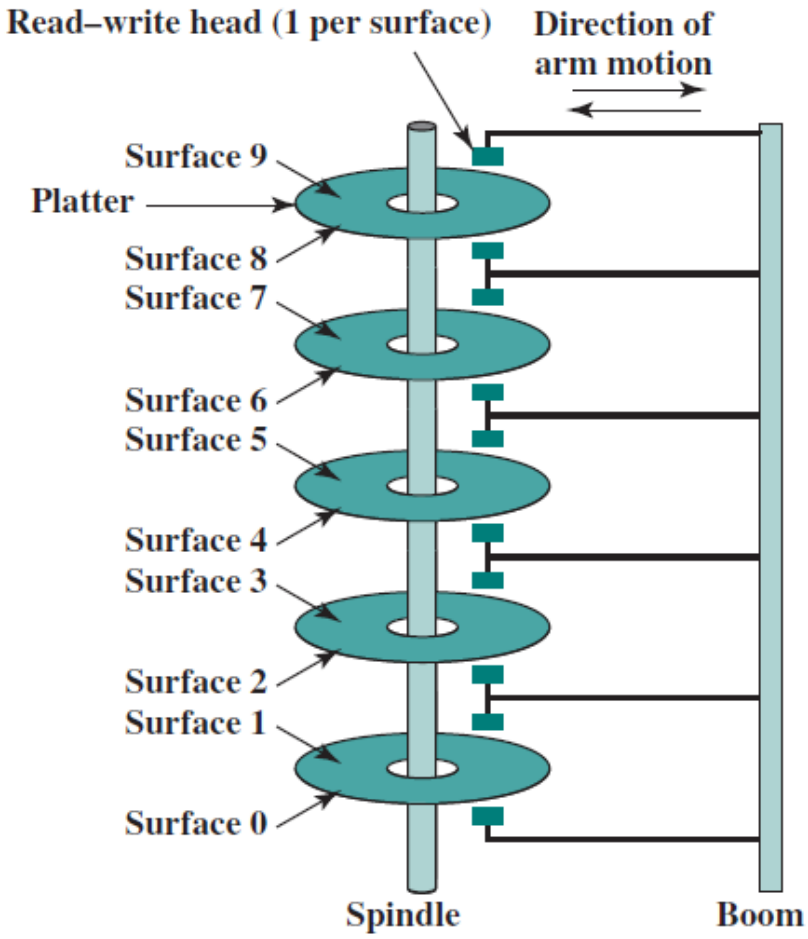


Figure 6.5 Components of a Disk Drive

Physical Characteristics

- **Fixed-head disk**
  - One read-write head per track
  - Heads are mounted on a fixed ridged arm that extends across all tracks
  - Such systems are rare today
- **Movable-head disk**
  - One read-write head
  - Head is mounted on an arm
  - The arm can be extended or retracted
- **Removable disk**
  - Can be removed and replaced with another disk
  - Advantages:
    - Unlimited amounts of data are available with a limited number of disk systems
    - A disk may be moved from one computer system to another
  - Floppy disks and ZIP cartridge disks are examples of removable disks
- **Double sided disk**
  - Magnetizable coating is applied to both sides of the platter

Typical Hard Disk Parameters

Table 6.2 Typical Hard Disk Drive Parameters

Characteristics	Constellation ES.2	Seagate Barracuda XT	Cheetah NS	Momentus
Application	Enterprise	Desktop	Network attached storage, application servers	Laptop
Capacity	3 TB	3 TB	400 GB	640 GB
Average seek time	8.5 ms read 9.5 ms write	N/A	3.9 ms read 4.2 ms write	13 ms
Spindle speed	7200 rpm	7200 rpm	10, 075 rpm	5400 rpm
Average latency	4.16 ms	4.16 ms	2.98	5.6 ms
Maximum sustained transfer rate	155 MB/s	149 MB/s	97 MB/s	300 MB/s
Bytes per sector	512	512	512	4096
Tracks per cylinder (number of platter surfaces)	8	10	8	4
Cache	64 MB	64 MB	16 MB	8 MB

