Operating Systems

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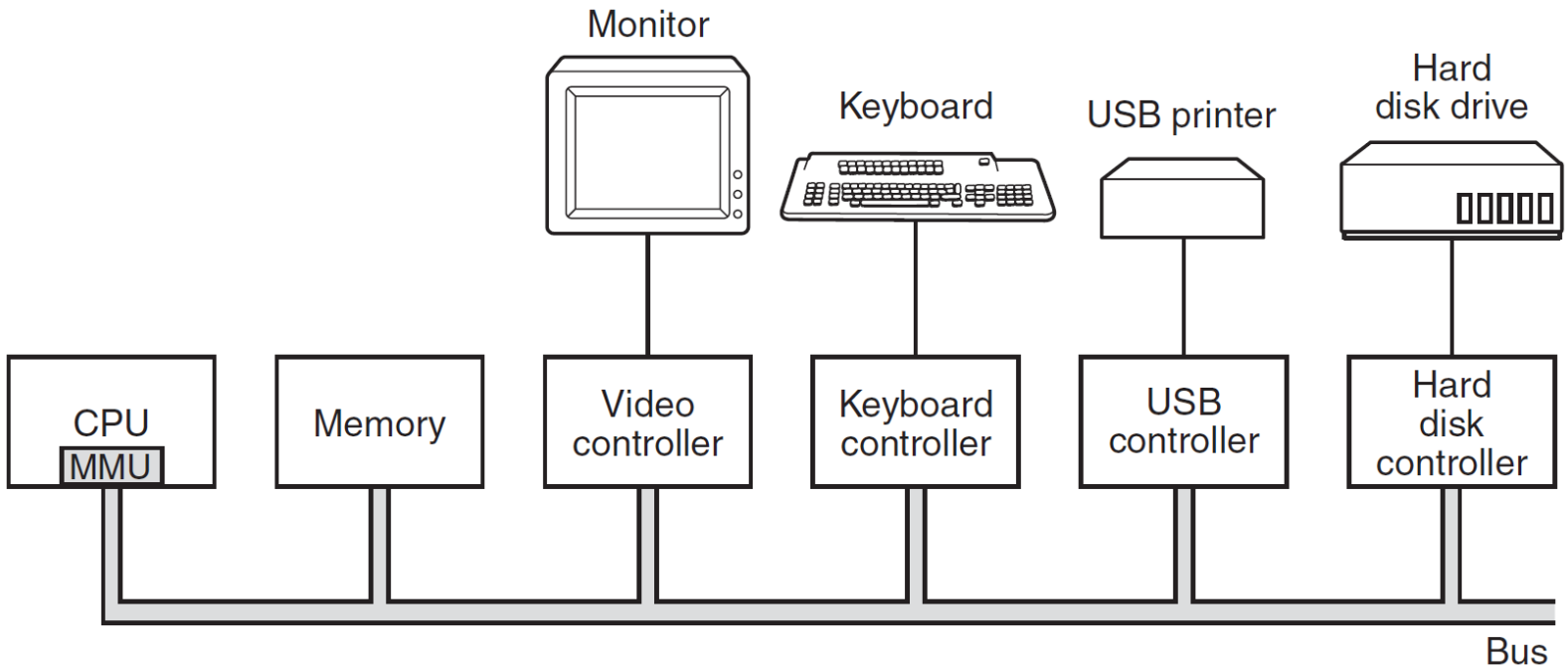
Chapter 1. Introduction

1.3 Computer hardware review

Simple personal computer

An operating system is tied to the hardware runs on. In the following, we provide a brief review of computer hardware as found in modern personal computer. Conceptually a simple personal computer can be abstracted to a model as:



Computer hardware review-Processor

CPU

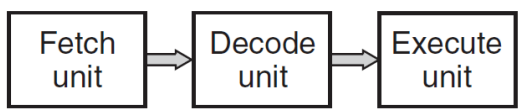
- The CPU is the brain of the computer and it has its own set of instructions.
- CPU fetches, decodes then executes an instruction at a time. This cycle is repeated.
- Several general purpose registers are there to be used for storing temporarily values because accessing memory is expensive.
- Other registers are there also like **program counter (PC), program status word (PSW), stack pointer (SP)**.
- The operating system must be aware of the registers when switching from one task to another.

