CS3.301 Operating Systems and Networks

Introduction and Course Overview

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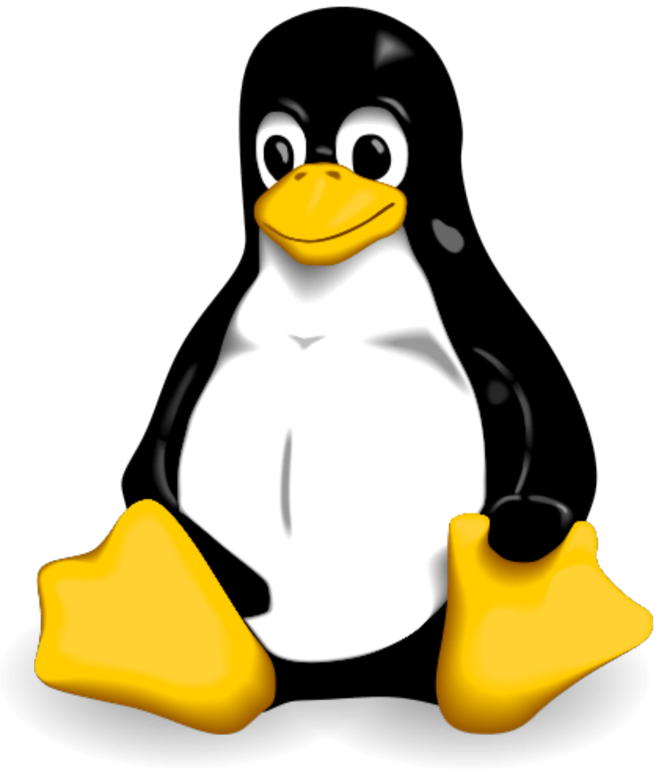
INTERNATIONAL INSTITUTE OF INFORMATION TECHNOLOGY
HYDERABAD

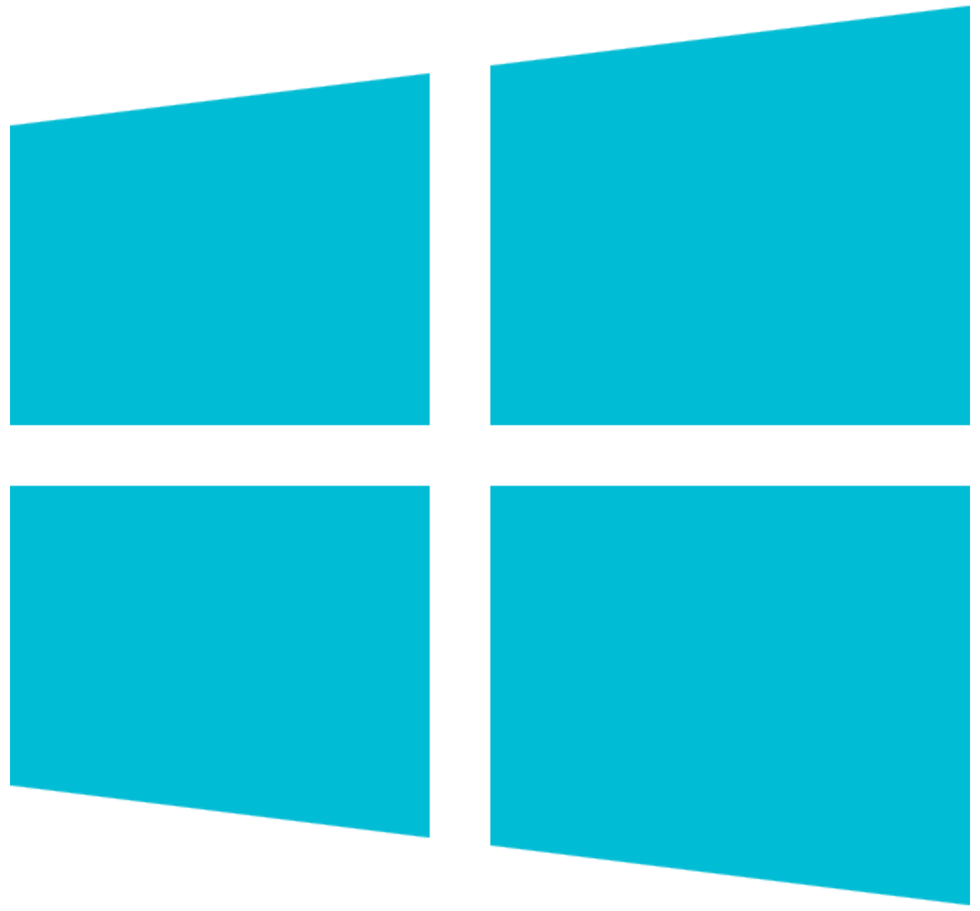
SERC
Software Engineering Research Centre

Which OS do you use?



Linux

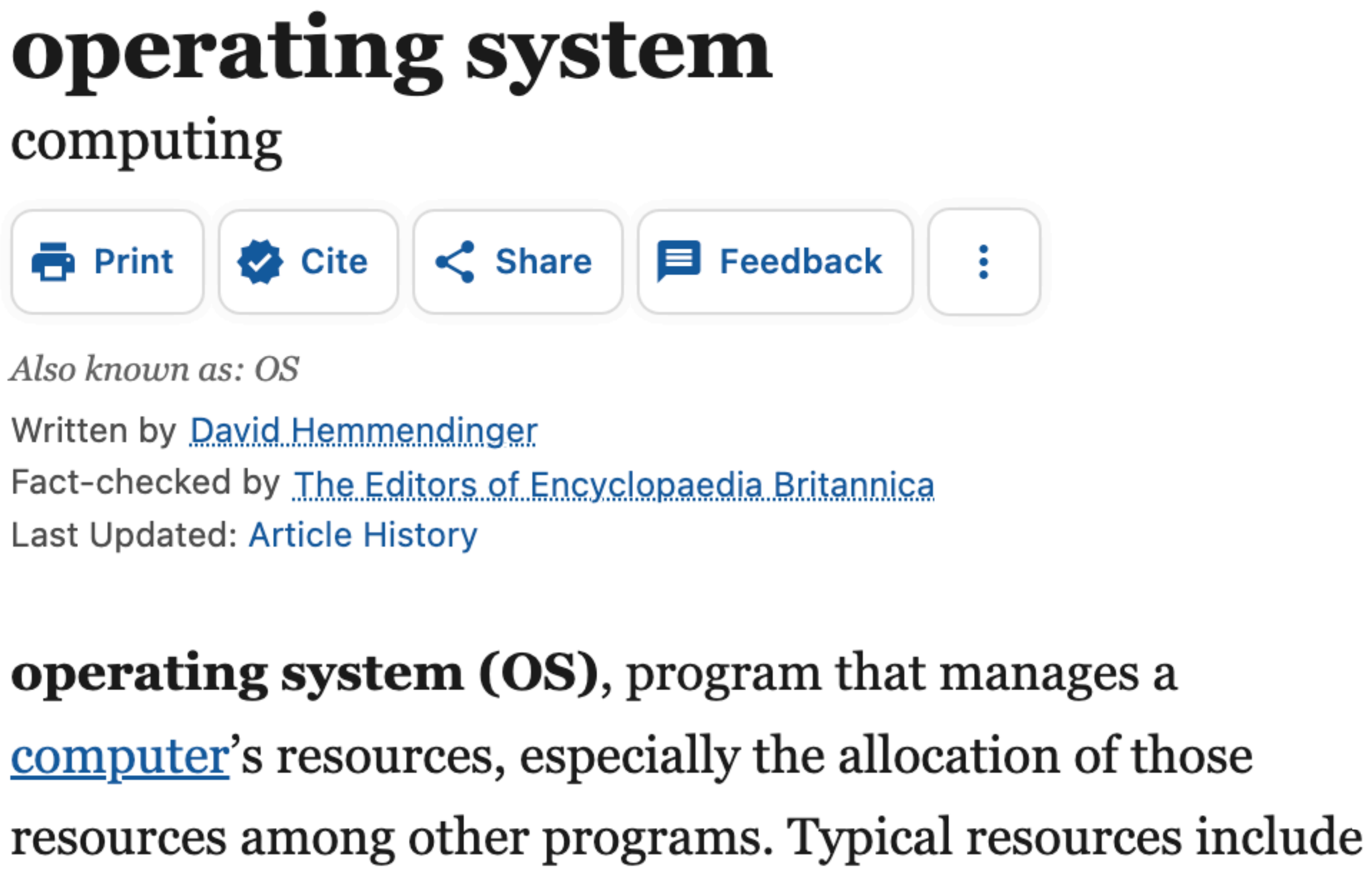
ChromeOS



Windows

OSX

Wait! what is an OS anyway?



operating system

computing

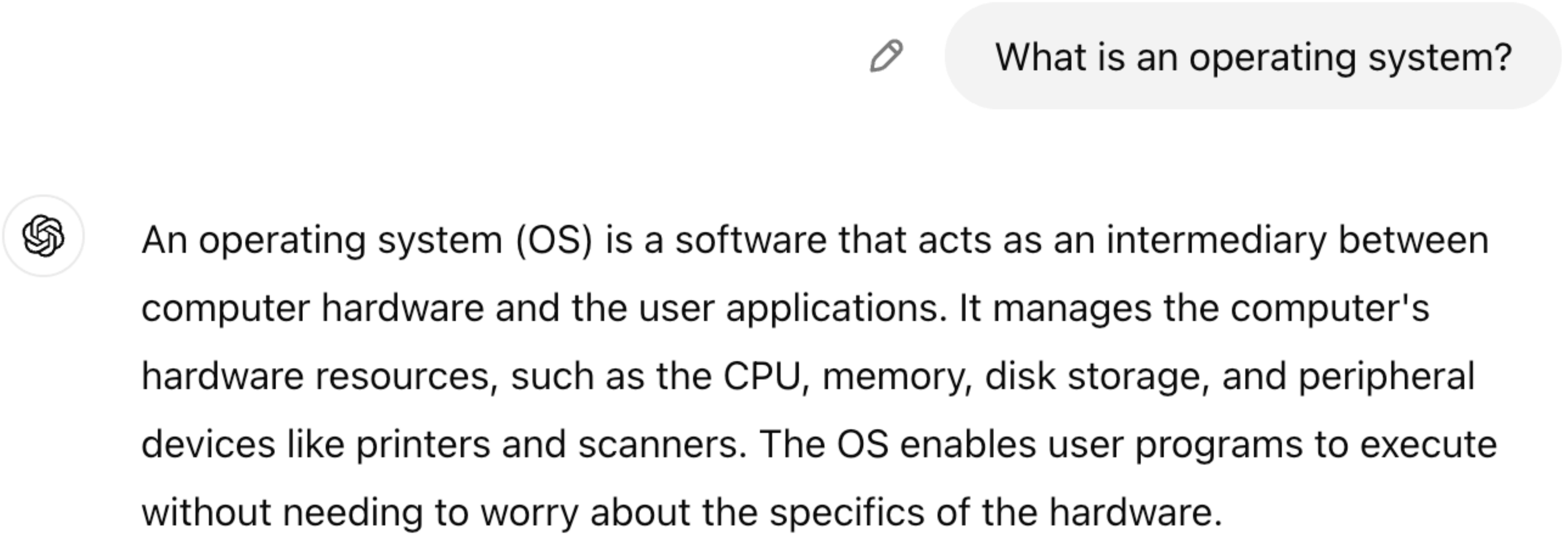
Also known as: OS

Written by David Hemmendinger

Fact-checked by The Editors of Encyclopaedia Britannica

Last Updated: Article History

operating system (OS), program that manages a computer's resources, especially the allocation of those resources among other programs. Typical resources include



