

CS330

Operating Systems

INTRODUCTION

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TOPICS

- Lets build a gaming system
- What are systems?
- What is a operating systems?
- OS as a resource manager
- Summary

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BUILDING A SYSTEM

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LETS BUILD A GAMING SYSTEM

Building a gaming system from scratch is the only surefire way to ensure that your system is capable of satisfying all of your personal preferences.

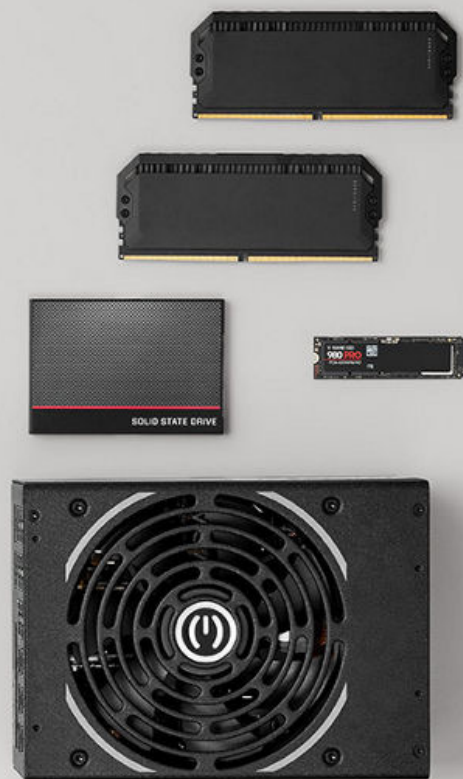
Looks complex. A big box with lots of **peripherals**.

What's in there?

Case + fans + ?



<https://www.intel.com/content/www/us/en/gaming/resources/how-to-build-a-gaming-pc.html>



Fans + Heatsink



Motherboard



RAM



Storage



Power



GPU



Processor



COMPONENTS

Central Processing Unit (CPU)

Graphics Processing Unit (GPU)

Motherboard

Memory (RAM)

Storage

Power Supply Unit (PSU)

System cooling

Gaming peripherals

Operating System (OS)



COMPONENTS

Central Processing Unit (CPU)

The brain of your PC, the CPU is responsible for executing **instructions** that are required for **programs to run**, dictating **tasks** to all other components. It impacts every facet of your experience, including gaming, streaming, content creation, and multitasking.

Faster Clock speed, more cores and more threads, enable you to do more at once, keeping your system smooth and responsive as you juggle multiple apps



COMPONENTS

Graphics Processing Unit (GPU)

Powerful components that plug into the PCIe x16 slot on your PC's motherboard. Together with the CPU, the GPU has a direct effect on your in-game FPS and is a must-have for anyone who wants to play demanding, graphics-heavy games.



COMPONENTS

Motherboard

The motherboard is the main circuit board and is connected to everything. The CPU sits directly on the motherboard and every other component—graphics cards, hard drives, memory, optical drives, wireless cards—integrates into the motherboard.



COMPONENTS

Putting all together

All components connect to the motherboard.

RAM

M.2 SSD

SSD / HDD

Mounting paste + CPU

CPU Fan

GPU

You have a barebone PC!



COMPONENTS

Test run outside the case

Connect the barebone PC to your monitor using HDMI cable. Bootup, you can see the BIOS program loading...



COMPONENTS

All ok!!!

Get the case ready.
Install Power supply,
and hookup all the
components in the ATX
Case.

Your box is ready.... Or
is something missing??

Operating system



COMPONENTS

Installing OS

BIOS program directs to the **Bootloader**
(Bootstrap program).

Get USB ready! What OS
you want to install?

Microsoft Windows

Linux

Unix

MacOS

ROS

...



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WHAT ARE SYSTEMS?

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WHAT ARE SYSTEMS

A **SYSTEM** is a collection of **hardware**, **software**, and **data** working together to *process information* and *complete tasks*. It takes an *input*, *processes* the data through a set of rules, and *outputs* a result.

Core Components

Hardware: Physical parts like the CPU, memory, and screens.

Software: Code and programs that tell the hardware what to do.

