Processes

Reading:

Silberschatz

chapter 4

Additional Reading:

Stallings

chapter 3

Outline

- Process Concept
- Programming Types
- Process States
  - Process Creation
  - Process Termination
- Process State Diagram
- Process Control Block
- CPU Switching
- Queuing diagram
- Schedulers
- Context Switch

Process Concept

- Definitions
  - A process is a program in execution
  - An instance of a program running on a computer
  - The entity that can be assigned to and executed on a processor
  - A unit of activity characterized by the execution of a sequence of instructions, a current state, and an associated set of system instructions

- Key Points
  - A program by itself is NOT a process
    - A program is a passive entity (file stored on disc)
    - A process is a active entity with associated resources and PC specifying the next instruction to execute
  - Two process may be associated with the *same* program
    - Considered to be separate sequence; *e.g.* copies of same program
  - Processes are separated; no process can directly affect the state of another process
    - WWW browser, the shell program, compiled running program, *etc*.

Programming Types

- *Uniprogramming* Vs *multiprogramming*
  - Uniprogramming - Only one process at a time
  - Multiprogramming
    1. Multiple process at a time
    2. Which process gets physical resources of machine?
       - Preemptive multitasking
       - Fairness – all process must get fair share of the CPU

Processes

➢ Execution model

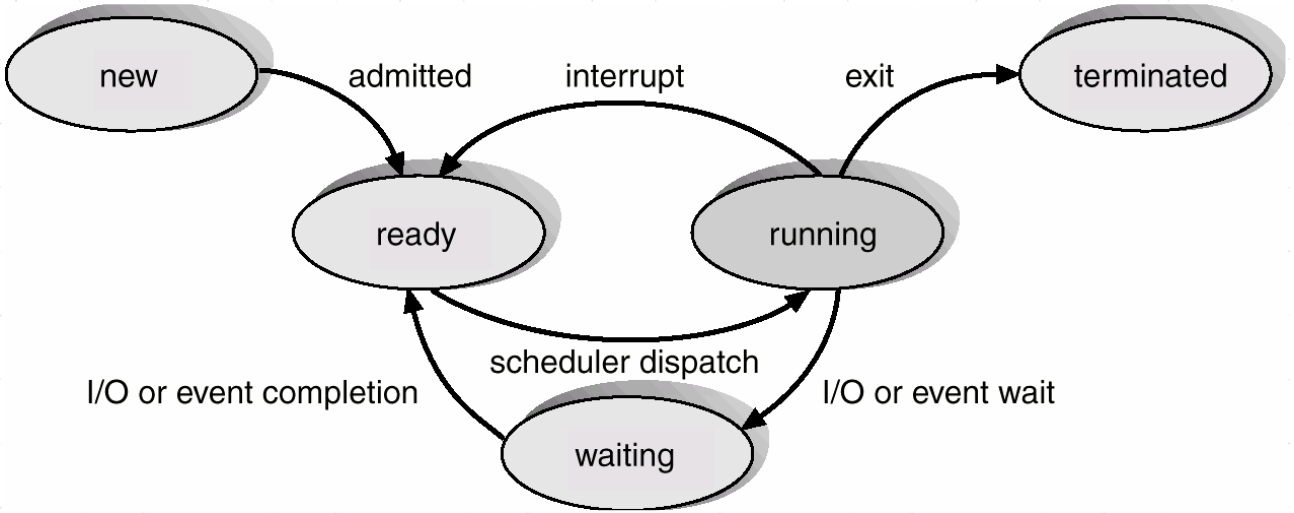
- OS components → Organized into number of sequential processes
- Each process → Block of code with a pointer showing next instruction to be executed
- How can several processes run on one CPU?
- OS makes this happen by ensuring
  - Fair scheduling → each process gets fair chance to run
  - Protection → processes do not modify each others state

Process State

As process executes it changes its state

- New
  - The process is being created, resource acquisition
- Ready
  - The processes that are prepared to execute at next opportunity
- Running
  - The process that is currently being executed by CPU
- Waiting
  - The process is waiting for some event to occur
- Terminated
  - The process has completed execution

Diagram of Process State



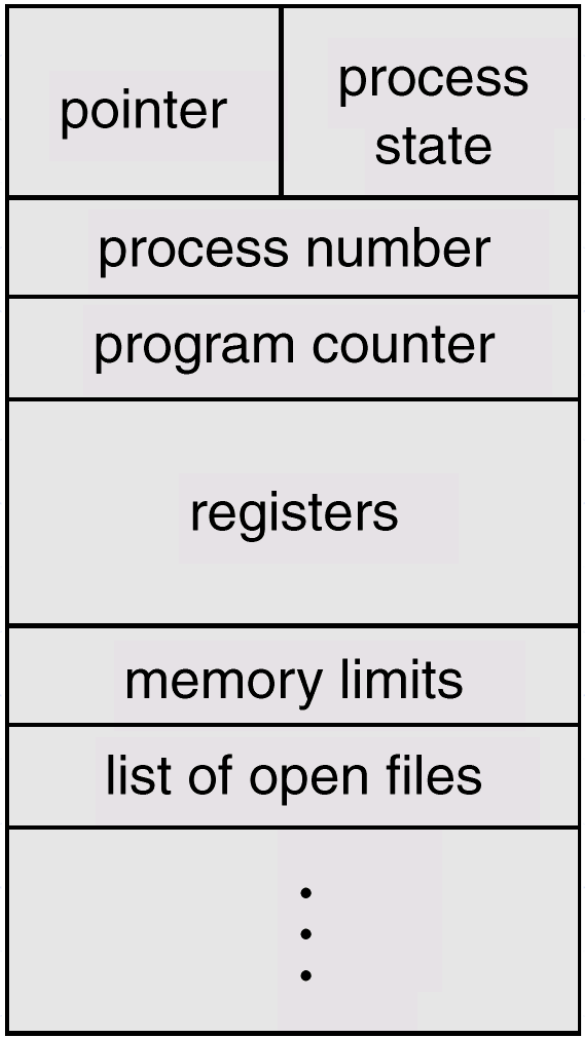
- Above state names are arbitrary and OS dependent
- The state they represents is found in all systems
- Only ONE process can be *running* but several process may be *ready* and *waiting*

