reSilient coMputer archItectures and LIfE Sciences

Politecnico di Torino

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PROCESS MANAGEMENT

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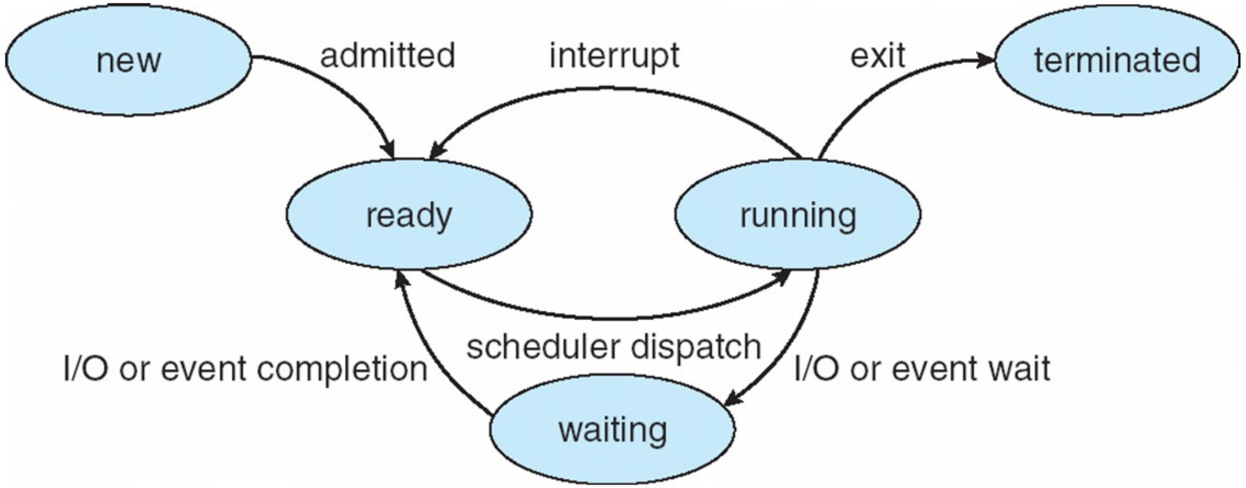
PROCESS DEFINITION

- Process – a program in execution
  - process execution must progress in sequential fashion.
  - No parallel execution of instructions of a single process
- Multiple parts
  - The program code, also called **text section**
  - Current activity including **program counter**, processor registers
  - Stack containing temporary data
    - Function parameters, return addresses, local variables
  - Data section containing global variables
  - Heap containing memory dynamically allocated during run time

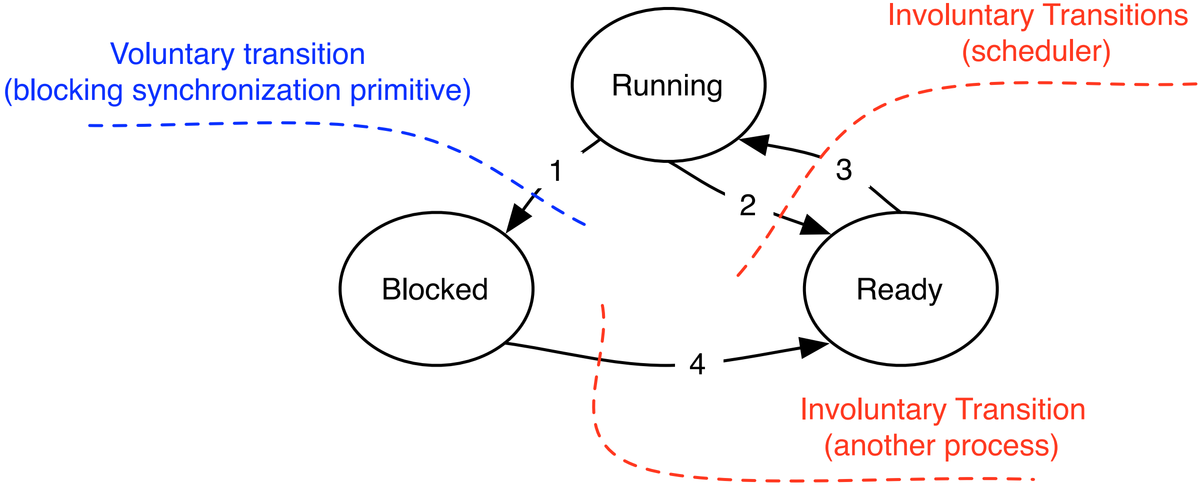
PROCESS STATE

- As a process executes, it changes state
  - New: The process is being created
  - Running: Instructions are being executed
  - Waiting: The process is waiting for some event to occur
  - Ready: The process is waiting to be assigned to a processor
  - Terminated: The process has finished execution
- Process State Diagram (PSD)



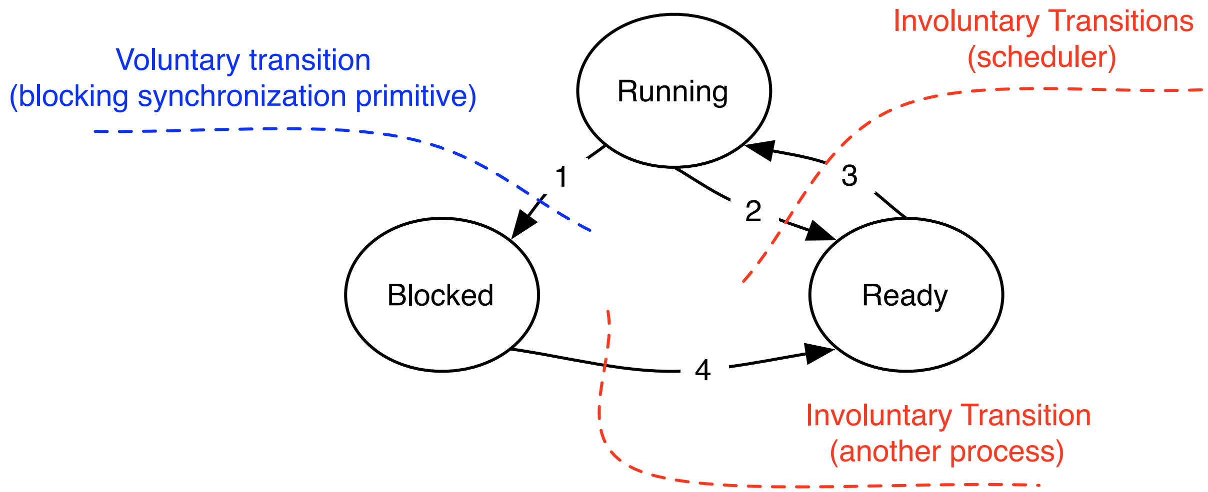
PSD TRANSITIONS

- Given N processes, and one processor, at any given time:
  - 1 process is in the running state
  - M processes can be blocked waiting for a resource to become available to resume the execution
  - N-M-1 are ready to be executed waiting to access the processor
- Transition 1 occurs when a process discovers that it cannot continue
  - For example it needs to use a portion of shared memory a now-ready process reserved for its own use



