Embedded Software

Introduction to operating systems

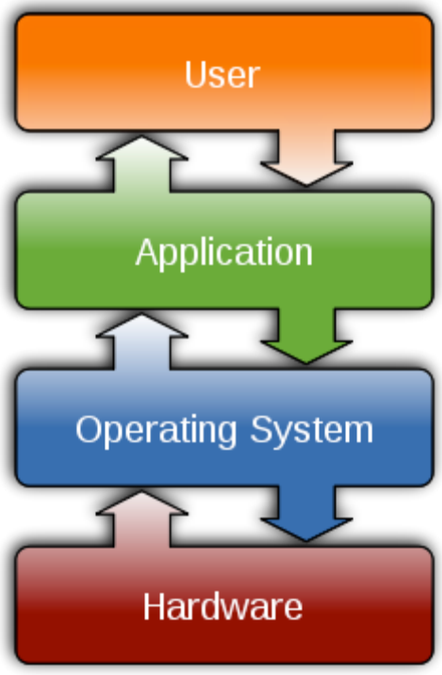
AARHUS
UNIVERSITY

Agenda

- What is an operating system?
- OS structure
  - Process management
  - Memory and storage mgmt.
  - I/O subsystem
- Operating systems - Real-Time OS’s

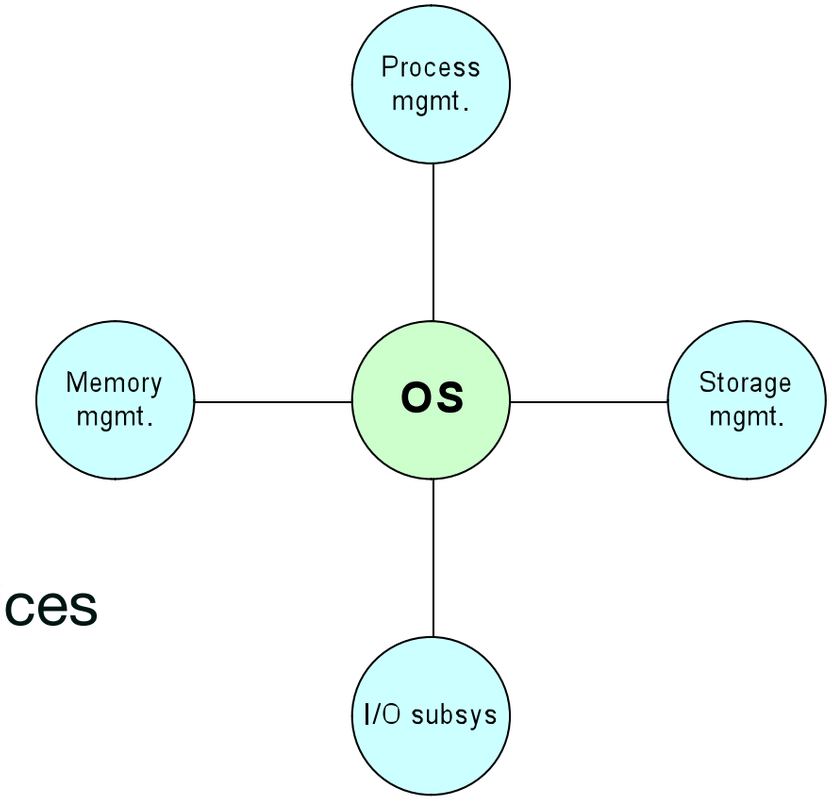
What is an operating system?

- What is an operating system?
  - Wikipedia: *“An operating system (OS) is software (…) that manages computer hardware resources and provides common services for efficient execution of various application software.”*

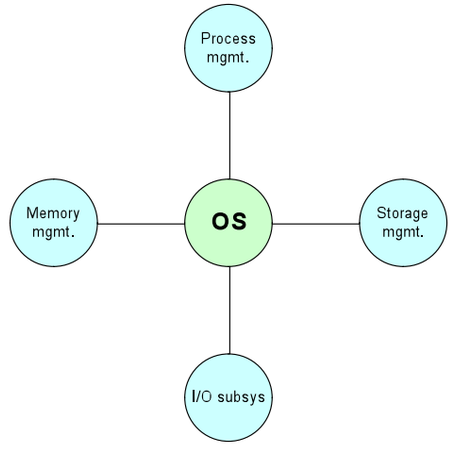


OS structure

- Many computer types – many OS designs
  - Mainframe OSs are optimized for HW utilization
  - Desktop OSs are optimized for generality
  - Embedded OSs are optimized for efficiency, size, safety, speed, low power
  - …
- Some commonalities, though:
  - Process management – handles multiprogramming and keep the CPU busy
  - Memory management – (de)allocation and process swapping
  - Storage management – persistent storage and cache
  - I/O subsystem management – manage I/O devices
- Let's take a look at process management



OS structure - Process management



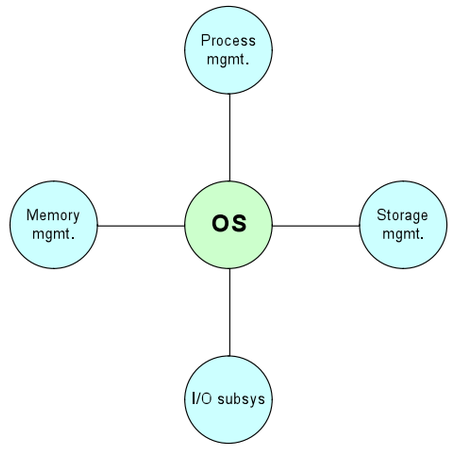
- ***What is a process? Is it a program?***
  - No - a process is a program in execution

- ***How many processes can run at a time?***
  - There can be many processes that want to run, but only one per CPU that actually runs

- The OS manages processes
  - Creates, deletes, and allocates resources for them
  - Swaps them in and out of memory
  - Suspends and resumes them
  - Provides mechanisms for synchronization and communication between processes

Process management – why?

- Processes either compute or perform device I/O

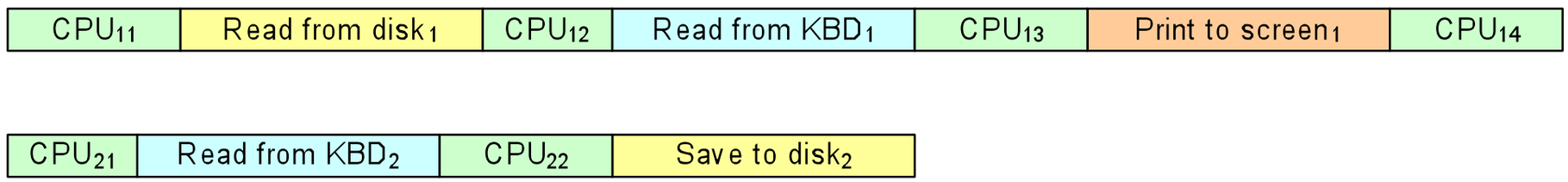


- ***What does a process do while it performs I/O?***
  - It must wait for I/O to complete before it can resume

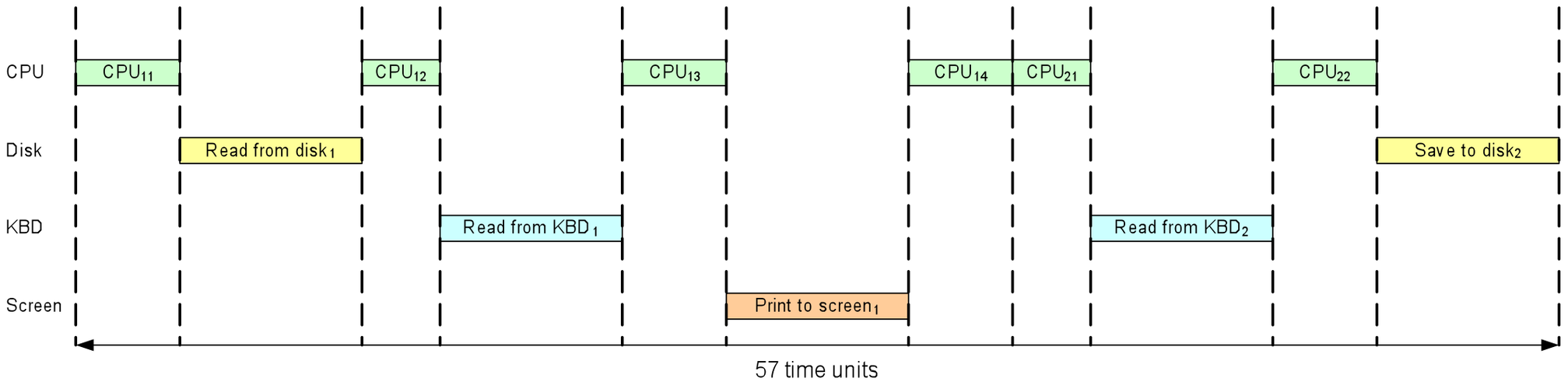
- ***What should the system do meanwhile?***
  - Without process management: CPU idles
  - With process management: Switch to another ready process

