Buffer: hardware implementation of a circular queue. Data continuously fed in, removed.

Burst Feeding: moving many characters into a buffer on a single interrupt. Solution to large overheads associated with interrupts for every single character.

Spooler: piece of code whose only job is to burst feed the interface from an area of memory that contains data waiting to go to the output devices.

Bidirectional Printing: allowing the print head to print in both directions, thus avoiding slow carriage returns. Increases speed of printer but requires more logic to reverse RAM addressing.

Daisy Chain: Bus Grant signal fed back through each controller. The first controller that has issued a Bus Request and received a Bus Grant block the Bus Grant signal from any further transmission down the line.

Direct Memory Access: a process by which a device can gain control of the bus for reading from or writing to memory.

Problem: CPU wastes time dealing with transfer

Becomes bottleneck in transfer if busy with other stuff

Solution:

Move CPU out of data transfer loop

More efficient

More effective use of each component while permitting CPU overall control

Hardware requirements

Device communicating with memory must have a DMA interface with

Memory Address Counter Register: (DMA) starting address in memory of data to be transferred.

Byte/Word Counter Register: (DMA) count of number of bytes/word to be transferred.

Memory Data Buffer: (DMA) stores outgoing data, received data or data to be transferred.

Control lines:

Bus Request: When device ready to transmit/receive data it must inform CPU that it requires bus. CPU completes its work on bus and allows to device become Bus Master

Bus Grant: CPU signals permission to peripheral controller it can have control of bus. Only device with Bus request will respond

Bus busy: Someone is using bus. Set by device using bus, not other device may use it meanwhile.

Cycle Stealing: Bus control arbitration done by Memory Bus Controller. CPU uses majority of Bus cycles and so all other devices must 'steal' cycles from the CPU.

Ampere's Law : Current creates magnetic field
Faraday's Law: Magnetic field induces current/Voltage

CPU cache: Small, High-speed, expensive, volatile
Main RAM: Large, Slower, Cheaper, volatile
Bulk Memory: Very Large, slow, very cheap, non-volatile

Tape ~ 140 MB/s 6TB
HD ~300MB/s 4TB
CD ~146 Mb/s 650MB
DVD ~20MB/s 4.7~50 GB

Mechanical Structure:
Head: Flies above medium < 1 micro Inch, Aerodynamic, moves in and out, maintaining height is problem
Track: circular path around one disk
Sector: Division of track

Magnetic tape: 1-D /sequential access device = to find a piece of data requires reading the entire tape up to the required point.

Magnetic Disks: 2D or 3D, random access, cheap, non-volatile, mass storage systems.

Seek time: delay on accessing data on a disk = time to move the head to the correct track and settle on it. Av: (N+1)t/3 ; Large N = Nt/3 ; start from 0 : (N-1)t/2

Track to track time: time taken to jump to adjacent track.

Rotational delay: time taken for the wanted sector to reach the head. Average: 0.5 of a disk revolution

Rotational Latency: waiting period until required data appears under the head, once track is reached. L = rotation period -t*i (were t*l is the time needed to move to track i).

Disk access time: seek time + rotational delay.

Areal density, bits density: amount of data that can be packed up on a storage medium (Gigabits per square inch).

Moore's law: nb of transistors doubles approx every 18 months.

Linear or Recording density: measure of how tightly the bits are packed within a length of track. Assumption: outer tracks << inner tracks. = areal density / track density.

CD vs DVD: data in CDs is written in a single layer, while the DVD uses multiple lasers operating at different wavelengths to allow data to be written to several layers on the disk.

Floppy Disks: removable medium, head in contact with disk.

Hard Disks: usually non removable; head flies above medium a <1 micro inch, 10x floppy disk.

Optical Disks: based on an optical read/write system. Three forms:
Read-Only (CD-ROM): 650-720 MB
Recordable(CD- R): ~ 700 MB
Re-writable(CD-RW) ~650 MB, magnetic-optical write, optical read, uses Kerr effect.

Timing track: (hard disk) permanently stored on the disk, marks start of each sector (even 0) One particular track on the surface of a platter used to identify the start of a tracks and sectors on the surface. In a multi-platter disk, there is likely to be a timing surface. The head needs to read the timing track before reading any data.

Drive Capacity: surface * tracks * sectors * bytes/sector

Total Data stored: capacity of (innermost) track * nb of tracks

Density of track i: $d_i = rdD/(r+i)$

Total amount of data: D= 2ndt (R-2r) ; for max storage: R-2r = 0

2 different storage schemes: Directory and linked list

Directory file: pre-determined area of the disk known by the interface and the OS that stores the addresses of the files. => random addressing.

Sector interleaving: technique by which the average rate of data transfer from the disk is matched to the rate of data processing on the interface.

Fracturing: large number of small and unusable spaces on the disk after files that have been edited become larger and can no longer be stored at their original location on the disk. A new

file might not be stored even though there is plenty of space on the disk. Empty space can be recovered by performing a **Disk squeeze.**

Disk squeeze: method to recover from fracturing - move each file so that empty space collects at the end.

Files as linked lists: - each directory entry consists of a file name and starting address on the disk. - each block of file would consist of the data followed by a pointer to the next block of the file. - a file is terminated by a null-pointer (an *end of file mark).*
The empty space is linked into a list and forms the *pool* or *heap* from which new data blocks may be retrieved. The directory information could include the file length.

Advantages: system uses space efficiently, **no disk squeeze needed.**
■^Disadvantages: might require head movement (= major slowdowns).

Direct access file: the addresses of all the blocks in a file may be held in a buffer and then a particular block may be found directly.

Bootstrapping: hardwiring the CPU to fetch its first instruction from the ROM on power up.

Control Register: register of the controller ensuring that the operations occurring before a piece of data can be retrieved (finding right track, selecting the right head, finding right sector...) take place and can be sequenced. Each bit = one operation of the device.

Storage device controller: "OUT" = from CPU to peripheral
"IN" = from peripheral to CPU

Interrupt Daisy Chain: from highest priority device to lowest. '1' set at input of highest priority device. Once a device in the chain interrupted all the others devices are blocked from interrupting.

Device driver: piece of software that maps a real device to the generic device.

Dirty bit: flags any data changes that would result in a change to the file on the disk.

Basic laws of Magnetics: