

# Operating System Labs

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# Operating System Labs

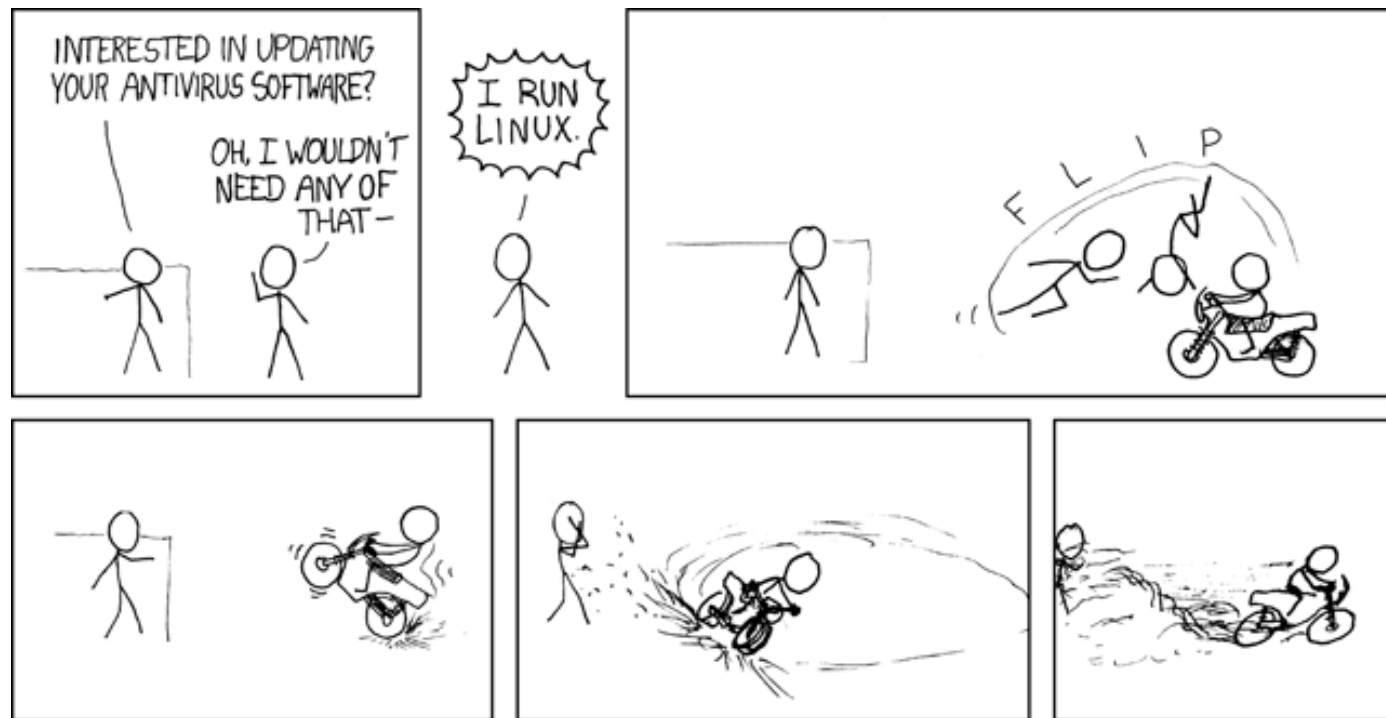
- Introduction to Unix (\*nix)
- Course Overview

