CISC 7310X

C03a: Process Management

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Acknowledgement

- This slides are a revision of the slides by the authors of the textbook

Outline

- Process Concept
- Process Scheduling
- Operations on Processes
- Interprocess Communication
- IPC in Shared-Memory Systems
- IPC in Message-Passing Systems
- Examples of IPC Systems
- Communication in Client-Server Systems

Program and Executing a Program

- A program is ***passive*** entity stored on disk in the form of **executable file**
- An operating system provides means to execute a program
  - e.g., execution of program started via GUI mouse clicks, command line entry of its name

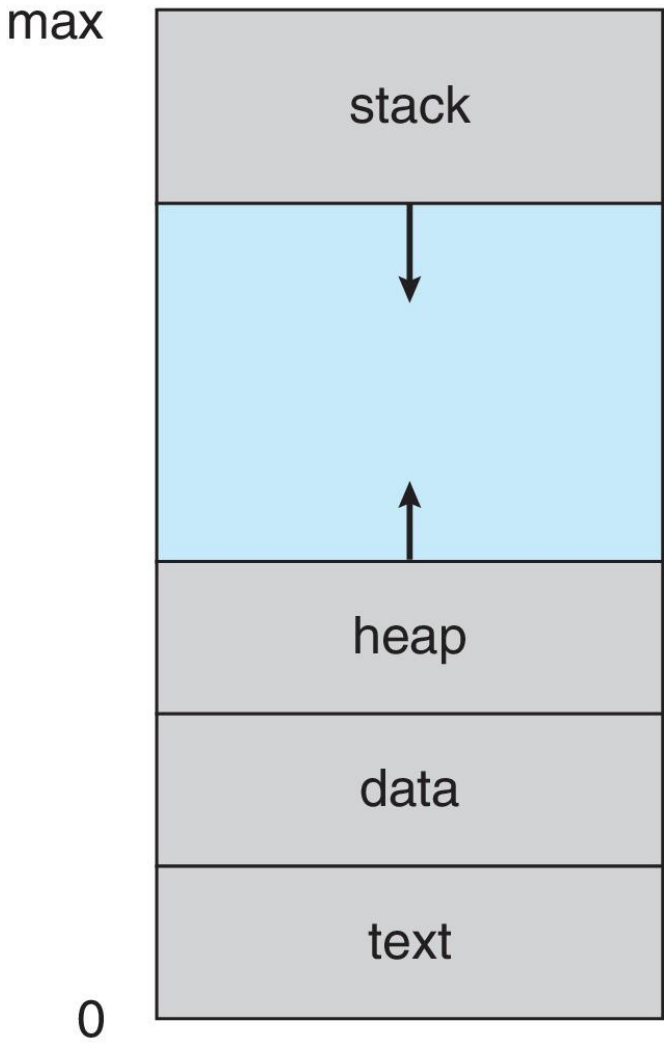
Process

- A process is a program in execution, as such, a program is a passive entity while a process is an active one
- A program becomes a process when executable file loaded into memory
- One program can be several processes
  - Consider multiple users executing the same program

