Computer Architectures & Operating Systems

Lecture 7: Hard Disk Drives

Griffith College

Introduction

- **This lecture looks at:**
- Why secondary storage is necessary.
- The historical context of secondary storage device development.
- Magnetic storage devices. Tape drives, disk drives.
- Disk drive development.
- Disk drive construction.
- Areal density.
- Calculating disk drive capacity, access time and transfer rate.

The Need for Secondary Storage

- **Secondary storage is needed to accommodate:**
  - Programs
  - Data to be processed.
  - Processed data.
- It is not sufficient to simply store programs and data in main memory.
- Main memory is volatile but lacks the capacity in any case.
- A means of persistent storage is required.

Secondary Storage Development

- Punched cards.
- IBM cards had 80 columns. -Influenced subsequent hardware development.
- Holes used to encode data.
- One line of programming per card.
- Program contained in a deck of cards.
- A program also had corresponding data cards.
- The use of punched cards began to decline in the 1960s.
- Replaced by magnetic tape.

IBM Card

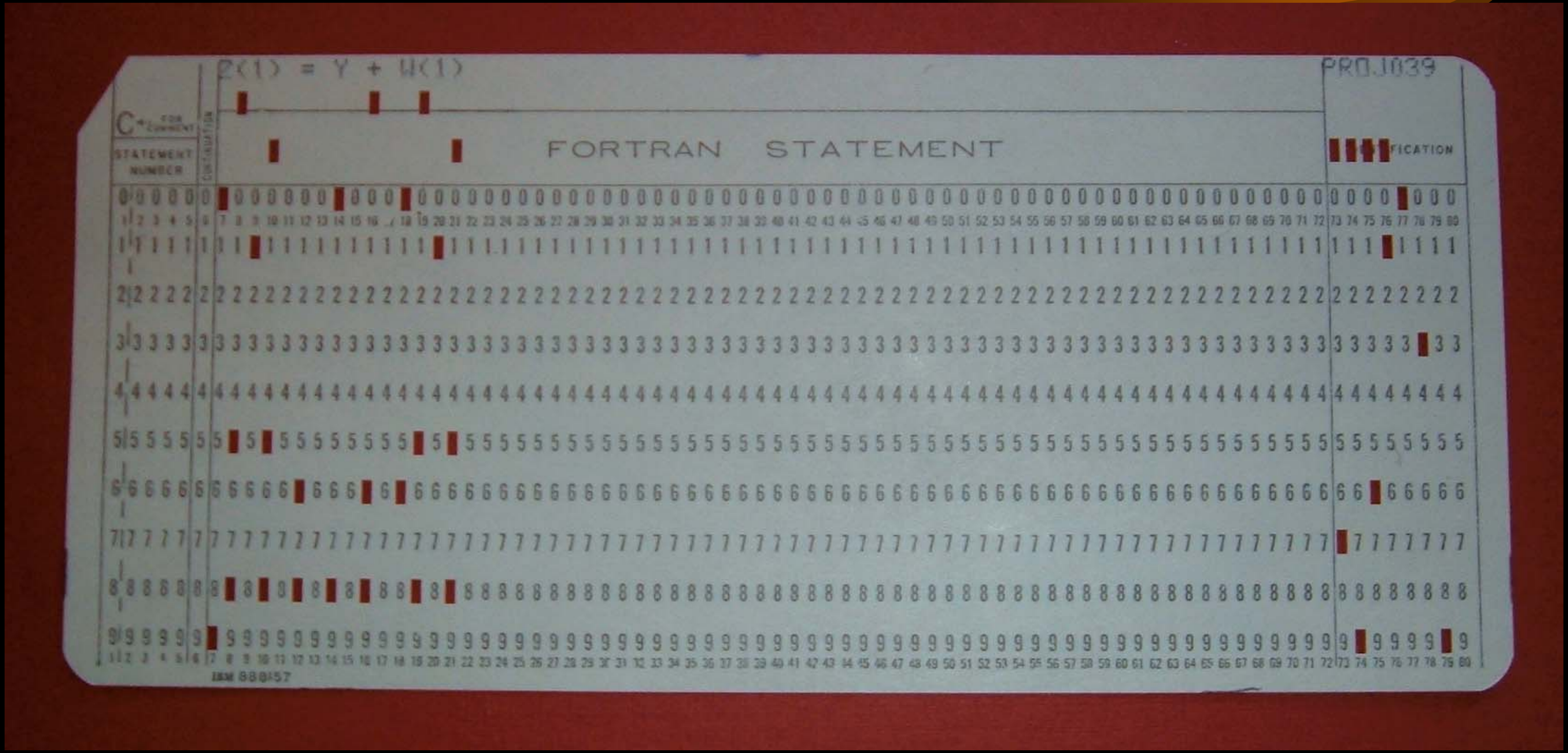


Figure 1: Fortran statement on an IBM punched card.

