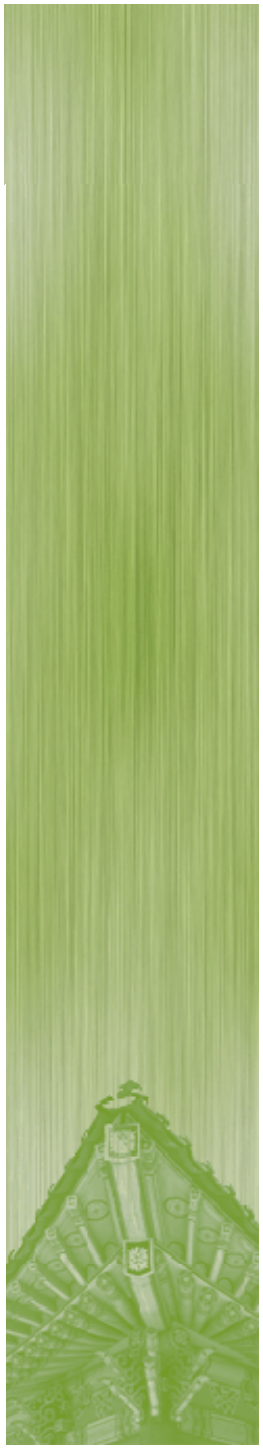

Introduction

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Today's Topics

- What is OS?
- History of OS

What is OS? (1)

- **Application view**
  - Provides an execution environment for running programs
  - Provides an abstract view of the underlying computer system
    - Processors → Processes, Threads
    - Memory → Address spaces (virtual memory)
    - Storage → Volumes, Directories, Files
    - I/O Devices → Files (ioctls)
    - Networks → Files (sockets, pipes, …)
    - …

What is OS? (2)

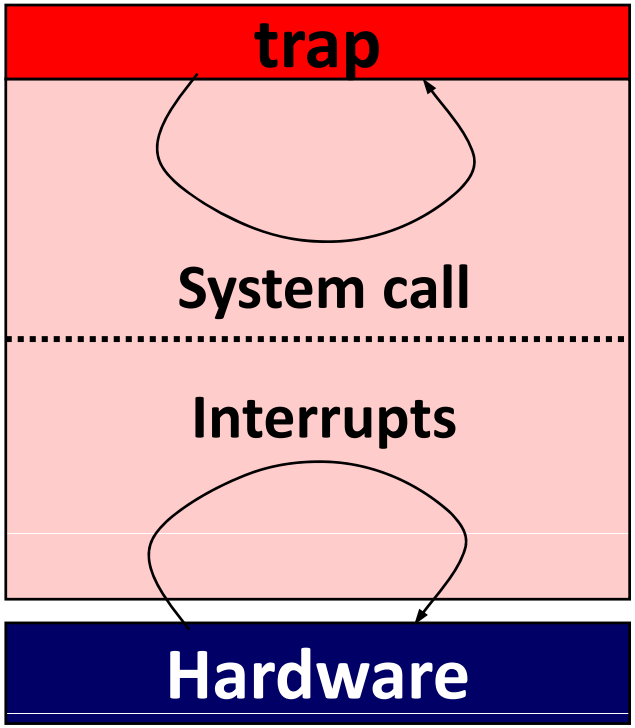
- **System view**
  - Manages various resources of a computer system
  - Sharing
  - Protection
  - Fairness
  - Efficiency
  - …

Resources

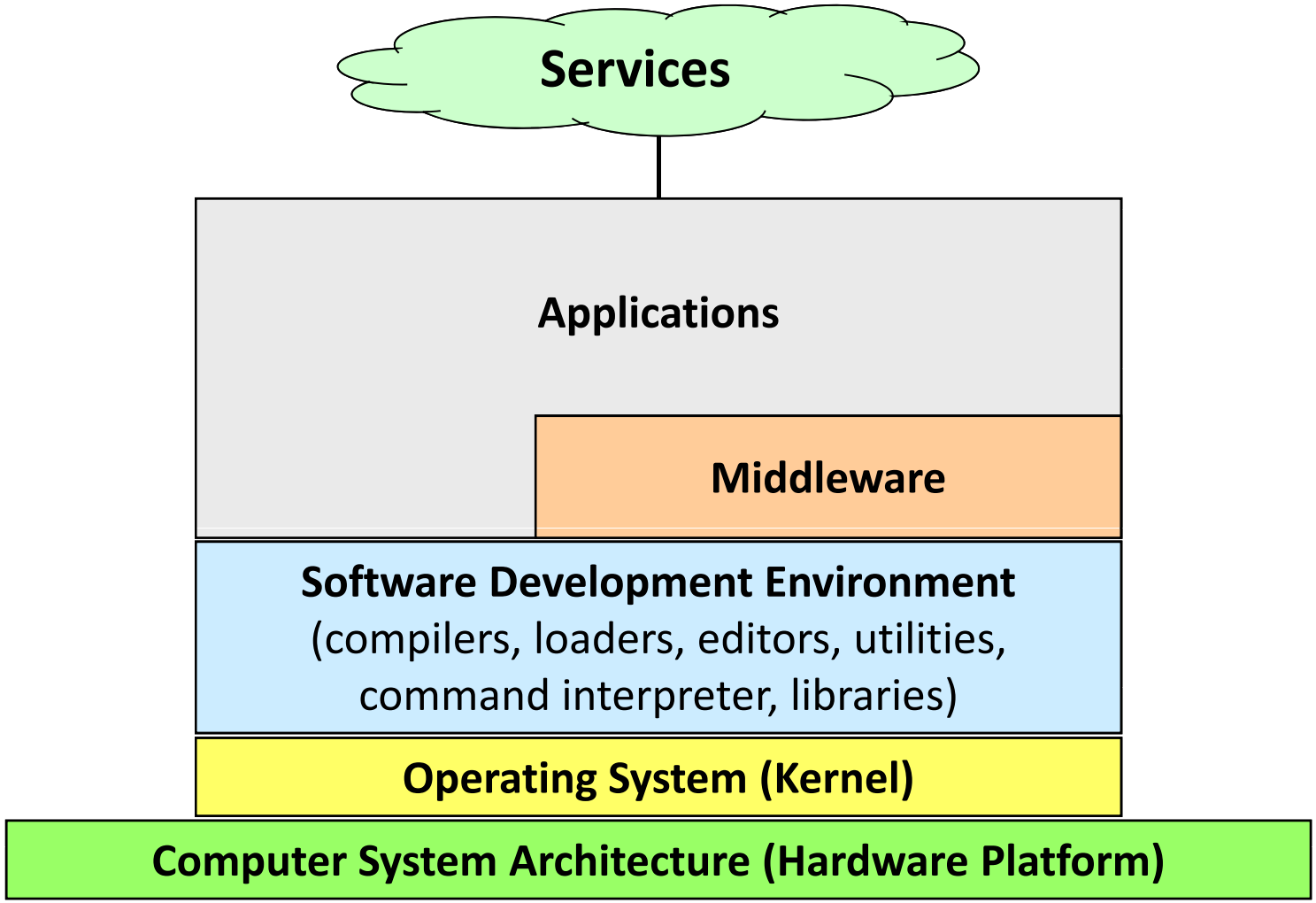
- **CPU**
- **Memory**
- **I/O devices**
- **Queues**
- **Energy**
- **…**

What is OS? (3)

- **Implementation view**
  - Highly-concurrent, event-driven software

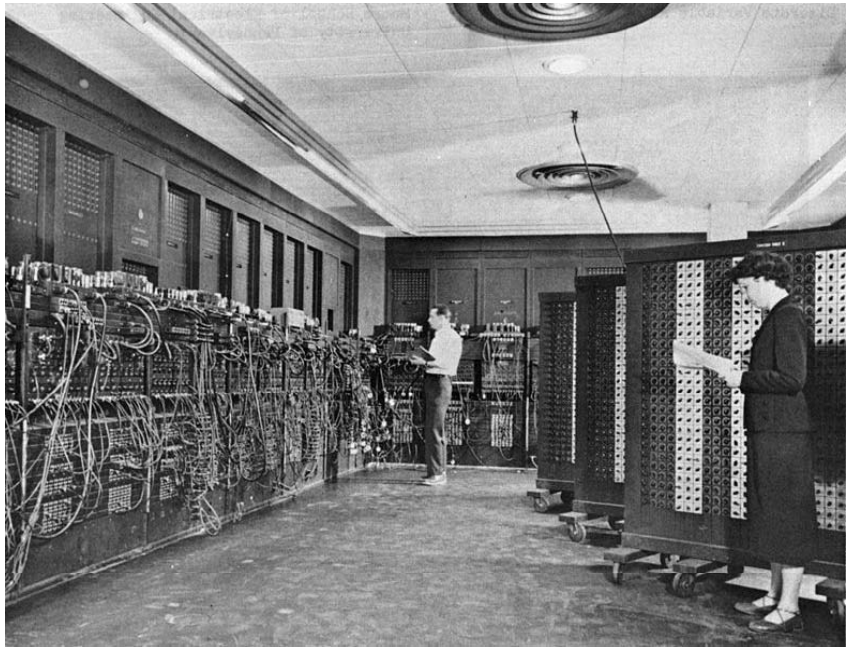


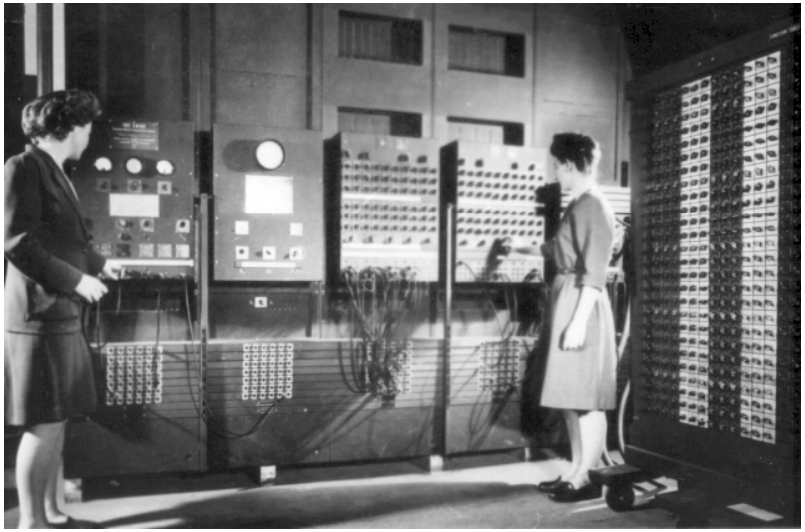
Computer Systems



1st Generation (1945-55)
-- Vacuum Tubes and Plugboards

- No OS
- No programming languages
- No assembly languages

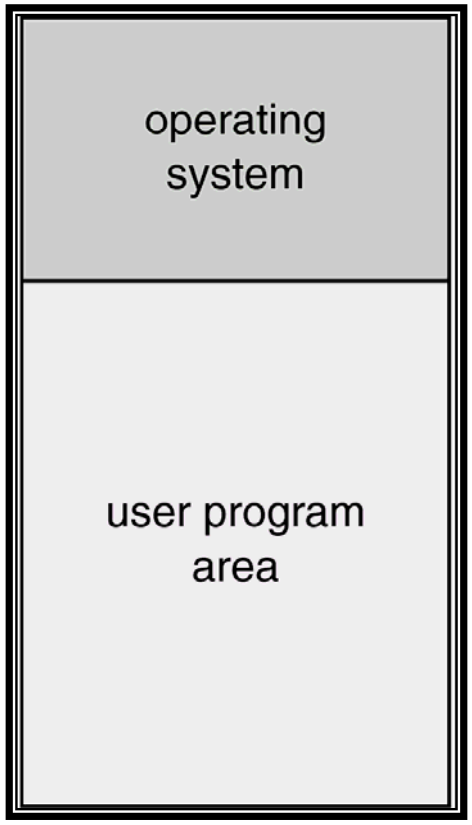




ENIAC (Electronic Numerical Integrator And Computer), 1946

2nd Generation (1955-65)
-- Transistors and Mainframes

- **Batch systems**
  - One job at a time
  - Card readers, tape drives, line printers
  - OS is always resident in memory and merely transfers a control.
  - CPU is underutilized due to the bottleneck in I/O



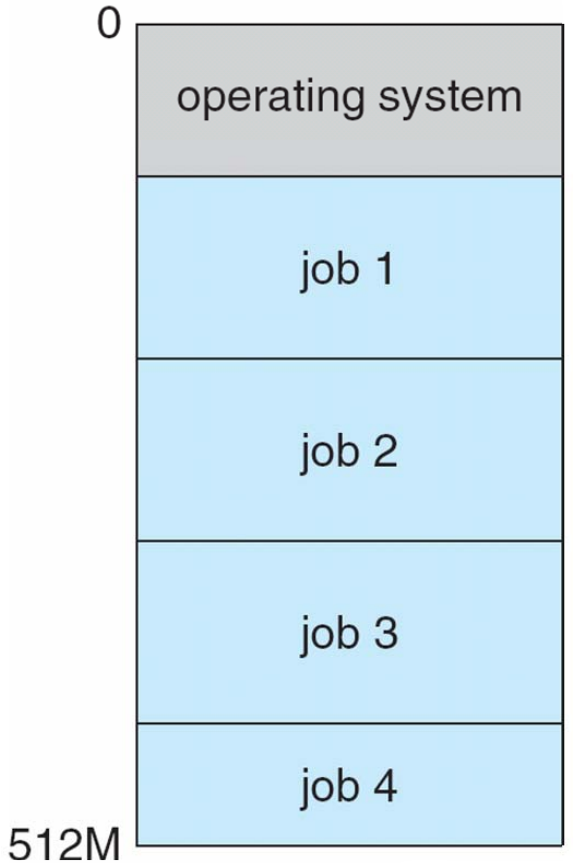
3rd Generation (1965-80)
-- Integrated Circuits (ICs)

- **Architectural advances**
  - Using ICs: better price/performance
  - Disk drives
  - On-line terminals

  - The notion of "Computer Architecture":
    - IBM System/360 family

3rd Generation (1965-80)
-- Integrated Circuits (ICs)

- **Multiprogrammed systems**
  - Increase CPU utilization
  - OS features
    - Job scheduling
    - Memory management
    - CPU scheduling
    - Protection
  - Spooling (Simultaneous Peripheral Operation On-Line)



3rd Generation (1965-80)
-- Integrated Circuits (ICs)

- **Time-sharing systems**
  - Improve response time
  - OS features
    - Swapping
    - Virtual memory
    - File system
    - Sophisticated CPU scheduling
    - Synchronization
    - Interprocess communication
    - Interactive shell
    - More protection, …

4th Generation (1980-)
-- LSIs & VLSIs

- **Architectural advances**
  - Microprocessors: smaller and faster
  - Storage: larger and faster
  - Personal computers
  - CPU work is offloaded to I/O devices
- **Modern OS features**
  - GUI (Graphical User Interface)
  - Multimedia
  - Internet & Web
  - Networked / Distributed, etc.

