Operating Systems Overview

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Outline

- Basics
- OS Concepts
- OS Structure

What is the OS used for?

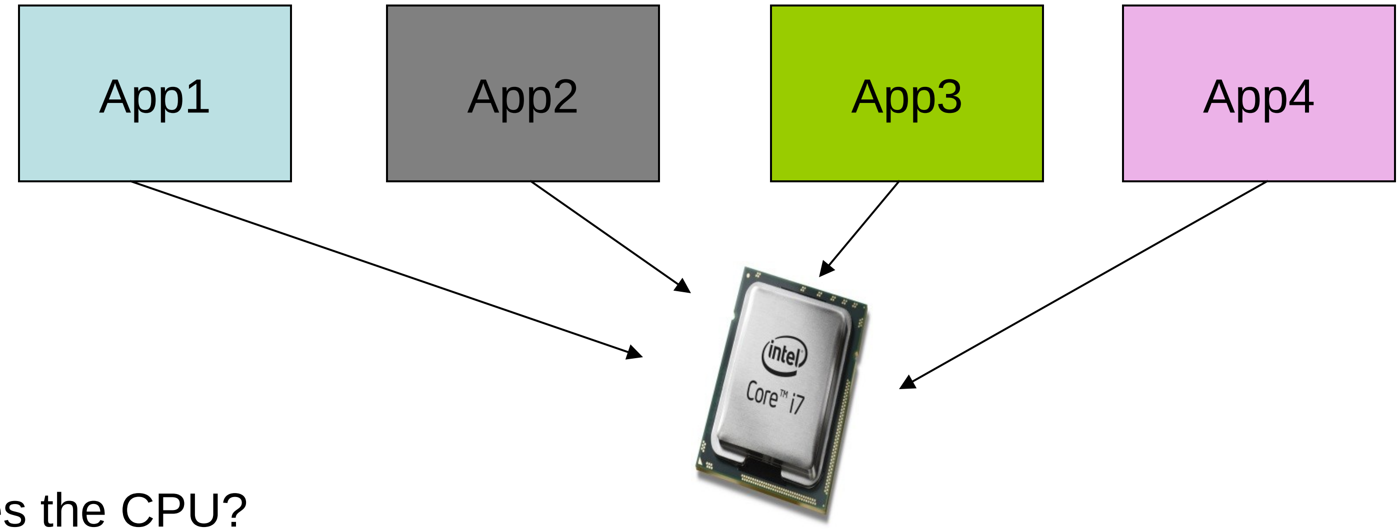
- Hardware Abstraction

  turns hardware into something that applications can use

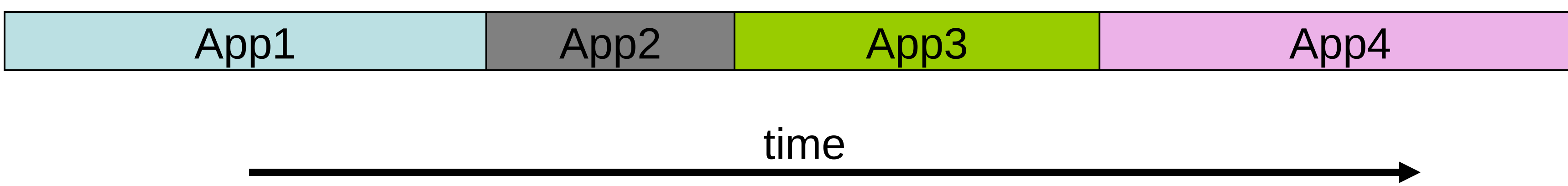
- Resource Management

  manage system's resources

Sharing the CPU

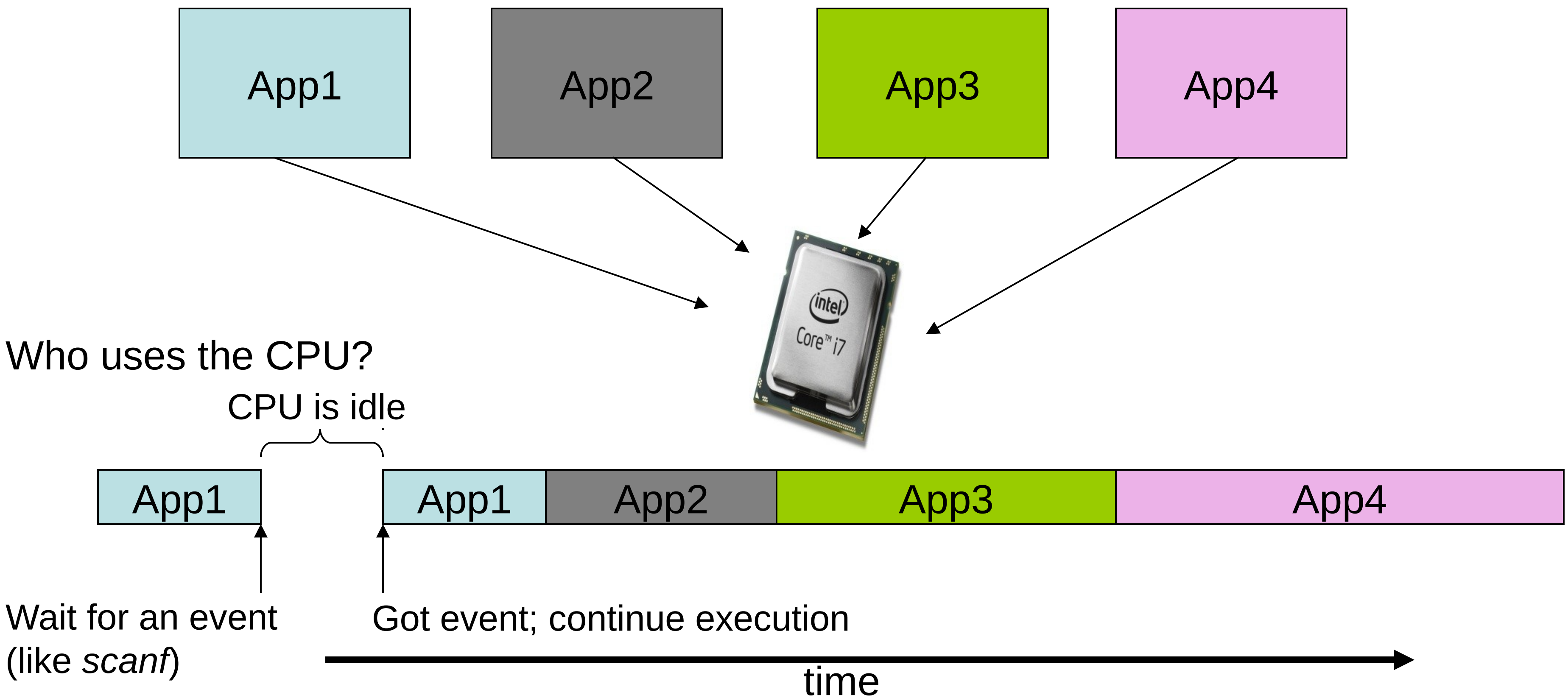


Who uses the CPU?



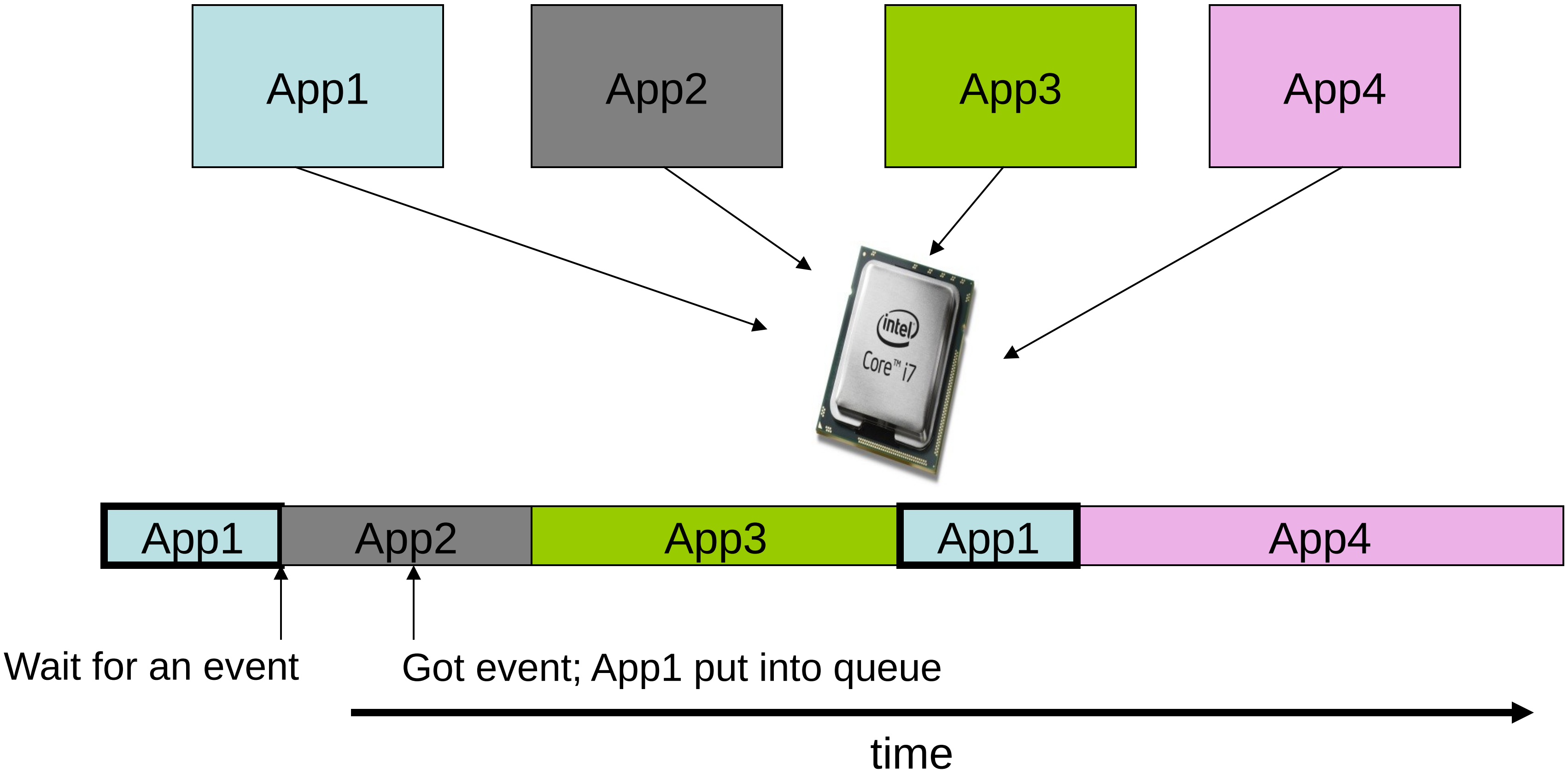
When one app completes the next starts

Idle CPU Cycles



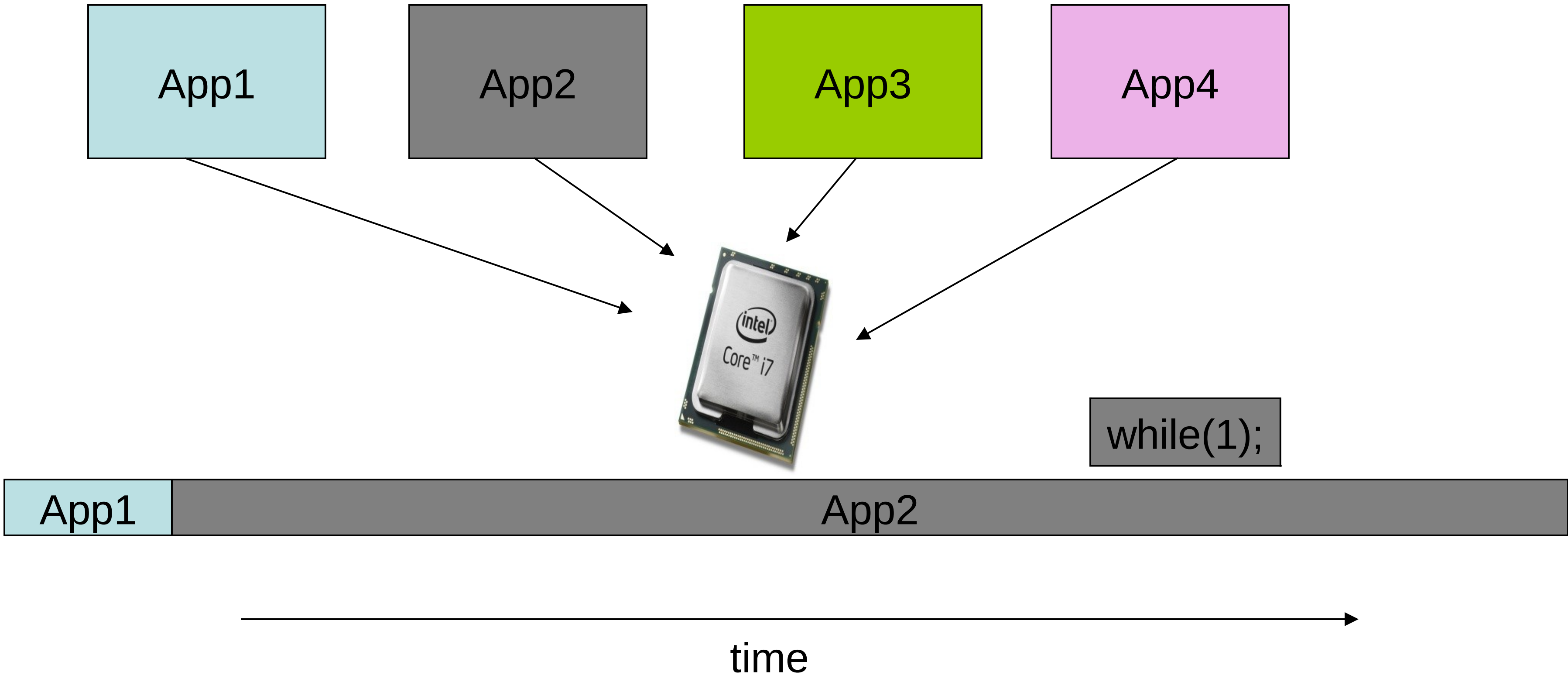
CPU is idle when executing app waits for an event.
Reduced performance.

When OS supports Multiprogramming



When CPU idle, switch to another app

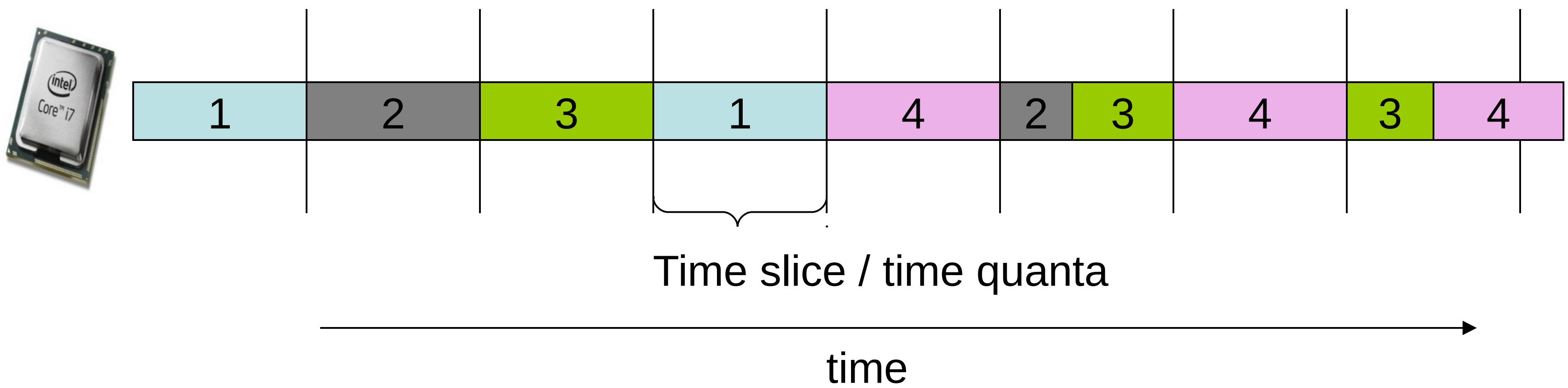
Multiprogramming could cause starvation



One app can hang the entire system

When OS supports Time Sharing (Multitasking)

- Time sliced
- Each app executes within a slice
- Gives impression that apps run concurrently
- No starvation. Performance improved

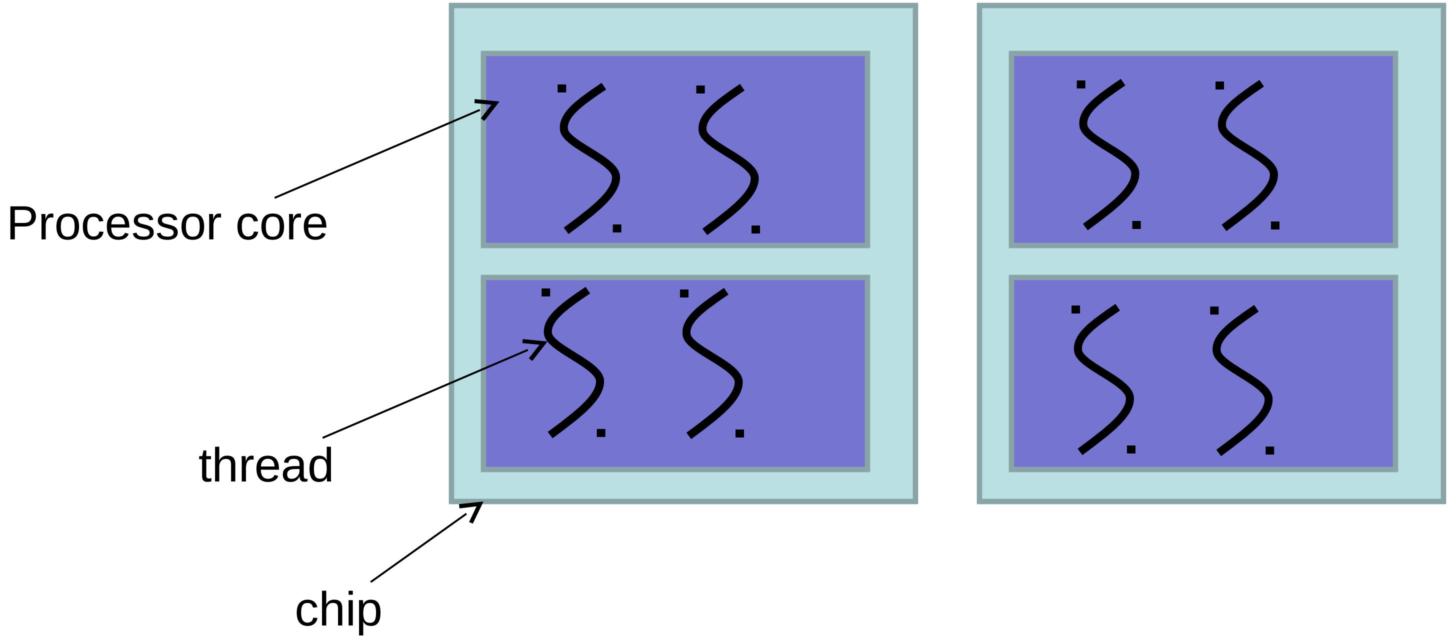


Other Shared Resources (examples)