Data: Information that enters the system and gets changed

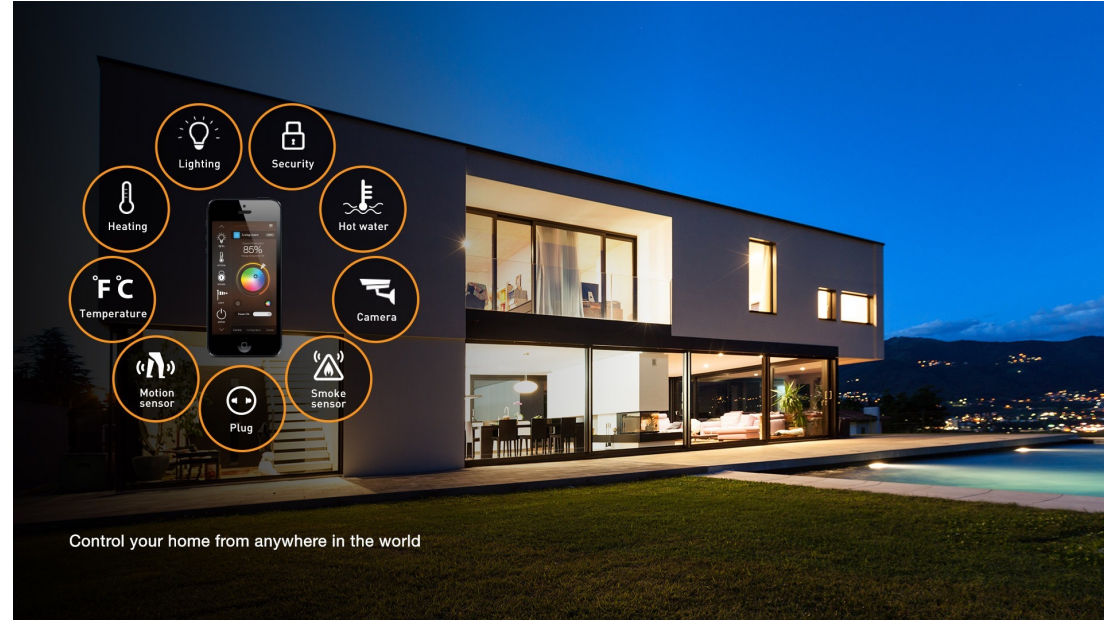
Examples:

Operating Systems, Embedded Systems, Database Systems, Networked Systems, etc.

WHAT ARE SYSTEMS



Autonomous cars

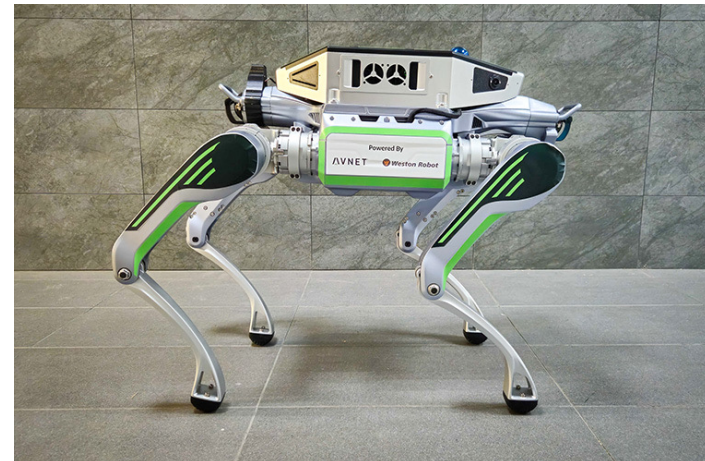


Smart Homes

Smart healthcare



AI & Robotics



WHAT ARE SYSTEMS

Autonomous car

An autonomous car is a complex **system of systems** that takes **inputs** from the *environment*, **processes** that data in real time, and **executes** precise physical actions.

Input: LiDAR, cameras, Radar, GPS/IMU

Process: Sensor fusion, Path planning, Control of mechanical components.

Output: Steering actuators, Throttle/braking, signaling etc.



WHAT ARE SYSTEMS

Smart Home

A smart home is a **distributed computing system** that *connects* everyday household appliances and devices to a *local network*, allowing them to *communicate* with each other and be *controlled automatically* or *remotely*.

Input: Environment sensors, water leakage, voice recognition, status monitors etc.

Process: Home assistance, cloud platform, Wifi connectivity etc

Output: Climate control, Lighting, security etc.



WHAT ARE SYSTEMS

Data centers

- Hundreds/thousands of servers
- Network gear (cables, switches, routers)
- Racks, Floors
- Cooling Units



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WHAT IS A OPERATING SYSTEM

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OPERATING SYSTEM IN A NUTSHELL

The **Operating System (OS)** acts as the foundational software manager. It sits directly between the **physical hardware** (e.g. sensors, chips, actuators) and the **Software** (eg. AI driving algorithms or smart home automation rules)

A OS manages all the **physical components** so that software programs *don't have to worry about* how the hardware works.

