


Operating Systems Process

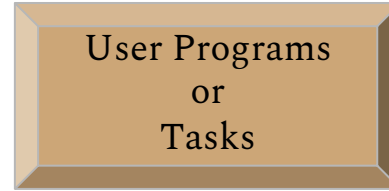


Process Concept

What to call the activities of CPU ?



Batch System



Time Sharing
System

These activities are called “**Processes**”

- ★ The terms “**job**” and “**process**” are used almost interchangeably.

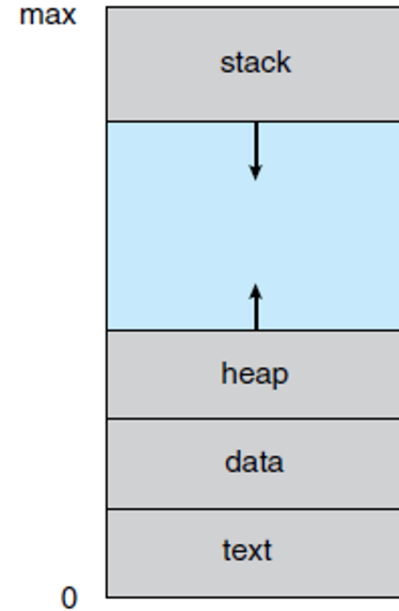
Process

*A process is a program that is **in execution**.*

But, it is more than the program codes. Program code is known as “text section” of a process.

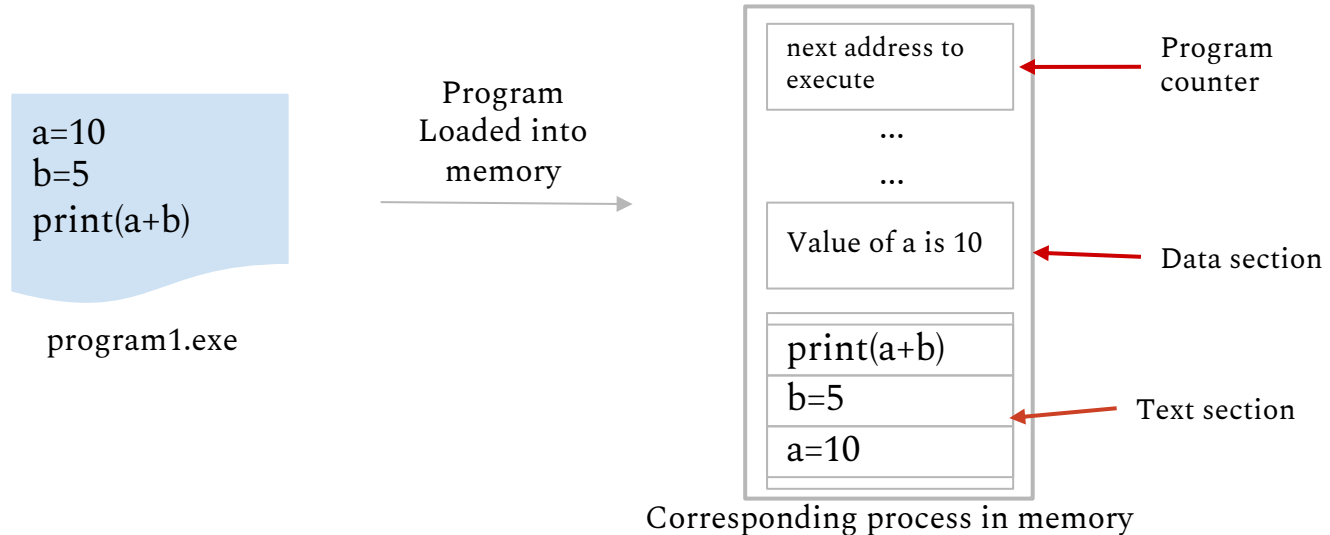
Besides code of the program, it contains -

- **Program Counter and Registers:** stores current activity of the process
- **Stack:** Temporary data (function parameter, local variables, return addresses etc.)
- **Data Section:** Global Variables
- **Heap:** dynamically allocated memory during runtime

