Overview of Operating Systems

ECE 373

Overview

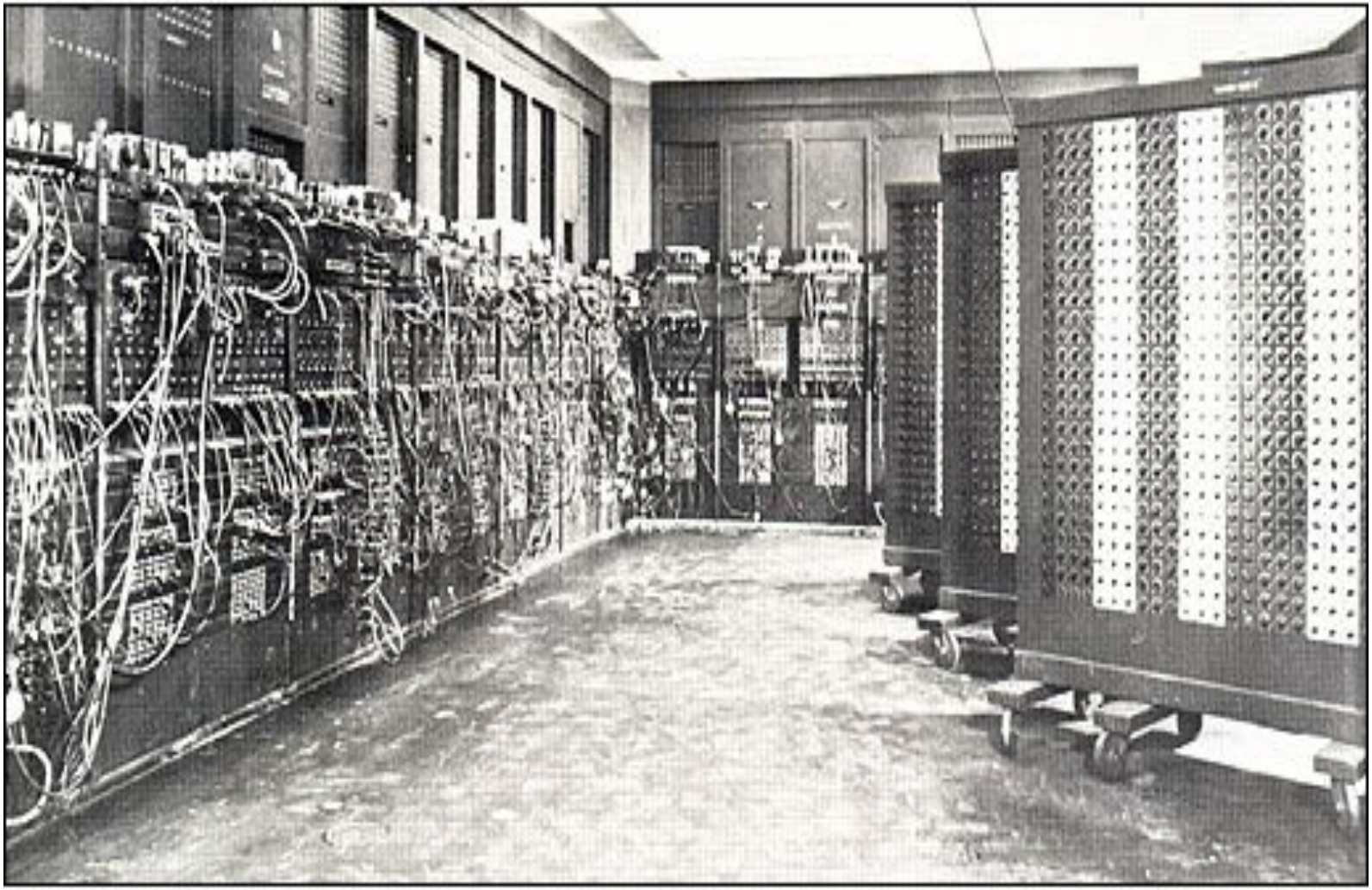
- What is an OS?
- A brief history of the OS
- Types of Operating Systems
- A view of the OS from above
- Different OS internals
- System calls
- Device drivers

What is an Operating System?

