Operating Systems
CS2006

Lecture 4

Process Management

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Process

- A computer program in execution on a machine is a process

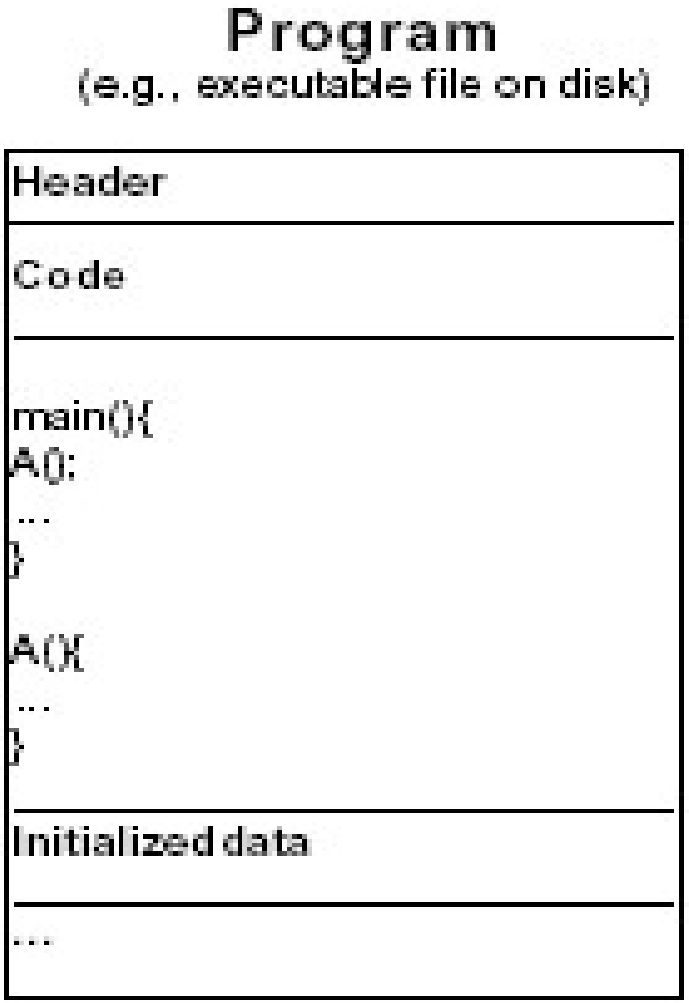
- More formally:
  - A Sequential stream of Execution in its own address space

Process Address Space

- A list of memory locations from some min (usually 0) to some max that a process can read and write.

- Contains
  - the executable program
  - program's data
  - Stack
  - Associated with a process is a set of registers e.g. PC, SP and other information to run the program.

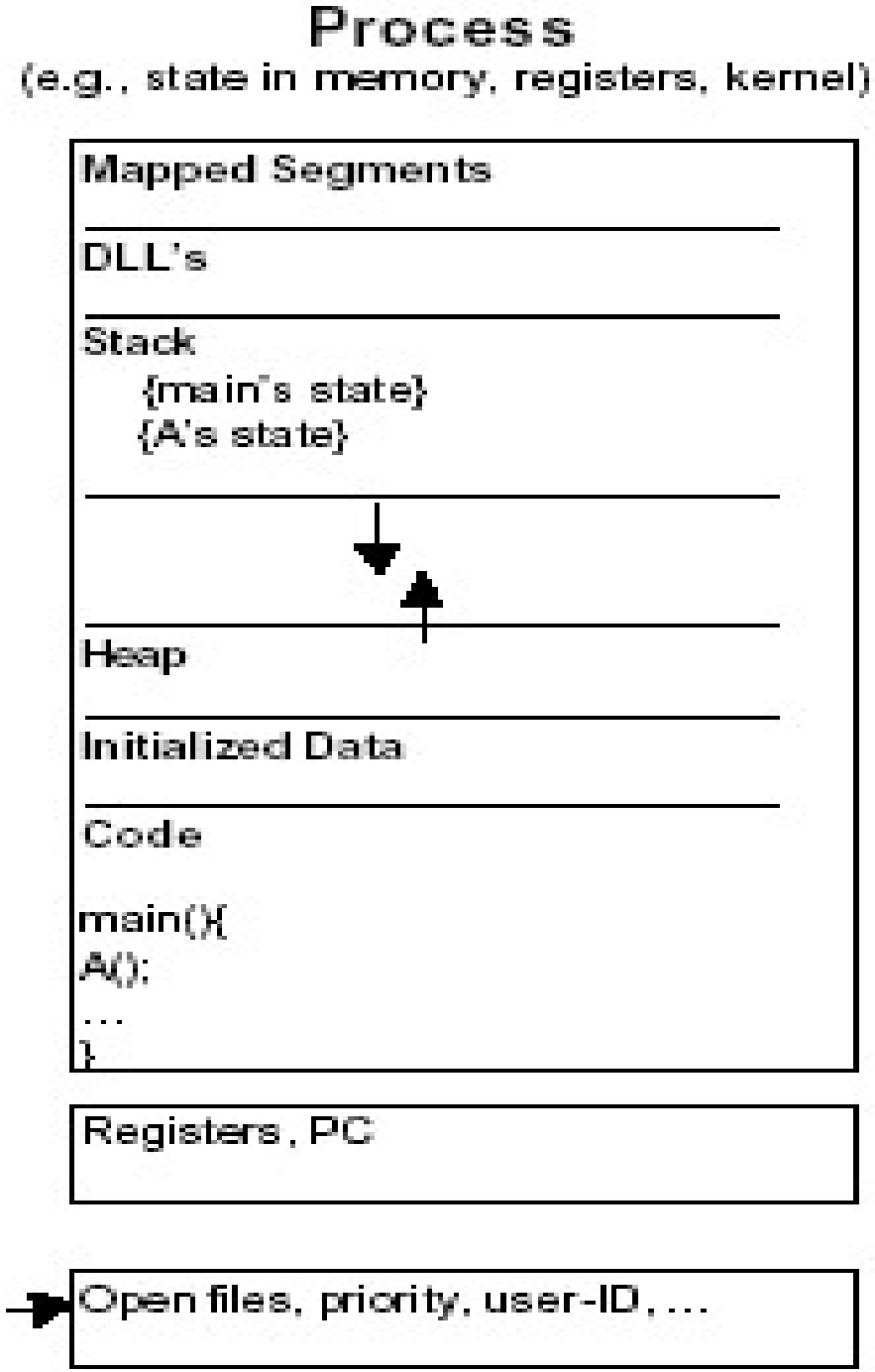
Process =? Program



- Program: series of commands (e.g. C statements, assembly commands, shell commands)

Process

- A process consists of
  - Code (text) section
  - Data section
  - Stack
  - Heap
  - CPU State (program counter, etc.)
  - Environment
  - Process control block (PCB)


Process
(e.g., state in memory, registers, kernel)
Mapped Segments
DLL's
Stack
{main's state}
{A's state}
Heap
Initialized Data
Code
main(){
A();
...
}
Registers, PC
Open files, priority, user-ID, ...

CPU State

- CPU registers contain the current state
  - Program Status Word (PSW): includes bits
  - Instruction Register (IR):
  - Program Counter (PC):
  - Stack Pointer (SP):
  - General purpose registers:

Memory Contents

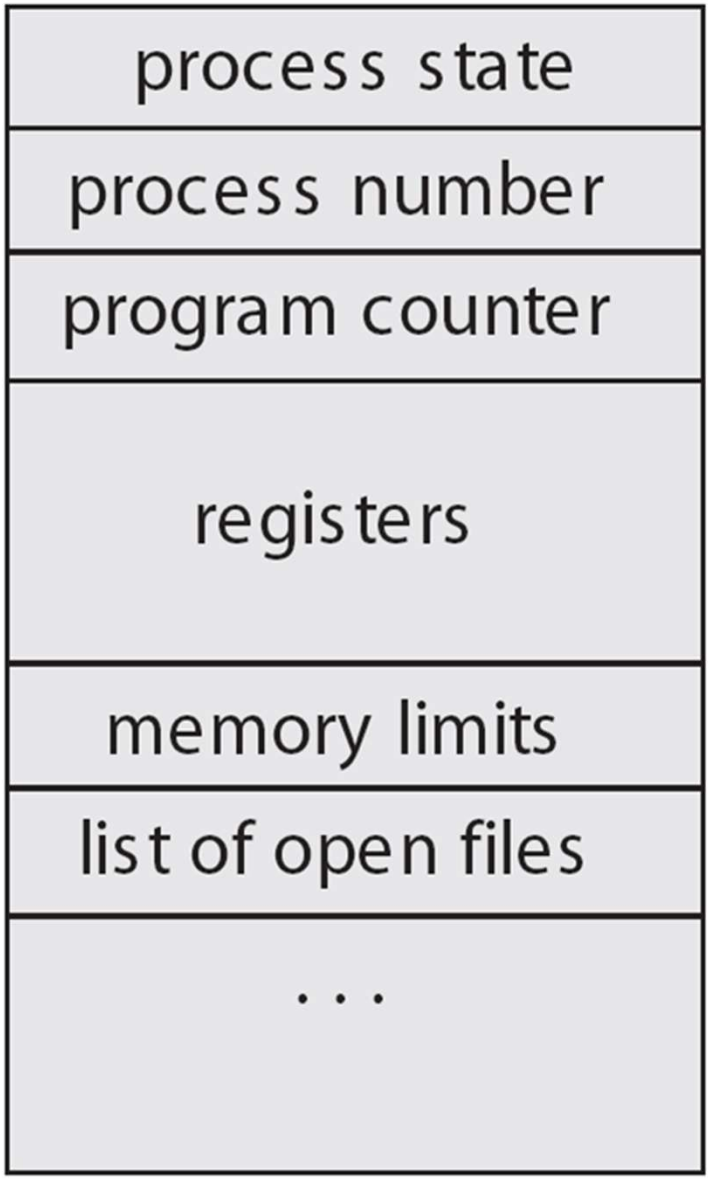
- Only a small part of an application's data can be stored in registers. The rest is in memory.
- Typically divided into a few segments:
  - Text/application code
  - Data
  - Heap
  - Stack
- All the addressable memory together is called?
  - The process's address space.

Environment

- Contains the relationships with other entities
- A process does not exist in a vacuum
- It typically has connections with other entities, such as
  - A terminal where the user is sitting.
  - Open files
  - Communication channels to other processes, possibly on other machines.

Process Control Block (PCB)

- The OS keeps all the data it needs about a process in the process control block (PCB)
- Thus another definition of a process:
  - "the entity described by a PCB"
- This includes many of the data items described above, or at least pointers to where they can be found
  - e.g. for the address space



Process Control Block (PCB)

- PCB is "the manifestation of a process in an operating system".

- **Data Structure** defined in the operating system kernel containing the information needed to manage a particular process.

- It must be kept in an area of memory protected from normal user access.

Process Control Block (PCB)

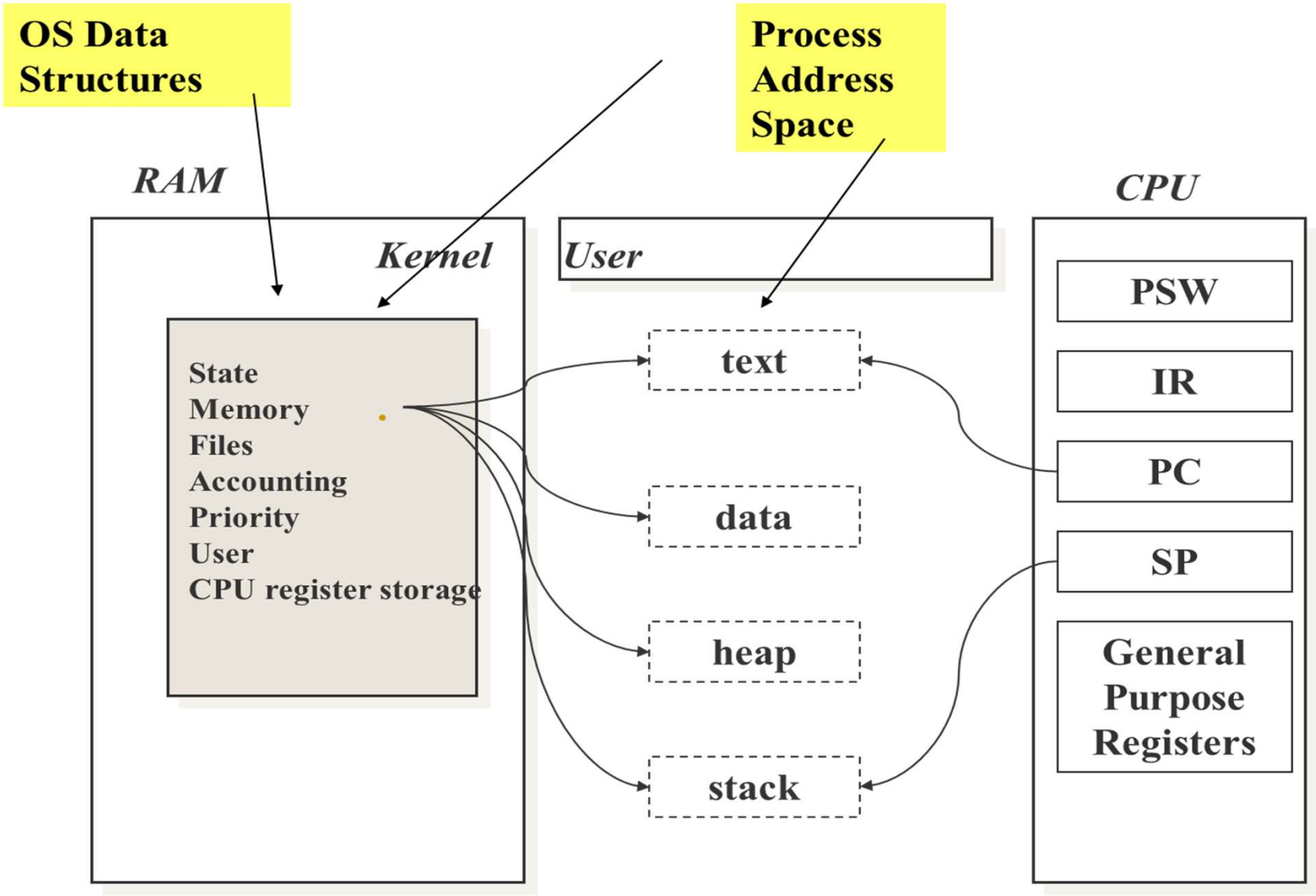
- PCB contains the Process information and attributes
  - Process state
  - Program counter
  - CPU registers
  - CPU scheduling information
  - Memory management information
  - Accounting information
  - I/O status information
  - Per process file table
  - Process ID (PID)
  - Parent PID, etc.

Process Identification

- Process ID, a unique numeric identifier

- User ID
  - Who runs the process. Why?
  - Used to determine what access rights the process has