Magnetic Storage

- Encoding of data onto a magnetically coated surface.
- Analog magnetic devices, eg. tape recorder, were already in existence.
- Magnetic encoding was also in use for magnetic core memories (Figure 2).
- 1952 IBM announces the 726 Tape Unit.
- 1956 IBM 305 RAMAC (Random Access Method of Accounting and Control) is the first computer to use a disk drive (Figure 3).
- 5MB on 50 disks, each of 24 inches in diameter.

Core Memory

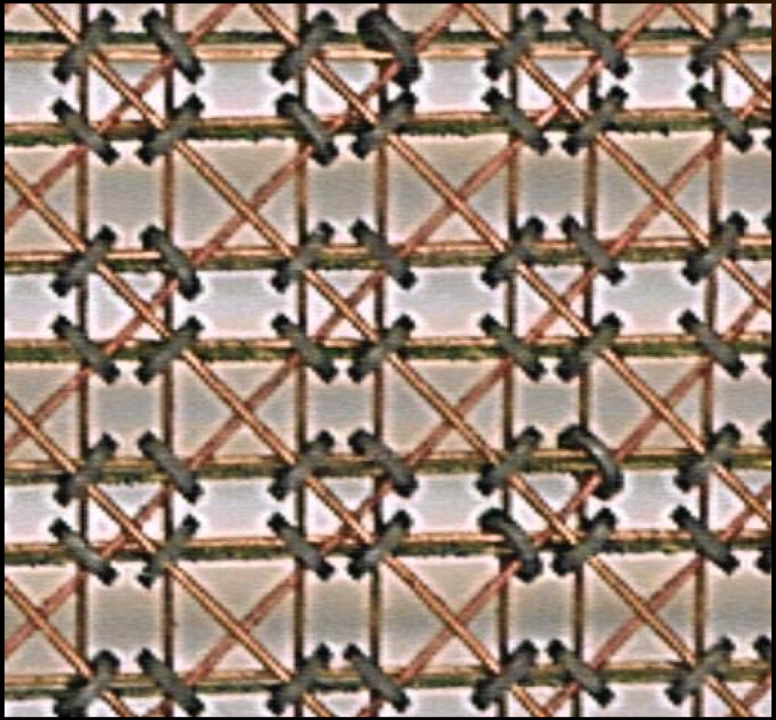


Figure 2: Close up scan of core memory

IBM 305 RAMAC

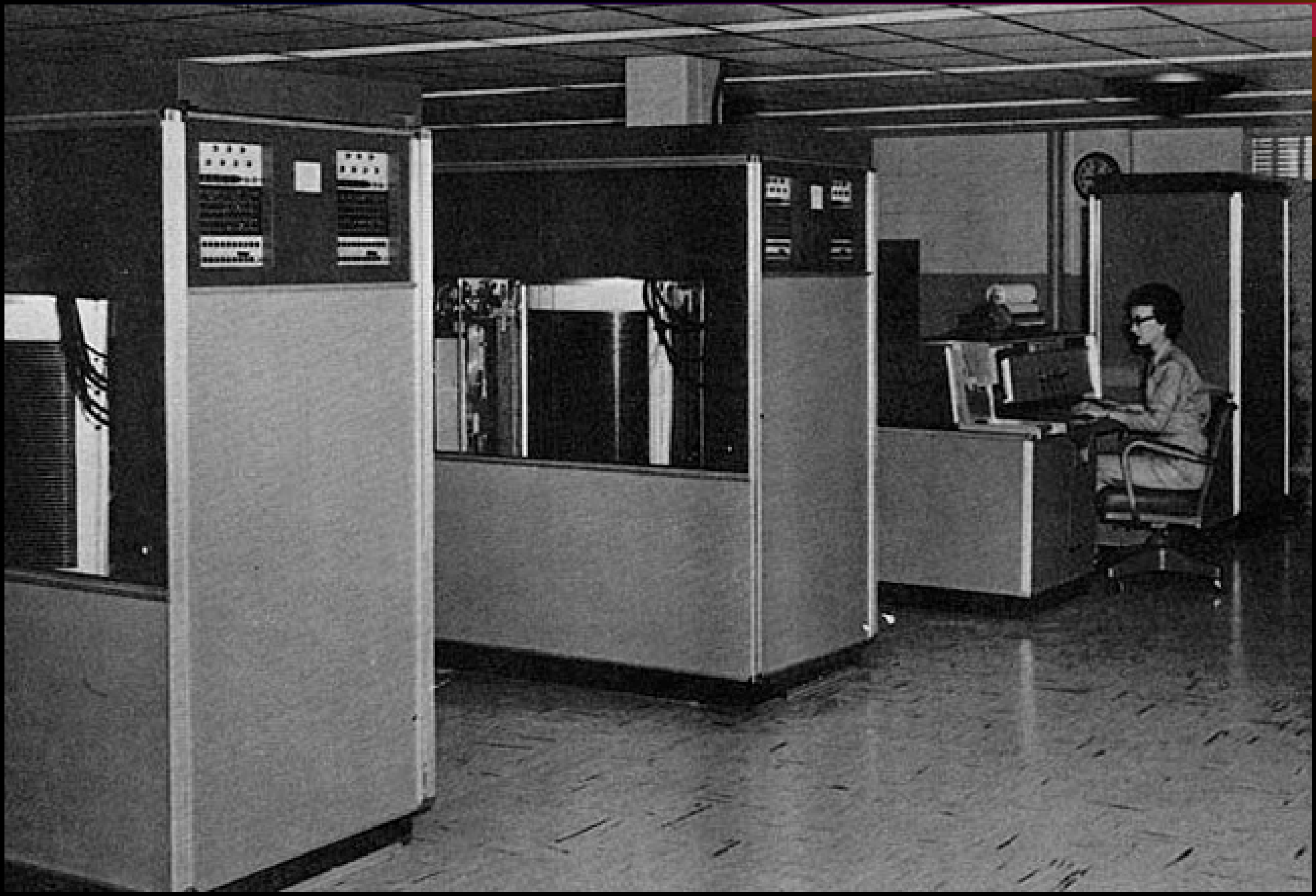


Figure 3: In 1956, the IBM 305 is the first computer to use a disk drive. It is also the last vacuum tube computer manufactured by IBM.

Magnetic Fields

- Electromagnetism: Hans Christian Oersted (1819)
- Compass needle deflected by a current carrying wire.
- A current carrying wire has a magnetic field.
- A magnetic field can induce a current in a wire moving through it.
- A current carrying head can be used to align the magnetism of particles on the disk surface.
- A coil passing over the moving disk can be used to read the magnetically encoded data from the disk surface.

Hard Disk Drives (HDD)

- The hard disk drive contains spinning platters.
- The platters consist of a substrate, typically aluminium and a magnetic coating.
- The coating contains tiny magnetic particles.
- Read / write heads ‘fly’ close to but not touching the surface of the disk (Figure 4).
- The particles in the platter coating can be magnetised in such a way that very small magnetic fields are created. (Write)
- The magnetic fields on the platter surface induce currents in the read head. (Read)