Table 6.2: Typical Hard Disk Drive Parameters

Timing of Disk I/O Transfer

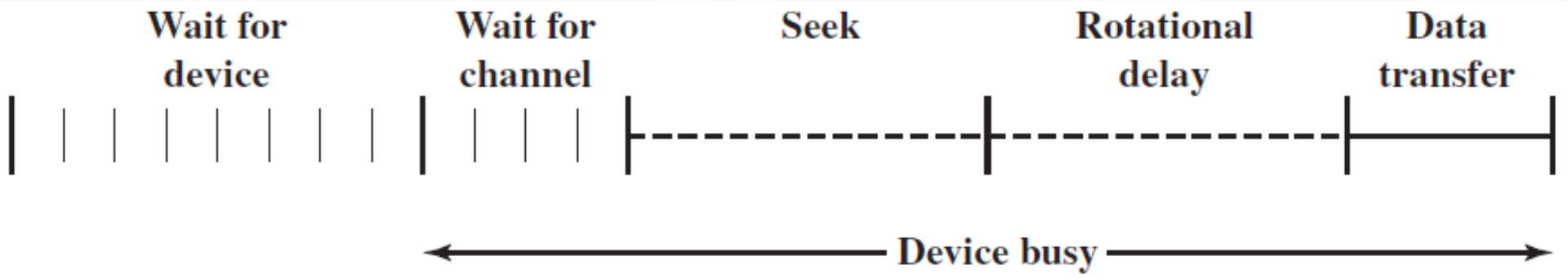


Figure 6.7 Timing of a Disk I/O Transfer

- **The actual details of disk I/O operation depend on the computer system, the operating system, and the nature of the I/O channel and disk controller hardware.**
- **A general timing diagram of disk I/O transfer is shown in Figure 6.7.**

Disk Performance Parameters

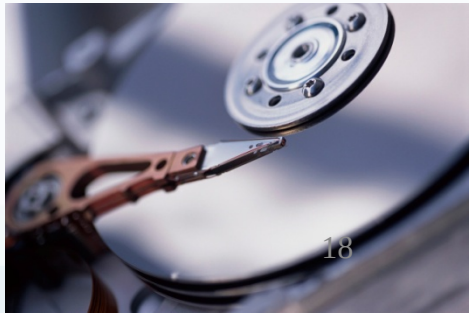
- **When the disk drive is operating, the disk is rotating at constant speed**
- **To read or write, the head must be positioned at the desired track and at the beginning of the desired sector on the track**

  i. **Track selection involves moving the head in a movable-head system or electronically selecting one head on a fixed-head system**

  ii. **Once the track is selected, the disk controller waits until the appropriate sector rotates to line up with the head**

1. Seek time

– **On a movable–head system, the time it to position the head at the track**



Disk Performance Parameters

2. Rotational delay (*rotational latency*)

- **The time it takes for the beginning of the sector to reach the head.**

3. Access time

- **The sum of the seek time and the rotational delay.**
- **The time it takes to get into position to read or write.**

4. Transfer time

- **Once the head is in position, the read or write operation is then performed as the sector moves under the head.**
- **This is the data transfer portion of the operation.**

Module Resources/ References

Dr. Muhammad M Iqbal* (NCIRL)

Recommended Book Resources

- **William Stallings, COMPUTER ORGANIZATION AND ARCHITECTURE DESIGNING FOR PERFORMANCE, NINTH EDITION, Boston, ISBN 13: 978-0-13-293633-0, PEARSON**
- **Patterson, D and Hennessy, J 2012, omputer Organization and Design: The Hardware/Software Interface, Revised 4th Edition Ed., Waltham, MA : Morgan Kaufmann**

Supplementary Book Resources

- **Morris, M. and Kime C 2008, Logic and Computer Design Fundamentals, Pearson International Edition**