## Operating Systems Design 1. Introduction

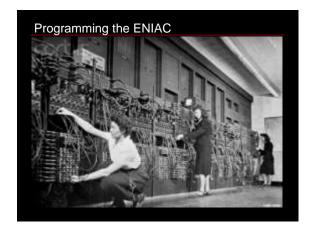
Paul Krzyzanowski pxk@cs.rutgers.ed In the beginning...

### 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 system
    - 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
  - nemory & 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 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

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