# Operating System Labs

- Introduction to Unix (\*nix)
- Course Overview

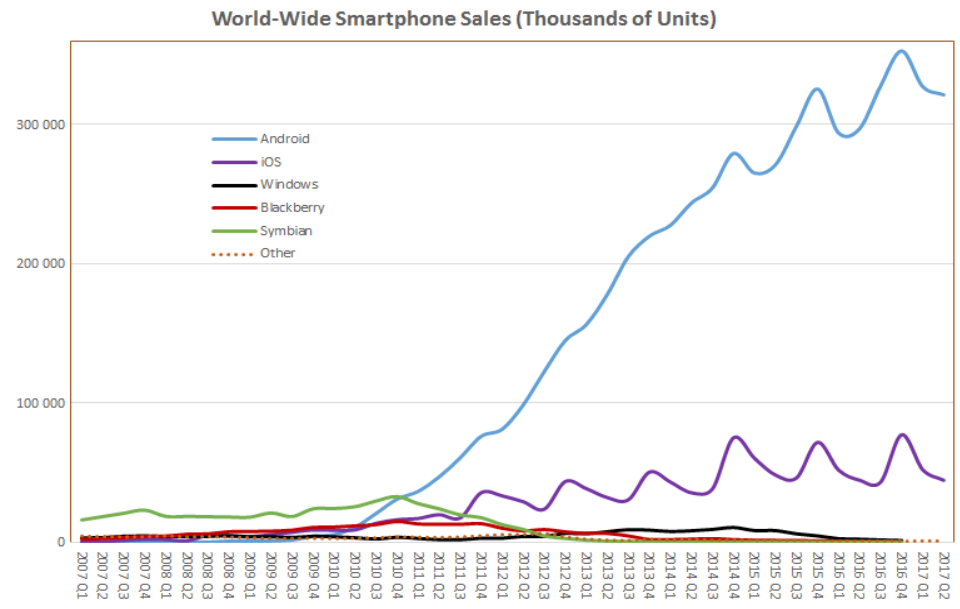
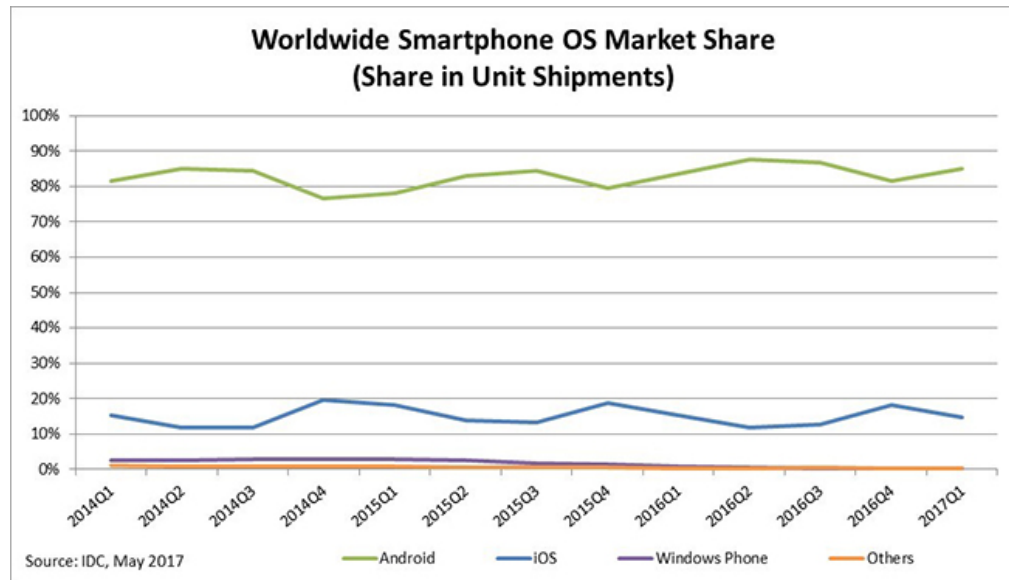
# Unix / \*nix

- What
  - A family of operating systems
  - Widely used
  - A cool thing



# Unix / \*nix

- Smartphone



# Unix / \*nix

- Web Server

| Source         | Date     | Unix, Unix-like |       |       |         | Microsoft Windows | References                                |
|----------------|----------|-----------------|-------|-------|---------|-------------------|---|
|                |          | All             | Linux | BSD   | Unknown |                   |   |
| W3Techs        | Feb 2015 | 67.8%           | 35.9% | 0.95% | 30.9%   | 32.3%             | <a href="#">[54]</a> <a href="#">[55]</a> |
| Security Space | Feb 2014 | <79.3%          | N/A   |       |         |                   | <a href="#">[56]</a> <a href="#">[57]</a> |
| W3Cook         | May 2015 | 98.3%           | 96.6% | 1.7%  | 0%      | 1.7%              | <a href="#">[58]</a>                      |

# Unix / \*nix

| Category   | Source                                       | Date     | Linux   | BSD and other Unix                            | Windows                    | In-house | Other  |       |
|--|--|----------|---|---|----------------------------|----------|--------|-------|
| Desktop, laptop, netbook   | Net Applications <sup>[68]</sup>             | Dec 2014 | 1.34% (Ubuntu, etc.)  | 7.21% (OS X)                                  | 91.45% (7, 8, XP, Vista)   |          |        |       |
| Smartphone, tablet, handheld game console, smart TV, Wearable computer | StatCounter Global Stats <sup>[69]</sup>     | Dec 2014 | 53.86% (Android)  | 31.10% (iOS)                                  | 1.87% (WP8, RT)            |          | 13.17% |       |
| Server (web)   | W3Techs <sup>[70]</sup>                      | Sep 2014 | 36.72% (Debian, Ubuntu, CentOS, RHEL, Gentoo)   | 30.18% (FreeBSD, HP-UX, Solaris, OS X Server) | 33.10% (W2K3, W2K8, W2K12) |          |        |       |
| Supercomputer  | TOP500 <sup>[67]</sup>                       | Nov 2014 | 97.0% (Custom)  | 2.4% (AIX)                                    | 0.2%                       |          | 0.2%   |       |
| Mainframe  | Gartner <sup>[64]</sup>                      | Dec 2014 | 28% (SLES, RHEL)  | 72% (z/OS) UNIX System Services               |                            |          |        |       |
| Gaming console   | Nintendo, Sony, Microsoft, Valve Corporation | Jun 2015 | <div>Device shipments, 2015</div> <div><div>Android</div><div></div><div>54.16%</div></div>                           |   |                            |          |        |       |
| Embedded   | UBM Electronics <sup>[71]</sup>              | Mar 2015 | <div><div>iOS/macOS</div><div></div><div>12.37%</div></div> <div><div>Windows</div><div></div><div>11.79%</div></div> |   |                            |          |        | 41.1% |
| Real time  | NewTechPress <sup>[72]</sup>                 | Nov 2015 | <div><div>Other</div><div></div><div>21.66%</div></div>   |   |                            |          |        | 24.8% |

OS Device Shipments, Gartner<sup>[23]</sup>

According to [Gartner](#), the following is the worldwide device shipments (referring to [wholesale](#)) by operating system, which includes smartphones, [tablets](#), [laptops](#) and [PCs](#) together.

# Unix / \*nix

- As your desktop OS (work with it)
  - Coding
  - Web
  - Text processing
  - Multimedia
  - Shells
    - a working space
- It's "Free"



# Unix / \*nix



# Unix / \*nix

- For studying general OS concepts
  - Open source
  - High quality documents (freely available)
  - Community

# Unix / \*nix

- History
  - Multics: mid-1960, MIT+GE+Bell Labs
    - “Multiplexed Information and Computing Service”, allowing multiple users to access a mainframe simultaneously
    - Segmentation, Dynamic linking
    - Complexity
    - Failed

# Unix / \*nix

- History
  - Unics: 1969, Ken Thompson, Dennis Ritchie
    - A game called *Space Travel*
    - Smaller than Multics
    - Using PDP-7 assemble language
    - Hierarchical file system, process, device files, command-line interpreter
    - Single task
      - “Uniplexed Information and Computing Service”
  - Core concepts of Unix

# Unix / \*nix

- History
  - C programming language, 1972, Dennis Ritchie
    - Rewrite unix for PDP-11

# Unix / \*nix



# THE C PROGRAMMING LANGUAGE

# GNU

- History
  - GNU Project, 1983, Richard Stallman
    - GNU: **G**NU is **N**ot **U**nix
    - Unix-like
    - Free software, contain no Unix code
    - GNU software
      - gcc (GNU C compiler)
      - gdb (GNU debugger)
      - Emacs
    - Free Software Foundation
    - Free Software License
      - GNU General Public License (GPL)

