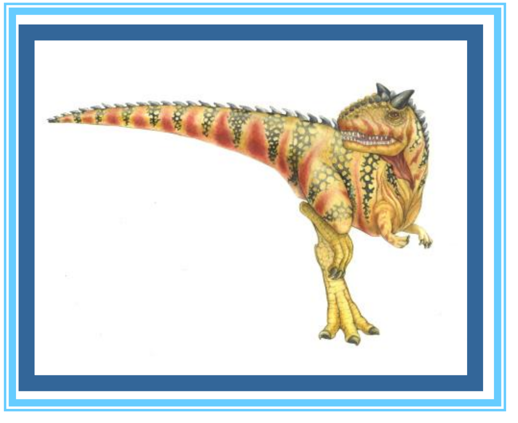
# Processes
# Day3: March 2022

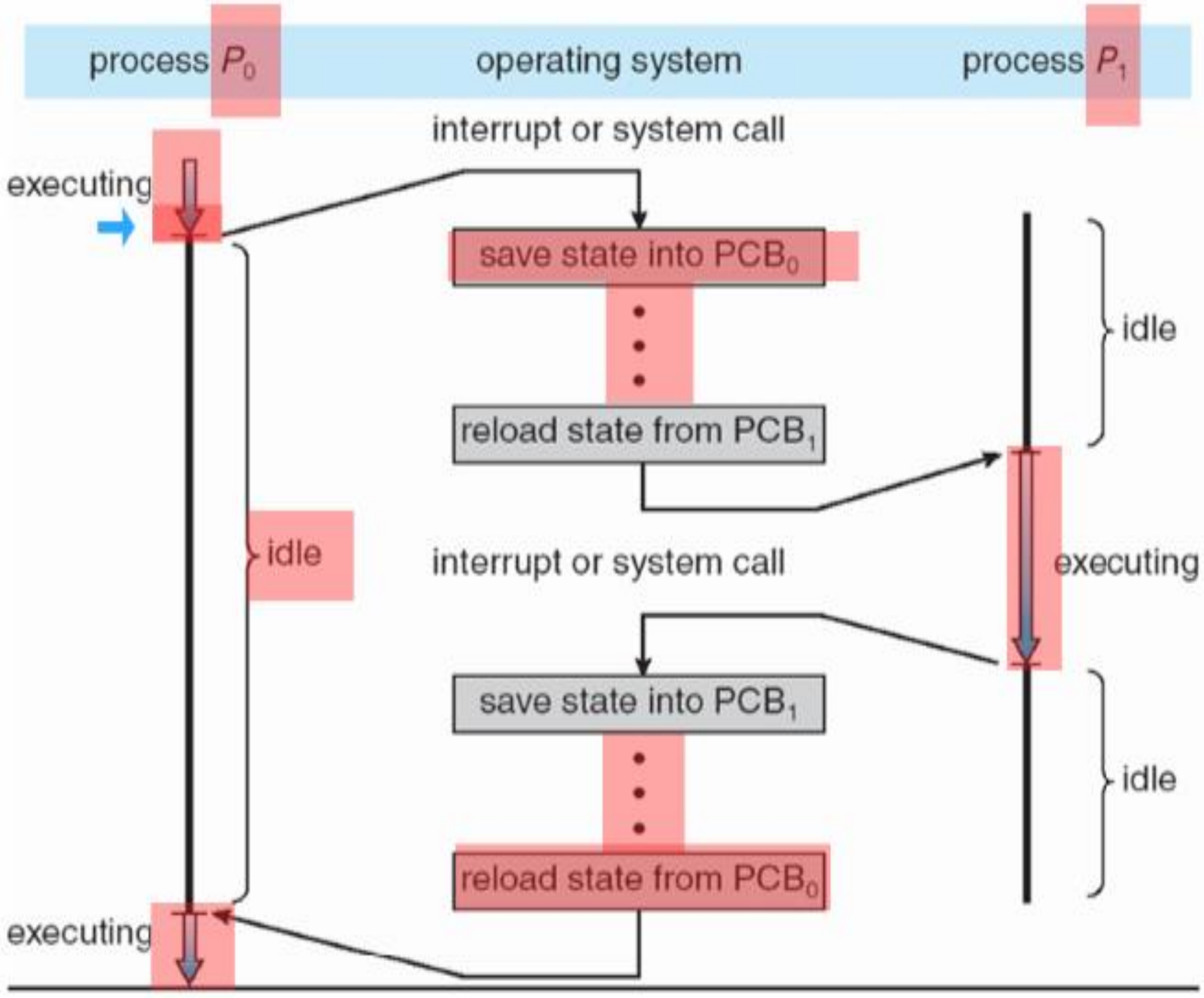
**Kiran Waghmare**



# Process Scheduling

- When there are two or more runnable processes then it is decided by the Operating system which one to run first then it is referred to as Process Scheduling.
- A scheduler is used to make decisions by using some scheduling algorithm.
- Given below are the properties of a **Good Scheduling Algorithm**:
  - Response time should be **minimum** for the users.
  - The **number of jobs processed per hour should be maximum** i.e Good scheduling algorithm should give maximum throughput.
  - The utilization of the CPU should be 100%.
  - Each process should get a fair share of the CPU.

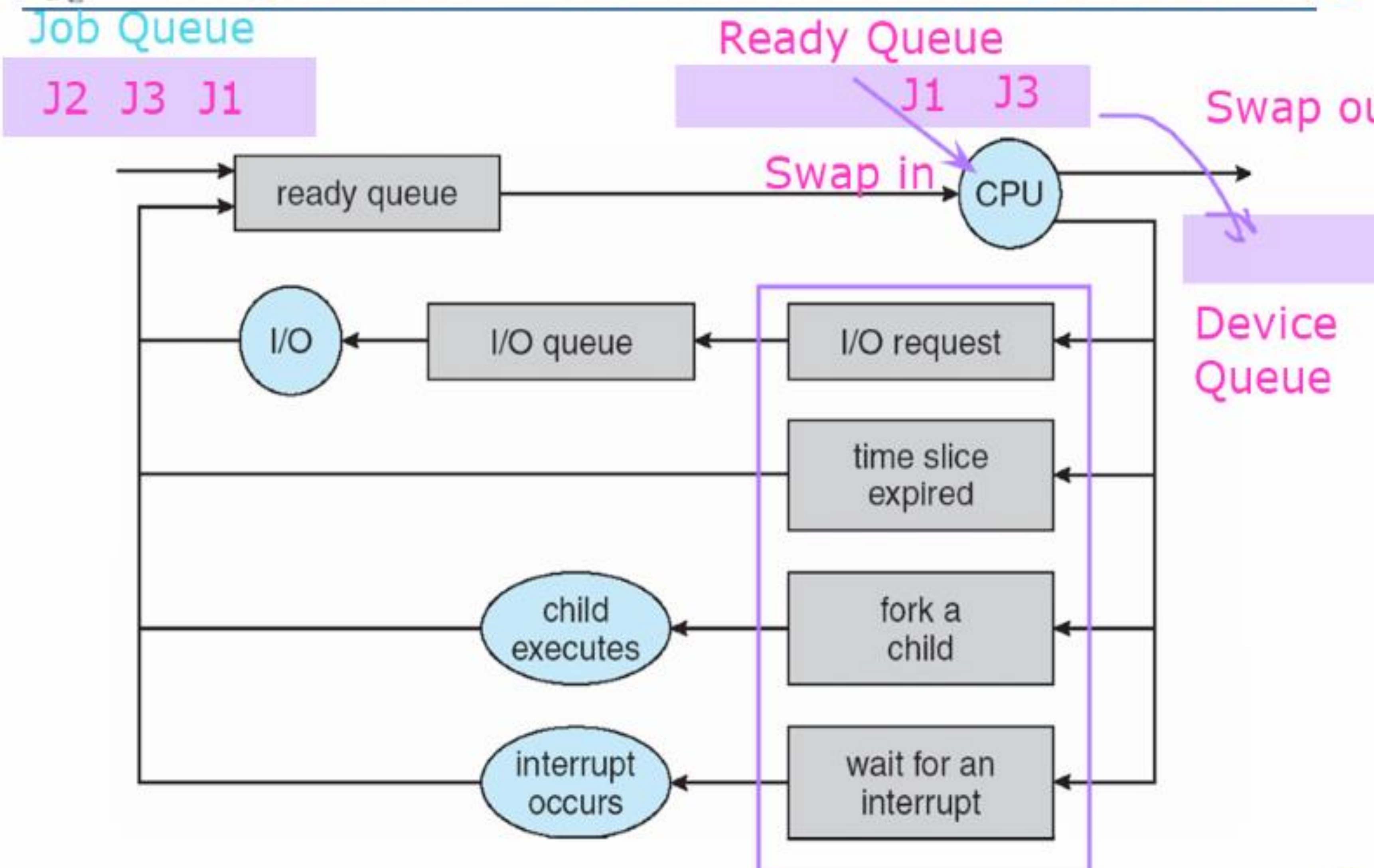
# CPU Switch From Process to Process



# Process Scheduling Queues

- **Job queue** – set of all processes in the system
- **Ready queue** – set of all processes **residing in main memory**, ready and waiting to execute
- **Device queues** – set of processes **waiting for an I/O** device
- Processes migrate among the various queues