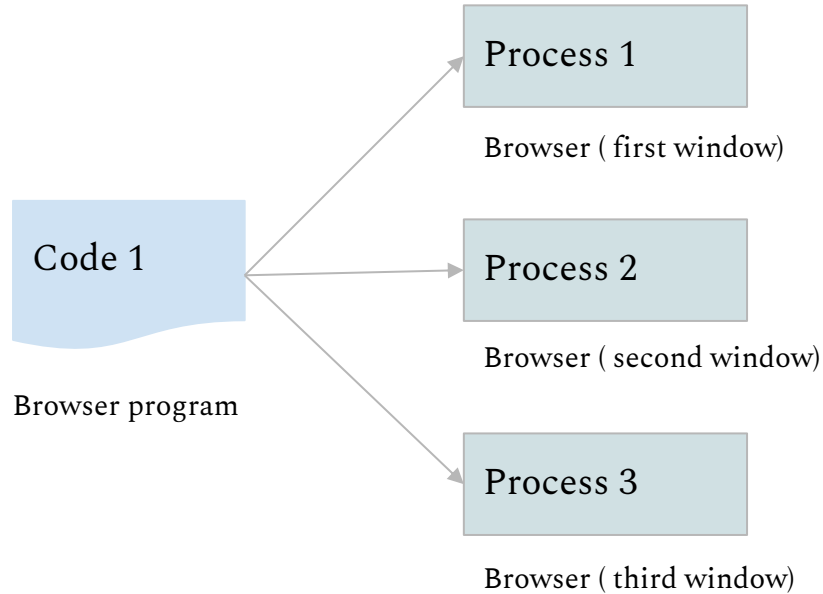


Program Vs Process

- **Program** is a collection of instructions that **can be executed**
- A program is a **passive** entity.
- A process is an **active** entity.
- A program becomes a process when it is loaded **into memory** for execution.



Same program, Different Process



- Program code is same
- Data, Heap, Stacks contains different information

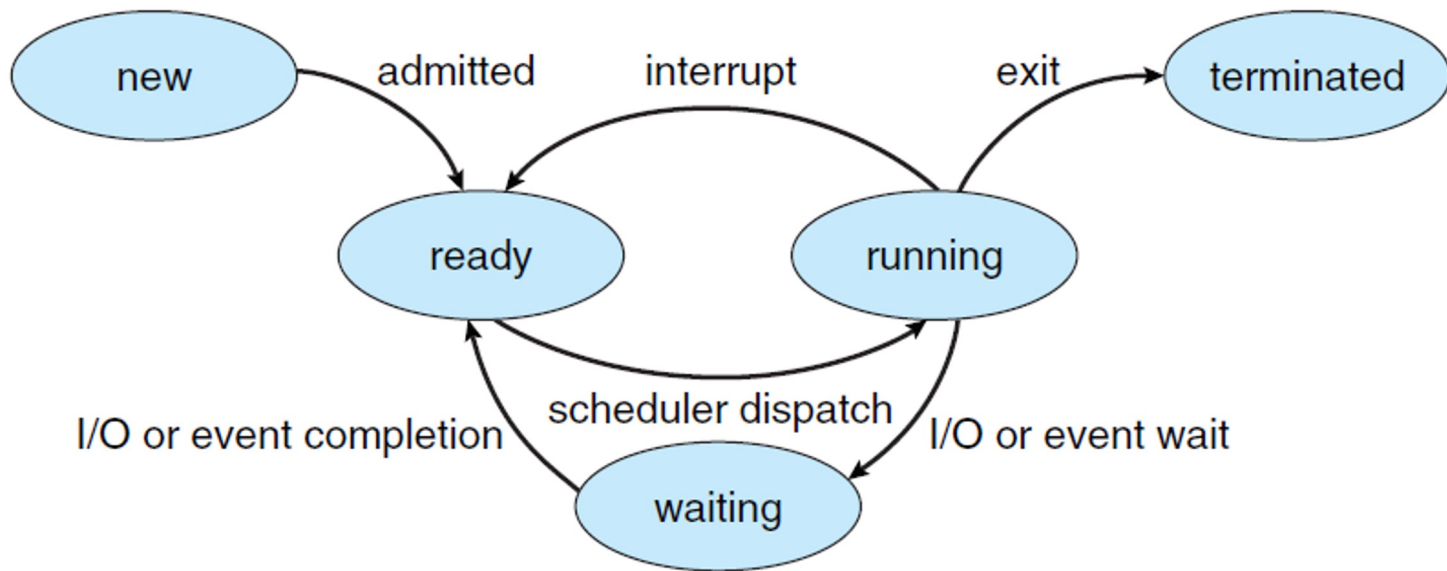
States of a Process

A process state defines the current activity of that process.

The states a process can be:

- ❑ **New:** Process is being **created**
- ❑ **Running:** Instructions are being **executed**
- ❑ **Waiting:** Process is **waiting** for some event to occur
- ❑ **Ready:** Waiting to be **assigned** to a processor
- ❑ **Terminated:** Process has **finished** execution

Process State Diagram



Representation of Processes in OS

Each process is represented in the operating system by a **Process Control Block (PCB)**

PCB is a data structure to store information of Processes such as -

Process state

Program counter

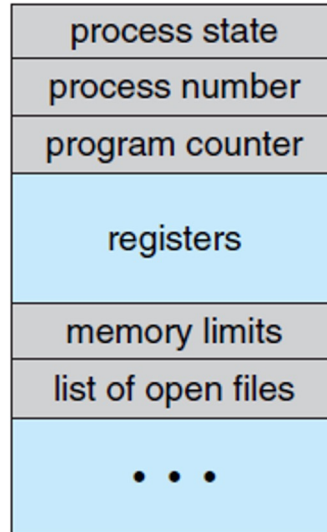
CPU registers

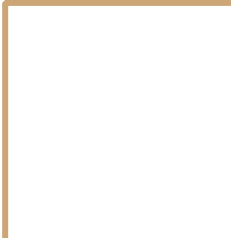
CPU scheduling information

Memory-management information

Accounting information


I/O status information





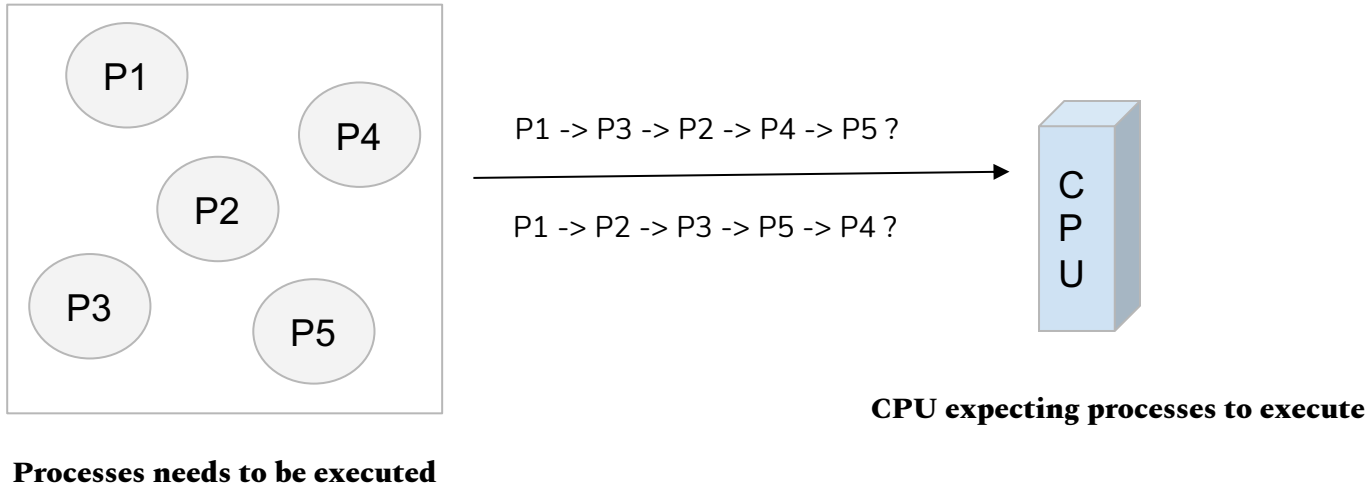
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Process Scheduling



Process Scheduling

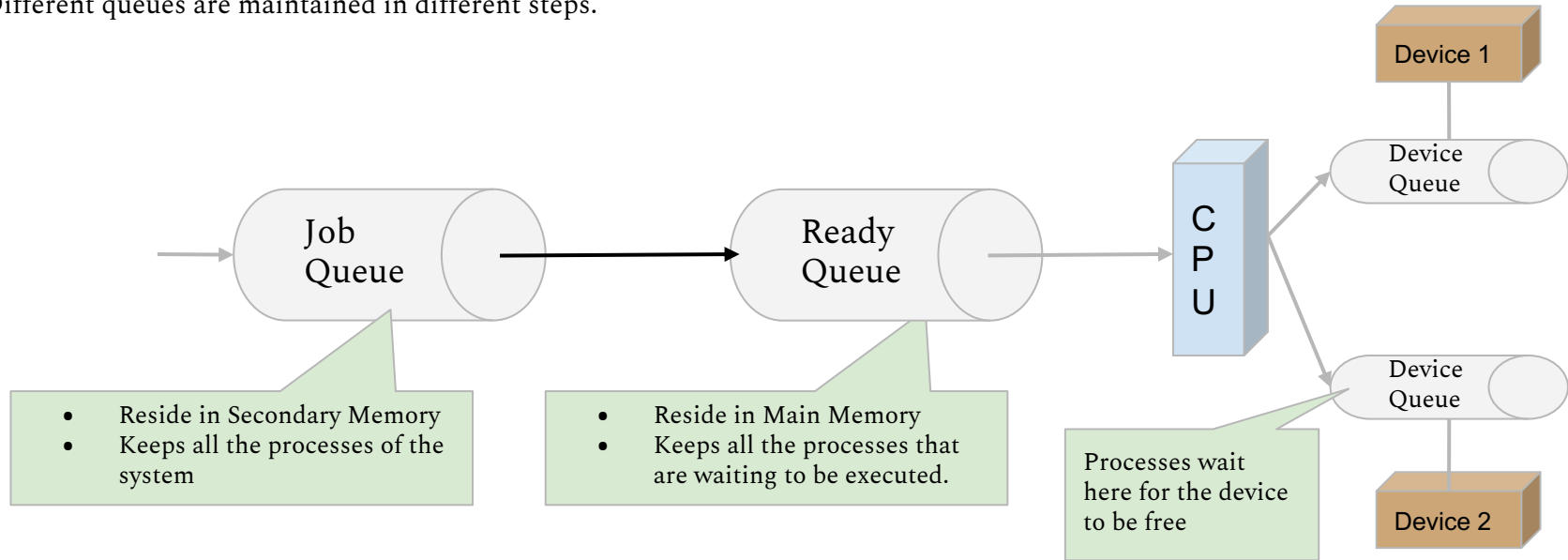
Multiple process is ready to execute.
But, which Process should be executed first?



