Computer Systems and Software

Hardware: Motherboard, CPU, RAM, Storage, Peripherals

Software: Firmware, System, Server-Side, Applications

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Technical Trainers

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Have a Question?

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Computer Systems

Components and Functionality

What is a Computer System?

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- **Computer system**: an integrated bundle of hardware and software components, e. g. smartphone, POS terminal, laptop
  - Enables **efficient data input, processing, and output**
  - Comprises **interconnected software and hardware components**
  - **Human-computer interaction** for the end-users / APIs for **machine-to-machine interaction**
- **Key elements**:
  - **Hardware**: RAM, input/output devices, storage devices, CPU
  - **Software**: operating systems, drivers, programs, apps

Evolution

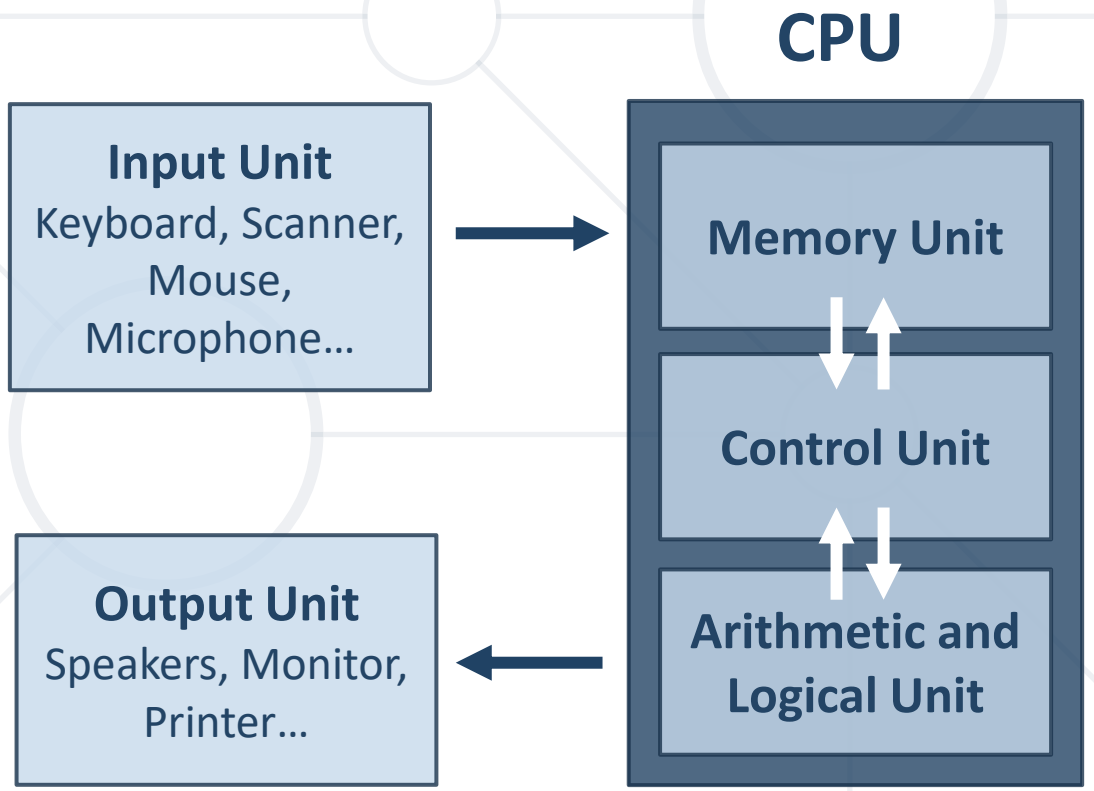
- **Early computing**: mechanical and electromechanical devices (e.g., Abacus, Babbage's Analytical Engine, ENIAC)
- **Advancements in technology**: transistors, integrated circuits, microprocessors (e.g., mainframe computers, minicomputers, personal computers)
- **Modern era**: pervasive computing, IoT, cloud computing, edge computing, rise of AI and machine learning

Computer Hardware

Motherboard, CPU, Memory, Storage, Peripherals

Computing Machines: Concepts

- **Hardware** refers to the **physical components** of a computer
- Central Processing Unit (**CPU**) – microprocessor
  - **Executes the code** (programs)
  - All **data processing operations**
- **Input devices**
  - Enter data
- **Output devices**
  - Get information



Computer System Hardware

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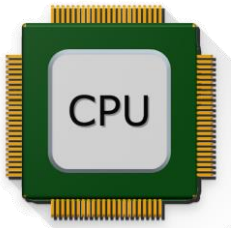


CPU

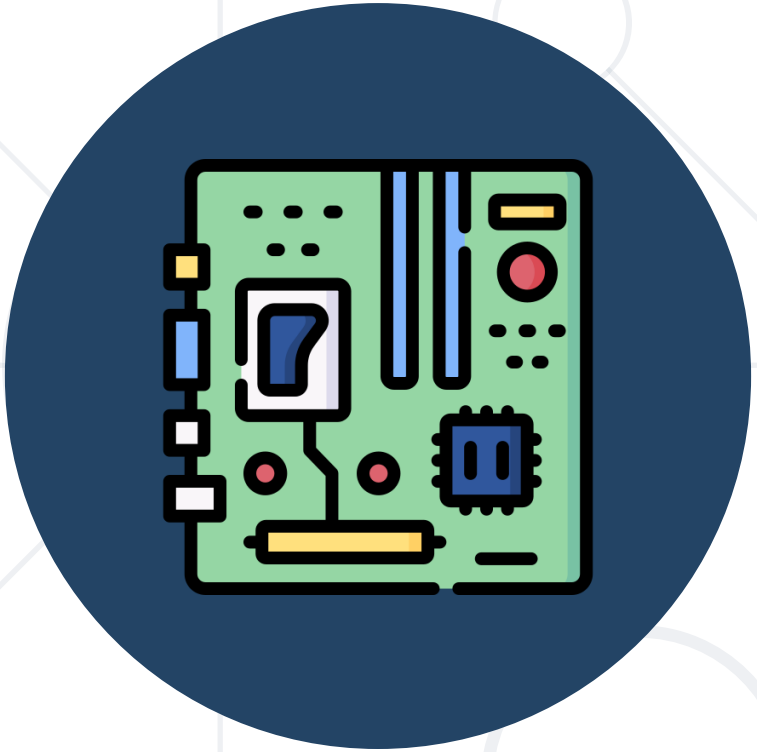
Disk Controller

USB Controller

Graphics Adapter

System Bus

Memory

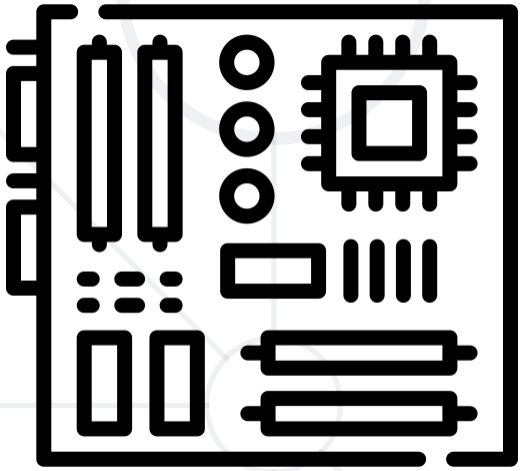


Motherboard

Backbone of a Computer System

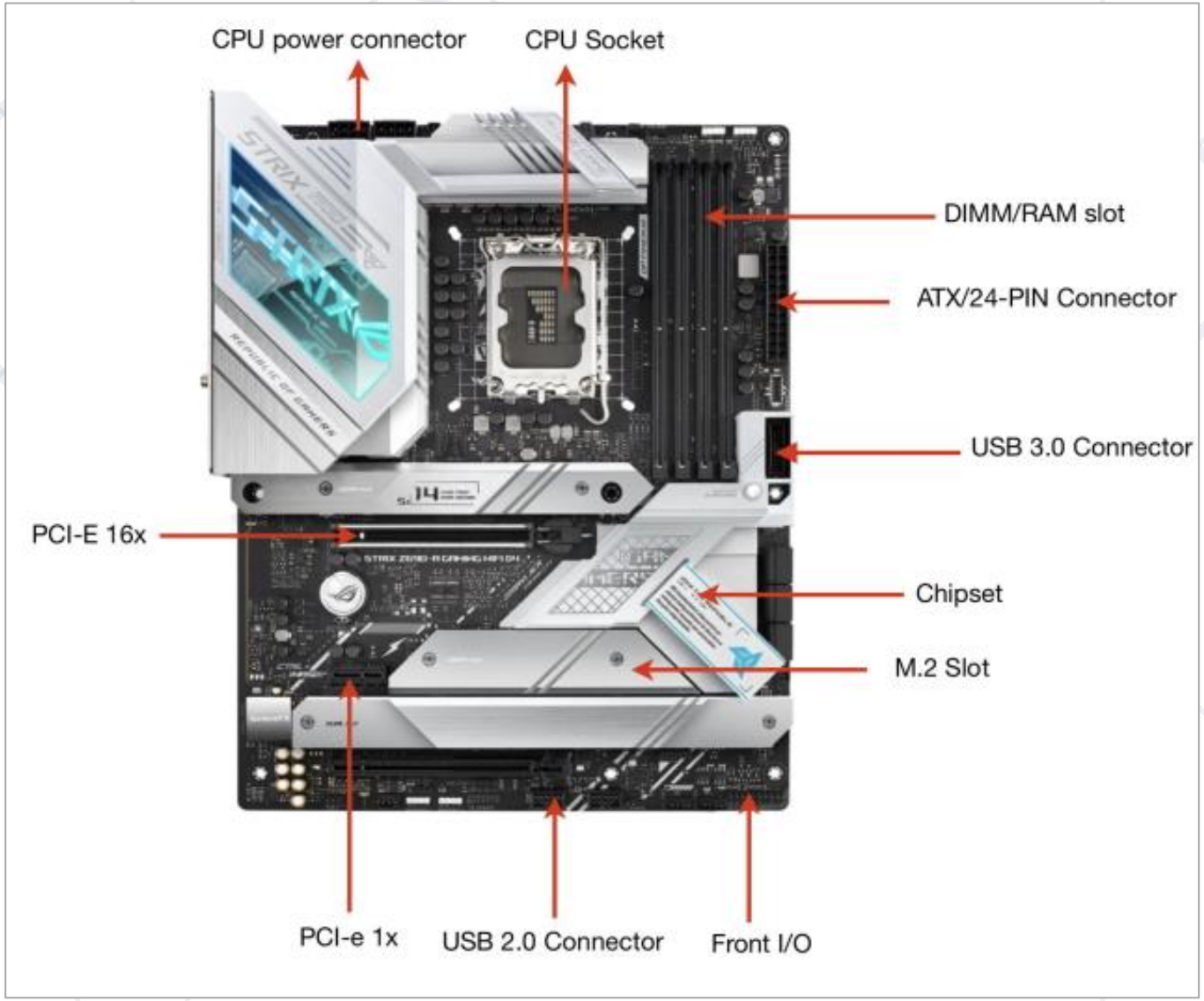
What is a Motherboard?

