# Introduction

Lecture 1

# Welcome

to the *Internal Strcuture of Operating* class

## You will learn, understand and experiment

- how operating systems work
- how basic POSIX (Linux) commands work
- how to use the Linux **command line**
- the history of Linux
- how use the development tools

## We expect

- to come to class
- ask a lot of questions

# Our team

## Lectures

- Alexandru Radovici (CD)
- Ioana Culic (AC)

## Labs

- Ana Gabriela Almăjanu (CD)
- Irina Bradu (AC)
- Andrei Dragtă (AC)
- Andreea Ocănoaia (CD)
- Irina Niță (CD)
- Cristian Paris (CD)
- Alexandra Văduva (CD)
- Alexandru Radovici (CD)

# Outline

## Lectures

- 12 lectures

## Labs

- 12 labs

# Homework

- 4 homework assignments

> *that will help you prepare for the hands on tests*

# Grading

| Part | Description | Points |
|---|---|---|
| Lecture tests | You will have a test at every class with subjects from the previous class. | 0.5p |
| Homework | You will have 4 homework assignments to exercise you for the hands-on tests | 1p |
| Lab activity | Your lab activity will be graded. | 0.5p |
| Hands-on midterm | You will have a practical test covering the first 9 weeks (a Saturday in December) | 4p |
| Theoretical exam | You will have a quiz on Moodle with French grading (in the exams period). | 2.5p |
| Hands-on exam | You will have a practical test covering all the subjects (in the exams period). | 2.5p |
| **Total** | *You will need at least **2.5p during the semester and 5 points in total** to pass* | **11p** |

# Notation

- *name* - this is a name
- **important** - this is important
- `command` - this is a command or a part of a source code

Code

```
$ command arguments
this is what the command wrote
$ command2 arguments
```

> `$` sigifies that the user can write a command, but is **not part of the command**.

*If you can’t explain it simply, you don’t understand it well enough*

Albert Einstein

# Bibliography


1. **Brian Ward**, *How LINUX Works*, 3rd Edition, No Starch Press, 2021
2. **Razvan Deaconescu, Razbvan Rughinis, Mihai Carabas, Alexandru Radovici**, *Utilizarea Sistemelor de Operare*, Printech 2021, download

# Operating System

the purpose of an OS

# Operating System

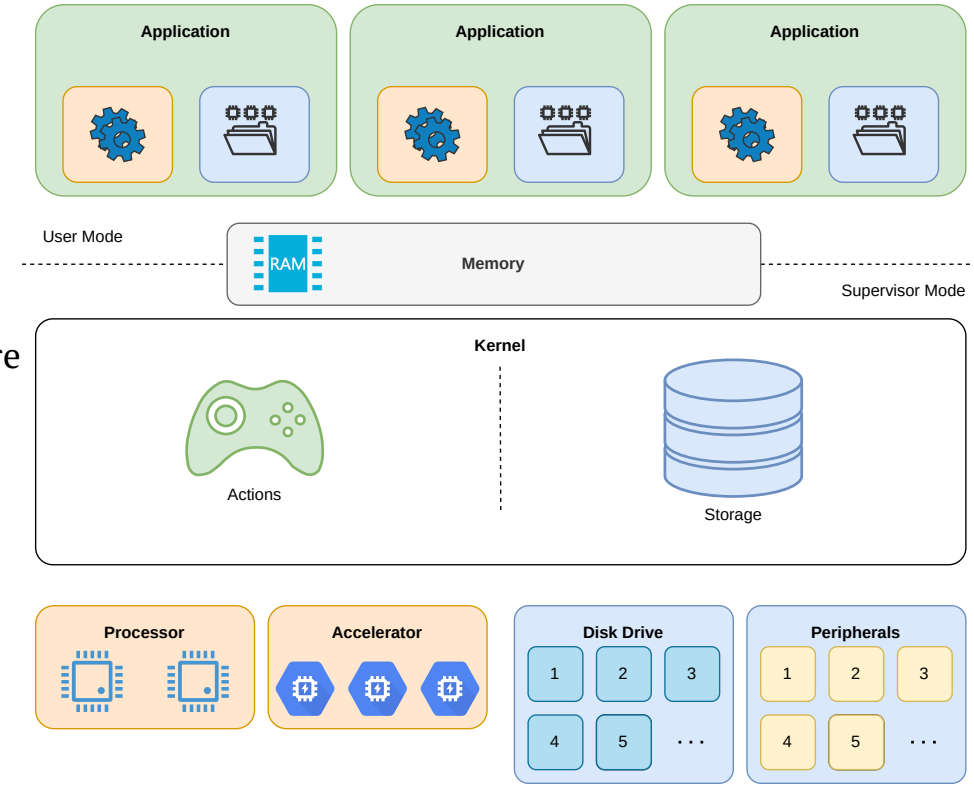
the main role

## Allow Portability

- provides a hardware independent API
- applications should run on any hardware

## Resources Management and Isolation

- allow applications to access resources
- prevent applications from accessing hardware directly
- isolate applications



# Desktop and Server Operating Systems

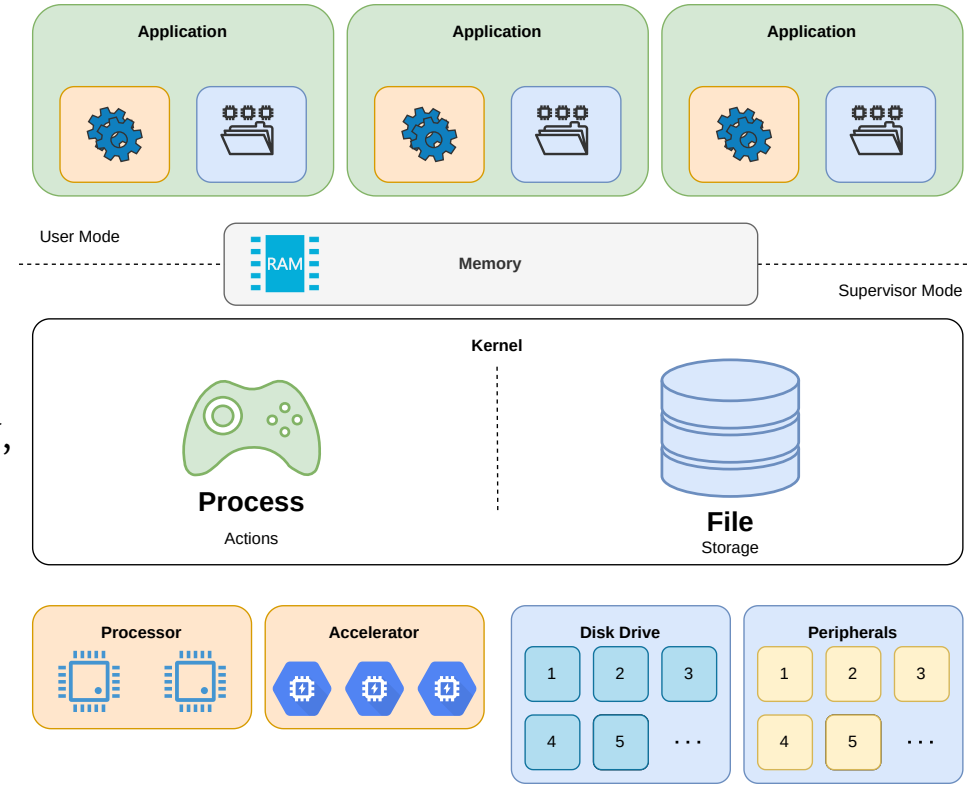
abstractions

## Actions

- *Applications*
- use the *Processor* and *Accelerators* (GPU, Neural Engine, etc)

## Data

- everything is a file
- peripherals are viewed as files (*POSIX*)
  - `/dev/input/keyboard` - keyboard
  - `/dev/fb` - screen (framebuffer)
  - `/dev/sda` - Disk Drive A (first)