Scheduling Queue

Stores the processes in **different steps of OS**.

Different queues are maintained in different steps.



Queueing Diagram

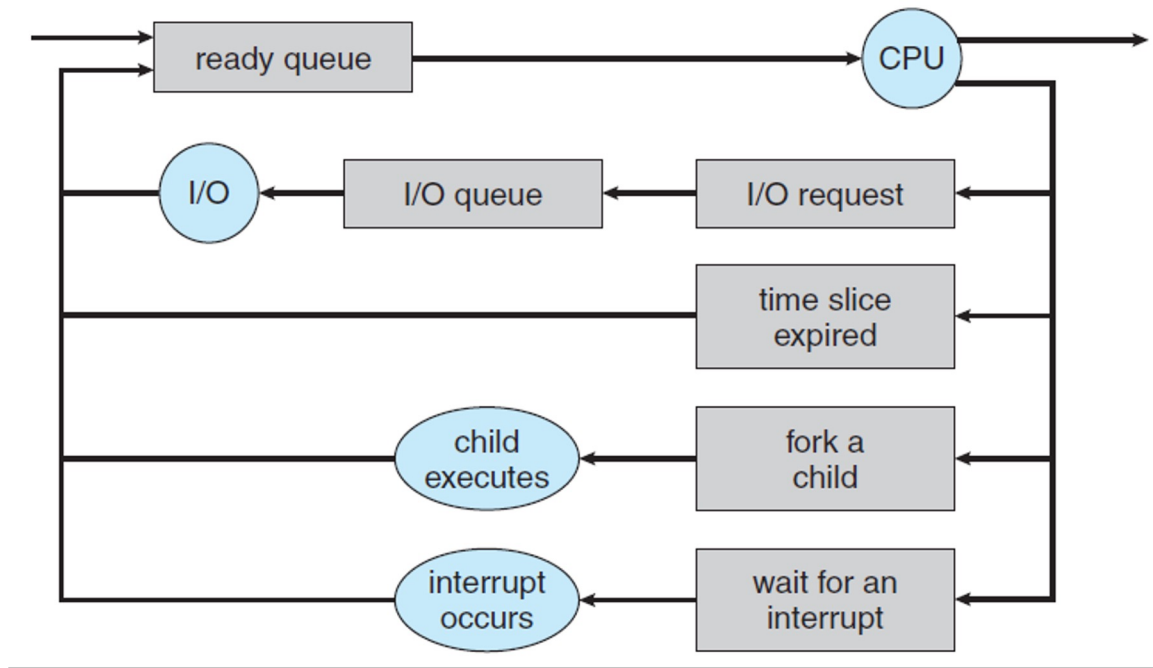
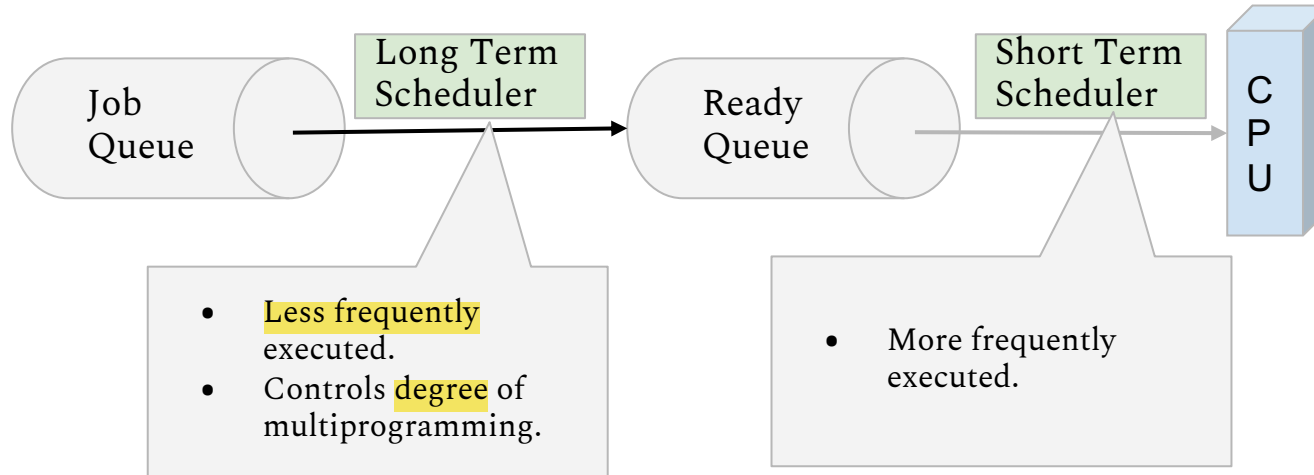


