Processes

CPEN333 – System Software Engineering

2023 W1

University of British Columbia

Introduction

- A process is a basic unit of execution.

- Normally, many processes run on a computer.
  - We discussed that process management is one of the responsibilities of an operating system.

- We are going to discuss some essential concepts related to processes here, and will focus on implementing multi-processing applications next.

Objectives

- To introduce the notion of a process
  - that is a program in execution, which forms the basis of all computation

- To describe a few features of processes, including
  - creation,
  - termination,
  - scheduling

Process Concept

- Current-day computer systems allow multiple programs to be loaded into memory and executed concurrently, as opposed to earlier computers which would allow only one program to be executed.

- An operating system executes a variety of programs, and potentially, many processes can execute concurrently, with the CPU(s) multiplexed among them.

- This evolution required firmer control and more compartmentalization of the various programs, resulting in the notion of a process.

Process

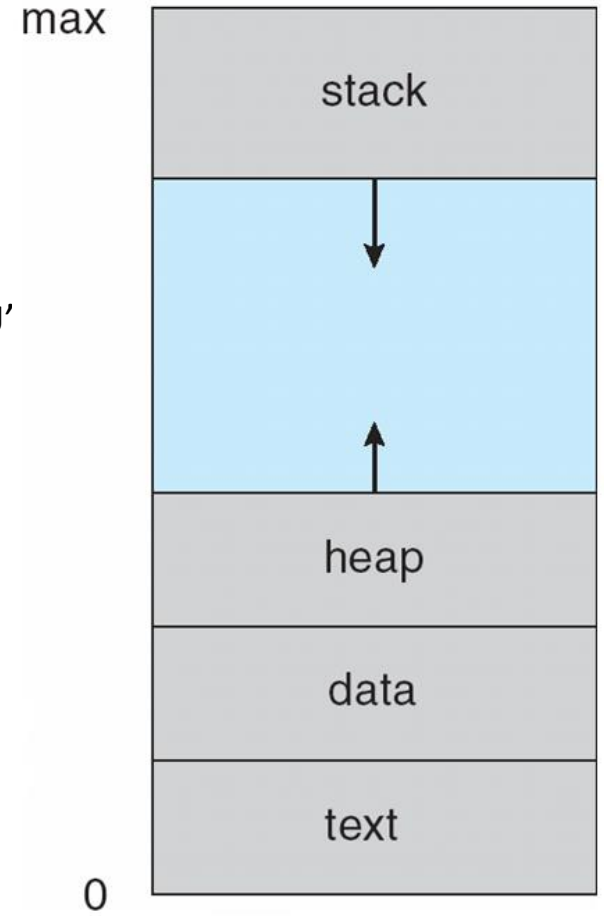
- A Process is
  - a program in execution
  - the unit of work in a modern system (To be compared with threads later)

- A program by itself is not a process
  - a program is a passive entity (e.g. a file on disk), whereas a process is an active entity.

- A process execution progresses in sequential fashion (following the usual flow of a program)

Process Concept (cont)

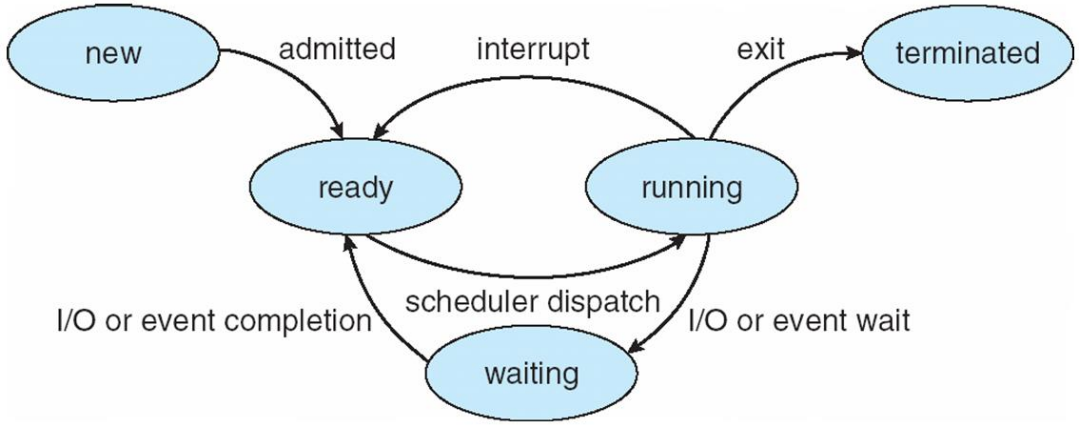
- A process is more than the program code (text section)
- A process also includes:
  - the current activity
    - program counter (indicates the address of the next instruction)
    - contents of the processor's registers (A register is a unit of the CPU' fast small internal memory)
  - generally the stack (temporary data such as function parameters, return addresses, …) and a data section (e.g. global variables)
  - and it may also include a heap (dynamically allocated memory at run-time)



Note: Historically, a C program has been composed of: text segment (code), data segment (initialized and uninitialized), stack and heap.