OS History

CTSS (1961, MIT)
(Compatible Time Sharing System)

OS/360 (1964, IBM)

MULTICS (1965, MIT, Bell Labs, GE)
(MULTiplexed Information and Computing Service)

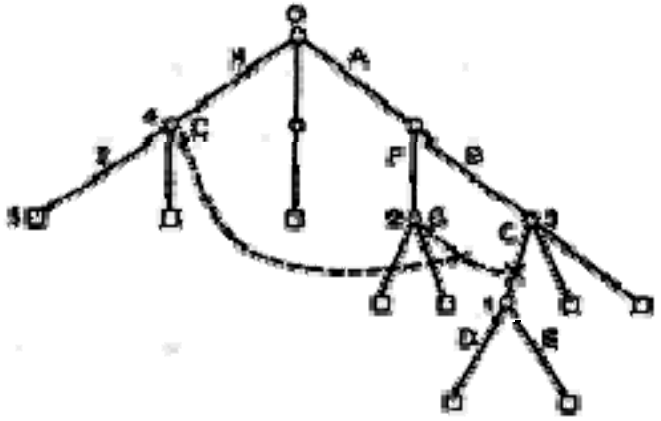
Unix (1969, Bell Labs)

Multics (1)

- **Multics**
  - **Mult**iplexed **I**nformation and **C**omputing **S**ervice
  - A time-shared, multi-processor mainframe "computing utility"
  - Originally started by MIT, GE, and Bell Labs for GE-645, a 36-bit system, in 1965.
    - Bell Labs quit in 1969 and built Unix.
    - GE's computer business, including Multics, was taken over by Honeywell in 1970.
    - Last system shutdown on 10/31/2000.
  - http://www.multicians.org

Multics (2)

- **Multics innovations**
  - Hierarchical file system.
    - File / directory / path name / working directory
    - Access Control Lists (ACLs).
    - Long names on entries.
    - Multiple names on entries.
    - Symbolic links.
    - Storage quotas.
    - Removable devices.
    - The backup procedures.



  - Lots of developments in management of virtual memory including segmentation and paging.

Multics (3)

- **Multics innovations (cont'd)**
  - Separating the command shell from the OS kernel.
  - Dynamic linking.
  - Implementation of an OS in a high level language (PL/1)
  - Management of shared memory.
  - Mapping of logical disk volumes onto physical volumes.
  - Many developments in the area of secure computer systems.
    - Multics was rated B2 by the NCSC in 1985.
    - A subsequent system (based on the Multics experience) built by Honeywell was the first computer system ever rated A1.

Multics (4)

- **Multics innovations (cont'd)**
  - Multics Relational Data Store (MRDS) in 1976.
    - The first commercial relational DBMS.
    - The MRDS query language was similar to early SQL.
    - Concurrent access to a database by multiple processes was supported.
    - The database could be backed up in its entirety.
  - Spreadsheets were developed on the Multics platform.
  - Multics supports BCPL, BASIC, APL, FORTRAN, LISP, C, COBOL, ALGOL 68, and Pascal.
  - Many optimizations for the LISP language through work on the Multics MACLISP compiler.

OS History: Unix

"… When BTL (Bell Telephone Laboratories) withdrew from the Multics project, they needed to rewrite an operating system in order to play space war on another smaller machine (a DEC PDP-7 with 4K memory for user programs). The result was a system which a punning colleague called UNICS (UNiplexed Information and Computing Services) – an 'emasculated Multics'; no one recalls whose idea the change to UNIX was."

-- Peter H. Salus, *A Quarter Century of Unix*, Addision-Wesley, 1994.

"… It was the summer of '69. In fact, my wife went on vacation to my family's place in California.... I allocated a week each to the operating system, the shell, the editor, and the assembler, to reproduce itself, and during the month she was gone, it was totally rewritten in a form that looked like an operating system, with tools that were sort of known, you know, assembler, editor, and shell .... Yeh, essentially one person for a month."