# Embedded Operating Systems

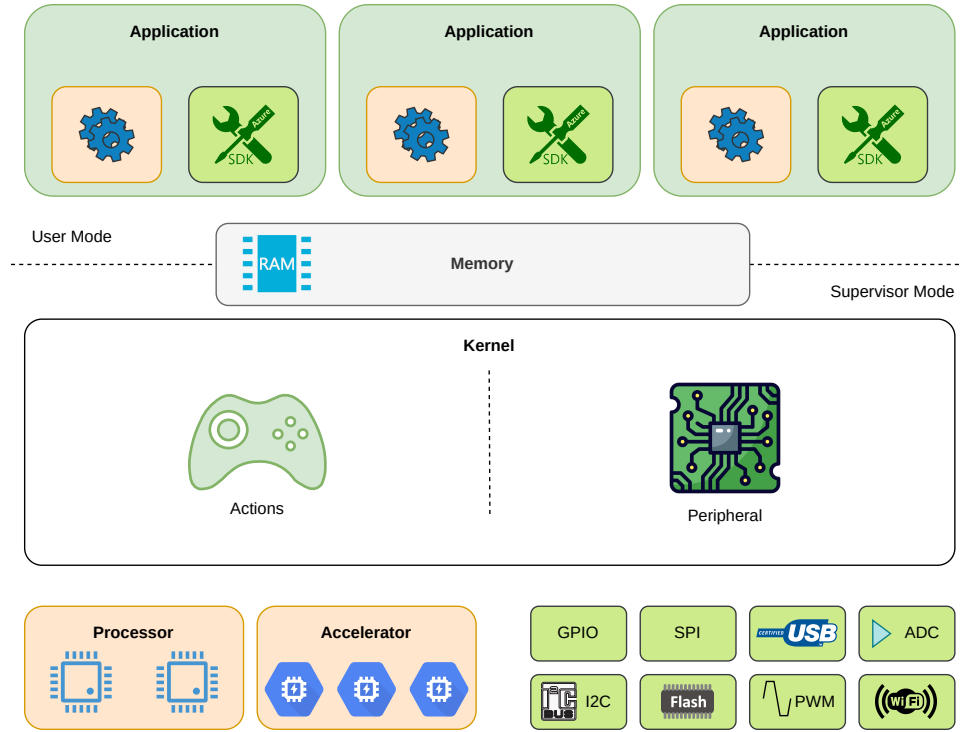
## Actions

- Simple *applications*
- use the *Processor* and *Accelerators* (Crypto Engines, Neural Engine, etc)

## Peripheral

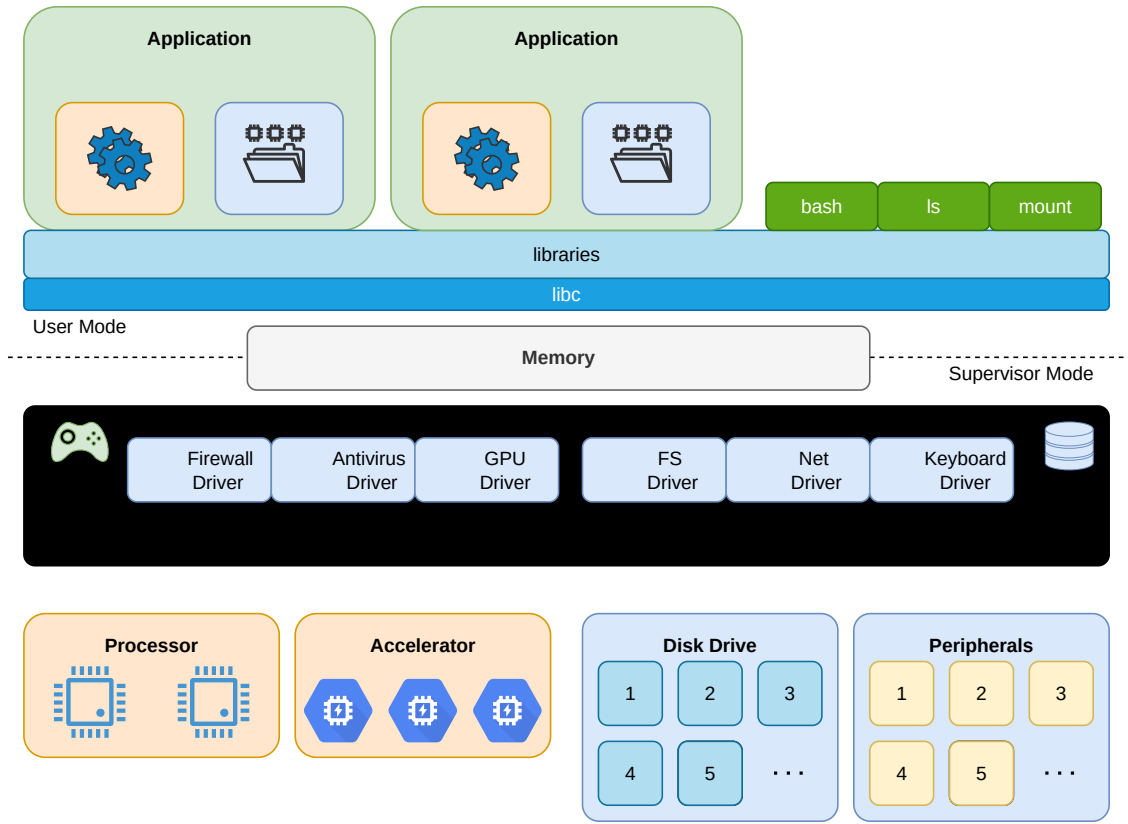
- provide a hardware independent API
- prevent processes from accessing the peripheral

