MODULE 8: Input/Output Systems

Lecture 8.1
Input/Output and Storage Systems

Prepared By:
- Scott F. Midkiff, PhD
- Luiz A. DaSilva, PhD
- Kendall E. Giles, PhD

Electrical and Computer Engineering

Virginia Tech

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Lecture 8.1 Objectives

- Describe the physical operation of magnetic disks, CDs, and DVDs

- Enumerate the main components of data transfer latency

- Describe the physical operation of input devices such as keyboards, mice, touchscreen, and joysticks

- Describe the physical operation of output devices such as laser and inkjet printers and video displays

- Calculate the bandwidth required to display video at a particular resolution and refresh rate

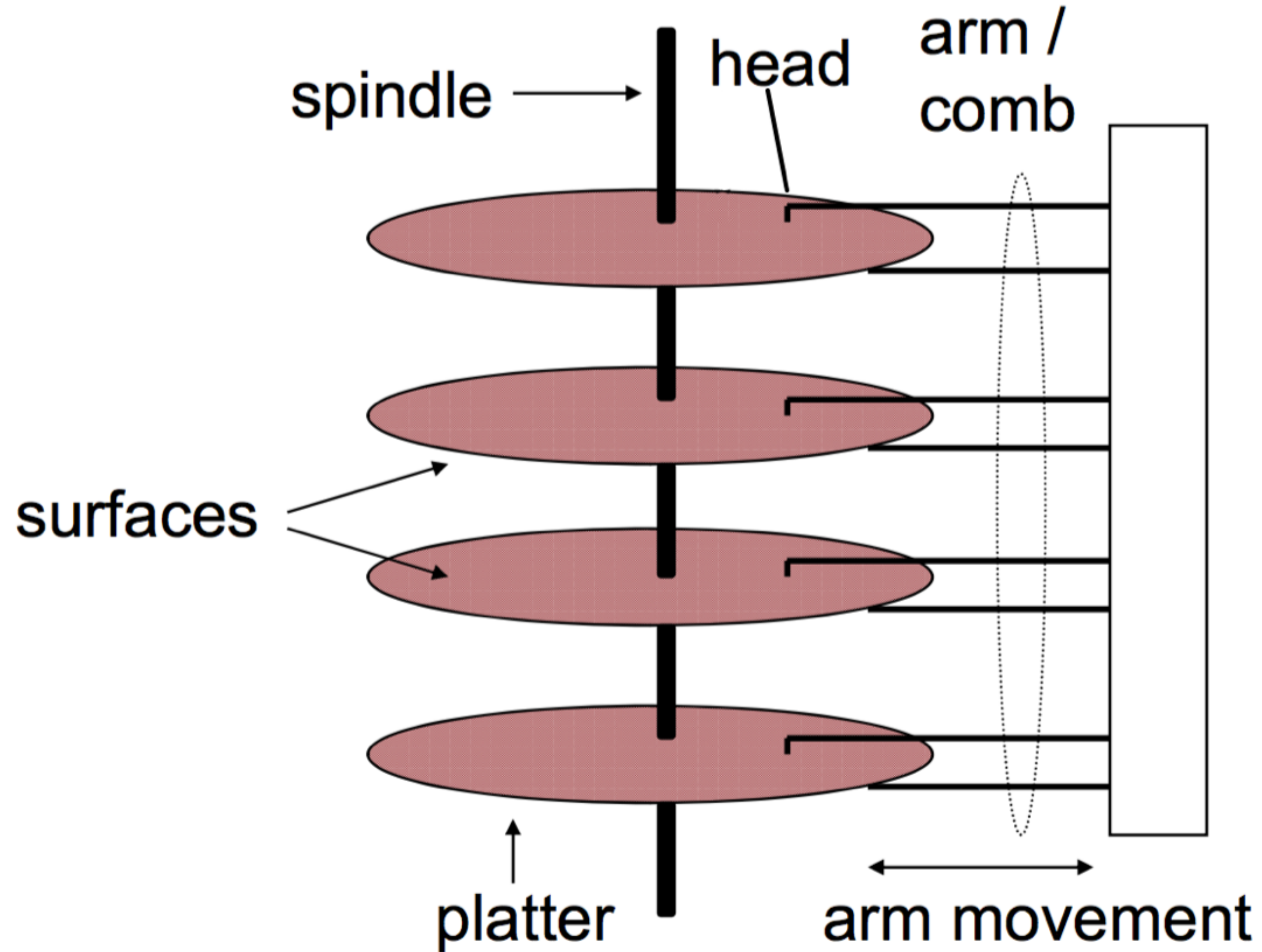VirginiaTech
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Introduction

