OS Overview

(Usage hints for this presentation)

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Agenda

- 1. Introduction
- 2. OS Plan

1. Introduction

1.1. Recall: Big Picture of IT Systems

- Explore **abstractions bottom-up**
  - **Computer Architecture**: Build computer from logic gates
    - Von Neumann architecture
    - CPU (ALU), RAM, I/O
  - **Experiment with OS concepts**
    - Explain core OS **management** concepts, e.g., processes, threads, virtual memory
    - Use GNU/Linux command line and explore system
  - **Experiment with containerization** for cloud infrastructures
    - Explain core concepts
    - Build images, run Docker **containers** and Kubernetes cluster

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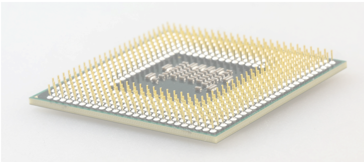

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"Tux, the Linux mascot" under CC0 1.0; from Wikimedia Commons

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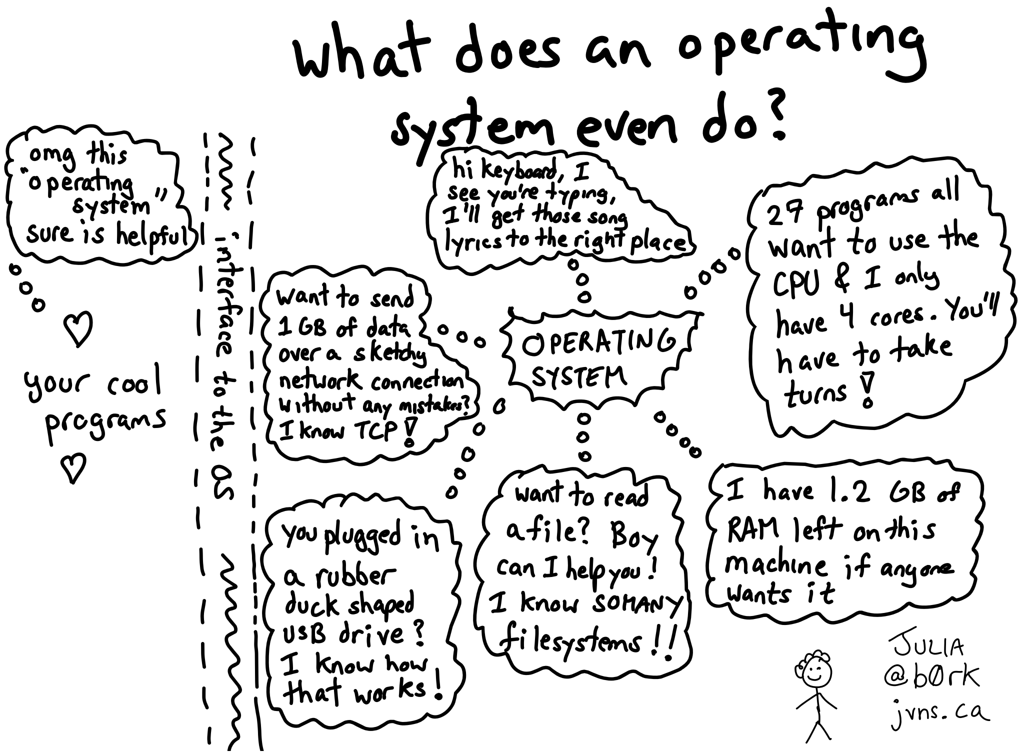
"Kubernetes logo" under Kubernetes Branding Guidelines; from GitHub