Process State

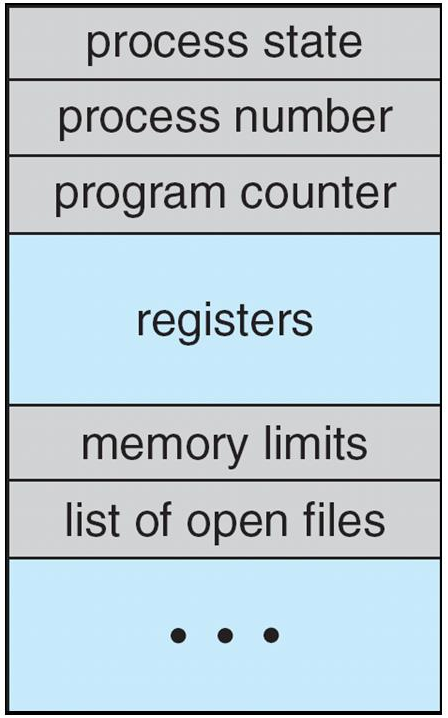
- The state of a process is defined in part by the current activity of that process. The states can be shown by a process state diagram.
- As a process executes, it changes state (note that these names are generic)
  - new: The process is being created
  - ready: The process is waiting to be assigned to a processor
  - running: Instructions are being executed
  - waiting: The process is waiting for some event to occur
  - terminated: The process has finished execution



Process Control Block (PCB)

- Each process is represented in the OS by a process control block (PCB).

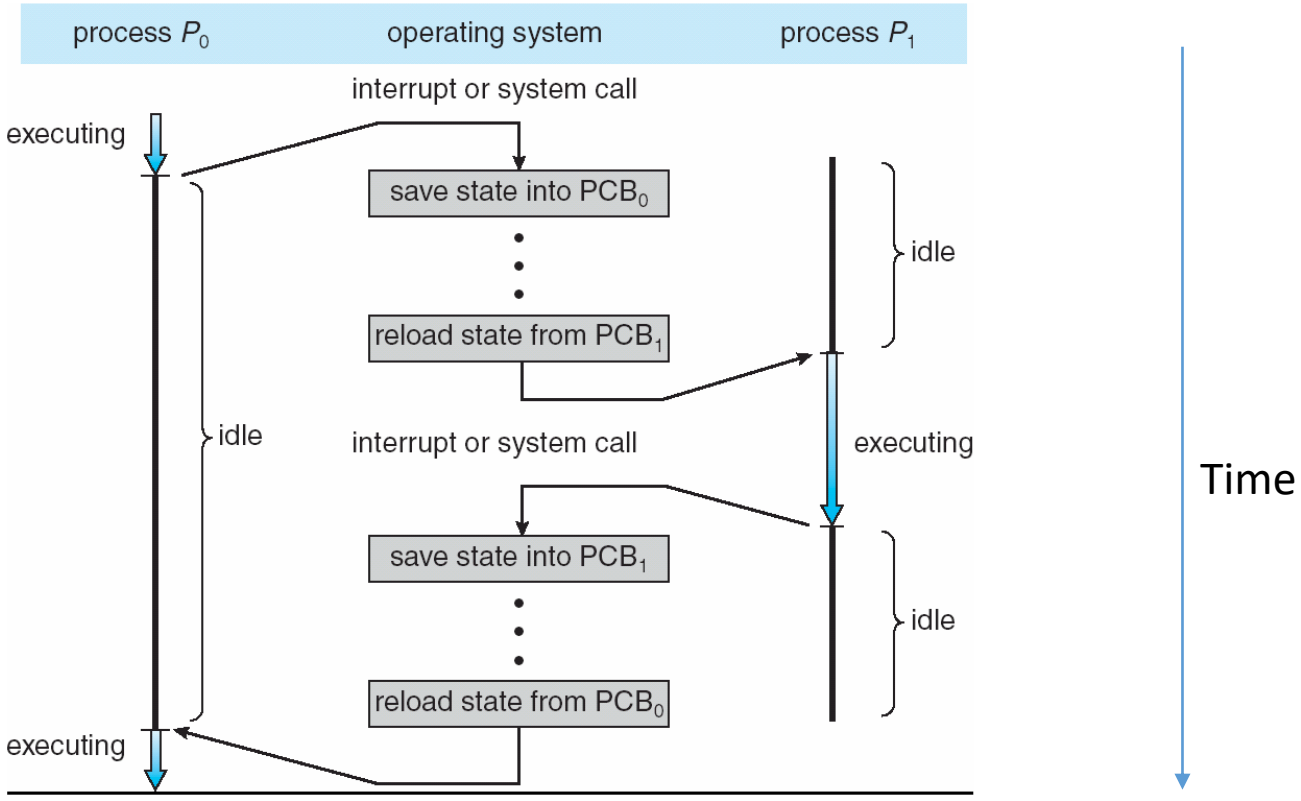
- The PCB contains many pieces of information associated with a specific process:
  - Process state (e.g. new, ready, running, halted, …)
  - Process number (a unique id number for each process)
  - Program counter (address of the next instruction to be executed)
  - CPU registers
  - CPU scheduling information (e.g. priority)
  - I/O status information
    - e.g. list of open files, I/O devices allocated
  - …