Disk Surface and Read / Write Head

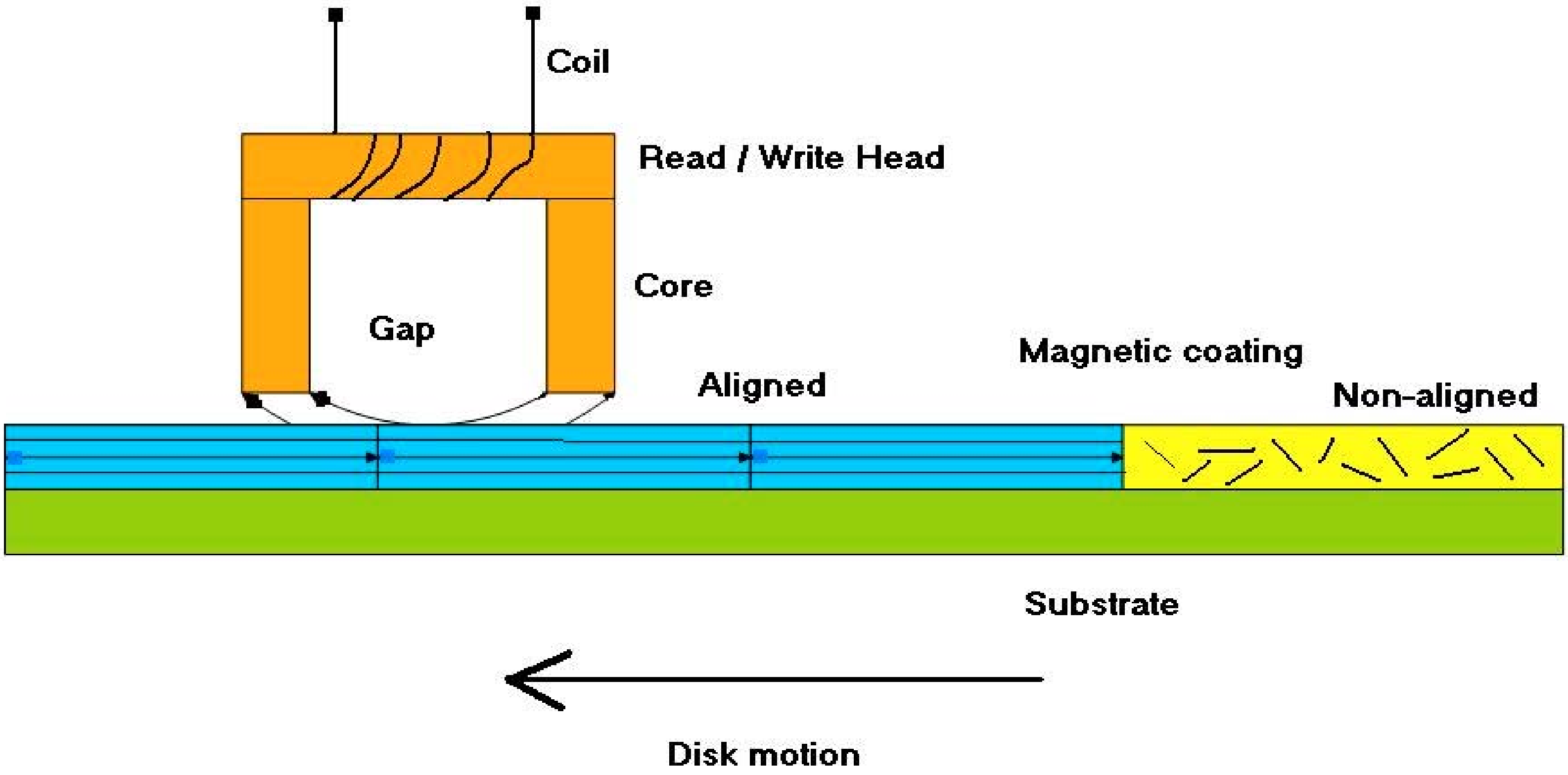