- Printers
- Keyboards
- RAM
- disks
- Files on disk
- Networks

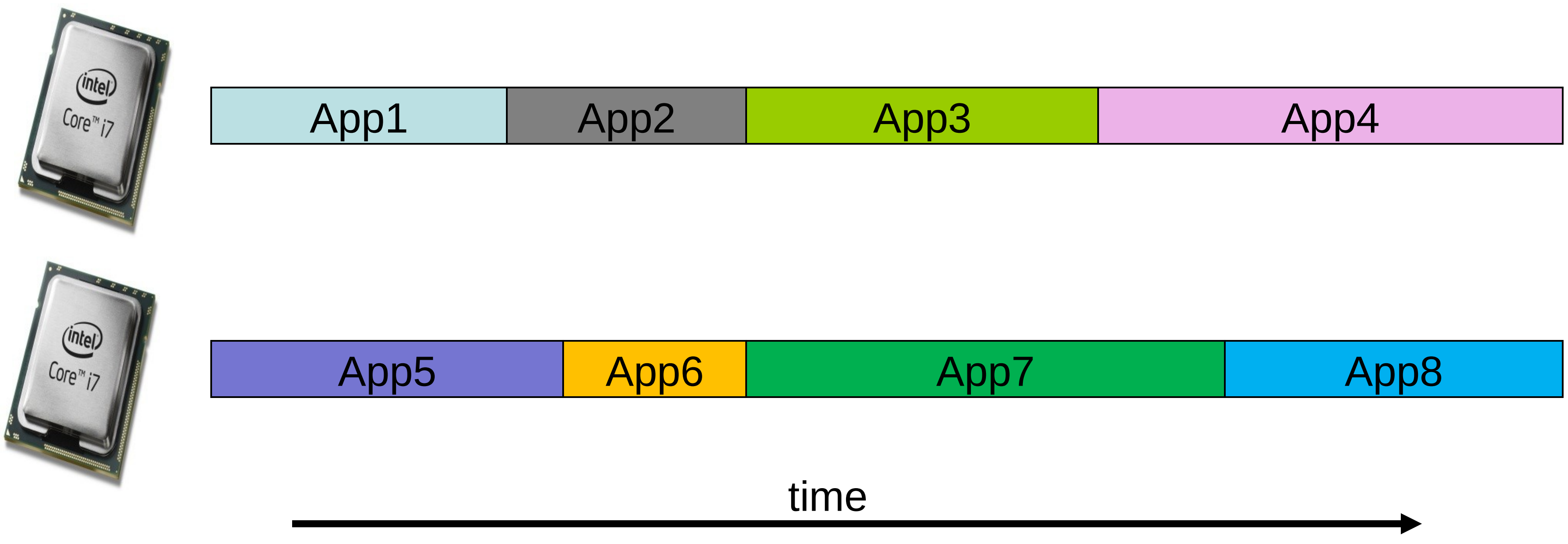
Multiprocessors

- Multiple processors chips in a single system
- Multiple cores in a single chip
- Multiple threads in a single core

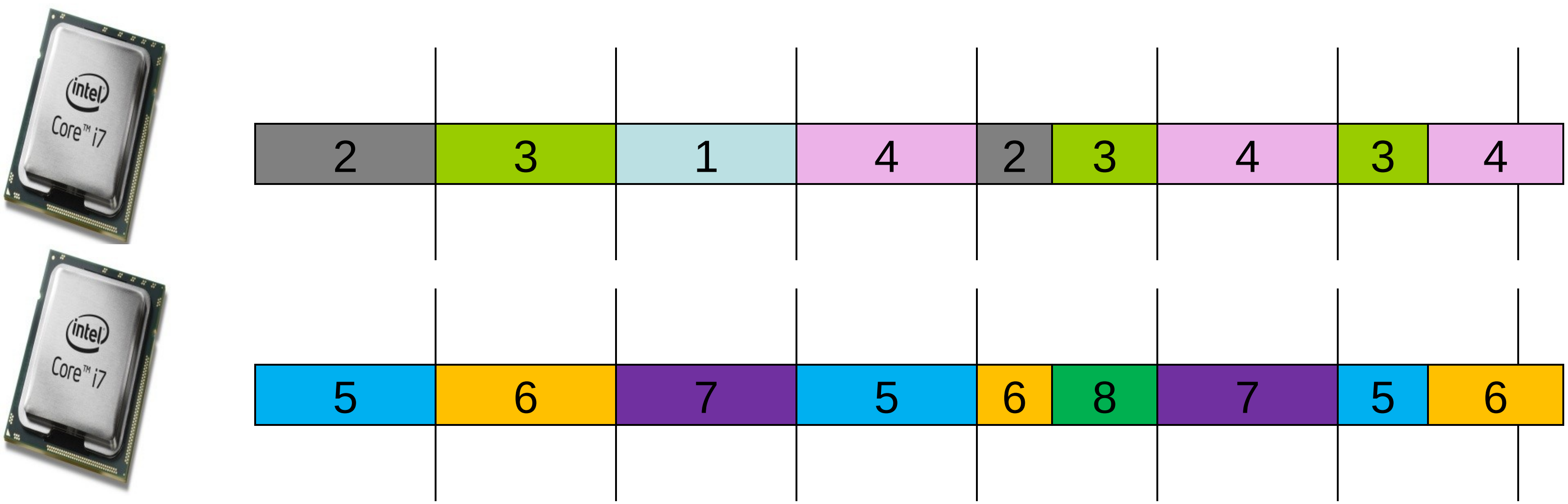


Multiprocessors

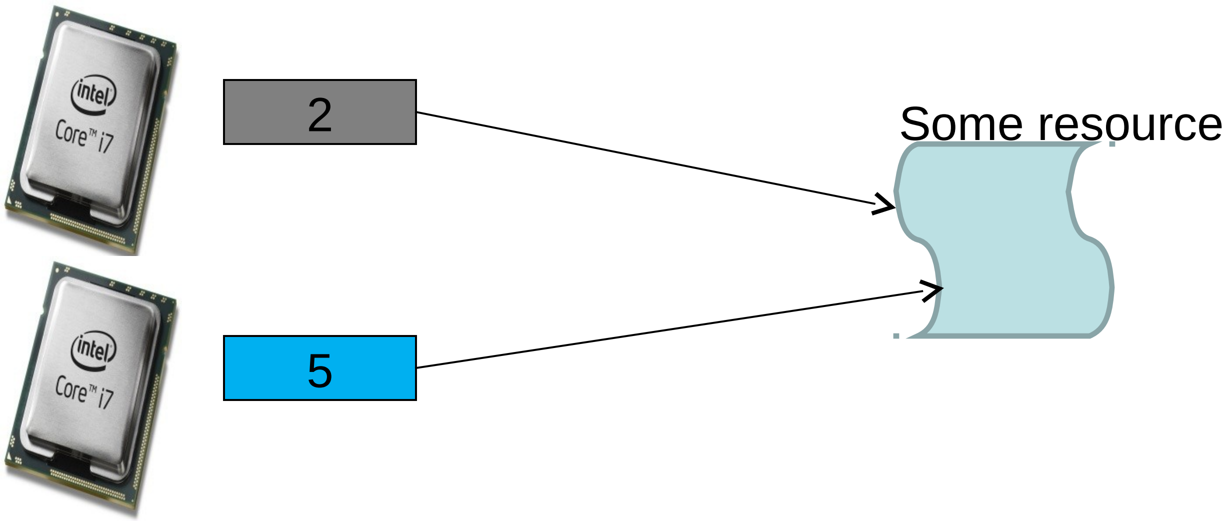
- Each processor can execute an app independent of the others