Process Control Block (PCB)

Each process is represented in OS by PCB. The PCB contains pieces of information associated with each process, including;

- Process state
- Program counter
- CPU registers
- CPU scheduling information
- Memory-management information
- Accounting information
- I/O status information

Process Control Block (PCB)



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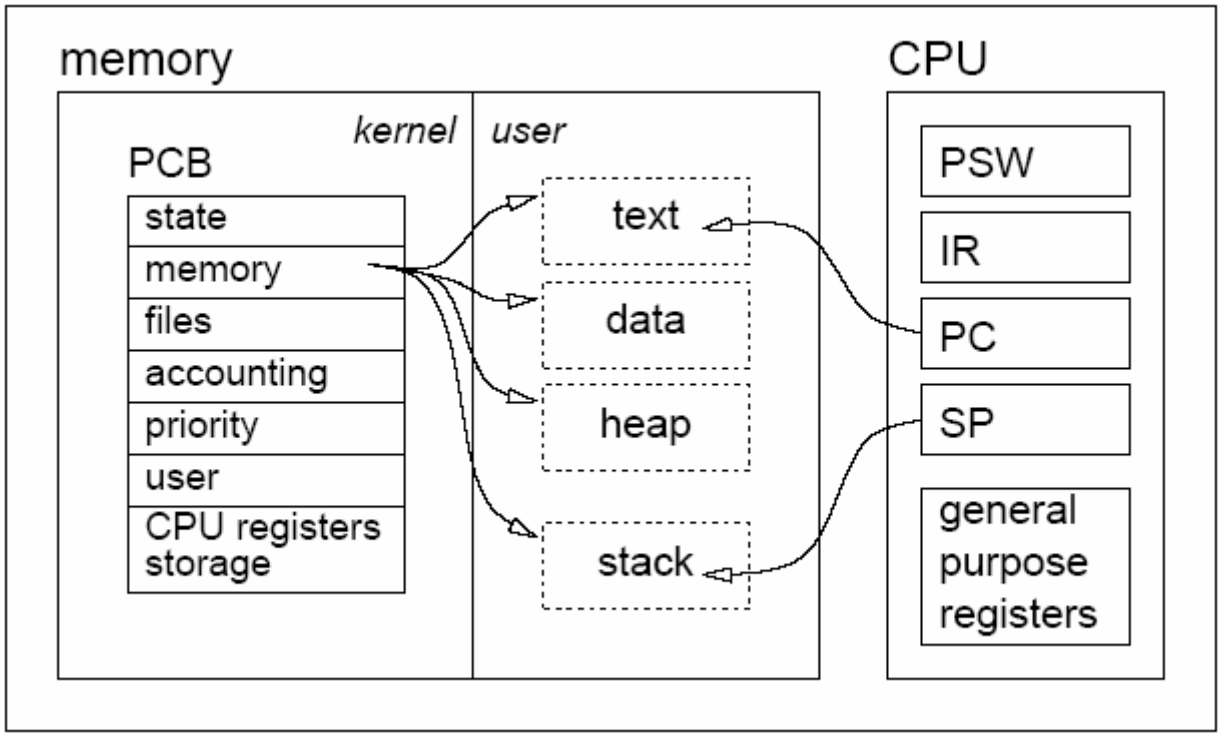