What is an OS?

- SW that makes HW useful
- Provides interface for users to mess with HW
  - Stores financial data, prints it when needed
  - Displays the monsters, creates the pew-pew noise when the trigger button is pressed
  - Reads the data from the network, displays the video, plays the music
- User programs?

Not all computers had an OS



Among the first assignments given to Eniac, first all-electronics digital computer, was a knotty problem in nuclear physics. It produced the answer in two hours. One hundred engineers using conventional methods would have needed a year to solve the problem

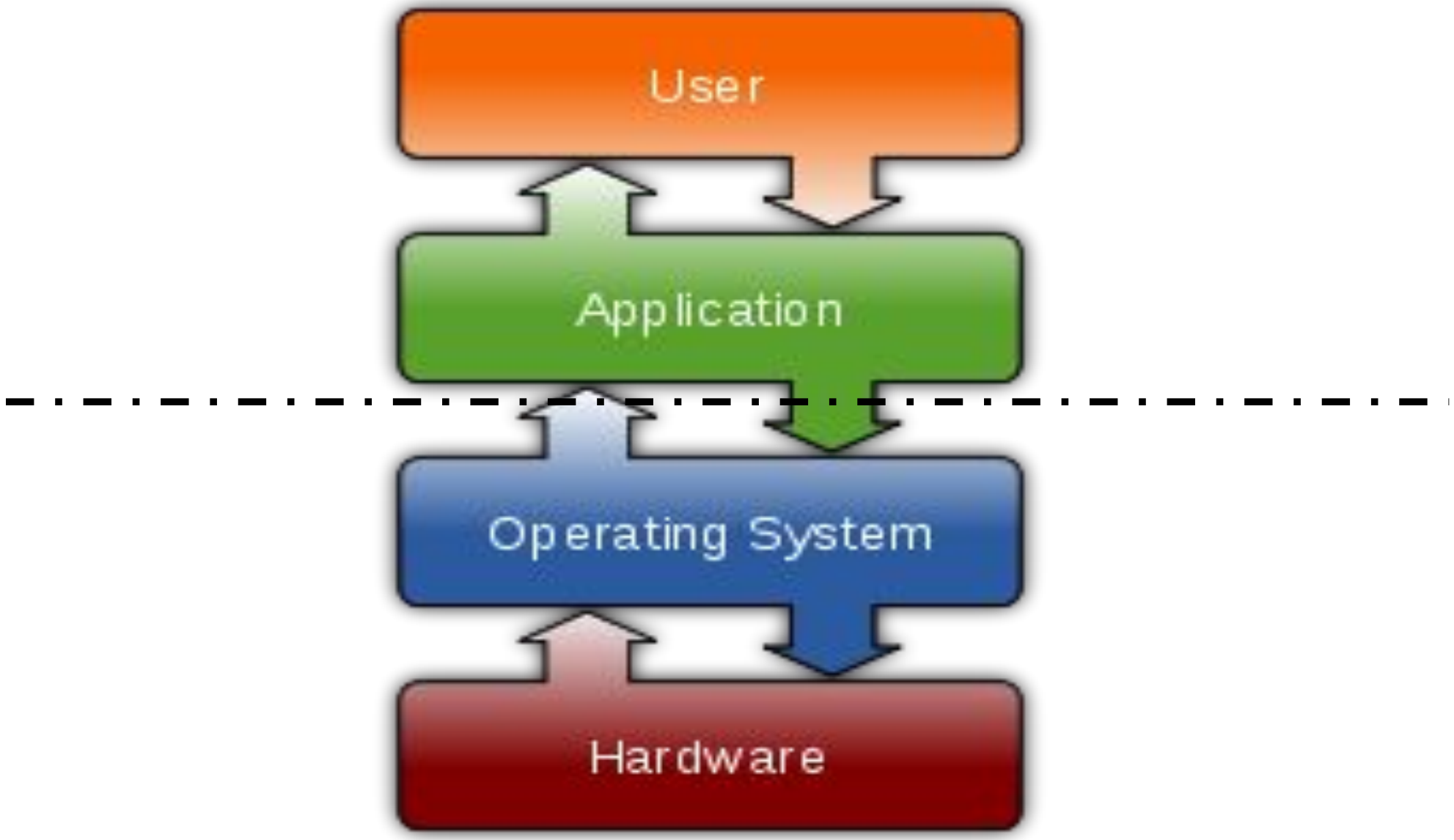
A brief history

- Mainframes
  - MCP, OS/360, MITS, TOPS-10, Multics, UNIX, VMS, Linux
- Microcomputers
  - CP/M, MS-DOS, AppleDOS, Mac OS, AmigaOS, Windows, Linux
- Embedded
  - Wind River, Symbian, Android, iOS, WinCE, RockBox, ThreadX, uCLinux, brickOS, DD-WRT, Open-WRT, Linux