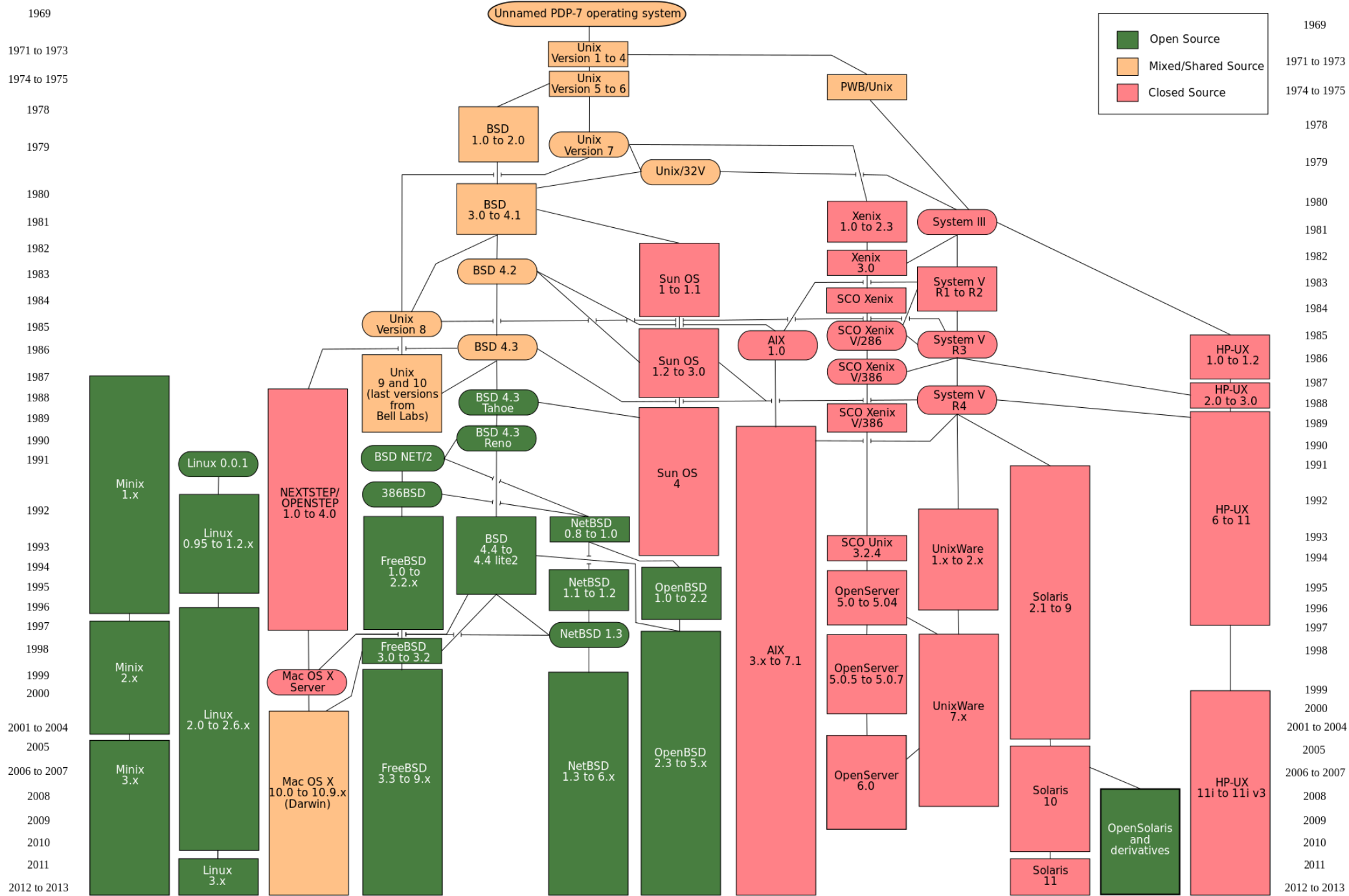
# Unix

- Unix standardization
  - ISO C
    - Standard for the C programming language
  - POSIX
    - IEEE Portable Operating System Interface
  - SUS
    - Single Unix Specification