Fig: Representation of Process Scheduling using Queueing-Diagram

Schedulers

Schedulers select processes from different queues to be passed to the next phase.



CPU Bound Vs I/O Bound Process

- CPU bound processes spend **more time doing computation** using processors than I/O.
- I/O bound processes spend more time in I/O than CPU.

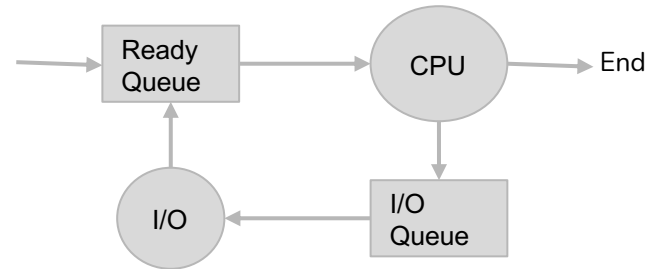
Long Term Scheduler must select wisely !

- What will happen if all processes are I/O bound ?

=> **Empty** ready queue

- What will happen if all processes are CPU bound ?

=> **Empty** waiting queue



Medium Term Scheduler

- Time-sharing system may use this scheduler.
- Swapping **reduce the degree** of multiprogramming.

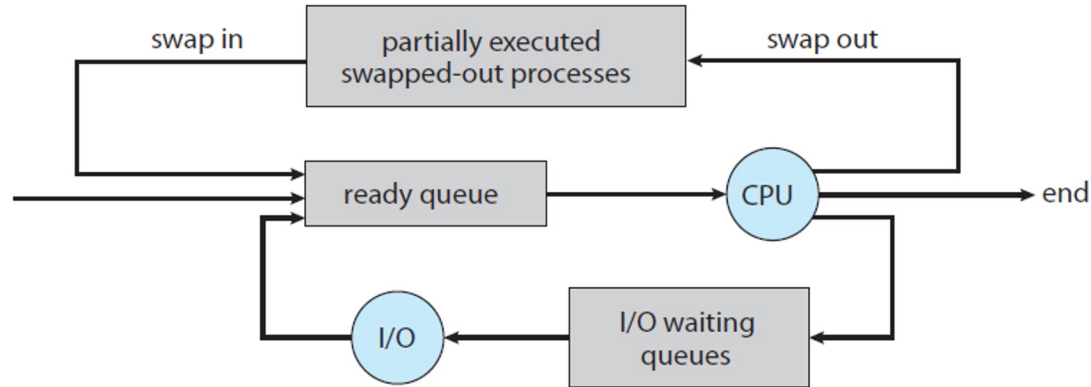
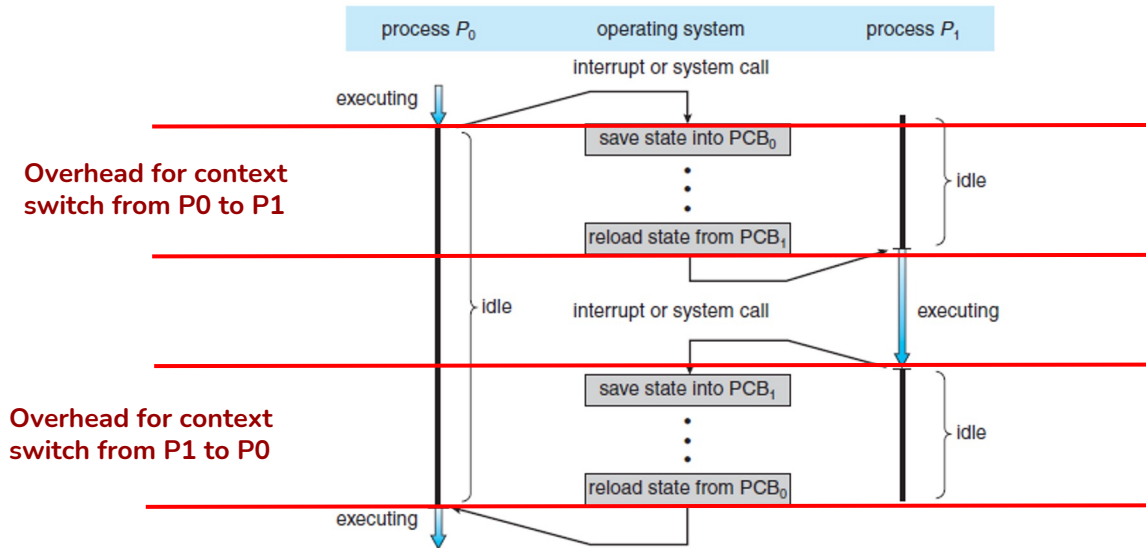