CPU Switch From Process to Process

- When the CPU switches from a process to another one, the state information (CPU registers, PC, …) must be saved to allow the process to be continued correctly afterward.

A diagram showing one CPU (or CPU core) switching from one process to another process:



Context Switch

- When CPU switches to another process, the system must save the state of the old process (*state save*) and load the saved state for the new process (*state restore*) via a context switch
  - Context of a process represented in the PCB
    - including CPU registers, process state, and memory management information

- Context-switch time is overhead
  - The system does no useful work while switching
  - Time dependent on hardware support

Threads

- The process model discussed implies that a process is a program that performs a single thread of execution.
- Many modern OSs have extended the process concept to allow a process to have multiple threads of execution.

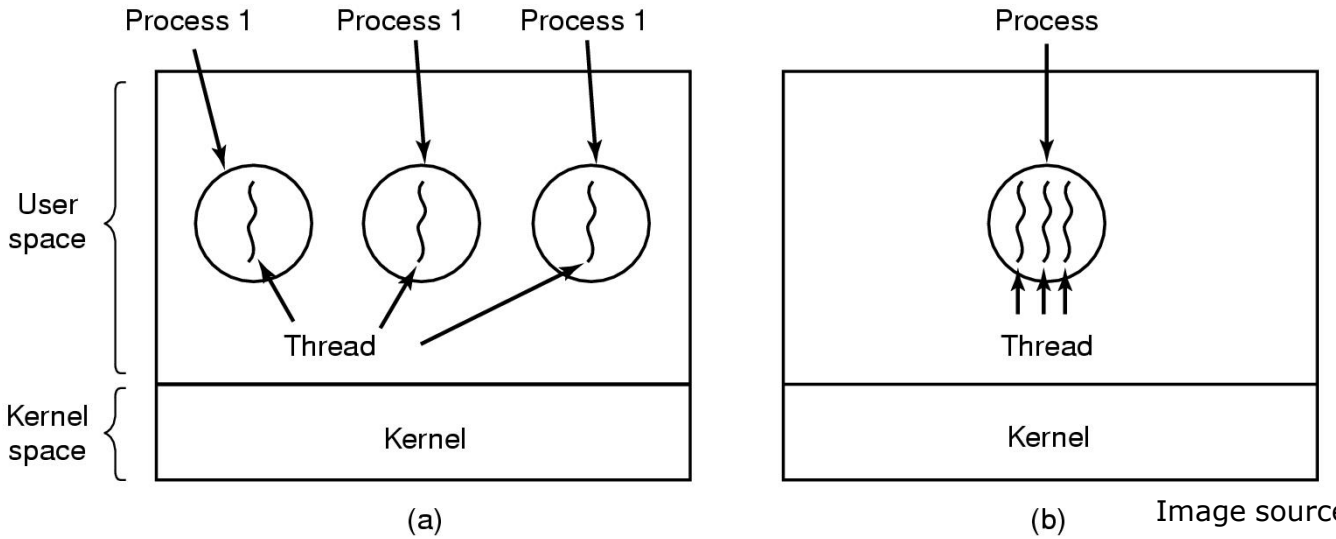
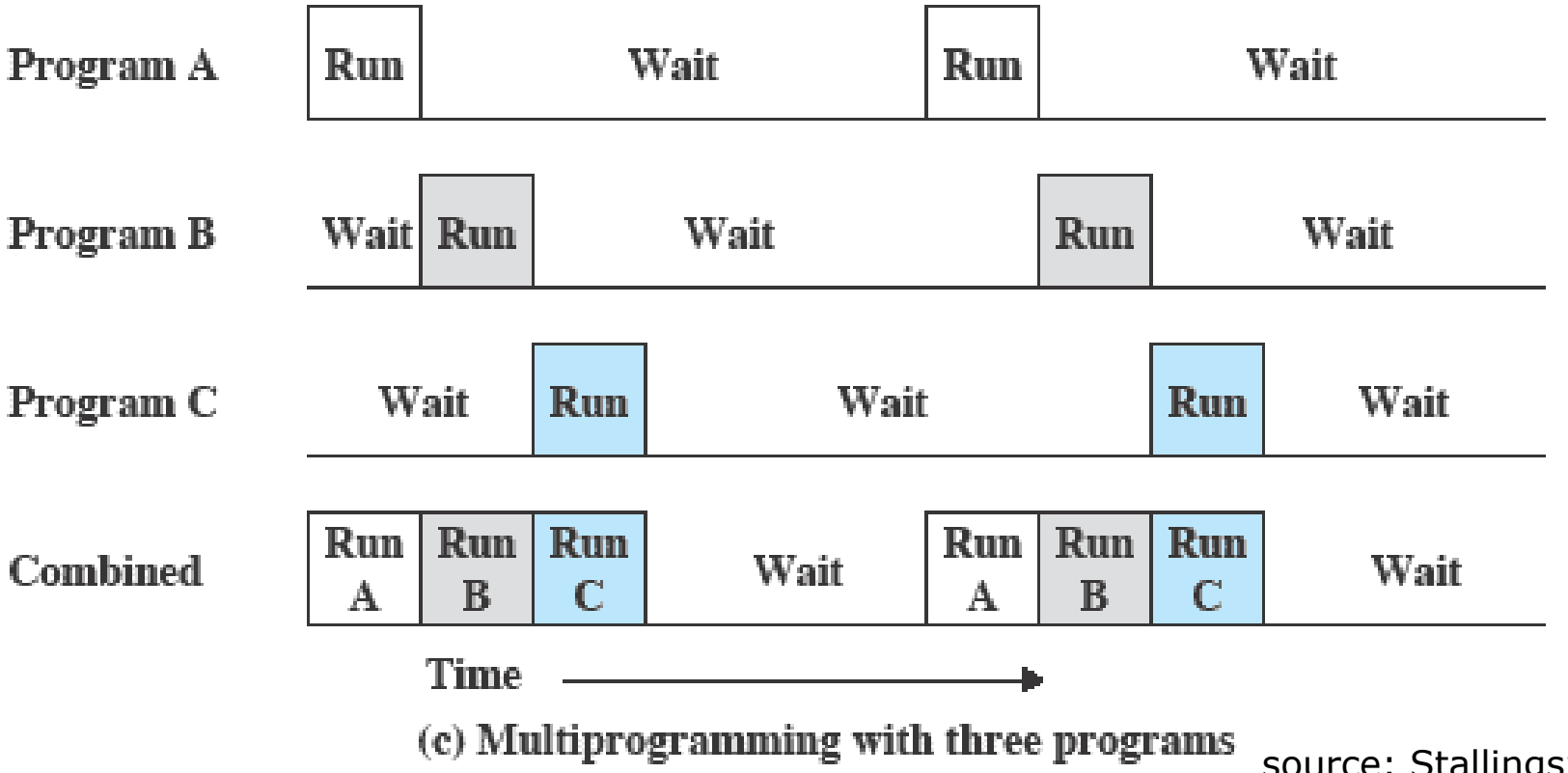


Image source: Tanenbaum's operating systems

- We postpone further discussions on threads to next.

Process Scheduling and time-sharing

- *Objective of time sharing*: to switch a CPU among processes so frequently that the users can interact with each program.