Multiprocessors and Multithreading

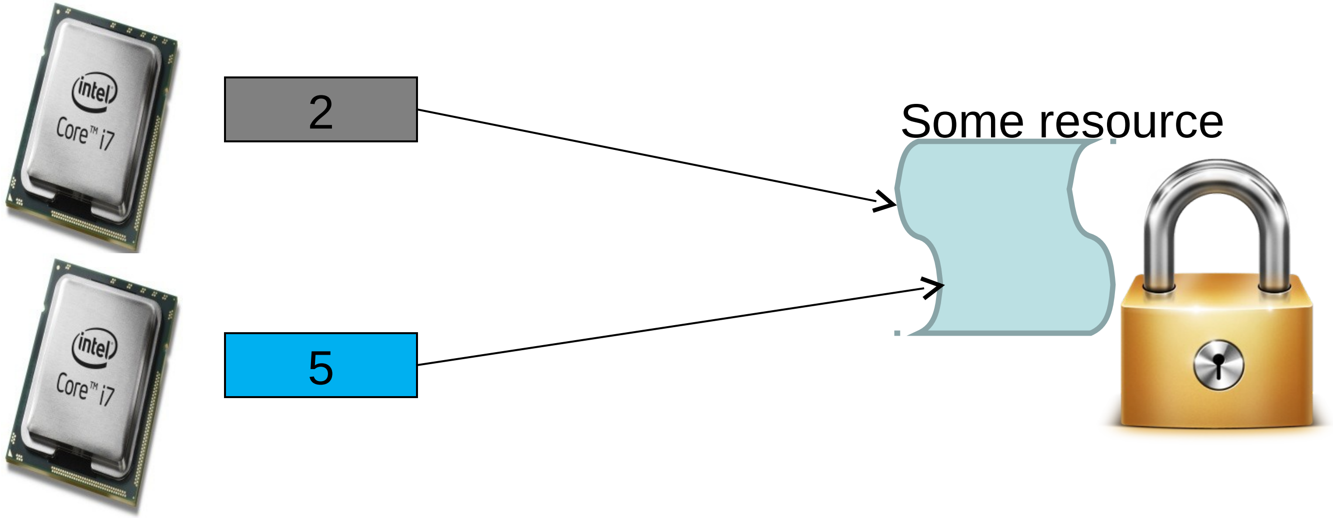


Race Conditions



- App2 and App5 want to write into some resource (like a file) simultaneously
- This results in a race condition
  - Need to synchronize between the two Apps

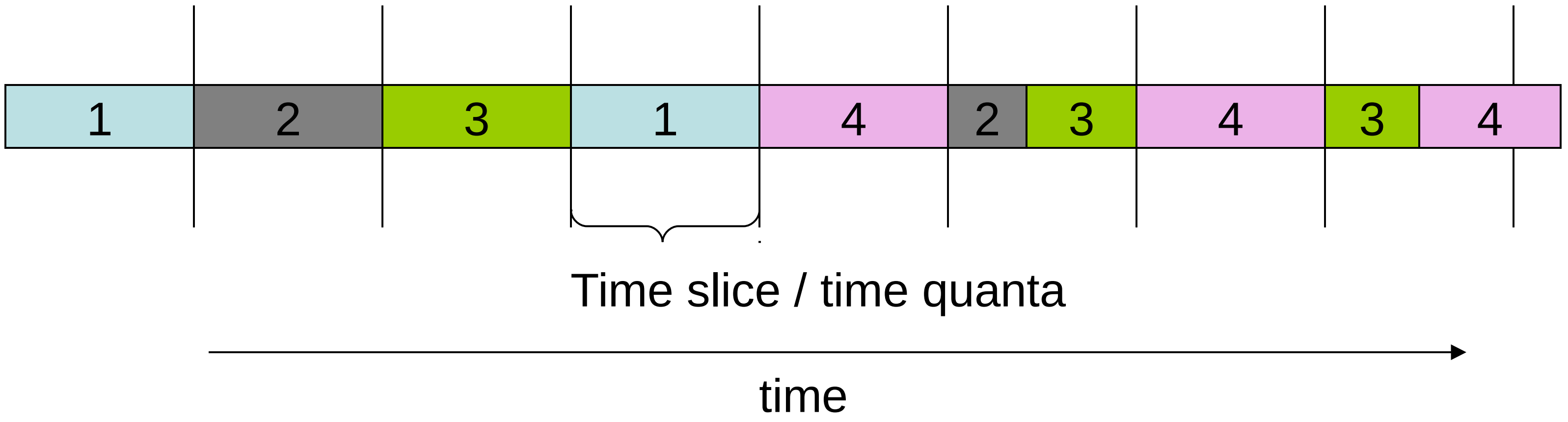
Synchronization



- The shared file is associated with a lock
- The lock ensures that only one App can access the resource at a time
- Sequence of Steps
  - App X locks the resource
  - App X accesses the resource, while App Y waits
  - App X unlocks the resource
  - App Y can now lock and then access the resource

Who should execute next?

- Scheduling
  - Algorithm that executes to determine which App should execute next
  - Needs to be fair
  - Needs to be able to prioritize some Apps over the others

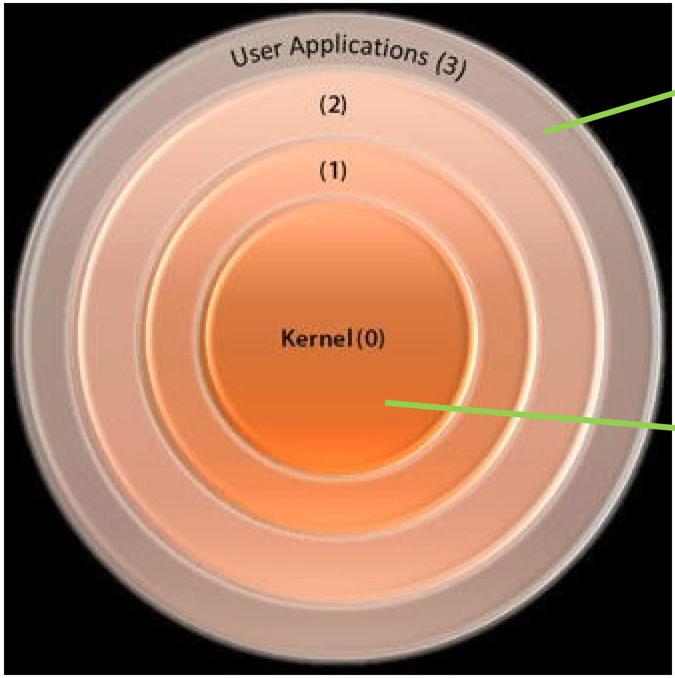


OS and Isolation

- **Why is it needed?**
  - Multiple apps execute concurrently, each app could be from a different user. Therefore needs isolation.
  - Preventing a malfunctioning app from affecting other apps

OS Isolation

- First ensure that the OS itself runs in a protected mode



Program Isolation

- Use virtual memory to ensure programs are isolated from each other
- Set page permissions
  - Execute, read only, read-write

OS and Security

- Why is it needed?
  - Defend against internal or external attacks from viruses, worms, identity theft, theft of service.
- How is it achieved?
  - Access Control
  - Passwords and Cryptography
  - Biometrics
  - Security assessment

Access Control

- Only authorized users can access files and other resources

	File 1	File 2	File 3	Program 1
Ann	own read write	read write		execute
Bob	read		read write	
Carl		read		execute read

Security Assessment

- How secure is my system?
- Can be done by
  - mathematical analysis
  - Manual / semi-automated verificiation method