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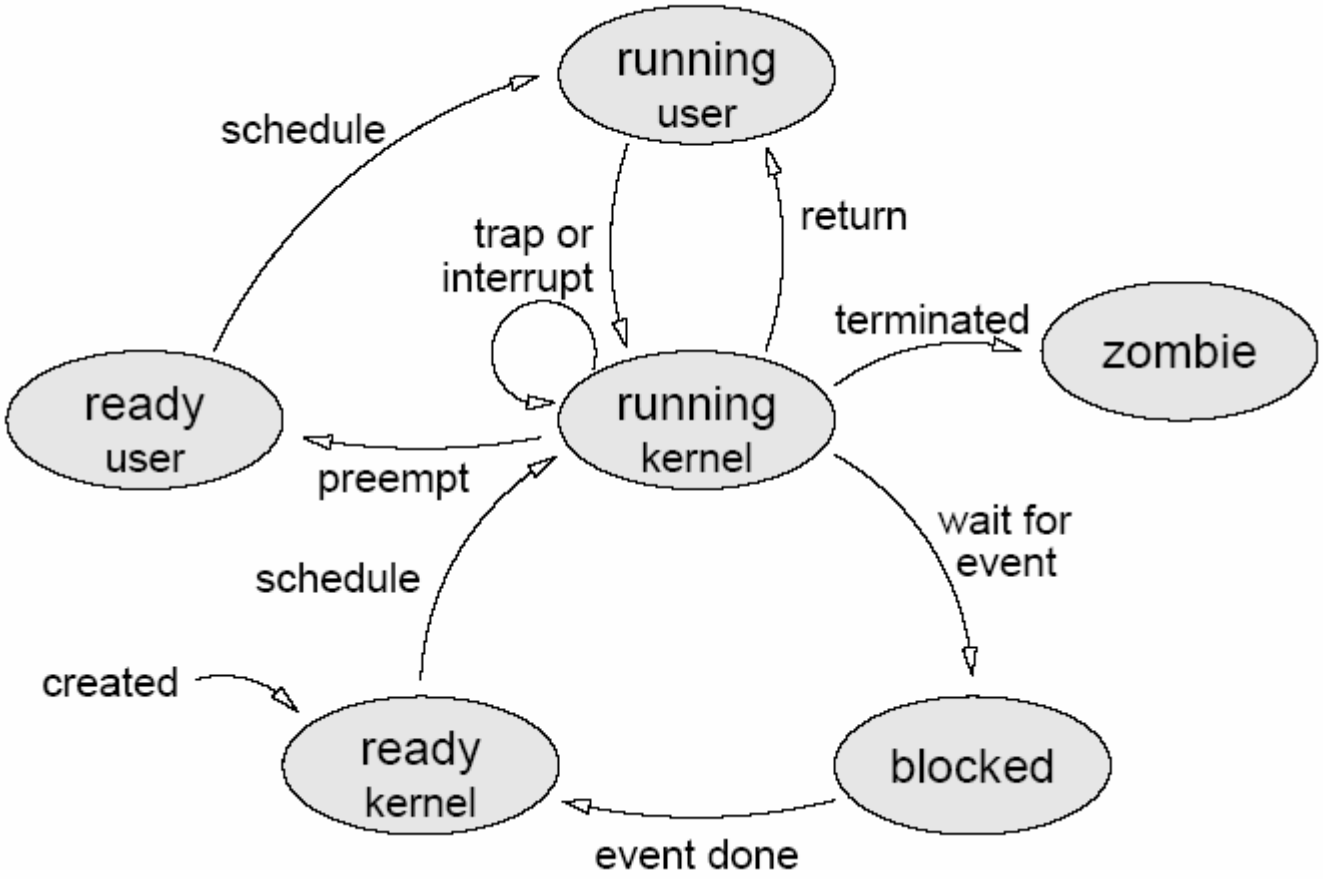
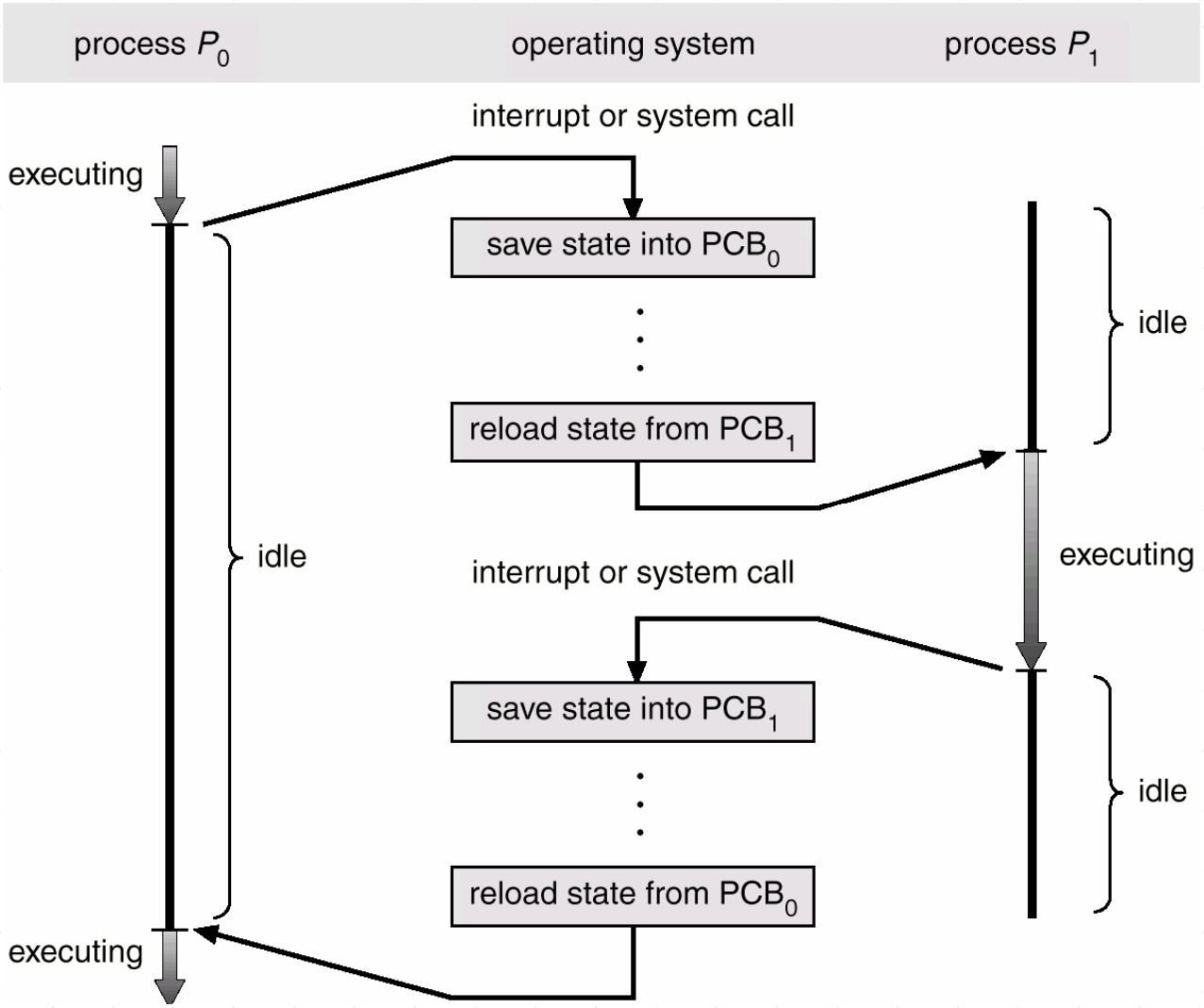


