

# Classic Systems: Unix and THE

Presented by Hakim Weatherspoon

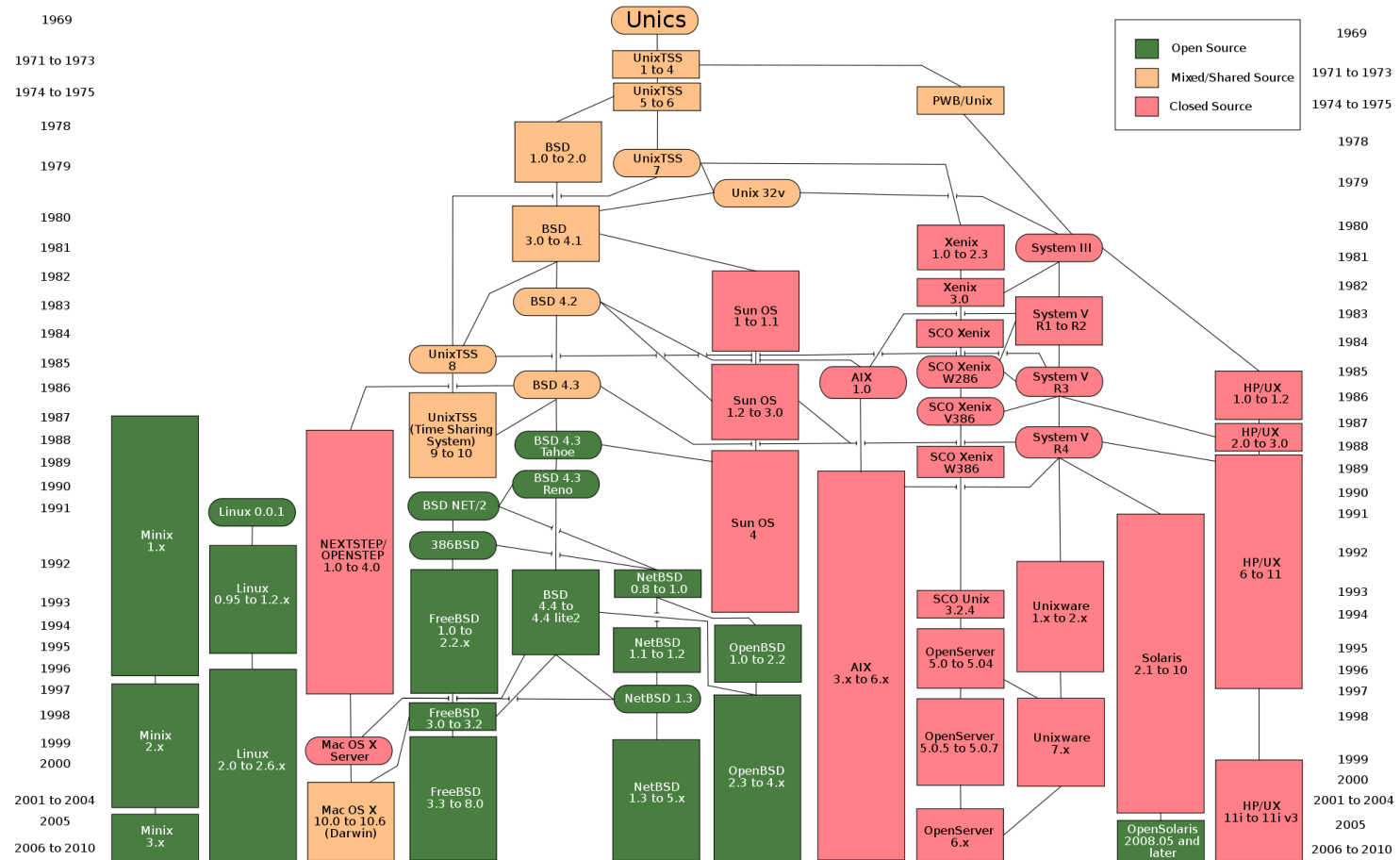
# The UNIX Time-Sharing System

Dennis Ritchie and Ken Thompson

- Background of authors at Bell Labs
  - Both won Turing Awards in 1983
- Dennis Ritchie
  - Key developer of *The C Programming Language*, Unix, and Multics
- Ken Thompson
  - Key developer of the B programming language, Unix, Multics, and Plan 9
  - Also QED, ed, UTF-8