Computer hardware review-Processor

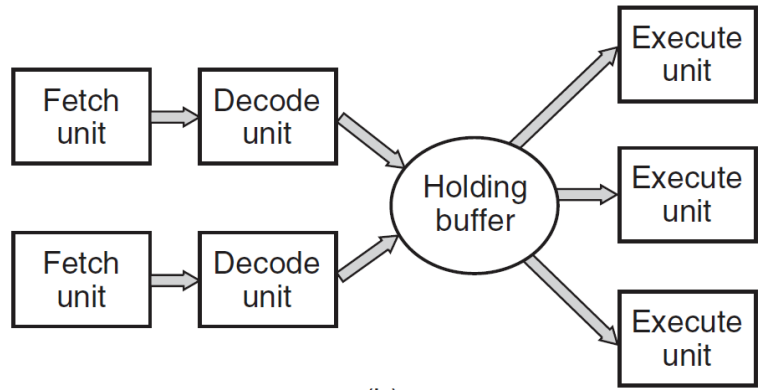
CPU

To improve performance:

- Pipelining happens when separate fetch, decode and execute units are there (a).
- Superscalar CPU has several execution units (integer, floating point, and boolean units) (b).



(a)



(b)

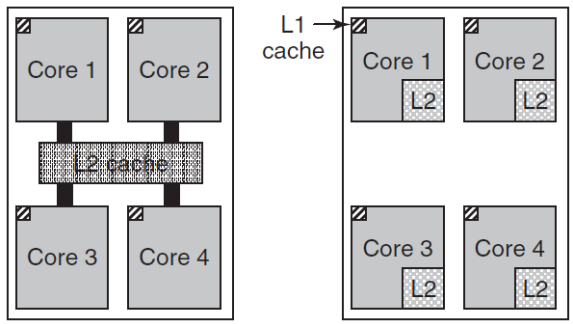
Computer hardware review-Processor

CPU Modes

- Most CPUs have two modes:
  - user mode.
  - kernel mode.
- To switch between CPU modes, a bit is set in PSW.
- Since a user mode program does not have permissions to do that in order to run privileged instructions, it request OS to run these instructions on behalf of it.
- This is done using a **system call** which is a trap to the kernel space.

Computer hardware review-Processor

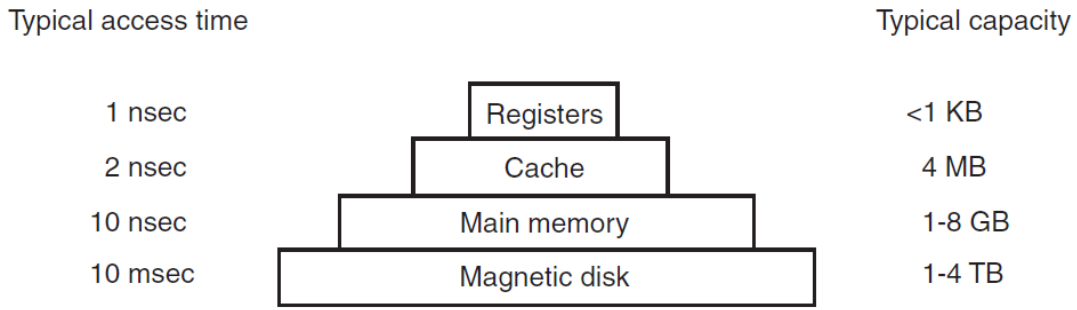
Multithreaded and multicore chips

- Moore's law states that the number of transistors in a chip doubled each 18 months. It proves correct for the last 3 decades and possibly one more decade.
- Increase number of transistors can provide **more execution units** as in superscalar CPU. More transistors can be used as **cache memory**.
- Increase number of transistors can be used to replicate some of the control units not only the functional unit. This introduces the **multithreading or hyperthtreading** concept, where switching between threads is in an order of nanoseconds (but it is not true parallelism). 

To OS it appears as a single core where it can be used to run processes.
- Another approach is to include more than one CPU (core) in a single chip (4, 8, 16, ...). GPU has thousands of cores in a single chip.

