CSE 323: Operating System Design

Introduction

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North South University (NSU)

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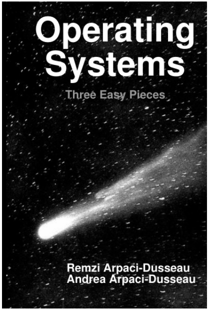
Original slides by Mathias Payer and Sanidhya Kashyap [EPFL]

Lecture Topics

- What you will learn in this course (and how)
- What an OS is and why you want one
- Why you should know about OSes

Class Materials

- **Slides** and **Lectures** on OS Design
- Textbook: Operating Systems: Three Easy Pieces
- Other Books:
  - Operating System Concepts, Silberschatz, Galvin & Gagne, 10th ed. (Wiley, 2019)
  - Modern Operating Systems, Tanenbaum & Bos, 4th ed. (Pearson, 2015)
- Coding Examples & Practice Problems



Grading & Office Hours

- **Assessment Methods**

Assessment Item	**Weight (%)**
Attendance	5
Assignment	5
Class Test	20
Mid Term	30
Final Exam	40

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- **Counseling Hours**

Day	Time
Saturday & Tuesday	10:00 AM – 11:00 AM
Sunday & Wednesday	11:00 AM – 01:30 PM

- **Contact**: Office: **719(A)** Email: salman@cse.uiu.ac.bd

What is an Operating System?

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User

Hardware

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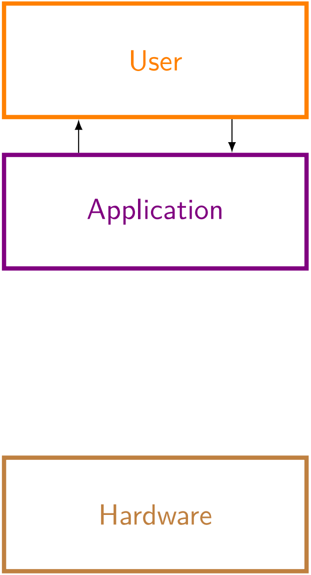

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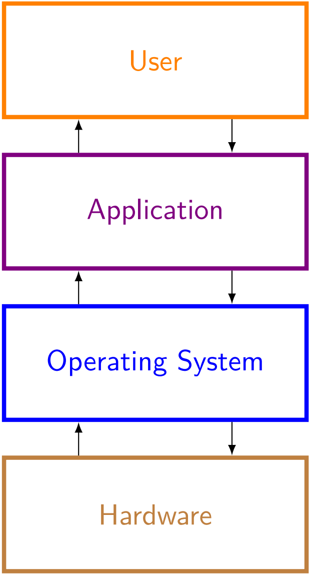

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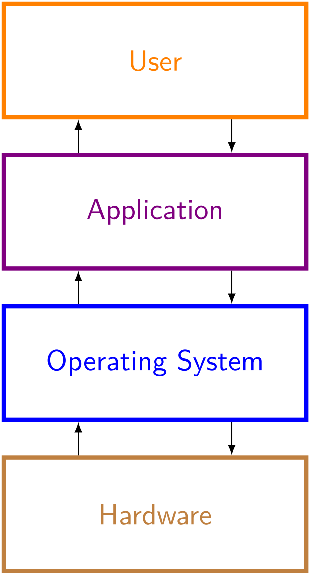

OS is middleware between applications and hardware.

- Provides standardized interface to resources
- Manages hardware
- Orchestrates currently executing processes
- Responds to resource access requests
- Handles access control

OS role #1: Standardized Interface

- Provides **common functionality** to access resources.
- Abstracts hardware, provides a **unified interface**.
    - Example: Network chips A and B are accessed using the same network API that allows sending and receiving packets.
- **Virtualization / Abstraction** of physical resources.

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- Abstracts hardware, provides a **unified interface**.
  - Example: Network chips A and B are accessed using the same network API that allows sending and receiving packets.
- **Virtualization / Abstraction** of physical resources.
- **Challenges:**
  - Defining the correct abstractions (e.g., what level)
  - What hardware aspects should be exposed and how much

OS role #2: Resource Management

The OS shares (limited) resources between applications.

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- Isolation: protect applications from each other
- Scheduling: provide efficient and fair access to resources
- Limit: share access to resources

OS Role Analogy

The OS is like a waiter that serves individual clients. The waiter knows the menu, records orders, and delivers food to the right table while keeping track of the bill.

Figure 1: OS as a waiter for processes

What management services does an OS provide?

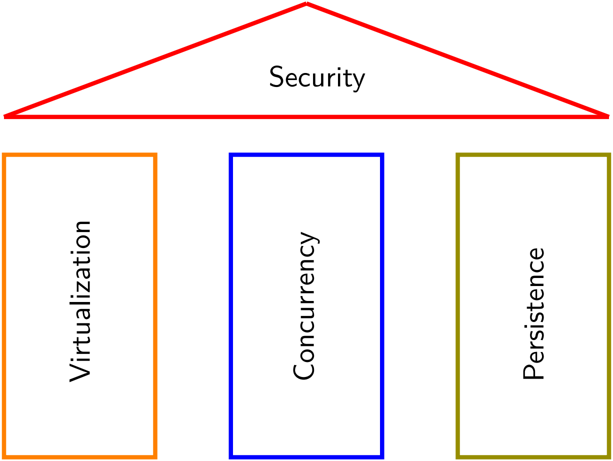
- ***CPU:*** initializes program counter/registers, shares CPU
- ***Program memory:*** initializes process address space, loads program (code, data, heap, stack)
- ***Devices:*** read/write from/to disk; device driver is hardware specific, abstracts to common interface

(Short) History of Operating Systems

- Started as a convenience library of common functions
- Evolved from procedure calls to system calls
- OS code executes at higher privilege level
- Moved from single process to concurrently executing processes

OS Building Blocks

OS design nicely separates into three pillars, with security as a transcendental layer covering/overarching all pillars.



Building block: Virtualization

Each application believes it has all resources for itself

- ***CPU:*** unlimited amount of instructions, continuous execution
- ***Memory:*** unlimited memory is available
- ***Challenge:*** how to share constrained resources

Building block: Concurrency

OS must handle ***concurrent events*** and untangle them as necessary.

- Hide concurrency from ***independent*** processes
- Manage concurrency from ***dependent*** processes by providing synchronization and communication primitives
- ***Challenge:*** providing the right primitives

Building block: Persistence

Lifetime of information is greater than lifetime of a process.

- Enable processes to access ***non-volatile information***
- Abstract how data is stored (through a file system)
- Be ***resilient to failures*** (e.g., power loss)
- Provide ***access control***
- ***Challenge:*** authentication and permissions

Building block: Security

OS is a gatekeeper, it ensures and enforces security. OS is also privileged and therefore frequently attacked.

- ***Isolate*** processes from each other and the OS
- ***Authenticate*** users (who is allowed to do what)
- Protect itself against malicious network/user input
- Harden program execution (through mitigations)
- ***Challenge:*** performance versus security

Why you should study OS!

- Build, modify, or administer an operating system.
- Understand design decisions
- Understand system performance
- Enables understanding of complex systems
- Turns you into a better (systems) programmer