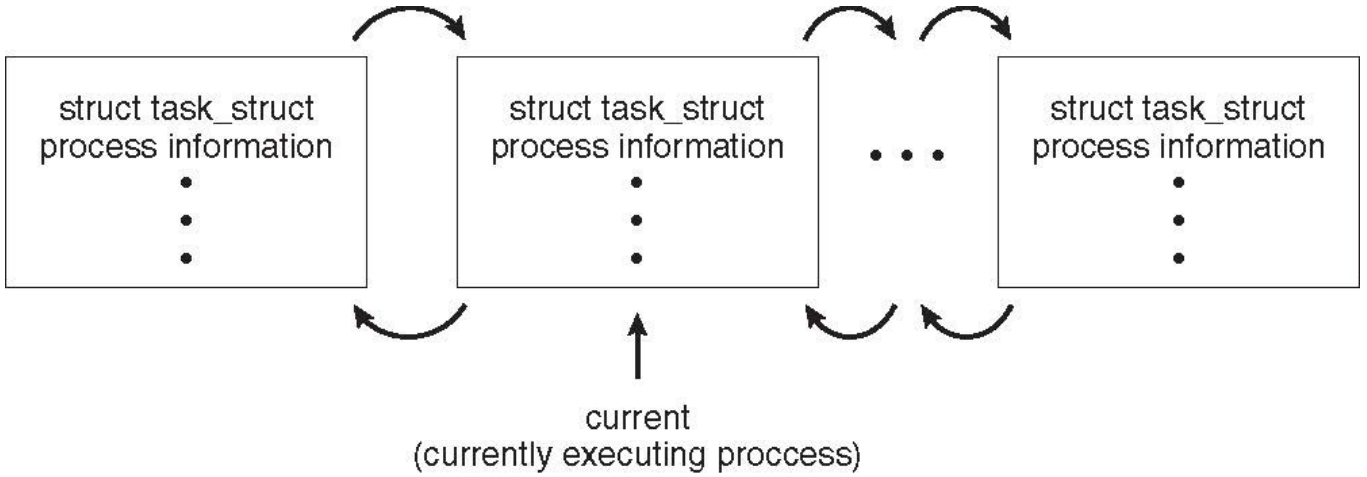
Process Control Block



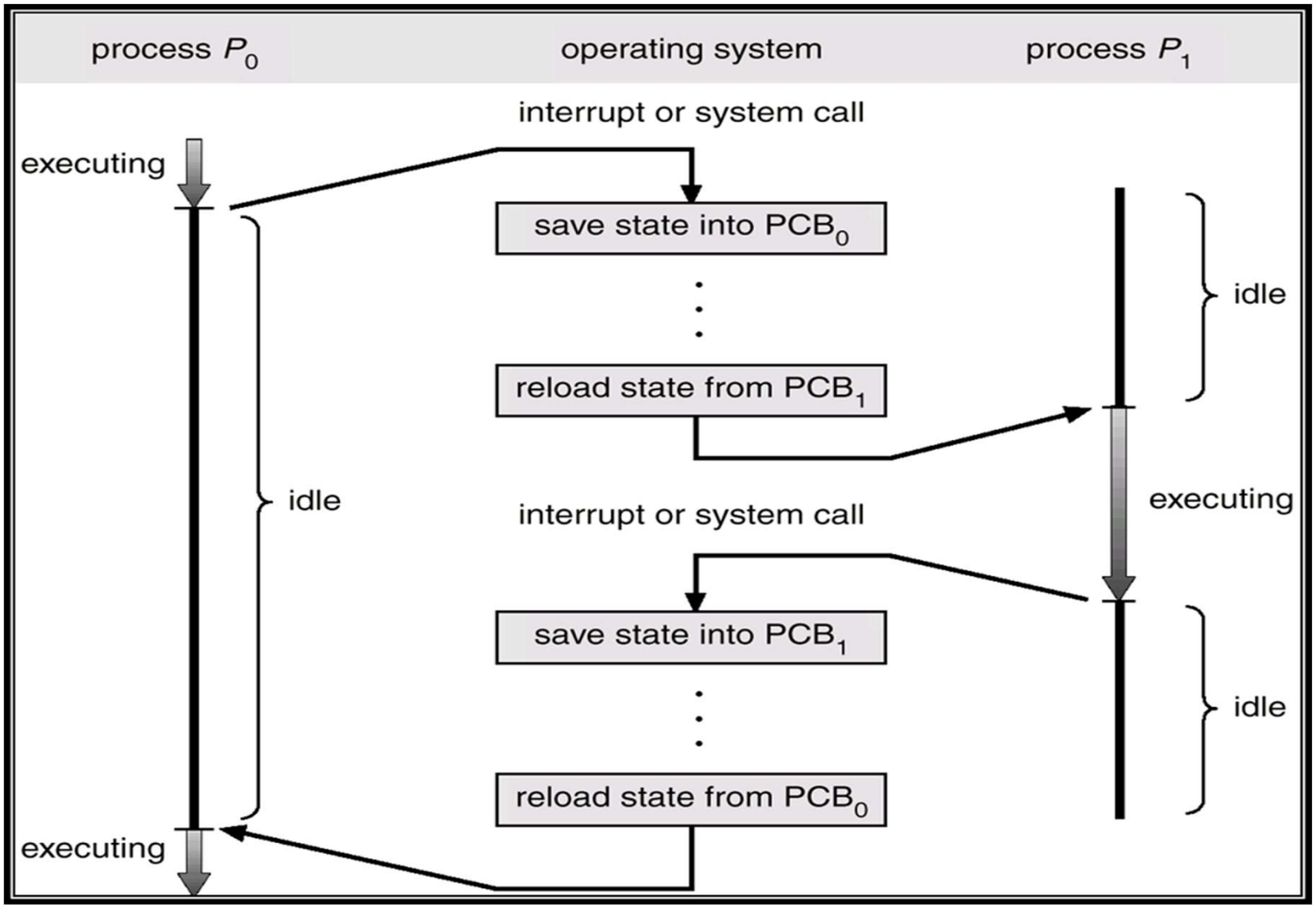
Process Representation in Linux

Represented by the C structure `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 */
```



CPU Switch From Process to Process



CPU Switch From Process to Process

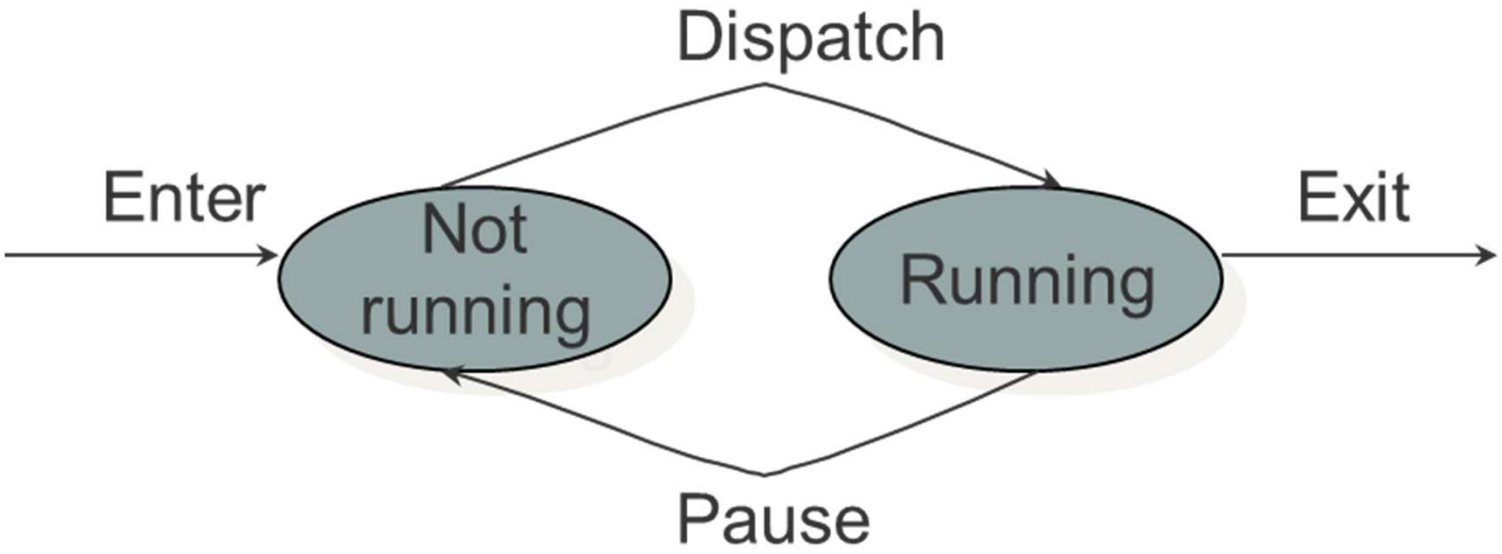
- Switching a process requires
  - Saving the state of old process
  - Loading the saved state of the new process

- This is called **Context Switch**
