Devices, Abstractions Provided, OS Structure

Prof. James L. Frankel
Harvard University

Hardware/Software Hierarchy

Applications
UI/Windowing/Shell/GUI
Operating System/System Calls
Hardware abstraction layer (HAL)
Hardware

Abstractions (1 of 2)

- Operating System provides an extended abstraction above the hardware
  - User identities, access control, and protection hierarchy
  - System calls
    - Convenient and protected interface to Input/Output devices and other system resources
  - File system
  - Protection/Security
  - GUI/Windowing system
  - Virtual memory
  - Consistent interface even with different hardware
  - Multitasking/Processes
  - Threads

Abstractions (2 of 2)

- Access to peripheral devices
- Network access
  - Network may be transparent to programmer
- Client Server Model
- Virtual Machine
  - Hypervisor

History of Operating Systems

- Single user
- Batch
- Multiprogramming with RJE, RJO
- Timesharing option (TSO)
- CTSS, Multics, Unix
- PC's

Computer Hardware Components (1 of 2)

- Processor (CPU – Central Processing Unit)
  - Arithmetic/Logic Unit (ALU)
  - Datapath
  - Sequencer
  - Program Counter
  - Stack Pointer
  - PSW (Processor Status Word)
  - General Purpose Registers
    - Registers can be accessed at instruction execution speed
  - Above is replicated in Multiple Cores

- Memory
  - Access to memory is slower than access to registers
  - User's data and code reside in memory
  - RAM (Random Access Memory)
  - Cache
  - Flash, ROM (Read Only Memory), EEPROM (Electrically Erasable Programmable ROM)

Simplified Block Diagram of Computer Hardware

Memory

CPU

Registers

Sequencer

HI

PC

LO

I/O Devices

ALU
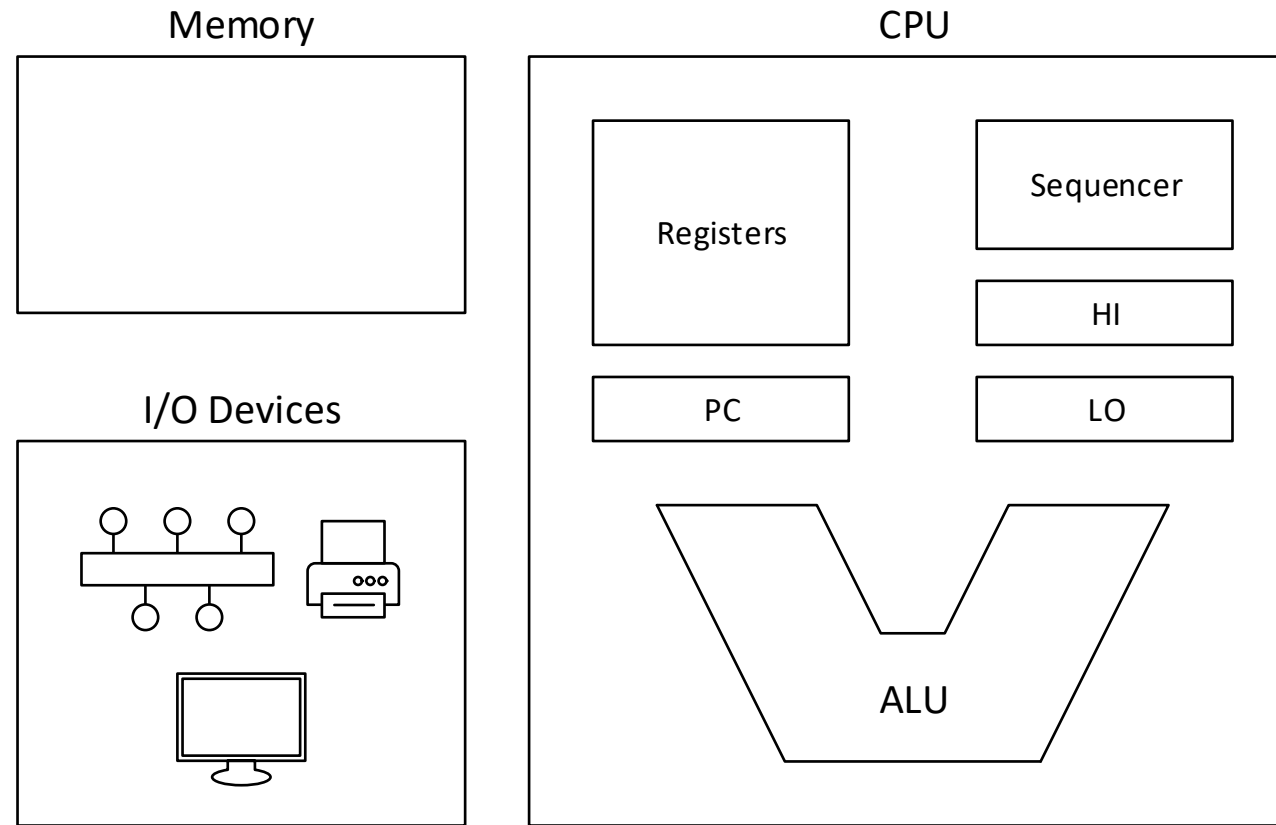
Computer Hardware Components (2 of 2)

- Disk Storage
  - Magnetic
  - SSD (Solid State Drives) – semiconductor mass storage devices
  - Optical (CD, DVD, Bluray) – read-only and read/write
- Magnetic tape
- Auxiliary Processors
  - GPU (Graphics Processing Unit)
- I/O (Input/Output) Devices

I/O Devices

- Display/Video
- Keyboard
- Pointing Devices
    - Mouse
    - Touchpad
    - Trackball
- Printer
- Scanner
- External Disks
- Serial ports
- Memory Card Readers
- Optical Disks
- Lots more…

- Networks

Processor Interconnects and Networks

- PCI (Peripheral Component Interconnect)
  - Replacement for the older ISA (Industry Standard Architecture) bus
- PCIe (PCI Express)
- SCSI (Small Computer System Interface)
- USB (Universal Serial Bus)
- SATA (Serial ATA) Interface
  - Replacement for the older PATA – Parallel ATA (AT Attachment from the early IBM PC/AT) – Interface
- DMI (Direct Media Interface)
- Ethernet, IEEE 802.3 (LAN) – Copper Coax Thicknet (10BASE5), Copper Coax Thinnet (10BASE2), Copper Twisted Pair (10BASE-T, 100BASE-TX, etc.), Fiber Optic Cable (10BASE-F, etc.)
- Firewire (IEEE 1394)
- Bluetooth, Bluetooth LE (Low Energy)
- IEEE 802.15.4 (Zigbee) (PAN)
- WiFi, IEEE 802.11 – a, b, g, n, ac through be, etc.

OS Concepts

- Processes

- Address Spaces

- Files

- I/O Capability
  - Allow unprivileged users to access I/O devices in an organized manner

- Protection

- Shell

- System Calls

Memory Partitioning

low

| I/O Registers (memory-mapped hardware) |
| Operating System |
| Program Code (text segment) |
| Static Zero Initialized Data (BSS segment) |
| Static Non-Zero Initialized Data (data segment) |
| Heap |
| ↓ |
| ↑ |
| Stack |