WHAT IS A OPERATING SYSTEM

Famous Operating Systems

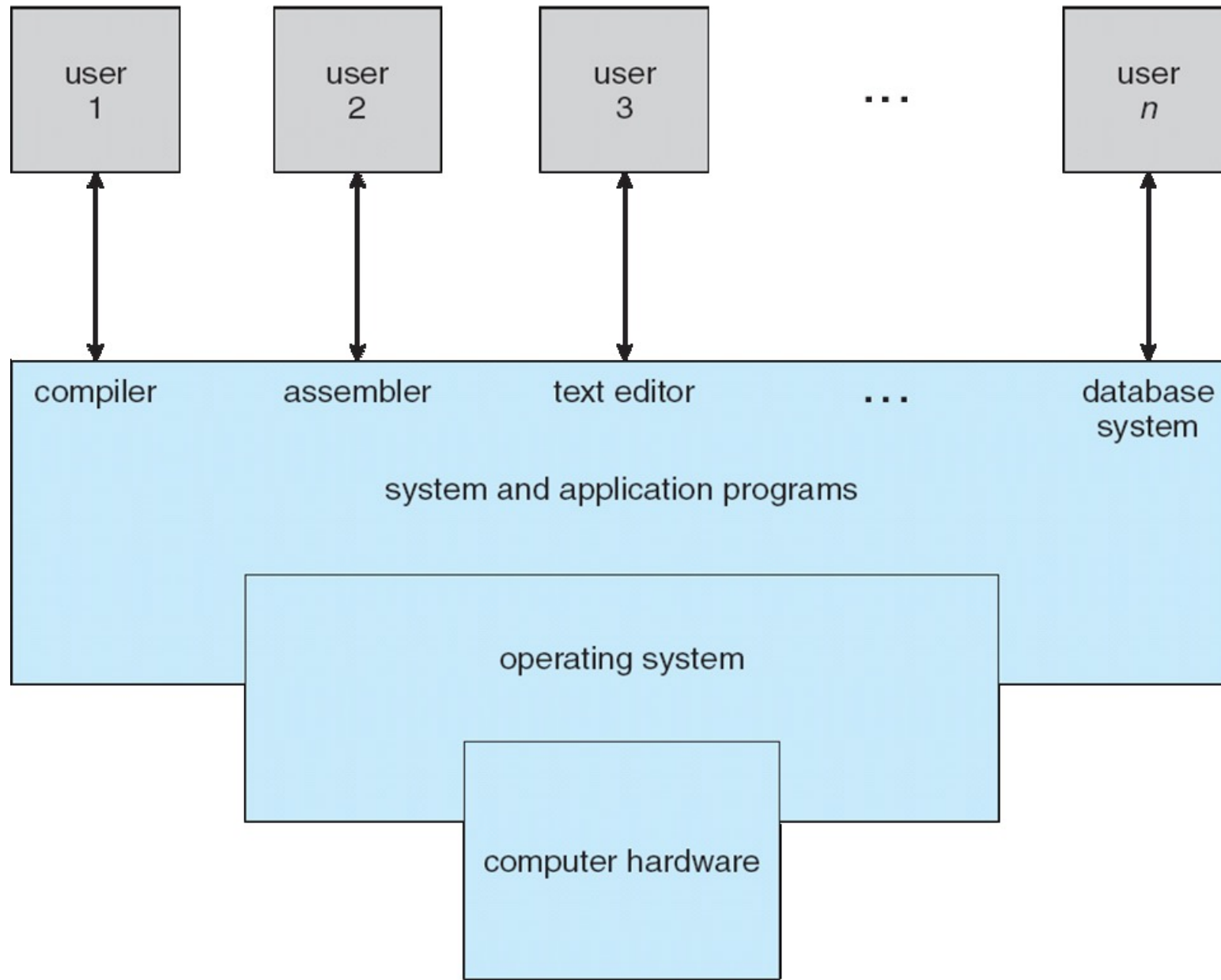


OPERATING SYSTEM

Computer system can be divided into **four** components:

- **Hardware** – provides basic computing resources
 - CPU, memory, I/O devices
- **Operating system**
 - Controls and coordinates use of hardware among various applications and users
- **Application programs** – define the ways in which the system resources are used to solve the computing problems of the users
 - Word processors, compilers, web browsers, database systems, video games
- **Users**
 - People, machines, other computers

OPERATING SYSTEM



OPERATING SYSTEM ROLE

OS is a **resource allocator**

- Manages *all resources*: A computer system has many resources that may be required to solve a problem: **CPU time, memory space, file-storage space, I/O devices**, and so on. The operating system acts as the **manager** of these resources.
- Decides between conflicting requests for **efficient** and **fair resource use**.

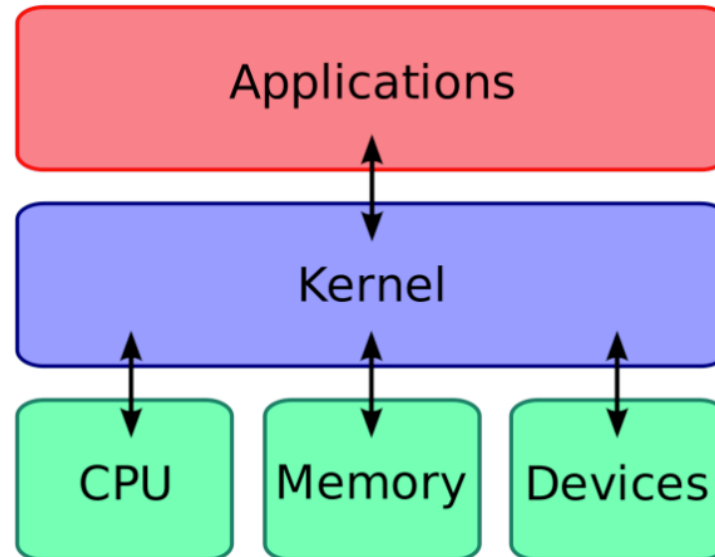
OS is a **control program**

- **Controls execution** of programs to **prevent** errors and **improper use** of the computer.