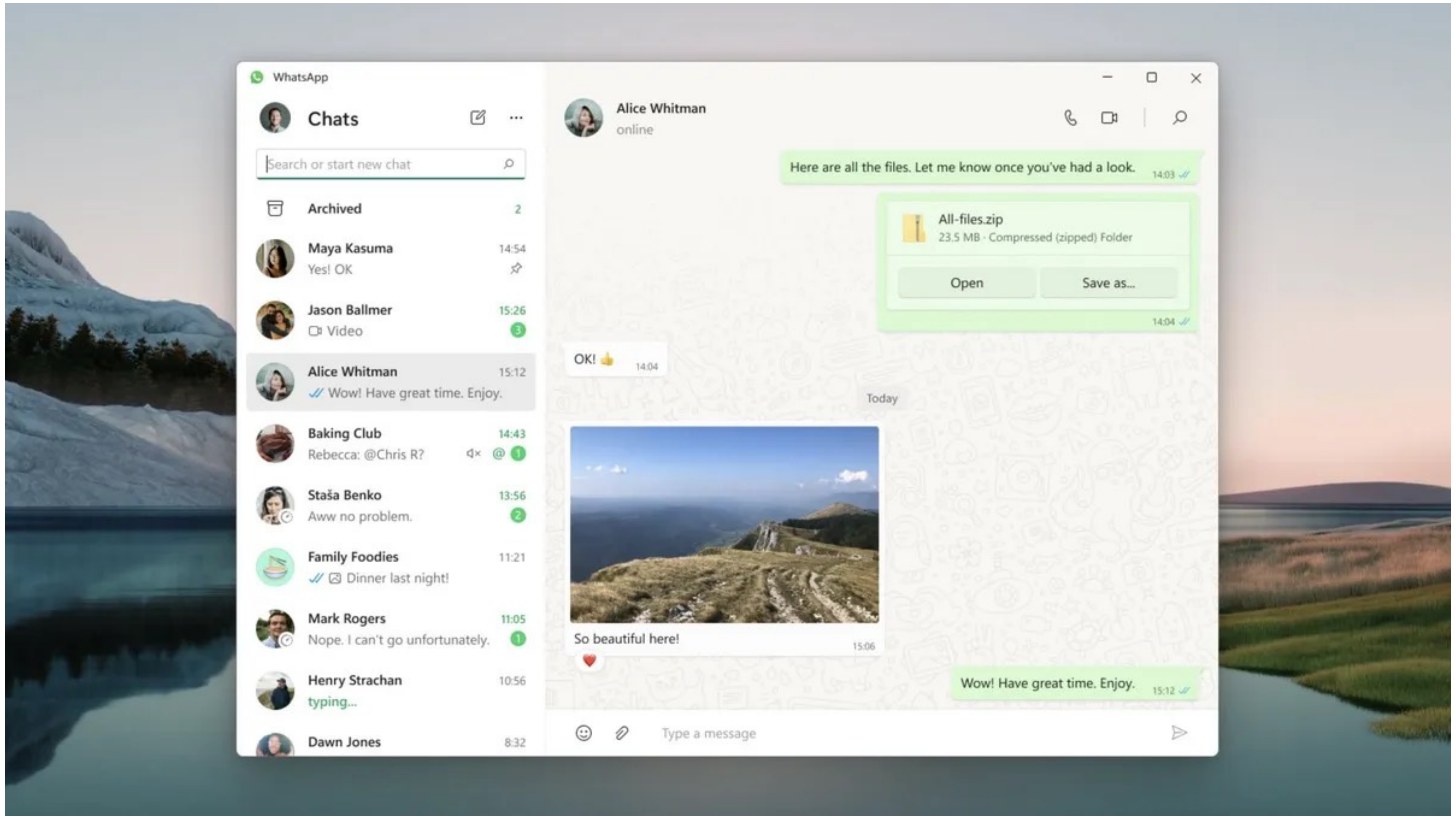
What is an operating system?

An operating system (OS) is a software that acts as an intermediary between computer hardware and the user applications. It manages the computer's hardware resources, such as the CPU, memory, disk storage, and peripheral devices like printers and scanners. The OS enables user programs to execute without needing to worry about the specifics of the hardware.

ChatGPT4 Version!

Caution: Use tools but be aware of the uncertainties they bring in!

Develop Whatsapp like Messaging System



Maya Kasuma 14:54
Yes! OK

Jason Ballmer 15:26
Video 3

Alice Whitman 15:12
Wow! Have great time. Enjoy.

Baking Club 14:43
Rebecca: @Chris R? @ 1

Staša Benko 13:56
Aww no problem. 2

Family Foodies 11:21
Dinner last night!

Mark Rogers 11:05
Nope. I can't go unfortunately. 1

Henry Strachan 10:56
typing...

Dawn Jones 8:32

Alice Whitman

Here are all the files. Let me know once you've had a look. 14:03

All-files.zip
23.5 MB · Compressed (zipped) Folder
14:04

OK! 👍 14:04

So beautiful here! 15:06

Wow! Have great time. Enjoy. 15:12

- Users authentication
- Send and receive chats
- Send and receive media contents
- Make audio, video calls
- Record audio, video
- …..

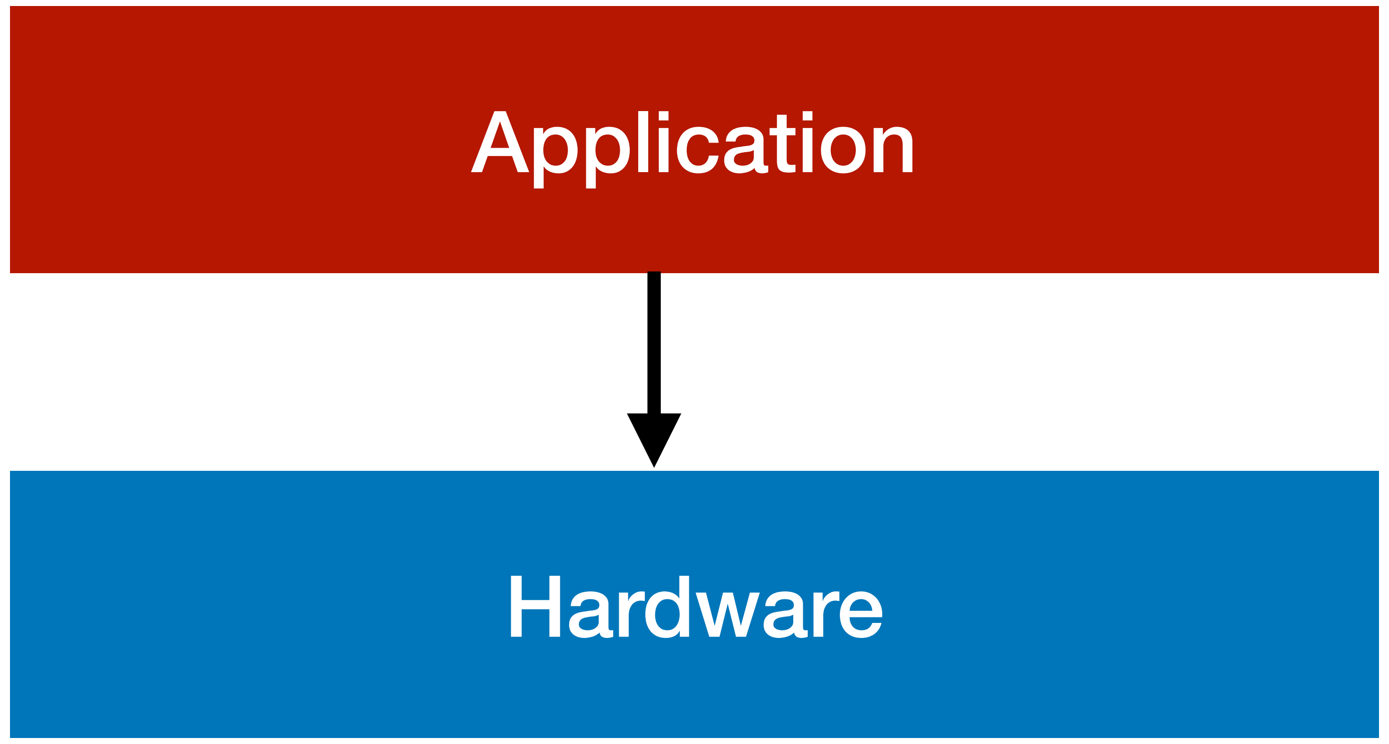
Source: cnet.com

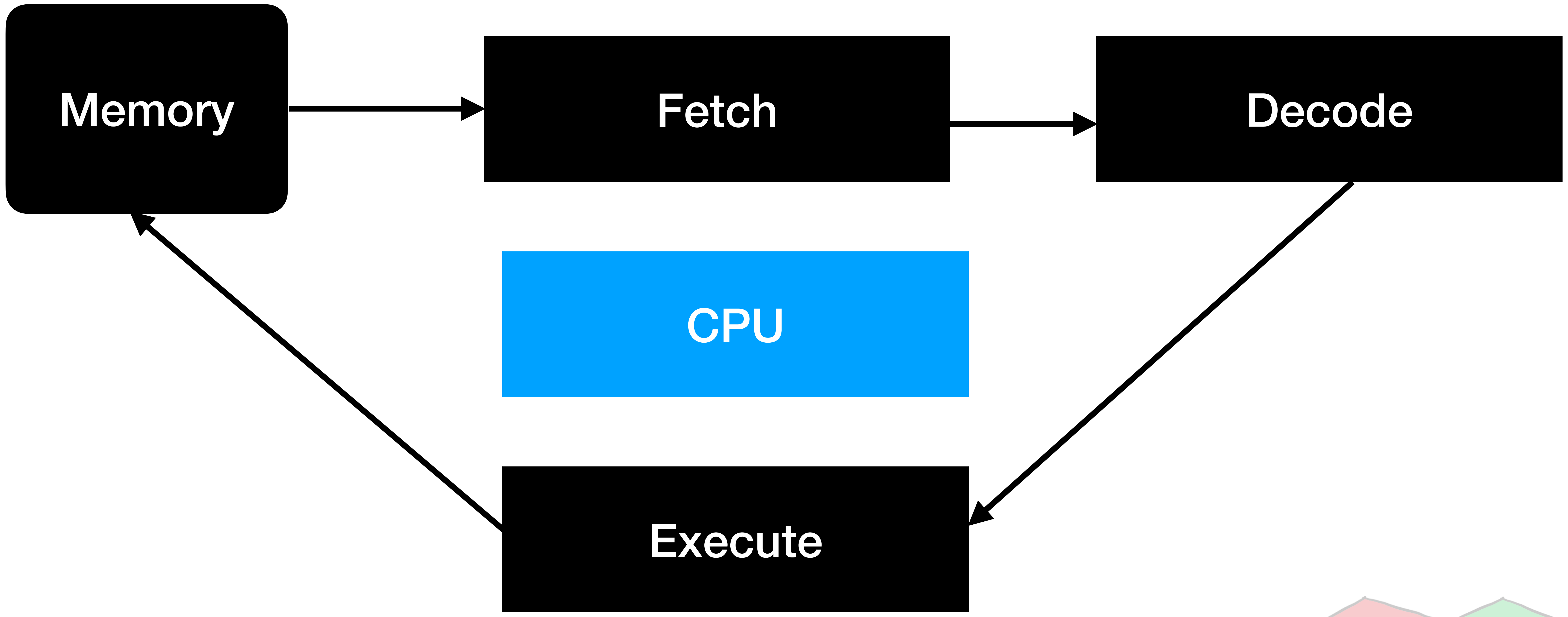
Any Program for that Matter!