Process management - example

- Consider two tasks:

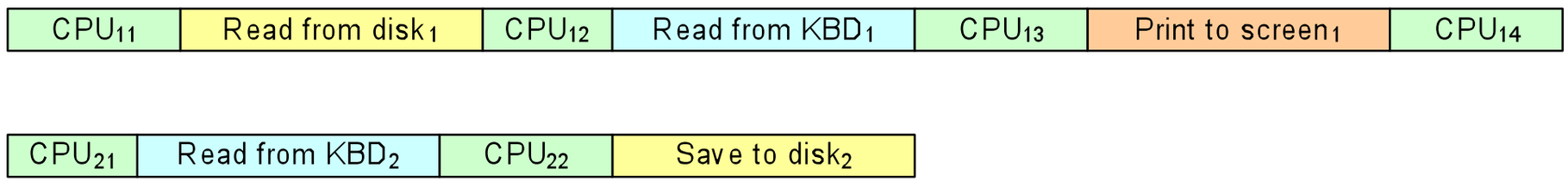


- ***Scheduling without resource management (batch processing)?***

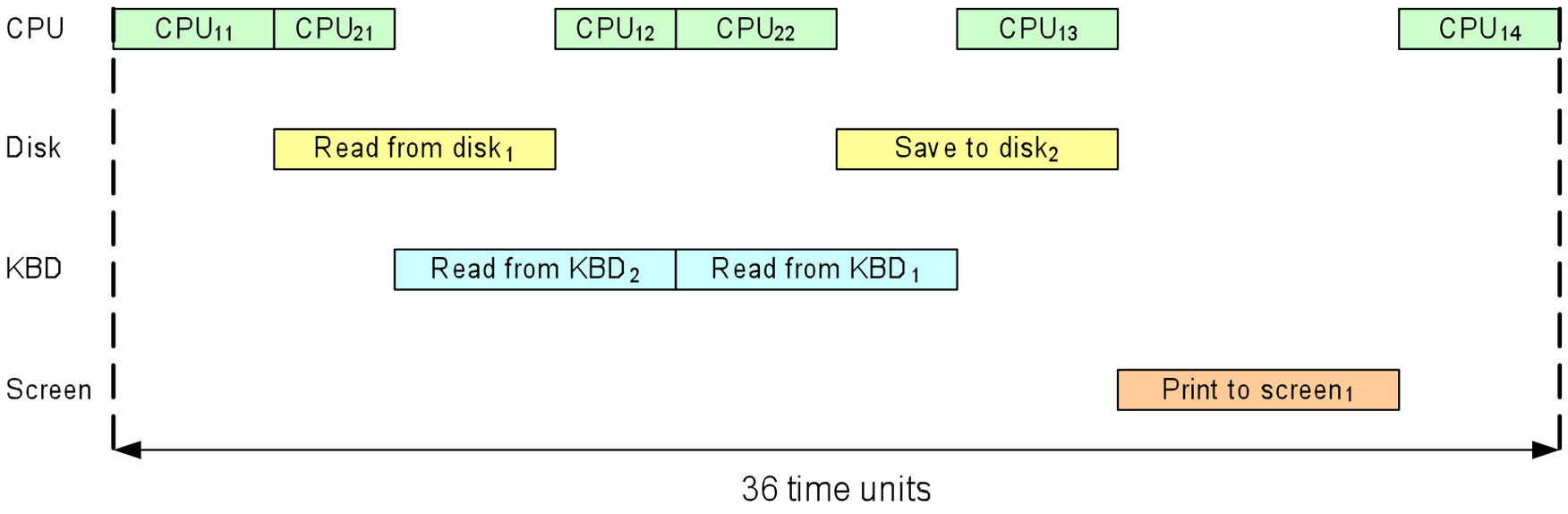


Process management - example

- Consider two tasks:



- ***Scheduling <u>with</u> resource management?***



Process management - protection

- Consider an “evil” process – what damage could it do?
  - Destroy, eavesdrop on, change other processes
  - Destroy OS
  - Destroy files and HW

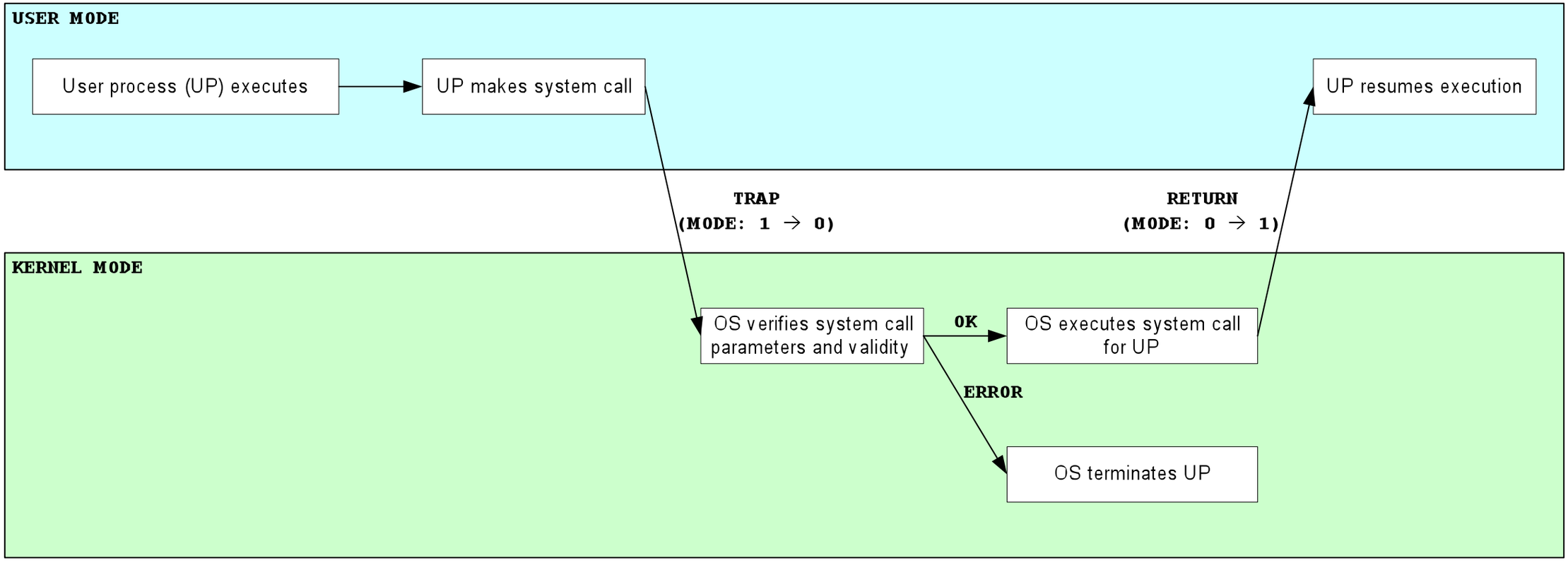
- The OS guards against this using dual-mode operation (MODE bit in CPU)
  - Applications run in user mode (AKA restricted mode)
  - The OS kernel runs in kernel mode (AKA protected, privileged, supervisor mode)

- Potentially dangerous operations (I/O, IPC, …) can only be done via privileged instructions
  - Restricted instructions – user and kernel mode
  - Privileged instructions – kernel mode only

Dual-mode operation – system calls

- When processes need to perform I/O, it does so via the OS via well-defined ***system calls*** (version 2.6.35: 337 different syscalls)