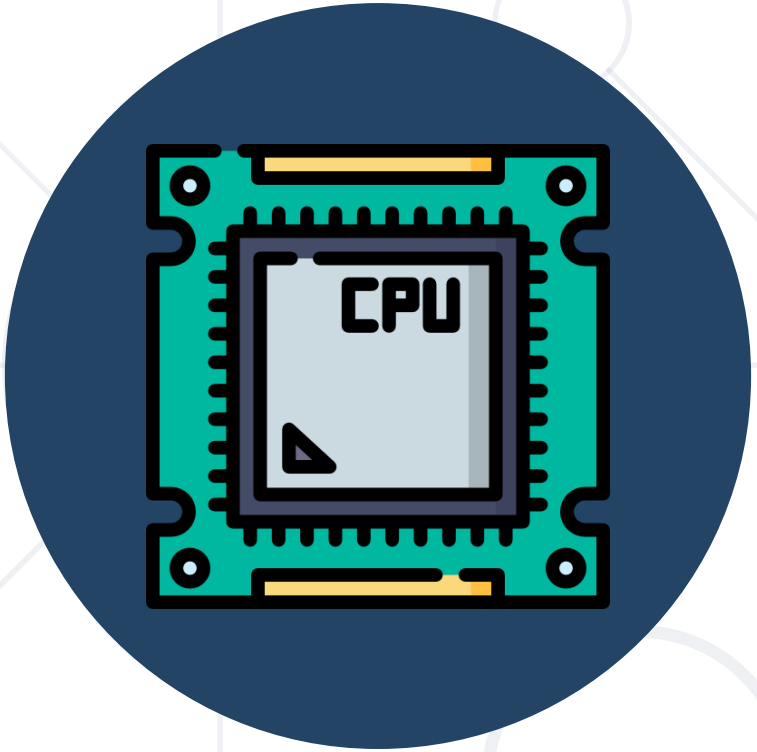
- **Motherboard** == central hub for **hardware connectivity**
  - **Communication** between all **hardware components**
- **Compatibility** considerations
  - Each motherboard is **designed to work with specific types** of **processors** and **memory**
- **Expansion slots** for enhanced functionality
  - **Video cards** for improved graphics performance
  - **Sound cards** for enhanced audio capabilities
  - **Network cards** for better internet connectivity



Motherboard Components

- CPU socket
- RAM slots
- Power connectors
- Chipset
- Expansion slots
- SATA connectors
- USB connectors
- Bluetooth module



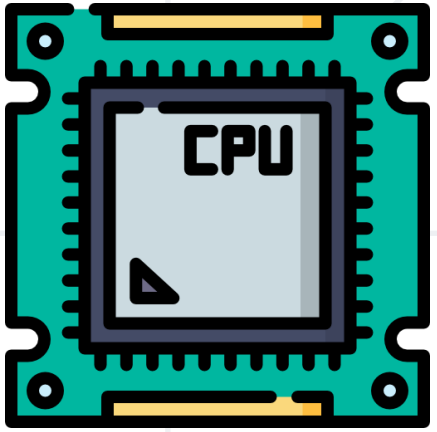


CPU (Microprocessor)

Central Processing Unit

What is CPU?

- **CPU** – the brain of the computer
  - Executes **calculations**, **actions**, and **runs programs**
  - Provides **processing power** and **instruction control**



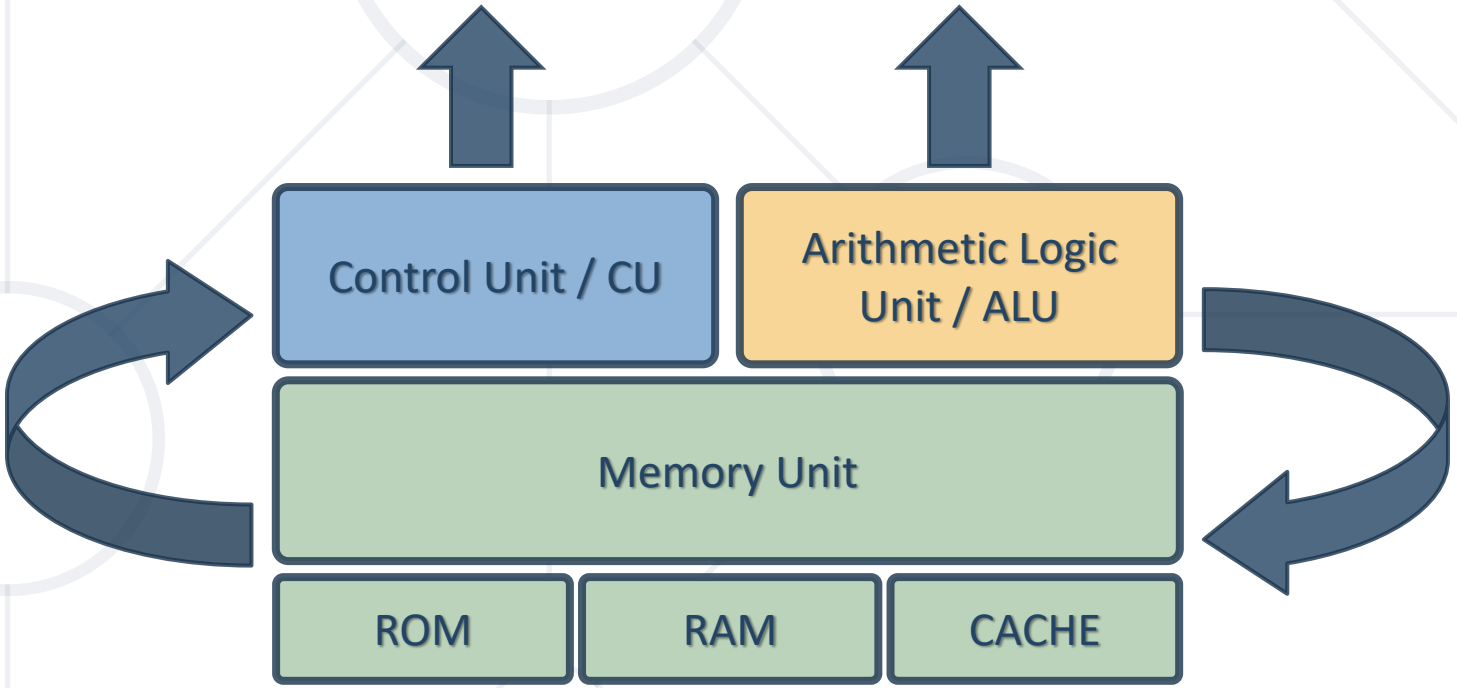
- Three **core components**
  - **Control Unit** (CU)
    - **Manages instruction flow** and **coordinates** hardware functions
  - **Arithmetic and Logical Unit** (ALU)
    - Performs **arithmetic** and **logic operations**
  - **Memory Unit** (MU)
    - **Stores** data, programs, and information

CPU Parts Workflow

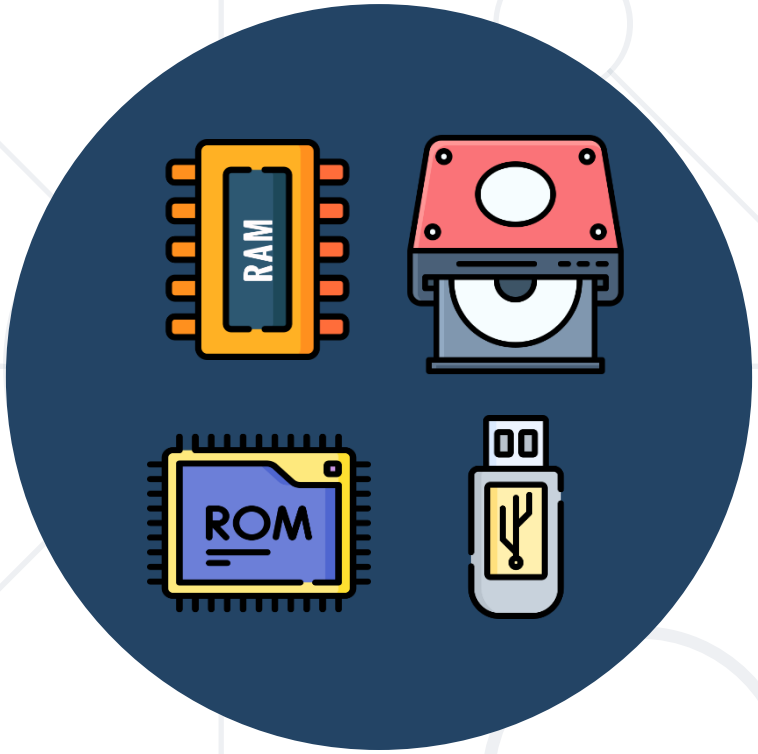
Step 2: Decode instructions into commands

Step 3: Execute commands

Step 1: Fetch instructions from the memory



Step 4: Store results in the memory



Memory and Storage

Storing Information in a Computer

Types of Memory

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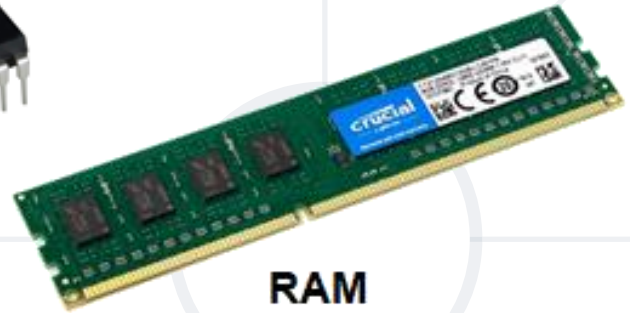
- **Primary memory**
  - **RAM** – read / write: stores data, required by the CPU during the **execution of a program**
  - **ROM** – read-only: stores **crucial data for the system** to operate, like the essential program for the computer boot