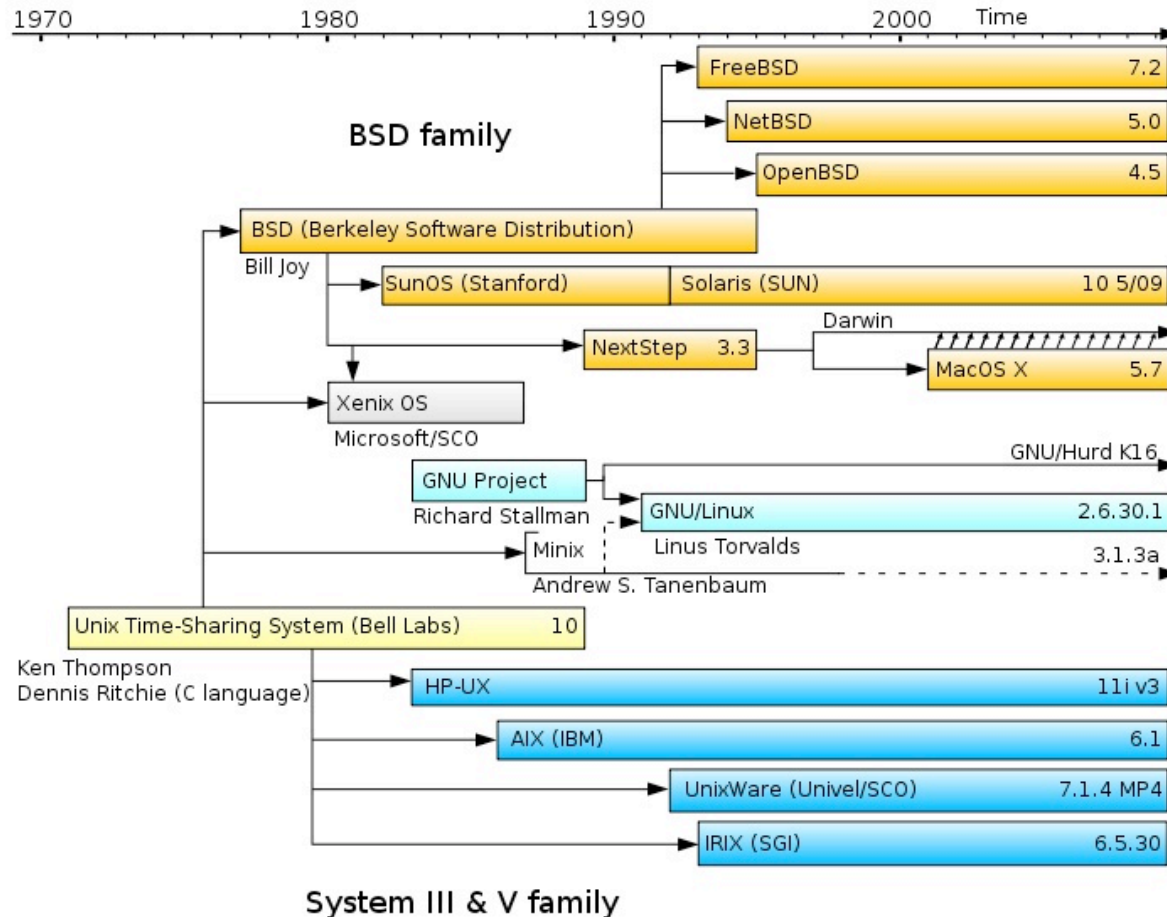
# The UNIX Time-Sharing System

## Dennis Ritchie and Ken Thompson



# The UNIX Time-Sharing System

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# The UNIX Time-Sharing System

Dennis Ritchie and Ken Thompson

- Classic system and paper
  - described almost entirely in 10 pages
- Key idea
  - elegant combination of a few concepts that fit together well

# System features

- Time-sharing system
- Hierarchical file system
- Device-independent I/O
- Shell-based, tty user interface
- Filter-based, record-less processing paradigm

# Version 3 Unix

- 1969: Version 1 ran PDP-7
- 1971: Version 3 Ran on PDP-11's
  - Costing as little as \$40k!
- < 50 KB
- 2 man-years to write
- Written in C



PDP-7



PDP-11

# File System

- Ordinary files (uninterpreted)
- Directories (protected ordinary files)
- Special files (I/O)