*usually* the applications and the kernel are compiled together into a **single binary**



# The OS Stack

kernel / libc / libraries / basic tools (commands) / applications

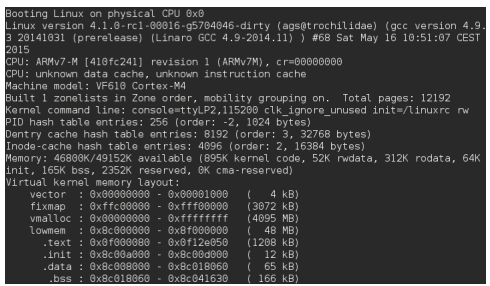


# Application Examples

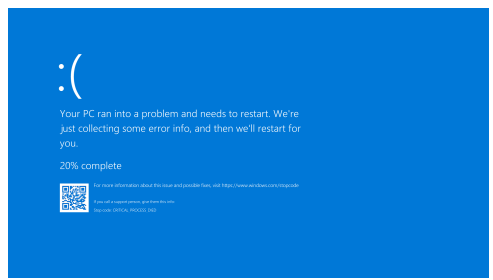
| What it does | Windows | Linux | macOS |
| --- | --- | --- | --- |
| Desktop | `explorer.exe` | `nautilus` | `Finder` |
| Applications | `taskbar.exe` | `gnome-shell` | `Dock` |
| Files | `explorer.exe` | `nautilus` | `Finder` |
| Settings | `start ms-settings:` | `gnome-control-center` | `System Settings` |
| Commands | `cmd.exe` or `powershell.exe` | `bash` or `zsh` | `bash` or `zsh` |
| Documents | `powerpoint.exe` | `libreoffice` | `Pages` |
| Edit Code | `code.exe` | `code` | `code` |

# Where can we see the OS

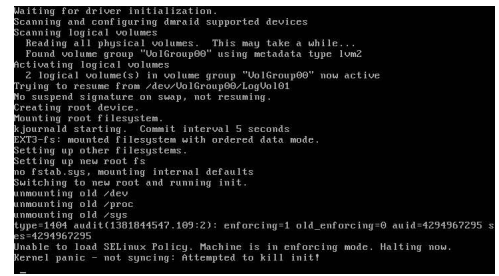
## During Boot




## Blue Screen (BSoD)

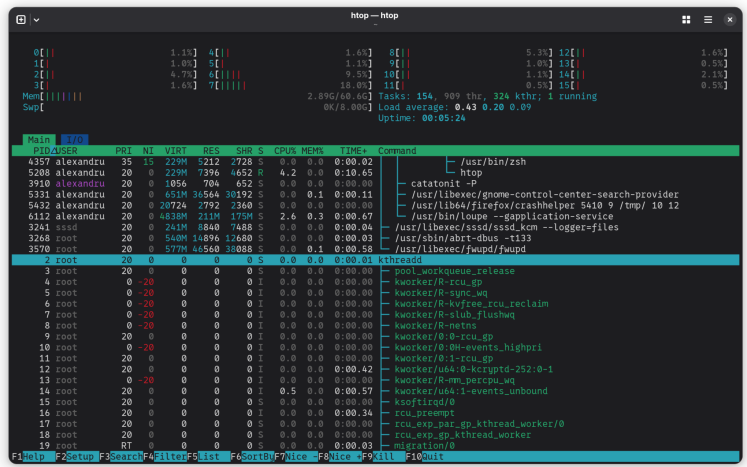



## Kernel Panic




# The Kernel

- is a collection of applications that run in priviliged mode
- one *main application* and several *utilities apps*




`htop`

# Virtual Machine

*run an OS within an application*

# The Idea

*run an operating system within an application*

Why?