ROM

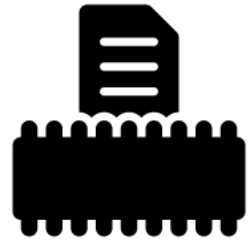


RAM

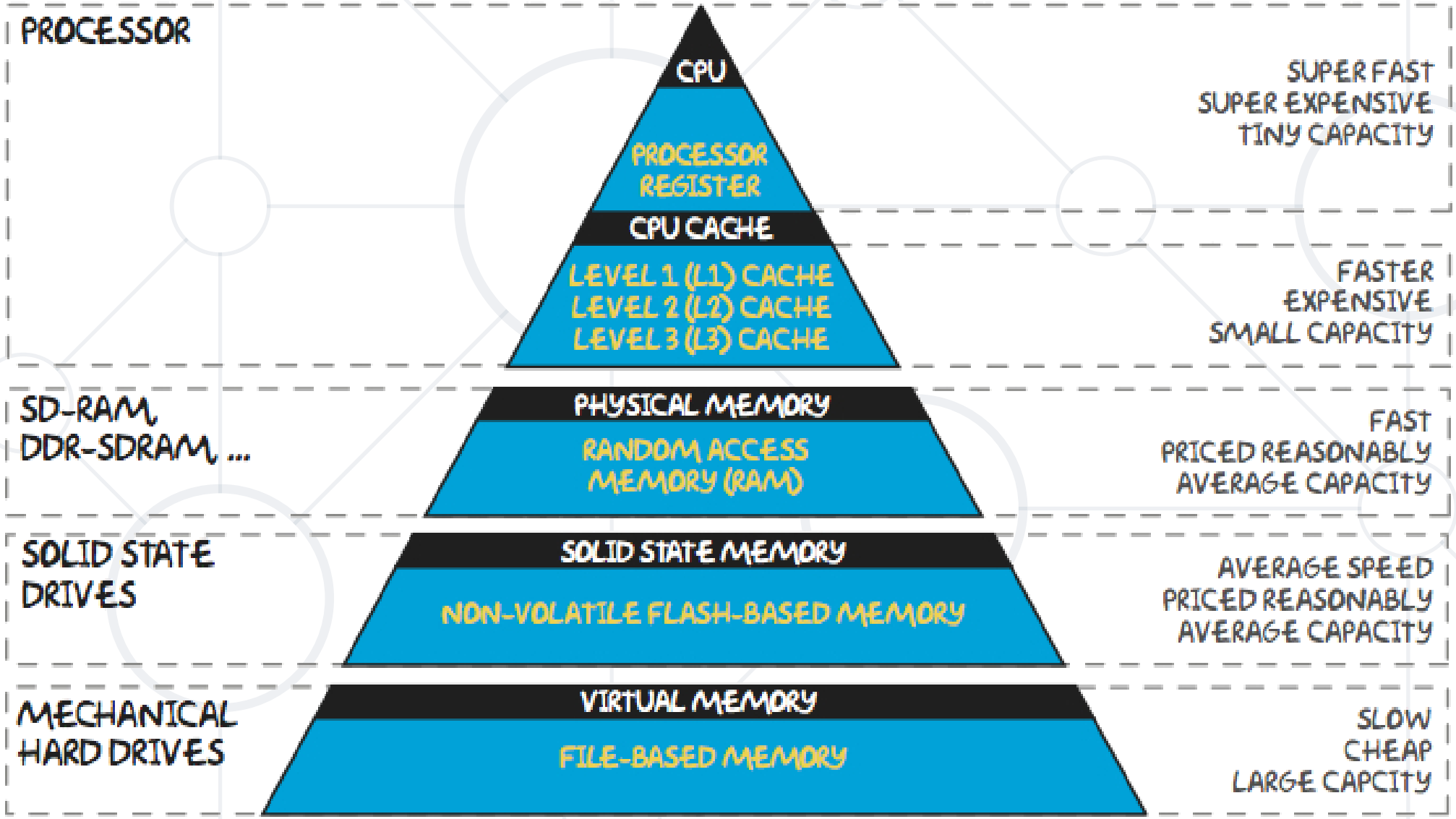
- **Secondary memory**
  - Not accessed directly by the processor
  - Examples: hard drive, SSD, flash, optical drive, USB drive

FLASH

- **Cache memory**
  - Part of the CPU, very fast: temporarily stores **frequently used instructions and data** to speed-up access



Memory Hierarchy

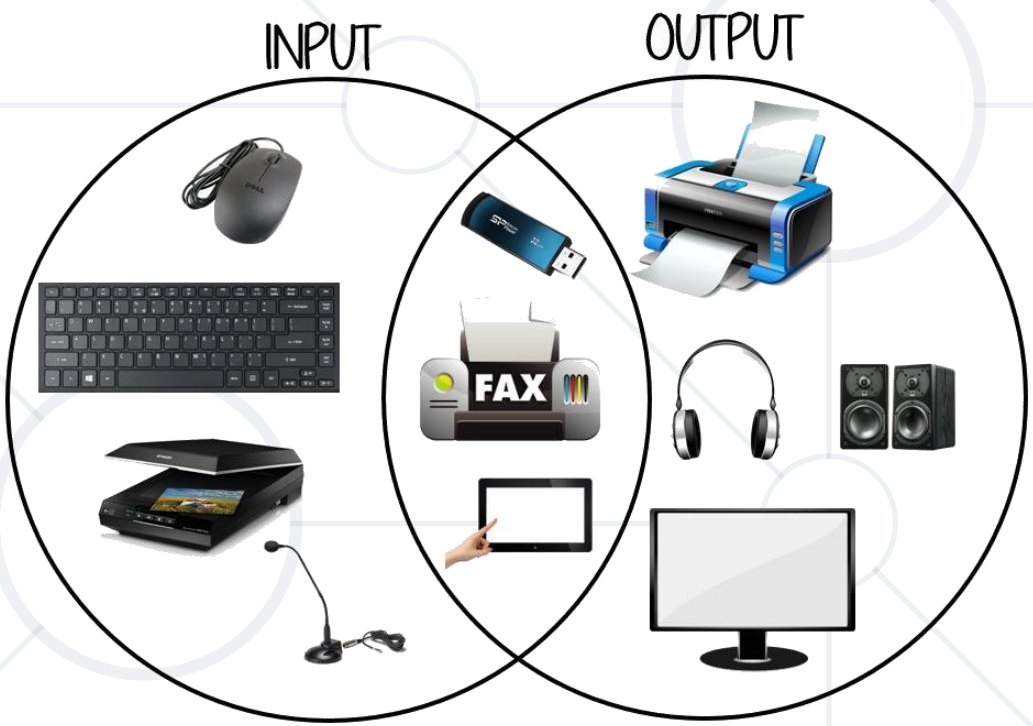


Peripheral Devices

Expanding Computer's Functionality

What is a Peripheral Device?

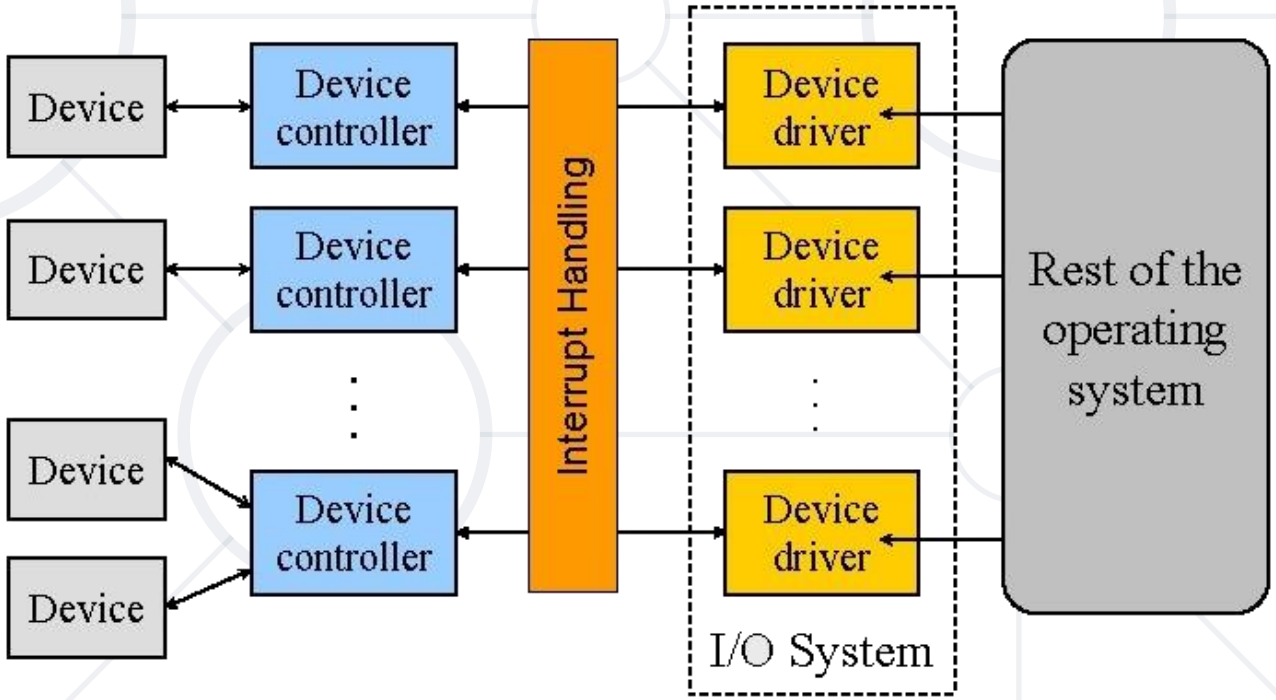
- **Any connected device** that expands computer's capabilities with **additional functionality**



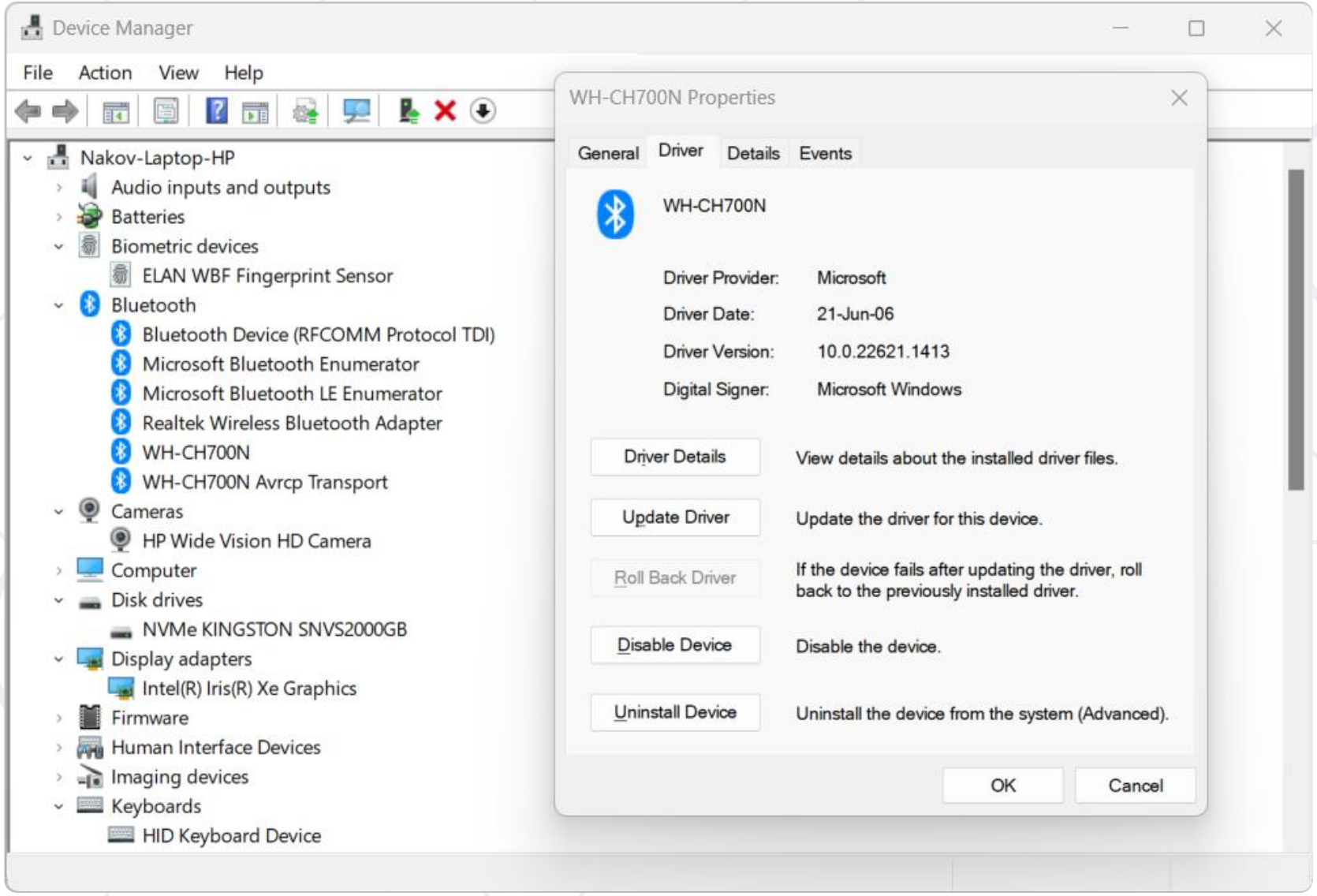
- **Three main categories**:
  - **Input devices** → **read data**, e.g. keyboard, mouse, microphone
  - **Output devices** → **write data**, e. g. speakers, printer, monitor
  - **Input/output** devices → **mixed**, network card, hard drive, touchscreen monitor