# Unix

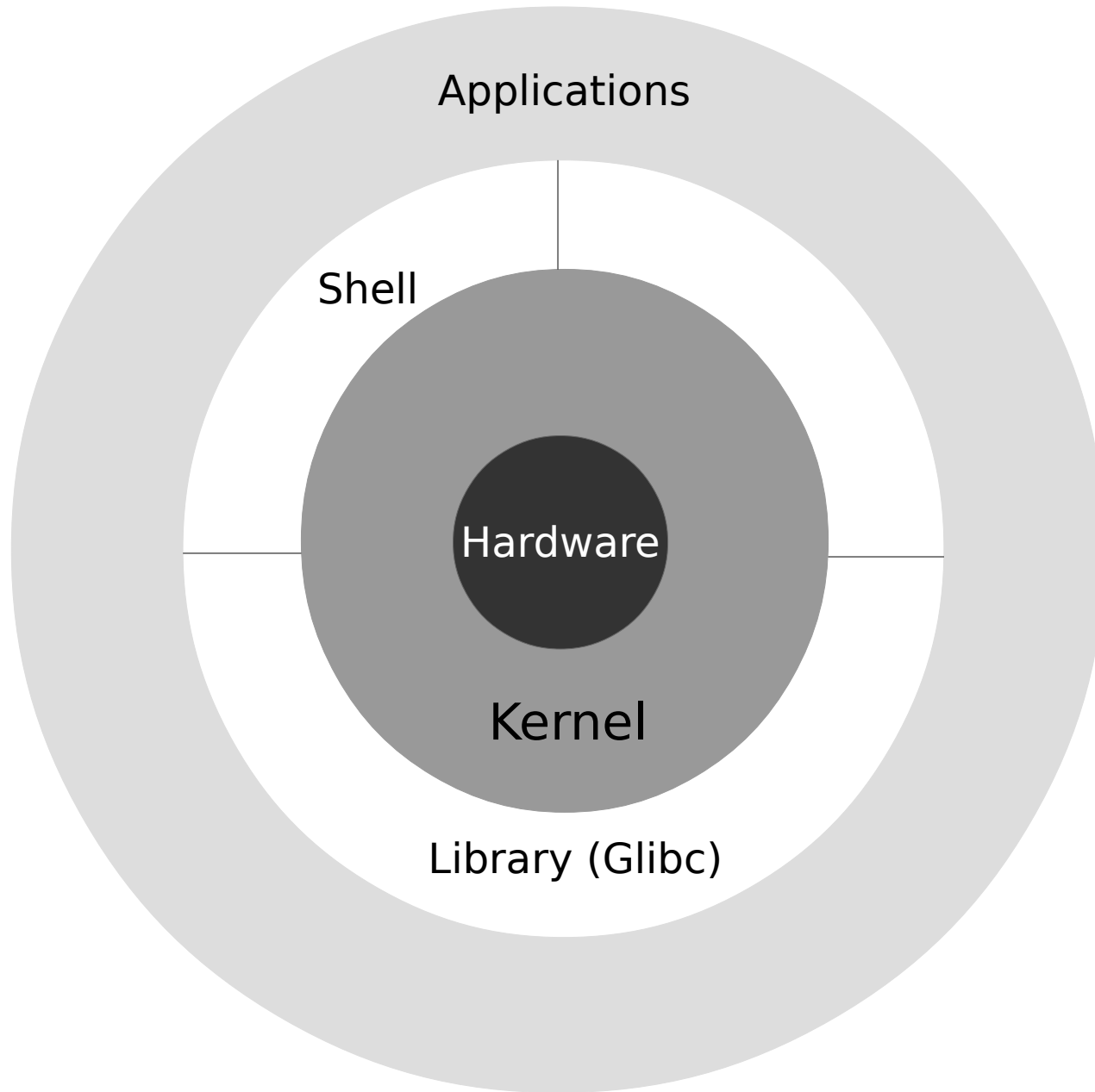
- Unix implementations
  - Unix v6, v7 (Bell lab)
  - FreeBSD (U.C. Berkeley)
  - Sun OS/Solaris (Sun)
  - System V (AT&T)
  - OS X (Apple)
  - Linux, 1991, Linus Torvalds
    - A (free) kernel with support of GNU packages
    - distributions
      - Ubuntu, Debian, CentOS, Fedora, Gentoo, ArchLinux
      - Android



# Operating System

- OS in the eyes of users
  - Can I run XX software?
- OS in the eyes of CS students
  - Process, thread, paging, file system, ...
  - Can I write XX software on it to make some money/change the world?

# Unix Operating System



# Unix Operating System

- Login
  - User name
  - Password
- File and Directory
  - Hierarchical structure
    - /home/ybwu/Documents/myfile
  - Root directory: “/”

# Unix Operating System

- Input and Output
  - Human-machine interaction
  - Keyboards
  - Monitors
- Files!

# Unix Operating System

- “Everything is a file”
  - Documents
  - Directories
  - Hard-drives
  - Keyboards
  - Printers
  - /proc
- The same API: open, read, write, close

# Unix Operating System

- File Input and File Output
  - File operations
  - File descriptor
    - unsigned int
    - Allocate when open a file
    - Revoke when close a file
    - read() / write()

```
int fd = open("foo", "r");  
read(fd, buffer, size);  
close(fd);
```