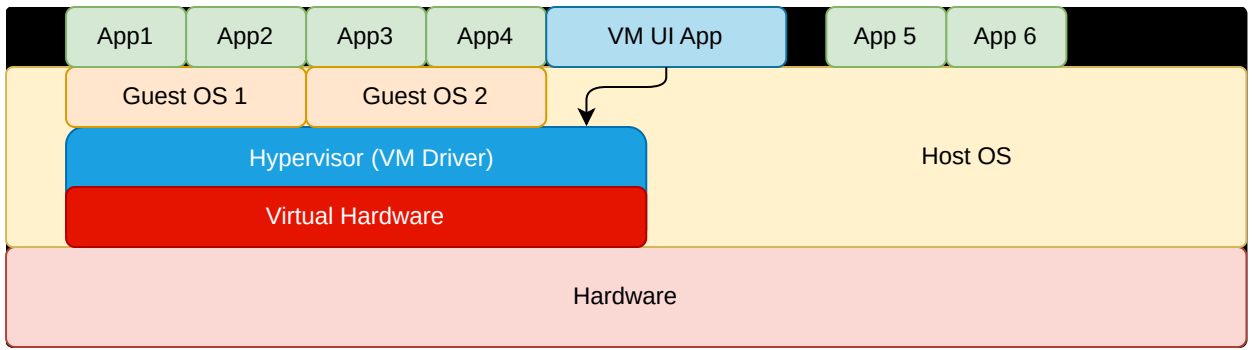
- Debug operating systems
- Run software that is not compatible with the OS your computer runs
- Securely share a server

Virtualization Software

- VirtualBox
- VMWare
- QEMU

# Simulation / Emulation

simulate all the hardware - very slow

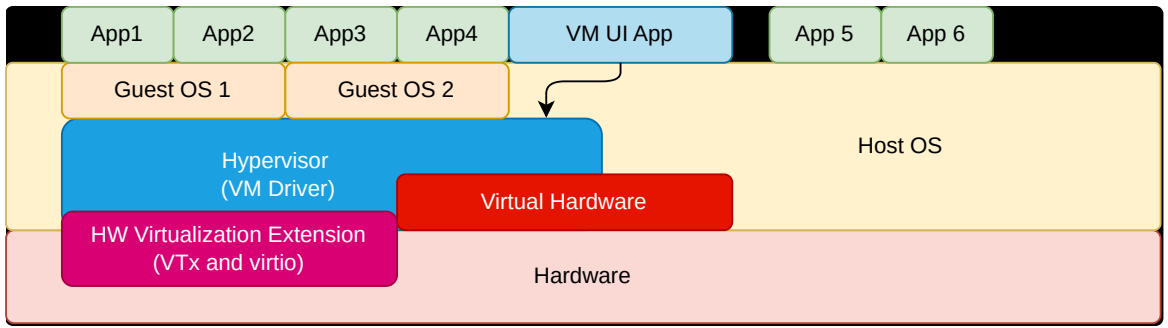



QEMU

- is able to simulate most of the available architectures
  - most used `x86`, `AMD64`, `arm`, `aarch64`, `powerpc`, `risc-v`

# Virtualization

use a part of the avalable hardware, emulates as if the system was running alone on the hardware




- Requires VT-x (Intel), … (AMD) and … (ARM) enabled
- The guest OS has to be built for the same CPU architecture as the host OS
  - *Apple Silicon* is ARM64 ( `aarch64` )

> Make sure you download a Linux version for `arm64` or `aarch64`

## Hypervisors

VMWare

VirtualBox

QEMU
via `hyper-v` , `KVM` or TODO
macOS

# Virtual Box

A Virtual Box Machine Settings Example

# Distribution

what poeple think an OS is

# UNIX

- allows several users
  - connect to the mainframe using several terminals
  - run several programs in paralel
- is open source up to version *UNIX System III*