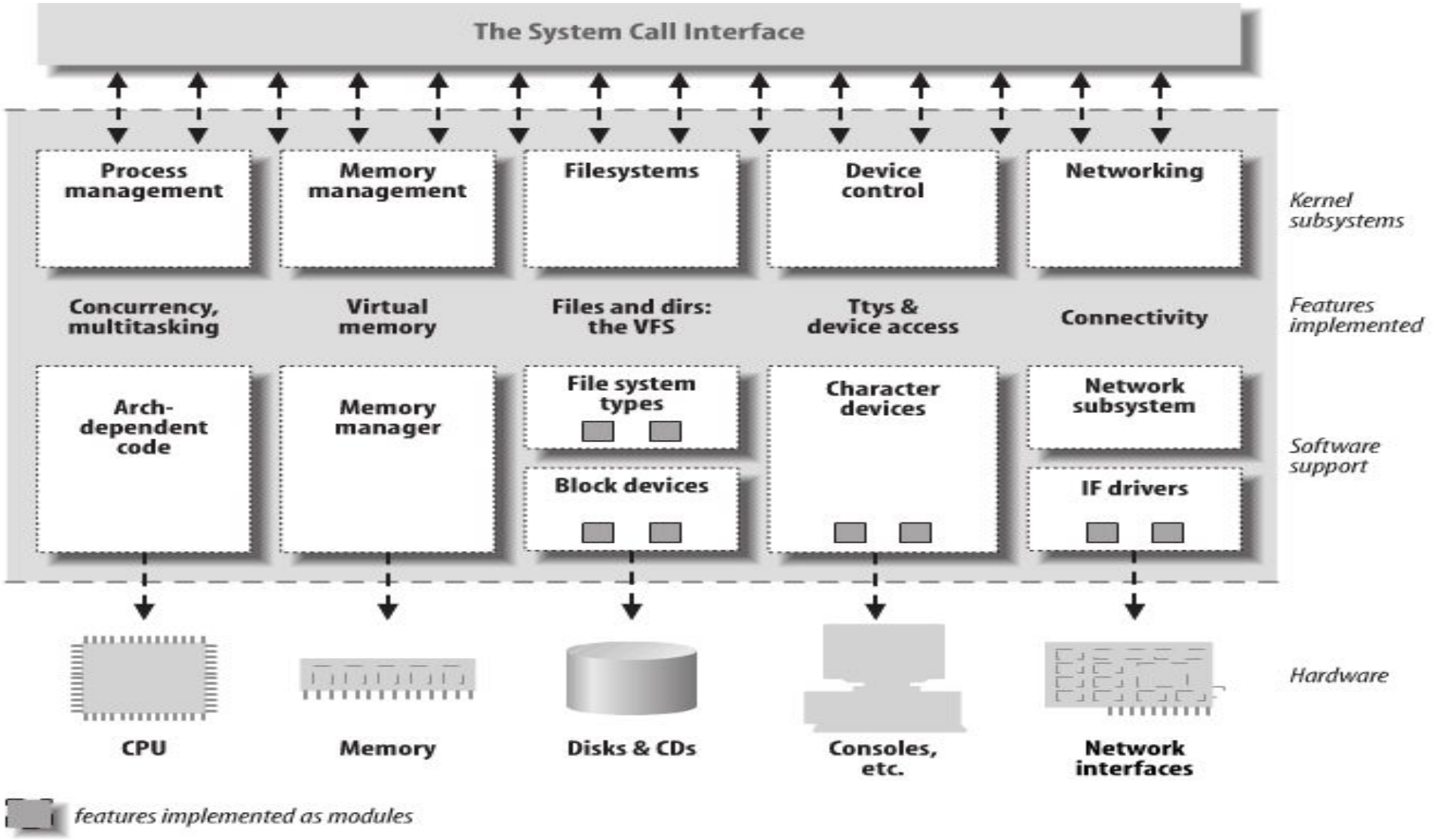
Types of OS's in the wild

- Single-user (Phones, PC's)
- Multi-user (Servers, mainframes, "cloud")
- Real-time (Stop lights, shuttle navigation)
- Embedded (Watch, routers, car engine, mp3)

Layers on top of layers



The OS overview



Process Scheduler

Process Scheduler

- OS thread that handles process scheduling
- Complicated piece of software
- Multithreaded operating systems need this
- Batch operating systems much simpler
- Timeslices...

Process Scheduler cont.

- Processes scheduled on CPU
  - Algorithms vary how this happens
  - Processes can be "pinned" or "affinitized"
- Code is architecture-dependent
  - x86 scheduler is different than ARM scheduler
  - e.g. Big/little - getting blurrier today
- Pre-emption

Memory Manager

Memory Manager

- RAM
- Swap
- Virtual vs. Physical
- Kernel vs. Userspace
- Allocate and free

I/O Subsystem

I/O Subsystem

- I/O – input/output
- Framework for data movement in system
- Many subsystems
  - PCI
  - USB
  - Storage
  - Network
  - Many more...

Interrupts

Interrupts

- Signal triggering a CPU there's something to do
- Drives the drivers
- IPI's
- Legacy interrupts
- MSI and MSI-X interrupts
- Shared interrupts
- http://en.wikipedia.org/wiki/Interrupt

System Calls

System Calls

- Main conduit from userspace to kernel space
- Linkage between C library and kernel through some glue in the kernel core
- System call glue written in assembly for the architecture
- Examples of common system calls
  - open(), write(), read(), close()
- The "man" pages chapter 2 are where the system calls live

System call man pages

```
[ppwaskie@ppwaskie-hc1 ~]$ man open
OPEN(2)                    Linux Programmerâs Manual                    OPEN(2)

NAME
       open, creat - open and possibly create a file or device

SYNOPSIS
       #include <sys/types.h>
       #include <sys/stat.h>
       #include <fcntl.h>

       int open(const char *pathname, int flags);
       int open(const char *pathname, int flags, mode_t mode);

       int creat(const char *pathname, mode_t mode);

DESCRIPTION
       Given a pathname for a file, open() returns a file descriptor, a small,
       non-negative integer for use in subsequent system calls (read(2),
       write(2), lseek(2), fcntl(2), etc.). The file descriptor returned by a
       successful call will be the lowest-numbered file descriptor not cur-
       rently open for the process.
```

