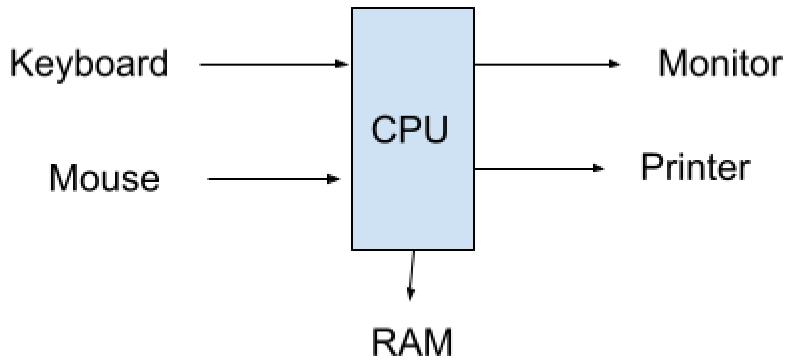
Operating Systems 1: Processes

Introduction

- We are using an OS daily. Even currently while watching the class.
- [POLL] Which OS are you using right now?
- Why learn OS?
    - To understand how the applications we develop or use really work. How are they able to get things done?

What is an OS?

Resource Manager



- Tell how every process basically needs different resources to do their work and to avoid conflicts, there needs to be someone to manage them. Like a Program Manager in a company.

Functionalities for Developers

- Interacting with Network
- Working with File System
- Imagine having to write the code to rotate the hard disk to fetch a file at a particular location.

Uni v/s Multiprogramming Computers

- Multiple programs being executed at a time (not necessary concurrently) instead of a single.
- Run the other one when first is waiting for some resources.
- Make full use of CPU
- [Show multiple programs running in parallel on Mac]
- Multitasking is the same as multiprogramming. Just used in windows.

Types of Multiprogramming

- Single v/s Multi User
- Preemptive v/s Non Preemptive -> OS can force process to be removed even before completion

fork()

- System Call
- Makes CPU come in Kernel Mode
- What is Kernel Mode
    - Non Preemptive
    - Key OS functionality
    - Atomic Execution
- Creates a new process with copy of the current variables

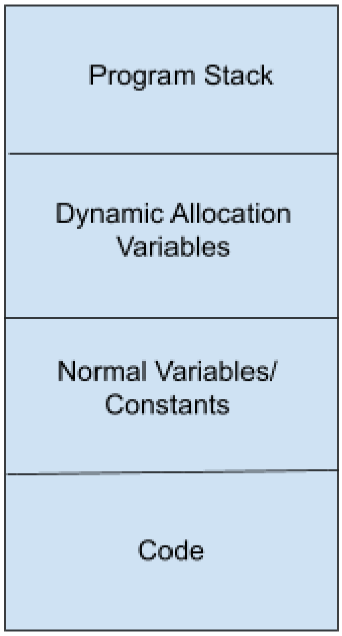
```
int main() {
  int a = 2;
  int b = 3;
  id = fork();
  print("hi");
}
```

- Id = zero in the child process.
- Non zero in the parent process.
- Less than zero means some error.
- [Show demo of how the program will work with 1 and 2 fork]
- [Show that n forks mean 2^n processes]
- How OS works
    - Even OS is a process that is started at the start of a program by BIOS that internally would start other processes. [Show systemd in Mac]

Process

- Program in execution
- Has resources allocated to it
- Unit of execution

What a process consists of



Process in memory

[Give hints regarding what all details wrt a process might be needed to store by an OS. Assume process class is there.]

- ID
- CPU related info (Priority etc.)
- Memory info (Limits etc.)
- Opened Files
- I/O related details
- Protection (Kernel/ User Mode)

All of these go in PCB (Process Control Block).

CPU Scheduling

CPU Bound v/s I/O Bound Processes

- I/O bound like Interactive programs. Most of the time waiting for I/O than using CPU.
- CPU Bound like scientific applications doing calculations

How I/O Happens

Interrupts

- Program raises a CPU Interrupt telling CPU that it is waiting for some I/O to happen
- Interrupts are signals emitted to tell the processor that some interruption is required.

- CPU sits idle till the I/O (network call, command line input etc.) which is very slow wrt CPU completes.

- This is a waste of CPU time and CPU can instead spend this time doing something useful.