- The OS (which is in kernel mode) verifies the system call and its parameters



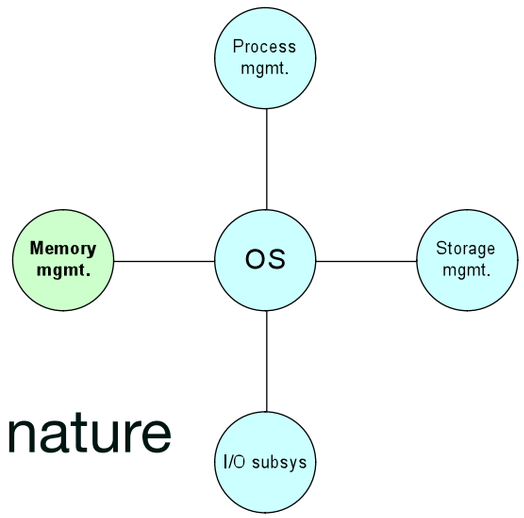
Dual-mode operation – system calls

- How often are system calls made?

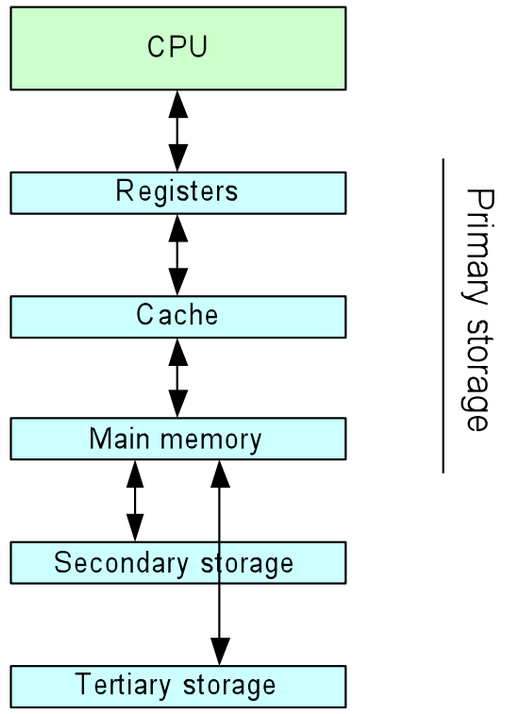
```
$ ./hello
Hello World!
```

OS Structure - Memory and storage mgmt.

- Memory management
  - Keep track of several processes in memory at a time
  - Decide which (parts of) processes to move in and out of memory
    - Many different algorithms depending on hardware and the OS' nature
  - Allocate and deallocate memory as necessary



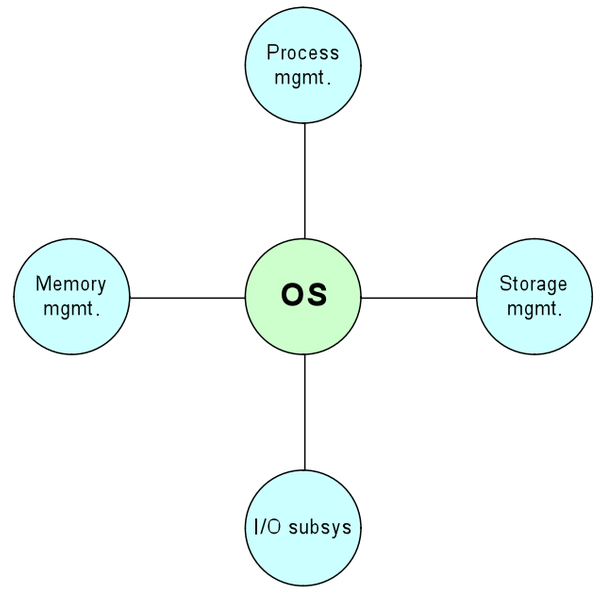
- Storage management
  - The primary storage is never big enough to accommodate all needs
  - A hierarchy of memory:
    - Size? Price (per MB)? Capacity? Bandwidth?
  - Move data in/out of hierarchy



OS Structure - I/O subsystem

- The I/O subsystem hides the oddities of individual I/O devices

- Instead, it provides a uniform interface (in Linux: a file)
  - The file is I/F to a device driver
  - The device driver knows how to operate the device



Operating systems - Real-Time OS's

- Real-Time Operating Systems (RTOSs) are OSs intended for RT systems (!)

- ***Some key properties?***
  - Minimum interrupt latency
  - Minimum task switching latency
    - Includes known worst case latency (must be small)
  - Static task priorities

- The programmer (you!) is responsible for correct priority assignment