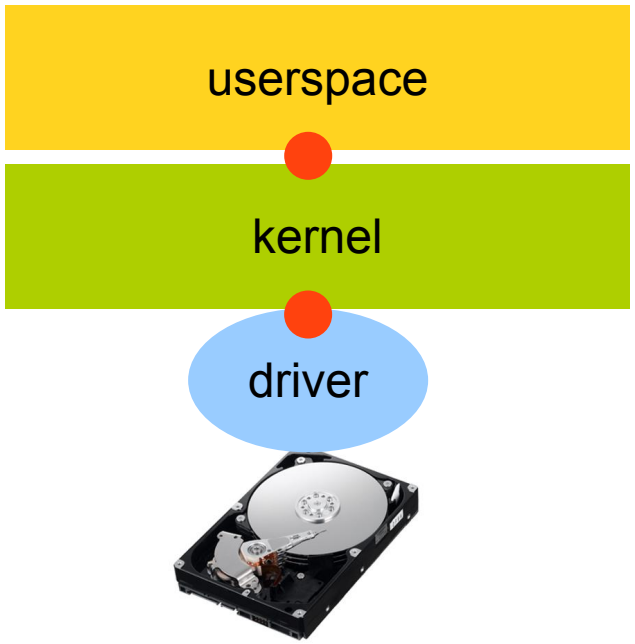
System calls for all

- Not all driver interfaces use the same system calls
- Block and char drivers use `open(), write(), close()` for example
- Network drivers use `socket(), select(), send(), shutdown()` for example

Device drivers

Device drivers

- The software that controls specific pieces of hardware
- Driver takes common commands from the OS and translates into hardware-specific stuff
- APIs in the OS provide common interfaces for services



Types of drivers

- Three main classes of drivers
  - Block drivers
  - Character drivers
  - Network drivers
- Driver class can apply to many types of devices
  - USB device can be char, block, or network
  - Interface cards (PCIe) can be network or block
  - Graphics typically char devices

Block drivers

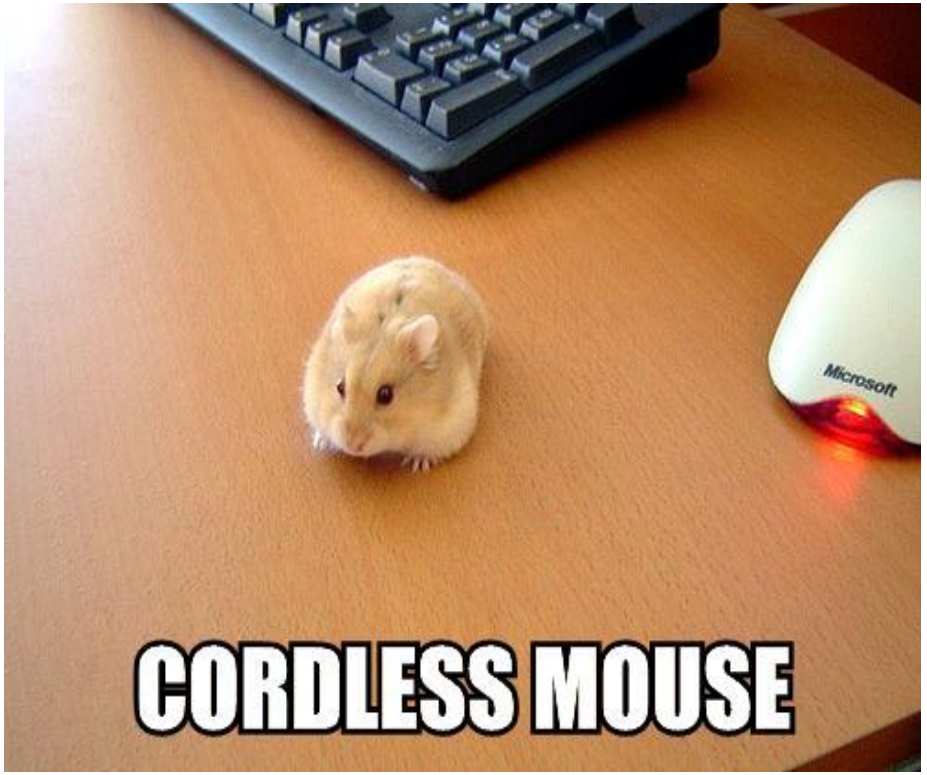
Block drivers

- Drivers that take and give data in rigid chunks of data (blocks...duh)
- Blocks are typically powers of 2, such as 512 bytes, 2048 bytes, etc.
- SCSI layer and SATA layer send blocks to disk drivers
- Blocks pushed down onto sectors on the hard drive
- SSD's, NVMe...