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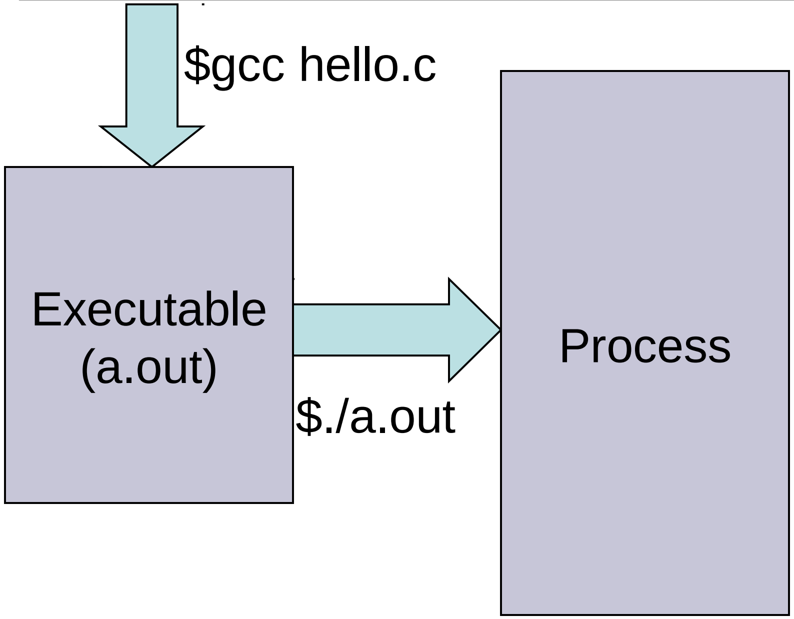
- OS Structure

Executing Apps (Process)

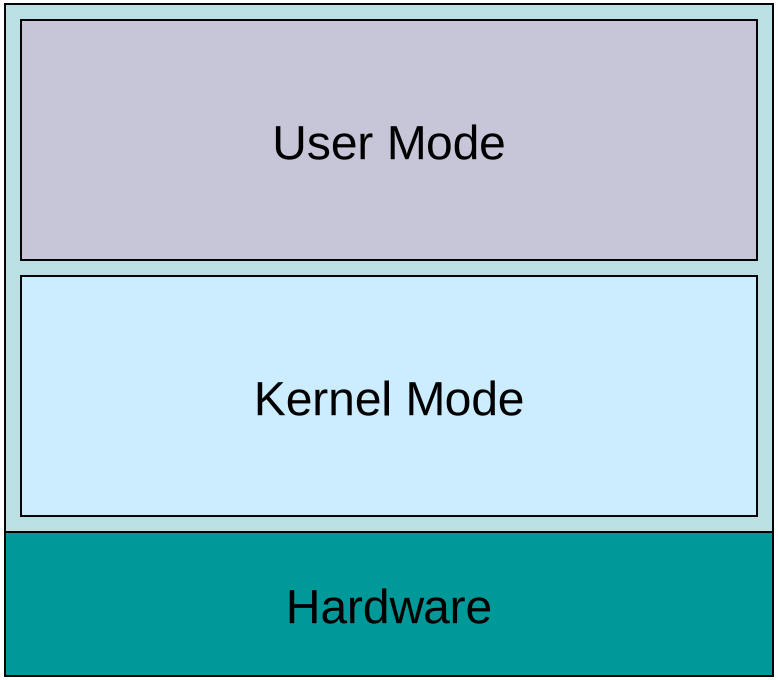
```c
#include <stdio.h>

int main(){
   char str[] = "Hello World\n";
   printf("%s", str);
}
```



- Process
  - A program in execution
  - Comprises of
    - Executable instructions
    - Stack
    - Heap
    - State
  - State contains : registers, list of open files, related processes, etc.

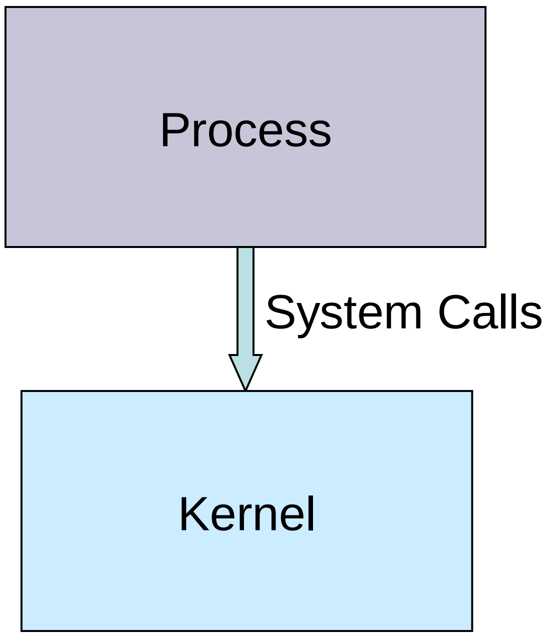
Operating Modes

- User Mode
  - Where processes run
  - Restricted access to resources
  - Restricted capabilities
- Kernel mode a.k.a. Privileged mode
  - Where the OS runs
  - Privileged (can do anything)

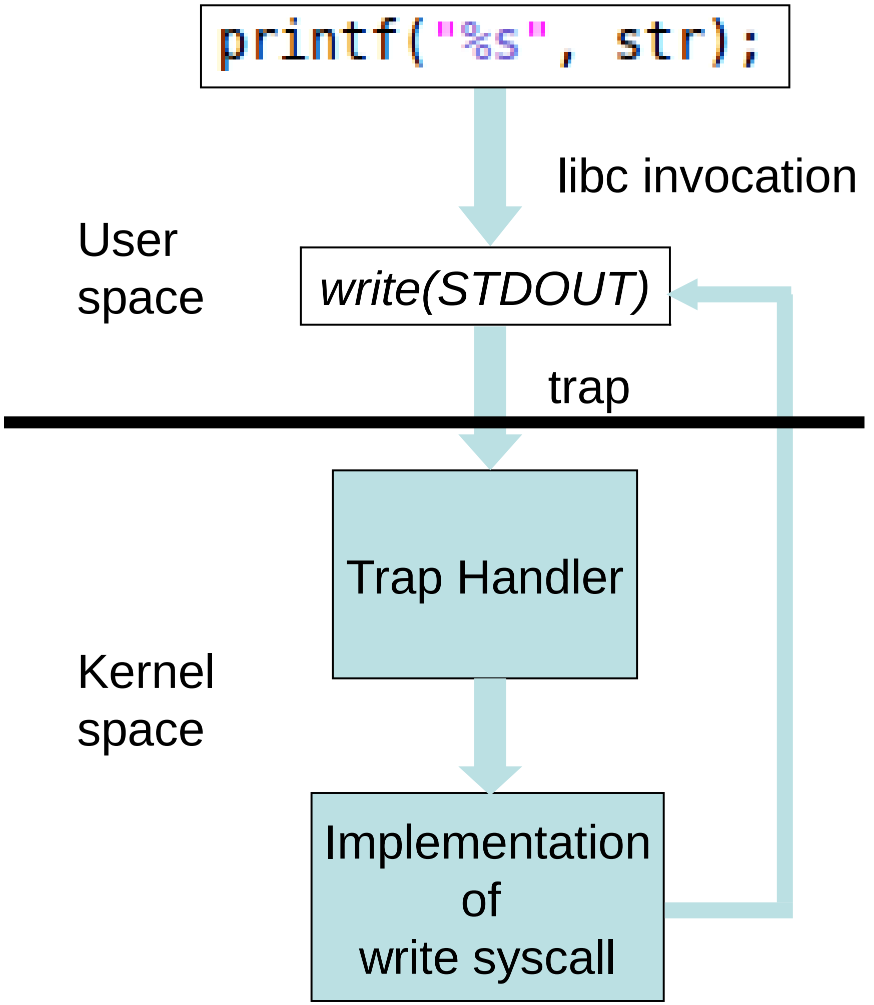


Communicating with the OS (System Calls)