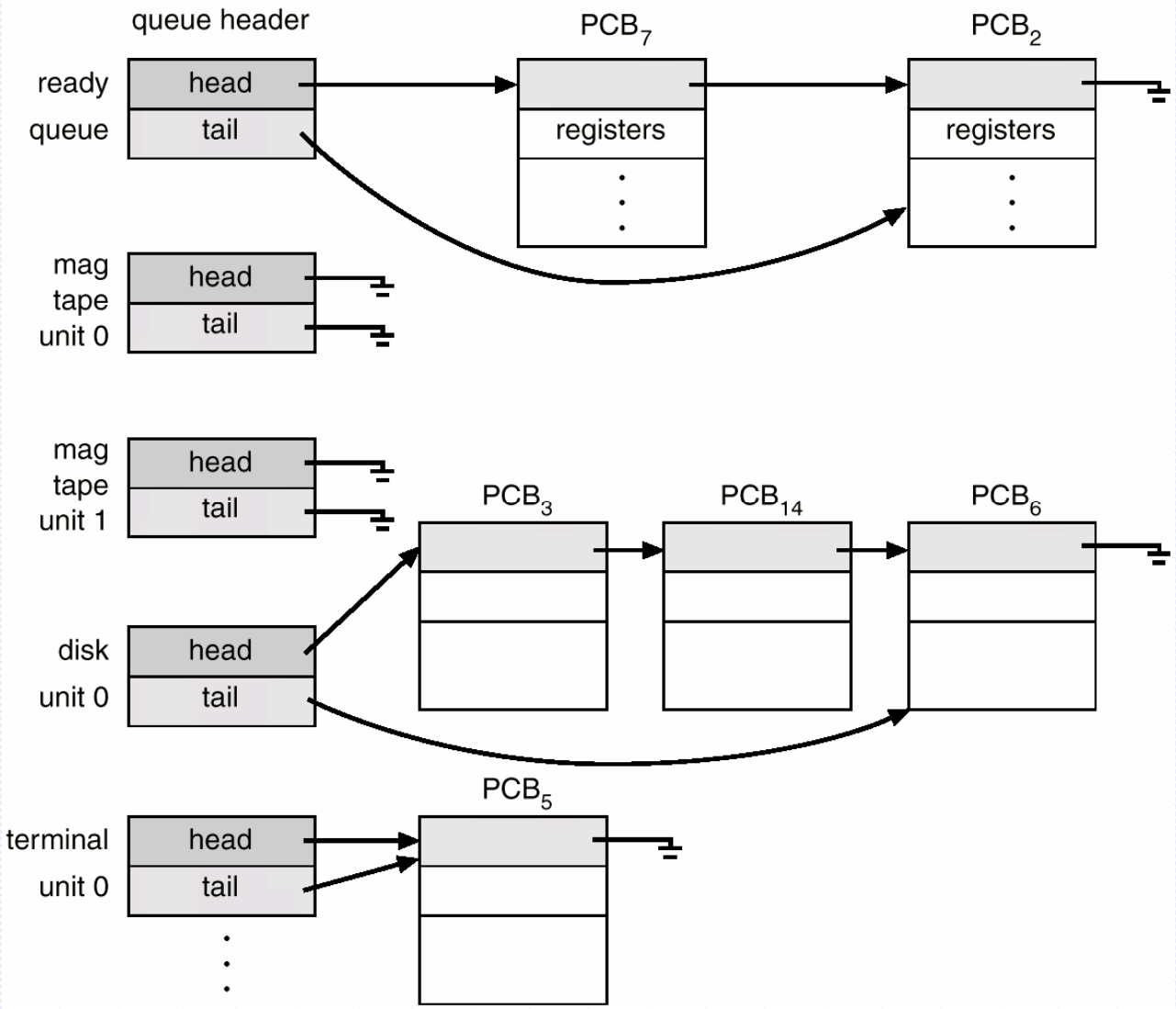
CPU Switching



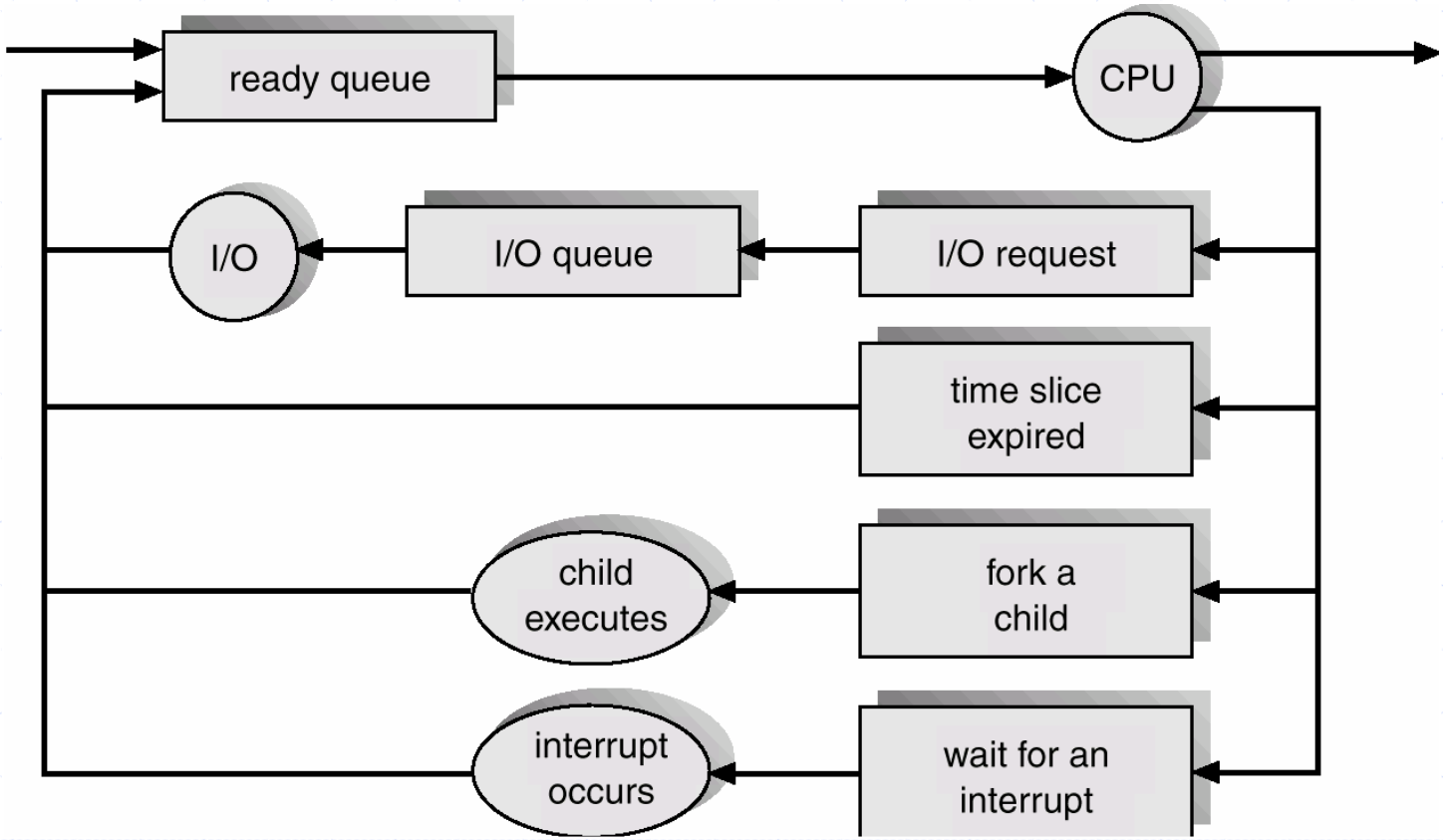
Process Scheduling Queues

- Job queue
  - An instance 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