- Once your app is build - Compiler comes into action (“c” -> “a.out”) to create the executable (“.dmg”, “.elf”, “.exe”)
- Executable contains: Instructions + data
- Instructions are run by the CPU
- CPU internally consists of registers
  - Program counter or PC
  - Operands of instructions, memory addresses

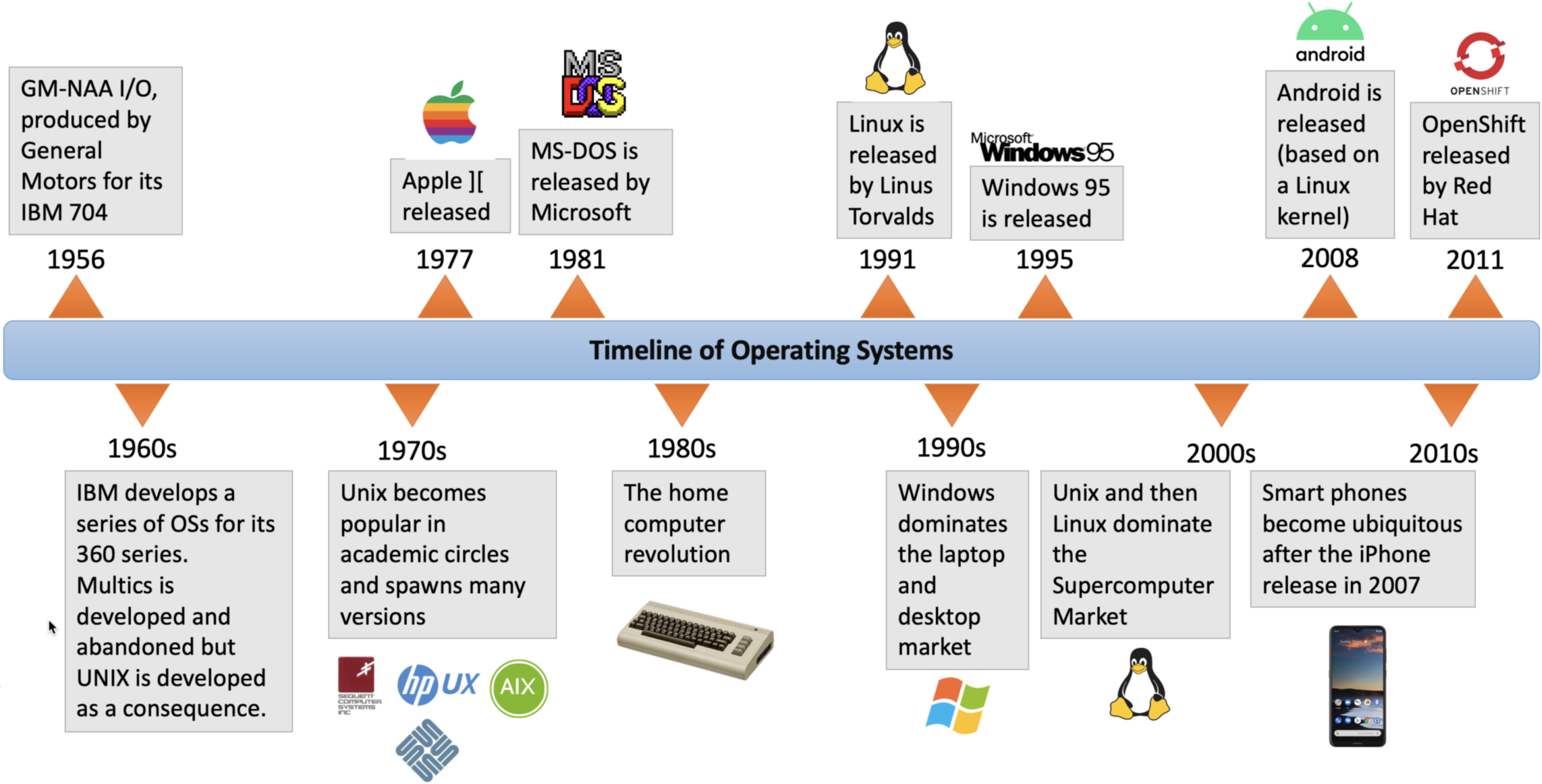
What if there were no OS?

- Application is a program: Processor will Fetch -> Decode -> Execute, Continue
- CPU will have the PC which points to the instructions in the memory





OS: A Brief History



1956
GM-NAA I/O, produced by General Motors for its IBM 704

1977
Apple][released

1981
MS-DOS is released by Microsoft

1991
Linux is released by Linus Torvalds

1995
Windows 95 is released

2008
Android is released (based on a Linux kernel)

2011
OpenShift released by Red Hat

Timeline of Operating Systems

1960s
IBM develops a series of OSs for its 360 series. Multics is developed and abandoned but UNIX is developed as a consequence.

1970s
Unix becomes popular in academic circles and spawns many versions

1980s
The home computer revolution

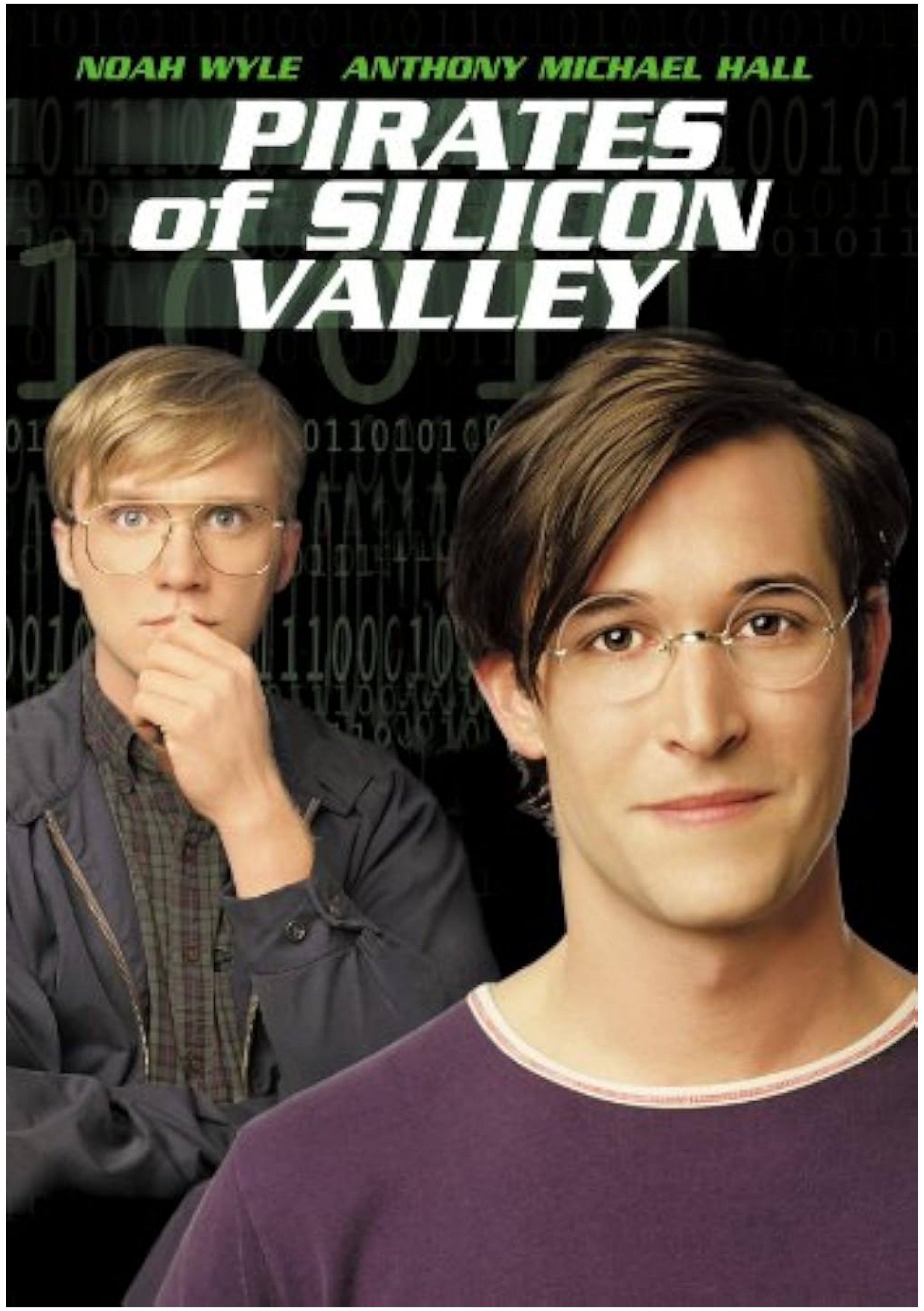
1990s
Windows dominates the laptop and desktop market

2000s
Unix and then Linux dominate the Supercomputer Market

2010s
Smart phones become ubiquitous after the iPhone release in 2007

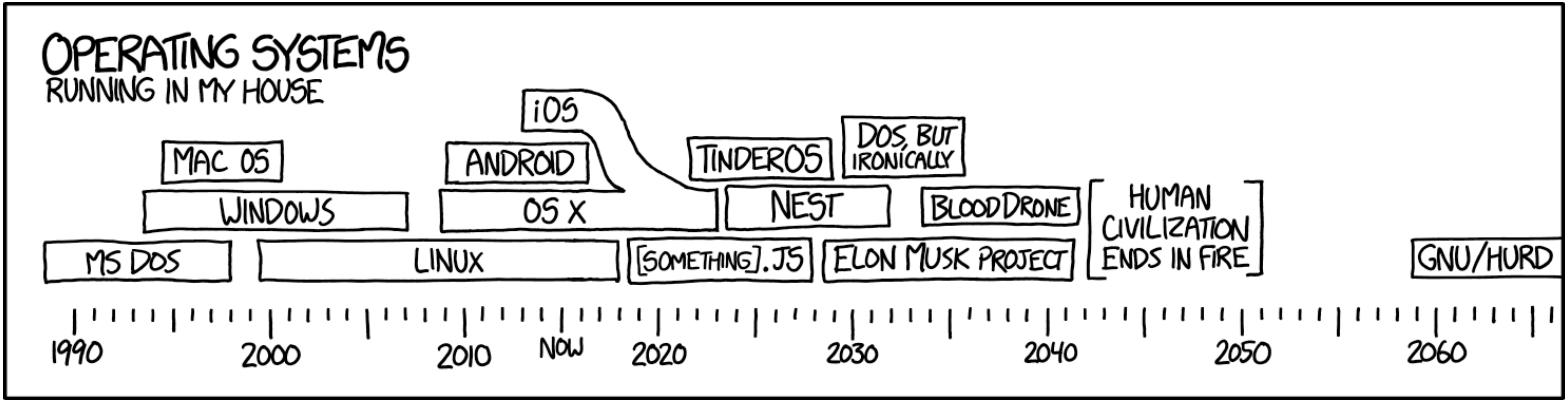
Source: https://www.orb-data.com/the-history-of-the-operating-system-from-paper-tape-to-openshift/

If you are into movies, do give a watch!