# Representation of Process Scheduling

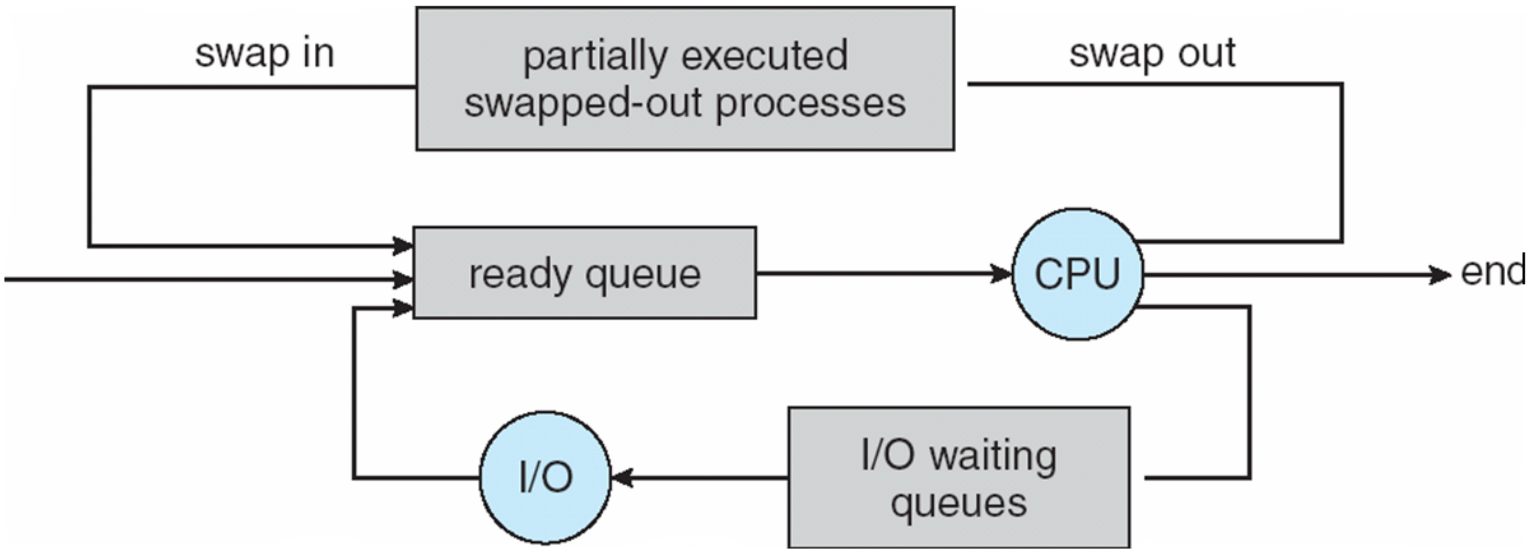


# Types of Schedulers

- There are three types of schedulers available:

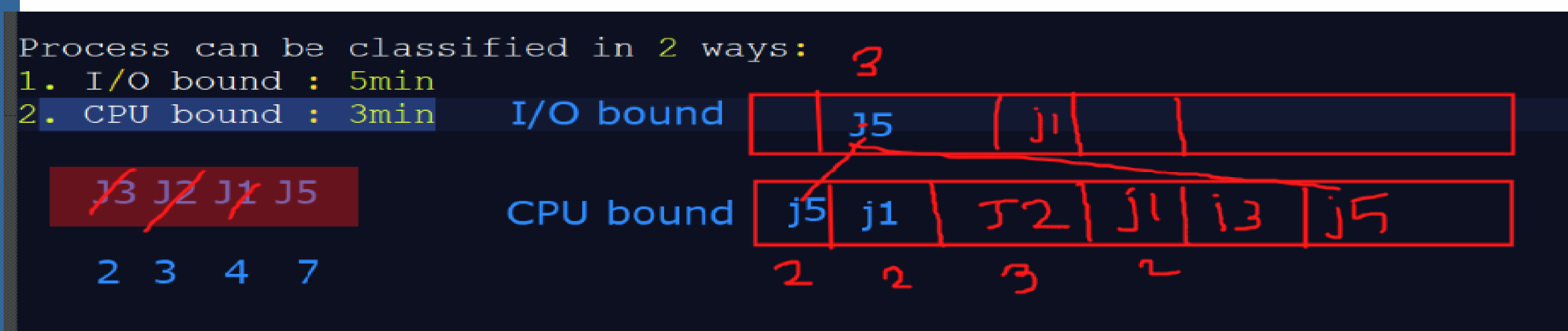
- Long Term Scheduler
- Short Term Scheduler
- Medium Term Scheduler

# Addition of Medium Term Scheduling



# Schedulers (Cont)

- Short-term scheduler **is invoked very frequently (milliseconds) ⇒ (must be fast)**
- Long-term scheduler is **invoked very infrequently (seconds, minutes) ⇒ (may be slow)**
- The long-term scheduler controls the *degree of multiprogramming*
- Processes can be described as either:
  - **I/O-bound process** – spends more time doing I/O than computations, many short CPU bursts
  - **CPU-bound process** – spends more time doing computations; few very long CPU bursts



# Context Switch

- When CPU switches to another process, the system must **save the state of the old process and load the saved state for the new process** via a context switch
- Context of a process represented in the PCB
- Context-switch time is overhead; the system does no useful work while switching
- Time dependent on hardware support

# Operations on Process

- Below we have discussed the two major operation **Process Creation** and **Process Termination**.
- **Process Creation**
- Through appropriate system calls, such as **fork or spawn**, processes may create other processes.
- The process which creates other process, is termed **the parent of the other process**, while the **created sub-process** is termed its **child.**
- Each process is given an integer identifier, termed as process identifier, or PID.
- **The parent PID (PPID**) is also stored for each process.
- On a typical UNIX systems the process scheduler is termed as sched, and is given PID 0. The first thing done by it at system start-up time is to launch init, which gives that process PID 1. Further Init launches all the system daemons and user logins, and becomes the ultimate parent of all other processes.

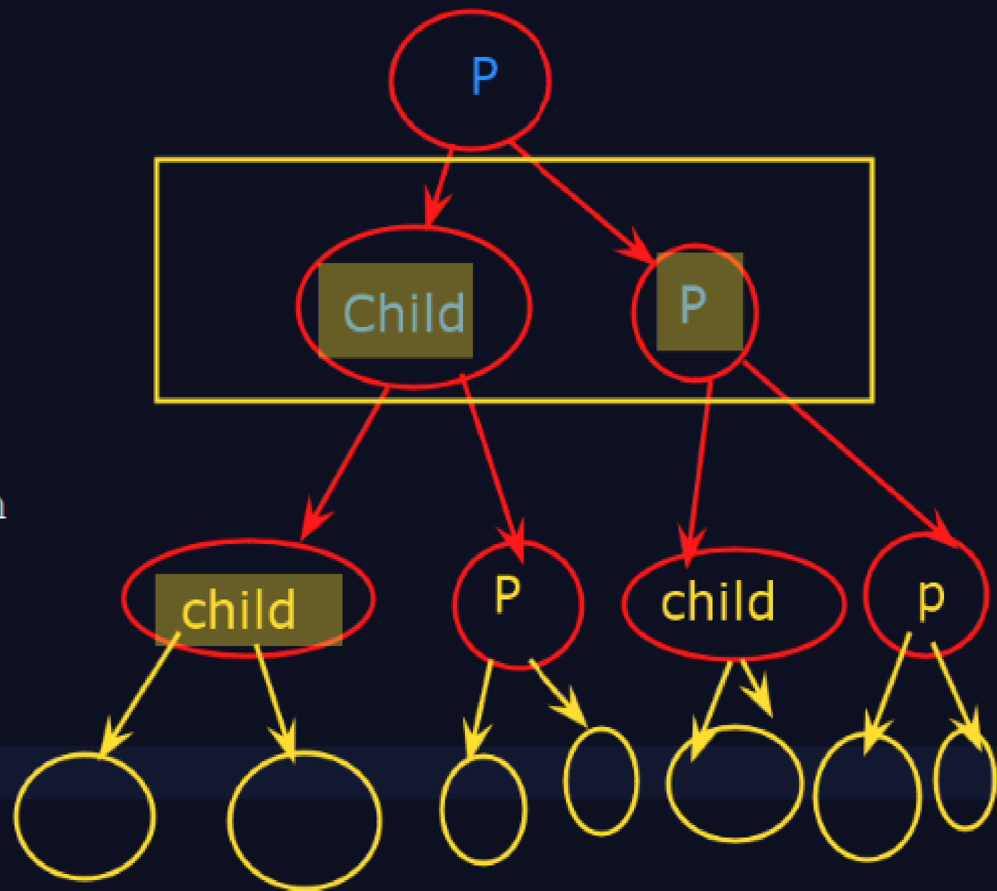
```c
#include<stdio.h>

void main(int argc, char *argv[])
{
    int pid;

    /* Fork another process */
    pid = fork();

    if(pid < 0)
    {
        //Error occurred
        fprintf(stderr, "Fork Failed");
        exit(-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");
        exit(0);
    }
}
```

**GATE Numerical Tip:** If fork is called for n times, the number of child processes or new processes created will be: 2^n – 1.

Short term scheduler:
-cpu scheduler
-ready queue
-faster

Medium term scheduler:
-Swapping
-device queue
-range

Process Operations:
-1. Process creation
system call : fork() or spawn
-parent process
-child process

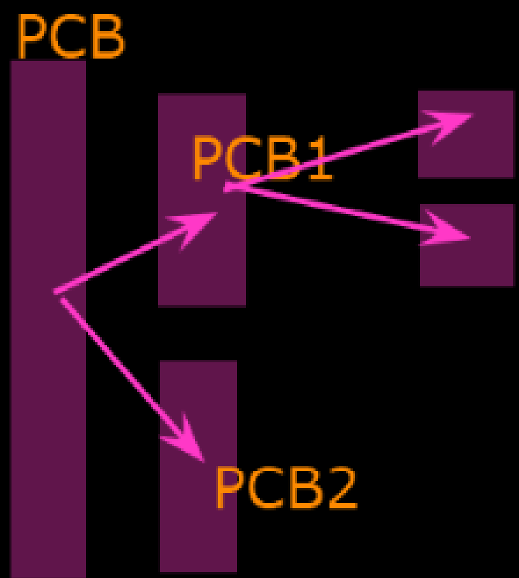



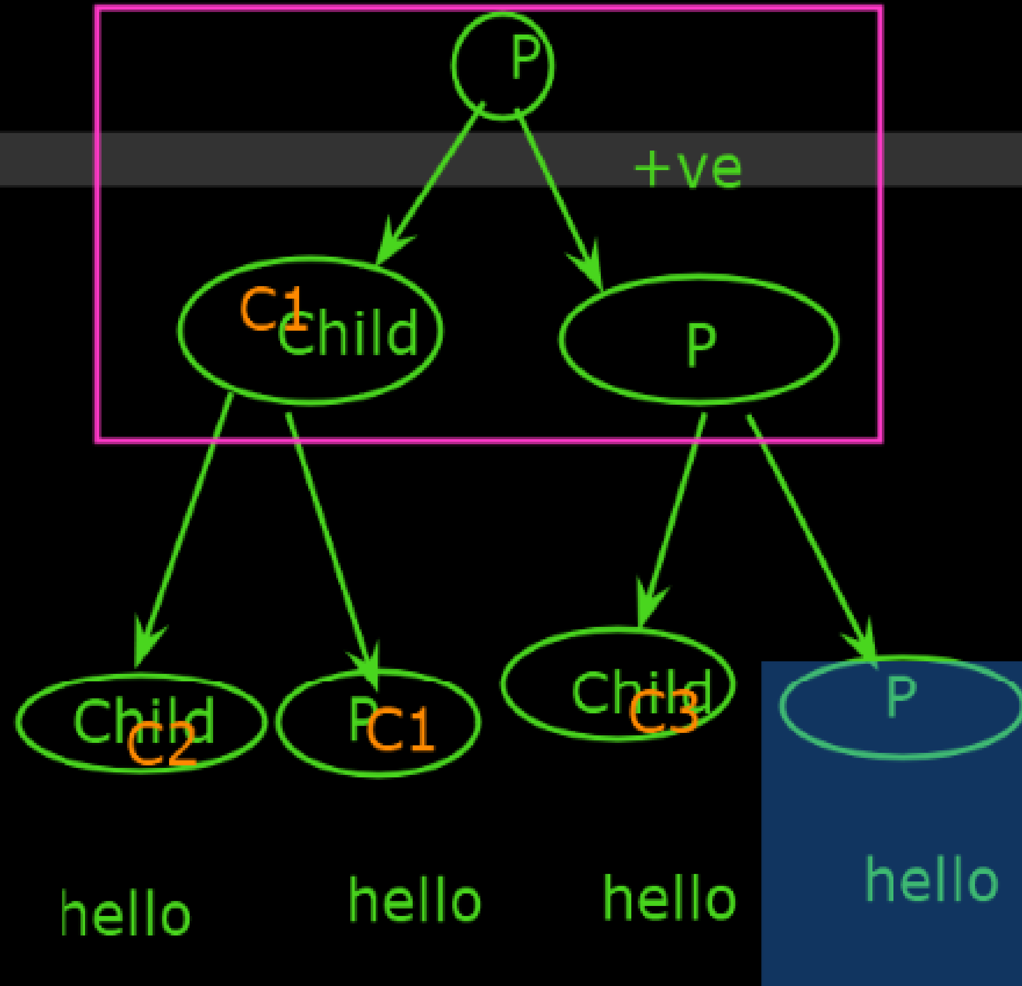

fork() : 2^n

fork() for child :2^n - 1

-2. Process termination

```
fork():
--------
-create a child process
    -   0 : child
    -   1 : parent
```




fork() = 2^n
fork() for child = 2^n-1

# Process Termination

- By making **the exit(system call),** typically returning an int, processes may request their own termination. This int is passed along to the parent if it is doing a wait(), and is typically zero on successful completion and some non-zero code in the event of any problem.

- **Processes may also be terminated by the system for a variety of reasons, including :**
- The inability of the system to deliver the necessary system resources.
- In response to a KILL command or other unhandled process interrupts.
- A parent may kill its children if the task assigned to them is no longer needed i.e. if the need of having a child terminates.

- The processes which are trying to terminate but cannot do so because their parent is not waiting for them are **termed zombies.** These are eventually inherited by init as orphans and killed off.

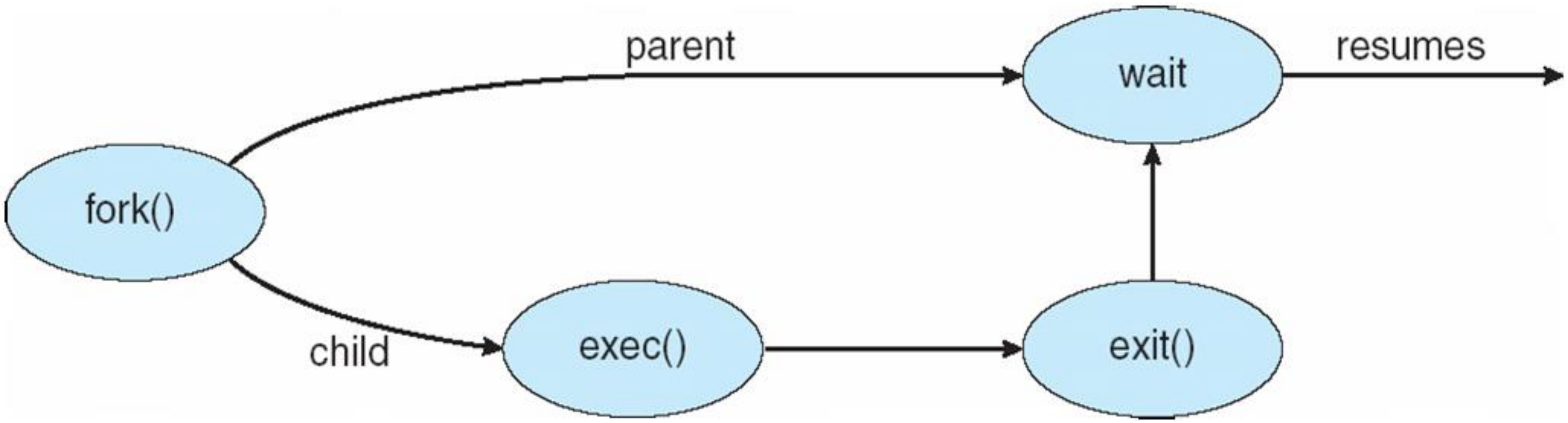
# Process Creation

- **Parent** process create **children** processes, which, in turn create other processes, forming a tree of processes
- Generally, process identified and managed via **a process identifier** (**pid**)
- Resource sharing
  - Parent and children share all resources
  - Children share subset of parent's resources
  - Parent and child share no resources
- Execution
  - Parent and children execute concurrently
  - Parent waits until children terminate

# Process Creation (Cont)

- Address space
  - Child duplicate of parent
  - Child has a program loaded into it
- UNIX examples
  - **fork** system call creates new process
  - **exec** system call used after a **fork** to replace the process’ memory space with a new program

