Operating Systems Design

1. Introduction

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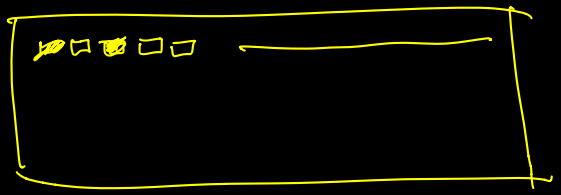
In the beginning…

There were no operating systems

"Preparing ENIAC for a series of runs was an incredibly involved process. First, detailed instructions had to be written defining the problem and a procedure for solving it. These instructions were programmed by adjusting switches manually and inserting thousands of cables into as many as forty large plug boards. A team of five operators might work several days on the external wiring and many more days searching for errors and correcting them."

— *Breakthrough to the Computer Age, Harry Wulforst, Charles Scribner's & Sons Pub., 1982*



1945

Late 1940s – 1950s

- Stored program concept: reload a program
- Reusable code ("subroutines")
- IBM SHARE (Society to Help Alleviate Redundant Effort)
- The OS emerges
  - Batch systems
    - Branch to a location in the OS that would cause the next program to get loaded and run
  - Common I/O routines for device access
    - *Precursor to device drivers*
  - Programmatic transition to reduce overhead of starting new jobs
  - Job control languages to define resource needs

1960s

- Goal: improve throughput
  - Use every possible second of CPU time
- Multiprogramming
  - Keep several programs in memory at once; switch between them
  - Works because of the speed mismatch between I/O and CPU
- The System Call (Atlas I Computer, Manchester)
  - Privileged & unprivileged modes
- Conversational interaction (human I/O)
- Direct storage access (file systems)
- Transaction processing systems (SABRE)
  - IBM & American Airlines

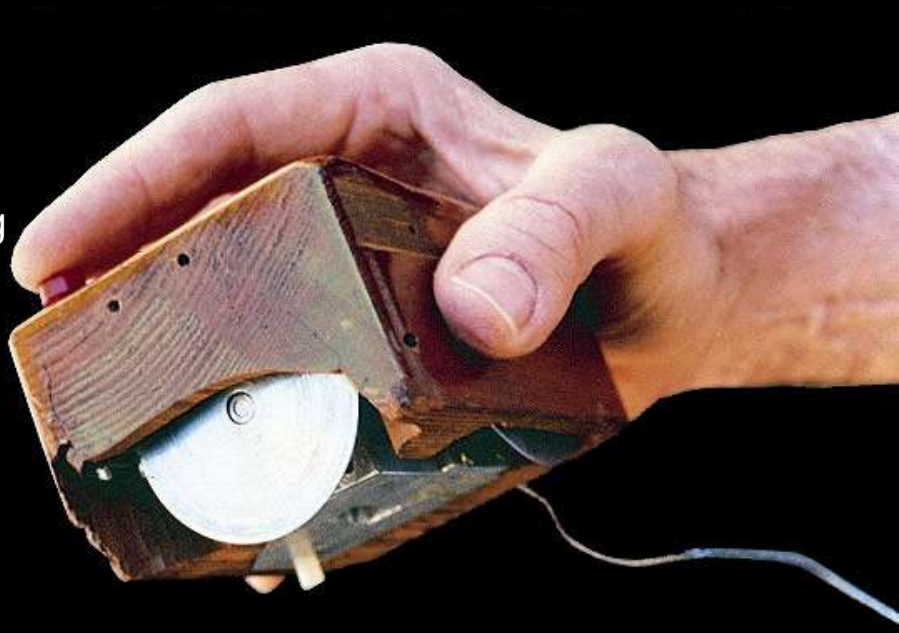
von Neumann

1960s

- Time sharing: preemption
  - CTSS (Compatible Time-Sharing System): Process scheduling
- 1961: DEC PDP-1 – first minicomputer ($125,000+)
- 1964: IBM System/360
  - PCP/360: sequential jobs (batch)
  - MFT: Multiple job system, fixed number of tasks
  - MVT: Multiple jobs, variable number of tasks (direct memory)
- IBM 360 introduced:
  - Direct Address Translation
    (precursor of virtual memory & the Memory Management Unit)
  - Channels: specialized processors for transferring data between main memory and an I/O device
    (*precursor of DMA*)