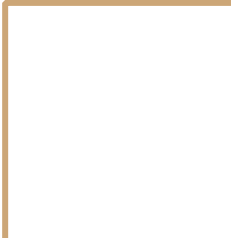
Fig: Addition of swapping in Queueing-Diagram

Context Switch

When an **interrupt occurs**, the system needs to **save** the current **context** (state) of the process **running on the CPU**.


- Context Switch:
1. **Storing** currently executed process context
 2. **Restoring** the **next process** context to execute





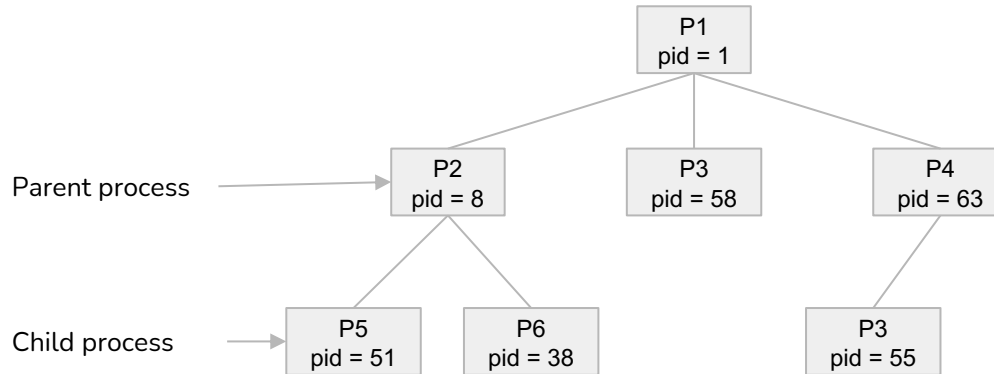
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Operations on Process



Process Creation

- A process is identified by a **unique PID** (**Process Identifier**) in the OS.
- A process **may** create new processes.



- Child process obtain resources from OS or are restricted to Parent's resources
- Parent process may **pass initializing data** to child process

Process Creation

- When a process creates **new process** -

The parent **continues to execute** concurrently with its children

Or,

The parent **waits** until some or all of its **children** have **terminated**

- Two address-space possibilities for the new process -

The child process is **a duplicate** of the parent process

Or

The child process has **a new program** loaded into it.

Process creation in UNIX

System Call: offers the services of the operating system to the user programs.

fork(): create a new process, which becomes the child process of the caller

exec(): runs an executable file, replacing the previous executable

wait(): suspends execution of the current process until one of its children terminates.

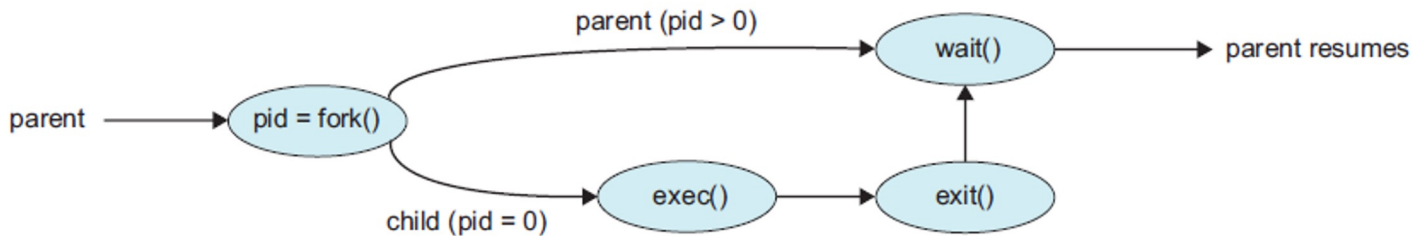


Fig: Process creation using fork() system call

```
#include <sys/types.h>
#include <stdio.h>
#include <unistd.h>

int main()
{
    pid_t pid;

    /* fork a child process */
    pid = fork();

    if (pid < 0) { /* error occurred */
        fprintf(stderr, "Fork Failed");
        return 1;
    }
    else if (pid == 0) { /* child process */
        execlp("/bin/ls", "ls", NULL);
    }
    else { /* parent process */
        /* parent will wait for the child to complete */
        wait(NULL);
        printf("Child Complete");
    }

    return 0;
}
```