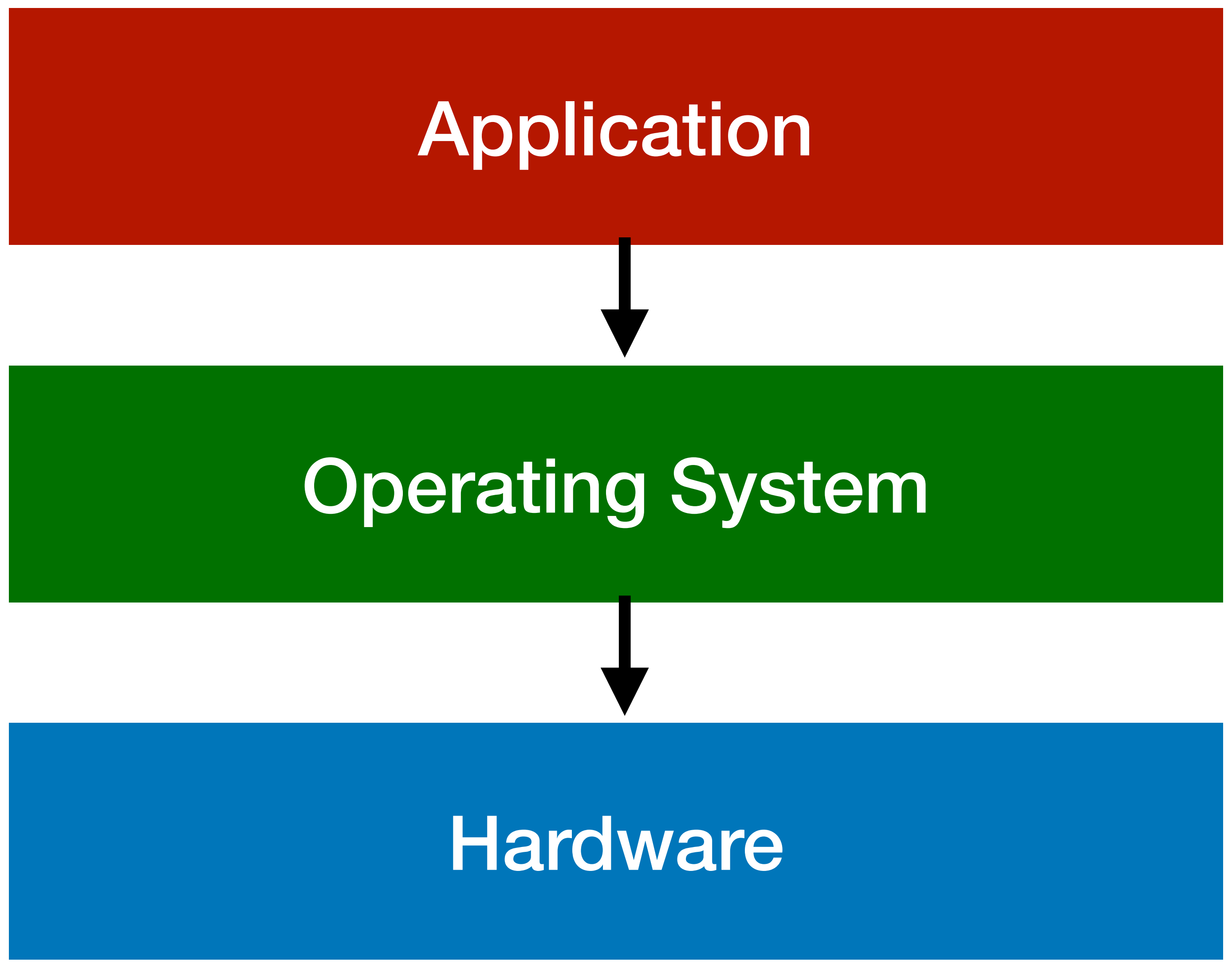
Source: imdb

Forever Lasting!



Source: xkcd.com

Operating Systems: An Overview



Application

Operating System

Hardware

- OS basically is a middleware between the hardware and the application/user program
- In charge of making sure that the system operates correctly and efficiently
- Does three key things:
  - Easy to execute programs
  - Manages memory
  - Handles the different I/O devices

:(

Your PC ran into a problem and needs to restart. We're just collecting some error info, and then we'll restart for you.

20% complete

For more information about this issue and possible fixes, visit https://www.windows.com/stopcode

If you call a support person, give them this info:

Stop code: CRITICAL_PROCESS_DIED

Whats the big deal?

- 8.5 million devices affected! - 1% of the entire windows users
- Airlines - Delta, KLM, Ryanair, Lufthansa,..
  - Many passengers were stranded in airports
- Financial organisations - London stock exchange, Visa, …
- Healthcare - independant pharmacies and GP surgeries
- Media, retail, train operating companies…….

Economic and social impact!!!

Abstraction holds the key

Lets draw some parallels

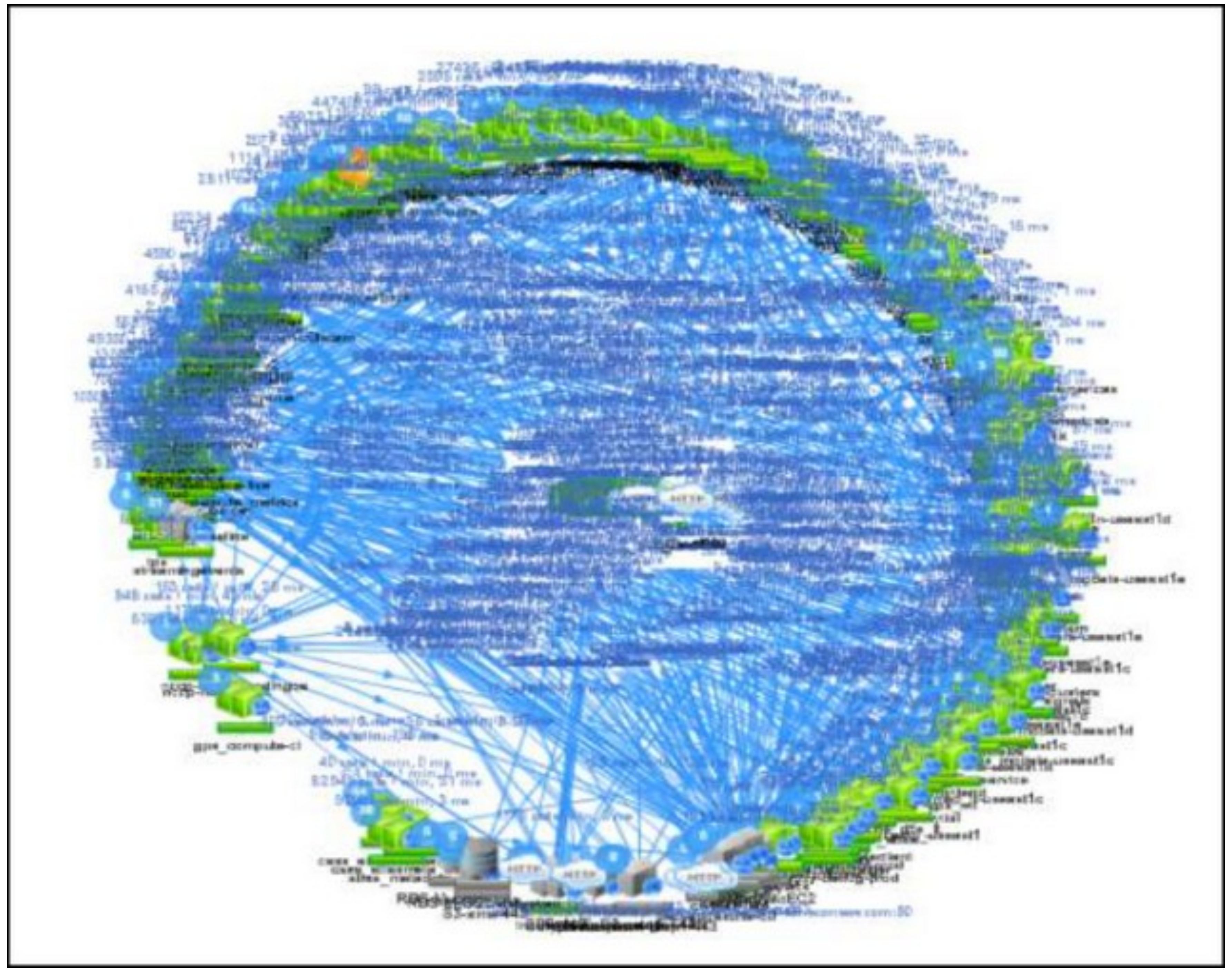
What you see as Netflix!

Source: netflix.com

- One of the key principles in system design - Try to keep things simple
- Abstraction and decomposition - Two main principles in Software Engineering
- Think of libraries in programming languages
  - Provides abstraction in terms of functions
  - All you need to know is functions to be called - Not how they work

Abstraction holds the key

Lets draw some parallels



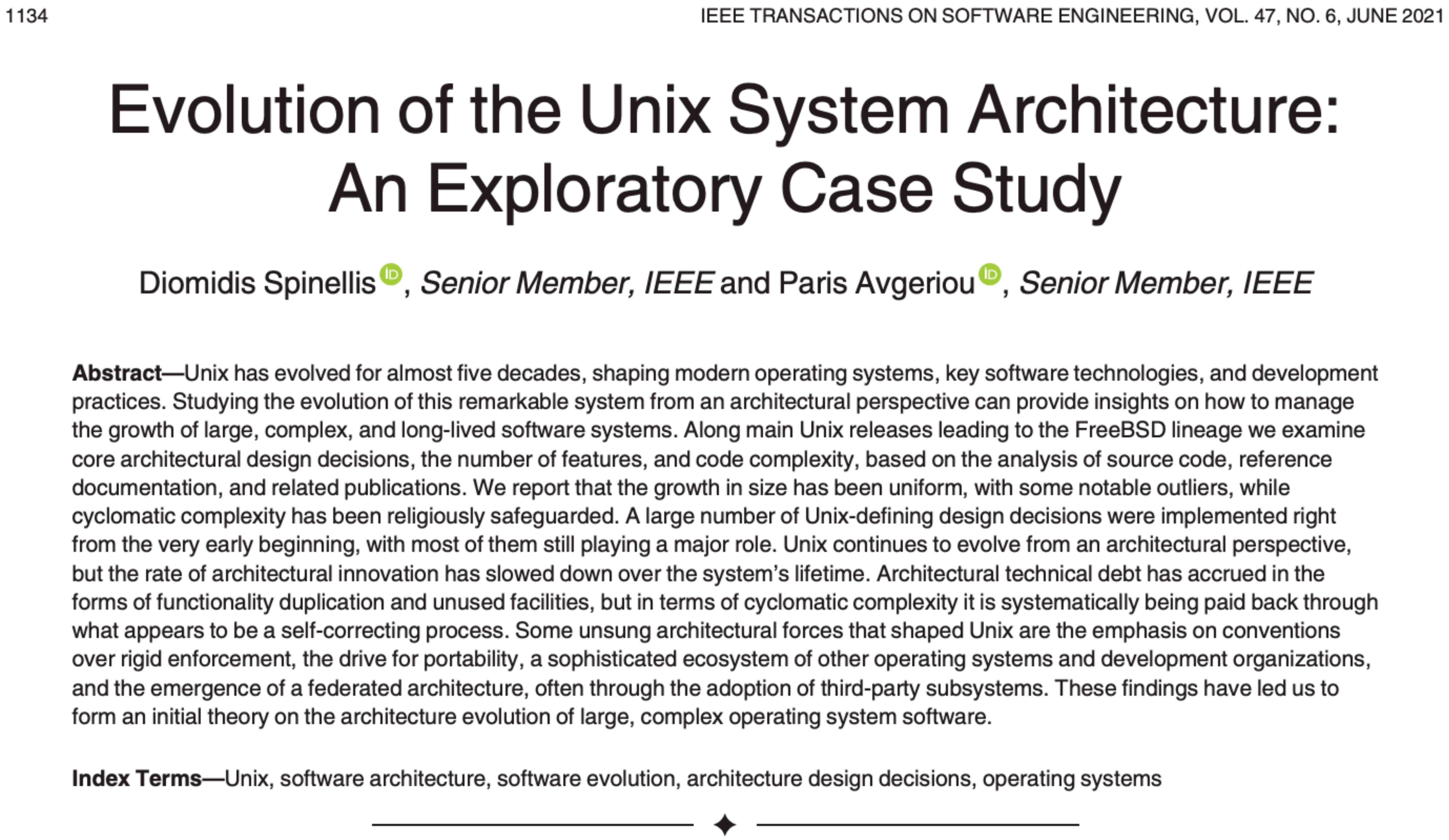
Behind the scenes!

