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Topic 15: Input and Output Devices

- Readings for this topic:
  - Silberschatz/Peterson: Sections 8.1-8.2.

- I/O Device Characteristics:
  - Terminal.
    - One character (8 bits of data or control function) is sent at a time, one interrupt per character.
    - 10-1800 characters per second.
    - Keyboard and display are independent in most systems (no automatic echo, full duplex).
    - Used to be handled with one interrupt per character, but often DMA nowadays.
  - Disk.
    - *Draw picture of spindle, platters, read/write-arm. Mention spaces between platters. Show prop.*
    - Typically 2-20 surfaces, 1024 tracks per surface, 64 sectors per track, 512 bytes per sector.
    - This is a total of about 600 Mbytes per disk pack, or 300,000 double-spaced typwritten pages. Typically sectors are fixed length (1024-8192 bytes are popular sizes).
    - Sectors can be read and written individually, or in adjacent groups:

        - Select desired read/write head.
        - *Seek*: move heads to correct track.
        - Wait for disk to rotate desired sector into position.
        - Read or write sector while it spins by.
    - Seek time = 5-50 ms, rotational latency is 0-16 ms (drive spins at 3600 RPM). This is the standard for medium-term computer storage.
    - Technology advances lately mostly in miniaturization. In 1975, 40 Mbytes took up space the size of a washing machine. Today, 400 Mbytes comes in 5 1/4" drive.
    - *Tell about heads flying, pressurization, disk crash.*
- Tape.
    - 9 tracks, 1/2" wide by 2400 feet long.
    - Variable length records (about 20-30000 bytes).
    - From 200 to 6250 bytes per inch (bpi).
    - Inter-record gap is about .6 inches.
    - Tape moves at 20-200 inches per second (up to several megabytes per second).
    - Can read or write, but cannot write in middle. Can skip records.
    - Tapes are DMA devices, not one interrupt per character.
    - *High-performance I/O devices have a lot of interesting mechanical design stuff in them. Tell about vacuum columns to buffer tape. These are needed because tape can be stopped or started quickly at the head, not so quickly at the reels.*
- Digital Videotapes.
    - Use same recording mechanism as 8mm videocassettes (helical) but store digital information instead of analog.
    - Density: 500 kbytes/inch of tape.

    - Capacity: 8-mm tape holds up to 2 Gigabytes (1 million pages of text).
    - Speed: .5 in/sec tape speed.
- Raster display.
    - Screen consists of an array of dots, called ‘‘pixels’’. Typically screen sizes are about 1000 dots high, 1100 dots across, or about 100 dots/in.
    - Each dot can be made black or white individually (or colored on some displays).
    - Since pixels are individually controllable, can create new fonts and draw pictures.
    - Some machines have special graphics processors to fill in pixels quickly, others do it all using programs in the main processor (just read and write bits). Laser Printer.
    - Page consists of an array of pixels, like for raster display. Typical density is about 300 pixels per inch (about 8 million pixels per page).
    - Printing rate is typically 5-30 pages per minute.
    - Most new raster printers use lasers and xerographic techniques.
    - Hardest problem in printer technology: paper mechanics.

- *Lecture 31 ended here.*

- Disks and tapes read and write blocks of information rather than single bytes:
    - Storage efficiency: For tapes written at 1600 bpi, 80-byte records use .05 inch, gaps use .6 inch, tape is all gap. However, 8000-byte records use 5 inches so gaps are only about 11% of the tape. In the case of disks, there are hundreds of bits of leader at the be-

ginning of each sector used to identify the sector and to synchronize when reading. For 512-byte sectors, nearly 50% of the disk space is wasted.

- Access efficiency: on disk it typically takes 25-50ms overhead before transfer begins. The actual transfer is only about 1 microsecond per byte. Thus one-byte transfers take 25ms total time/byte, 1000-byte transfers take about 26 us total time/byte. *Re-iterate the importance of eliminating seeks.*

- Thus most software that deals with disks and other I/O devices attempts to process information in large blocks (usually sequentially).