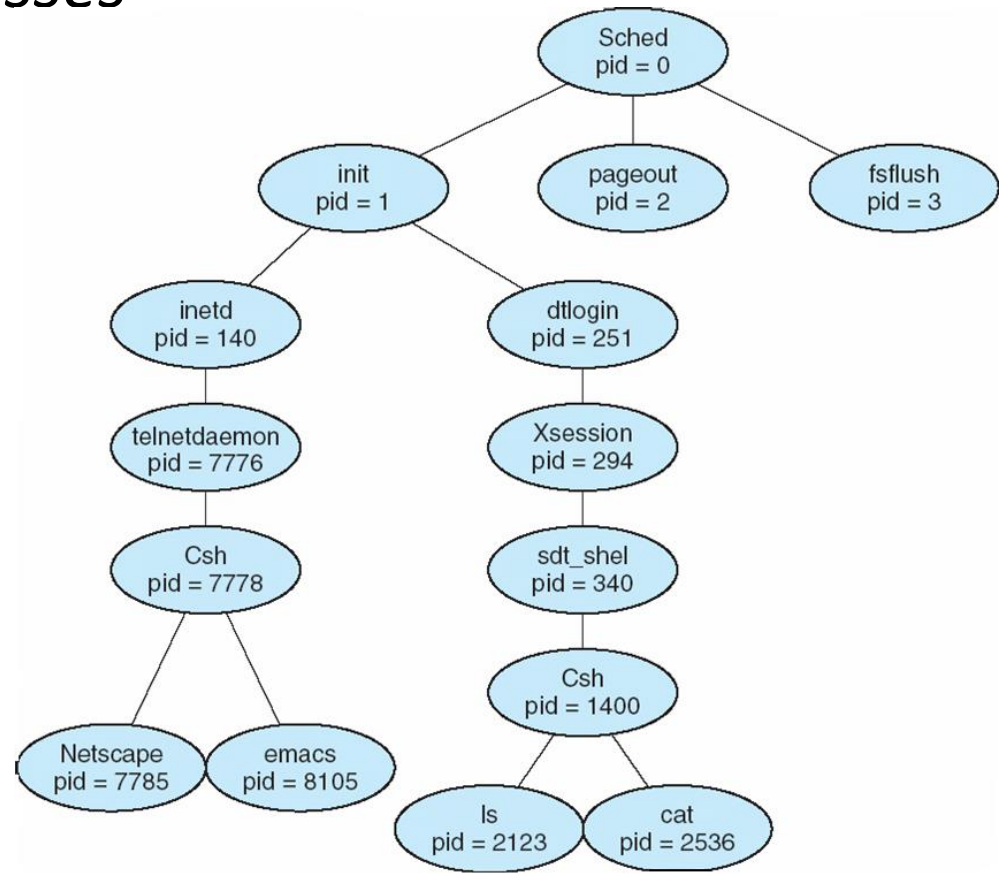


(c) Multiprogramming with three programs

source: Stallings'

Process Creation

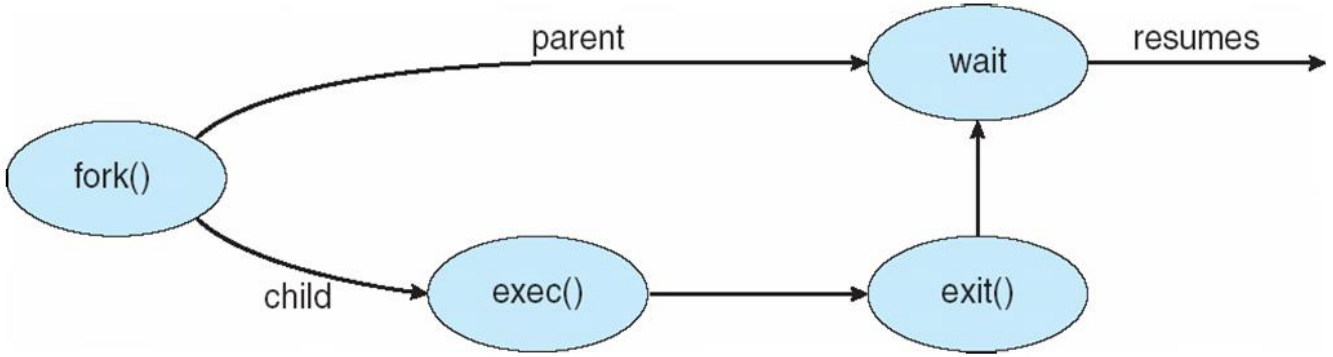
- **Parent** process create **children** processes, which, in turn may create other processes, forming a *tree of processes*
  - *e.g. a tree of processes on a typical Solaris:*



e.g. use "ps –el" command in macOS or UNIX

Process Creation (cont)

- Generally, a process is identified and managed via a unique process identifier (pid)
  - is an integer number
  - e.g. used in Windows and UNIX-based OS
- A process will need certain resources (CPU time, memory, files, I/O devices) to accomplish its tasks.
- UNIX's way: two steps
  - fork system call creates new process
  - exec system call is used after a fork to replace the process' memory space with a new program
    - e.g.:



A ***system call*** is the programmatic way of a program requesting a service from the kernel.