Source: netflix.com

- One of the key principles in system design - Try to keep things simple
- Abstraction and decomposition - Two main principles in Software Engineering
- Think of libraries in programming languages
  - Provides abstraction in terms of functions
  - All you need to know is functions to be called - Not how they work

OS can be also thought of as a black box!

Keeping things Simple is the Key!



1134 IEEE TRANSACTIONS ON SOFTWARE ENGINEERING, VOL. 47, NO. 6, JUNE 2021

Evolution of the Unix System Architecture: An Exploratory Case Study

Diomidis Spinellis, *Senior Member, IEEE* and Paris Avgeriou, *Senior Member, IEEE*

Abstract—Unix has evolved for almost five decades, shaping modern operating systems, key software technologies, and development practices. Studying the evolution of this remarkable system from an architectural perspective can provide insights on how to manage the growth of large, complex, and long-lived software systems. Along main Unix releases leading to the FreeBSD lineage we examine core architectural design decisions, the number of features, and code complexity, based on the analysis of source code, reference documentation, and related publications. We report that the growth in size has been uniform, with some notable outliers, while cyclomatic complexity has been religiously safeguarded. A large number of Unix-defining design decisions were implemented right from the very early beginning, with most of them still playing a major role. Unix continues to evolve from an architectural perspective, but the rate of architectural innovation has slowed down over the system's lifetime. Architectural technical debt has accrued in the forms of functionality duplication and unused facilities, but in terms of cyclomatic complexity it is systematically being paid back through what appears to be a self-correcting process. Some unsung architectural forces that shaped Unix are the emphasis on conventions over rigid enforcement, the drive for portability, a sophisticated ecosystem of other operating systems and development organizations, and the emergence of a federated architecture, often through the adoption of third-party subsystems. These findings have led us to form an initial theory on the architecture evolution of large, complex operating system software.

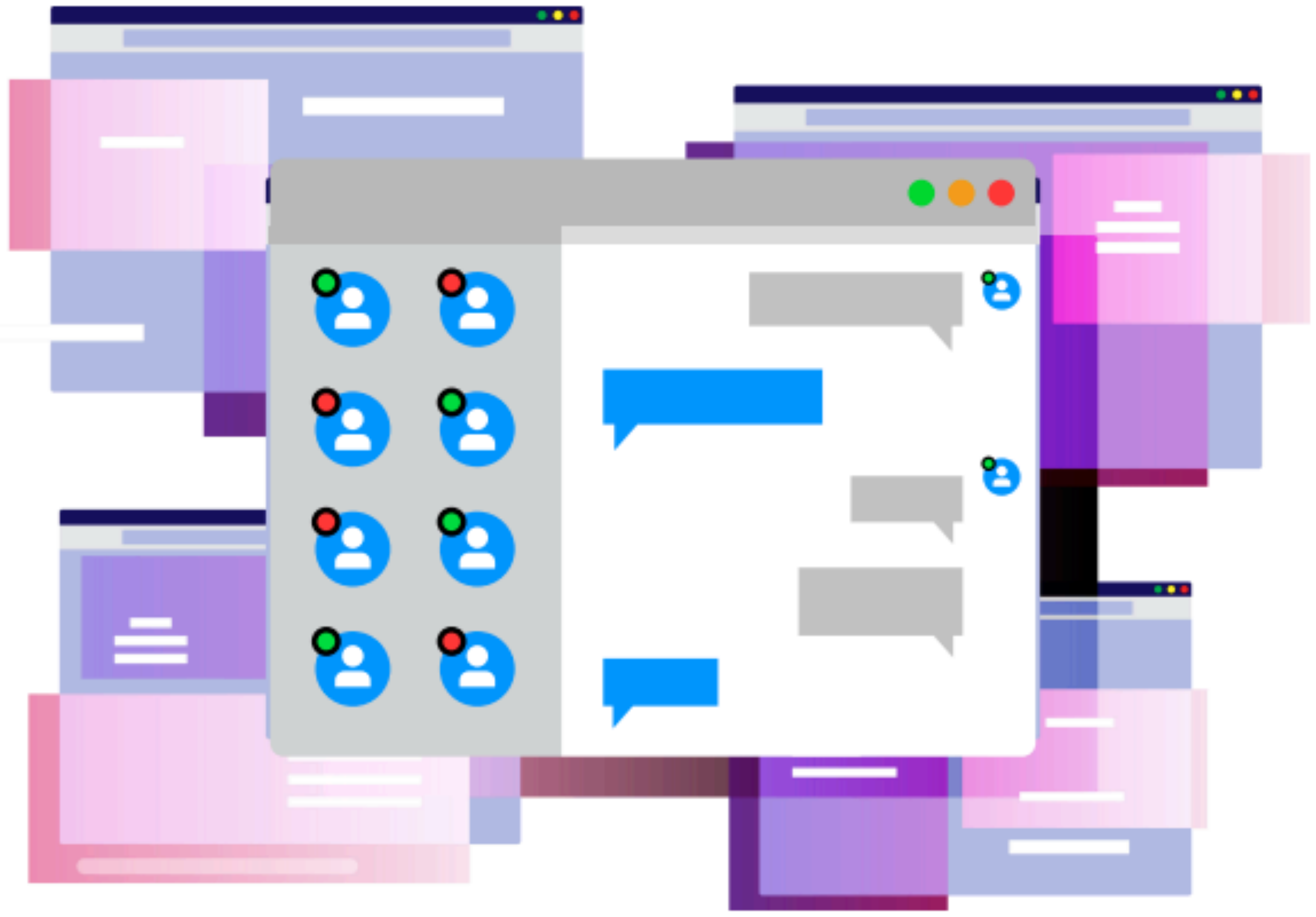
Index Terms—Unix, software architecture, software evolution, architecture design decisions, operating systems

Diomidis Spinellis, Paris Avgeriou, **Evolution of the Unix System Architecture: An Exploratory Study**, IEEE TSE, 2021 https://ieeexplore.ieee.org/abstract/document/8704965/

What does an OS abstract?

Think about the messaging system that needs to be developed

- The messaging application runs on the CPU
- It requires RAM to run but it feels that it has infinite RAM
- There are also other application that needs to run simultaneously
- The application also needs to store data -> images, videos, documents…
- Application also have to interact with devices (Camera, USB,…)



The Three Pillars of Operating Systems

Virtualization (Process and Memory)

1. OS gives every process a feeling that it has own CPU
2. Every process feels that its enough memory

Concurrency

1. Multiple process can run at the same time without resulting in problems
2. OS Provides mechanisms to make them work together

Persistance

1. Disk is an I/O device. It needs to be managed and handled.
2. OS handles interactions with the disk and performs storage management

Process Virtualization

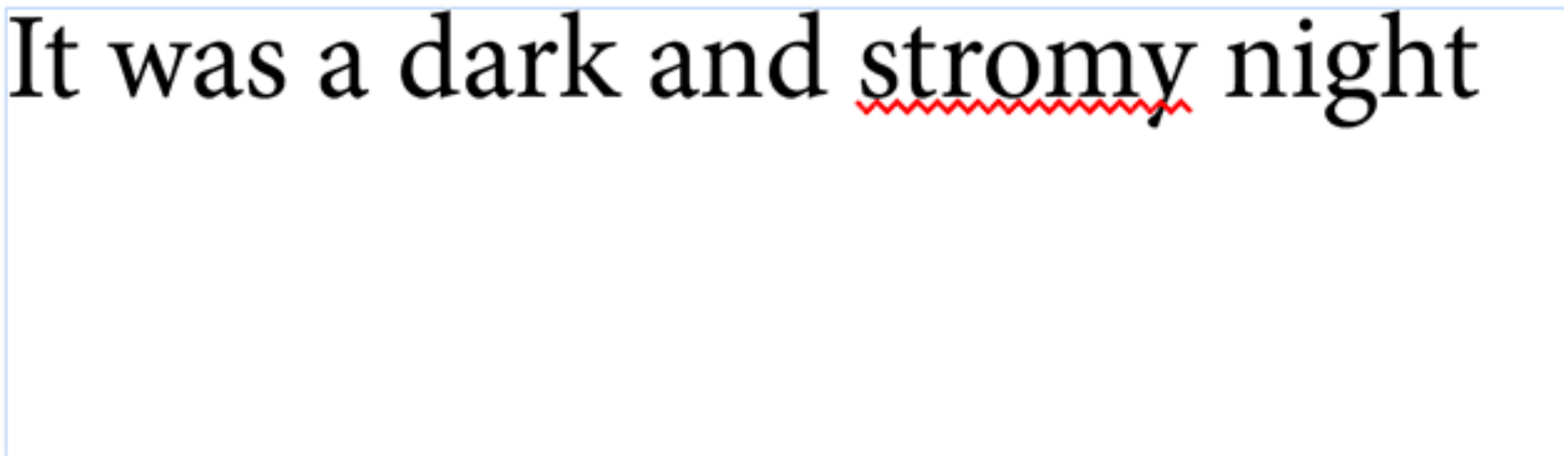
- How many CPU does your computer have?
- Is the number of process equal to the number of CPU your computer have?
- Lets look into a simple example…

Memory Virtualization

- Every process requires memory to run
- How many processes are active in your system?
- What’s the total memory they require?
- How’s CPU managing this?

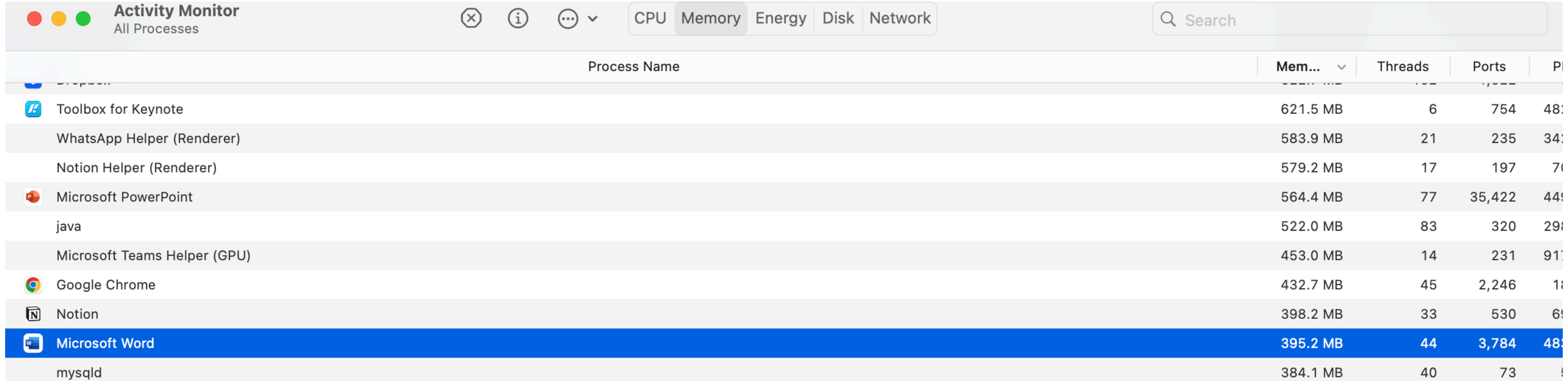
Concurrency

- OS has to juggle between multiple processes
- Heard of multi-threaded programs? But wait heard of threads?