Ken Thompson & Dennis Ritchie (Bell Labs, AT&T)


- mainframes provide a lot of hardware
  - needs to be shared by several users
  - each user has a terminal connected to the mainframe
- writes UNIX

# The POSIX Standard

Portable Operating System Interface

Defines:

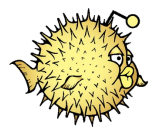
- how an OS should work (*everything is a file*)
- how the C API looks like (ex `stdio.h`, `unistd.h`)
- what commands (basic software) should be available

Allows:

- applications to be portable
  - *in C/C++ source code format only* ->

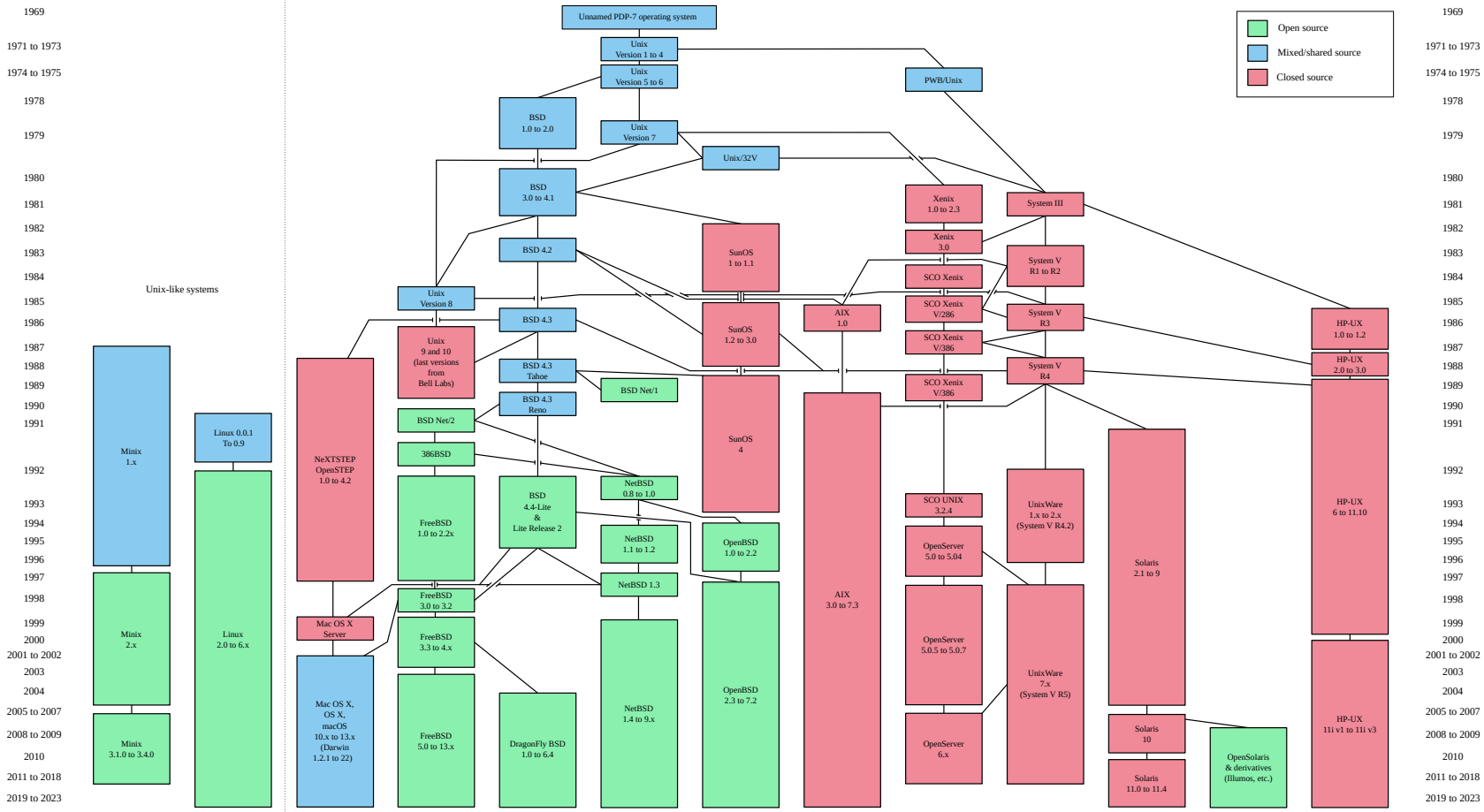
When UNIX became closed source ->

UC **Berkely Software Distribution (BSD)**

| FreeBSD | Darwin | OpenBSD | NetBSD |
| --- | --- | --- | --- |
|  |  |  |  |

New kernels

| **Minix** | **Linux** |
| --- | --- |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1971 to 1973
1974 to 1975
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2005 to 2007
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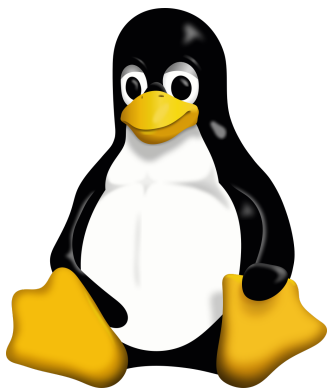
2011 to 2018
2019 to 2023
Unix-like systems
Minix 1.x
Minix 2.x
Minix 3.1.0 to 3.4.0
Linux 0.0.1 To 0.9
Linux 2.0 to 6.x
Unnamed PDP-7 operating system
Unix Version 1 to 4
Unix Version 5 to 6
Unix Version 7
PWB/Unix
BSD 1.0 to 2.0
Unix/32V
BSD 3.0 to 4.1
BSD 4.2
Unix Version 8
BSD 4.3
BSD 4.3 Tahoe
BSD 4.3 Reno
Unix 9 and 10 (last versions from Bell Labs)
BSD Net/1
BSD Net/2
386BSD
FreeBSD 1.0 to 2.2x
FreeBSD 3.0 to 3.2
FreeBSD 3.3 to 4.x
FreeBSD 5.0 to 13.x
BSD 4.4-Lite & Lite Release 2