# Unix Operating System

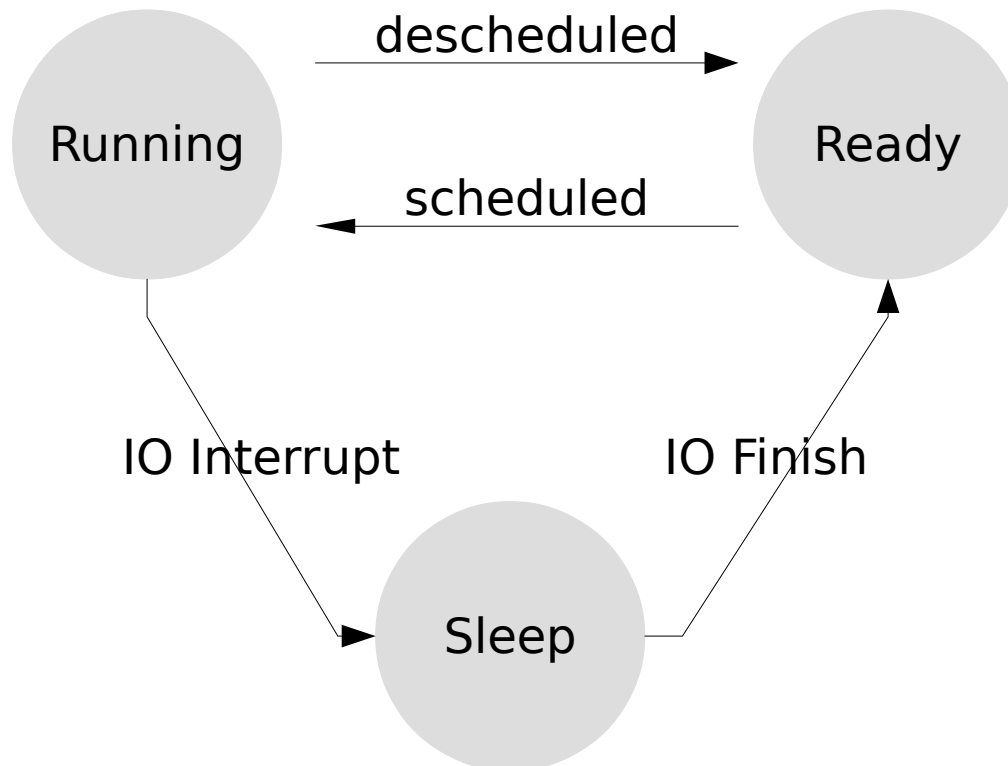
- File Input and File Output
  - Standard input, output, error
    - 3 file descriptors
    - Automatic allocated for every process

```
read(STDIN_FILENO, buffer, size);  
write(STDOUT_FILENO, buffer, size);  
write(STDERR_FILENO, buffer, size);
```