1.1.1. OS Responsibilities

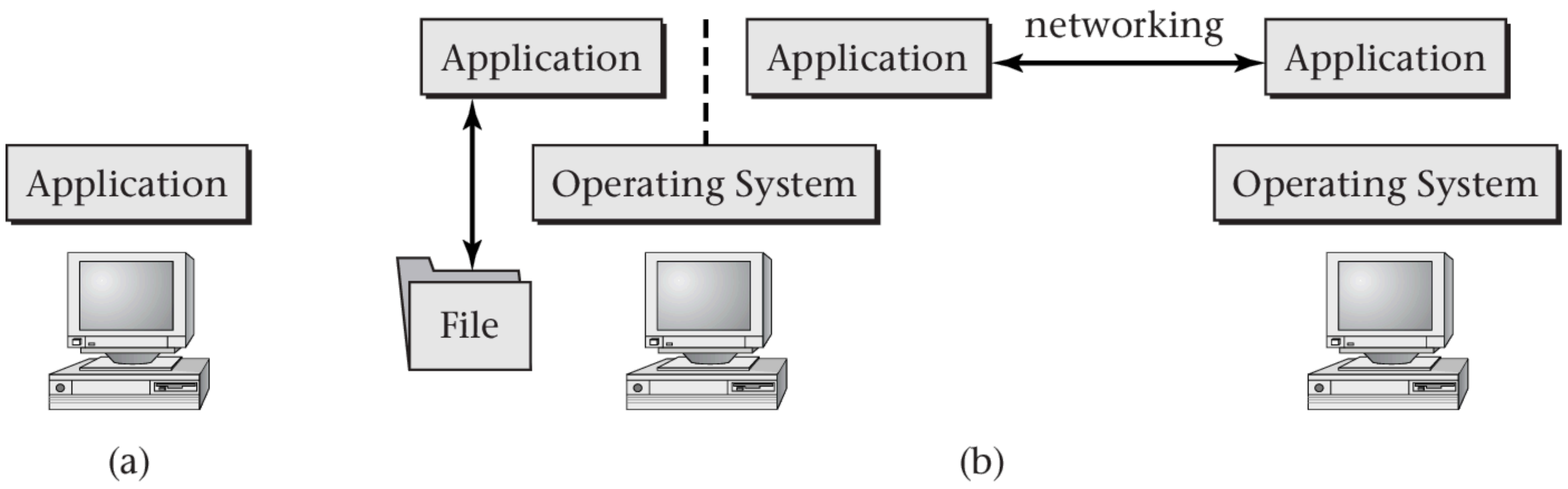


What does your OS even do?

Figure © 2016 Julia Evans, all rights reserved; from julia's drawings. Displayed here with personal permission.

1.1.2. Definition of Operating System

- Definition from (Hailperin 2019): **Software**
  - that **uses hardware** resources of a computer system
  - to provide support for the **execution of other software**.



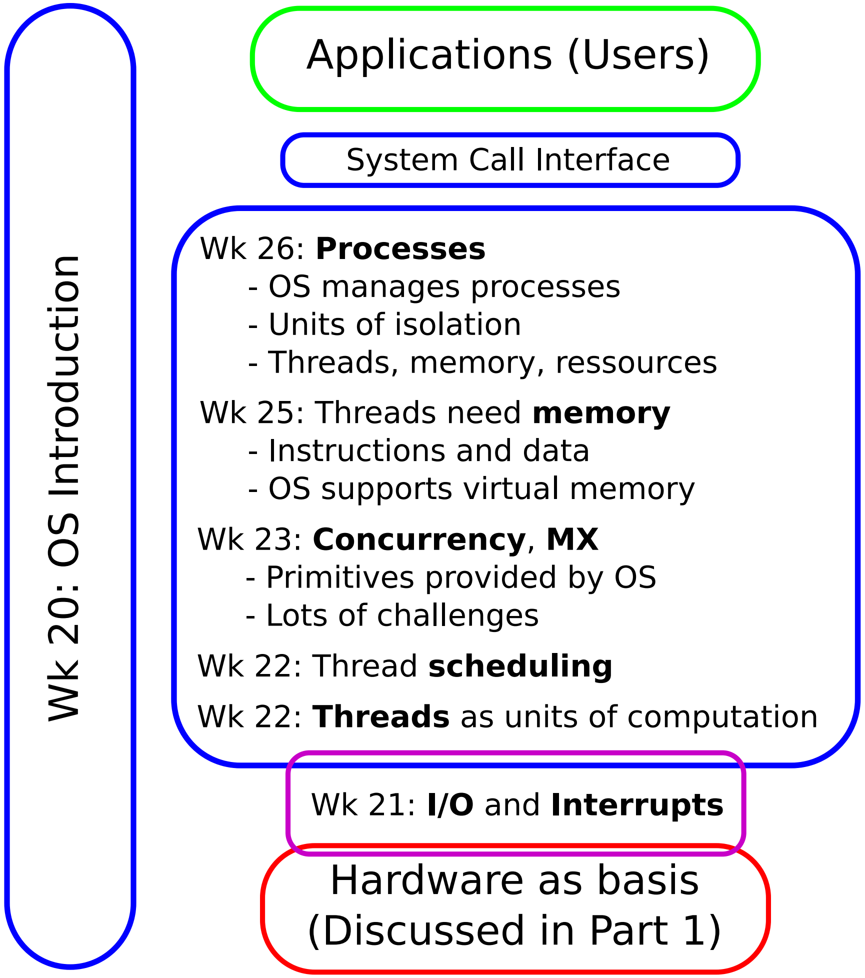
“Figure 1.1 of (Hailperin 2019)” by Max Hailperin under CC BY-SA 3.0; converted from GitHub

1.2. Prerequisite Knowledge

- Be able to write, compile, and execute small *Java* programs
  - What is an object? What is the meaning of `this` in Java?
  - How do you execute a program that requires a command line argument?
- Be able to explain basic *data structures* (stacks, queues, trees) and *algorithms* (in particular, hashing)
- Being able to explain the database *transaction concept* and *update anomalies*

2. OS Plan

2.1. Big Picture of OS Part



Speaker notes

Although the Hack computer does not have an OS, it will help to recall how you interact with that machine. On Hack, you are able to run a single program, where you access hardware directly. E.g., reading from the keyboard requires access to a special memory location that represents the state of the underlying hardware device.