PSD TRANSITIONS

- Transition 4 occurs when the event the process was waiting for occurs
  - For example, the running process sets free the shared memory it previously locked, which the blocked process was waiting for

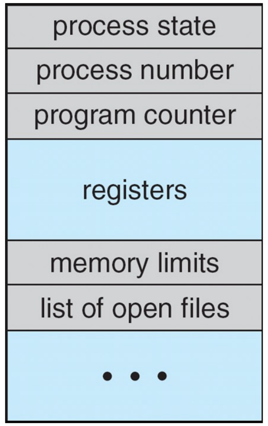


- Transitions 2 and 3 are caused by the operating system
  - Preemptive scheduler: process is moved from running to ready after a certain time quantum (time slice) is expired
  - Cooperative scheduler: process voluntary moves from running to ready

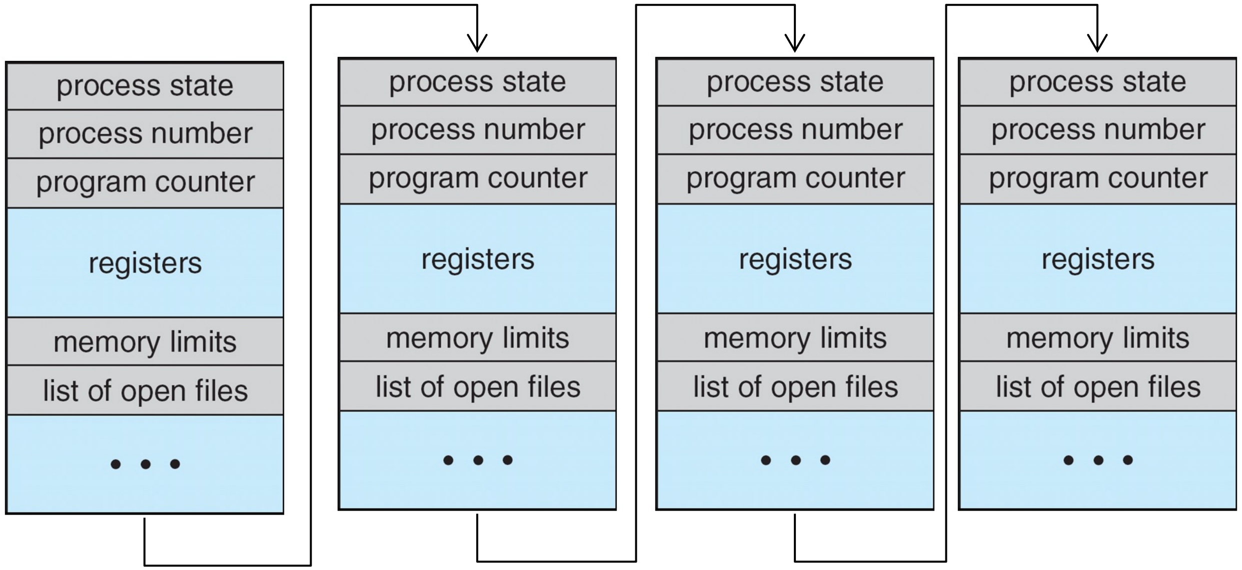
PROCESS CONTROL BLOCK (PCB)

- The CPU Manager describes each process using the PCB containing:
  - Process state
  - Program counter
  - CPU registers
  - CPU scheduling information
  - Memory-management information
  - Accounting information
  - I/O status information

- Example of PCB



- One PCB is maintained for each process

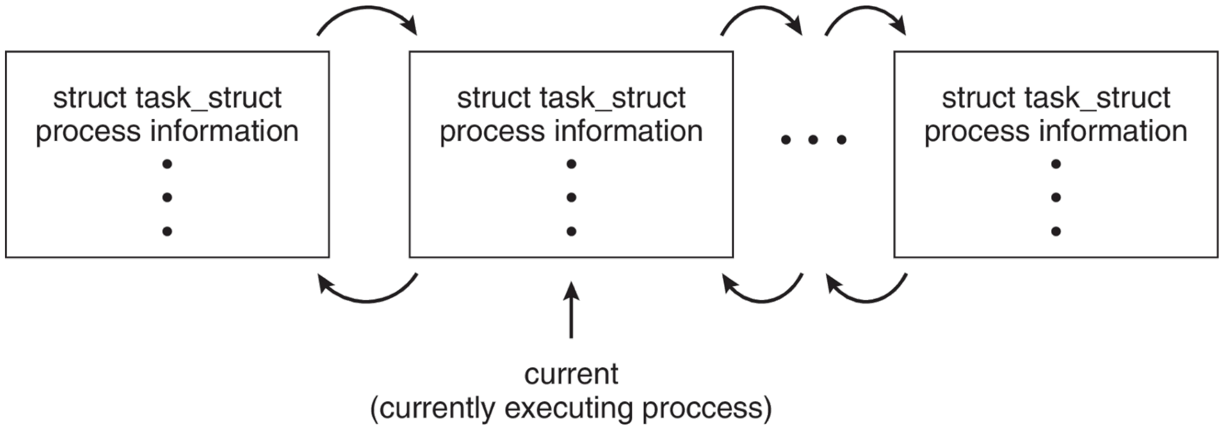


PROCESS REPRESENTATION IN LINUX

Represented by the C structure

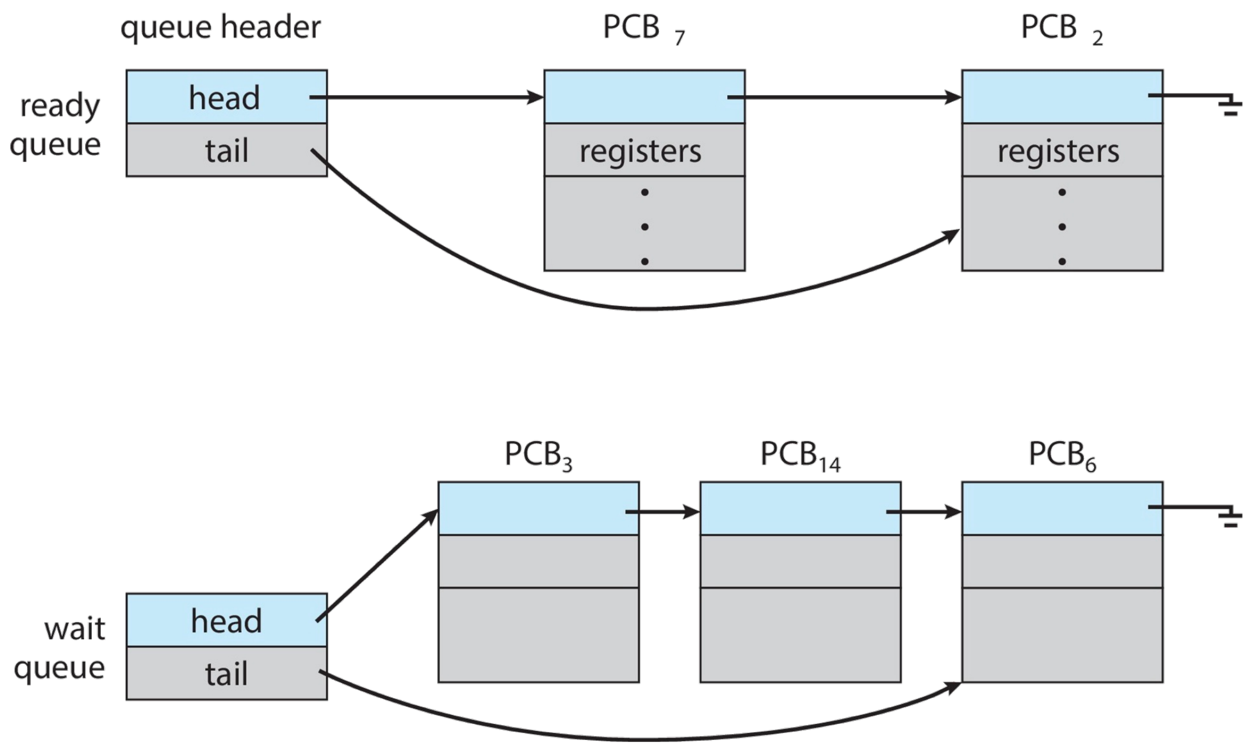
```
struct task_struct {
   pid t_pid;          /* process identifier */
   long state;         /* state of the process */
   unsigned int time_slice   /* scheduling
   information */
   struct task_struct *parent;/* this
   process's parent */
   struct list_head children; /* this
   process's children */
   struct files_struct *files;/* list of open
   files */
   struct mm_struct *mm;     /* address space
   of this process */

}
```