# Unix Operating System

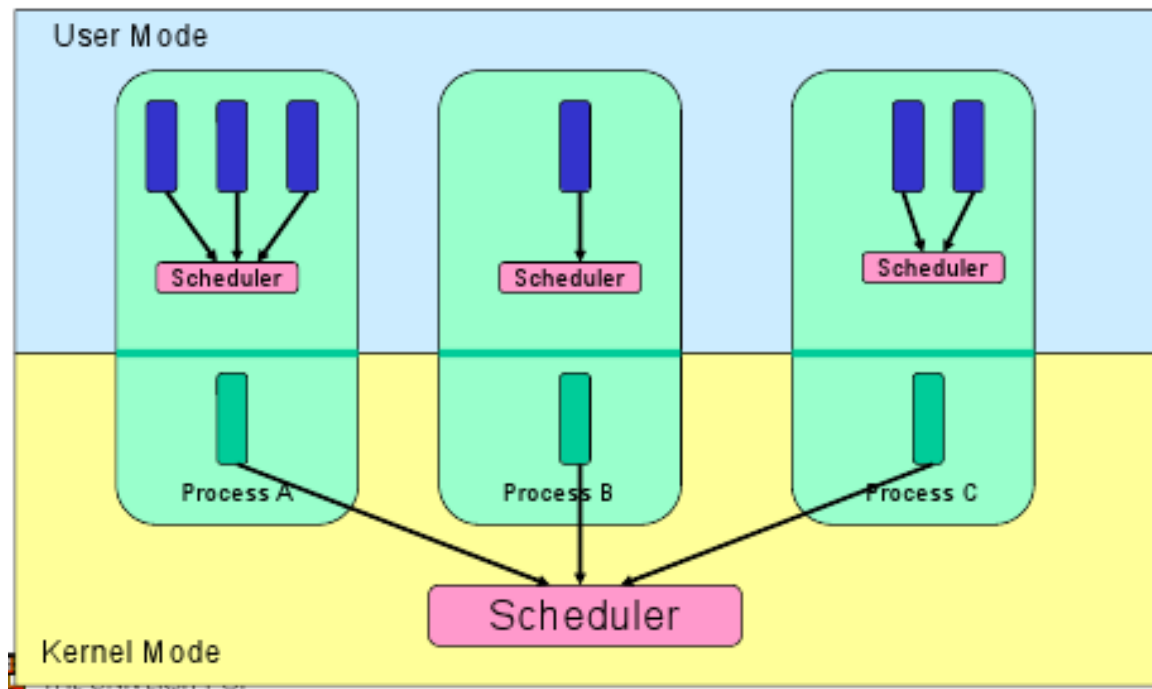
- Process

- Process ID (PID)
- Process status: ready, run, sleep



# Unix Operating System

- Thread
  - Processes that share same address spaces, file descriptors, ...
  - Kernel thread / User thread



# Unix Operating System

- Communications of processes
- Example: Signal
  - Tell a process that something has happened
  - Example
    - pressing Ctrl+C generate a signal to terminate current process

# Unix Operating System

- Memory management
  - Segmentation
  - Paging
- File system
  - Inode

# Unix Operating System

- Handling Errors
  - Not only report error, also provide detail info.
  - Variable: `errno`
  - Function: `void perror(char* msg);`
    - Print msg
    - Print error message string corresponding to the current `errno`

# Unix Operating System

- System Call and Library Function
  - System Call:
    - Provided by kernel
    - Doing restricted operations with hardware
    - User mode, kernel mode
  - Library Function
    - Provided by user mode software developer
    - Some functions reused many times

# Unix Operating System

```
#include <stdio.h>
void foo()
{
    printf("bar\n");
}
```

← User application

```
printf()
fprintf()
malloc()
atoi()
```

← Library Functions  
(Glibc)

```
write(), reads(),
mmap()
```

← System Calls

Kernel



# Unix Operating System

- Summary
  - terms
    - File descriptor, stdin, stdout, stderr
    - Process, thread, Pid
    - errno, perror(),
    - Signal: Ctrl + C
  - System Call
  - Library Functions

# Operating System Labs

- Introduction to \*nix
- Course Overview

# Course Overview

- Objectives
  - Reviewing core concepts of OS
  - Having some fun on coding
- How
  - Reading
  - Coding
  - Presentation

# Course Overview

- In this semester:
  - 5 projects
    - each one has two parts (part a, part b)
  - Bonus points to oral presentations
  - Course website:  
<http://ybwu.org/ecnu-oslabs/index.html>

# Course Overview

- Project 0 (part a)
  - To get familiar with Linux
  - Shell command
    - cd, ls, mkdir, rm, ...
  - Dev environment
    - gcc, gdb

# Course Overview

- Project 0 (part b)
  - Sorting
  - Warm up with Linux programming
  - I/O system call

# Course Overview

- Project 1 (part a)
  - Implement your own shell
    - Linux process API
    - Redirect
    - Pipe

# Course Overview

- Project 1 (part b)
  - xv6
    - xv6 is a modern re-implementation of Sixth Edition Unix in ANSI C for multiprocessor x86 systems.
    - Implemented by MIT PDOS  
<https://pdos.csail.mit.edu/6.828/2019/xv6.html>
  - Adding a system call for xv6
    - Getting familiar with xv6
    - How a system call is handled



# Course Overview

- Project 2 (part a)
  - Implement your own malloc() / free()
    - Dynamic memory allocation
    - The pointer of C programming language

# Course Overview

- Project 2 (part b)
  - xv6 scheduler
    - Implement a multi-level feedback queue scheduler for xv6
    - Getting familiar with context switch, co-routines,...

# Course Overview

- Project 3 (part a)
  - Implement your own lock
    - Introduction to concurrency
    - Linux pthread API
    - Thread safe data structures

# Course Overview

- Project 3 (part b)
  - xv6 virtual memory
    - Adding a NULL pointer handler
    - Adjusting the arrangement of xv6 address space

# Course Overview

- Project 4 (part a)
  - Implement a file defragmentor
    - Reorganize file blocks
    - basic concepts of file system

# Course Overview

- Project 4 (part b)
  - xv6 kernel thread
    - supporting kernel threads in xv6
    - clone(), join(),...