It was a dark and stromy night

Spell check in Microsoft Word



Process Name	Mem...	Threads	Ports	P
Toolbox for Keynote	621.5 MB	6	754	48
WhatsApp Helper (Renderer)	583.9 MB	21	235	34
Notion Helper (Renderer)	579.2 MB	17	197	7
Microsoft PowerPoint	564.4 MB	77	35,422	44
java	522.0 MB	83	320	29
Microsoft Teams Helper (GPU)	453.0 MB	14	231	91
Google Chrome	432.7 MB	45	2,246	1
Notion	398.2 MB	33	530	6
Microsoft Word	395.2 MB	44	3,784	48
mysqld	384.1 MB	40	73	

How many threads are active in Microsoft Word?

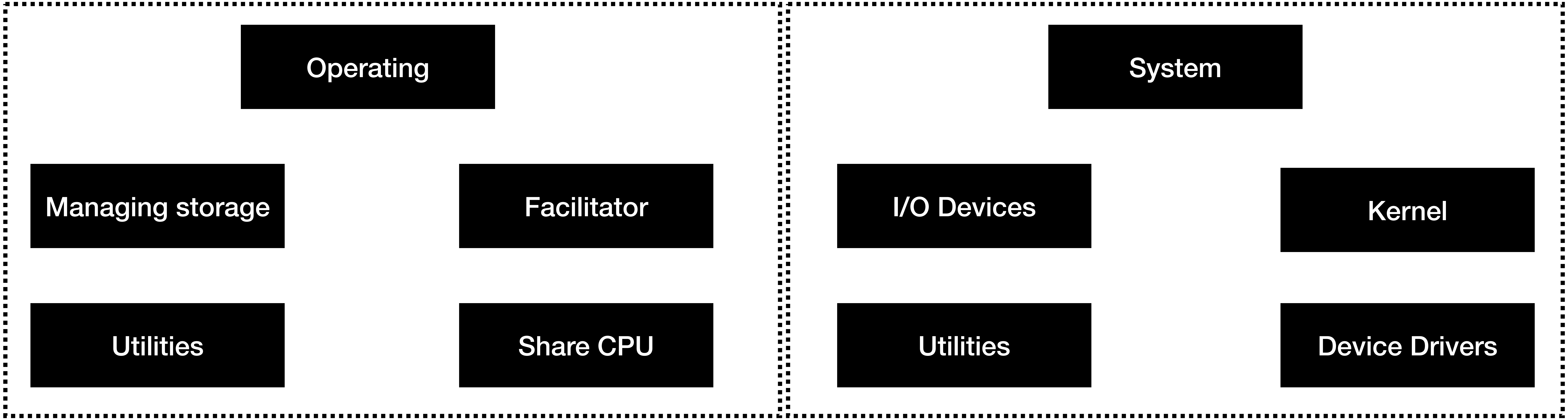
Spell check image source: https://creativepro.com/check-spelling-dynamically/

Persistence

- RAM is Volatile
- Hardware and software are needed to store data persistently
    - Hardware: I/O devices such as hard drive, SSDs, etc.
    - Software:
        - File system manages the disk
        - File system is responsible for any files that the user creates
        - Read, writes are handled by file system which interacts with low level device drivers

“Operating System” - Dual Roles

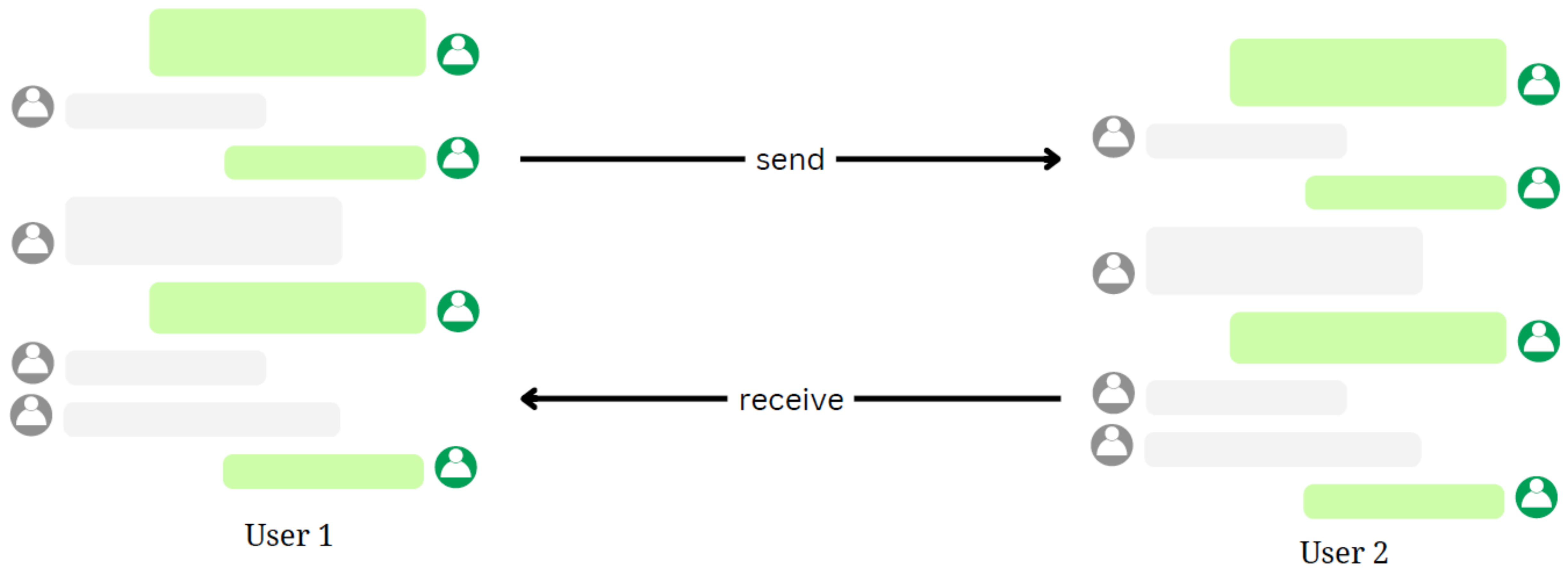
Resource Management and Hardware Abstraction



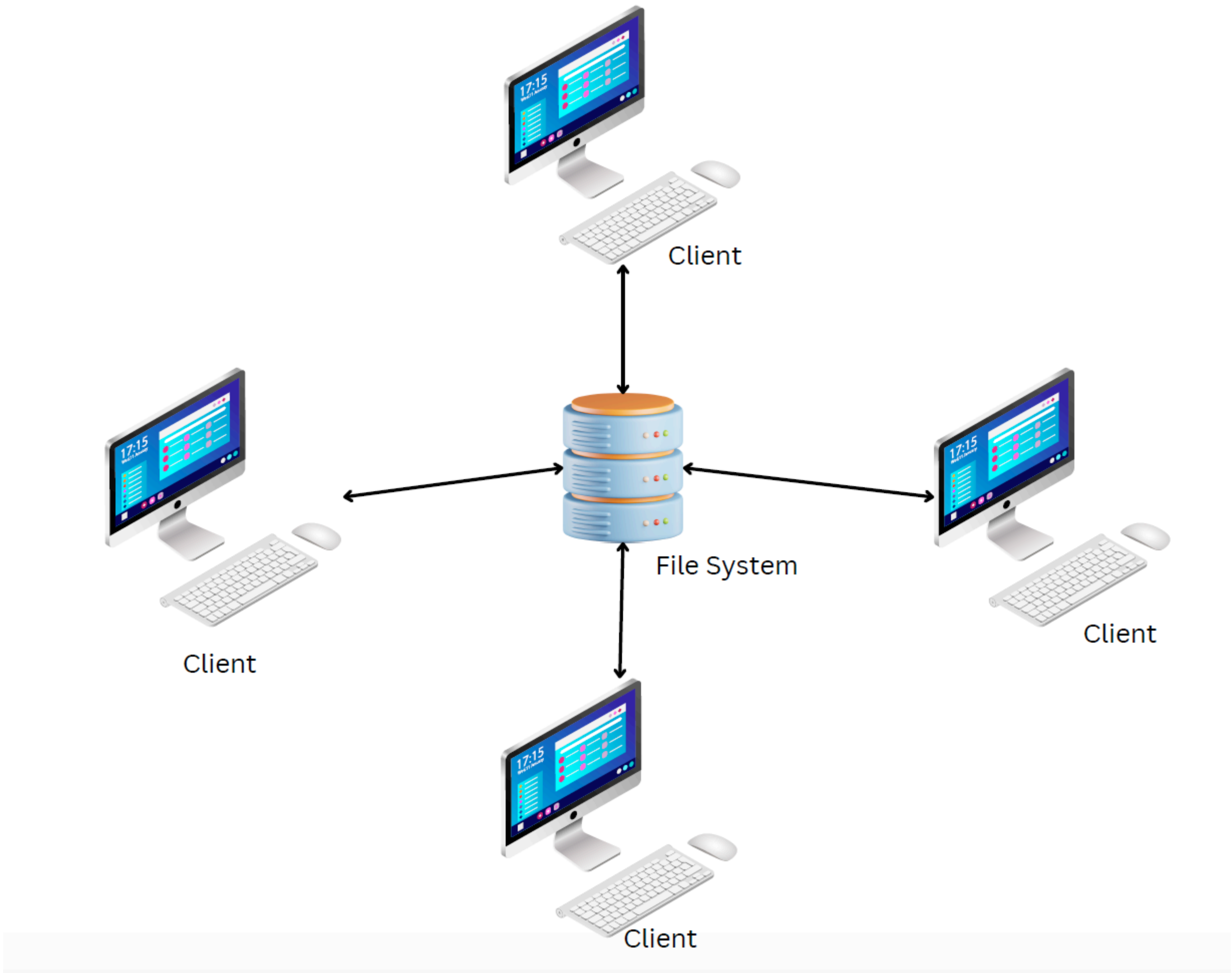
Key Design Goals Of OS

- **Abstraction**: Convenience and easy to use
- **High Performance**: Minimize overhead, Virtualisation should be done but minimise overhead
- **Reliability:** OS must continously run without crashing
- **Other attributes**: Energy efficiency, Security, Mobility
- **Remember:** OS itself is a massively complex software (Softwares rely on OS to function correctly!!)

But how does multiple systems interact?