DragonFly BSD 1.0 to 6.4
NeXTSTEP OpenSTEP 1.0 to 4.2
Mac OS X Server
Mac OS X, OS X, macOS 10.x to 13.x (Darwin 1.2.1 to 22)
NetBSD 0.8 to 1.0
NetBSD 1.1 to 1.2
NetBSD 1.3
NetBSD 1.4 to 9.x
SunOS 1 to 1.1
SunOS 1.2 to 3.0
SunOS 4
OpenBSD 1.0 to 2.2
OpenBSD 2.3 to 7.2
AIX 1.0
AIX 3.0 to 7.3
Xenix 1.0 to 2.3
Xenix 3.0
SCO Xenix
SCO Xenix V/286
SCO Xenix V/386
SCO UNIX 3.2.4
OpenServer 5.0 to 5.04
OpenServer 5.0.5 to 5.0.7
OpenServer 6.x
System III
System V R1 to R2
System V R3
System V R4
UnixWare 1.x to 2.x (System V R4.2)
UnixWare 7.x (System V R5)
Solaris 2.1 to 9
Solaris 10
Solaris 11.0 to 11.4
OpenSolaris & derivatives (Illumos, etc.)
HP-UX 1.0 to 1.2
HP-UX 2.0 to 3.0
HP-UX 6 to 11.10
HP-UX 11i v1 to 11i v3
Open source
Mixed/shared source
Closed source

# The Linux Kernel

- is the actual operating system
- invisible to the user
  - except when it boots 🏁 and panics 😱
- 25 mil line of code (LOC)
- manages all the system resources



Meet *Tux*

*Linus Torvalds* (University of Helsinky)

- did not agree with A Tannenbaum about how Minix should work
- wrote this own 👨‍💻 *POSIX compliant* OS, called it *Linu**x***

# GNU Software

Basic *UNIX* commands and software **rewritten**

- startup software ( `init` )
- most of what we call today *coreutils*
- C Compiler -> GNU Compiler Collection ( `gcc` )
  - C and C++ standard libraries
  - `flex` / `yacc`
- X Windows Systsem ( `x11` )

**Modern Software**

- *coreutils* are being rewritten in Rust (*uutils*)
- `gcc` is being slowly replaced by LLVM
- `x11` is being replaced by Wayland