THE CPU SCHEDULER

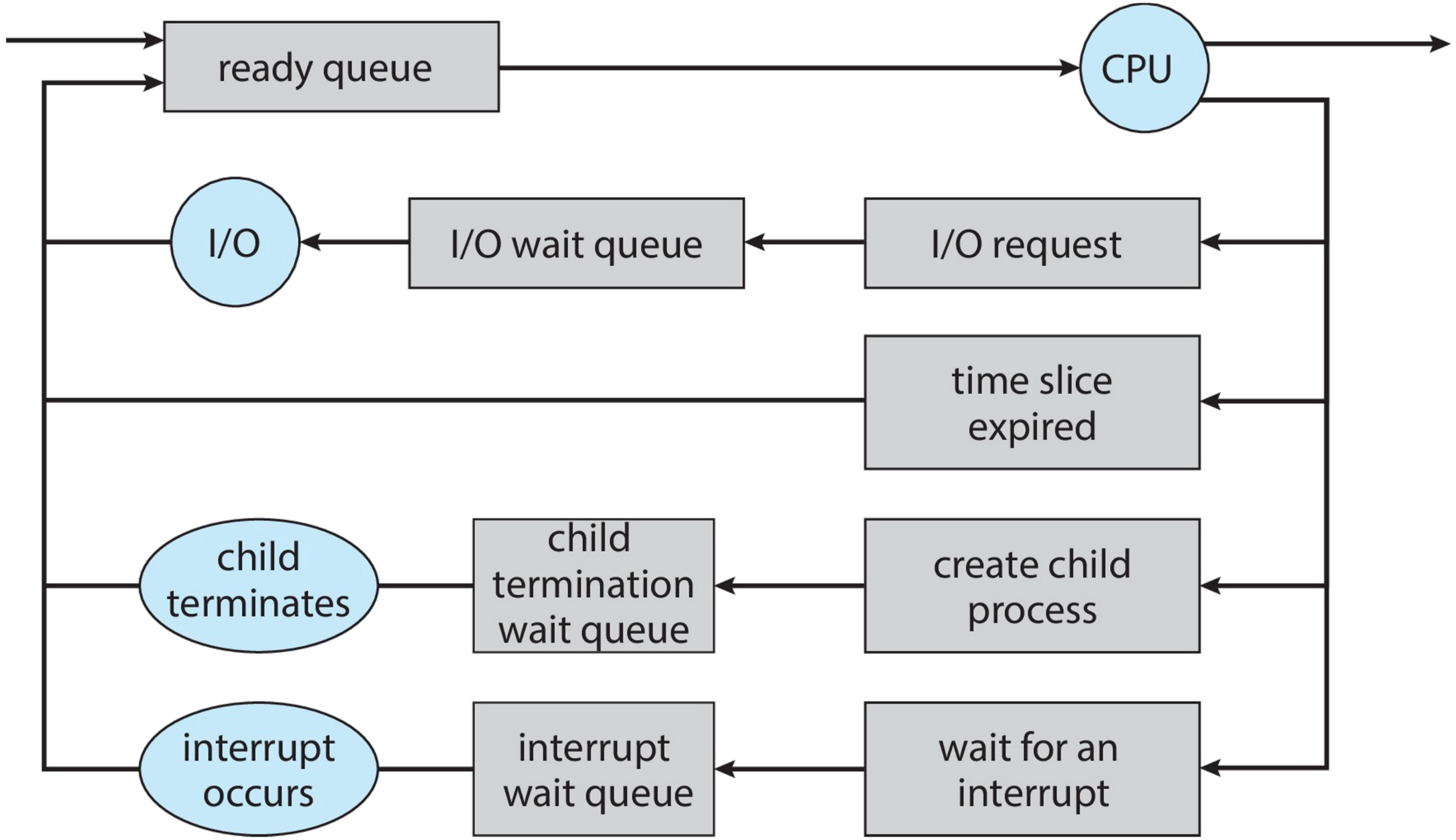
- It is the part of the CPU manager that implements the process state transitions and decides which process must run
- The goal is to maximize CPU use
- Maintains scheduling queues of processes
  - Ready queue – set of all processes residing in main memory, ready and waiting to execute
  - Wait queues – set of processes waiting for an event (i.e., I/O)
  - Processes migrate among the various queues