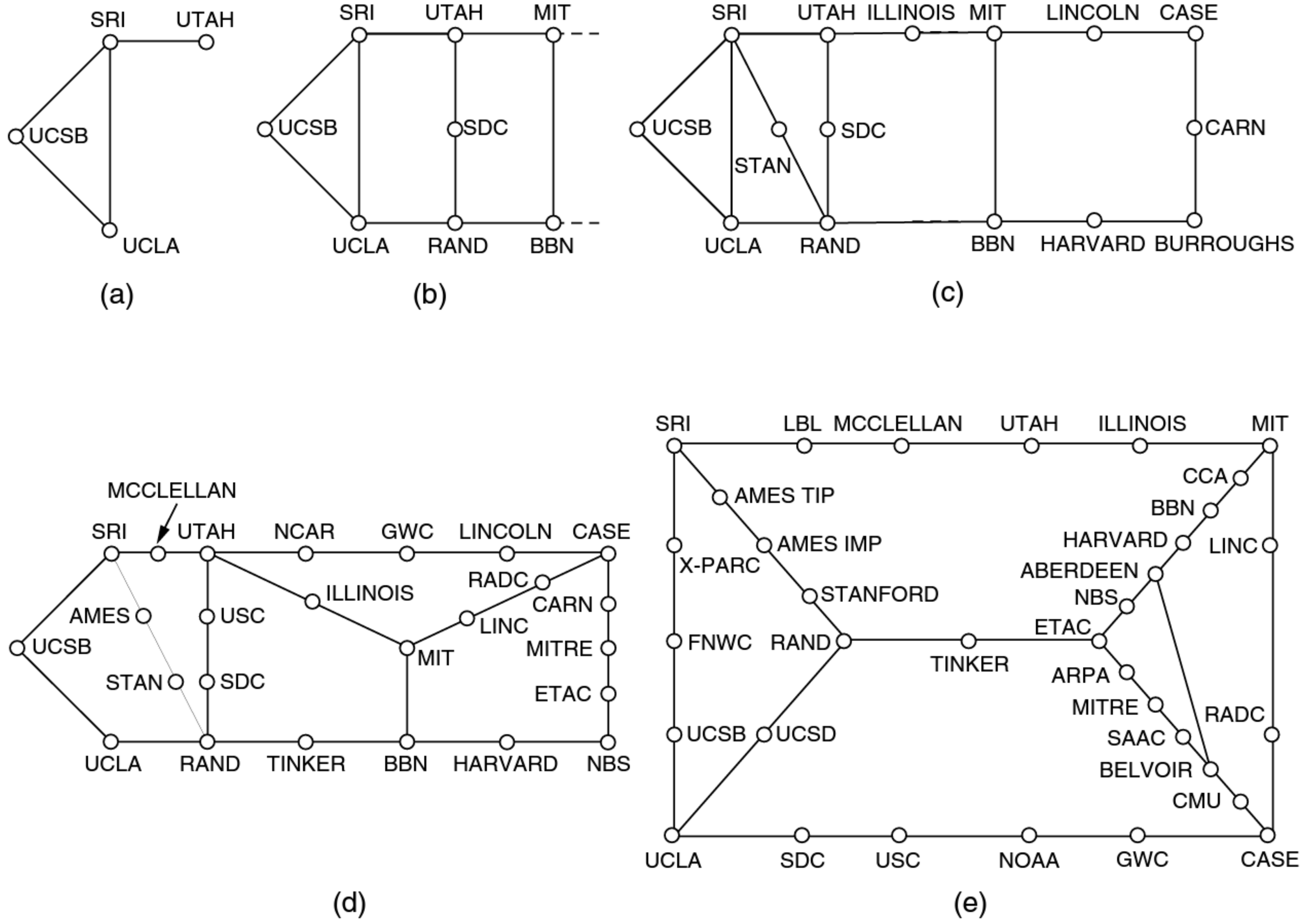


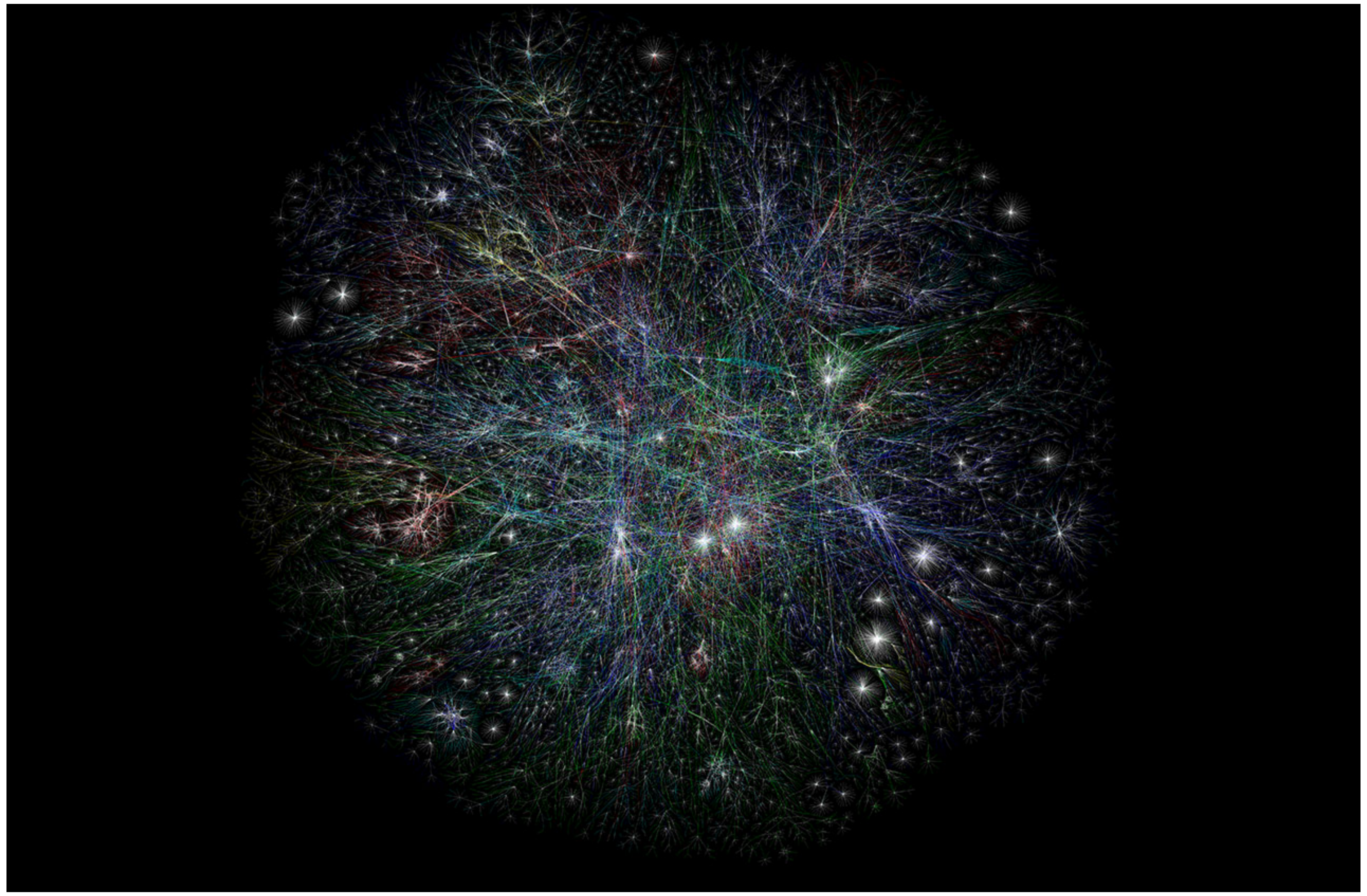
Whatsapp Chat example



Network File System

Any Guess on this?

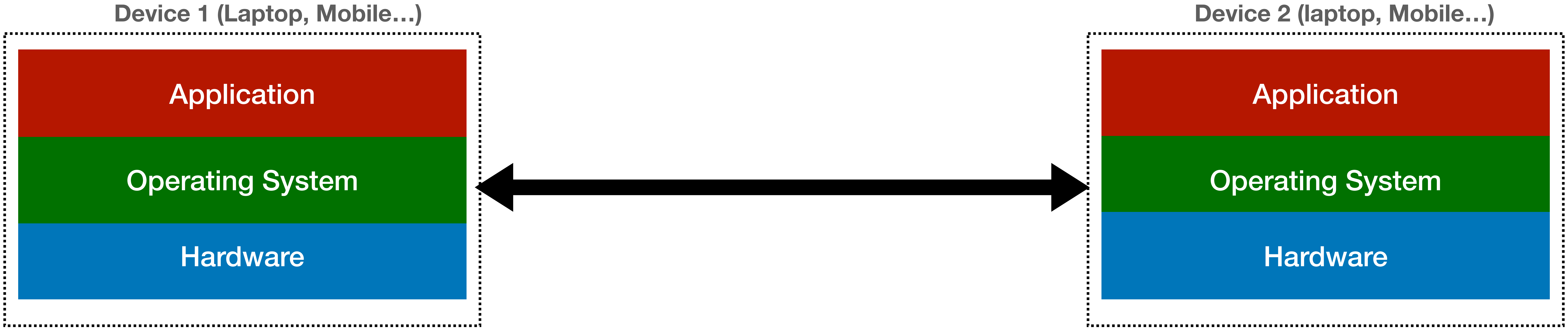




A Map of the internet (as of 2012)

Growth of ARPANET, source: Computer Networks, 5e, Tannenbaum and Weatherall

Computer Networks: The horizontal



- How can application from device 1 and 2 communicate?
- How to ensure the data/information reaches reliably?
- What if multiple applications are running and are communicating?

Networks - Different Components

- Different types of network - PAN, LAN, MAN, WAN,..
- Some terminologies - subnets, hosts, routers, switches, transmission lines, interconnected networks (internet) not Internet
- **internet** - formed when distinct networks are interconnected (network of networks)
- Subnets - collection of communication lines and routers owned by network operators
- Protocol - Agreement between communicating parties on how the communication needs to proceed

The Different Pieces of Networks

- As more and more networks started joining ARPANET, need for common protocol arise
  - Invention of TCP/IP model
- Implementing TCP/IP on different platforms was encouraged
  - Sockets - 4.2BSD Release of Berkeley Unix
  - Using networks with sockets proved effective and efficient
- As scale increased, difficult to remember the address of the system
  - Domain Name System (DNS)
  - How to find route from one point to another?

Course Outline

Getting the base right

Building concurrent processes that can communicate

Building a network file system

→ Timeline

This Course

Process and Memory Virtualization	Concurrency	Persistence
Networking intro	Addressing and Routing	Network file Systems

Grade Distribution

Component	Weightage
Final Exam	30%
Mid-term Exam	15%
Quiz	5%
Mini projects	30%
In-class activities/Bonus	5%
Project	15%

Note: The instructor reserves the right to make any changes based on the course progress