Peripheral Devices Control

- Device **controller**
  - A **physical device** for **connection** between a peripheral device and the computer
  - E. g. USB controller
- Device **driver**
  - **System software**, which enables the **communication and data transfer** between devices and the system



Device Manager in MS Windows



Computer Software

Firmware, System Software, Applications

Overview of Computer Software

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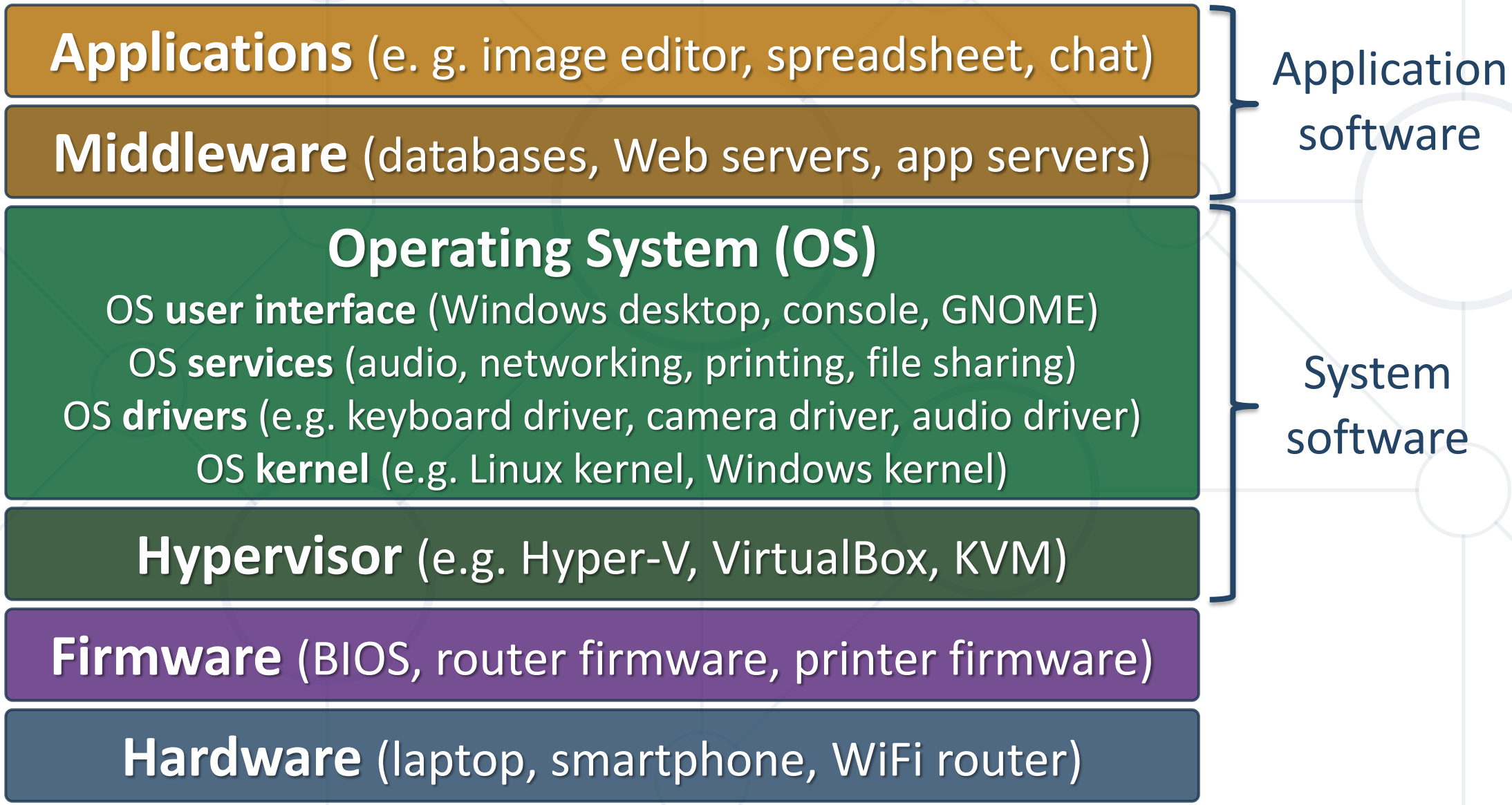
- **Computer software** – definition
  - Computer programs, instructions, and data that enable a computer system to **perform specific tasks**
- **Types** of software:
  - **Application software**: help the business to run, e.g. email software, spreadsheets, word processing, CRM systems, …
  - **System software**: interacts with and **manages the hardware**
- **Standalone apps** vs. **software systems** (client + server)

Software Stack



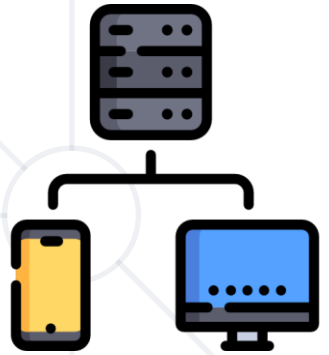
Layers of Software

- **Firmware** and **embedded software**
  - **Low-level software** used to operate a hardware device
- **System software**
  - **Manages and controls hardware**, platform for applications
  - **Operating systems** (OS) – Windows, Linux, macOS, Android
  - **Hypervisors** – runs virtual machines (VMs) in the host OS
- **Application software**
  - Business applications, office apps, multimedia, communication
  - Several types: **Web apps**, **desktop apps**, **mobile apps**

Software Systems

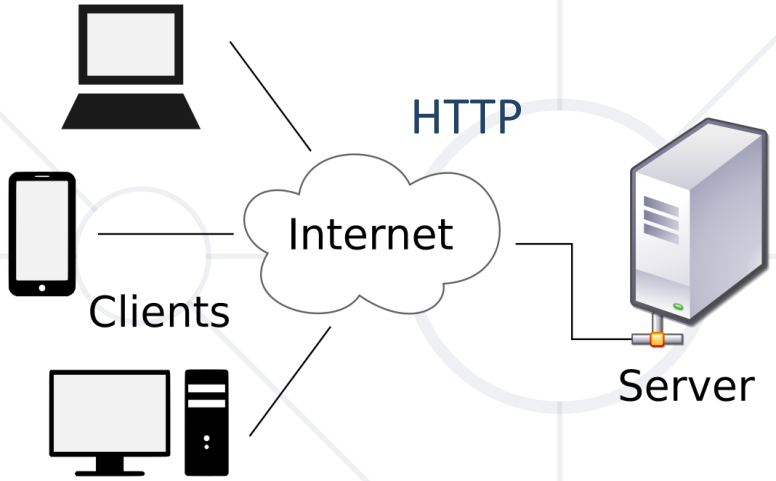
- **Standalone apps**
  - Run **locally**, store their data locally, do not need Internet
  - Examples: Windows Calculator, Windows Explorer, Minesweeper

- **Software systems**
  - Consists of several **components** (e. g. client + server)
    - Example: mail server (remote) + mail client app (local)
  - **Cloud apps**: hold all user data in the cloud + local client
    - Example: Google Docs, Discord, Trello, Canva

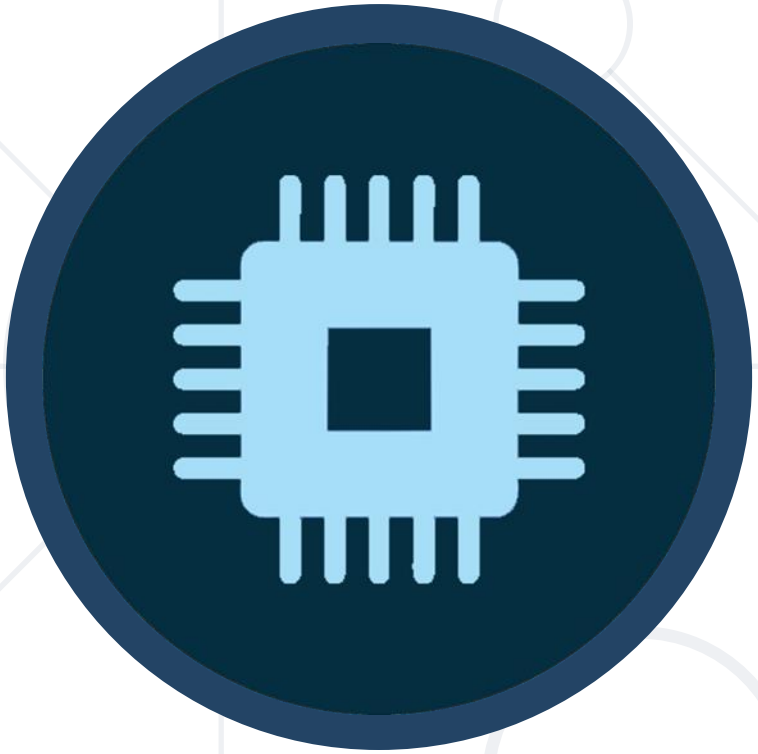


Front-End and Back-End

- **Front-end** and **back-end** separate the modern apps into **client-side** (UI) and **server-side** (data) components
- **Front-end** == client-side components (Desktop / mobile app / Web browser)
  - Implement the **user interface** (UI)
- **Back-end** == server-side components (data and business logic APIs)
  - Implements **data storage and processing**



- **HTTP** connects front-end with back-end



Firmware

Bridge between Hardware and Software

What is Firmware?