OPERATING SYSTEM

A kernel is “The one program running at all times on the computer”

- Everything else is either
 - A **system program** (ships with the operating system, but not part of the kernel)
 - or
 - An **application program**, all programs not associated with the operating system



OPERATING SYSTEM

A bootstrap program is loaded at power-up or reboot

- Typically stored in **ROM** or **EPROM** (Erasable Programmable ROM), generally known as **firmware**
- **Initializes** all aspects of system: from CPU registers to device controllers to memory contents.
- The bootstrap program must know how to load the **operating system** and how to start executing the system.

GOALS OF A OPERATING SYSTEM

The primary goals of an operating system (OS)

- **User Convenience:** It should be easy to use, providing a user-friendly interface and making it simple to interact with the system.
- **Program Execution:** It facilitates the execution of user programs, providing the necessary environment and services for them to run.
- **Resource Management:** The OS manages and allocates the computer's resources, including the CPU, memory, disk storage and input/output devices, to ensure fair utilization.
- **Security:** The OS protects the system and user data from unauthorized access, ensuring confidentiality, integrity and availability of information.

Additionally:

- **Efficient Resource Utilization:** It should aim to maximize the performance and utilization of computer resources like CPU, Memory and I/O devices, ensuring that the system runs smoothly and efficiently.
- **Reliability:** It should be robust and reliable, able to handle errors and exceptions gracefully, ensuring that the system continues to operate smoothly.

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OS AS A RESOURCE
MANAGER

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OS AS A RESOURCE MANAGER

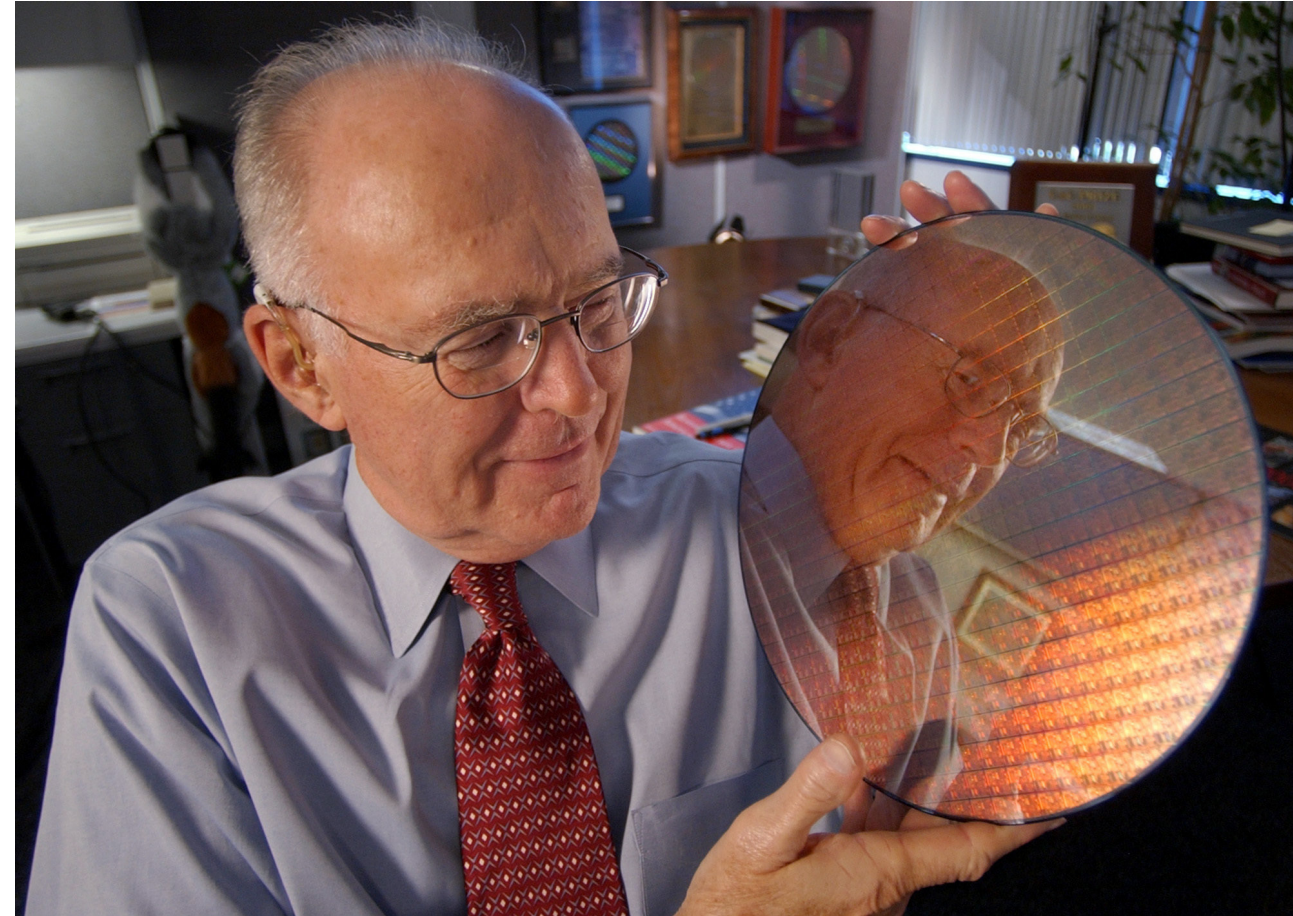
- A OS manages hardware:
 - Processor(s)
 - Memory / RAM
 - Disk / Storage