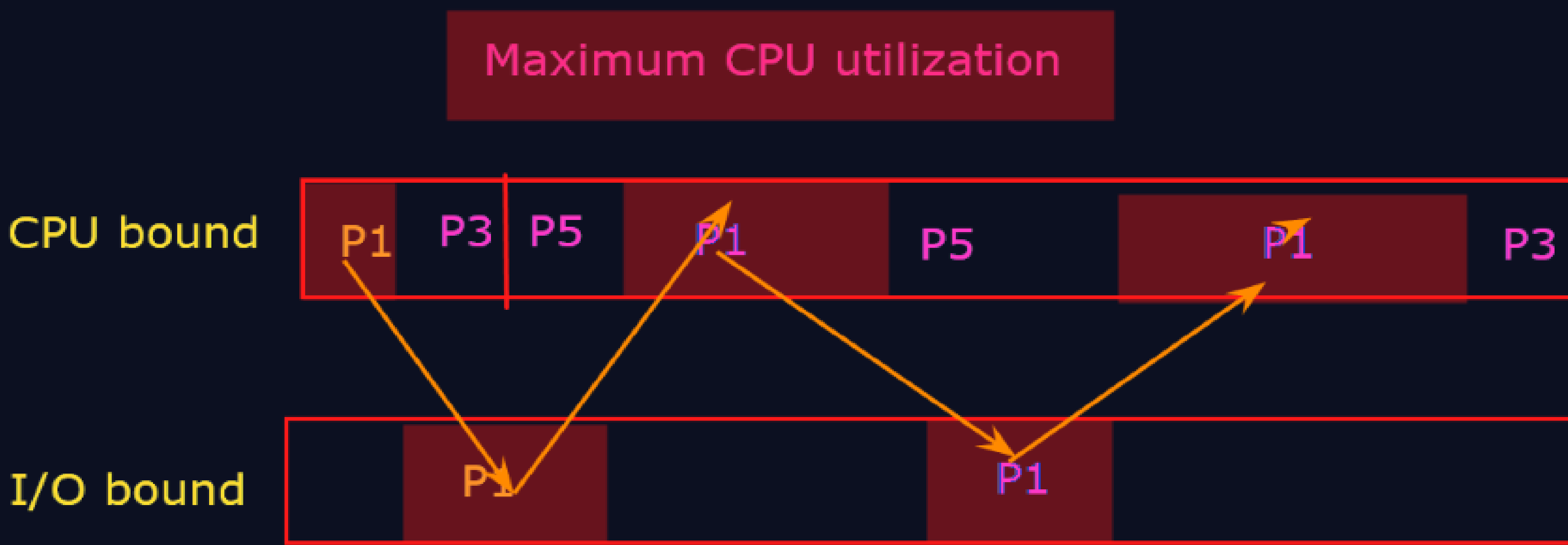
# Process Creation



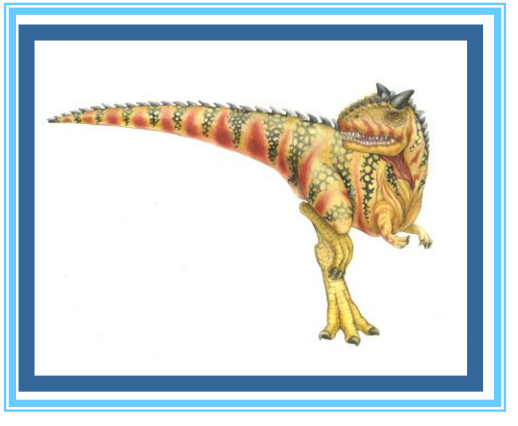
# Process Termination

- Process executes last statement and asks the operating system to delete it (**exit**)
  - Output data from child to parent (via **wait**)
  - Process' resources are deallocated by operating system
- Parent may terminate execution of children processes (**abort**)
  - Child has exceeded allocated resources
  - Task assigned to child is no longer required
  - If parent is exiting
    - Some operating system do not allow child to continue if its parent terminates
      - All children terminated - **cascading termination**

-CPU utilization : Cpu burst: duration for which CPU will execute
-I/O Burst



# Chapter 5:  CPU Scheduling

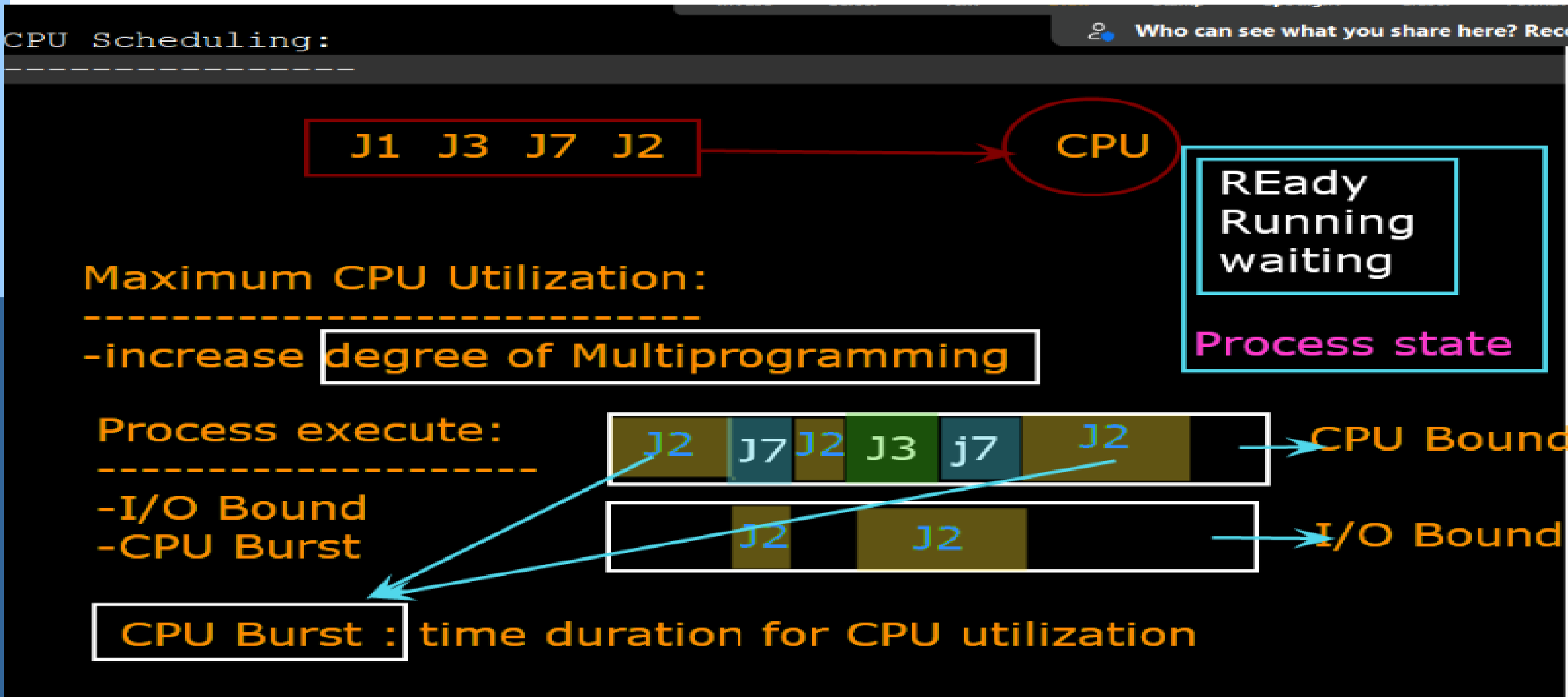


# Chapter 5:  CPU Scheduling

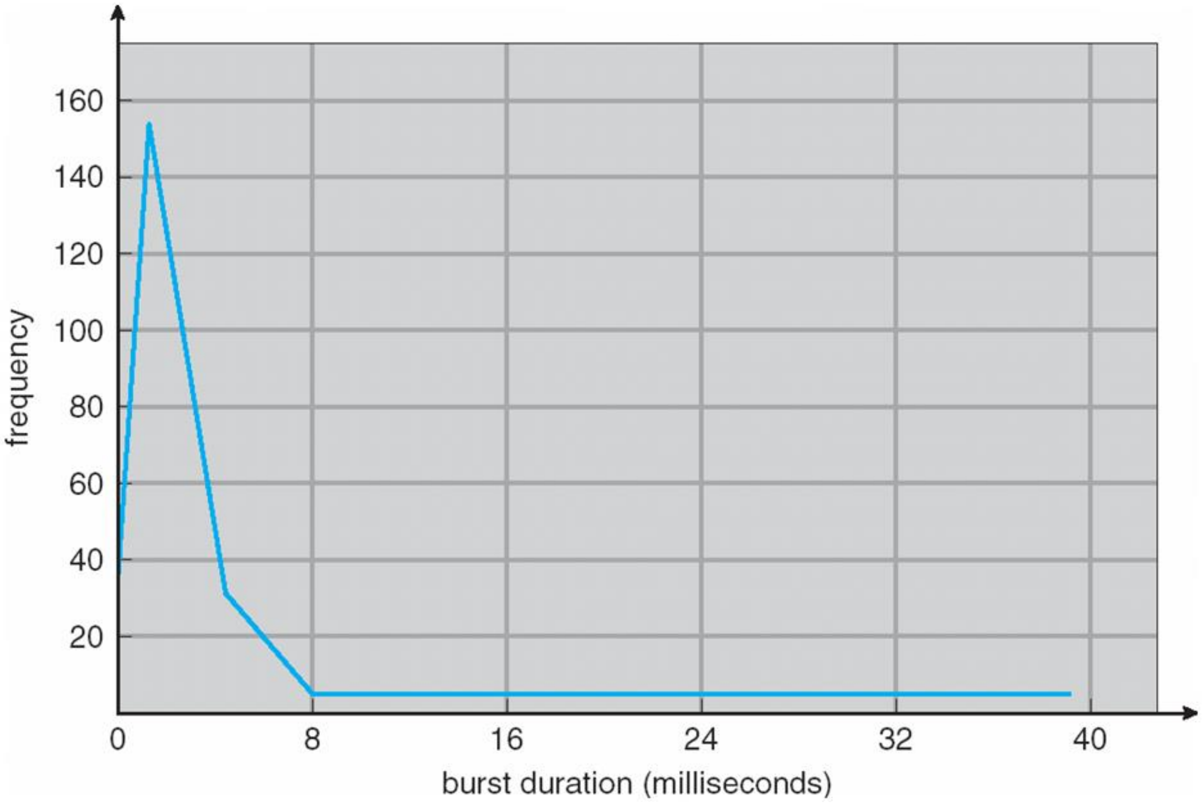
- Basic Concepts
- Scheduling Criteria
- Scheduling Algorithms
- Thread Scheduling
- Multiple-Processor Scheduling
- Operating Systems Examples
- Algorithm Evaluation