SCHEDULING CRITERIA

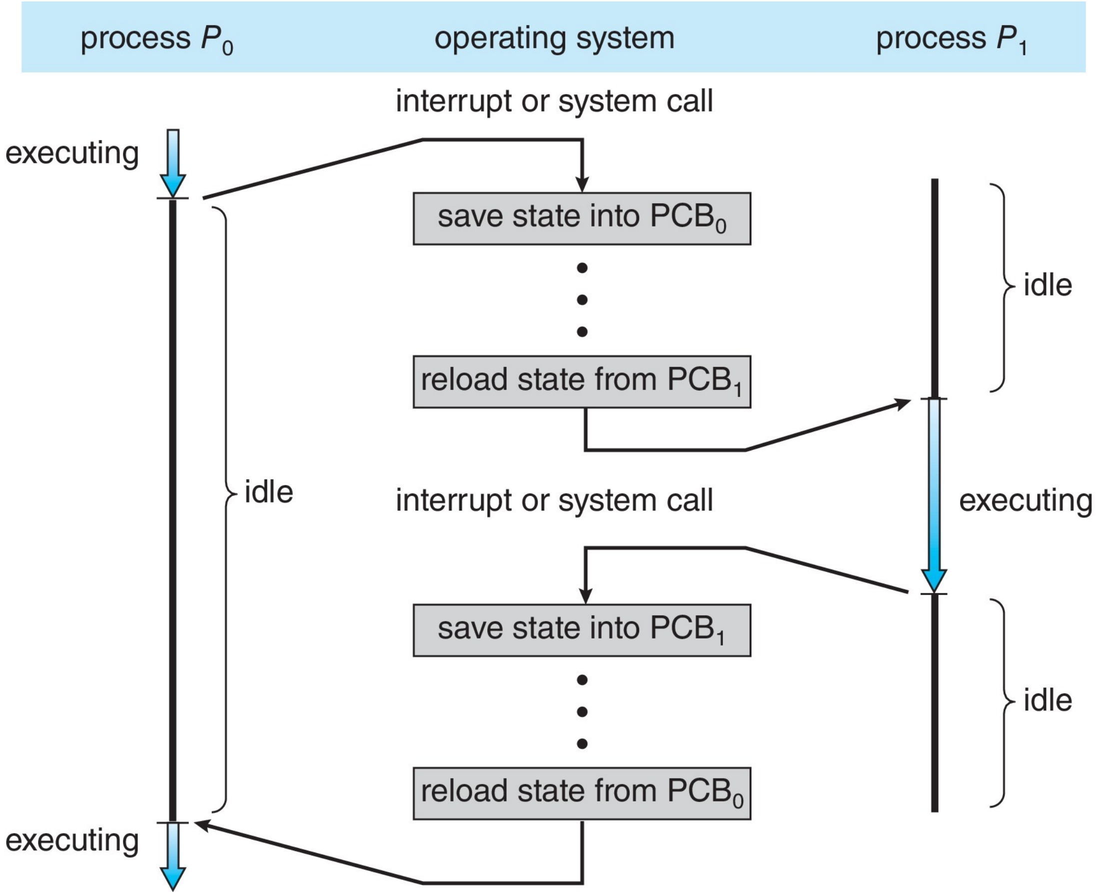
- CPU utilization – keep the CPU as busy as possible
- Throughput – # of processes that complete their execution per time unit
- Turnaround time – amount of time to execute a particular process
- Waiting time – amount of time a process has been waiting in the ready queue
- Response time – amount of time it takes from when a request was submitted until the first response is produced.

REPRESENTATION OF PROCESS SCHEDULING



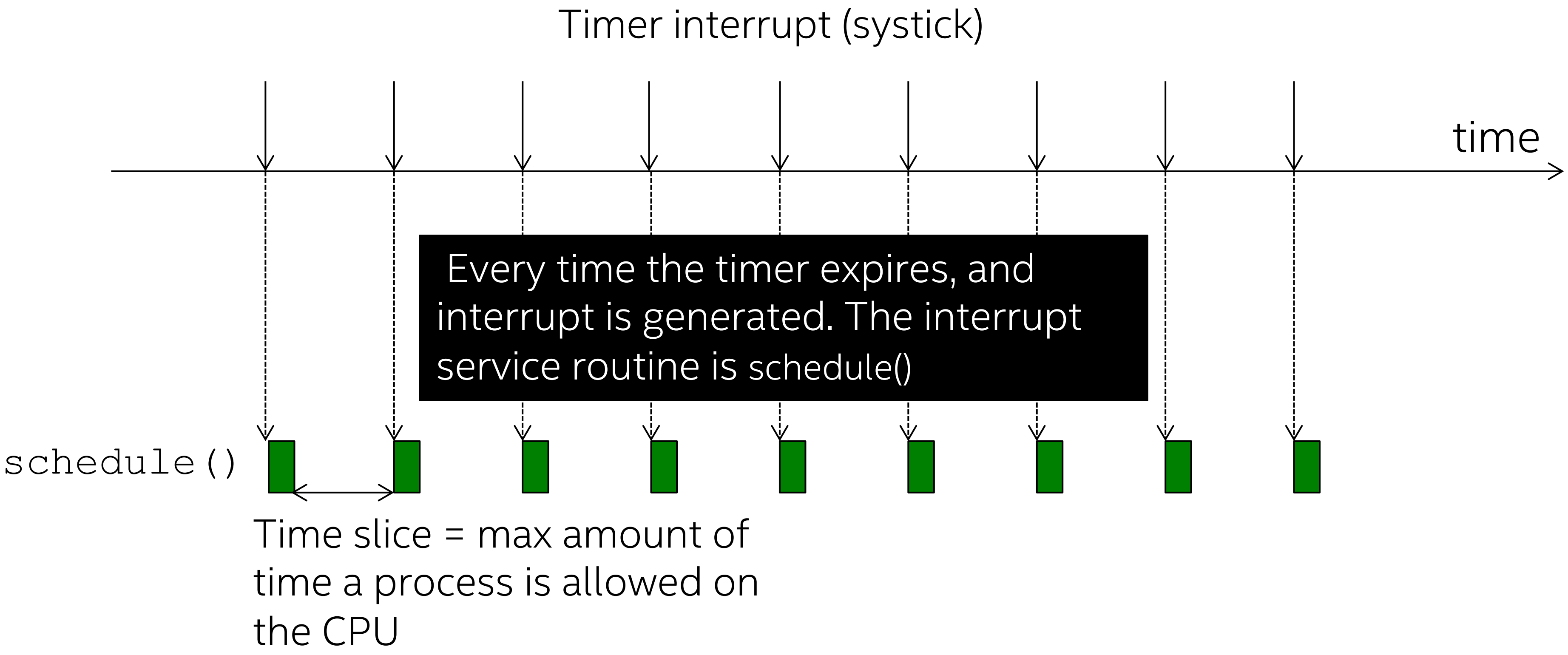
CONTEXT SWITCH

- 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 pure overhead; the system does no useful work while switching
  - The more complex the OS and the PCB ➔ the longer the context switch
- Time dependent on hardware support
  - Some hardware provides multiple sets of registers per CPU ➔ multiple contexts loaded at once