OS AS A RESOURCE MANAGER

Moore's law

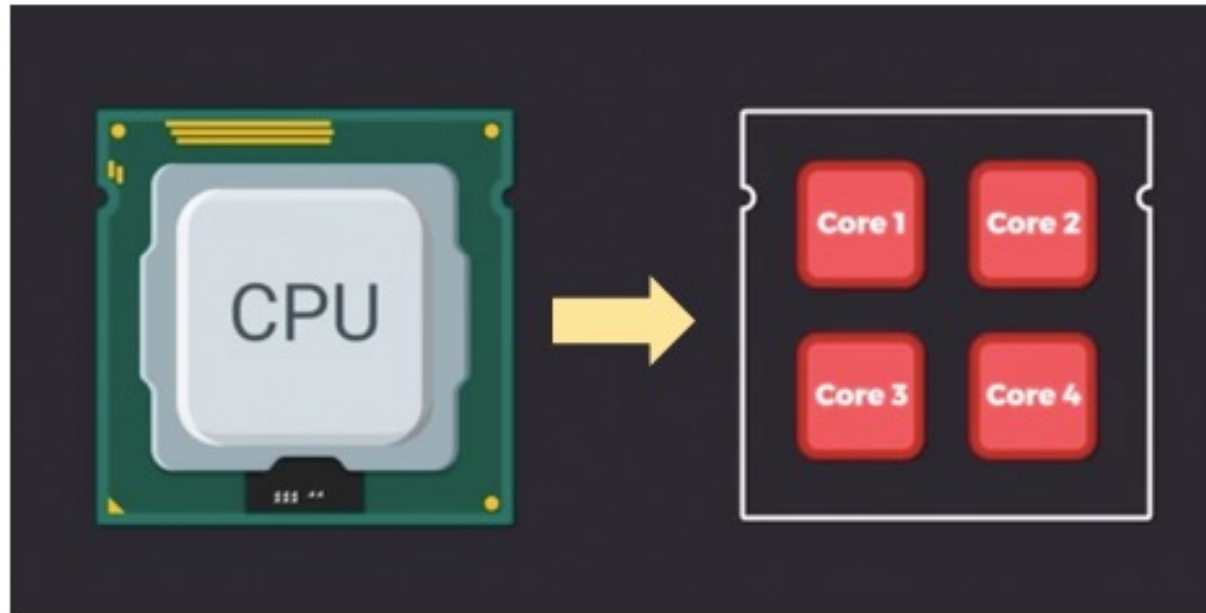
“The number of transistors on a microchip doubles approximately every two years, while the cost of computers is halved”



OS AS A RESOURCE MANAGER

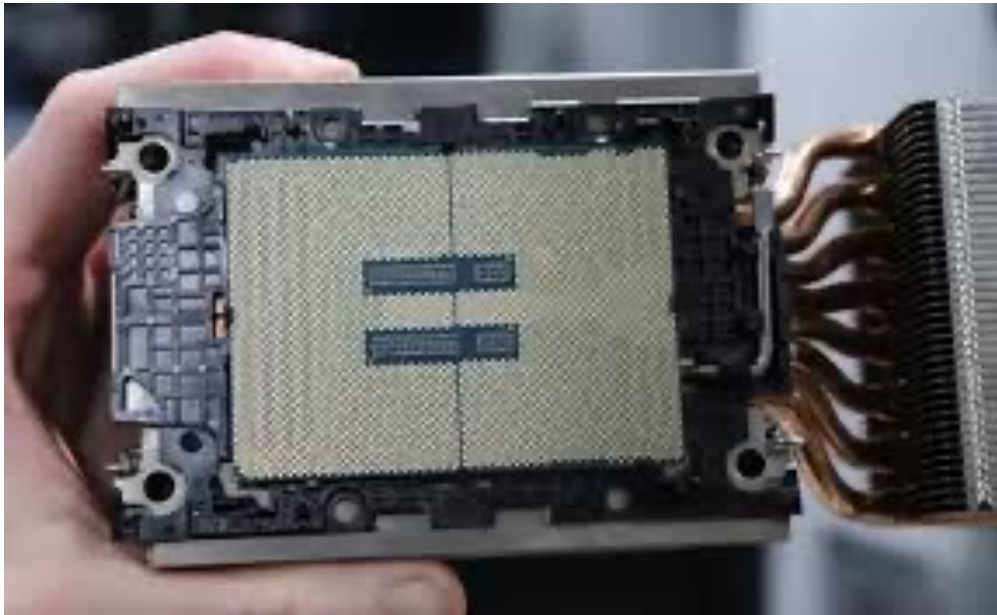
Multi-core processors

- Modern processors have multiple cores [Multi-core systems]
- Each core can execute parts of a program
- Lots of requests may occur at the same time
- Need to deal with **concurrent** requests