With OSs, applications no longer have direct access to hardware. Instead, OSs manage applications and their use of hardware. You will learn that the core part of OSs is called kernel, and each vendor’s kernel comes with a specific interface to provide functionality to applications, usually in the form of so-called system calls. E.g., when you access `System.in` in Java to read keyboard input, the Java runtime executes a system call to ask the OS for keyboard input.

Starting from system calls, we will look into techniques for input/output processing (I/O for short) such as access to the keyboard. Recall that in Hack you programmed a loop to wait for keyboard input. Clearly, such a loop keeps the CPU busy even if no key is pressed, wasting the resource CPU if other applications could perform useful computations. Hence, I/O is usually paired with interrupt processing, which does not exist in Hack. Briefly, interrupts indicate the occurrence of external events, and OSs come with interrupt handlers. Then, for example, keyboard processing code only runs in response to key presses.

In contrast to Hack, OSs manage the execution of several applications, and each application might contain several so-called threads of execution. It is up to application programmers to decide how many threads to use for a single application (and you will create threads in Java).

The OS manages all those threads and their scheduling for execution on the CPU (or their parallel execution on multiple CPU cores). Usually, scheduling mechanisms involve time slicing, which means that each thread runs for a brief amount of time before the OS schedules a different thread for execution. Such scheduling happens in intervals of about 10 to 50 milliseconds, creating the illusion of parallelism even if just a single CPU core exists. Such time-sliced or parallel executions are also called concurrent executions.

If shared resources are accessed in concurrent executions, subtle bugs may arise, a special case of which are update anomalies in database systems. The notion of mutual exclusion, MX for short, generalizes several synchronization mechanisms to overcome concurrency challenges, and we will look at typical related OS mechanisms and their use in Java.

Just as in Hack, instructions and code of applications need to be stored in memory. Differently from Hack with its Harvard architecture, code and instructions are stored uniformly in RAM in our von Neumann machines, and the OS manages the allocation of RAM. Importantly, mainstream OSs provide support for virtual memory, which does not exist in Hack. Briefly, with virtual memory the OS manages the allocation of memory in the form of RAM and disk space to all running applications.

Bringing all these concepts together, mainstream OSs manage processes as abstraction for resource management of applications, where the OS isolates different processes from each other. Importantly, threads of a single process cooperate and share resources (such as virtual memory or files).

To sum up, this figure visualizes what OS topics will be discussed when, and how topics build upon each other.

Note that some parts of this figure are hyperlinked to other presentations, which the mouse pointer should indicate.

2.2. A Quiz

Did you get an overview?

1. Select correct statements about OS concepts (1/3).
   - [ ] The main part of an OS is called core.
   - [ ] The main part of an OS is called kernel.
   - [ ] Applications use special registers or memory locations to interact with hardware.
   - [ ] Application code invokes system calls to interact with hardware.
   - [ ] Hardware devices can trigger interrupts to indicate events that should be handled by the OS.
2. Select correct statements about OS concepts (2/3).
   - [ ] The OS manages the execution of applications in terms of threads.
   - [ ] The OS creates a new thread for each system call.
   - [ ] The OS schedules threads for execution on CPU cores.
   - [ ] The OS creates new threads to make use of all CPU cores.
   - [ ] Time-slicing creates an illusion of parallelism on single CPU cores.
   - [ ] The OS locks shared resources to avoid update anomalies.
3. Select correct statements about OS concepts (3/3).
   - [ ] Kernel code is stored in ROM.
   - [ ] Applications can access more RAM if they need it.
   - [ ] The OS manages applications as processes.
   - [ ] The OS allocates RAM as part of virtual memory.
   - [ ] Threads of a process share resources.
   - [ ] The OS protects files with encryption.

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Bibliography

Hailperin, Max. 2019. *Operating Systems and Middleware – Supporting Controlled Interaction*. revised edition 1.3.1. https://github.com/Max-Hailperin/Operating-Systems-and-Middleware--Supporting-Controlled-Interaction.

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