- System call invokes a function in the kernel using a Trap
- This causes
  - Processor to shift from user mode to privileged mode
- On completion of the system call, the execution gets transferred back to the user mode process



Example (write system call)



System Call vs Procedure Call

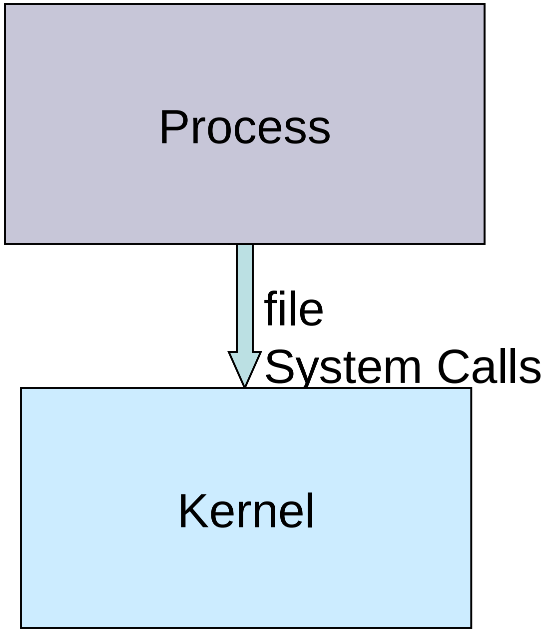
System Call	Procedure Call
Uses a TRAP instruction (such as int 0x80)	Uses a CALL instruction
System shifts from user space to kernel space	Stays in user space (or kernel space) … no shift
TRAP always jumps to a fixed addess (depending on the architecture)	Re-locatable address

System Call Interfaces

- System calls provide users with interfaces into the OS.
- What set of system calls should an OS support?
  - Offer sophisticated features
  - But yet be simple and abstract whatever is necessary
  - General design goal : rely on a few mechanisms that can be combined to provide generality

Files

- Data persistent across reboot
- What should the file system calls expose?
  - Open a file, read/write file, creation date, permissions, etc.
  - More sophisticated options like seeking into a file, linking, etc.
- What should the file system calls hide?
  - Details about the storage media.
  - Exact locations in the storage media.



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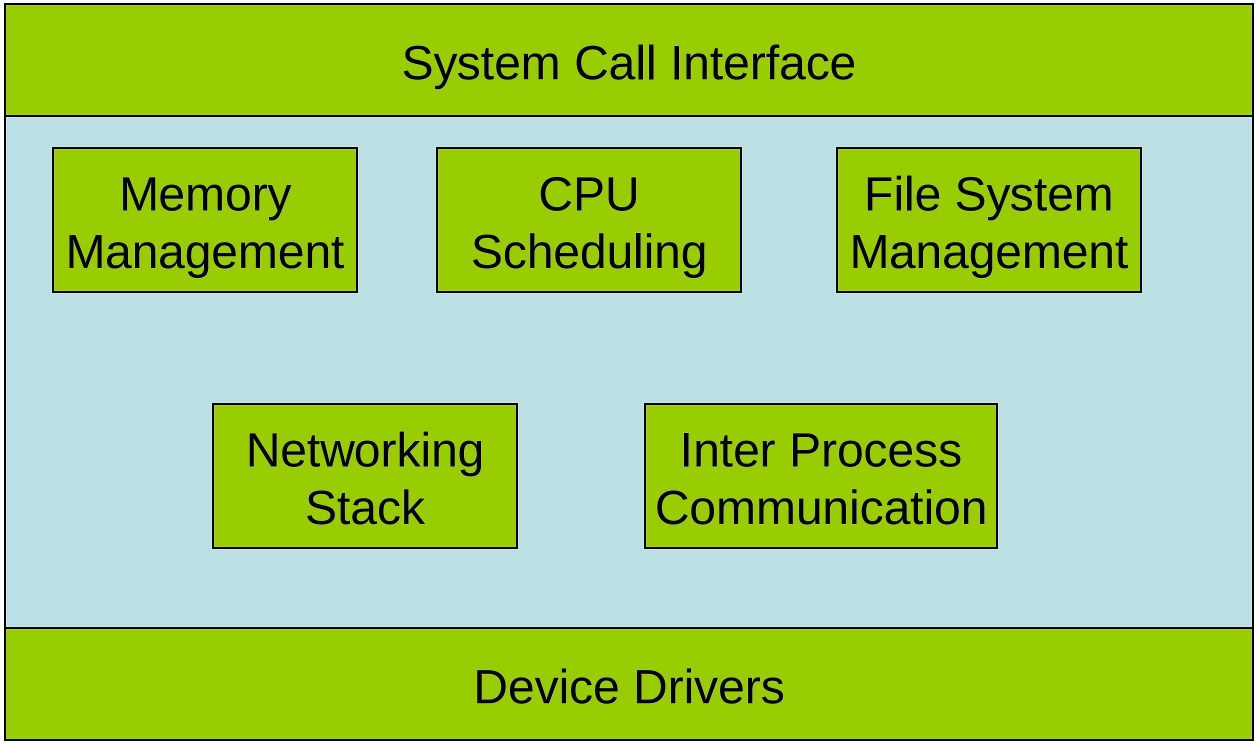
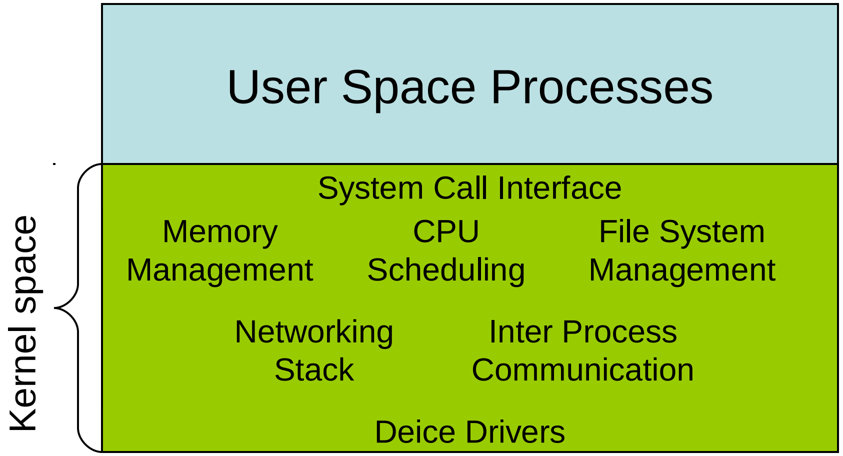
- **OS Structure**

What goes into an OS?