# Directories

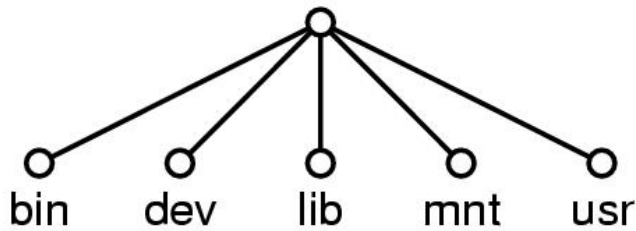
- root directory
- path names
- rooted tree
- current working directory
- back link to parent
- multiple links to ordinary files

# Special Files

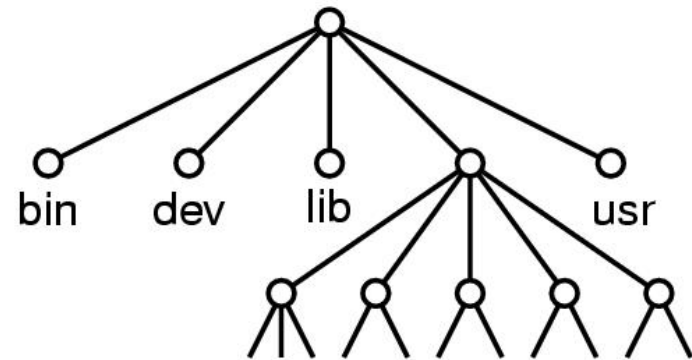
- Uniform I/O model
  - Each device associated with at least one file
  - But read or write of file results in activation of device
- Advantage: Uniform naming and protection model
  - File and device I/O are as similar as possible
  - File and device names have the same syntax and meaning, can pass as arguments to programs
  - Same protection mechanism as regular files

# Removable File System

- Tree-structured
- *Mount*'ed on an ordinary file
  - Mount replaces a leaf of the hierarchy tree (the ordinary file) by a whole new subtree (the hierarchy stored on the removable volume)
  - After mount, virtually no distinction between files on permanent media or removable media



(a)



(b)

# Protection

- User-world, RWX bits
- set-user-id bit
- super user is just special user id

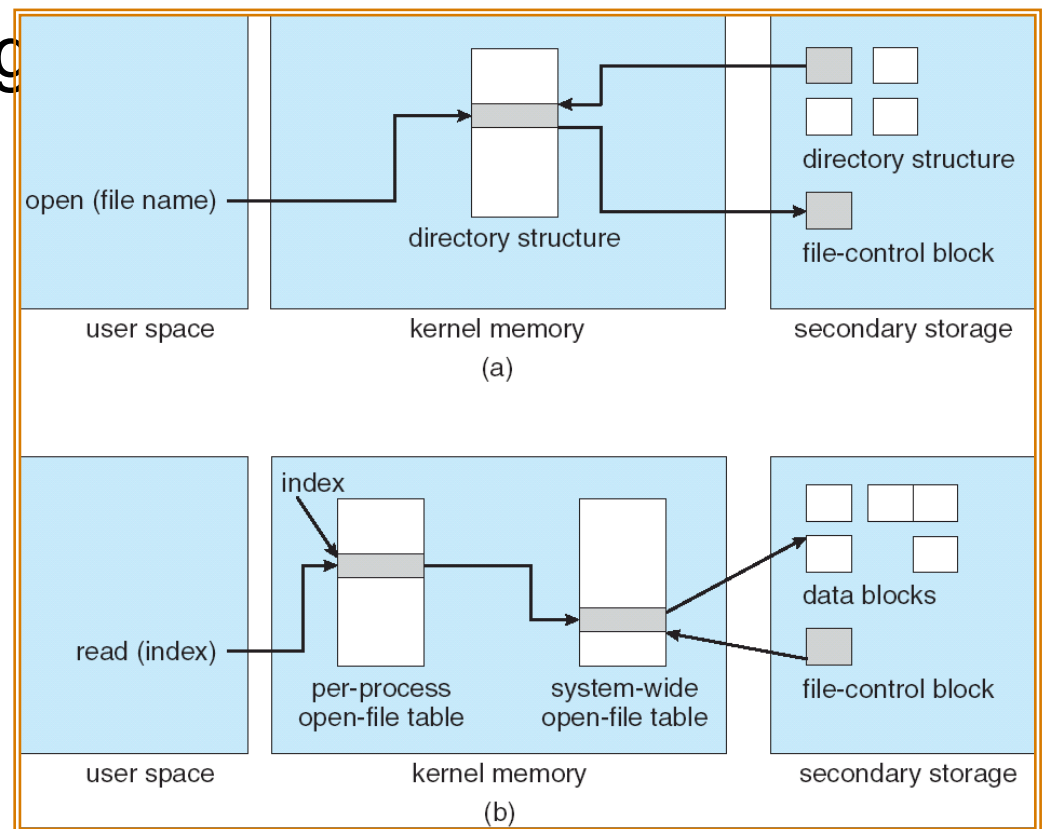


# Uniform I/O Model

- open, close, read, write, seek
  - Uniform calls eliminates differences between devices
- other system calls
  - close, status, chmod, mkdir, ln
- bytes, no records