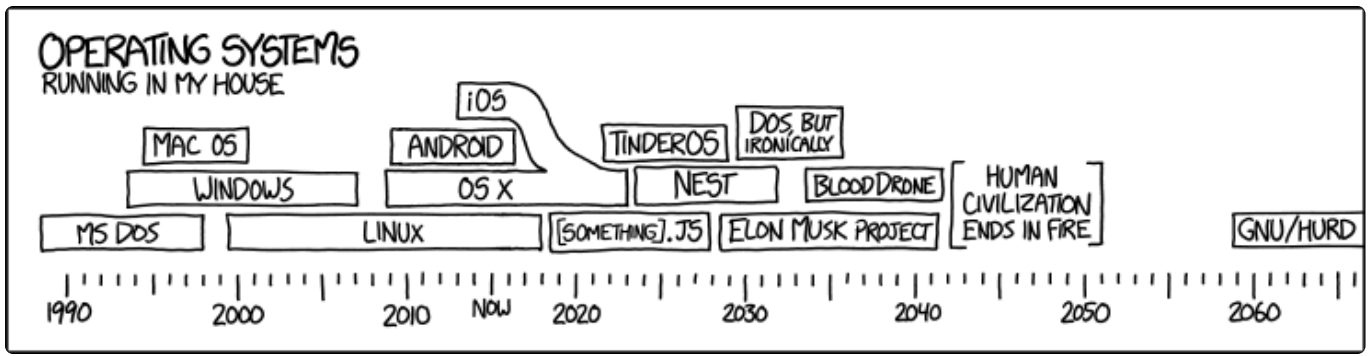
*Richard Stallman* (MIT)

His vision is that software should be:

- free to share and modify
- GPL and LGPL licenses
  - allows selling and modifying
  - modified code must be relicensed under GPL

# GNU/Linux = ❤

GNU Software on top of the Linux kernel




- GNU Hurd 👷🚧🏗️ (*work in progress for many many years*)
- The Linux kernel 🐧 still is the *temporary replacement*

# Base Distributions

The main Linux distributions that started it

*Took the Linux kernel, added the GNU libraries and tools and wrote a package manager to install software*

| | Name | Tagline | Package Format | Package Manager | Release Year |
|---|---|---|---|---|---|
|  | Slackware | *Oldest distribution* | `tgz` | `pkgtool` | 1993 |
|  | Debian | *Free Software* | `deb` | `apt` / `dpkg` | 1993 |
|  | Red Hat Linux | *Enterprise* | `rpm` | `dnf` / `rpm` | 1995 |

These are the base for most of the modern distributions that we have today.

# Modern Distributions

| | Name | Tagline | Parent | Package Format | Package Manager | Release Year |
|---|---|---|---|---|---|---|
|  | SUSE Linux | *Enterprise-grade Linux* | *Originally Slackware, later RPM-based* | `rpm` | `zypper`, `yast` | 1994 |
|  | ArchLinux | *Minimal Linux* | N/A | `pkg.tar.zst` | `pacman` | 2002 |
|  | Fedora | *Desktop Linux* | *Red Hat Linux renamed* | `rpm` | `dnf` / `rpm` | 2003 |
|  | Ubuntu | *Linux for Humans* | Debian | `deb` and `snap` | `apt` / `dpkg` and `snap` | 2004 |
|  | openSUSE | *Stable, usable Linux for everyone* | SUSE Linux | `rpm` | `zypper`, `rpm` | 2005 |

# Which is the most used Linux distribution?

# Non GNU Distributions

They use Linux, but most of the software is not from GNU

| | Distribution | Tagline | Parent | Package Format | Package Manager | Release Year |
|---|---|---|---|---|---|---|
|  | Android | *Mobile Linux platform* | Linux kernel (AOSP) | `.apk` (only Android apps) | AOSP tools (not typical package manager) | 2008 |
|  | ChromeOS | *The cloud-first OS* | Gentoo Linux | Custom ( `.crx` , `.apk` , others) | `portage` , `cros_sdk` , Flatpak (via Crostini) | 2011 |

# Conclusion

we talked about

- What is Operating System is
- The Operating System Stack
- Virtual Machines
- History of Linux
- Distributions