Process Termination

- A process normally terminates when it finished executing its last statement and asks the operating system to delete it (exit)
  - All process' resources are deallocated by the OS

- Parent may terminate the execution of children processes (abort), e.g. when:
  - Task assigned to child is no longer required
  - If parent is exiting, an operating system may not allow child to continue if its parent terminates (All children terminated - **cascading termination**)

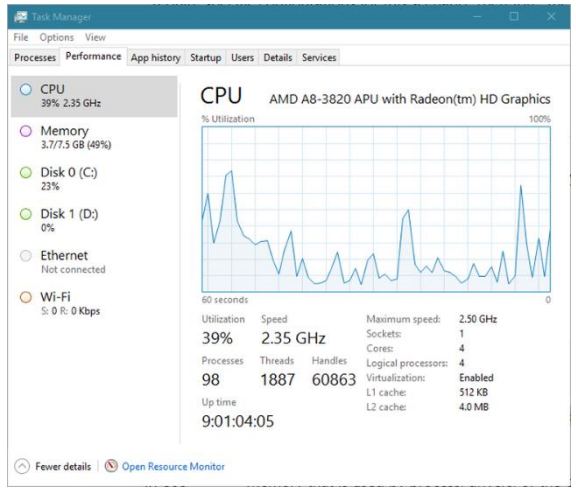
Multiprocess Architecture – Chrome Browser

- Web browsers ran multiple processes so that if one web site causes trouble, entire browser does not hang or crash
- Google Chrome Browser is multiprocess with 3 categories
  - **Browser** process manages user interface, disk and network I/O
  - **Renderer** process renders web pages, deals with HTML, Javascript, new one for each website opened
    - Runs in **sandbox** restricting disk and network I/O, minimizing effect of security exploits
  - **Plug-in** process for each type of plug-in

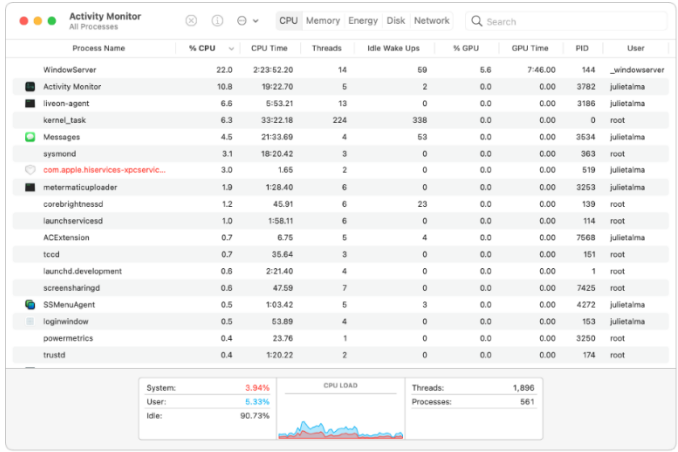
Alternatively, for Chromium see: https://www.chromium.org/developers/design-documents/multi-process-architecture/

OS Tools

- Windows task manager
  - use *ctrl+shift+esc* or run *task manger* from the start menu
  - https://docs.microsoft.com/en-us/cpp/atl/using-task-manager



- macOS activity monitor
  - use spotlight to find and run activity monitor
  - https://support.apple.com/en-ca/guide/activity-monitor/welcome/mac



References

- Windows task manager
  - https://docs.microsoft.com/en-us/cpp/atl/using-task-manager
  - https://en.wikipedia.org/wiki/Task_Manager_(Windows)

- macOS activity monitor
  - https://support.apple.com/en-ca/guide/activity-monitor/welcome/mac

- Some sections in chapter 3 of Operating Systems Concepts book

Acknowledgement: This set of slides is partly based on the PPTs provided by the Wiley's companion website for the operating system concepts book (including textbook images, when not explicitly mentioned/referenced).