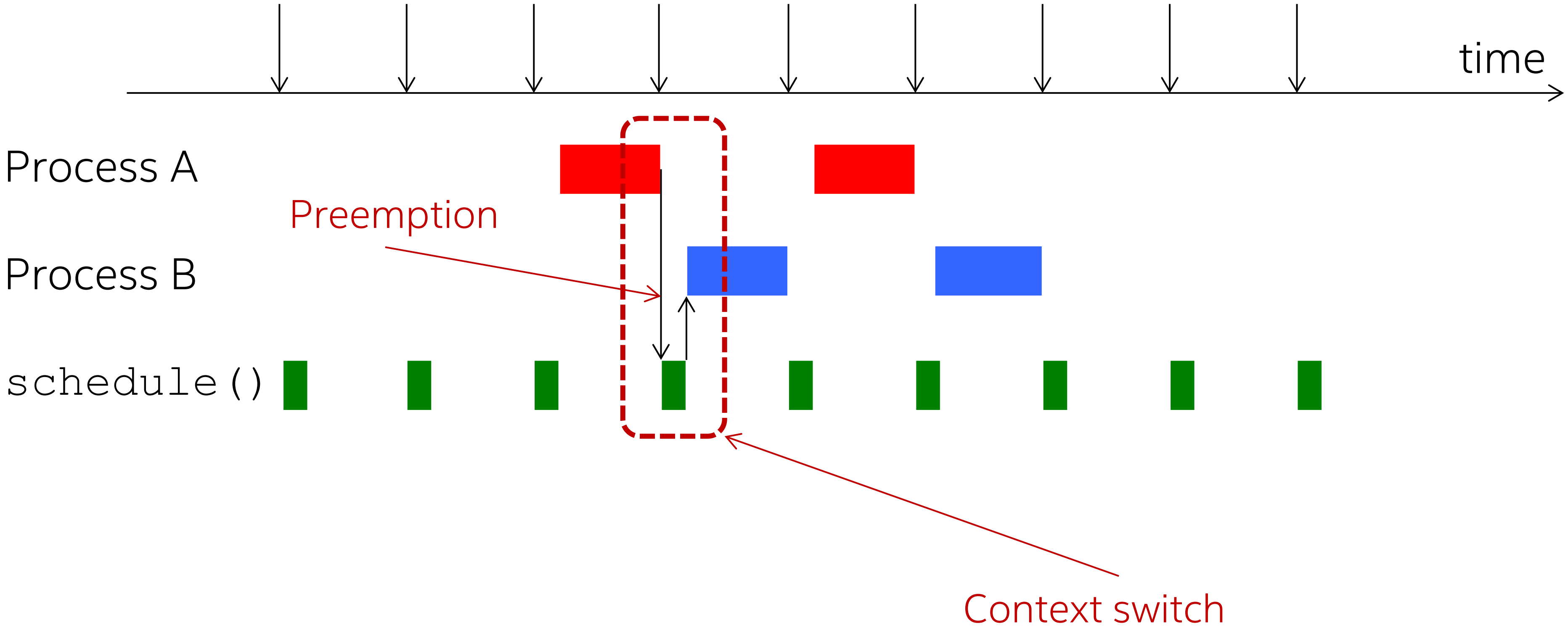
SCHEDULER ACTIVATION

- It is called periodically (via timer interrupt) or in response to events



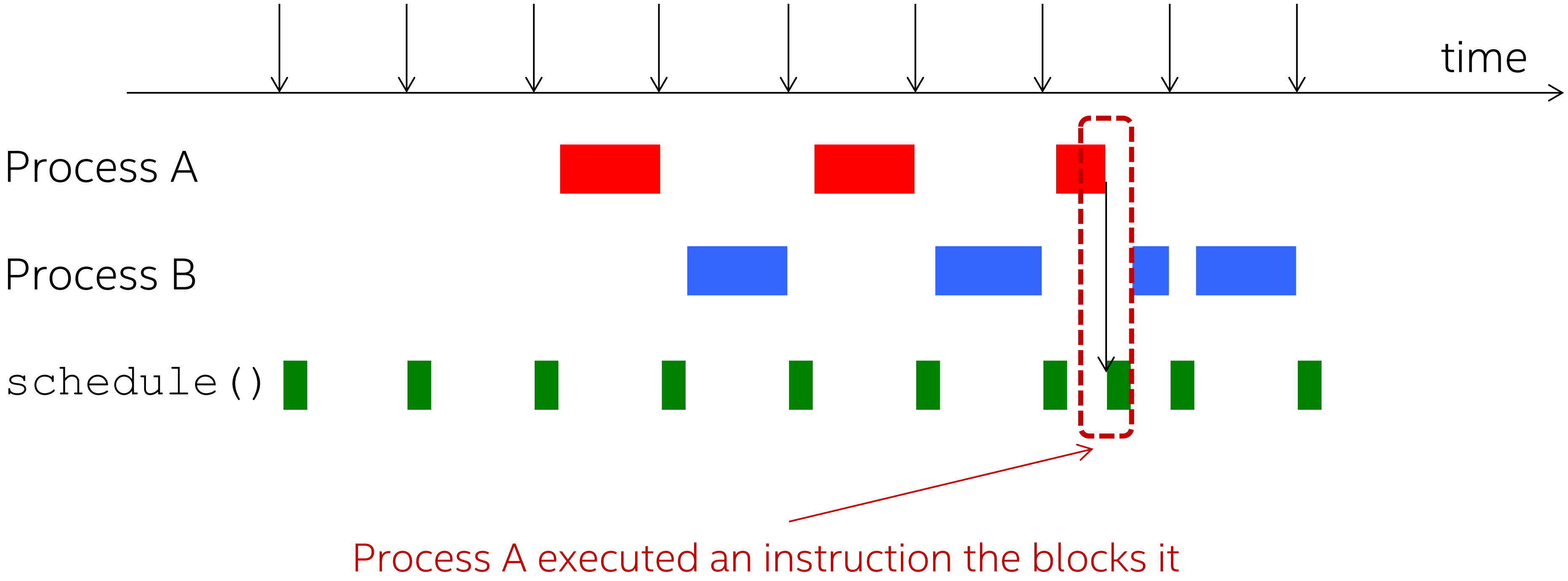
PREEMPTION

- Operation performed to evict a running process from the CPU
- Example: upon reaching the end of the time slice, process A is moved from running to ready, while process B is moved from ready to running



BLOCKING

- Preemption may take place as a result of an operation the running task performs
- Example: Process A is moved to blocked state, while process B is set running



WHAT DOES A PROCESS (OR TASK) LOOK LIKE?

- Basic task
  - Sequence of statements executed once for each instance of the task (e.g., do_instance())
  - Instance of the task = execution of the function x()
    - The task starts with the first instruction of function x()
    - The task terminates after the last statement of function x()
  - An initialization function x_init() is executed once for setting up the memory used by task x
  - If task x needs to keep in memory data to be used by different instances, global variables shall be used (e.g., persistent_data)

```
int persistent_data;

Task x()
{
  do_instance();
}

x_init()
{
  initialization();
  ...
}
```

WHAT DOES A PROCESS (OR TASK) LOOK LIKE?