- Data storage and retrieval is one of the primary functions of computer systems
  - Computers are often more useful to us as data storage and retrieval devices than they are as computational machines
- All computers have I/O devices connected to them
  - And I/O and data storage devices significantly affect overall system performance

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Mass Storage

- Non-volatile: retain information indefinitely after power is removed

- Examples:

    - Magnetic Disks

    - Magnetic Tape

    - Optical Disks (CDs and DVDs)

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Magnetic Disks

spindle → head   arm / comb

surfaces

platter   arm movement

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Physical Characteristics

- Surfaces of each disk platter are covered with magnetic material and information is recorded by magnetizing small areas of the material

    - For hard disk, platter is made of metal or glass

- Disk surface logically divided into tracks, subdivided into sectors

    - Sector (eg 512 bytes) smallest unit that can be read from disk

- Arm is positioned over the desired track

- Platters rotate at constant speed (eg 3600 to 10,000 RPM)

- One head used for reading/writing at any given time

Data Transfer Latency

- Maximum data transfer speed is controlled by:

  - Seek time – time to place the head on the desired track

    ‣ Largest contributor to latency

    ‣ Average seek time around 10 ms

  - Rotational latency – time for the desired sector to appear under the head

    ‣ Average about $\frac{1}{2}$ the time of a complete revolution (4-8 ms)

  - Transfer time – time to transfer the sector from the disk platter once the head is positioned over the sector

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CHECK POINT

As a checkpoint of your understanding, please pause the video and make sure you can do the following:

- Describe the physical operation of magnetic disks
- Enumerate the main components of data transfer latency

If you have any difficulties, please review the lecture video before continuing.

Diskettes

- Flexible plastic platter coated with magnetic material

  - Usually encased in rigid plastic

- Access time is slower

  - Flexible disk does not spin as fast as a hard disk (~300 RPM)

  - Access time ~ 250-300 ms

- Capacity

  - Most common: 1.44 MB

  - High-capacity disk drives (e.g. Zip drives): eg 100-250 MB

- Rapidly falling into disuse

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CD

- Aluminum-coated plastic

  - Reflects light differently from lands or pits created in the stamping process

  - A '1' is assigned to a pit-land or land-pit transition, and a '0' is assigned to a smooth area (no transitions)

  - Use Reed-Solomon code for error correction

- Capacity: 700 MB

  - Equivalent to 74 minutes of audio in digital stereo format

- Good for distributing large amounts of data

  - After initial cost of creating a master, very inexpensive

- CD-ROM

DVD

- Digital versatile disk

  - Evolution of the CD-ROM

- Capacity

  - If a single side is used, up to 4.7 GB

  - DVD standards allow for up to 17 GB

- Backwards compatible with CD

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Input Devices

- Rely on human muscles and human reaction time to produce input data

    - Very low data rate requirements

- Examples:

    - Keyboard

    - Mouse and trackball

    - Joystick

    - Pen and graphics tablet

    - Touch screen

    - Mic

Keyboard

- When a character is typed, a bit pattern is created that is transmitted to the computer

- Encoding of characters and control commands

    - 7-bit ASCII code (128 bit patterns)

    - Expanded ECMA-23 standard (shift, escape, control, function keys,...)