OS AS A RESOURCE MANAGER

- Multicore processors
 - Adding more processor cores helped improve performance; but need to write multi-threaded programs
 - Intel Xeon 8490h 1.90GHz~3.50GHz **60Core**/120Thread Processor (15000 USD)
 - Apple M3 Ultra 32-core CPU/ **80 Core** GPU
 - Nvidia Geforce RTX 4090 **18,432** CUDA **cores**



OS AS A RESOURCE MANAGER

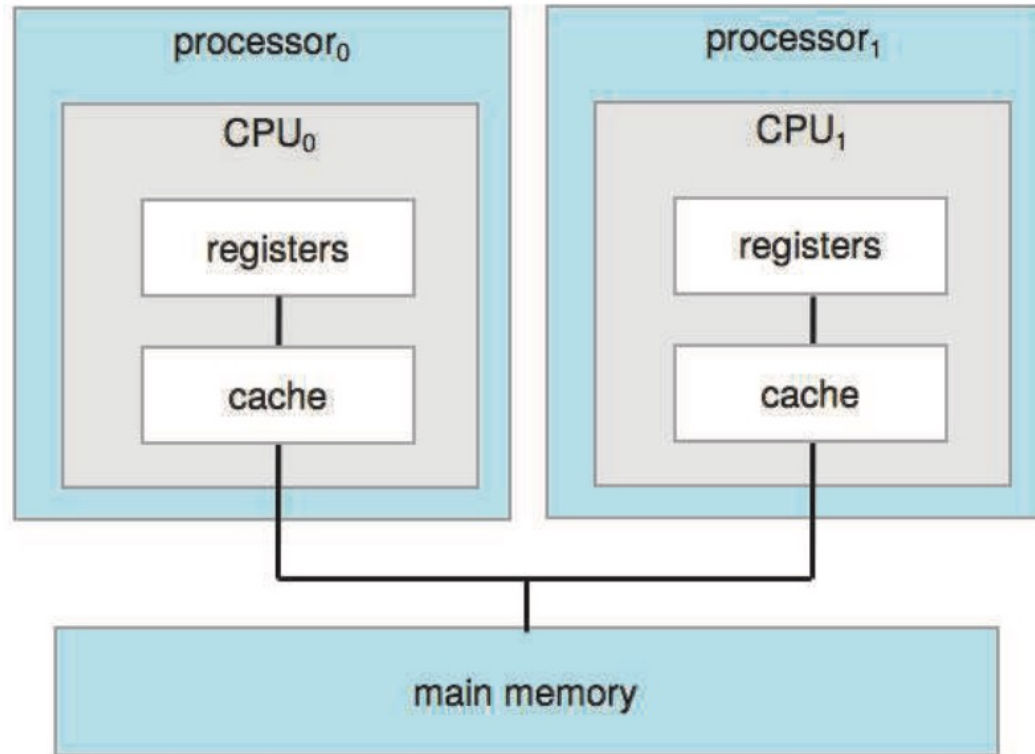


Figure 1.8 Symmetric multiprocessing architecture.