- Part of OS responsible for switching the processor among the processes is called **Dispatcher**

Process States

- At any given time a process is either running or not running
- Number of states
  - Running
  - Not Running
- When the OS creates a process, the process is entered into Not Running state

Two-state process model



- Processes that are Not Running at a particular time should be kept in some sort of a queue

How process state changes_1

Ready

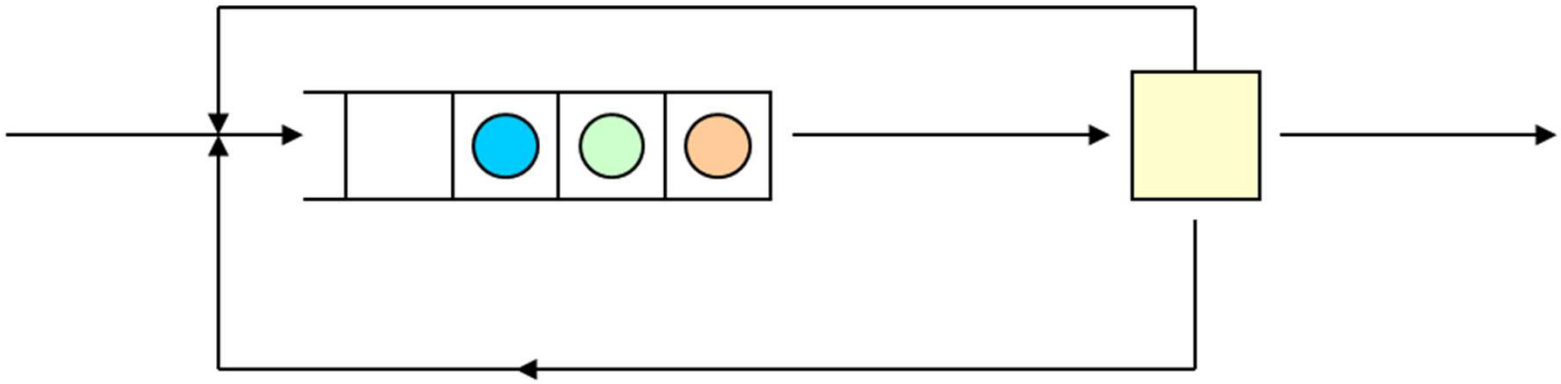
➔ a := 1
b := a + 1