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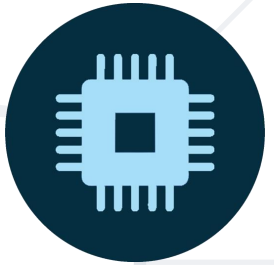

- **Firmware** == **permanent**, low-level software, **embedded** in a device's read-only memory (ROM)
  - Controls device's basic functions and provides a **stable foundation** for higher-level software
  - Example: WiFi router's firmware, coffee machine firmware
- **Functions** of firmware
  - Hardware **initialization** during the boot process
  - **Management** of low-level hardware operations (e. g. device **initialization**, hardware **diagnostics**, and system **booting**)

Firmware: Devices and Use Cases

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- **Examples** of firmware applications
  - BIOS / UEFI in laptops and desktop computers
  - Firmware in routers, printers, scanners
  - Embedded systems, such as IoT devices

- **Firmware updates**
  - Most devices allow firmware updates to improve functionality or fix issues
  - Can be critical for security and performance

System Software

Foundation for Application Software

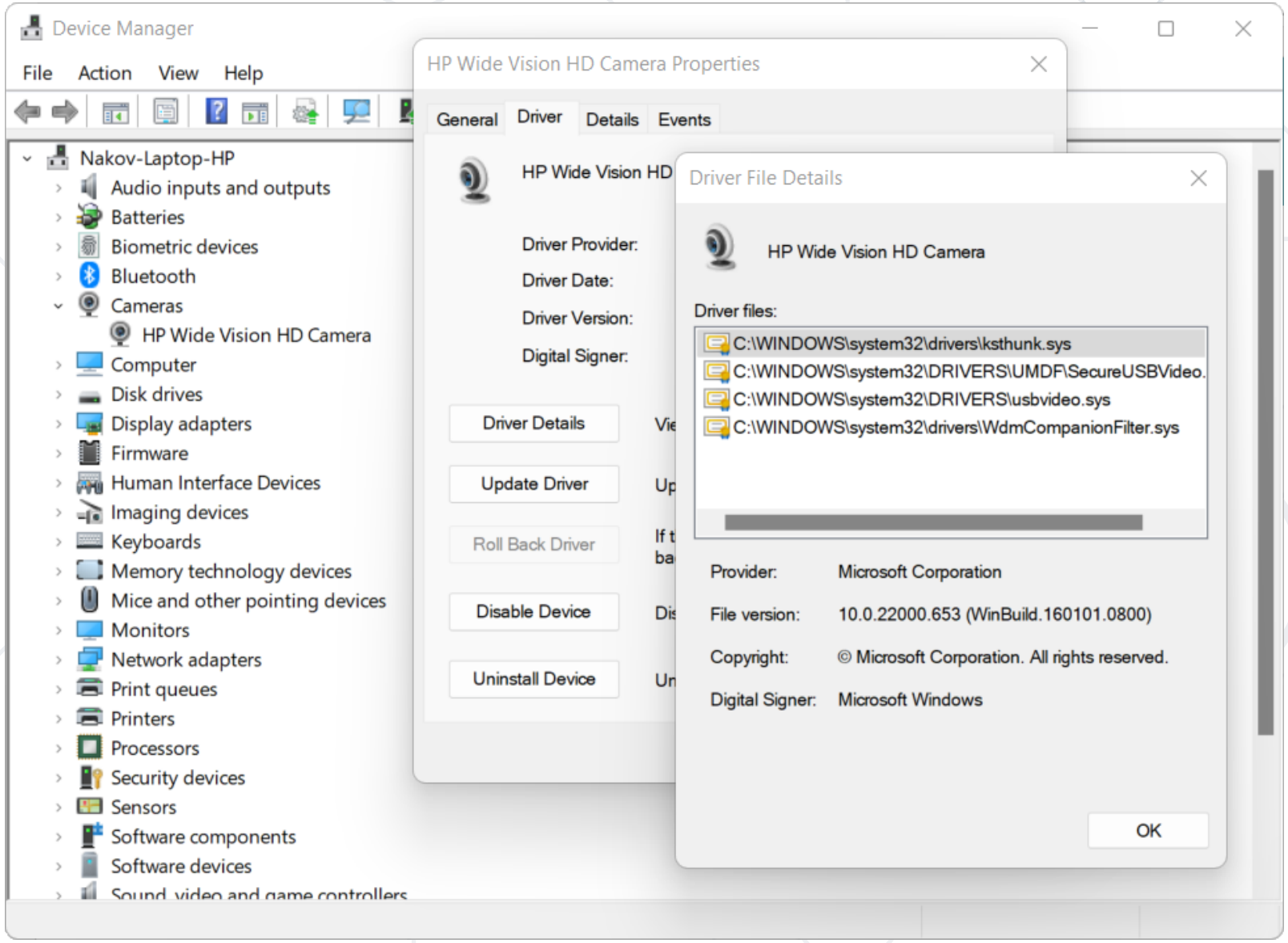
What is System Software?

- Software designed to **manage** and **control** computer **hardware**, providing a **platform** for **application software**
- Examples of system software
  - **Hypervisors** – runs virtual machines (VMs) in the host OS
  - **Operating systems** (OS) – Windows, macOS, Linux, Android
  - **Device drivers** – software that enables communication between hardware and operating system), e. g. mouse driver
  - **System utilities** – tools for system maintenance and optimization, e. g. anti-virus, task manager, print spooler

Operating Systems

- Windows, macOS, Linux, Android, iOS
- Manage the **hardware** and **software** resources
- Manage **processes** (concurrently running apps)
  - Distribute the system resources between all processes
- Manage **file system** and **memory** (RAM)
- Manage **users**, **security** and **access control**
- System **updates** and **maintenance**

Device Drivers



- In Windows, the "**Device Manager**" lists all devices, drivers, etc.

System Utilities

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- Tools that help **maintain** and **optimize** a computer system
  - **Antivirus** and **malware** protection (e.g. Winows Defender)
  - System **backup** and **recovery** (e. g. Macrium Reflect)
  - Disk **cleanup** and **defragmentation** (e. g. CCleaner)
  - Performance **monitoring** and **diagnostics** (Task Manager)
  - Software **updates** and **patches** (e. g. Windows Update)
  - System hardware **information** (e. g. CPU-Z)
  - System **logs viewer** (e. g. Windows Events Viewer)

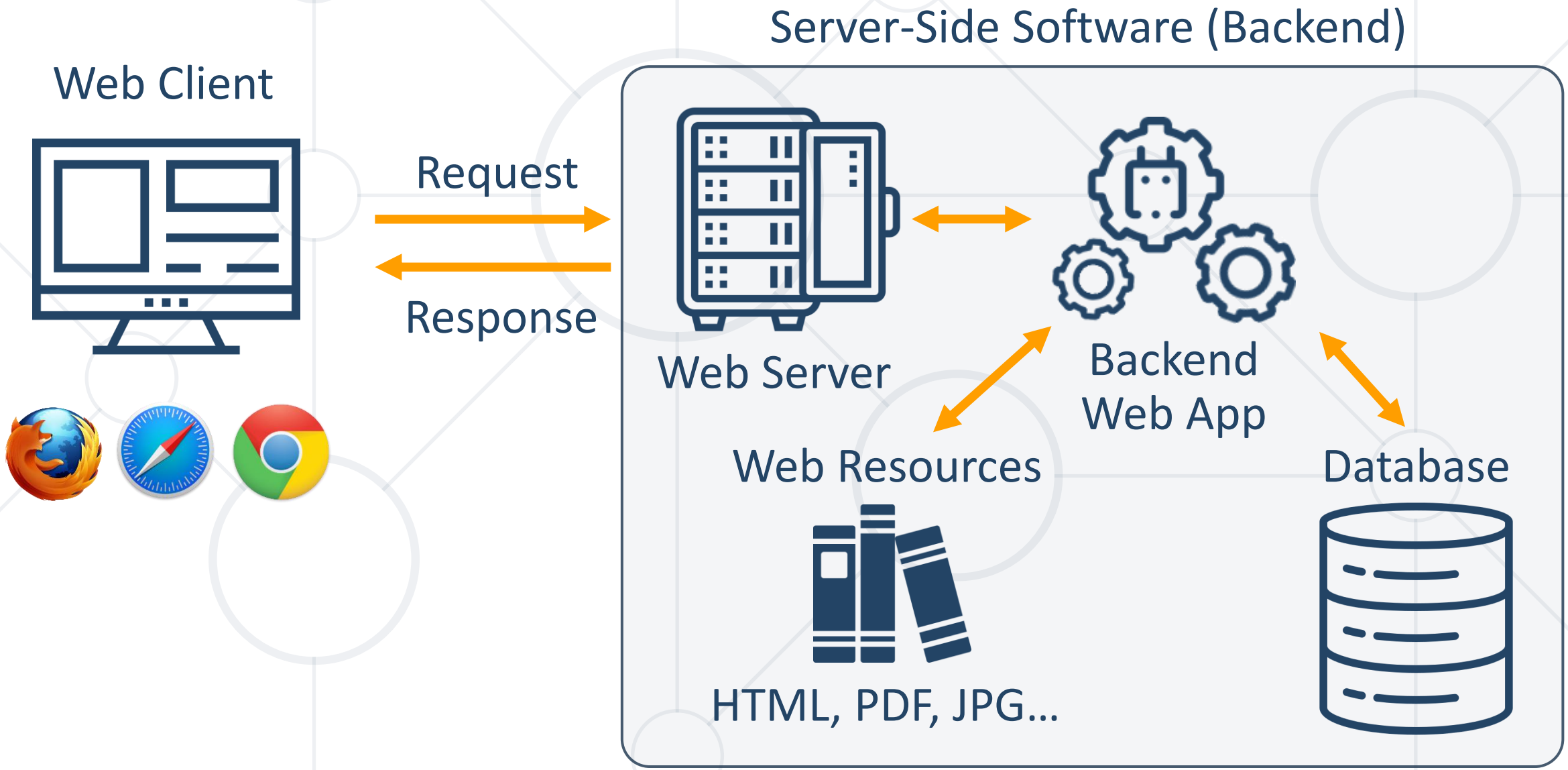
Server-Side Software (Backend)

Facilitating Backend Operations and Web Services

Server-Side Software Examples

- **Server-side software** (backend software) runs on a remote server, processes requests and delivers data to client devices
- **Common types** of server-side software
  - **Web** servers (e. g. Apache, Nginx, IIS)
  - **Database** servers (e. g. MySQL, PostgreSQL, MongoDB)
  - **Application** servers / runtimes (e. g. Tomcat, Node.js, .NET Core)
  - **Mail** servers (e. g. Microsoft Exchange Server, Postfix)
  - **File** servers (e. g. Windows File Server, Samba)
  - **Authentication servers** (e. g. FreeIPA, Active Directory)

The Client-Server Model in Web Apps



Server-Side vs. GUI

- **Server-side** software (backend software):
  - **Executes** on a **remote server**, rather than on the user's device
  - Handles **data processing, storage, and retrieval**
  - Powers Web applications, backend APIs, cloud services, etc.
  - Requires **efficient resource management** for optimal performance
- Graphical User Interface (**GUI**) / **front-end** apps:
  - **Executes** on the **user's device** (desktop, mobile, or Web)
  - Providing seamless and visually **appealing user experience**
  - Can be **Web** apps, **desktop** apps, or **mobile** apps

Application Software

Apps for the End Users

What is Application Software?