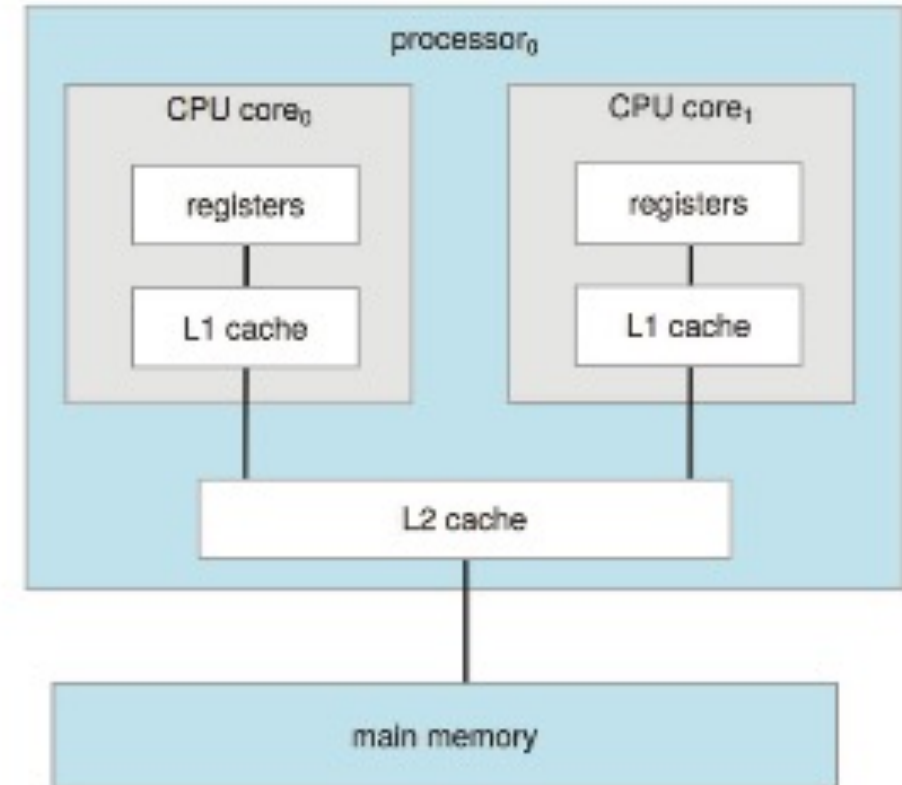


Figure 1.9 A dual-core design with two cores on the same chip.

OS AS A RESOURCE MANAGER

- Memory Manager
 - Single computer
 - Shared Memory computer
 - Distributed Memory computer
 - Non-uniform memory access computer

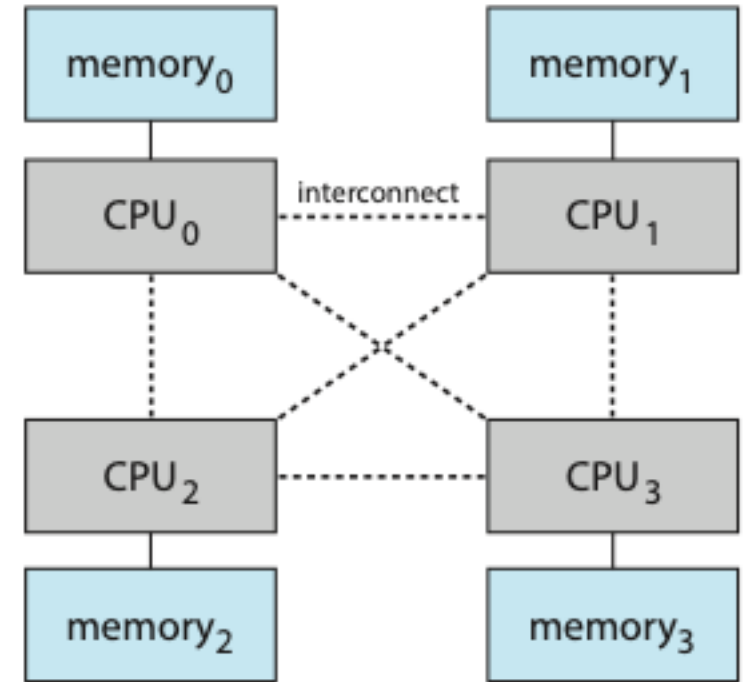
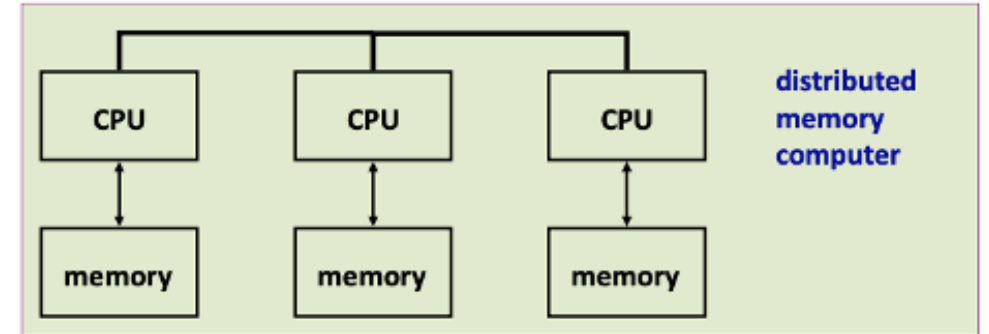
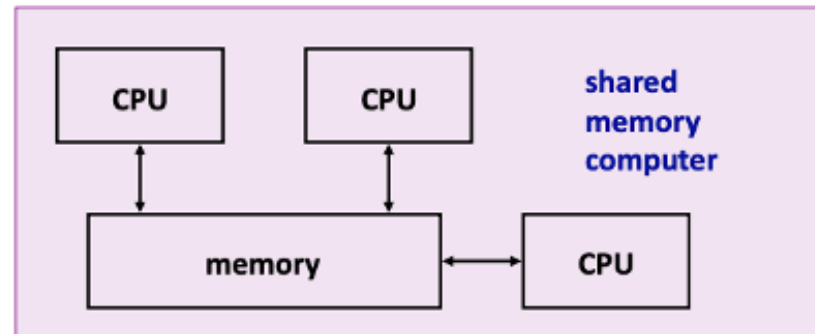
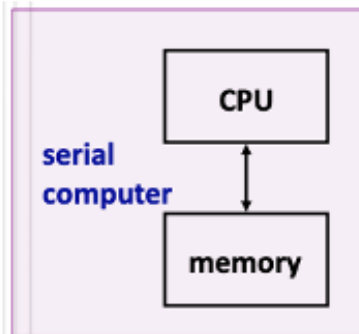


Figure 1.10 NUMA multiprocessing architecture.