c := b + 1
read a file
a := b - c
c := c * b
b := 0

Ready

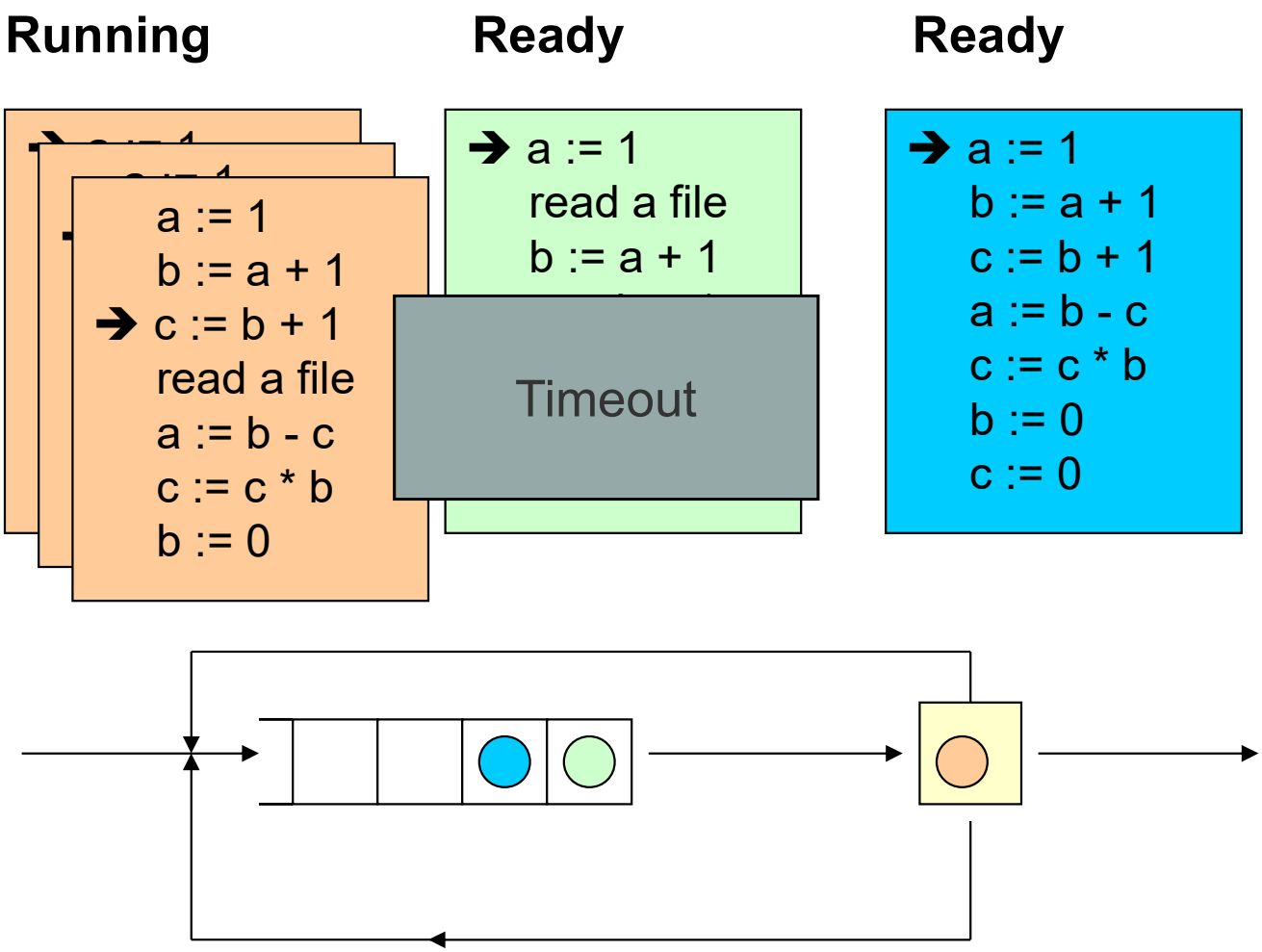
➔ a := 1
read a file
b := a + 1
c := b + 1
a := b - c
c := c * b
b := 0

Ready

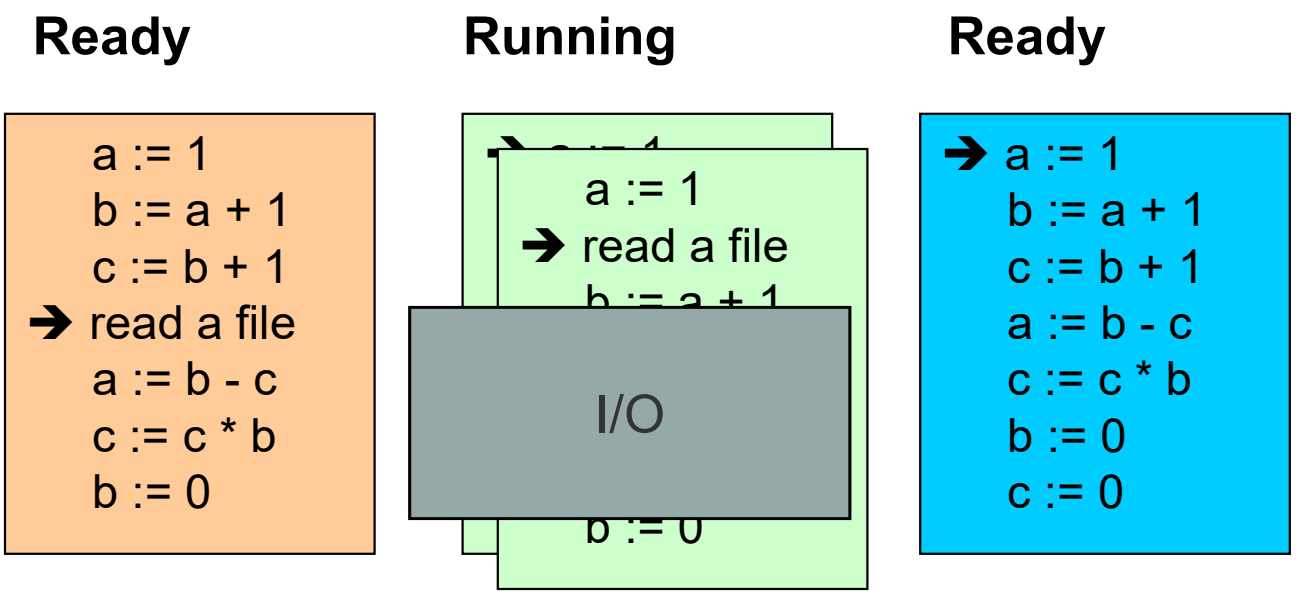
➔ a := 1
b := a + 1
c := b + 1
a := b - c
c := c * b
b := 0
c := 0

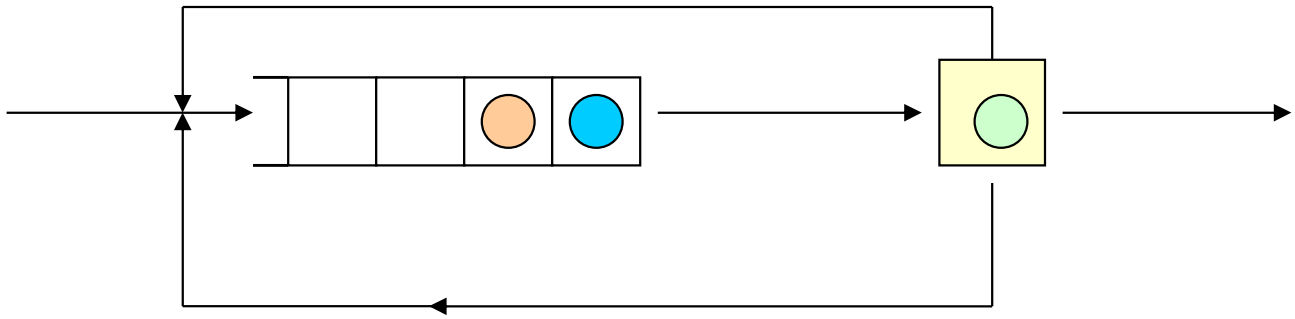


How process state_2

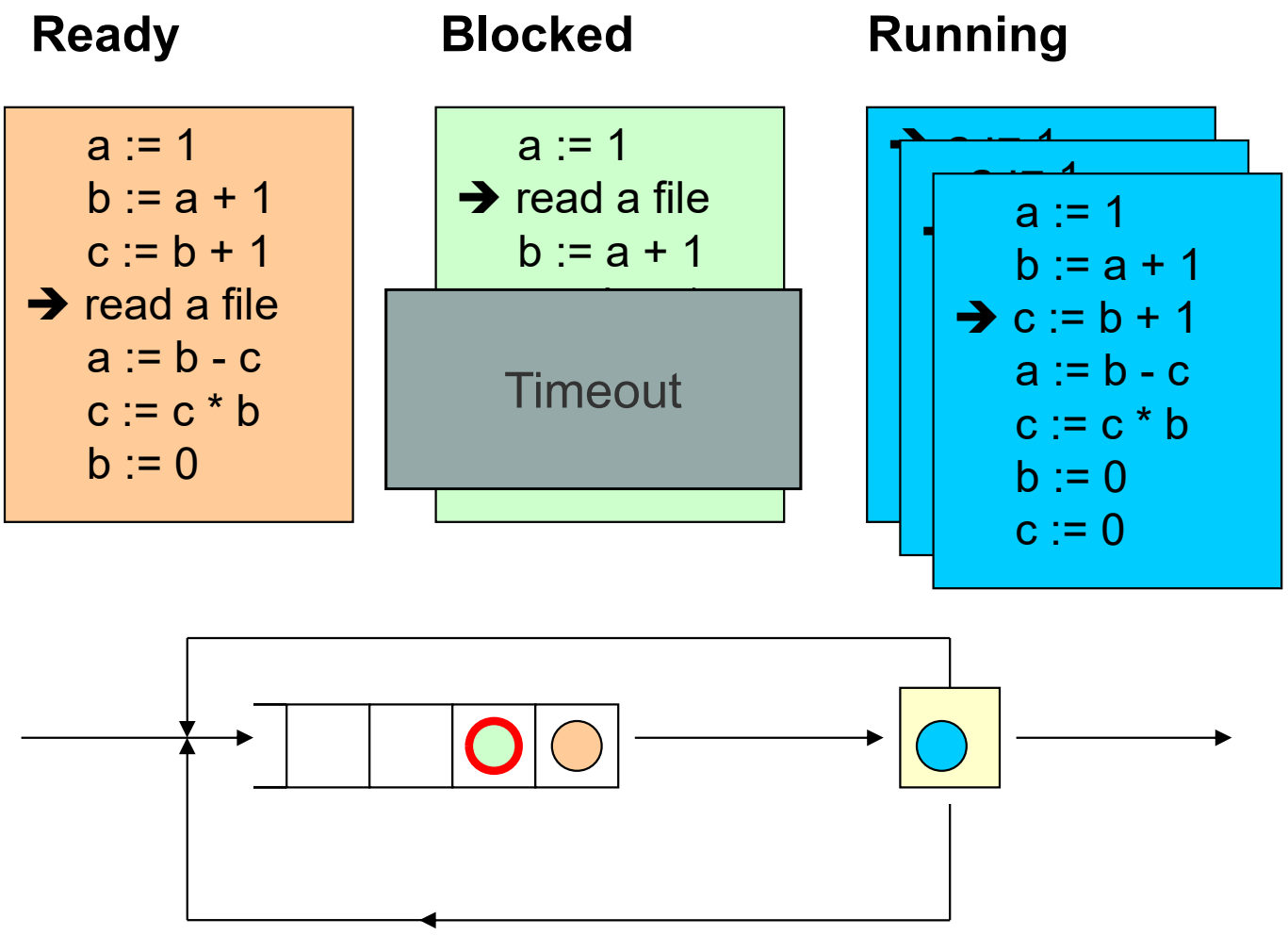


How process state changes_3

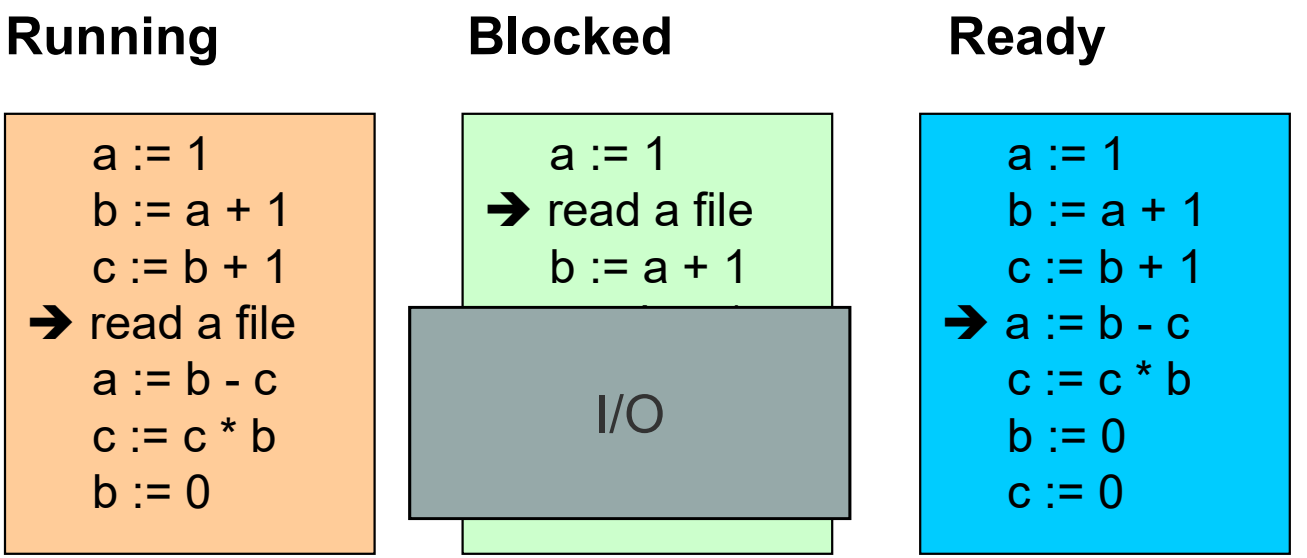


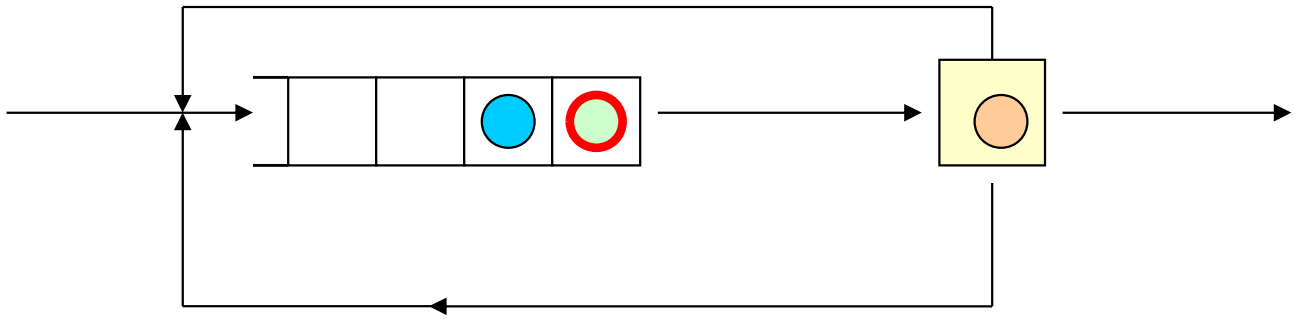