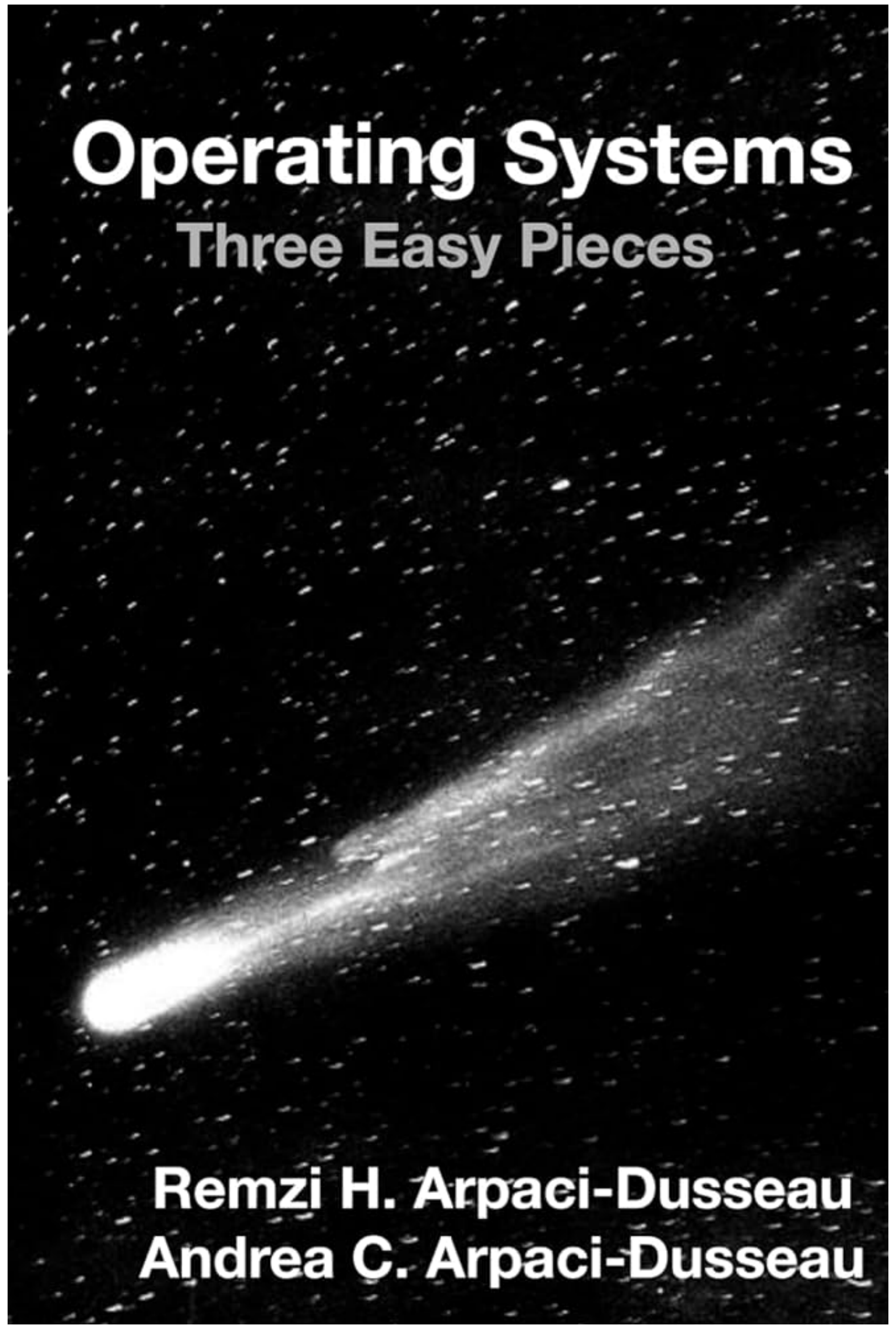
Course Logistics

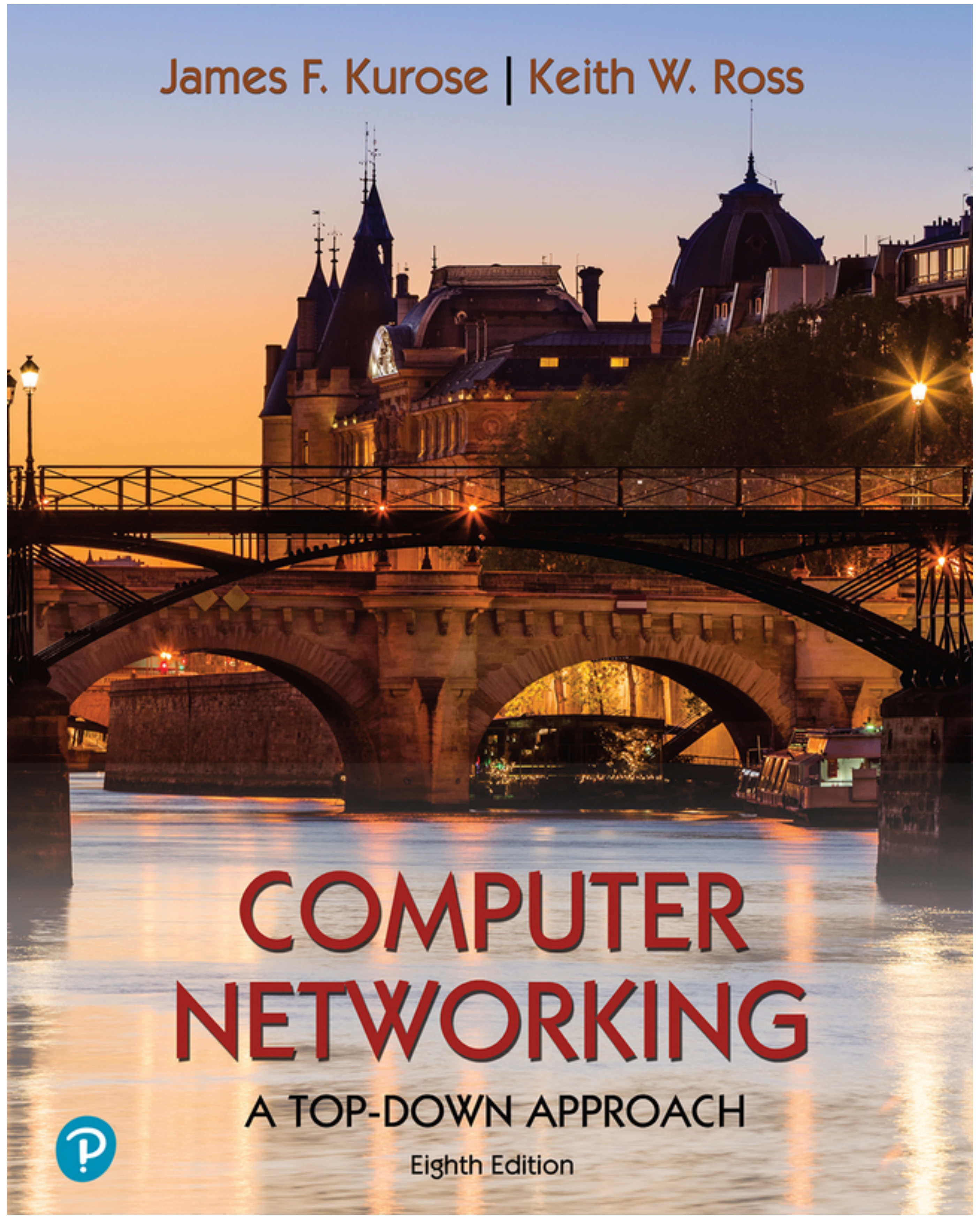
- Course announcements and management - Moodle
- Assignments and projects - Github Classroom
- All resources, information and materials - https://karthikv1392.github.io/cs3301_osn/
- The complete course schedule is already posted (minor changes may happen!)
- Instructor office hours - Thursday 12:00 PM to 1:00 PM
- Lets keep the classes lively and interactive!
- Feedbacks are always welcome!

OSN Continuous Feedback

Course Logistics

Materials





- The OS book is available as e-copy: https://pages.cs.wisc.edu/~remzi/OSTEP/
- Very important to read the **book + the slides + website posts + being attentive!!**

Course Logistics

Some Ground Rules

- **Zero Tolerance on Plagiarism!**
  - Every submission will go through different checks
  - If found, the points will be 0 and may result in an F grade
  - Check the institute policy on Academic misconduct
- You may use AI tools but use them wisely! - Check course policy page
  - Try to understand rather than blindly using generated code!
- Please respect the class timings!

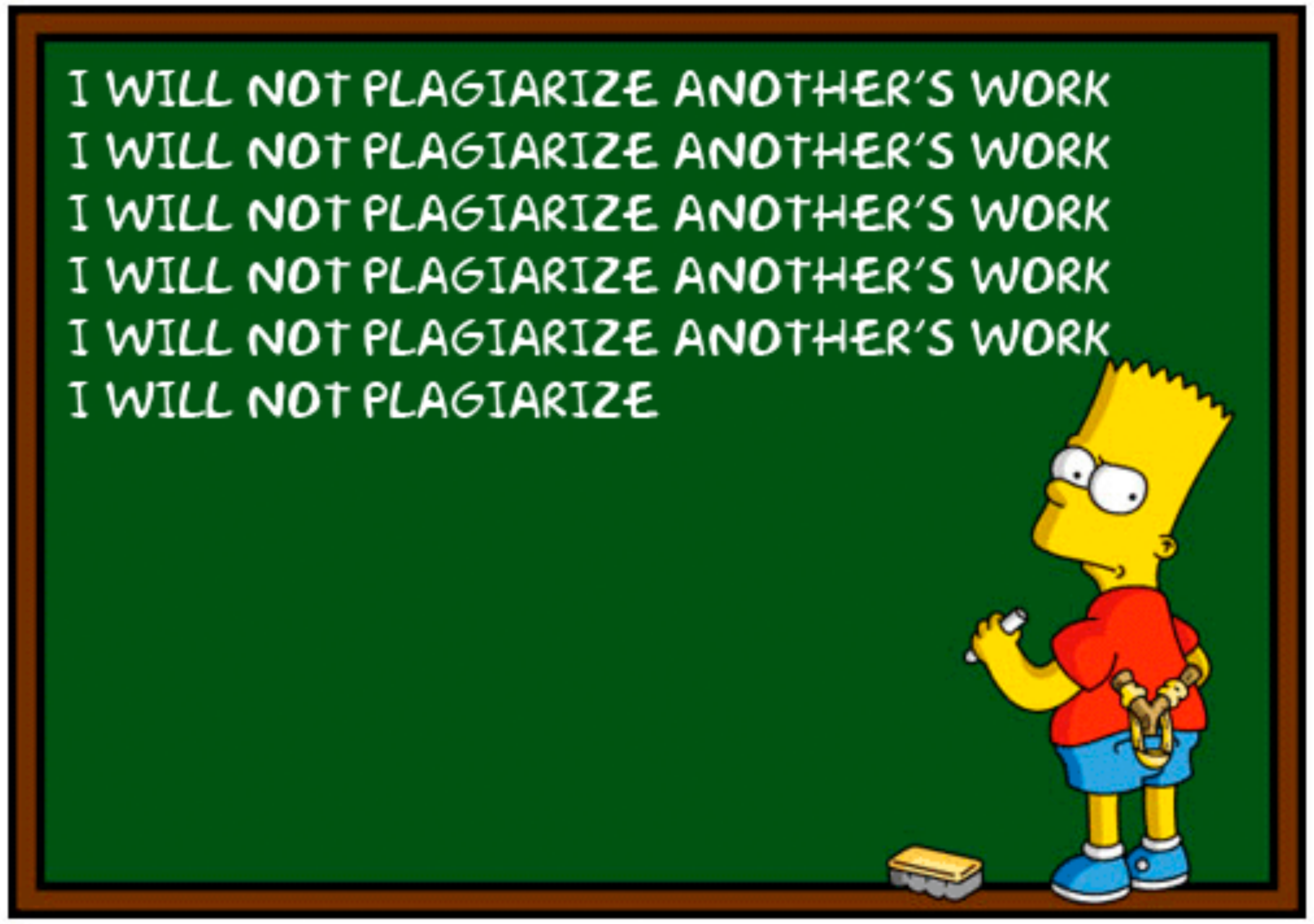

I WILL NOT PLAGIARIZE ANOTHER'S WORK
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Image Source: Florida Tech News

Course Logistics

Communication and Engagement

- We have planned many ways to make this a very engaging course
- Take part in tutorial sessions - Not just for projects but for more understanding!
- Instructor office hours are available - Walk into office for any queries!
- TA Office hours - Pleaser do use them but kindly respect the timings!
  - Remember TAs are also students and they have their own commitments
- Document will be shared for posting questions
  - Check the questions before you post one!
  - Add questions to the respective category

Course Logistics

Projects

- There will be a mini project 0 (Warmup) and three other mini projects each about a month duration
    - All the mini projects will be graded, there will be viva as well (total 30%)
    - Mini project 3 will be a team project (team of 2)
- Final course project (15%) - Team of 4
- No extensions will be granted unless there is any emergency (get approval):
    - Use extra days and soft deadlines
    - Any submission over the hard deadline will not be considered and will be evaluated with 0

Meet the Team!

Special Mention: Last year TAs

Karthik Vaidhyanathan

Divij D

Ashna Dua

Jhalak Akhilesh Banzal

Aryan Chandramania

Divyansh Pandey

Ishan Gupta

Kritin Maddireddy

Prakhar Singhal

Sanchit Jalan

Miryala Sathvika

Shrikara A

Tanish Gupta

SCAN ME

Thank you

Course site: karthikv1392.github.io/cs3301_osn
Email: karthik.vaidhyanathan@iiit.ac.in
Twitter: @karthi_ishere