Char drivers

Char drivers

- Drivers that take a stream of characters
- Character streams often contain some type of opcode with data
- Streams can be variable length (unlike block devices)
- Common char devices are:
  - Keyboard
  - Mouse
  - Printer

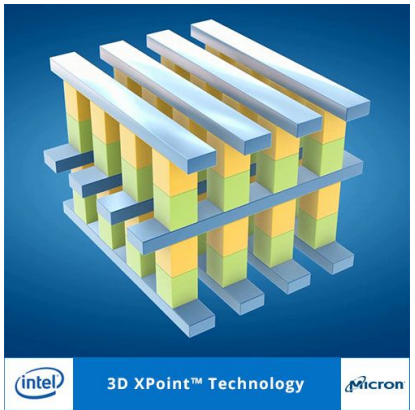


Network drivers

- Network drivers are different animals than block and char drivers
- Unpredictable patterns of traffic
- Network drivers typically not tied directly to system call interface
- Network drivers can be
  - Wireless Ethernet devices
  - Wired Ethernet devices
  - Cell phone LTE transciever

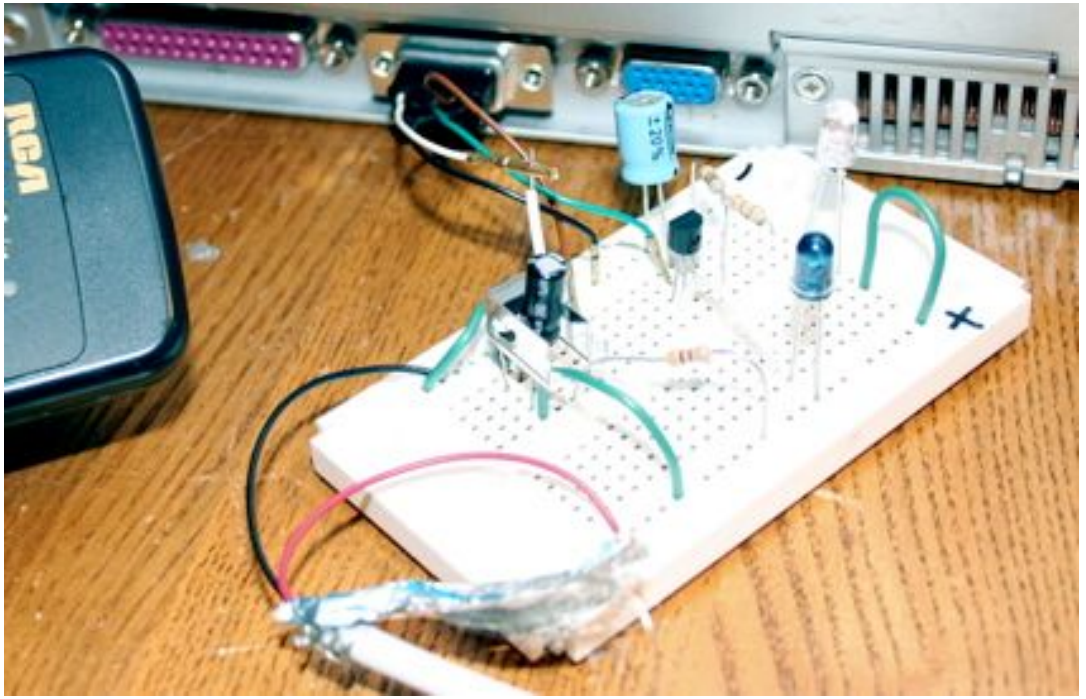
Hybrid devices

- Not all devices fit into one "category"
- Good example, 3D Xpoint NVDIMM (e.g. Optane)
  - New tech from Micron and Intel (controversy)
  - Phase-changing memory lattice
  - Can be block device or char device depending on firmware configuration



Hardware

- Voltages and signals
- Bits and bytes
- Registers and busses
- GPIOs and LEDs
- Sensors and motors



Wrap-up

- Operating Systems: big (complex) programs
- Operating Systems abstract specific hardware interfaces into common APIs for software
- Each block in the OS has a purpose
- Drivers are the abstraction of the hardware, keep "the devil in the details"