

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

Programming the ENIAC



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

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
 - 11 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

The End