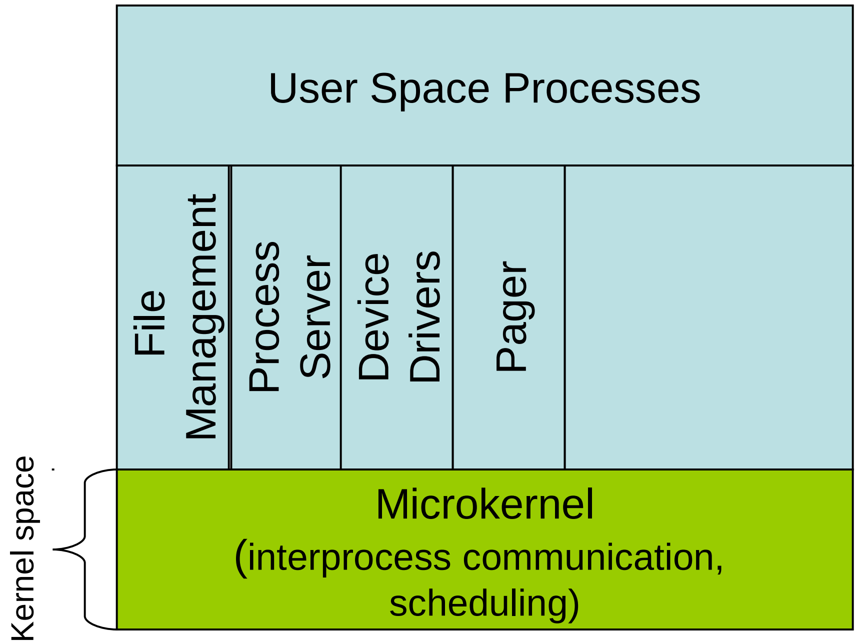


OS Structure : Monolithic Structure



- Linux, MS-DOS, xv6
- All components of OS in kernel space
- Cons : Large size, difficult to maintain, likely to have more bugs, difficult to verify
- Pros : direct communication between modules in the kernel by procedure calls

OS Structure : Microkernel



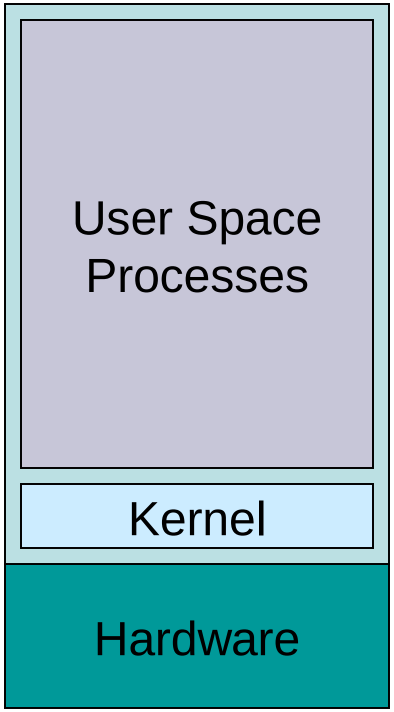
Eg. QNX and L4

- Highly modular.
  - Every component has its own space.
  - Interactions between components strictly through well defined interfaces (no backdoors)
- Kernel has basic inter process communication and scheduling
  - Everything else in user space.
  - Ideally kernel is so small that it fits the first level cache

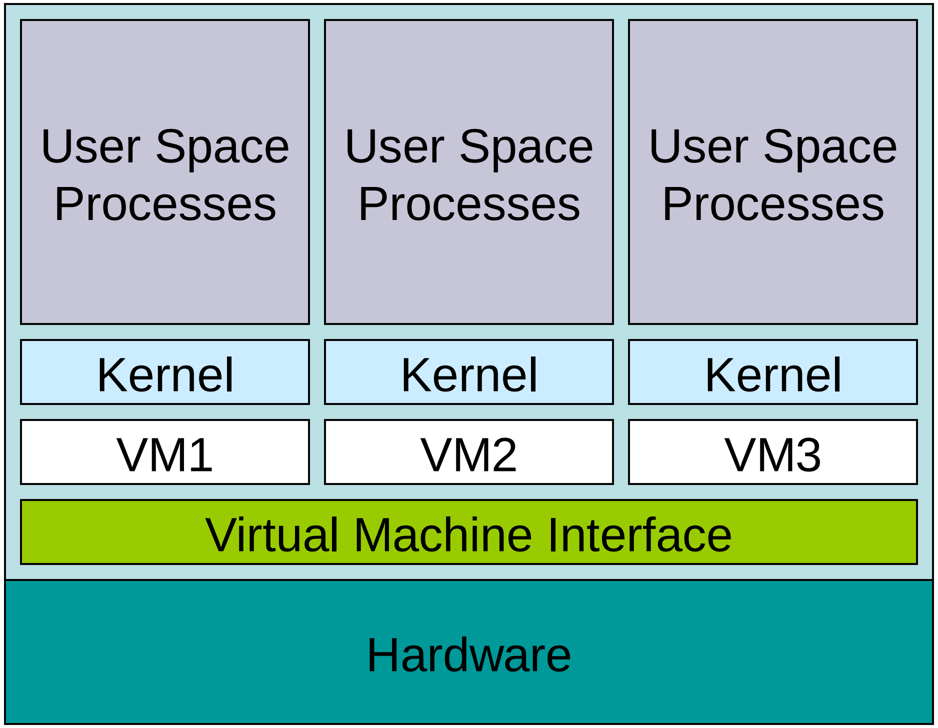
Monolithic vs Microkernels

	Monolithic	**Microkernel**
Inter process communication	Signals, sockets	Message queues
Memory management	Everything in kernel space (allocation strategies, page replacement algorithms,)	Memory management in user space, kernel controls only user rghts
Stability	Kernel more ‘crashable’ because of large code size	Smaller code size ensures kernel crashes are less likely
I/O Communication (Interrupts)	By device drivers in kernel space. Request from hardware handled by interrupts in kernel	Requests from hardware converted to messages directed to user processes
Extendibility	Adding new features requires rebuilding the entire kernel	The micro kernel can be base of an embedded system or of a server
Speed	Fast (Less communication between modules)	Slow (Everything is a message)

Virtual Machines



No virtual Machines



With virtual Machines

for next class

- Please revise / learn
  - memory management in Intel i386 (especially GDTs, page tables, and page size extensions)

(http://www.logix.cz/michal/doc/i386/chp05-00.htm)

  - Real mode and protected mode in Intel i386

    (Shifting from real mode to protected mode)