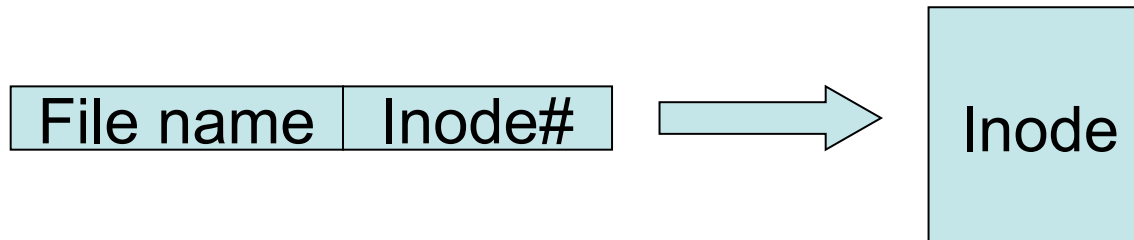
# File System Implementation

- System table of i-numbers (i-list)
- i-nodes
- path name scanning
- mount table
- buffered data
- write-behind



# I-node Table

- short, unique name that points at file info.
- allows simple & efficient fsck
- cannot handle accounting issues



# Processes and images

- text, data & stack segments
- process swapping
- pid = fork()
- pipes
- exec(file, arg1, ..., argn)
- pid = wait()
- exit(status)

# The Shell

- `cmd arg1 ... argn`
- `stdio` & I/O redirection
- filters & pipes
- multi-tasking from a single shell
- shell is just a program
  
- Trivial to implement in shell
  - Redirection, background processes, `cmd` files, etc

# Traps

- Hardware interrupts
- Software signals
- Trap to system routine

# Perspective

- Not designed to meet predefined objective
- Goal: create a comfortable environment to explore machine and operating system
- Other goals
  - Programmer convenience
  - Elegance of design
  - Self-maintaining

# “THE”-Multiprogramming System

Edsger W. Dijkstra

- Received Turing Award in 1972
- Contributions
  - Shortest Path Algorithm, Reverse Polish Notation, Bankers algorithm, semaphore's, self-stabilization
- Known for disliking 'goto' statements and using computers!



# “THE”-Multiprogramming System

Edsger W. Dijkstra

- Never named “THE” system; instead, abbreviation for “Technische Hogeschool Eindhoven”
- Batch system (no human intervention) that supported multitasking (processes share CPU)
  - THE was *not* multiuser
- Introduced
  - software-based memory segmentation
  - Cooperating sequential processes
  - semaphores

# Design

- Layered structure
  - Later Multics has layered structure, ring segmentation
- Layer 0 – the scheduler
  - Allocated CPU to processes, accounted for blocked proc's
- Layer 1 – the pager
- Layer 2 – communication between OS and console
- Layer 3 – managed I/O
- Layer 4 – user programs
- Layer 5 – the user

# Perspective

- Layered approach
  - Design small, well defined layers
  - Higher layers dependent on lower ones
    - Helps prove correctness
    - Helps with debugging
- Sequential process and Semaphores

# Next Time

- Read and write review:
  - *SEDA: An Architecture for Well Conditioned, Scalable Internet Services*, Matt Welsch, David Culler, and Eric Brewer. Proceedings of the Eighteenth ACM Symposium on Operating Systems Principles (Banff, Alberta, Canada, 2001), pages 230--243
  - *On the duality of operating system structures*, H. C. Lauer and R. M. Needham. ACM SIGOPS Operating Systems Review Volume 12, Issue 2 (April 1979), pages 3--19.

# Next Time

- Read and write review:
- Lab 0 – finish today
- Lab 1 – available later today and due next Friday
- Project Proposal due in two weeks
  - Possible projects presentations Tuesday night, syslab
  - Also, talk to faculty and email and talk to me
- Check website for updated schedule