- Extended task
  - It is a function that starts once, and never ends
  - Data can be local variables
  - Initialization operations are performed once, before starting the end-less loop
  - The end-less loop implements the operation of the task (e.g., do_instance())
  - The end-less loop typically contains a statement to block the task until it is needed (e.g., WaintEvent())
    - A certain amount of time is elapsed
    - A resource becomes available
    - …
  - When the task is blocked others may run

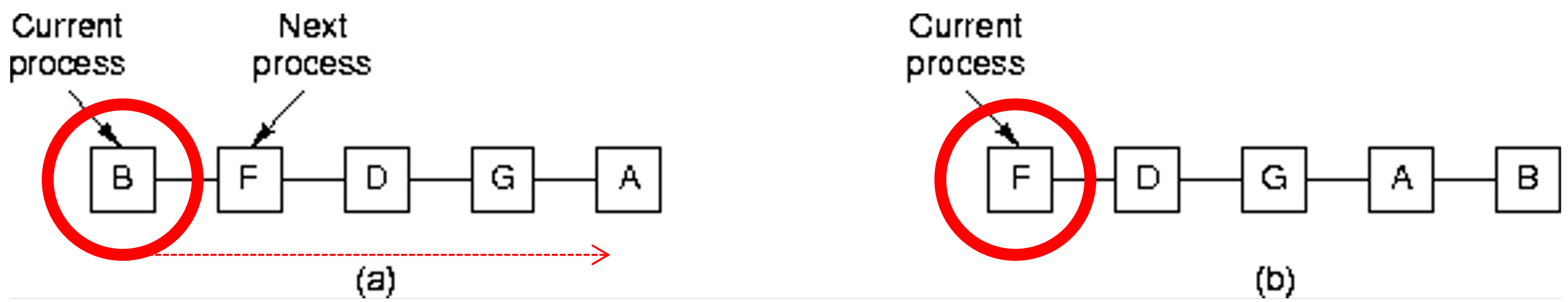
```
Task x()
{
   int local;

   initialization();

   for (;;)   /* End-less loop */
   {
     WaitEvent();
     do_instance();
   }
}
```

SCHEDULING ALGORITHMS

- It is the criteria to pick up a process among those ready to make it running
- Simplest form of scheduling: Round Robin
  - Processes are inserted into a FIFO queue {B, F, D, G, A}
  - The top of the queue is executed (see figure a)
  - When exiting from running state it is queued to the last position of the queue (see figure b)



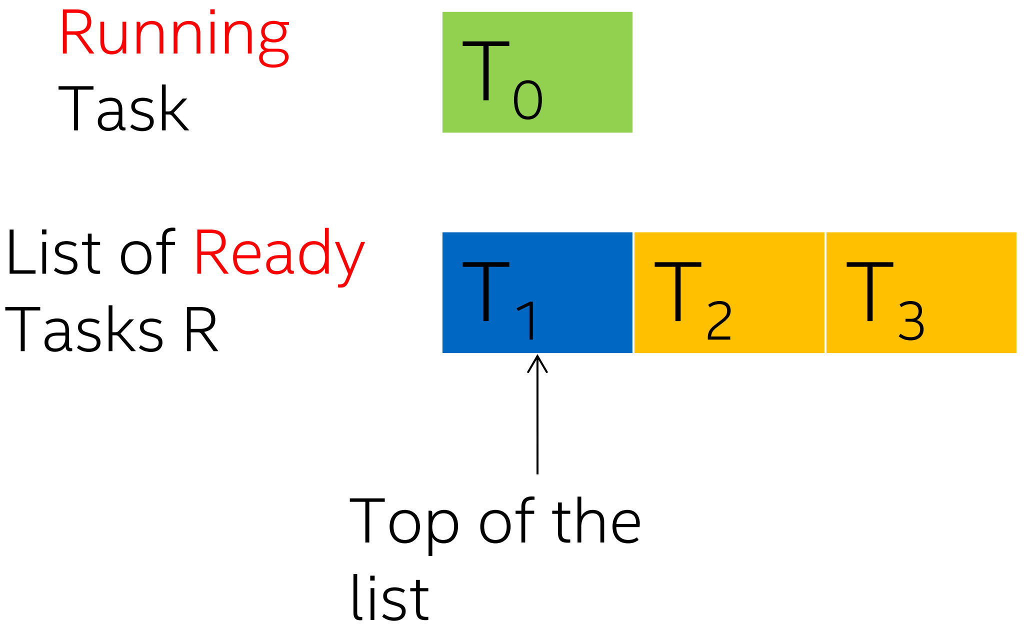
ROUND ROBIN SCHEDULER

- Possible implementation

```
Schedule(ReadyList R, RunningTask T)
{
  T->TCB.state = READY;
  save_context(T->TCB);

  append_to_list( T, R );

  Q = top_of_list( R );
  restore_context(Q->TCB);
  Q->TCB.state = RUNNING;
}
```



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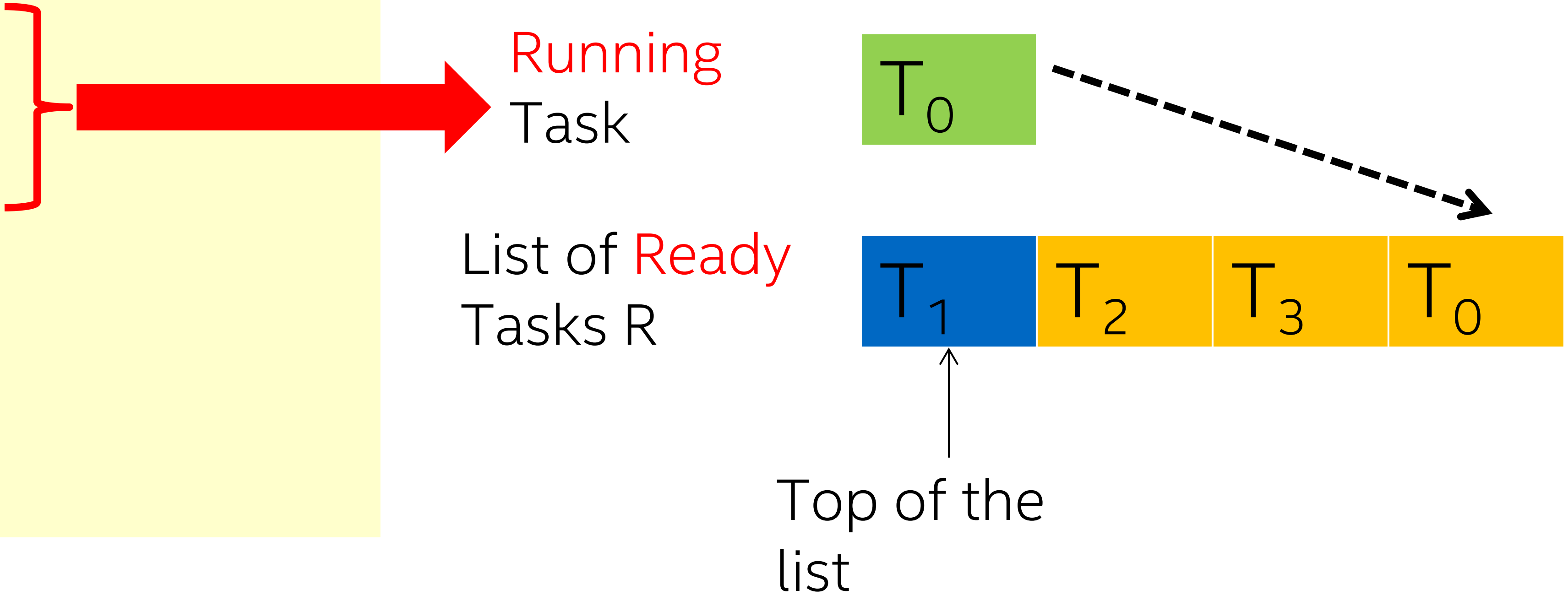