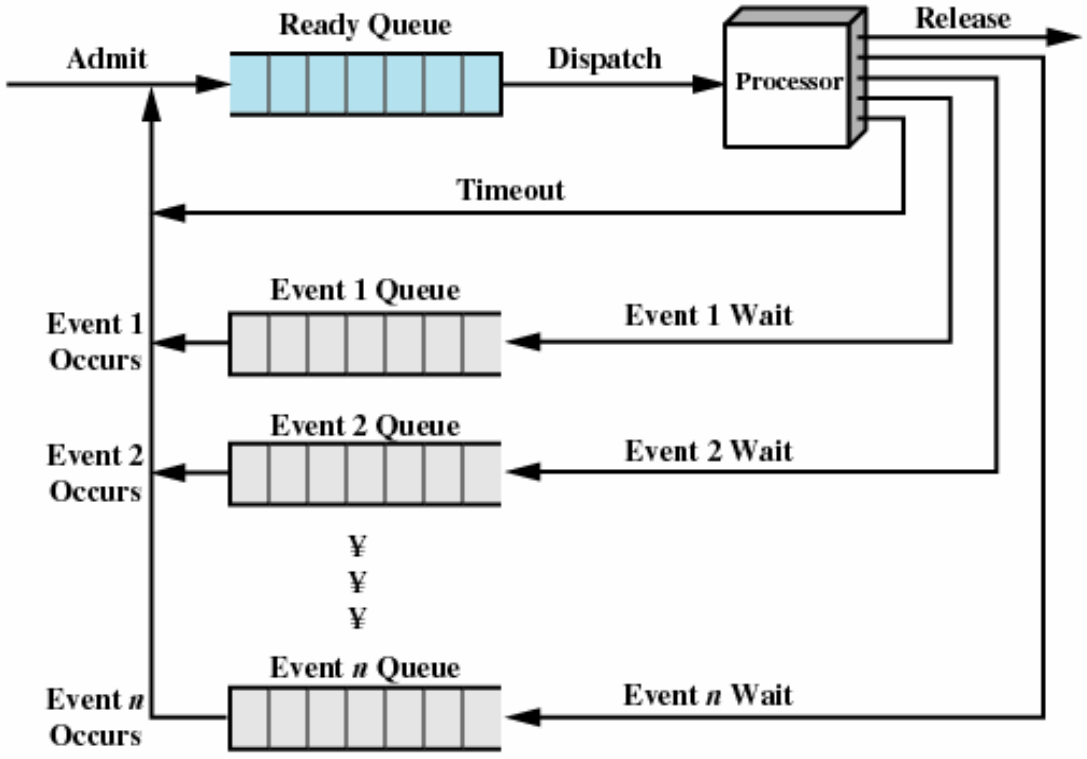
Ready And Various I/O Device Queues



Queuing Diagram



Multiple Blocked Queues



(b) Multiple blocked queues

Schedulers

- Long-term (job) scheduler
  - Selects a process from pool
  - Loads them into memory for execution
  - Controls the degree of multiprogramming
    - # process in memory, stable – invoke during departure
  - Can afford to take more time in decision – long execution time
  - I/O bound process, CPU bound process, best combination

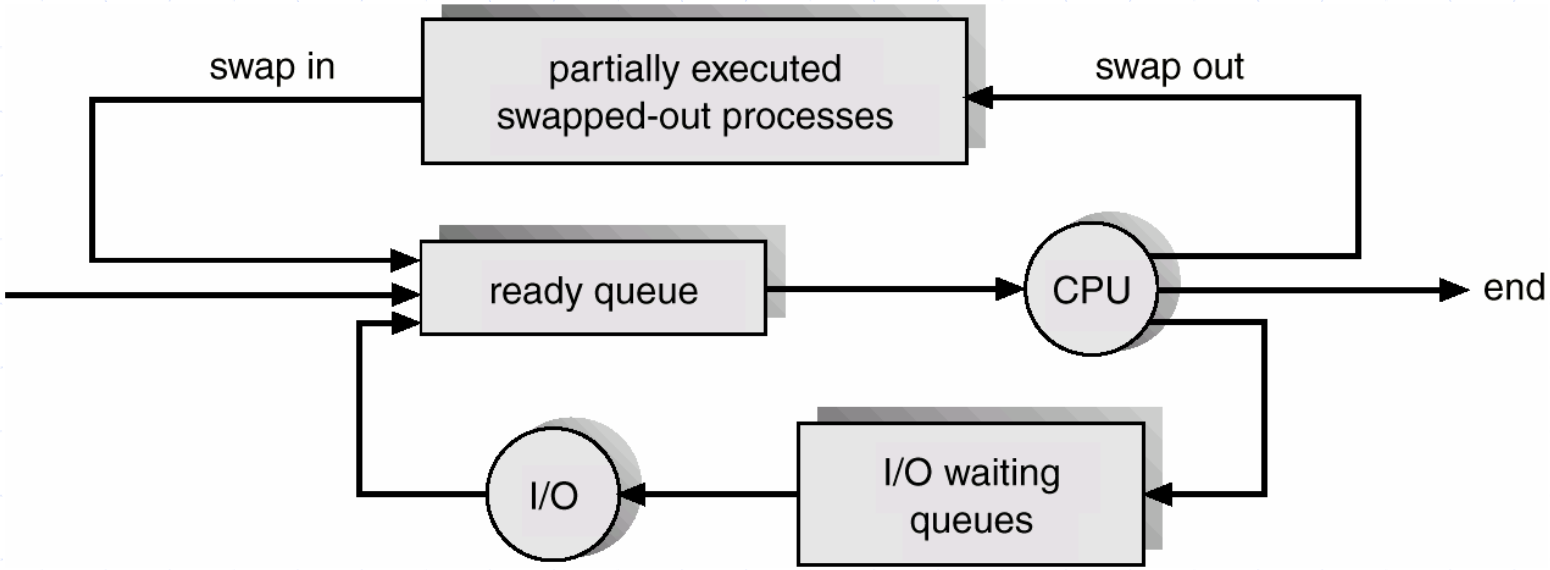
- Short-term (CPU) scheduler
  - Selects from the processes that are ready to execute
  - Allocates *CPU to one of them*