How process state changes_4



How process state changes_5





How process state changes_6

Blocked

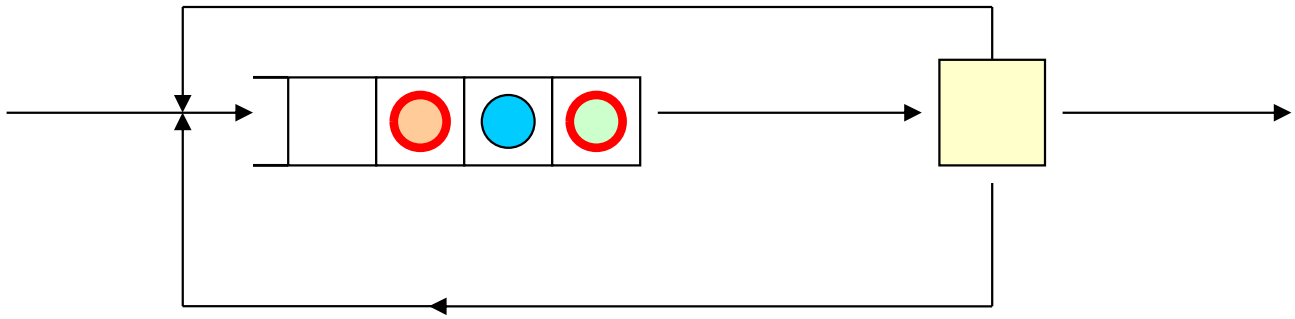
```
    a := 1
    b := a + 1
    c := b + 1
➔   read a file
    a := b - c
    c := c * b
    b := 0
```

Blocked

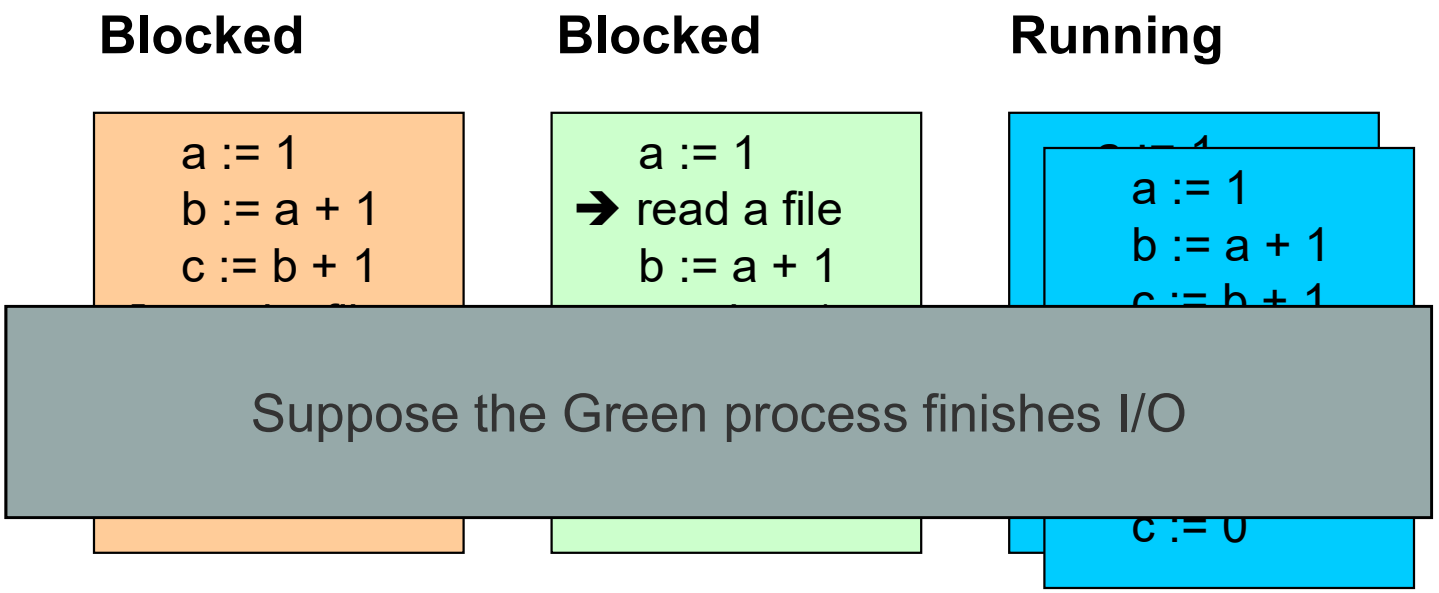
```
    a := 1
➔   read a file
    b := a + 1
    c := b + 1
    a := b - c
    c := c * b
    b := 0
```

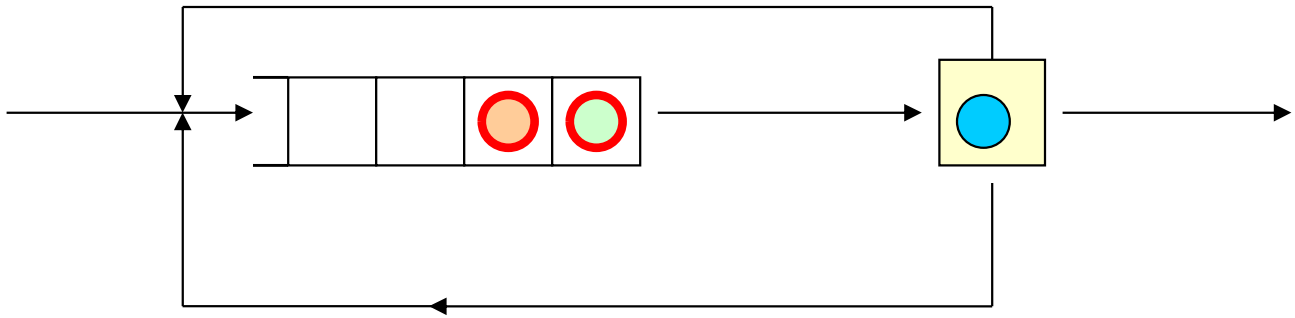
The Next Process to Run cannot be simply selected from the front