# Basic Concepts

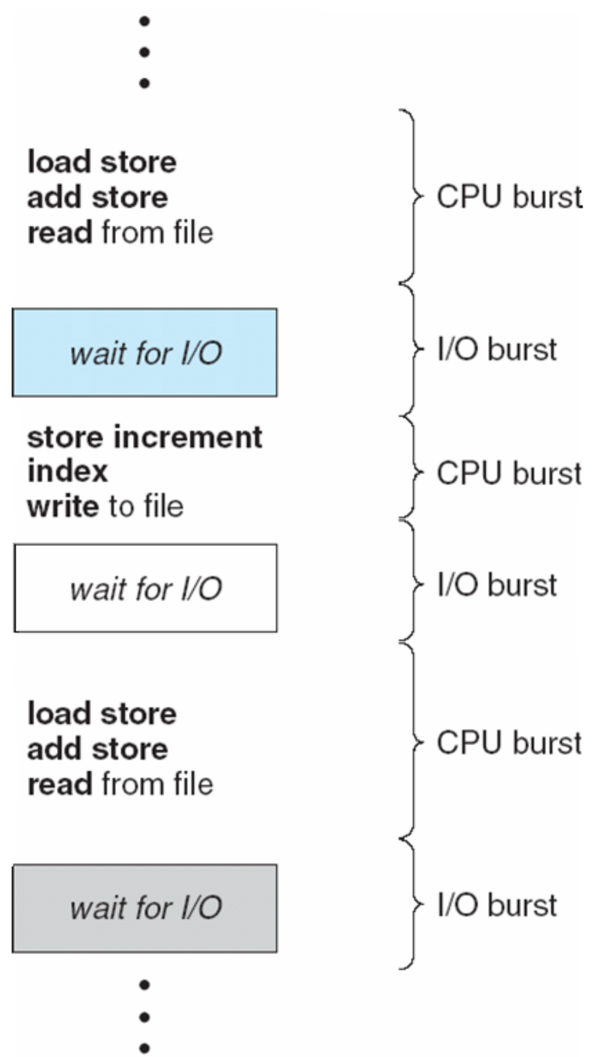
- Maximum CPU utilization obtained with multiprogramming
- CPU–I/O Burst Cycle – Process execution consists of a *cycle* of CPU execution and I/O wait
- **CPU burst** distribution



# Histogram of CPU-burst Times



# Alternating Sequence of CPU And I/O Bursts



# CPU Scheduler

- Selects from among the **processes in memory that are ready to execute**, and allocates the CPU to one of them
- CPU scheduling decisions may take place when a process:
  1. Switches from **running to waiting state**
  2. Switches from **running to ready state**
  3. Switches from **waiting to ready**
  4. Terminates
- Scheduling under 1 and 4 is **nonpreemptive**
- All other scheduling is **preemptive**

# Dispatcher

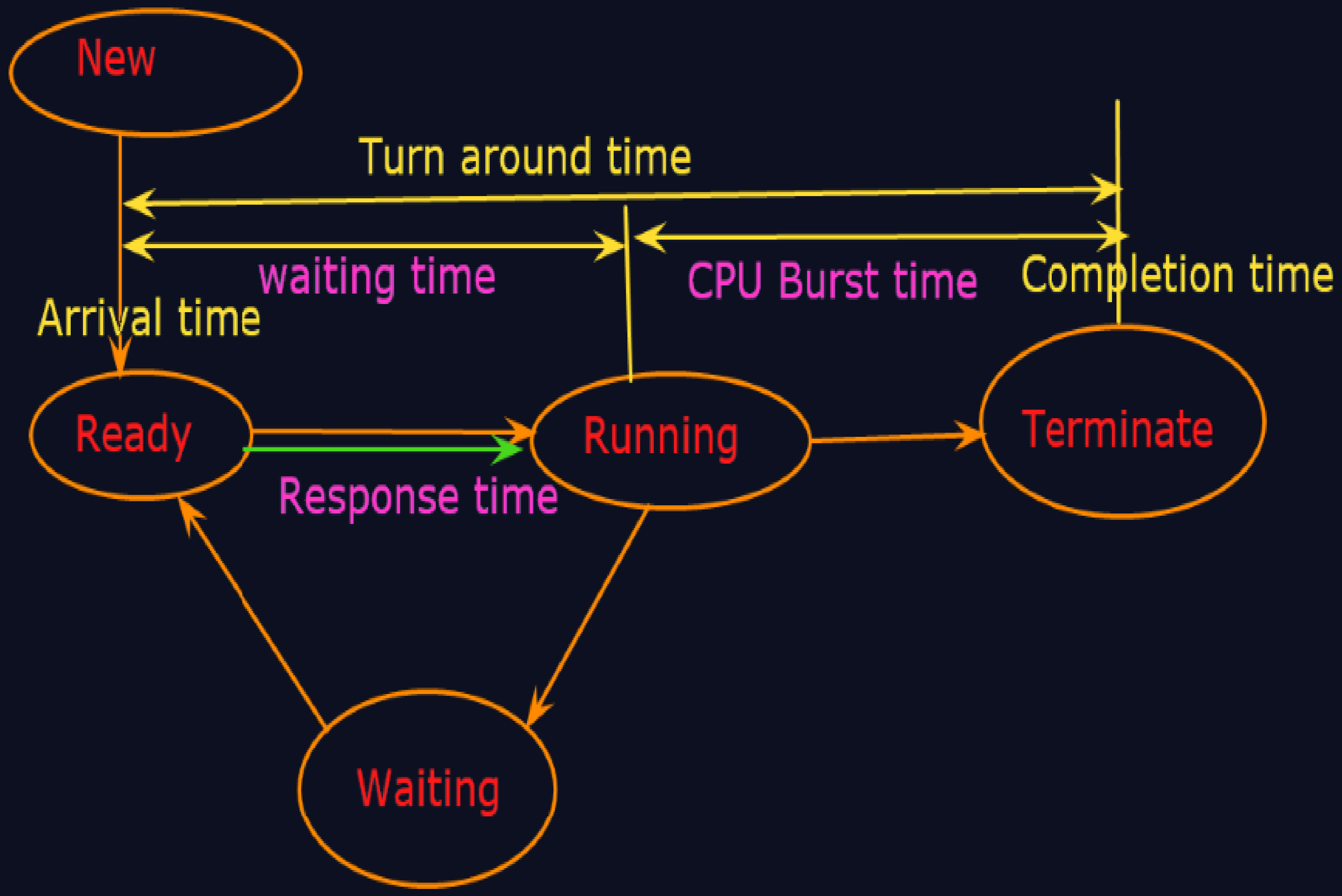
- Dispatcher module gives control of the CPU to the process selected by the short-term scheduler; this involves:
  - switching context
  - switching to user mode
  - jumping to the proper location in the user program to restart that program
- **Dispatch latency** – time it takes for the dispatcher to stop one process and start another running