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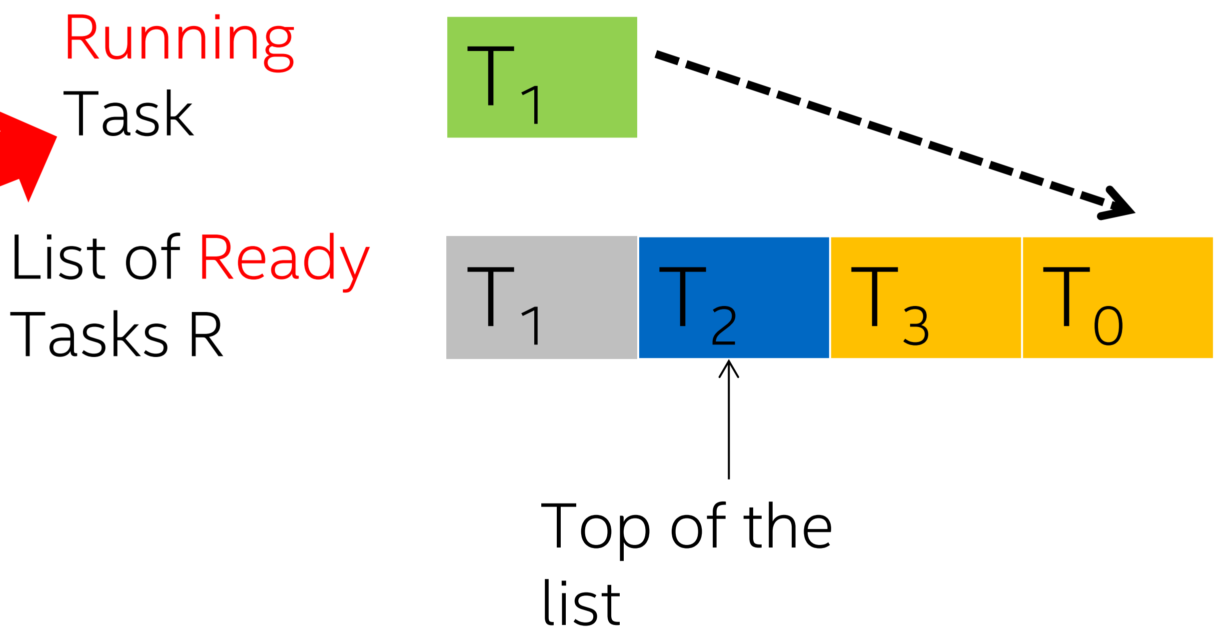
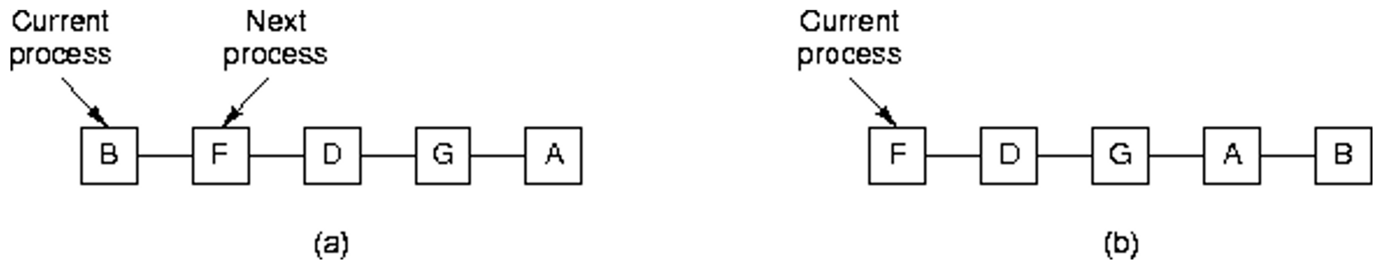


SCHEDULING ALGORITHMS

- In Round Robin all processes are equal



- What if B has a more important task to do with respect to the others?
  - After it run, it has to wait 4 time slices before running again

- Solution:
  - To differentiate processes assigning a weight factor → <u>priority</u>
  - To adopt a scheduling approach based on priority → <u>priority-based scheduling</u>

PRIORITY-BASED SCHEDULER

```
Schedule(ReadyList R, RunningTask T)
{
  Q = top_of_list( R );

  if( Priority(Q) > Priority(T) )
  {
    T->TCB.state = READY;
    save_context(T->TCB);

    append_to_list( T, R );

    restore_context(Q->TCB);
    Q->TCB.state = RUNNING;
  }
}
```

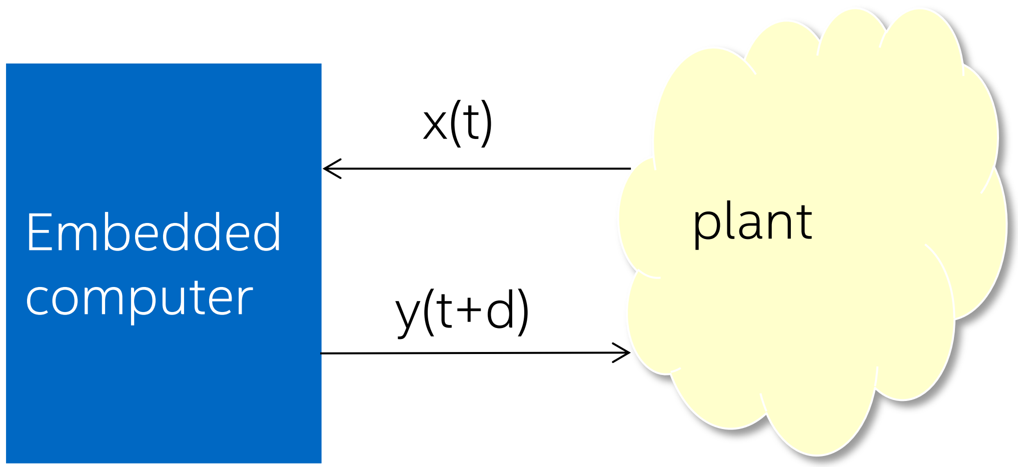
- Preemption of a running task & context switch happen only if a ready task exists whose priority is **greater than** that of the running task
- If the running task has priority equal to that of the highest priority ready task **preemption does not happen**
- Highest priority running task is preempted when it has to be blocked

SCHEDULING ALGORITHMS

- A priority function is defined which returns numerical value T for process p:
  - T = Priority(p)
- <u>Static priority:</u> unchanged for lifetime of p
- <u>Dynamic priority:</u> changes at runtime