```
➔   a := b - c
    c := c * b
    b := 0
    c := 0
```

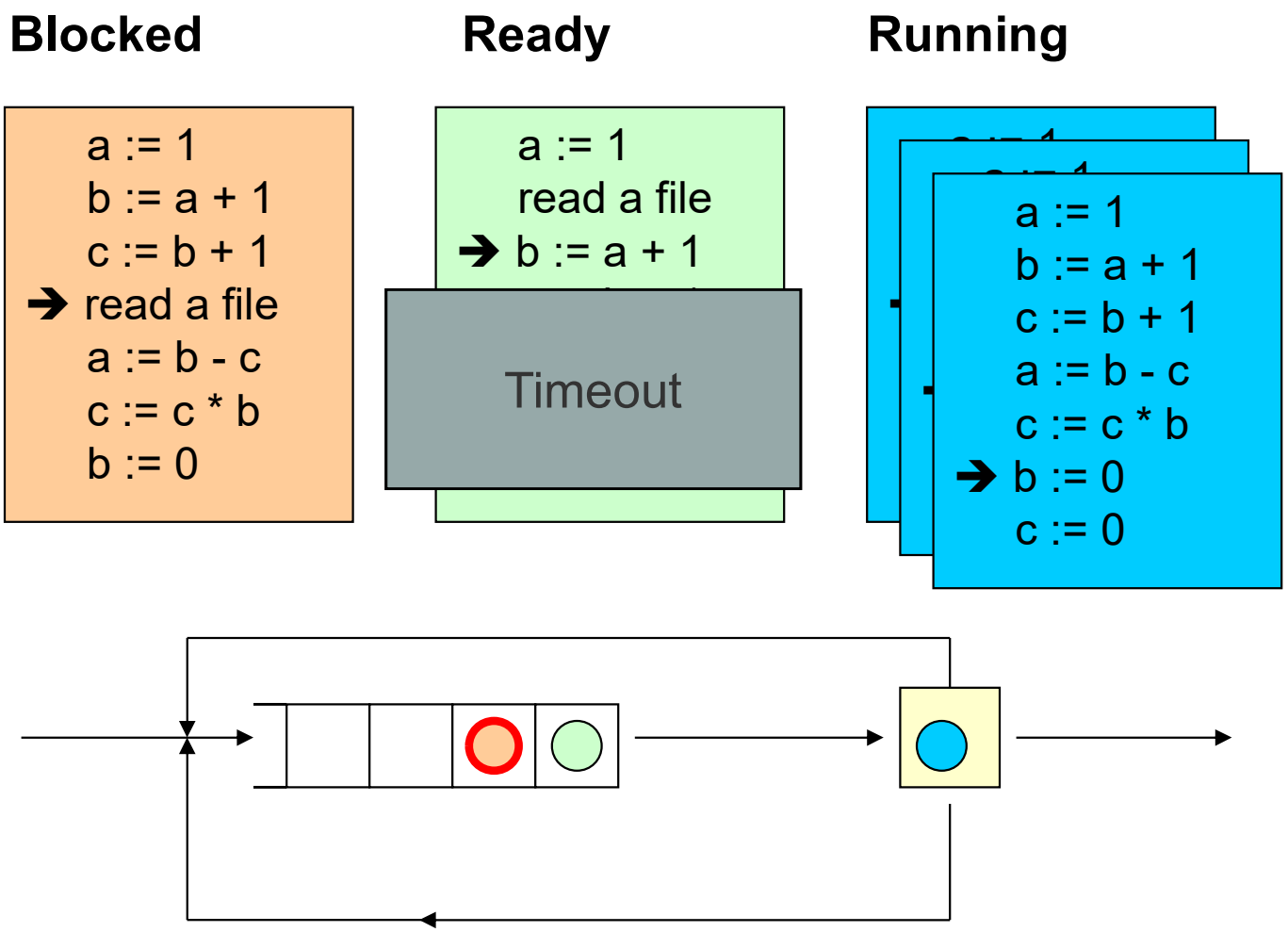


How process state changes_7

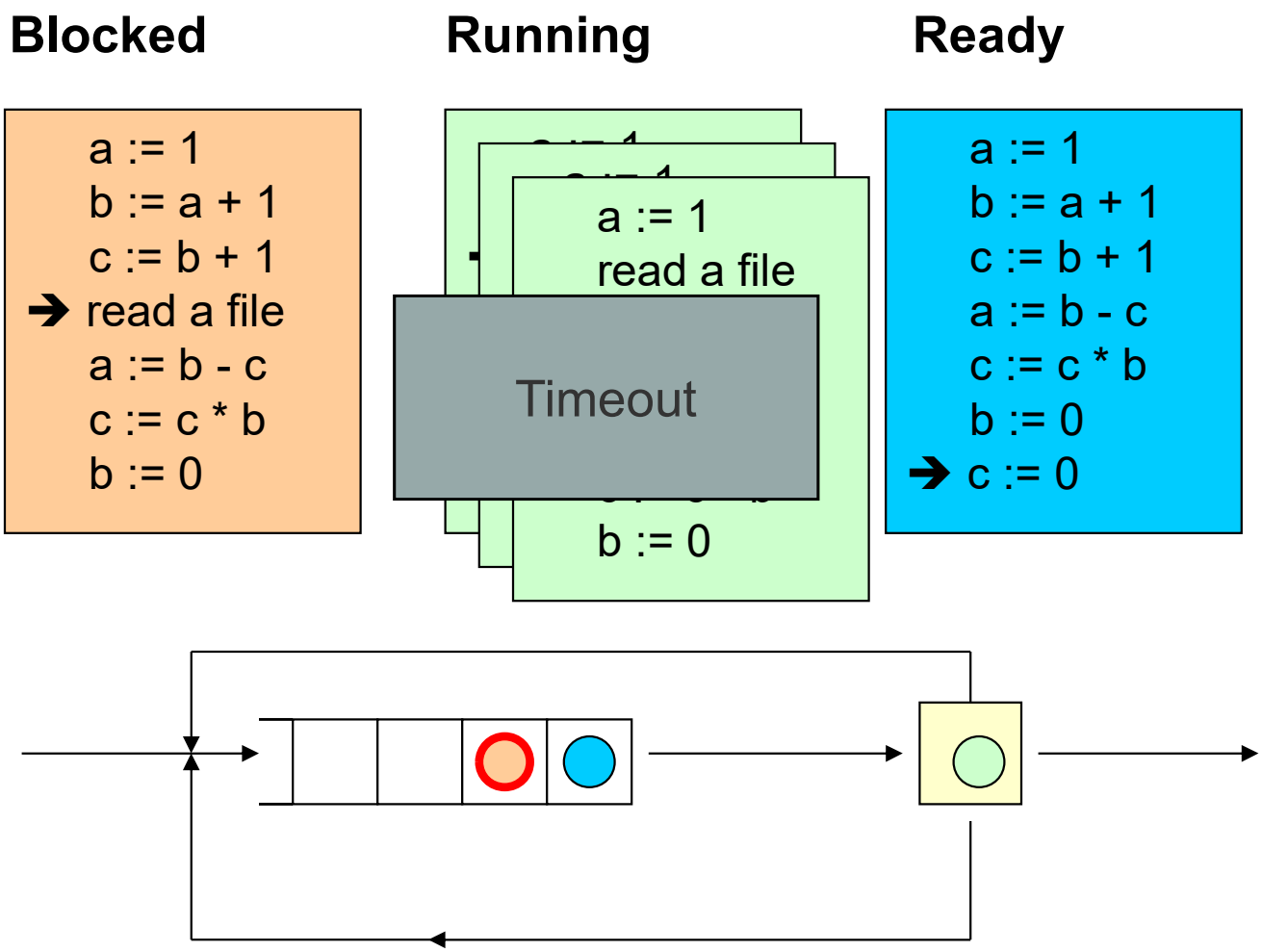




How process state changes_8



How process state changes_9



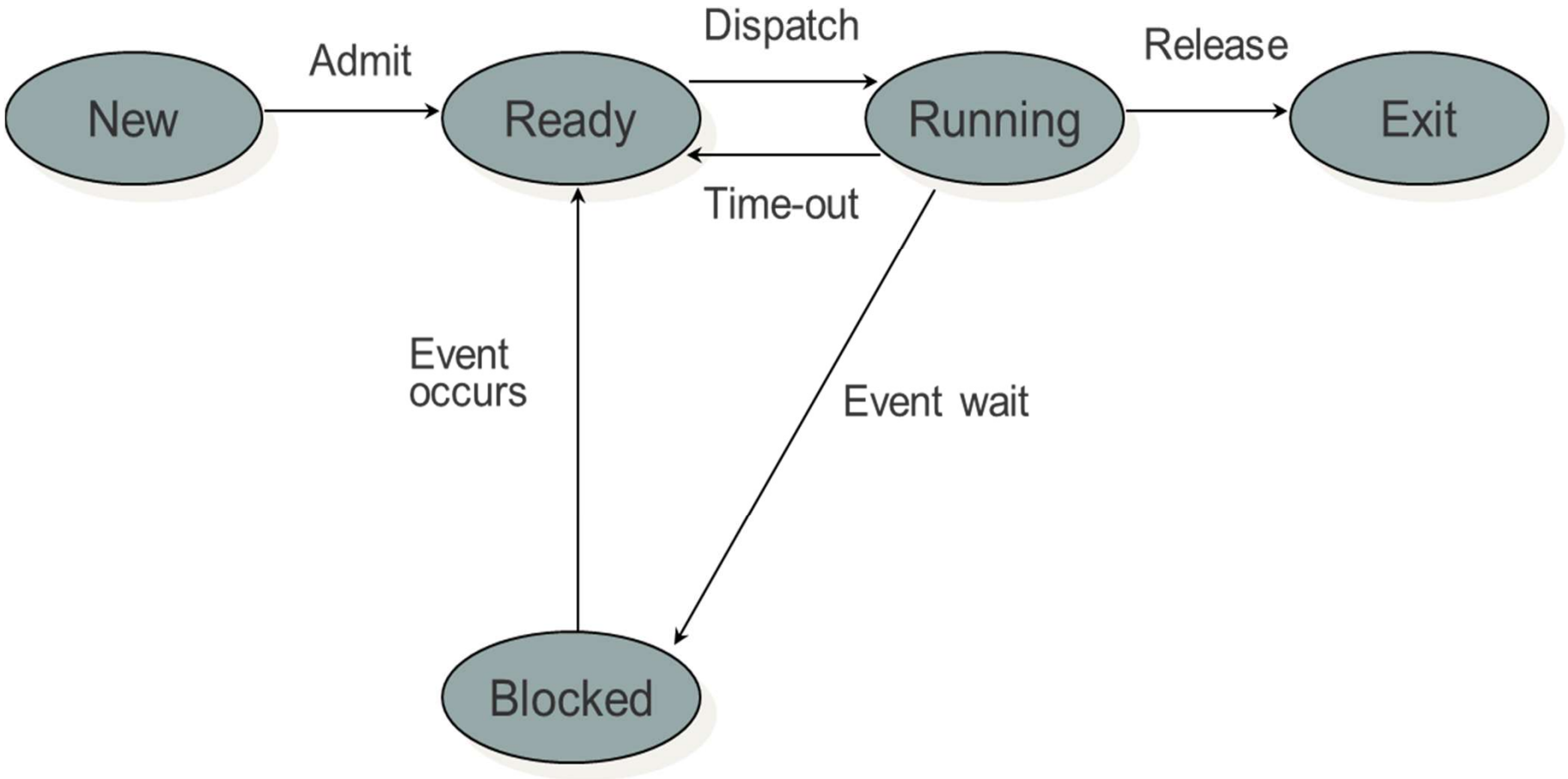
Problem in Two-state Process model

- A process may be waiting for I/O request
- A single queue for both the ready to run and waiting processes
- The dispatcher cannot simply select the process at the front, it can be a busy process
- In the worst case, it has to scan the whole queue to find the next process to run Solution?
- Split the Not Running state to:
  - Waiting
  - Ready

Five-state Process Model

- Running: currently being run
- Ready: ready to run
- Blocked: waiting for an event (I/O)
- New: just created, not yet admitted to set of run-able processes
- Exit: completed/error exit

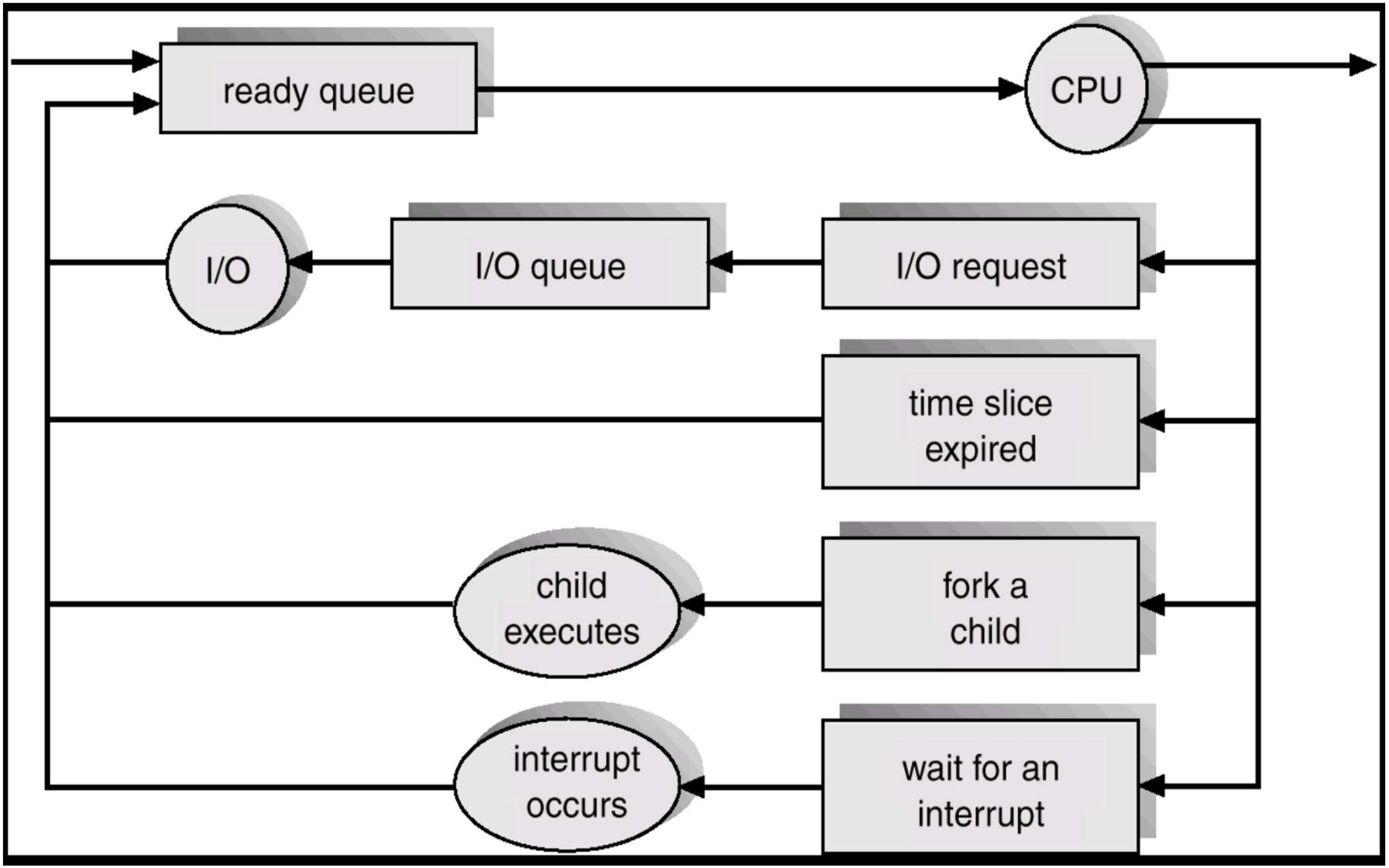