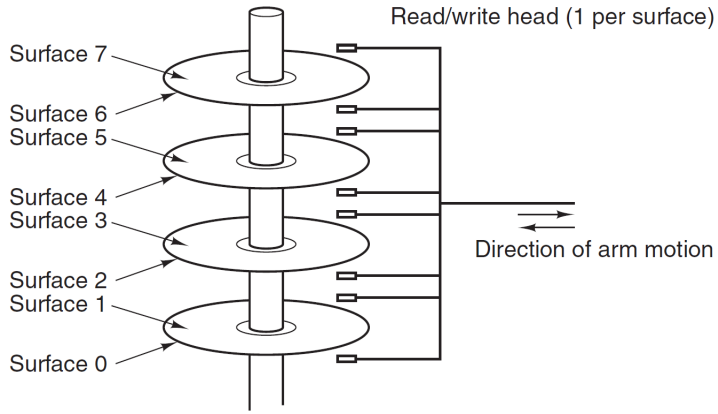
Computer hardware review-Memory

- **Registers:** made from the same material of the CPU. They are just as fast. less than 1Kbyte.
- **Cache memory:** controlled by the hardware. Arranged in cache lines normally of 64 bytes long. Normally consists of two levels; L1, around 16Kbytes, L2, in order of Mega bytes.
- **RAM:** called core memory. It is the work place, where process is executed from there.
- **ROM:** some code stored there and cannot be changed, like bios, bootstrap code, some I/O cards have their low level code on ROM. EEPROM can be erased and then programmed, like flash memory.
- **CMOS memory:** RAM powered by battery where time and date are stored besides some configuration parameters.



Computer hardware review-Disks

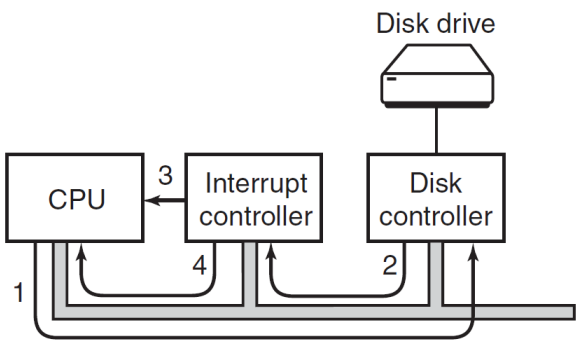
- **Hard disk:** consists of mechanically moving parts in speeds; 5400, 7200, 10,800 RPM or more, as in the figure:

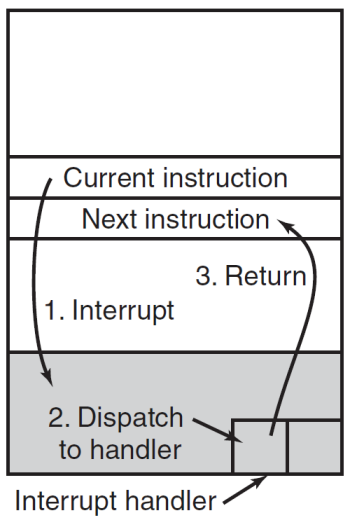


- **Track:** circle formed from a complete rotation of the platter at any head position.
- **Cylinder:** the set of all tracks on platters.
- **Sector:** the overlap of track and physical sector. Size is 512 bytes.
- **SSD disk:** solid state drive, which is a large flash memory.
- **Virtual memory:** RAM is extended beyond physical size using part of the HD.
- **MMU:** helps in mapping generated addresses to physical addresses.
- **Context switch:** switch from one program to another

Computer hardware review-I/O Devices

- I/O devices usually consist of two parts controller and device itself.
- Controller is a chip or more that control the device, accepts commands then carry them out.
- The device has fairly simple interface to comply with the standards and because there is not much to do.
- Device driver is the part of OS that talks to I/O controller registers.
- I/O devices controller registers might be mapped into memory or live in their space.





Computer hardware review-I/O Devices

- I/O can be done in one of three ways. When the user program issues a system call the device driver deals with the device in one of three ways:
  1. Busy waiting (polling): device driver keeps the CPU busy polling for the requisite data.
  2. Interrupt: device driver asks the device to do something and continue doing something else until receiving interrupt telling the requisite data is ready.
  3. DMA: device driver programs the DMA chip with memory address, device and direction for moving data and continue doing something else until receiving an interrupt from DMA controller to inform device driver of finished operation. DMA does transfer without CPU intervention.
- Interrupts have priorities, the highest serviced first, since often the interrupts occur almost while servicing another interrupts.