# Course Overview

- Projects
  - P0, P1: single
  - P3, P4, P5: groups of three.
- Grading
  - The quality of your projects (code, documentation)
- Optional: oral presentation (with bonus points)
  - P3, P4, P5
- General advice
  - Start early
  - Build your projects incrementally

# Course Overview

- How
  - Reading
  - Coding
  - Presentation



# Course Overview

- Reading is important
  - You may spend >50% of your time on reading materials.



# Course Overview

- Reading
  - The main text book:
    - *Operating Systems: Three Easy Pieces*, by Remzi H. Arpaci-Dusseau and Andrea C. Arpaci-Dusseau
    - <http://pages.cs.wisc.edu/~remzi/OSTEP/>

# Course Overview

- Reading
  - Reference for Unix programming:
    - *Advanced Programming in the UNIX Environment*, by W. Richard Stevens, Stephen A. Rago
  - Reference for C programming:
    - *The C Programming Language*, by Brian W Kernighan, Dennis M. Ritchie
  - Reference for Linux kernel:
    - *Linux Kernel Development*, by Robert Love

# Course Overview

- Reading
  - RTFM
  - “Read The Manual”
  - Xv6 source code/textbook
    - We will use an old version of xv6 in projects

# Course Overview

- Coding
  - Using C, no C++, no Java ...
  - Compile with gcc
  - Debug with gdb
  - Maybe without IDE
- Make your code
  - Well structured
  - Clean
  - Easy to read

# Course Overview



# Course Overview

- Presentation
  - you will present one of your projects
  - About
    - What have you done
    - How to accomplish them
    - Your favorite parts
    - What did you learn
    - ...

# Operating System Labs

|    | 9.2 | 9  | 16 | 23 | 30 | 10.7 | 14 | 21 | 28 | 11.4 | 11  | 18   | 25  | 12.2 | 9   | 16   | 23  | 30   |
|----|-----|----|----|----|----|------|----|----|----|------|-----|------|-----|------|-----|------|-----|------|
|    | w1  | w2 | w3 | w4 | w5 | w6   | w7 | w8 | w9 | w10  | w11 | w12  | w13 | w14  | w15 | w16  | w17 | w18  |
| P0 | L   | L  |    |    |    |      |    |    |    |      |     |      |     |      |     |      |     |      |
| P1 |     |    | L  | L  |    |      |    |    |    |      |     |      |     |      |     |      |     |      |
| P2 |     |    |    |    |    | L    | L  |    |    |      |     |      |     |      |     |      |     |      |
| P3 |     |    |    |    |    |      |    |    |    | L    | L   | oral |     |      |     |      |     |      |
| P4 |     |    |    |    |    |      |    |    |    |      |     |      |     | L    | L   | oral |     | oral |



# Course Overview

- Policies
  - Plagiarism policy
  - Late policy

# Course Overview

- Plagiarism policy
  - What is OK
    - Discuss programming specifications
      - What is the meaning of “redirection”
    - Discuss reading materials
      - What are the differences between exec functions?
    - Discuss implementation strategies
      - How to make the lock faster?

# Course Overview

- Plagiarism policy
  - What is NOT OK
    - Copy codes/docs from someone
    - Beg someone to write a copy for you

# Course Overview

- If we discover any improper code sharing
  - **ALL** participants will loss **ALL** credits of the project
- No Cheating!

# Course Overview

- Late policy
  - For P0, P1
    - Late handins are NOT accepted.
  - For P2, P3, P4
    - Your group will have 3 “late days”.
    - You need to email TA at least 1 hour before the dateline.
    - If all your 3 “late days” are used, late handins will not be accepted.
- Start Early!

# Course Overview

- Contact
  - Instructor:
    - 吴苑斌, [ybwu@cs.ecnu.edu.cn](mailto:ybwu@cs.ecnu.edu.cn)
    - 911 Science Building B
  - TA:
    - 赵晓臻, [51184506053@std.ecnu.edu.cn](mailto:51184506053@std.ecnu.edu.cn)
    - 刘宇芳, [yfliu.antnlp@gmail.com](mailto:yfliu.antnlp@gmail.com)
- Office hour
  - TBD

# Course Overview

- Project 0 due
  - 21:00 Sep. 15th
- Submissions
  - Class 1: `oslab2019_class1@163.com`
  - Class 2: `oslab2019_class2@163.com`
  - See course websites for more requirements

# Course Overview

- Next Week:
  - Lectures : 教书院 219
  - Labs: 理科楼 B517, B519