Five-state Process Model



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.
- Process migration between the various queues.

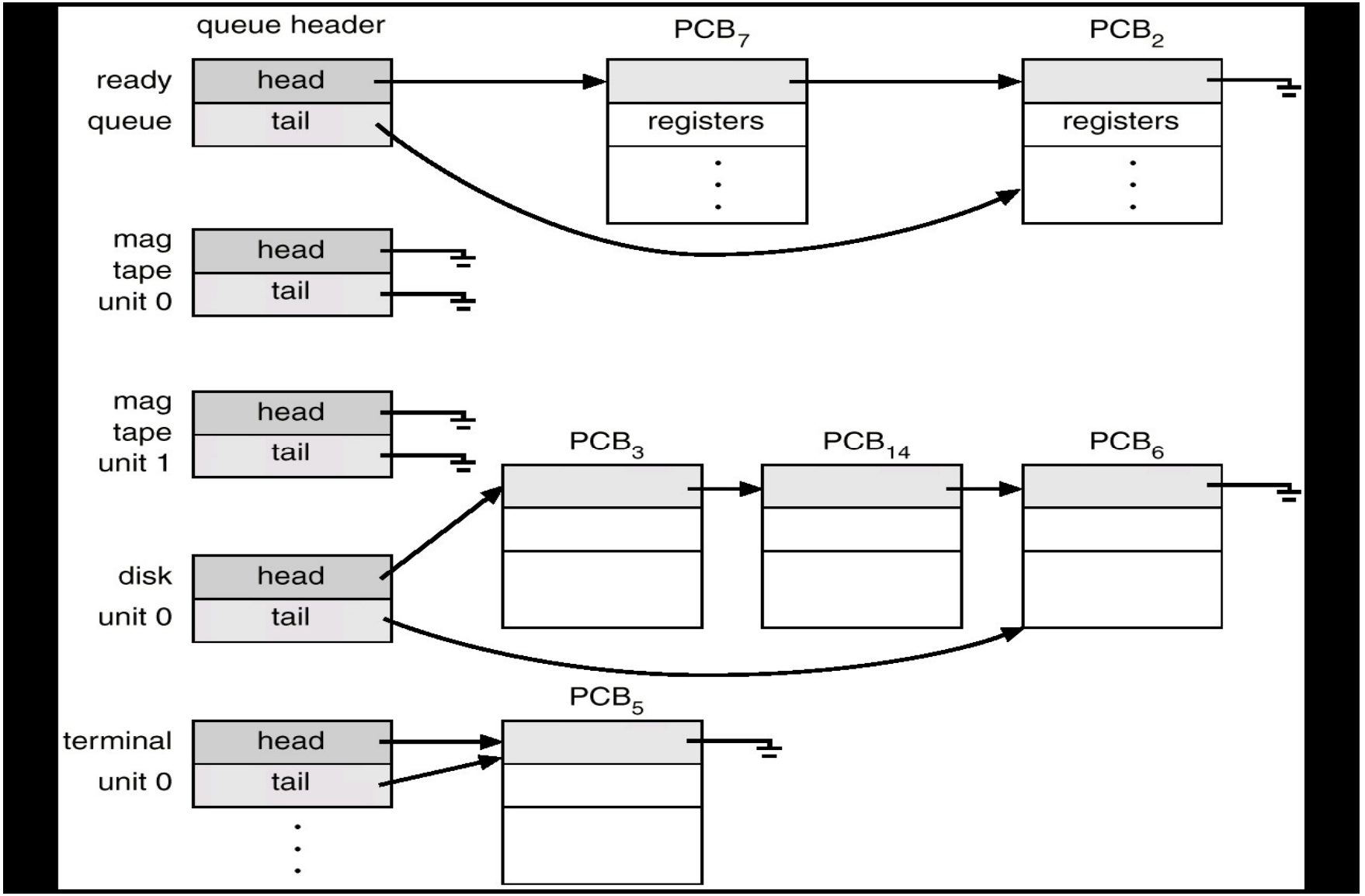
Process Scheduling View



Scheduling Queues

- The queues are generally stored as linked lists
- A queue header points to the first and the final PCB's in the list
- We extend each PCB to include a pointer field that points to the next PCB in the ready queue

Scheduling Queues



References

- Operating System Concepts (Silberschatz, 8th edition) Chapter 3
- http://siber.cankaya.edu.tr/OperatingSystems/ceng328/node87.html
- http://www.personal.kent.edu/~rmuhamma/OpSystems/Myos/processControl.htm
- http://www.tutorialspoint.com/operating_system/os_processes.htm
- http://wiki.answers.com/Q/Explain_process_control_block
- http://www.gitam.edu/eresource/comp/gvr(os)/4.2.htm
- http://www.sal.ksu.edu/faculty/tim/ossg/Process/p_create.html