Figure 3.9 Creating a separate process using the UNIX `fork()` system call.

```
int main(){  
    fork();  
    fork();  
    printf("A");  
}
```

```
int main(){  
    fork();  
    fork();  
    fork();  
    printf("A");  
}
```

```
int main(){
    a = fork();
    if(a==0)
fork();
    fork();
    printf("A");
}
```

```
int main(){
    fork();
    a = fork();
    if(a==0)
fork();
    printf("A");
}
```

```
int main(){
    int x = 1;
    a = fork();
    if(a==0){
        x = x -1;
        printf("value of x is: %d", x);
    }
    else if (a>0){
        wait(NULL);
        x = x +1;
        printf("value of x is: %d", x);
    }
}
```


Process Termination

A process is terminated when -

It executes its last statement

Or

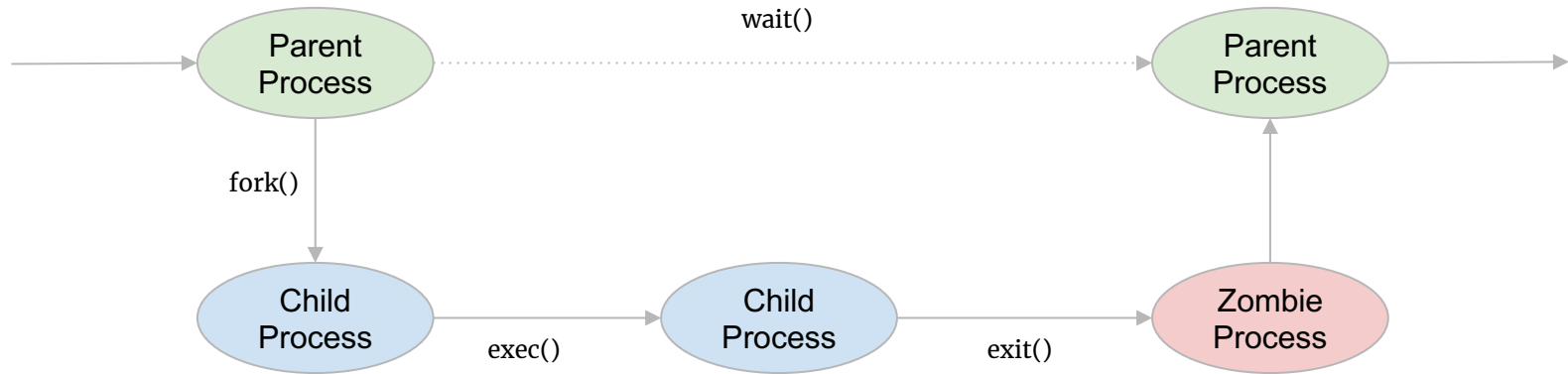
Termination cause by another process


When a process is terminated, the resources are deallocated.

A parent may terminate its child if -

1. Child has exceeded the usage of resources
2. Task assigned to child is no longer needed
3. Parent is exiting (cascading termination)


Zombie Process in UNIX





Operating Systems

Interprocess Communication



Processes in the system

Processes running **concurrently** may be -

Independent (cannot affect or be affected by other process)

Or

Cooperating (can affect or be affected by other process)

Process cooperation is needed for -

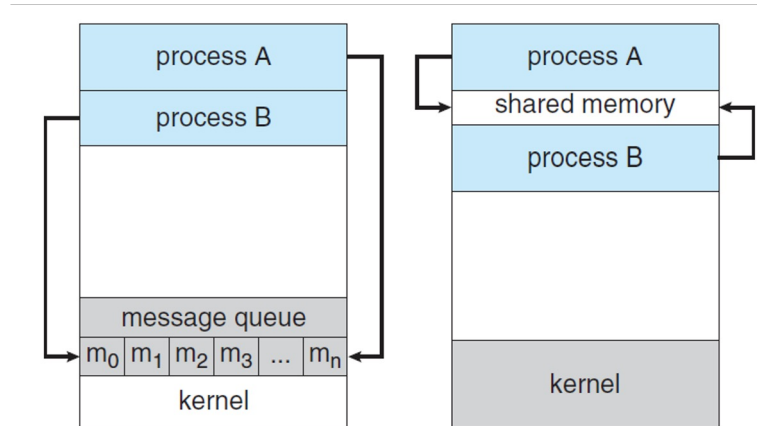
- Information sharing
- Computational speedup
- Modularity
- Convenience

Inter Process Communication

IPC is a **mechanism** to exchange data and information among processes.