  - Some time-sharing OS **no** long-term scheduler, simply put new process in memory for short-term scheduler
    - *e.g.* UNIX, MS Windows

Medium Term Scheduling

- Additional intermediate level of scheduling

  temporarily remove processes from memory, active contention of CPU



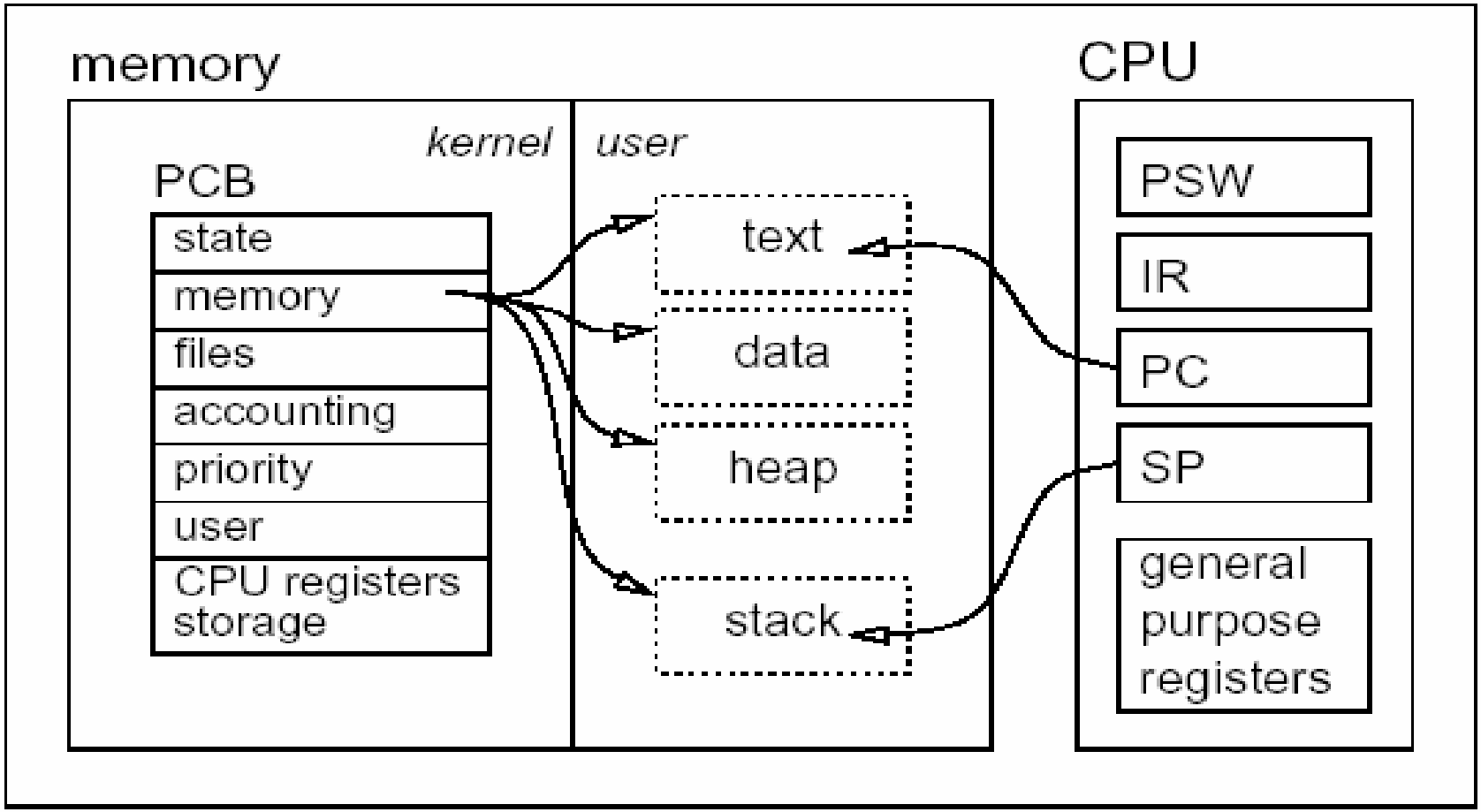
Context (Process) Switch

- CPU switches to another process
  - Save the current context/state of the old process
  - Load/restore the saved context/state for new process
  - The context is represented in PCB of process
- Context-switch time is overhead; the system does no useful work while switching
- Time dependent on hardware support
  - *Sun UltraSPARC* provides multiple set of registers
  - Context switch here simply requires changing the pointer to current register set (if processes > registers, save to memory)
- OS should *masks/disables all interrupts* while saving the process state, Implementation?

CPU Control

- Most Computers has ONE CPU
- When a process is running, scheduler/dispatcher cannot run, OS May loose control
- How does the OS regain the control of CPU?