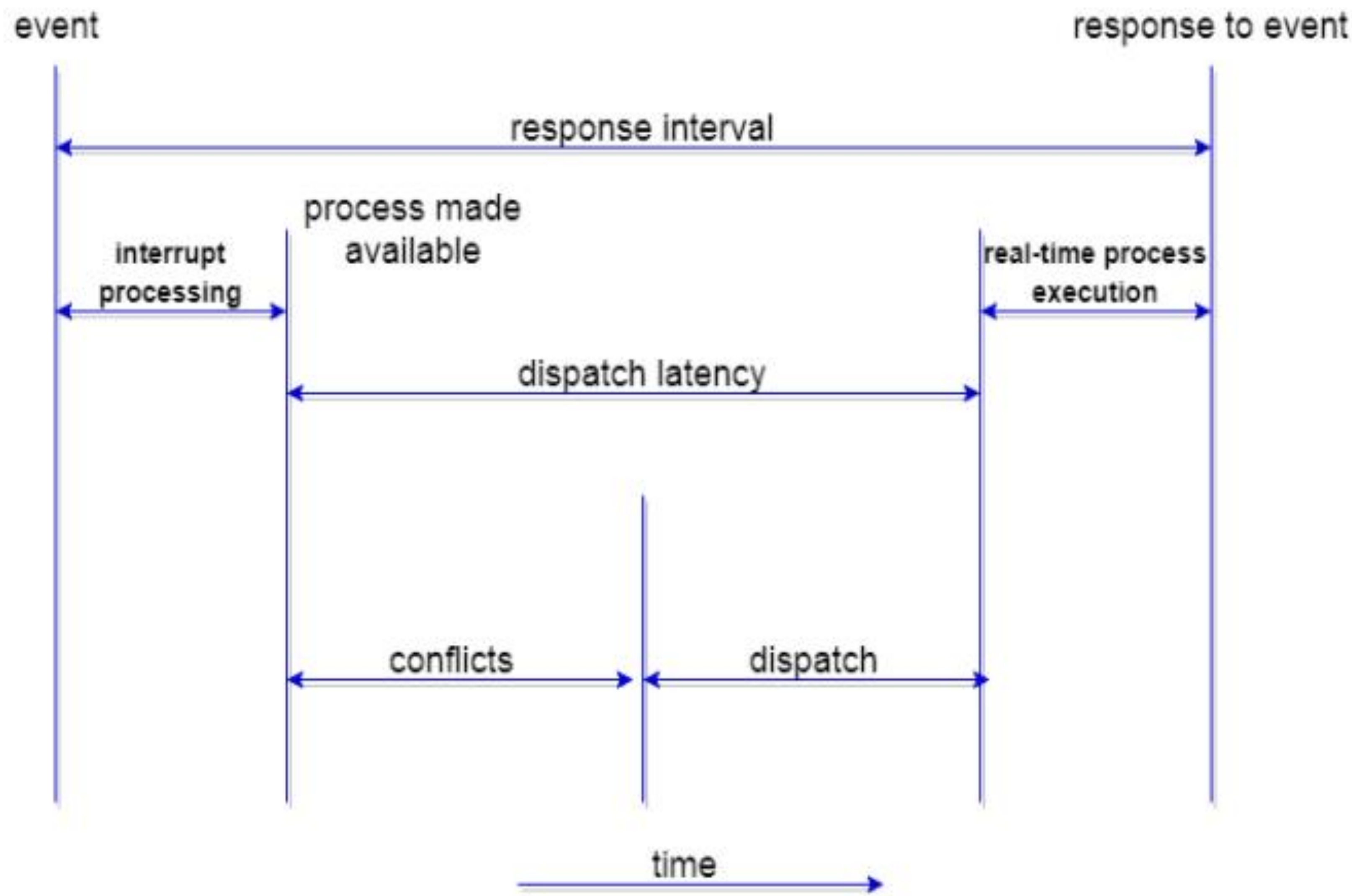
# Scheduling Criteria

- **CPU utilization** – keep the CPU as busy as possible
- **Throughput** – # of processes that complete their execution per time unit
- **Turnaround time** – amount of time to execute a particular process
- **Waiting time** – amount of time a process has been waiting in the ready queue
- **Response time** – amount of time it takes from when a request was submitted until the first response is produced, not output (for time-sharing environment)

# CPU Scheduling: Dispatcher

- Another component involved in the CPU scheduling function is the **Dispatcher**.
- The dispatcher is the module that gives control of the CPU to the process selected by the **short-term scheduler**. This function involves:
  - Switching context
  - Switching to user mode
- Jumping to the proper location in the user program to restart that program from where it left last time.
- The dispatcher should be as fast as possible, given that it is invoked during every process switch.
- The time taken by the dispatcher to stop one process and start another process is known as the **Dispatch Latency**.
- Dispatch Latency can be explained using the below figure:


New
Turn around time
waiting time
CPU Burst time
Completion time
Arrival time
Ready
Running
Terminate
Response time
Waiting


event
response to event
response interval
process made available
interrupt processing
real-time process execution
dispatch latency
conflicts
dispatch
time

| Process | Arrival time | CPU Burst Time (in millisecond |
|---|---|---|
| P0 | 2 | 8 |
| P1 | 3 | 6 |
| P2 | 0 | 9 |
| P3 | 1 | 4 |

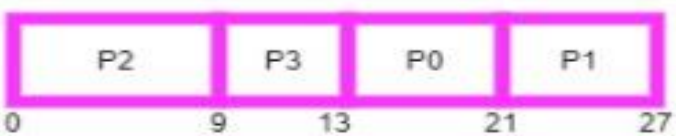



Figure: Non-Preemptive Scheduling

| Process | Arrival time | CPU Burst Time (in millisecond |
|---|---|---|
| P0 | 2 | 3 |
| P1 | 3 | 5 |
| P2 | 0 | 6 |
| P3 | 1 | 5 |


Figure: Preemptive Scheduling

# CPU Scheduling: Scheduling Criteria

- There are many different criteria to check when considering the **"best"** scheduling algorithm, they are:
- **CPU Utilization**
- To make out the best use of the CPU and not to waste any CPU cycle, the CPU would be working most of the time(Ideally 100% of the time). Considering a real system, CPU usage should range from 40% (lightly loaded) to 90% (heavily loaded.)
- **Throughput**
- It is the total number of processes completed per unit of time or rather says the total amount of work done in a unit of time. This may range from 10/second to 1/hour depending on the specific processes.
- **Turnaround Time**
- It is the amount of time taken to execute a particular process, i.e. The interval from the time of submission of the process to the time of completion of the process(Wall clock time).
- **Waiting Time**
- The sum of the periods spent waiting in the ready queue amount of time a process has been waiting in the ready queue to acquire get control on the CPU.
- **Load Average**
- It is the average number of processes residing in the ready queue waiting for their turn to get into the CPU.
- **Response Time**
- Amount of time it takes from when a request was submitted until the first response is produced. Remember, it is the time till the first response and not the completion of process execution(final response).
- In general CPU utilization and Throughput are maximized and other factors are reduced for proper optimization.

# Scheduling Algorithms

- First Come First Serve(FCFS) Scheduling
- Shortest-Job-First(SJF) Scheduling
- Priority Scheduling
- Round Robin(RR) Scheduling
- Multilevel Queue Scheduling
- Multilevel Feedback Queue Scheduling
- Shortest Remaining Time First (SRTF)
- Longest Remaining Time First (LRTF)
- Highest Response Ratio Next (HRRN)

- Here we have simple formulae for calculating various times for given processes:
- **Completion Time:** Time taken for the execution to complete, starting from arrival time.
- **Turn Around Time:** Time taken to complete after arrival. In simple words, it is the difference between the Completion time and the Arrival time.
- **Waiting Time:** Total time the process has to wait before it's execution begins. It is the difference between the Turn Around time and the Burst time of the process.
- For the program above, we have considered the arrival time to be 0 for all the processes, try to implement a program with variable arrival times.

-Multi level Queue

Sequence: P1-P2-P3

| Process | Burst | CT | TAT | WT | RT |
|---|---|---|---|---|---|
| P1 | ~~24~~ | 24 | 24 | 0 | 0 |
| P2 | ~~3~~ | 27 | 27 | 24 | 24 |
| P3 | ~~3~~ | 30 | 30 | 27 | 27 |

P1 P2 P3

27 17

Starvation

| P1 | P2 | P3 | |
|---|---|---|---|

0 24 27 30

First-Come-First-Serve Scheduling

Shortest Job First

Convey Effect

| P2 | P3 | P1 |
|---|---|---|

# First Come First Serve

| Process | BT | CT | TAT | WT | RT |
|---|---|---|---|---|---|
| P1 | 21 | 21 | 21 | 0 | 0 |
| P2 | 3 | 24 | 24 | 21 | 21 |
| P3 | 3 | 27 | 27 | 24 | 24 |