Two fundamental model of IPC -

1. Shared Memory
2. Message Passing

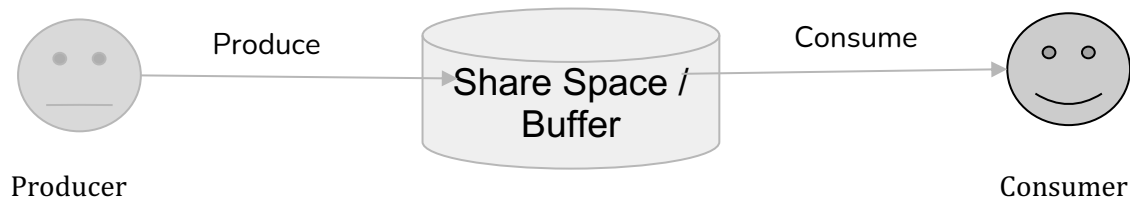


Shared Memory System

(Producer-Consumer Problem)

Producer: produces products for consumer

Consumer: consumes products provided by producer



Producer-Consumer Problem (Producer)

```
item next_produced;

while (true) {
    /* produce an item in next_produced */

    while (((in + 1) % BUFFER_SIZE) == out)
        ; /* do nothing */

    buffer[in] = next_produced;
    in = (in + 1) % BUFFER_SIZE;
}
```

Here, BUFFER_SIZE = 7

When buffer is full,
in = 6, out = 0

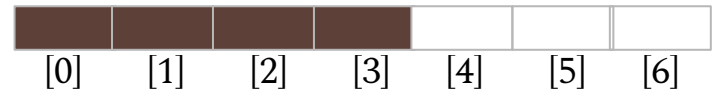


in: next free position in buffer
out: first full position in buffer

Both initialized with 0.

in = 0
out = 0

When buffer is not full,
In = 4, out = 0



Producer-Consumer Problem (Consumer)

```
item next_consumed;  
  
while (true) {  
    while (in == out)  
        ; /* do nothing */  
  
    next_consumed = buffer[out];  
    out = (out + 1) % BUFFER_SIZE;  
  
    /* consume the item in next_consumed */  
}
```

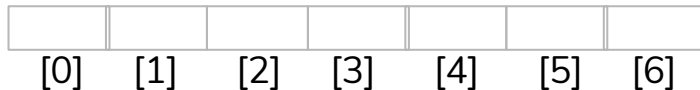
in: next free position in buffer
out: first full position in buffer

Both initialized with 0.

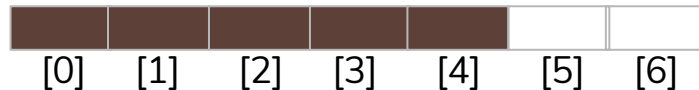
in = 0
out = 0

Here, BUFFER_SIZE = 7

When buffer is empty,
in = 0 , out = 0



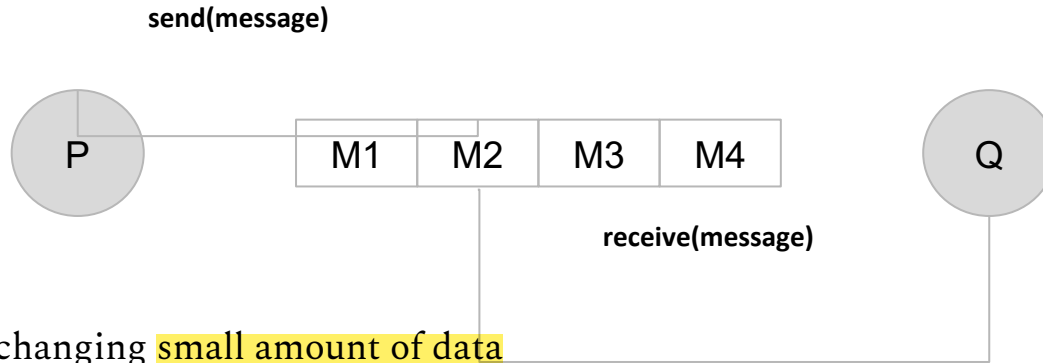
When buffer is not empty,
In = 5, out = 0



Message Passing System

If processes P and Q want to communicate, they **must send messages** to and *receive* messages from each other.

A communication link must exist between P and Q.



- Useful for exchanging **small amount of data**
- More suited for distributed systems than shared memory