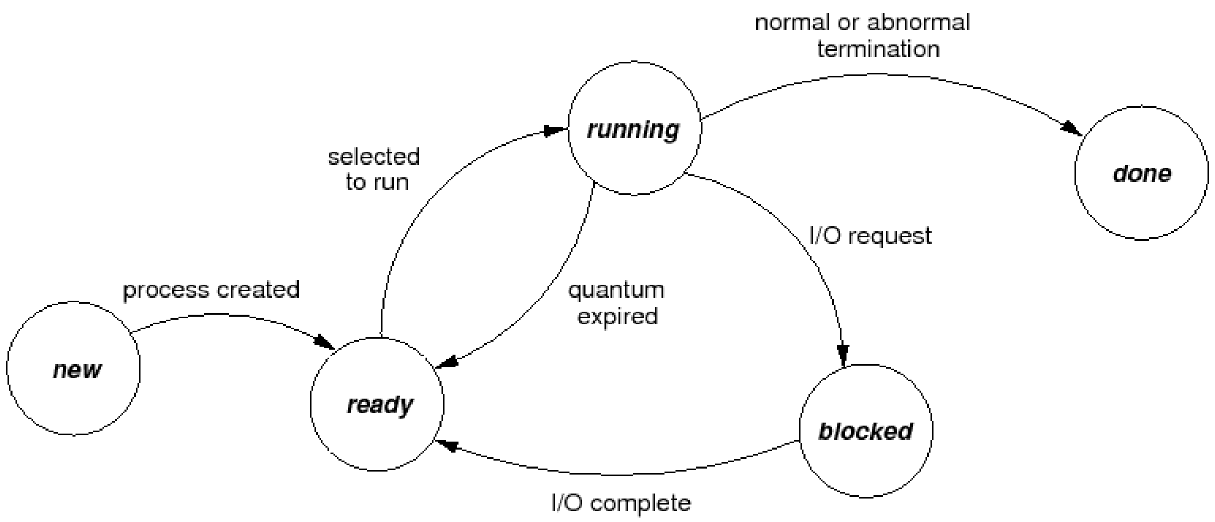
Why CPU Scheduling

- Utilize the CPU to fullest

Metrics wrt Processes

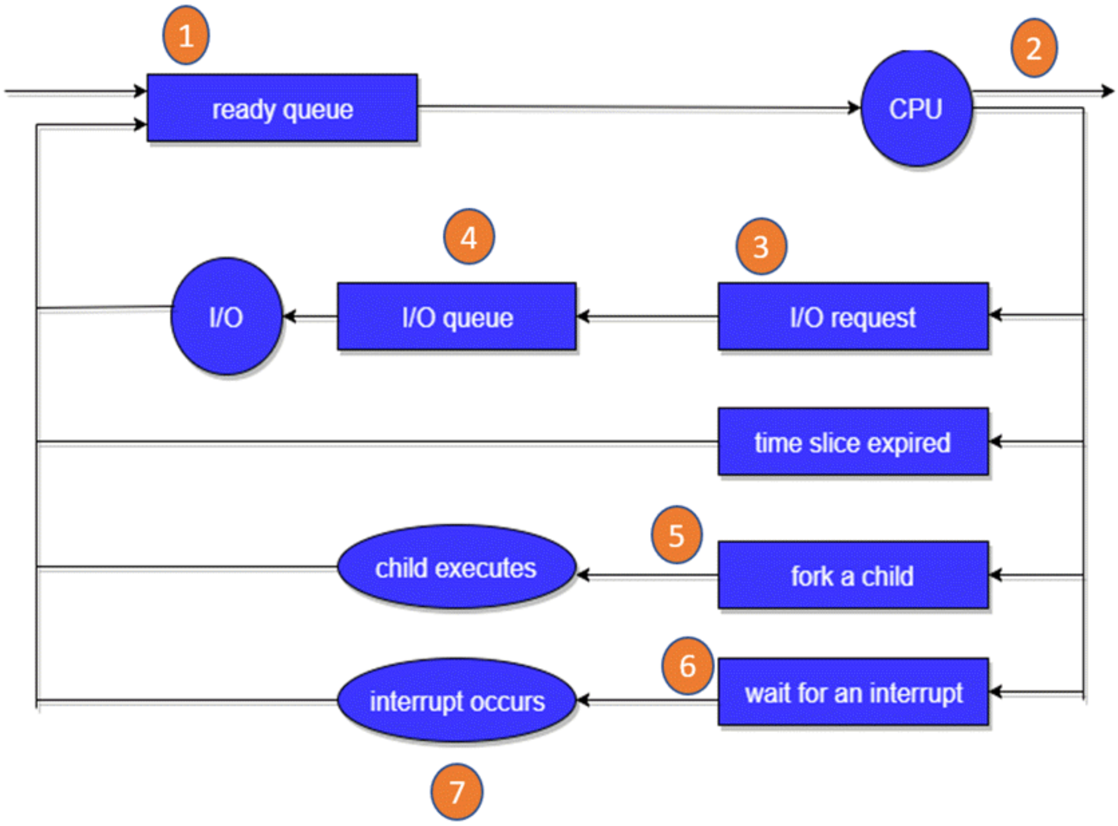
- Throughput: Number of process per unit time
- Arrival Time: When a process comes to CPU
- Wait Time: Time till completion when process isn't executing but is waiting for I/O or waiting to be assigned to CPU.
- Burst Time: Time needed to make the process execute completely.
- Completion Time: Time when a process completes its execution,
- I/O Burst Wait Time: Time for I/O to happen
- Turnaround Time = Completion Time - Arrival Time
- Response Time = Time when process first starts running (gets assigned to CPU)
- Schedule Time = Time to completely finish all processes
- Deadline: Expectation by which process should ideally finish
    - Underrun: When process finishes before deadline
    - Overrun: When process finishes after deadline