Sequence: P1-P2-P3

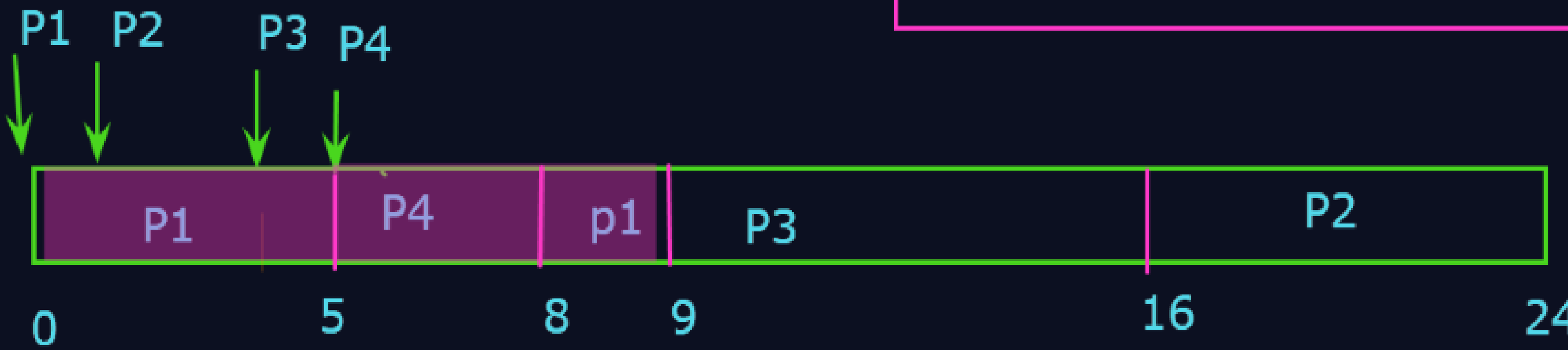

P1
P2
P3

AWT=(0+21+24)/3=15
ATAT=(21+24+27)/3 = 24

| Process | Arrival time | Burst time |
| --- | --- | --- |
| P1 | 0 | ~~6~~ |
| P2 | 2 | 8 |
| P3 | 4 | ~~7~~ |
| P4 | 5 | ~~3~~ |

SJF

P4-P1-P3-P2 : Preemptive



# Shortest-Job-First (SJF) Scheduling

- Associate with each process the length of its next CPU burst.  Use these lengths to schedule the process with the shortest time
- SJF is optimal – gives minimum average waiting time for a given set of processes
  - The difficulty is knowing the length of the next CPU request

# Shortest Job First(SJF) Scheduling

- Shortest Job First scheduling works on the process with the shortest burst time or duration first.

- This is the best approach to minimize waiting time.
- This is used in Batch Systems.
- It is of two types:
  - Non Pre-emptive
  - Pre-emptive
- To successfully implement it, the burst time/duration time of the processes should be known to the processor in advance, which is practically not feasible all the time.
- This scheduling algorithm is optimal if all the jobs/processes are available at the same time. (either Arrival time is 0 for all, or Arrival time is same for all)

# Shortest Job First

| Process | BT | CT | TAT | WT | RT |
|---|---|---|---|---|---|
| P1 | 21 | 27 | 27 | 6 | 6 |
| P2 | 3 | 3 | 3 | 0 | 0 |
| P3 | 3 | 6 | 6 | 3 | 3 |

Sequence: P2-P3-P1

| P2 | P3 | P1 |
|---|---|---|

0 3 6 27

P1
P2
P3

27

ATAT= 12

AWT= 3

# Priority Scheduling

- A priority number (integer) is associated with each process
- The CPU is allocated to the process with the highest priority (smallest integer ≡ highest priority)
  - Preemptive
  - nonpreemptive
- SJF is a priority scheduling where priority is the predicted next CPU burst time
- Problem ≡ **Starvation** – low priority processes may never execute
- Solution ≡ **Aging** – as time progresses increase the priority of the process

# Round Robin Scheduling

- Round Robin(RR) scheduling algorithm is mainly **designed for time-sharing systems**. This algorithm is similar to FCFS scheduling, but in Round Robin(RR) scheduling, preemption is added which enables the system to switch between processes.
- A fixed time is allotted to each process, called a **quantum**, for execution.
- Once a process is executed for the given time period that process is preempted and another process executes for the given time period.
- **Context switching is used to save states of preempted** processes.
- This algorithm is simple and easy to implement and the most important is thing is this **algorithm is starvation-free** as all processes get a fair share of CPU.
- It is important to note here that the length of time quantum is generally from 10 to 100 milliseconds in length.

Round Robin : $\boxed{\text{RR}}$

Time Slice : quantum 3

| Process | Arrival time | Burst time |
|---|---|---|
| P1 | 0 | ~~21~~ 18 |
| P2 | 2 | ~~3~~ |
| P3 | 4 | ~~6~~ 3 |
| P4 | 5 | ~~2~~ |

P1 P2 P3 P4

RR

| P1 | P2 | P3 | P4 | P1 | P3 | P1 | P1 | P1 | P1 | P1 |
|---|---|---|---|---|---|---|---|---|---|---|

0 3 6 9 11 14 17 20 23 26 29 32

2

5

0 8 3 = 11

## Round Robin: time slice (quantum) = 1

| Process | BT | CT | TAT | WT | RT |
|---|---|---|---|---|---|
| P1 | 21 | 27 | 27 | 6 | 6 |
| P2 | ~~3~~ | 3 | 3 | 0 | 0 |
| P3 | ~~3~~ | 6 | 6 | 3 | 3 |

Sequence: P1-P2-P3

| 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

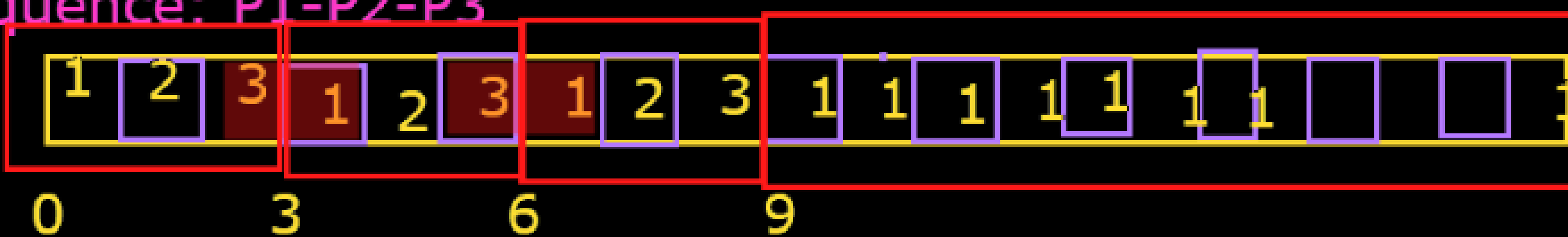
P1
P2
P3

Quantum=2

Round Robin: time slice (quantum) = 1

| Process | BT | CT | TAT | WT | RT |
|---|---|---|---|---|---|
| P1 | 21 | 27 | 27 | 6 | 0 |
| P2 | ~~3~~ | 8 | 8 | 5 | 1 |
| P3 | ~~3~~ | 9 | 9 | 6 | 2 |

Sequence: P1-P2-P3



## Some important characteristics of the Round Robin(RR) Algorithm are as follows:

1. Round Robin Scheduling algorithm resides under the category of Preemptive Algorithms.
2. This algorithm is one of the oldest, easiest, and fairest algorithm.
3. This Algorithm is a real-time algorithm because it responds to the event within a specific time limit.
4. In this algorithm, the time slice should be the minimum that is assigned to a specific task that needs to be processed. Though it may vary for different operating systems.
5. This is a hybrid model and is clock-driven in nature.
6. This is a widely used scheduling method in the traditional operating system.

# Important terms

1. **Completion Time** It is the time at which any process completes its execution.
2. **Turn Around Time** This mainly indicates the time Difference between completion time and arrival time. The Formula to calculate the same is: **Turn Around Time = Completion Time – Arrival Time**
3. **Waiting Time(W.T):** It Indicates the time Difference between turn around time and burst time. And is calculated as **Waiting Time = Turn Around Time – Burst Time**

# Advantages of Round Robin Scheduling Algorithm

- Some advantages of the Round Robin scheduling algorithm are as follows:
- While performing this scheduling algorithm, a **particular time quantum is allocated** to different jobs.
- In terms of average response time, this **algorithm gives the best performance.**
- With the help of this algorithm, **all the jobs get a fair allocation** of CPU.
- In this algorithm, there are **no issues of starvation or convoy effect**.
- This algorithm deals with all processes without any priority.
- This algorithm is **cyclic in nature.**
- In this, the newly created process is added to the end of the ready queue.
- Also, in this, **a round-robin scheduler generally employs time-sharing** which means providing each job a time slot or quantum.
- In this scheduling algorithm, each process gets a chance to reschedule after a particular quantum time.