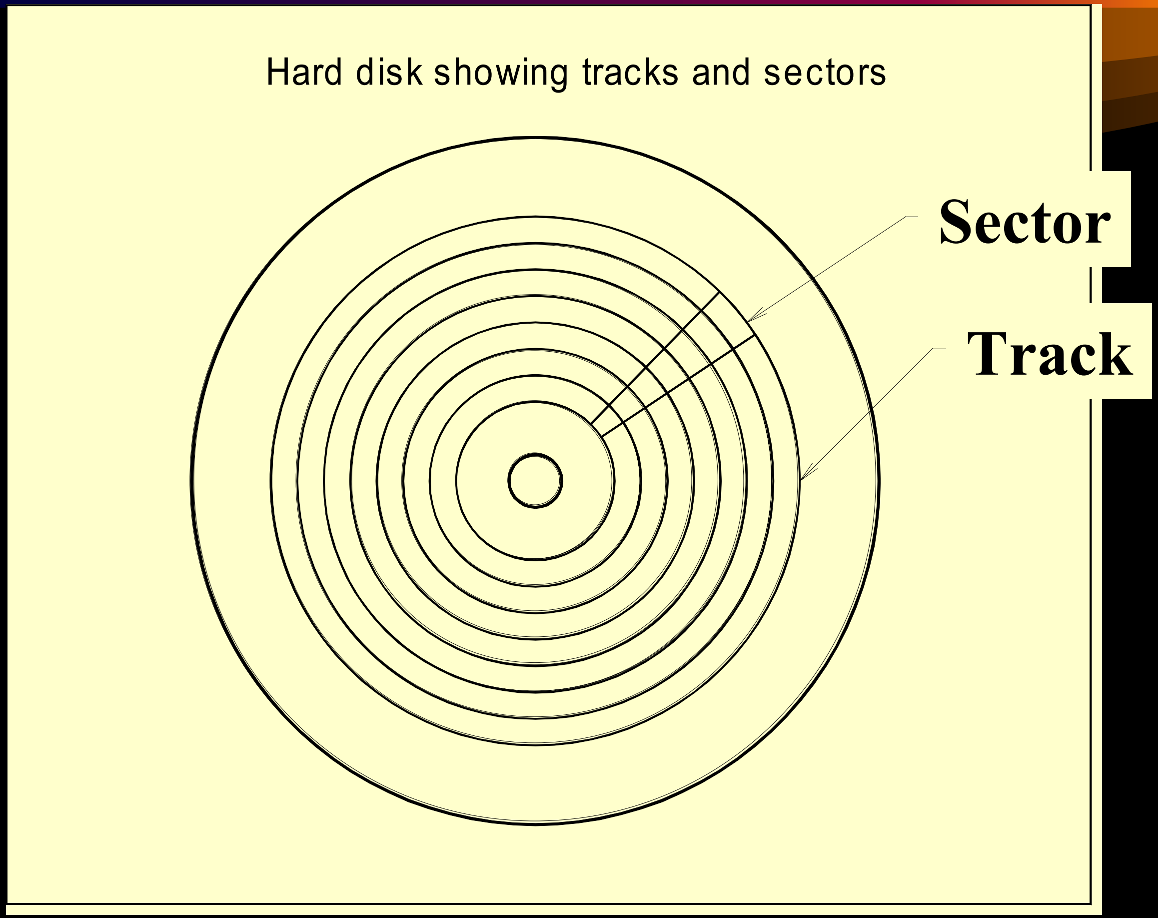
Figure 4: Magnetic disk surface and read/write head.