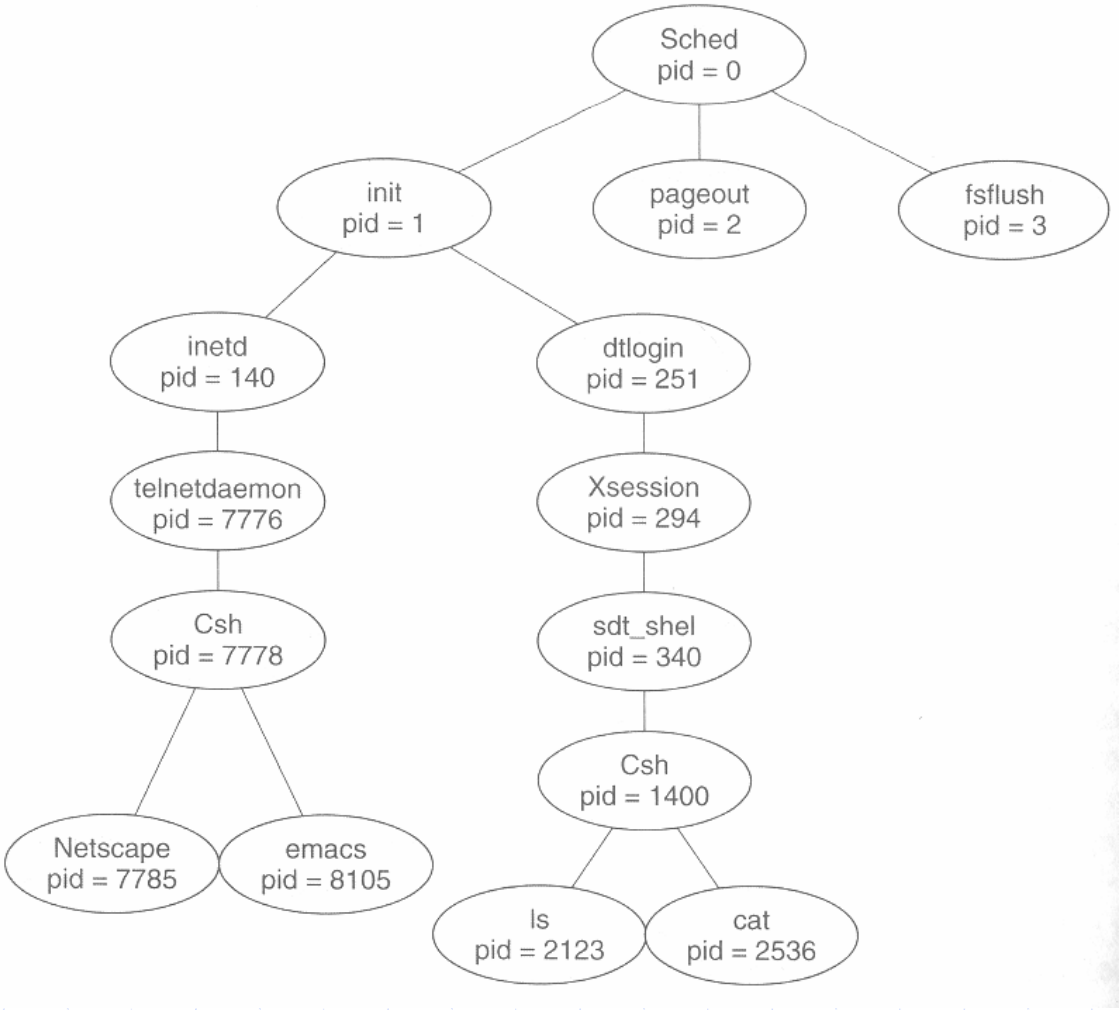
Process Memory Components



Process Creation

- Parent process → children processes → other processes; *tree of processes*
- 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 Identifier
  - Most OS (UNIX, Windows), process → unique pid
  - Unique Integer

Process Creation



Process Tree: Typical example from Solaris system

Process Creation

- 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

```
#include <unistd.h>          /* Symbolic Constants */
#include <sys/types.h>       /* Primitive System Data Types */
#include <stdio.h>           /* Input/Output */

Init main()
{
pid_t pid;       /* variable to store the child's pid */

/*  create a new process* /
pid = fork();

If (pid < 0) {/* error occurred, fork returns -1 on failure   */
        fprintf (stderr, “Fork Failed”);
        exit(-1);
}

else if {pid == 0) {/* child process, fork() returns 0 to the 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);
        }
}
```

Forking a separate process in UNIX

Process Creation

```
#include <stdio.h>
#include <windows.h>

int main(VOID)
{
STARTUPINFO si;
PROCESS_INFORMATION pi;

    // allocate memory
    ZeroMemory(&si, sizeof(si));
    si.cb = sizeof(si);
    ZeroMemory(&pi, sizeof(pi));

    // create child process
    if (!CreateProcess(NULL, // use command line
      "C:\\WINDOWS\\system32\\mspaint.exe", // command line
      NULL, // don't inherit process handle
      NULL, // don't inherit thread handle
      FALSE, // disable handle inheritance
      0, // no creation flags
      NULL, // use parent's environment block
      NULL, // use parent's existing directory
      &si,
      &pi))
    {
       fprintf(stderr, "Create Process Failed");
       return -1;
    }
    // parent will wait for the child to complete
    WaitForSingleObject(pi.hProcess, INFINITE);
    printf("Child Complete");

    // close handles
    CloseHandle(pi.hProcess);
    CloseHandle(pi.hThread);
}
```

Creating separate process using Win32 API

Process Termination

- Process terminates when it executes last statement and asks the OS 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
  - Parent is exiting
    - Operating system does not allow child to continue if its parent terminates
    - Cascading termination