Computer hardware review-Buses

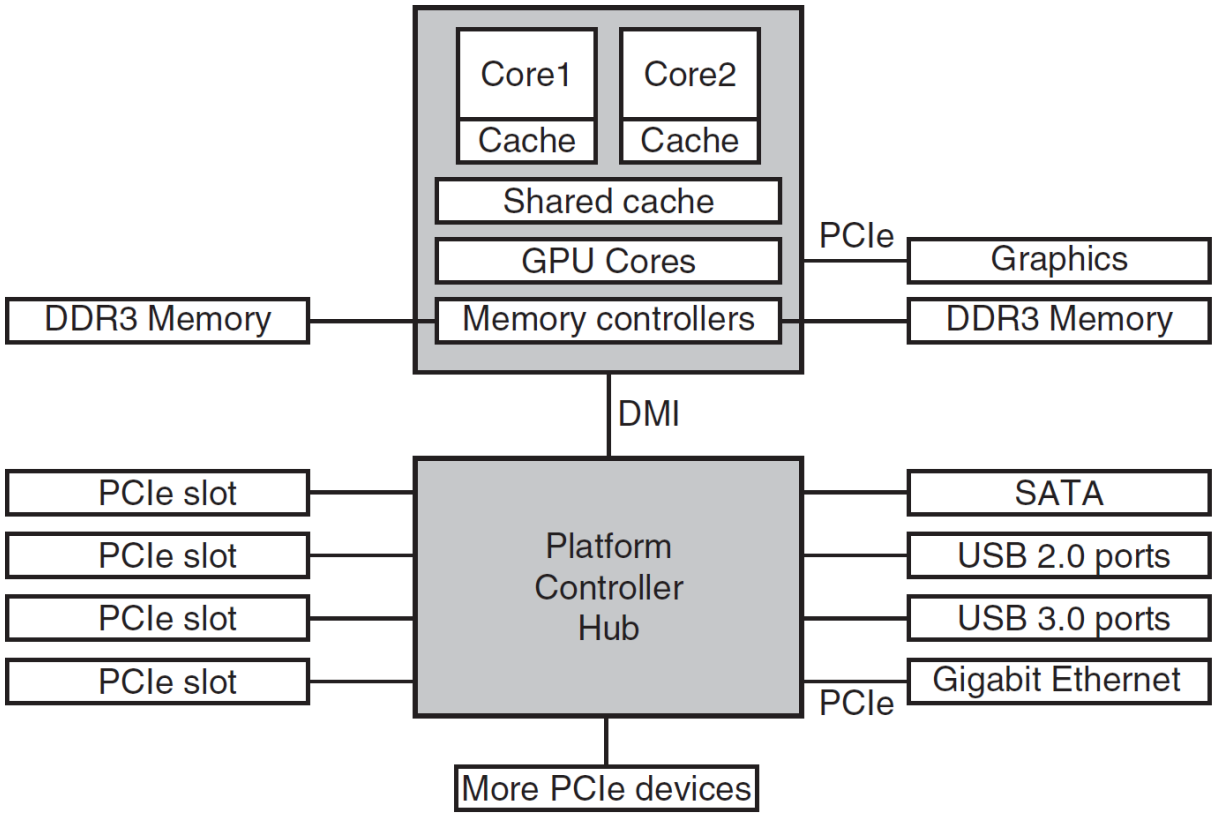
Current x86 system has several buses

- PCIe (Peripheral Component Interconnect Express) bus: its a serial bus that has a speed of ten gigabits/second. it replaces PCI, PCI-X, AGP. PCI replaces ISA. (PCI 2.0 with 16 lanes has a speed of 64Gbps)
- DDR3/DDR4 bus: where the CPU talks to DDR3/DDR4 memory.
- DMI bus (Direct Media Interface): connects the CPU to a hub. The hub connects to USB devices, SATA devices (HD, CD,..) and to other PCIe devices.
- Cache buses: connects the core to a shared cache.
- USB: used to connect slow devices to the computer. USB 1.0 at 12 Mbps, USB 2.0 at 480 Mbps and USB 3.0 larger than 5 Gbps.
- SCSI (Small Computer System Interface): connects fast devices like hard disks to computer, at a rate of 640 MB/s. Usually used in servers and workstations

Computer hardware review-Buses

Plug and Play

what plug and play does is have the system automatically collect information about the I/O devices, centrally assign interrupt levels and I/O addresses, and then tell each card what its numbers are.



Computer hardware review-Booting the computer

Booting the computer

- **BIOS** (Basic Input Output System) lies in a chip on motherboard inside the PC. The BIOS consists of low level I/O software responsible for reading from keyboard, writing to the screen and do I/O on disks among other things.
- When the computer boots, it starts BIOS which checks the size of the RAM. BOIS checks if the keyboard and other basic devices are present and working correctly. It also checks for the devices connected to PCIe bus and configure any new ones.
- Then the BOIS reads the boot sector from the booting device to check which partitions to boot from and then loads the boot loader which in turn loads the kernel.