17 Input and Output Devices

I/O Device Characteristics:

- Terminal.
  - One character (8 bits of data or control function) is sent at a time. Rate is typically 200–1800 characters per second (2400–19200 bits/sec).
  - 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.
- Raster display.
  - Screen consists of an array of dots, called "pixels". Typically screen sizes are about 1100 dots high, 1500 dots across, at more than 100 dots/in.
  - Each dot can be made black or white individually (or colored).
  - 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 software running on main CPU (just read and write bits).
- Laser Printer.
  - Page consists of an array of pixels, like for raster display. Typical density is about 300 (600) pixels per inch (about 8 (16) million pixels per page).
  - Printing rate is typically 5-50 pages per minute.
  - Most new raster printers use lasers and xerographic techniques.
  - Hardest problem in printer technology: paper mechanics.
- Disk.
  - Typically 2-20 surfaces, 1000-2000 tracks per surface, 32-64 sectors per track, 1024-8192 bytes per sector.

- Currently, 20.5 GBytes disk is 3.5" x 1" and costs roughly $200 < $10 / GByte).
- Sectors can be read and written individually, or in adjacent groups:
  - *Seek*: move heads to correct track.
  - Select desired read/write head.
  - 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 3600/7200/10000) RPM).
- Technology advances lately mostly in miniaturization. In 1975, 40 Mbytes took up space the size of a washing machine.

• 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.

• 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.

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 beginning 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. Notice 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).