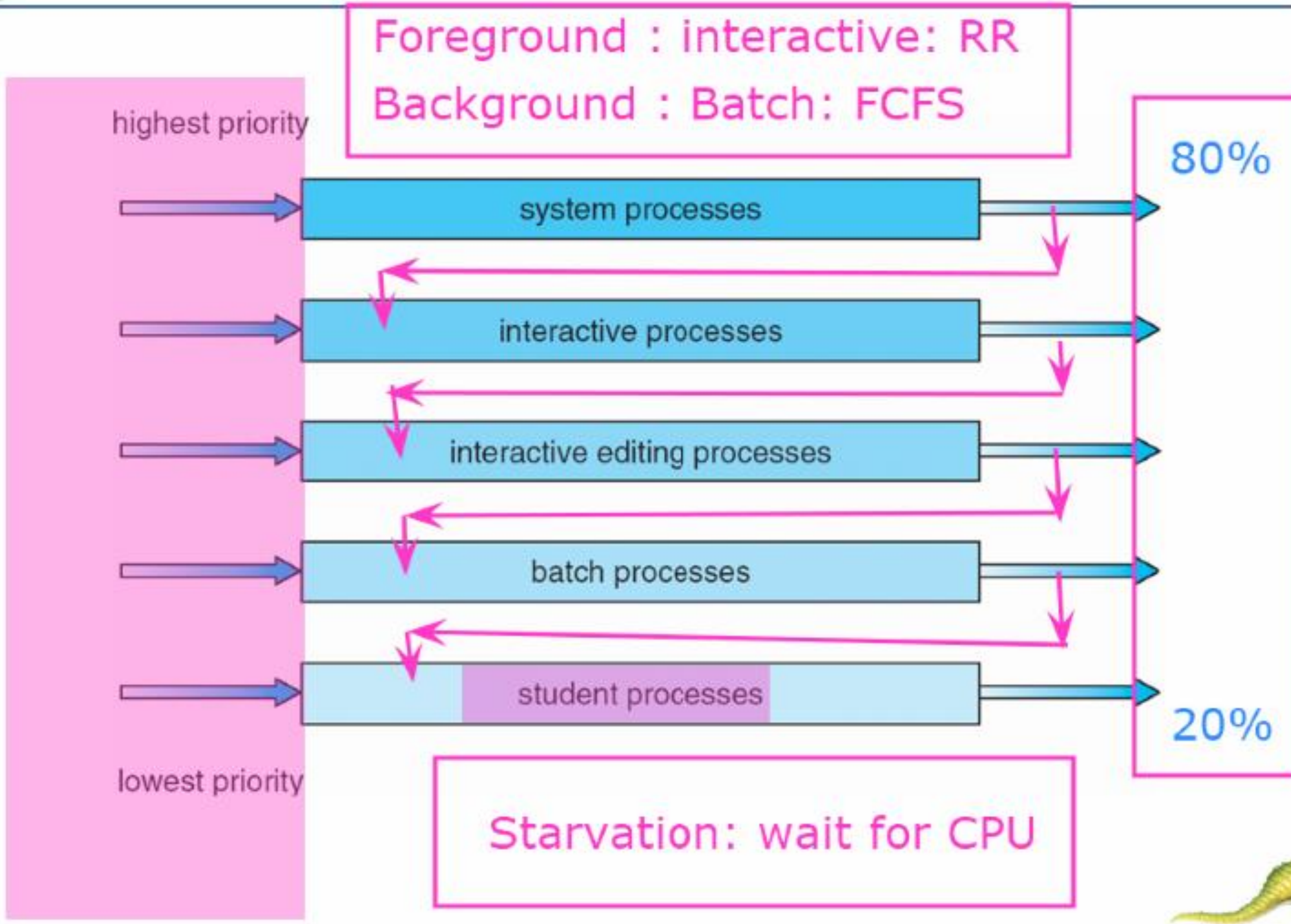
# Disadvantages of Round Robin Scheduling Algorithm

- Some disadvantages of the Round Robin scheduling algorithm are as follows:
- This algorithm spends **more time on context switches**.
- For **small quantum**, it is time-consuming scheduling.
- This algorithm **offers a larger waiting time and response time**.
- In this, there is **low throughput.**
- If time quantum is less for scheduling then its Gantt chart seems to be too big.

# Multilevel Queue

- Ready queue is partitioned into separate queues:
  foreground (interactive)
  background (batch)
- Each queue has its own scheduling algorithm
  - foreground – RR
  - background – FCFS
- Scheduling must be done between the queues
  - Fixed priority scheduling; (i.e., serve all from foreground then from background). Possibility of starvation.
  - Time slice – each queue gets a certain amount of CPU time which it can schedule amongst its processes; i.e., 80% to foreground in RR
  - 20% to background in FCFS

# Multilevel Queue Scheduling



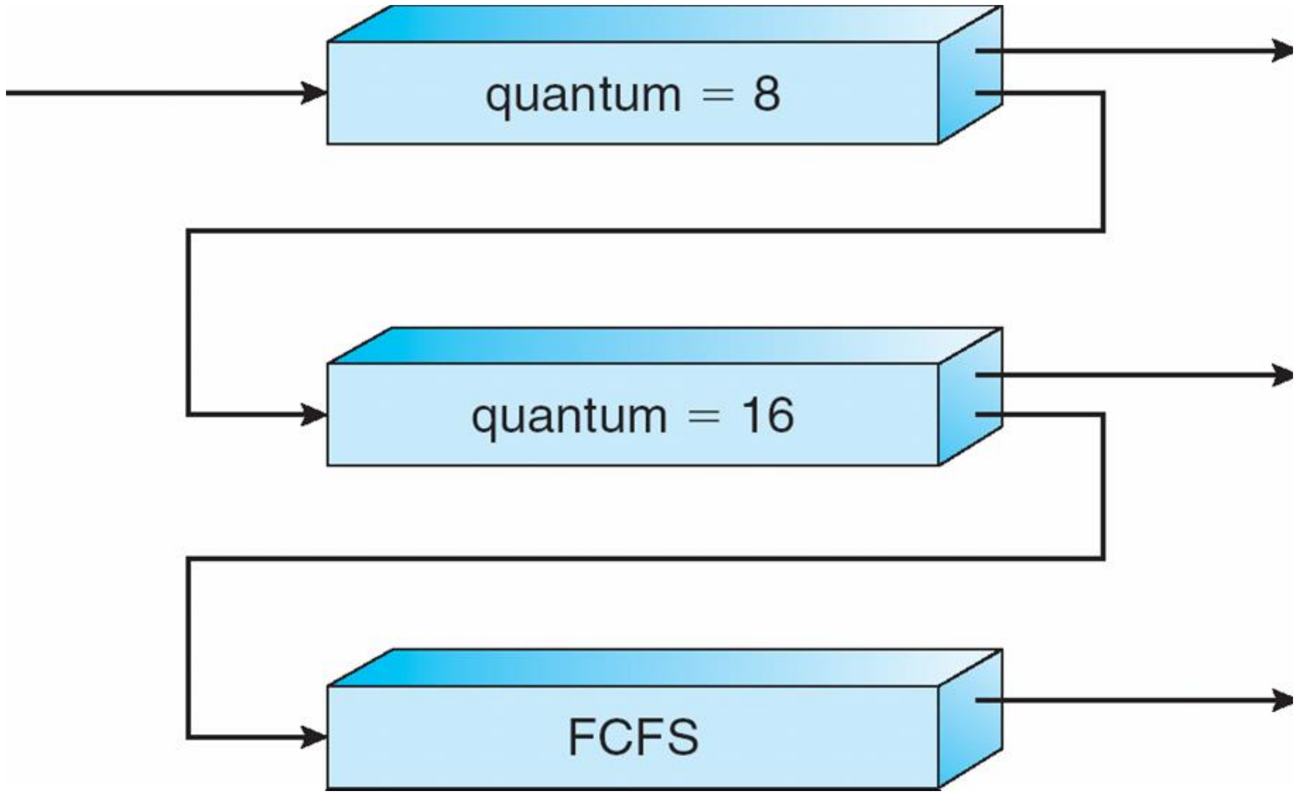
# Multilevel Feedback Queue

- A process can move between the various queues; aging can be implemented this way
- Multilevel-feedback-queue scheduler defined by the following parameters:
  - number of queues
  - scheduling algorithms for each queue
  - method used to determine when to upgrade a process
  - method used to determine when to demote a process
  - method used to determine which queue a process will enter when that process needs service

# Example of Multilevel Feedback Queue

- Three queues:
  - $Q_0$ – RR with time quantum 8 milliseconds
  - $Q_1$ – RR time quantum 16 milliseconds
  - $Q_2$ – FCFS
- Scheduling
  - A new job enters queue $Q_0$ which is served FCFS. When it gains CPU, job receives 8 milliseconds. If it does not finish in 8 milliseconds, job is moved to queue $Q_1$.
  - At $Q_1$ job is again served FCFS and receives 16 additional milliseconds. If it still does not complete, it is preempted and moved to queue $Q_2$.

# Multilevel Feedback Queues



# File Permission

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| d | r | w | X | r | w | x | r | w | x |

file type

User
Owner

Group

Other

chmod u+w g+x o-r m1.txt

Symbolic Mode
-----------------
-chmod
- +:= Adding permission
- - := Removing permission

0:no permission
1:execute
2:write
3:write Execute
4:read
5:read execute
6:read write
7read write execute

r
w
x

File
Permission

Absolute Mode
-bits ( 1/0 )
- 1 => ON
- 0 => OFF

rw- rw- r--
110 110 100
6 6 4

chmod 664 color.txt
chmod 761 f1

rwx rw- --x
111 110 001

## Vi Editor

1. vi filename.sh

2. Esc + i(insert)

3.Add th bash command & code

4.Esc + :wq

w(save) + q(exit)

5. chmod +x filename.sh

(permission granted)

6. Execute : ./filename.sh
or
Execute : bash filename.sh