- **Application software** is designed for users to perform **specific business tasks**, catered to their **individual needs**
- Examples of application software
  - **Productivity** tools (Microsoft Office, Google Workspace)
  - **Multimedia** software (Adobe Photoshop, VLC Media Player)
  - **Communication** apps (Zoom, WhatsApp, MS Teams)
  - **Web browsers** (Google Chrome, Mozilla Firefox, Safari)
  - **Games** (Fortnite, League of Legends)

Web Apps

Applications, Accessed from the Web Browser

Web Applications

- What are **Web apps**?
  - Accessed through a **Web browser** with an **active Internet** connection
  - **Platform-independent**
    - Accessible on any device with a Web browser
    - Desktop / mobile Web browsers
  - **Automatic updates** (always up-to-date)
    - No need for manual installation or updating

Web Applications (2)

- **Benefits** of **Web apps**
  - **Scalability**: easily accommodate a growing user base
  - **Centralized data storage**: simplifies data management and backup
  - **Lower device requirements**: minimal hardware needed (processing is done on the server-side)
  - **Easier collaboration**: real-time collaboration
  - **Cross-platform compatibility**: works across various operating systems and devices

Testing Challenges for Web Apps

- **Compatibility:** if the app works consistently across **different Web browsers** and different **screen sizes** (responsive design)
- **Usability:** testing for **accessibility**, **intuitive use** on different devices, and ease of **navigation**
- **Network conditions:** Web apps rely on an active internet connection→ testing under **different network conditions**
- **Security:** Web apps deal with sensitive data → testing for **vulnerabilities** such as XSS attacks and SQL injection
- **Performance:** performance can be affected by network speed / server load / browser capabilities → testing for **scalability / load capacity**

Trello Project Management Web App

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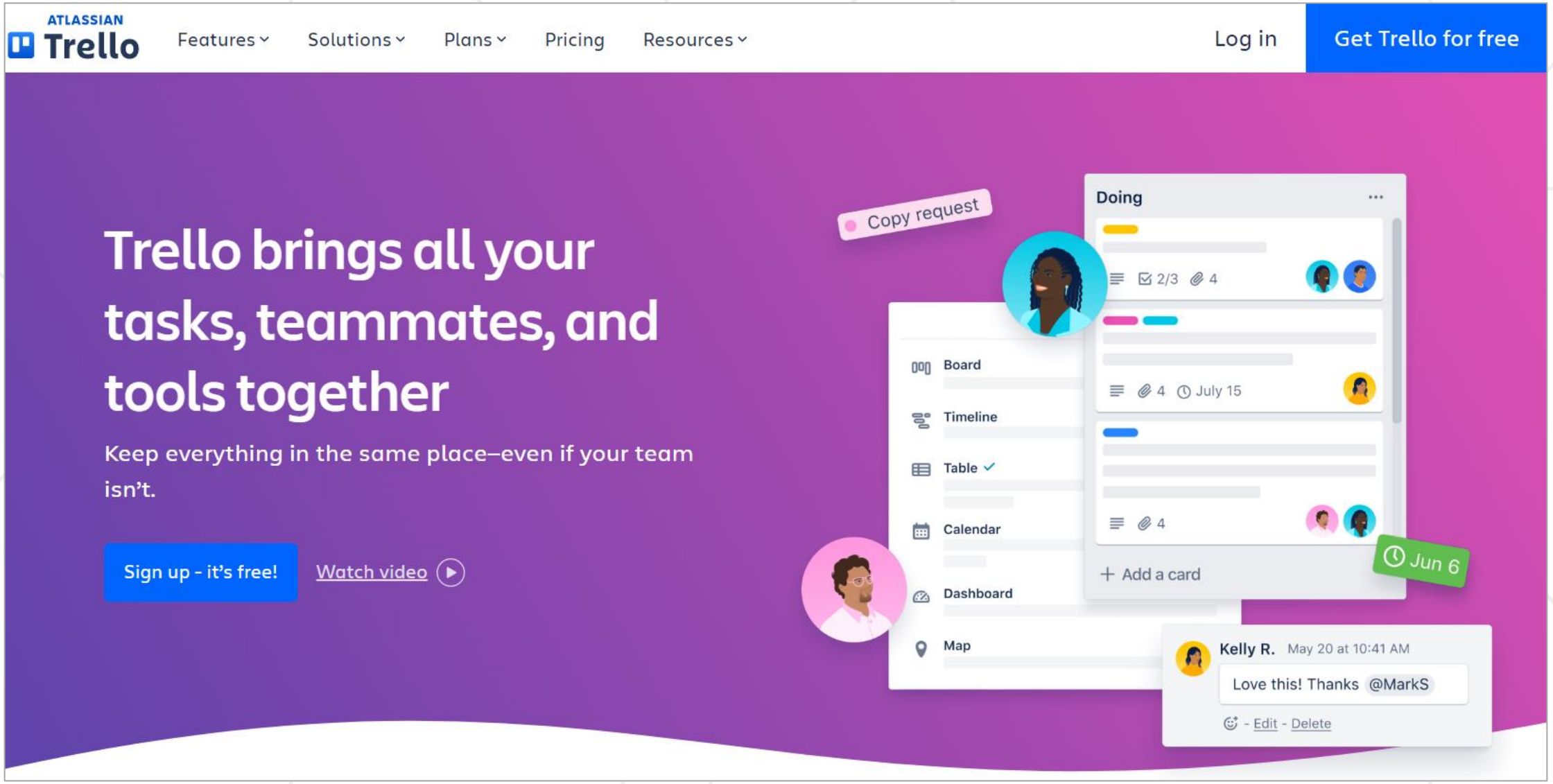

Trello Web App – Example

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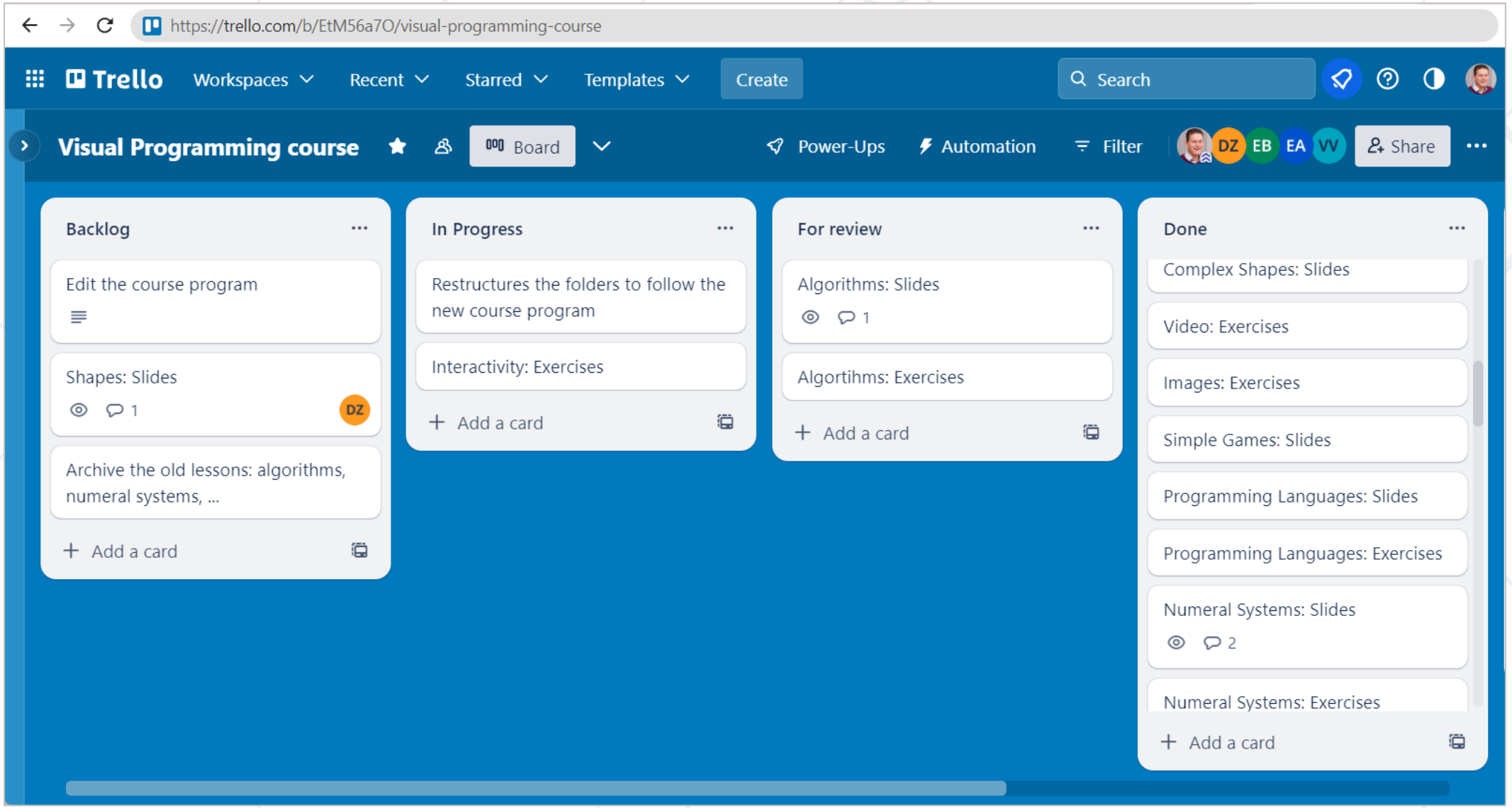


Desktop Apps

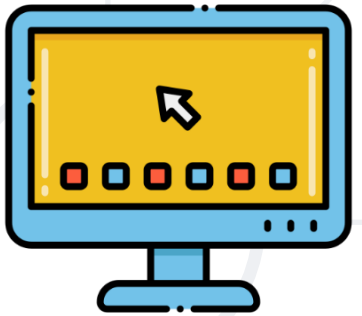
Applications Running Locally on Your Laptop

Desktop Applications

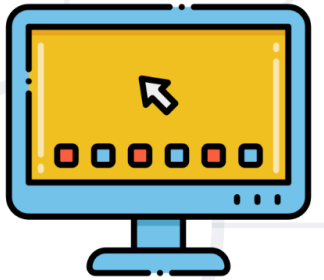
- What are **desktop apps**?
  - **Installed** and **run locally** on a user's computer
    - Store their data locally or remotely (depends)
  - **Offline access**
    - Can be used without an Internet connection
  - **More features**
    - Often more feature-rich than Web apps
    - Better integrated with the host OS

Desktop Applications (2)

- **Benefits** of **desktop apps**
  - **Performance**: faster processing and response time, as tasks are executed locally
  - **Customization**: easily tailored to individual user preferences and needs
  - **Integration**: compatible with other locally installed software and hardware
  - **Cost-effective**: one-time purchase or licensing fees, instead of recurring subscription costs (depends)