-- Ken Thompson

Unix

- **Unix Features**
  - Hierarchical file systems
    - Special files: uniform I/O, naming, and protection.
    - Removable file systems via mount/umount
    - i-node
  - Process control
    - fork(), exec(), wait(), exit()
    - Pipes for inter-process communication
  - Shells
    - Standard I/O and I/O redirection
    - Filters
    - Command separators
    - Shell scripts
  - Signals

OS History: UNIX (1969-85)

More info: UNIX History at http://www.levenez.com/unix/

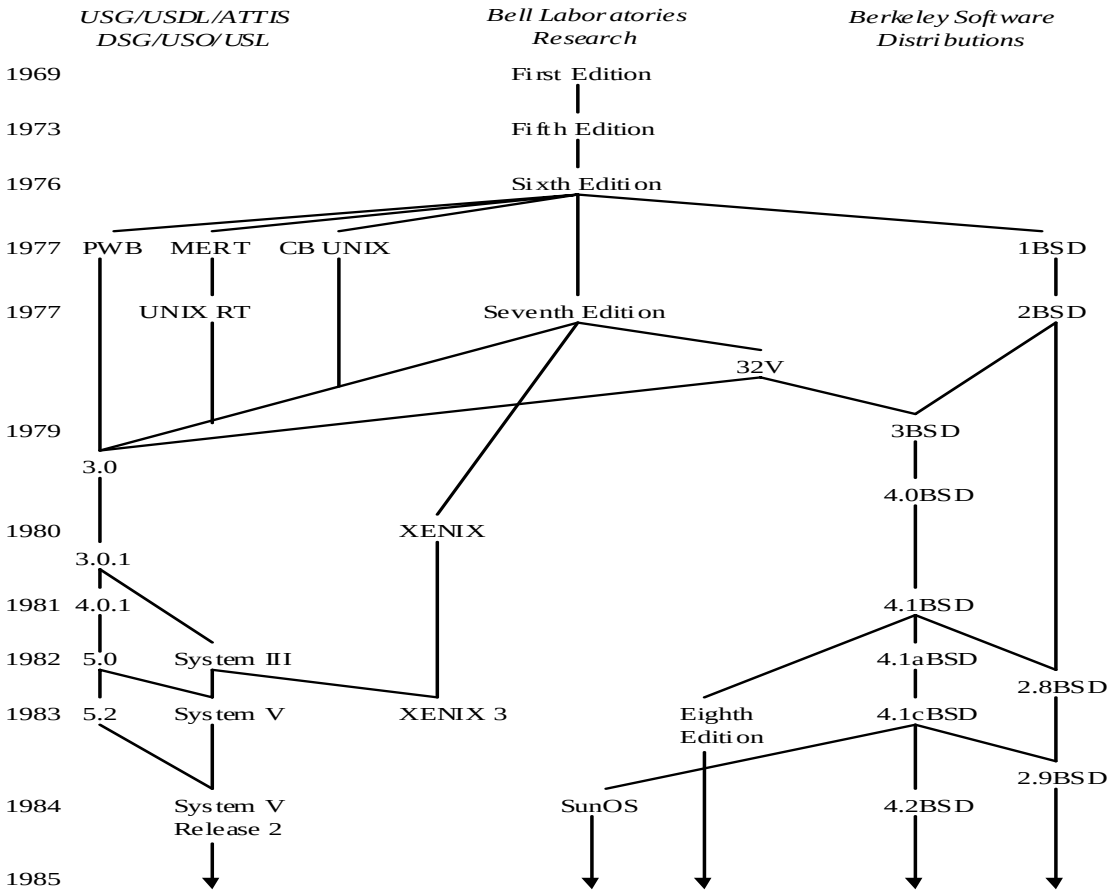


Figure 1.1 The UNIX system family tree, 1969-1985

OS History: UNIX (1985-96)