OS AS A RESOURCE MANAGER

- Storage Manager

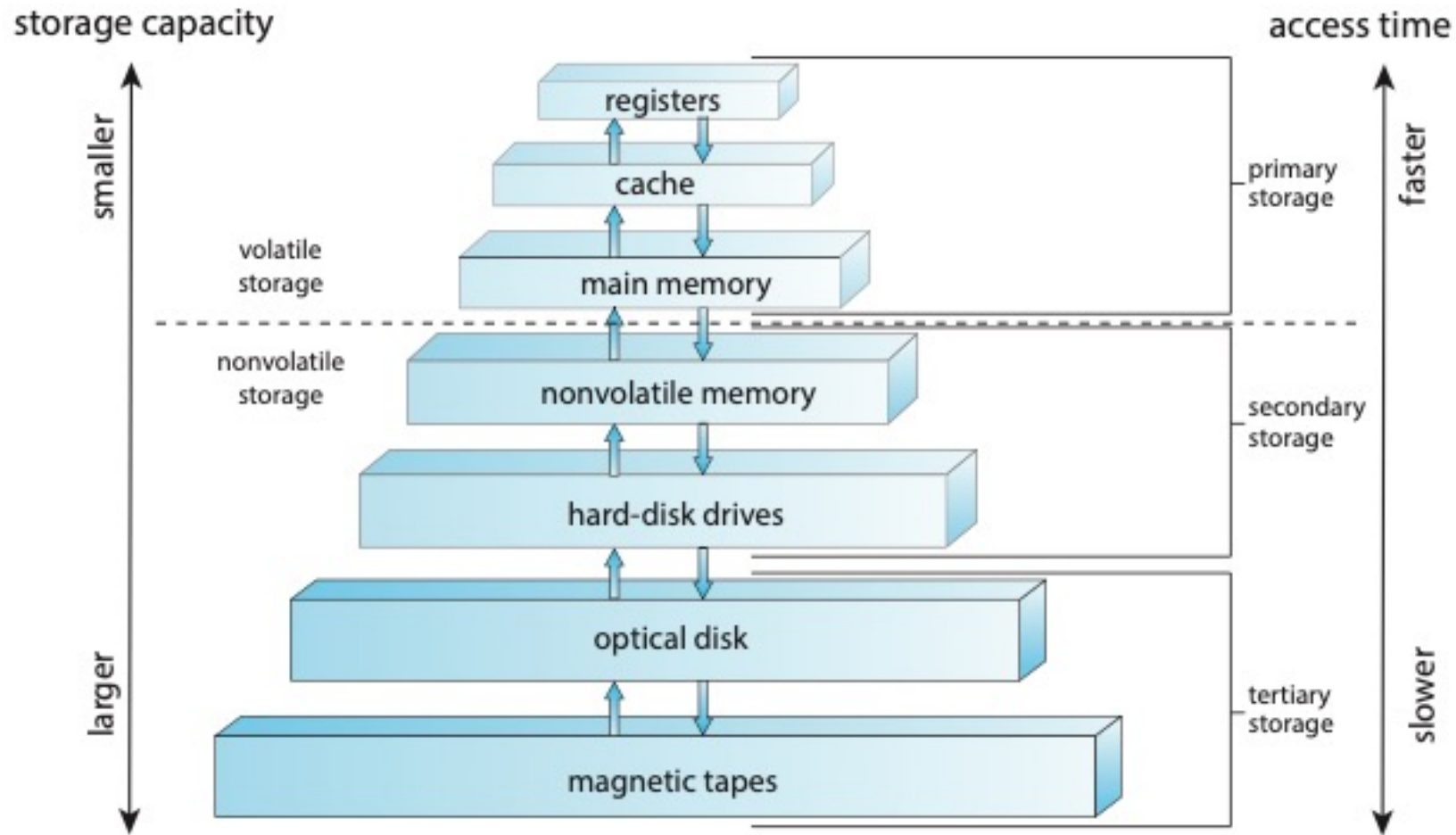


Figure 1.6 Storage-device hierarchy.

SUMMARY

- A **SYSTEM** is a collection of **hardware**, **software**, and **data** working together to *process information* and *complete tasks*
- The **Operating System (OS)** acts as the foundational software manager. It sits directly between the **physical hardware** and the **Software**
- A OS manages all the **physical components** so that software programs *don't have to worry about* how the hardware works.