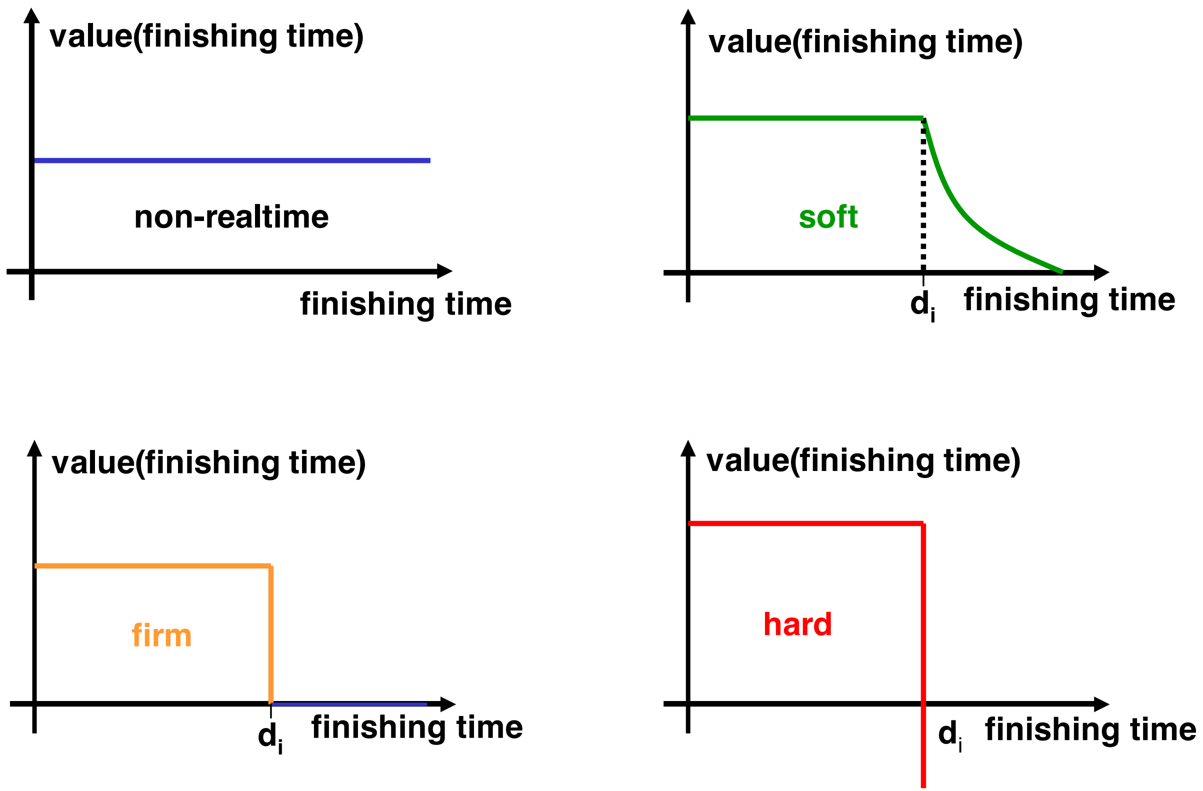
TYPE OF SYSTEMS

- Non real-time system: computer that has to respond to external events correctly
  - Example: given x(t) at time t → output y must be delivered anytime
- Real-time system: computer that has to respond to external events both correctly and within a finite, specified period of time called deadline
  - Example: given x(t) at time t → output y must be delivered no later than t+d
  - Right result too late is as bad as giving wrong or no result



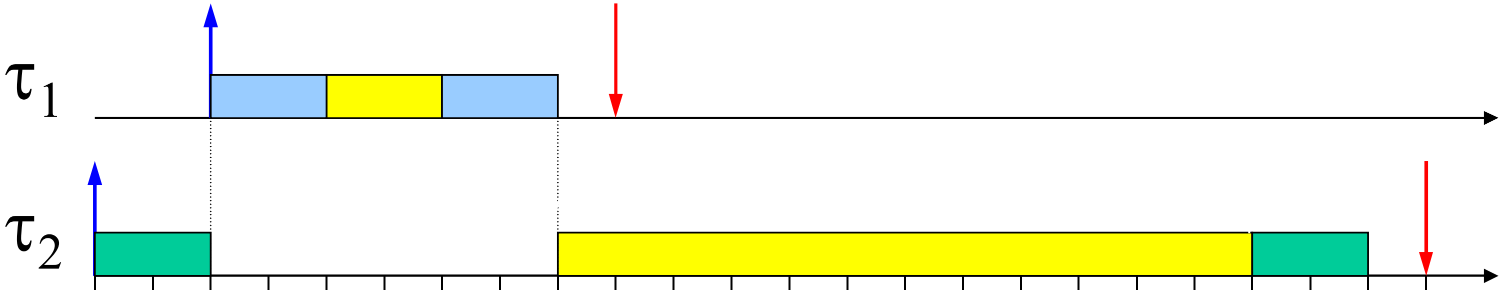
REAL TIME FLAVORS

- A process is <u>hard real time</u> if missing its deadline may cause catastrophic consequences on the environment under control
- A process is <u>firm real time</u> if missing its deadline makes the result useless, but missing does not cause serious damage
- A process is <u>soft real time</u> if meeting its deadline is desirable (e.g. for performance reasons) but missing does not cause serious damage

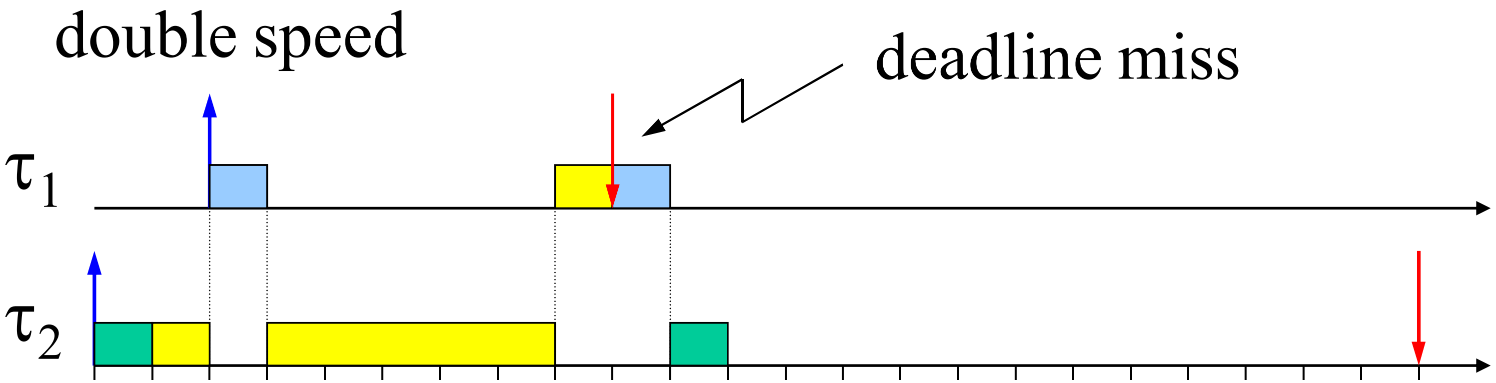


REAL TIME VS FAST

- The objective of a real-time system is to guarantee the timing behavior of each individual process



- The objective of a fast system is to minimize the average time of a set of processes takes to complete



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DAUIN

QUESTIONS?

THANK YOU!