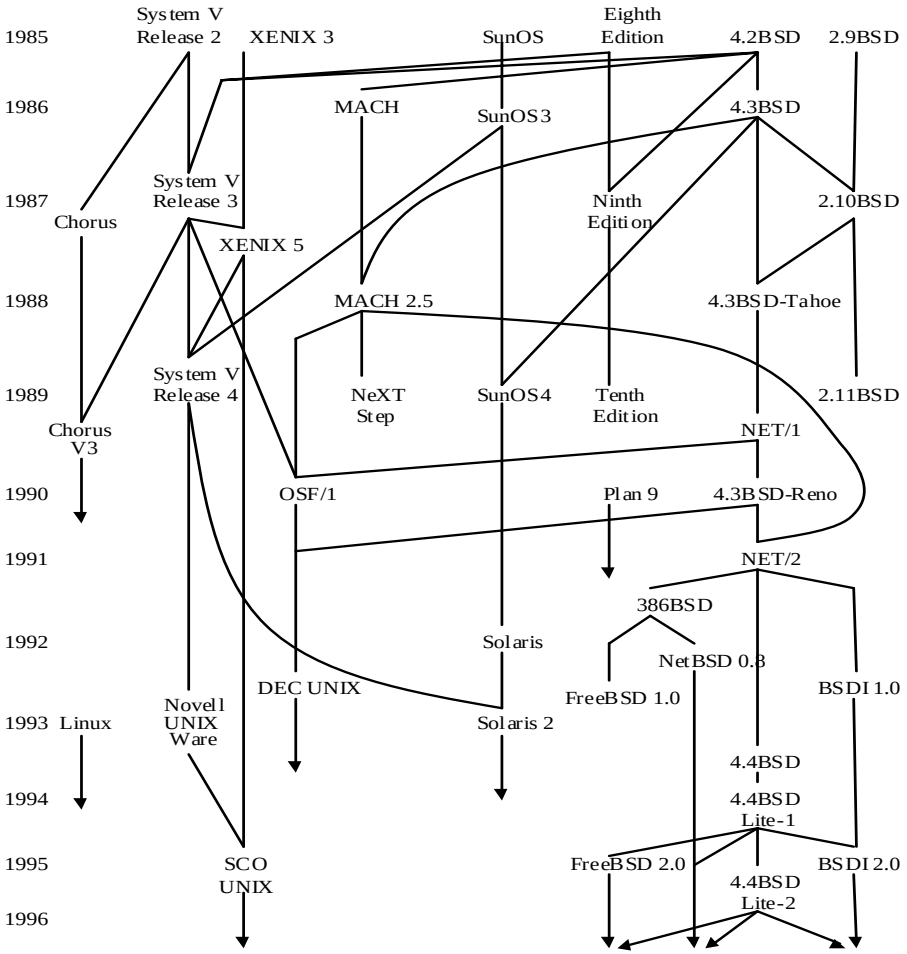


Figure 1.2 The UNIX system family tree, 1986-1996

OS History: UNIX

- Sun Solaris
- HP HP-UX
- IBM AIX
- Compaq (Digital) Tru64
- SGI Irix
- SCO Unixware

- Linux
- FreeBSD, NetBSD, OpenBSD
- Apple Mac OS X, etc.

Multics vs. Unix

- **Comparison**
  - Multics:
    - Top-down approach
    - 150 Man-Years for design and system programming, another 50 Man-Years for improvements
    - Too complicated, too costly hardware
    - Many novel ideas had a great impact
  - Unix:
    - Bottom-up approach
    - Simplicity, elegance, and ease of use
    - Low cost hardware, university adoption
    - 2 Man-Years
    - The root of the modern operating systems

OS History: Windows & Linux

1981 82 84 86 88 90 91 92 93 94 95 96 97 98 99 00 01 03

MS-DOS Family

1.0 2.0 3.0 3.2 4.0 5.0 6.0 7.0

Windows Family

1.0 2.0 3.0 3.1 95 98 98 SE ME

Windows for WorkGroup Family

3.1 3.11

Windows NT Family

3.1 3.5 3.51 4.0 2K XP Server 2003

Linux

0.01 0.99 1.0 1.2 2.0 2.1 2.2 2.4 2.6