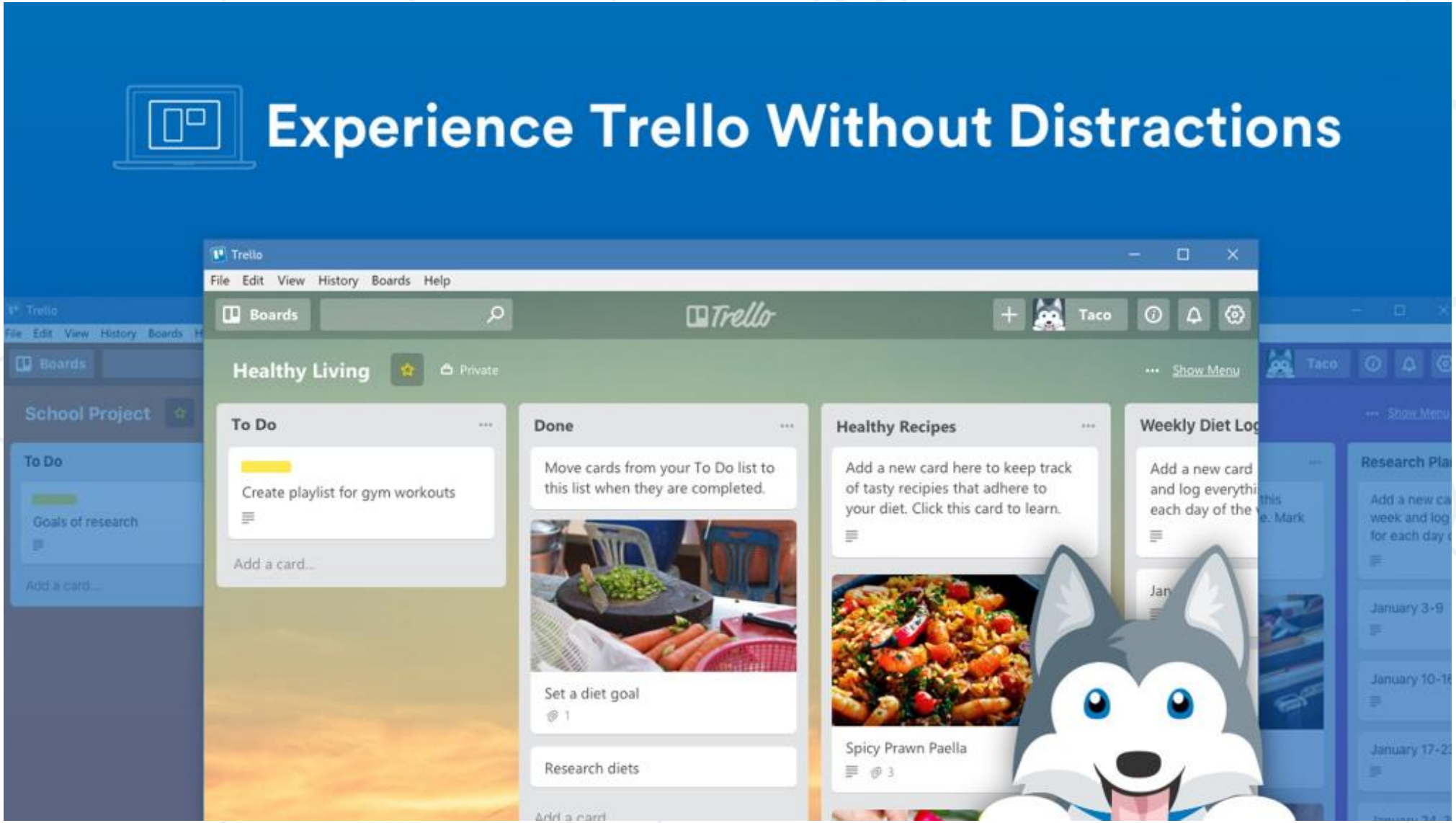


Testing Challenges for Desktop Apps

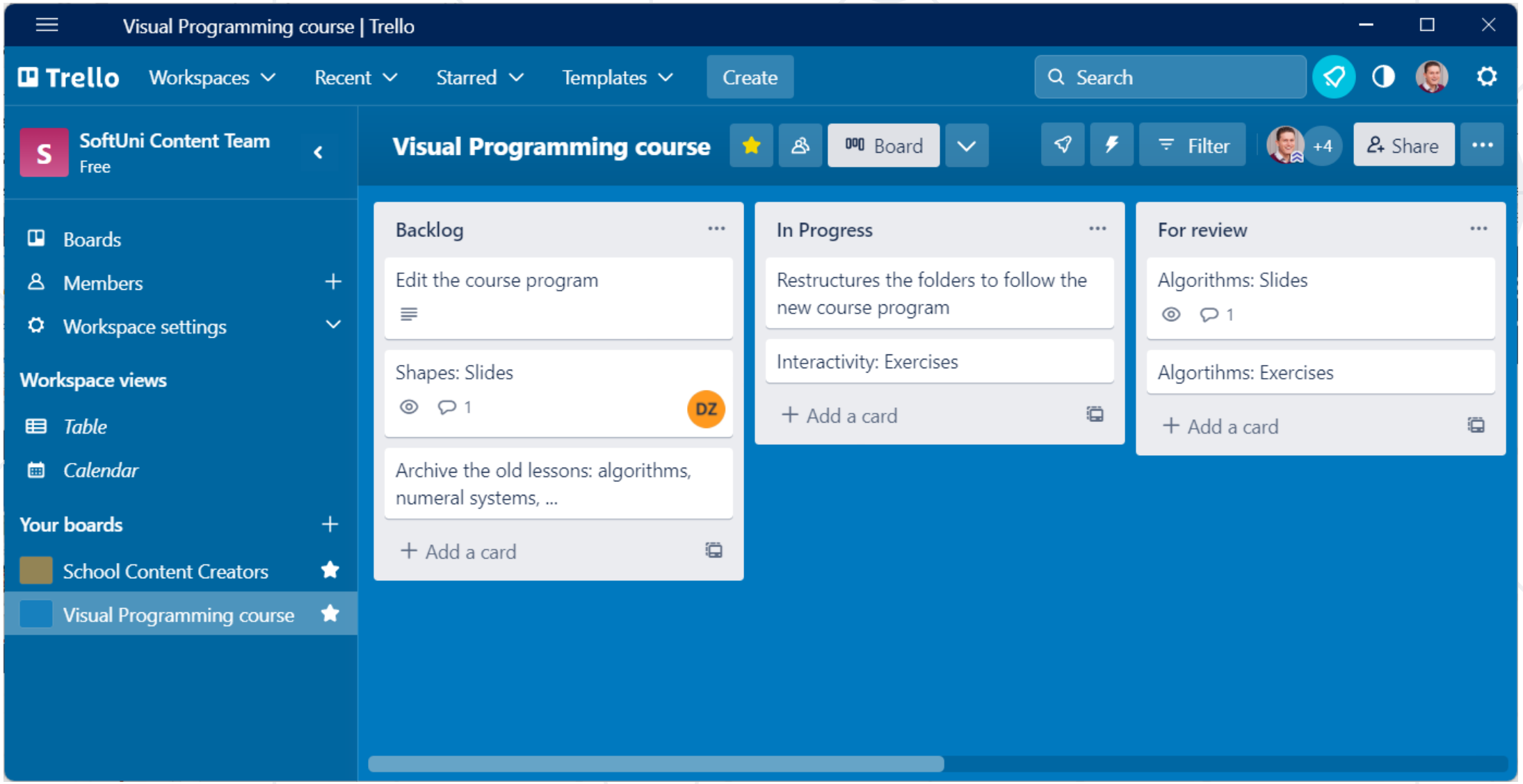


- **Installation / uninstallation** including any **dependencies** or **prerequisites**
- **Performance testing on different hardware configurations** – **processors**, **memory**, and **graphic cards**
- **Compatibility testing** for **different operating systems** and their **different versions**
- **User interface testing**: desktop apps often have complex **UI** that need to be thoroughly tested
- **Integration testing** with **other desktop applications**

Trello Project Management Desktop App



Trello Desktop App – Example

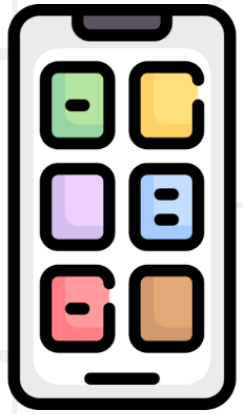


Mobile Apps

Applications Running Locally on Mobile Device

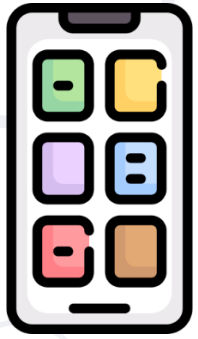
Mobile Applications

- What are **mobile apps**?
  - Designed specifically for **smartphones** and **tablets**
  - Accessible through **dedicated app stores** (e.g., Google Play, Apple App Store)
  - Optimized for **touchscreen interfaces** and mobile device features (adaptable UI design for different screen sizes)
  - Can work **offline**, **online** or mixed



Mobile Applications (2)

- **Benefits** of **mobile apps**
  - **Portability**: access apps and data on-the-go, anytime, anywhere
  - **Push notifications**: real-time updates and alerts for improved user engagement
  - **Device-specific features**: leverage device capabilities like GPS, camera, and sensors
  - **Offline functionality**: some apps can operate without an Internet connection
  - **Streamlined user experience**: tailored for smaller screens and touch-based interactions



Testing Challenges for Mobile Apps

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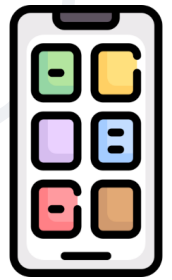
- **Compatibility** across different devices and OS versions is crucial for mobile apps (**many different devices** and **versions in use**)
- **User interface testing** – **design and layout** has significant impact on the user's experience on a **smaller screen**



- **Performance testing** – performance may be affected by **limited processing power** and **memory** on the user's device
- **Battery life testing** – to ensure that the app does not significantly **drain** the user's device **battery**