Hard Disk Construction

- Platters: The platters can be seen in Figure 5.
- Read /write heads (Figure 5).
- Spindle motor.
- Tracks - Arranged in concentric circles on the platter surfaces. Data is written onto the tracks.
- Sectors - Track segments
- Cylinders - Corresponding tracks on each platter surface. For example, the outermost track on the top and bottom surfaces of each platter.

Figure 5: Spinning HDD

Tracks & Sectors



Tracks, Sectors & Cylinders

- Typically, the platters spin at 5400 r.p.m. or 7200 r.p.m. and the read/write heads hover on an air cushion caused by the high spin rate.
- The entire construction is sealed from the outside environment. Even a tiny amount of dust or moisture would render the drive useless.
- The read/write heads of a typical drive can move to over 200 different positions in order to perform a read or write. These positions are referred to as cylinders.
- Tracks, sectors and cylinders are logical rather than physical.

Drive Capacity

- **The Hard Drive capacity depends on:**

- The number of platter surfaces used.
- The number of tracks on each surface.
- The number of sectors per track.
- The amount of data bits per unit surface area is referred to as the areal density.
- Bits per inch of track * Tracks per inch (Measured radially)

Calculating Drive Capacity

- Consider the following hard disk specification and calculate the capacity of the disk in Mb. (Use reasonable approximations.)

- 2 platters, with 2 surfaces on these platters in use.
- Tracks per surface: 3711
- Sectors per track : 96
- Bytes per sector : 512

Calculating Drive Capacity

- **The capacity of the Drive is:**

- 3711 * 96 * 512 * 4 bytes
- = 729612288 bytes
- = 729612288 / 1024 * 1024 Mb
- = 695 Mb

Calculating Access Time

- Access time really means the average access time.
- Sometimes the required data will be far away from where the heads are and sometimes it will be nearby.
- It depends on the rotational speed of the disk and the time it takes to position the read/write heads. (seek time)
- If it is known from manufacturers specifications that the average seek time is 10 ms then the average access time can be calculated.
- The calculation assumes that on average the required data will be halfway round the disk.

Calculating Access Time

- The average access time therefore is the average seek time plus the time it takes for the disk to make a half revolution.
- The time required for the disk to spin to where the data begins is called the rotational latency.

- The access time is the sum of these two components:
  - 1. The seek time (Position the heads)
  - 2. The rotational latency (Disk rotates to start of data)

Calculating Access Time

- A drive has a seek time of 10ms. The rotational speed is 7200 r.p.m. Calculate the access time.

- Average access time

  = average seek time + (0.5 x 60 x 1000)/7200

  = 10 + 4.16 ms

  =14.16 ms

Transfer Rate

- The sustained transfer rate means the rate at which the disk will deliver data in a sustained manner.
- If it is not available from the manufacturer it can be calculated quite easily.
- It is necessary to know the rotational speed (spin rate) and the number of sectors per track. (For sectors per track, use the minimum number given.)

Maximum Transfer Rate

- If a disk has 512bytes per sector and a rotational speed of 7200r.p.m. (120 r.p.s.), calculate the maximum transfer rate:

- Maximum Transfer rate = 512 x 96 x 120 bytes per second
- = 5.89Mb/second