- Most keyboards buffer the last few characters typed

Mouse

- Mouse allows the user to move the cursor rapidly over the screen for selecting or pointing

- Information about direction of movement and input from mouse buttons are transmitted to the host

- Optical mouse

  - Transmits two pairs of low-powered optical signals from its bottom, one pair for x-direction, one for y-direction

  - Photodetectors sense the light reflected from these lines and determine the direction the mouse is moving, sometimes using gridded mouse pad

- Mechanical mouse

  - Hard rubber ball rolls as the mouse is moved

  - Potentiometers within the mouse sense direction of movement

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Touchscreens

- Photonic touchscreen

    - A matrix of beams cover the screen in vertical and horizontal directions

    - If the beam is interrupted (by a finger or another object) the position is determined by the interrupted beam

- An alternative: screen is covered by a touch-sensitive surface

    - User must make contact with the screen to make a selection

Joysticks

- Indicate position by the distance a rod that protrudes from the base is moved

- Potentiometer within the base translate X-Y position into voltages that are encoded in binary for input to a digital system

- Rotation of the rod allows for an additional dimension to be indicated (e.g. height)

- Eg, widely used in video games

CHECK POINT

As a checkpoint of your understanding, please pause the video and make sure you can do the following:

- Describe the physical operation of CDs, and DVDs

- Describe the physical operation of input devices such as keyboards, mice, touchscreen, and joysticks

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Output Devices

- Hardware used to communicate to the outside world the results of processing or data retrieval performed by a computer system

- Examples:

  - Printers

  - Displays

Laser Printers

- Laser discharges selected areas according to a bit-mapped representation of the page to be printed

    - Work in similar way to copiers

- Charged areas pick up electrostatically sensitive toner powder

- Paper is heated to fix the toner on the page

    - Note that toner is a form of plastic, and it is essentially melted on to the surface

- Special languages developed for transmitting information from computer to printer

    - Adobe PostScript

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Inkjet Printers

- Electronically charged ink is sprayed through a jet nozzle and passed through an electronic field

    - Field deflects the ink to form a dot-matrix character

    - Color inkjet printers use multiple nozzles

- Resolution between that of dot-matrix printers and that of laser printers

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Video Displays

- Cathode ray tube (CRT)

    - Vertical and horizontal deflection plates steer an electron beam that sweeps the display

- Plasma displays

    - Cells holding an inert mixture of gases are located between two panels of glass

    - Gas in the cells is electrically turned into a plasma that excites phosphors to emit light

- Liquid crystal displays (LCDs)

    - Pixels are arrayed in front of a light source or reflector

- Light-emitting diode displays (LEDs)

    - Pixels are LED lights that emit light in response to an electric current

Pixels

- Short for 'picture element'

- Row and column addresses for the positions on the screen are indexed into the frame buffer (or display RAM) that holds the bit patterns for the image to be displayed

- Each pixel can be represented by 1 (b/w) or multiple (color) bits

- Number of bits in frame buffer to represent each pixel determines maximum number of colors possible

- Screen must be updated often for illusion of continuous motion

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Video Bandwidth Example

- Consider a monitor with 1024 x 768 pixel resolution and refresh rate of 60 Hz

  - Assume 24 bits/pixel are used

- What is the required bandwidth?

  24 bits/pixel x (1024 x 768) pixels x 60 Hz = 1.13 Gbps

CHECK POINT

As a checkpoint of your understanding, please pause the video and make sure you can do the following:

- Describe the physical operation of output devices such as laser and inkjet printers and video displays
- Calculate the bandwidth required to display video at a particular resolution and refresh rate

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Summary

- Data storage and retrieval is one of the primary functions of computer systems

- Magnetic disk, magnetic tape, CD, and DVD provide non-volatile storage at increasingly low costs

- Examples of input devices include keyboards, mice, touchscreen, and joysticks

- Examples of output devices include printers and video displays

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