Process Lifecycle



Process Scheduling Queues

When a process is not running, it is waiting in one of the scheduling queues.



Dispatcher

- Picks the process from Ready Queue and assigns it to the CPU for scheduling.
- Moves the PCB out of CPU into the registers for execution.

Context Switch

- We as humans when we do multiple tasks in parallel, it takes some time to recall what had happened earlier.
- Moving a process out of register, storing it in memory in ready queue, replacing it with another process is known as context switch
- Context switch takes time and thus an algorithm that involves a lot of context switch isn't good.

Scheduling Algorithms

- Assume no I/O
- No context switch time

FCFS

- Non Preemptive.
- When we have to select a new process from the ready queue, select the process that has arrived the earliest.

PId	Arrival Time	Burst Time	Response Time	Completion Time	TAT	Wait Time
1	0	4				
2	1	5				
3	2	6				
4	3	8				
5	4	2				
6	5	4				

[Show how scheduling will work for above by filling the above table, as well as via a Gantt chart]

SRTF

- Shortest Response Time First
- Preemptive

PId	Arrival Time	Burst Time
1	0	8
2	1	6
3	2	4
4	3	2
5	4	6
6	5	1

[Show the scheduling via Gantt chart and show how preemptive behaviour happens.]

Starvation

- Some processes have to keep on waiting for very long and don't get CPU time because of other new processes coming ahead.

Round Robin

- Preemptive
- Time Quantum (q)
- After every q units, check the process most ahead in the queue and schedule that.

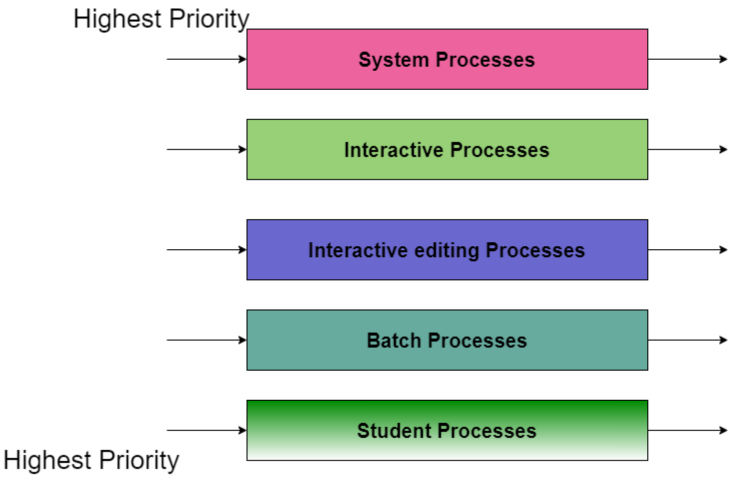
- New process gets added behind the queue.
- Current process gets added at the end when preempted.

PId	Arrival Time	Burst Time
1	0	4
2	1	5
3	2	6
4	3	3
5	4	4
6	5	1

Homework
- Learn about SJF and Priority scheduling.
- [Give a brief idea about them. The only difference is in one, the process with highest priority is selected, in the other the process with the shortest time.]

Multilevel Queues

- In real systems, a single scheduling algorithm might not work well.
- For different type of processes, we might need different scheduling algorithms.
- Example:
    - For I/O bound processes, RR with short time
    - For CPU intensive, maybe something else.



    - If there is a process in the highest queue, pick that. Else go to lower queues. Each queue internally may have its own scheduling algorithm.