

Hardware overview

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January 24, 2022

Computer system overview

applications:

run on kernel

kernel:

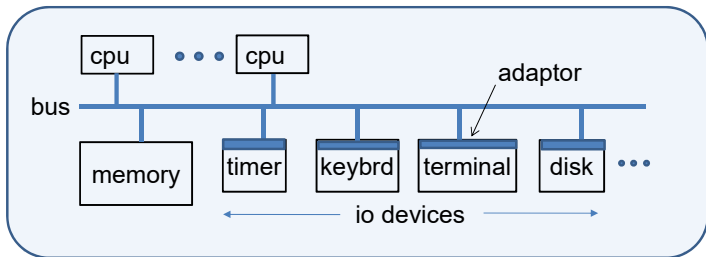
runs on hardware

provides processes, filesystem, io

hardware:

CPUs, memory, io devices

Machine hardware



- **CPUs, memory and IO devices** connected by bus
- **Memory** is an array of bytes
 - CPU can read/write any location
- **IO devices** attach to bus via **adaptors**
 - CPU can read/write locations in adaptors to do io operations
 - adaptor can also interrupt CPU when io operation has completed

CPU (aka processor) – 1

- Executes (machine) instructions from memory
- State
 - general-purpose registers (gpr)
 - instruction pointer (ip) // aka program counter
 - stack pointer (sp)
 - processor status (ps)
 - arith/logic flags: overflow, carry, zero, ...
 - mode: user/kernel
 - intrpts on/off
 - paging on/off
 - ...
 - address-translation stuff
 - regs holding addresses of segment/page/interrupt tables
 - ...

- Instructions
 - move (between cpu registers)
 - load/store (between cpu and memory)
 - arith/logic

 - *jmp addr*
 - *jmp condition addr*

 - *call addr*:
 - store ip on stack
 - $ip \leftarrow addr$

 - *ret*:
 - restore ip from stack

 - io (input/output):
 - read/write io adaptors

- Instructions
 - `sw-intrpt n` // traps, exceptions, syscalls; initiated by cpu
 - store ip, ps on stack
 - $ip \leftarrow intrpt_table[n]$
 - $ps \leftarrow intrpt\text{-off, kernel-mode}$
 - rti:
 - restore ip, ps from stack
 - `hw-intrpt n` // initiated by external agent (adaptor)
 - same action as `sw-intrpt`
 - ...
 - **Privileged** instr: executable only in kernel-mode
 - access io adaptors, ps reg, `intrpt_table` address reg, ...
 - attempting to execute in user-mode causes exception
 - user-mode \rightarrow kernel-mode: only via sw/hw intrpts

Adaptors

- Adaptors (aka controllers)
 - CPUs/memory \longleftrightarrow adaptor \longleftrightarrow device
 - device: display, keyboard, mouse, disk, USB, Wifi, Ethernet, ...
- Devices have varying data unit size, transfer bandwidth, latency
- Disk adaptor // disk holds data blocks at surface/track/sector
 - data register: holds input/output data
 - control register:
 - operation: read, write, seek, ...
 - location in disk
 - address of buffer in memory
 - io completion intrpt on/off
 - busy: on/off // for non-interrupt IO
 - dma on/off // direct memory access

- Array of bytes
 - accessible to all CPUs and dma-capable adaptors

- Reality: multiple levels of memory
 - caches local to cpus → global memory
 - small/fast → large/slow

- Active agents: CPUs and adaptors
- Execute independently
- Interact via
 - io instructions
 - CPU reads/writes adaptor registers
 - hw-interrupts
 - adaptor makes CPU execute io code
 - shared memory
 - buffers accessed by CPU and by adaptor via dma