

# Operating Systems Design

## 1. Introduction

Paul Krzyzanowski  
[pxk@cs.rutgers.edu](mailto:pxk@cs.rutgers.edu)

In the beginning...

# There were no operating systems

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“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

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- 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

Time sharing

# 1960s

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- Goal: improve throughput
  - Use every possible second of CPU time
- Multiprogramming *multitasking*
  - 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

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- **Time sharing:** preemption yield
  - 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

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- 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

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- 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

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- 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

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- 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

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- 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

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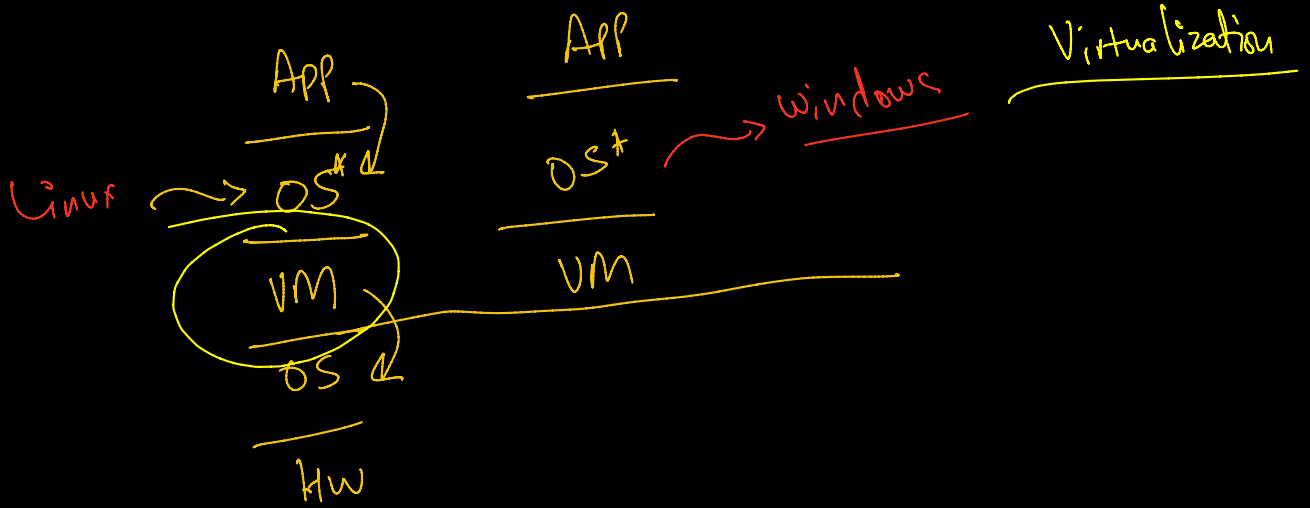
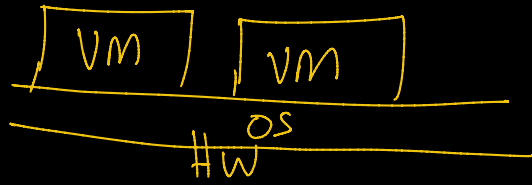
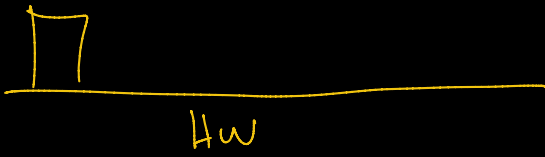
- 1990: Windows 3.0
- 1993: Window NT
  - New OS built from scratch
- Open Source Operating Systems
  - Linux, FreeBSD, NetBSD, OpenBSD
- 1995: Windows 95
  - Built-in Internet support (networking usually via modem)
- Network PC, Thin clients
- PCI bus: Plug & Play hardware

# 2000s

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- 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

Webserver



Cloud computing

# The End