Trello Project Management Mobile App

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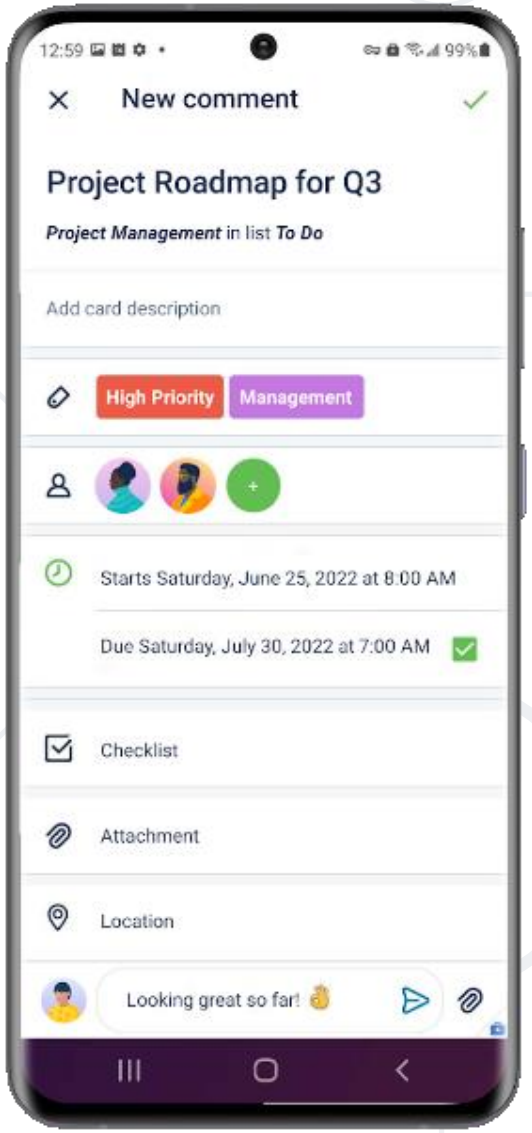
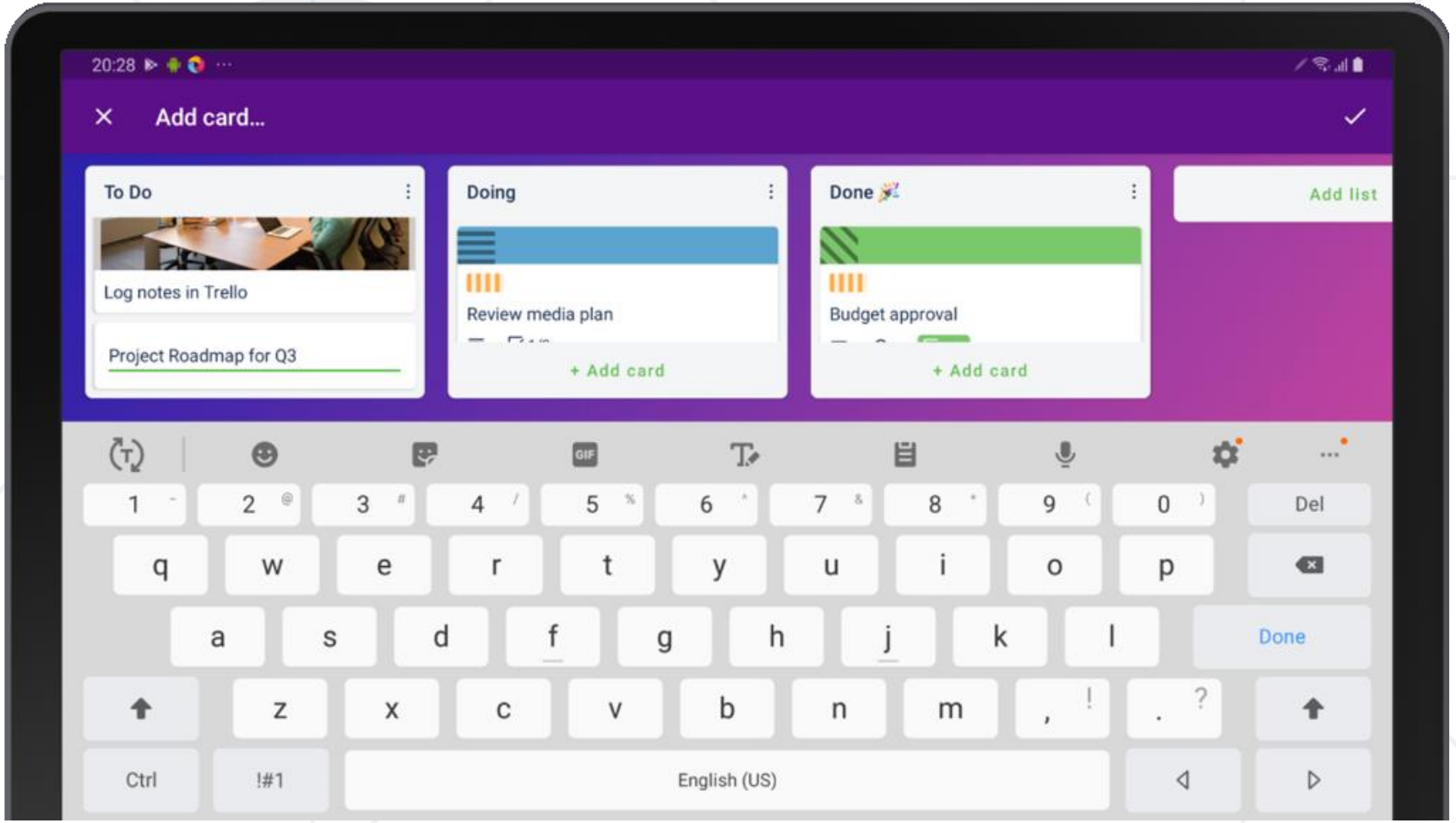
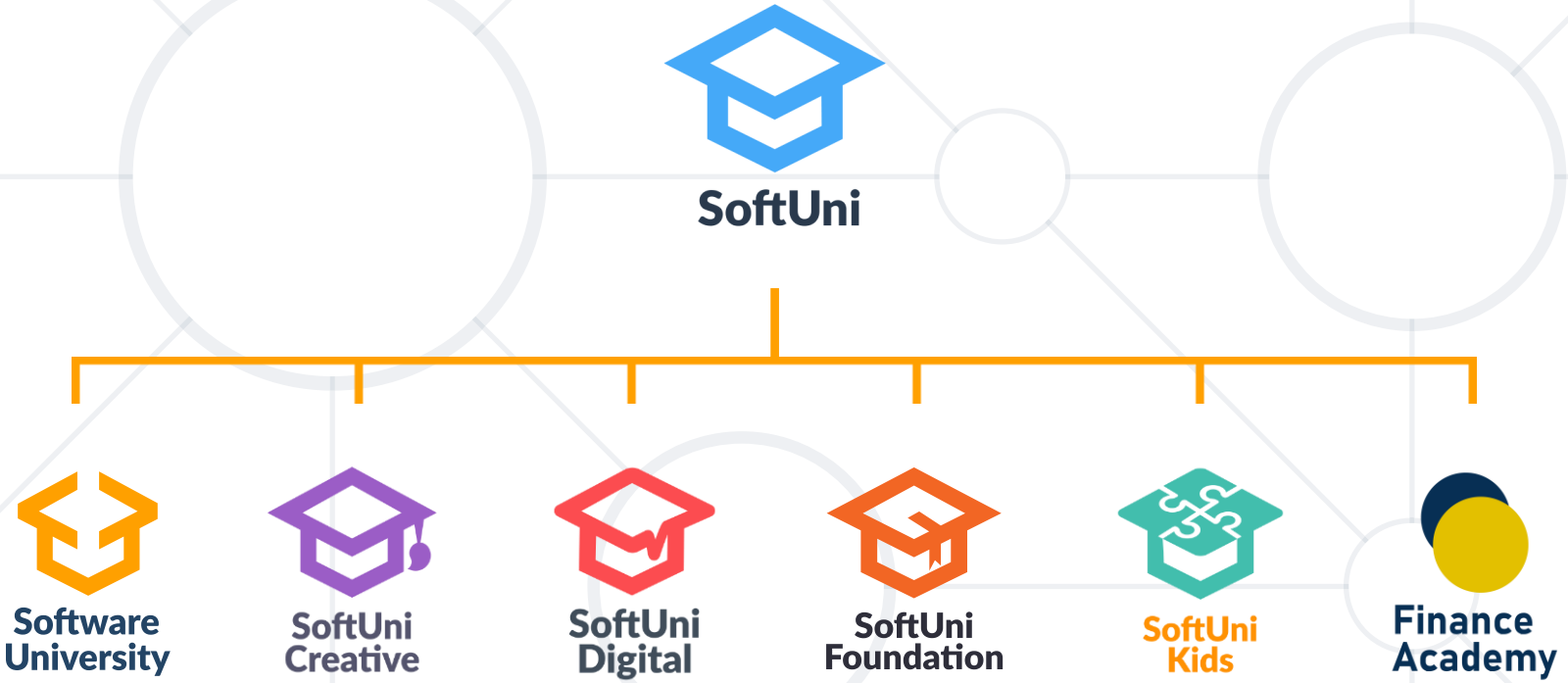




Summary

- **Hardware** is the **physical part**, whereas **software** is a **set of instructions** for the computer
  - Main computer parts are the **motherboard** (ties together all components), **CPU** (code execution), **input** / **output devices**
- **Software** – programs, running in the computer
  - **Firmware** and **system** software (OS, hypervisors)
  - **Server-side** software (back-end) vs. GUI / front-end apps
  - **Application** software (end-user apps): **Web** apps, **desktop** apps, **mobile** apps
  - **Software systems** (client + server) and **cloud apps**

Questions?



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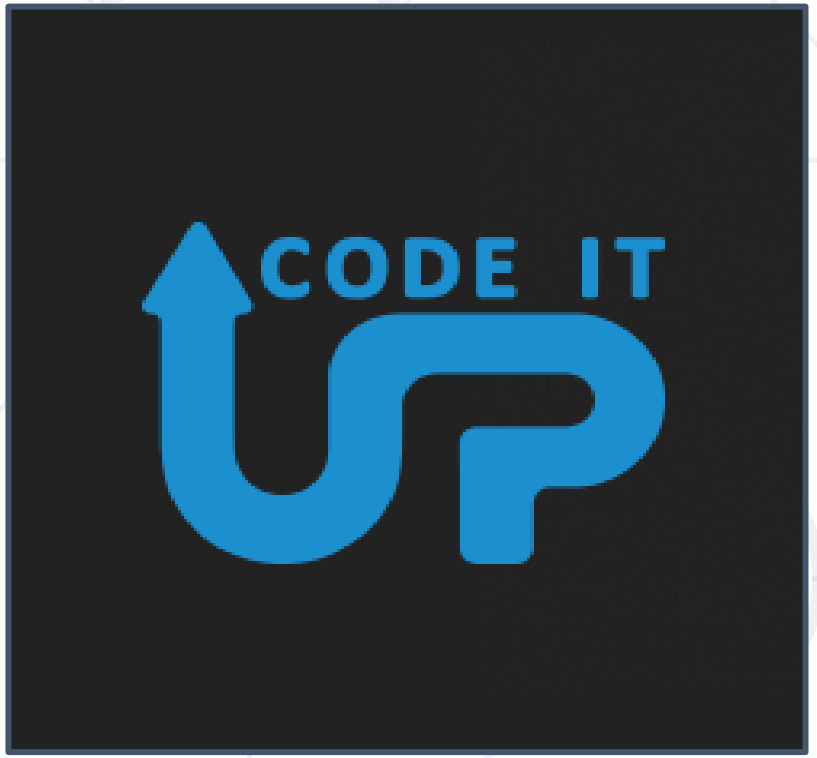

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