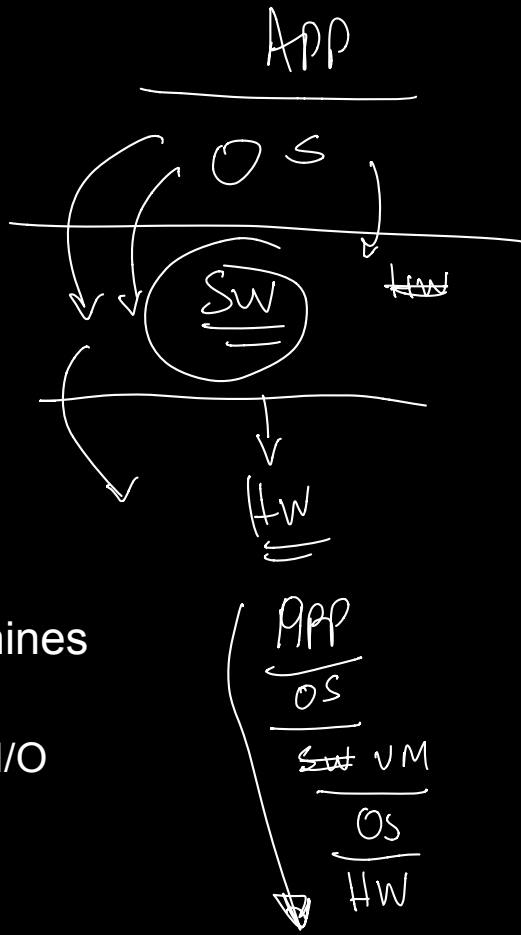
December 9, 1968: The Mother of All Demos

- Douglas Engelbart
  Stanford Research Institute (SRI), Augmentation Research Center
- Fall Joint Computer Conference
- Introduced:
  - Computer mouse
  - Windows
  - Video conferencing
  - WYSIWYG word processing (with cut & copy) & embedded objects
  - Collaborative editing
  - Version control
  - Hypertext



Late 1960s – 1970s

- 1968-1969:
  - User-friendly interfaces: mouse, windowing
  - Data networking
- 1970s: UNIX
  - Portable operating system
  - Written in a high level language
- 1972: Virtual Machines (VM/370)
- Microprocessors emerge
  - CP/M: dominant OS for 8080 family of machines
    - CCP: command interpreter
    - BDOS: file operations, printing, and console I/O
    - BIOS: character I/O, disk sector read/write
  - 1977: Apple II



1973: Xerox Alto

- The first *personal* computer
  - Desktop UI metaphor and a mouse
  - Inspired by Douglas Englebart's On-Line System
- Specs
  - TI bit-slice processor
  - 128-512 KB RAM
  - 2.5MB removable hard disk
  - Ethernet
  - B&W CRT
  - 3-button mouse
  - Small fridge-sized cabinet
- Inspired the Mac & Microsoft Windows

Late 1970s: Home PCs

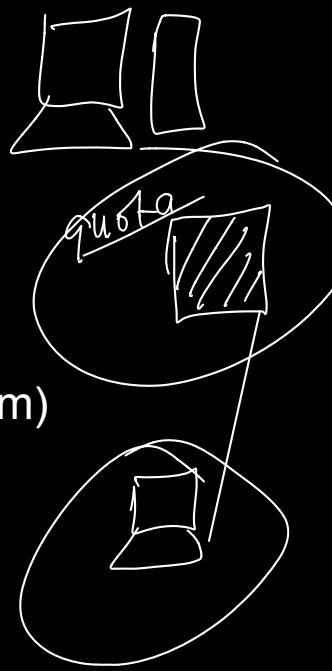
- 1975: Early PCs – targeted at hobbyists
  - Connect your own teletype or use a front panel
  - Build it from a kit
  - Write your own OS drivers
- 1977: Buy & Use personal computers
  - Apple II
  - Commodore PET
  - Radio Shack TRS-80 Model I
- Followed by:
  - Atari 400, Atari 800, TI-99/4A, Vic 20, Commodore 64, …

1980s

- 1981: IBM PC
  - Open architecture; Microsoft OS
  - Only proprietary component was the BIOS
- 1982: BIOS was reverse engineered
  - PC clones (Compaq, Columbia, Dell, HP, …)
- 1984: Macintosh
- Client-server networking
  - Network file systems

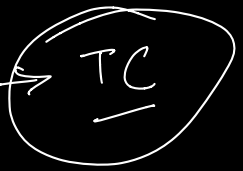
1990s

- 1990: Windows 3.0
- 1993: Window NT
  - New OS built from scratch
- Open Source Operating Systems
  - Linux, FreeBSD, NetBSD, OpenBSD
- 1995: Windows 95
  - Built-in Internet support (networking usually via modem)
- Network PC, Thin clients
- PCI bus: Plug & Play hardware



2000s

- PC-based machine virtualization
  - Virtualization ~~support~~ added by Intel & AMD (2006)
  - Virtual machine migration
- Cloud computing, on-demand data centers
- Focus on mobility
  - iOS, Android, BlackBerry OS, Windows Mobile
- Security
  - Hardware authentication, Storage encryption, digital rights management
    - Trusted Platform Module
  - Personal firewalls
  - Address space layout randomization



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