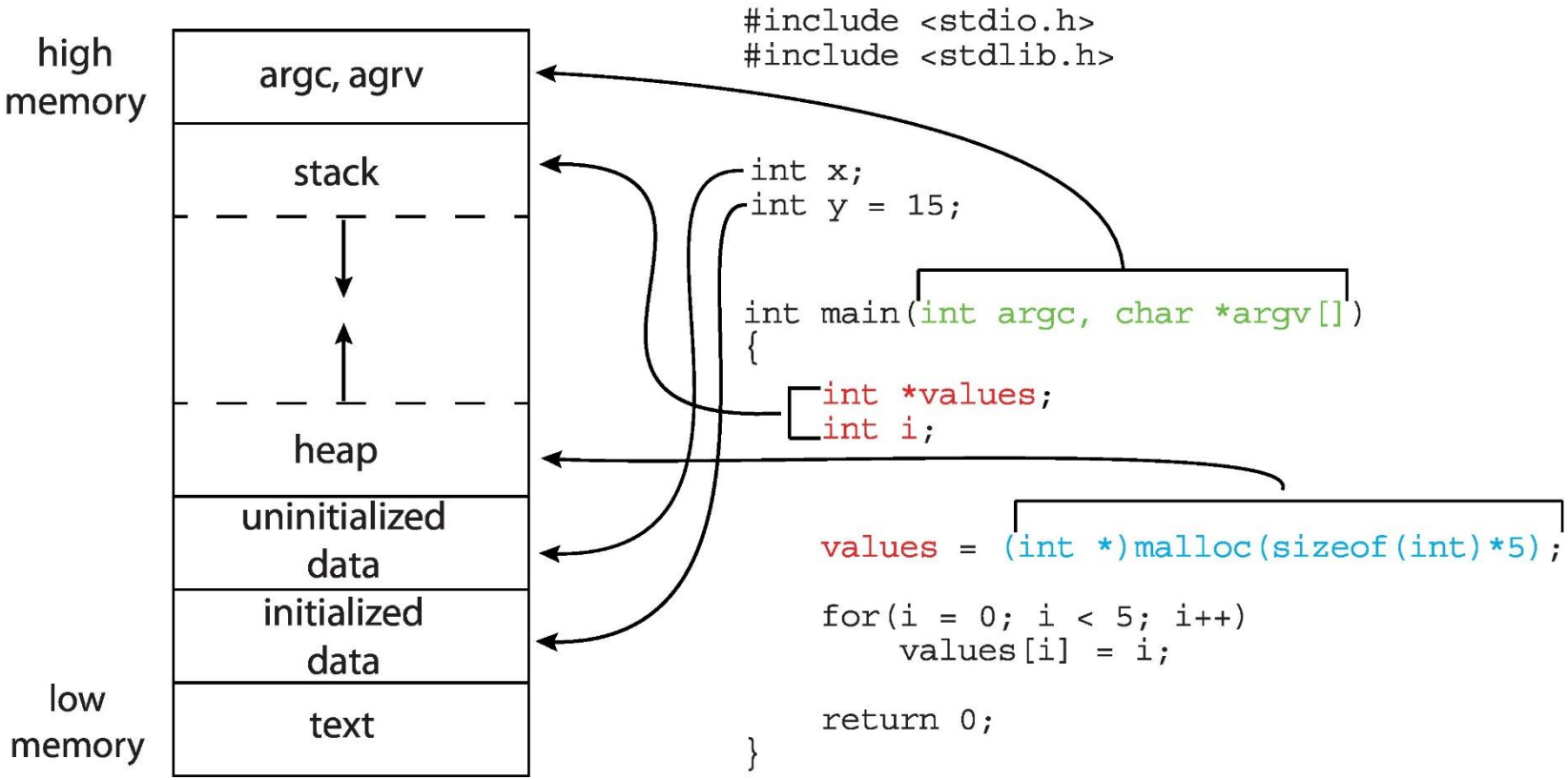
Process: Multiple Parts

- A process consists of multiple parts, generally,
  - 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 in Memory



Memory Layout of a C Program



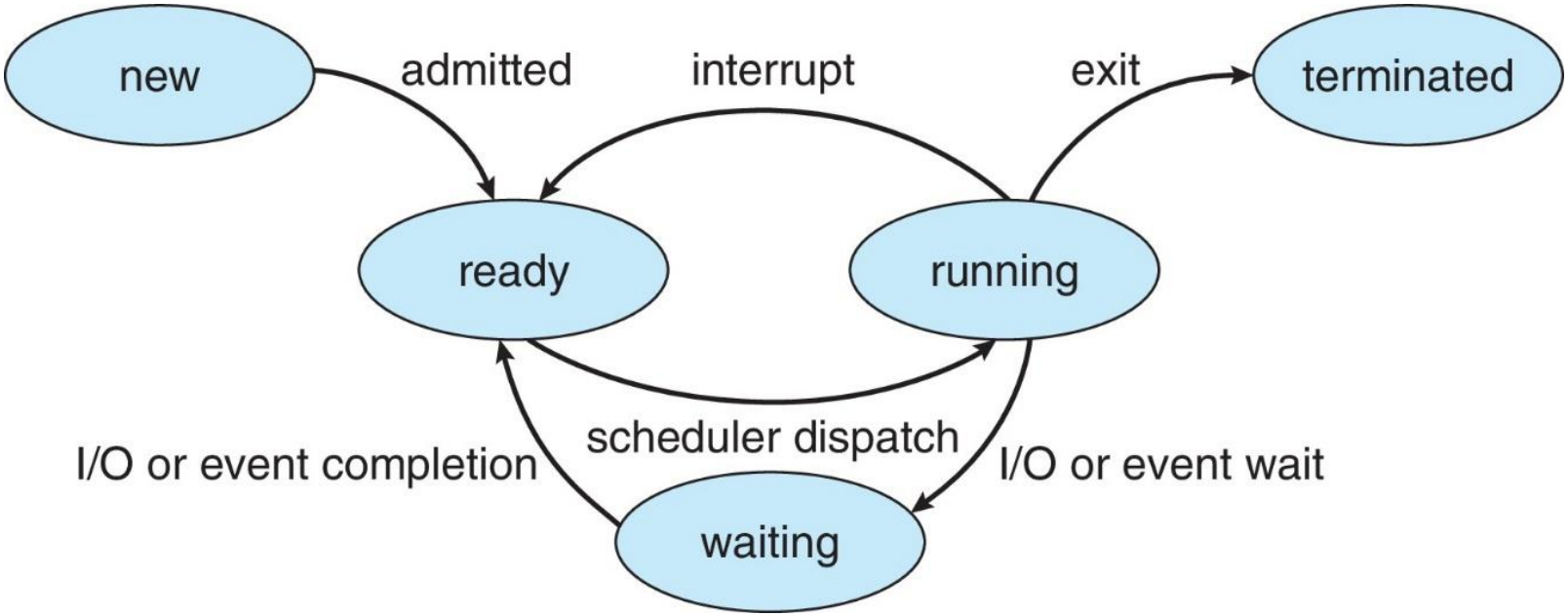
Questions?

- Concept of process
- Parts of a process
- Memory layout

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

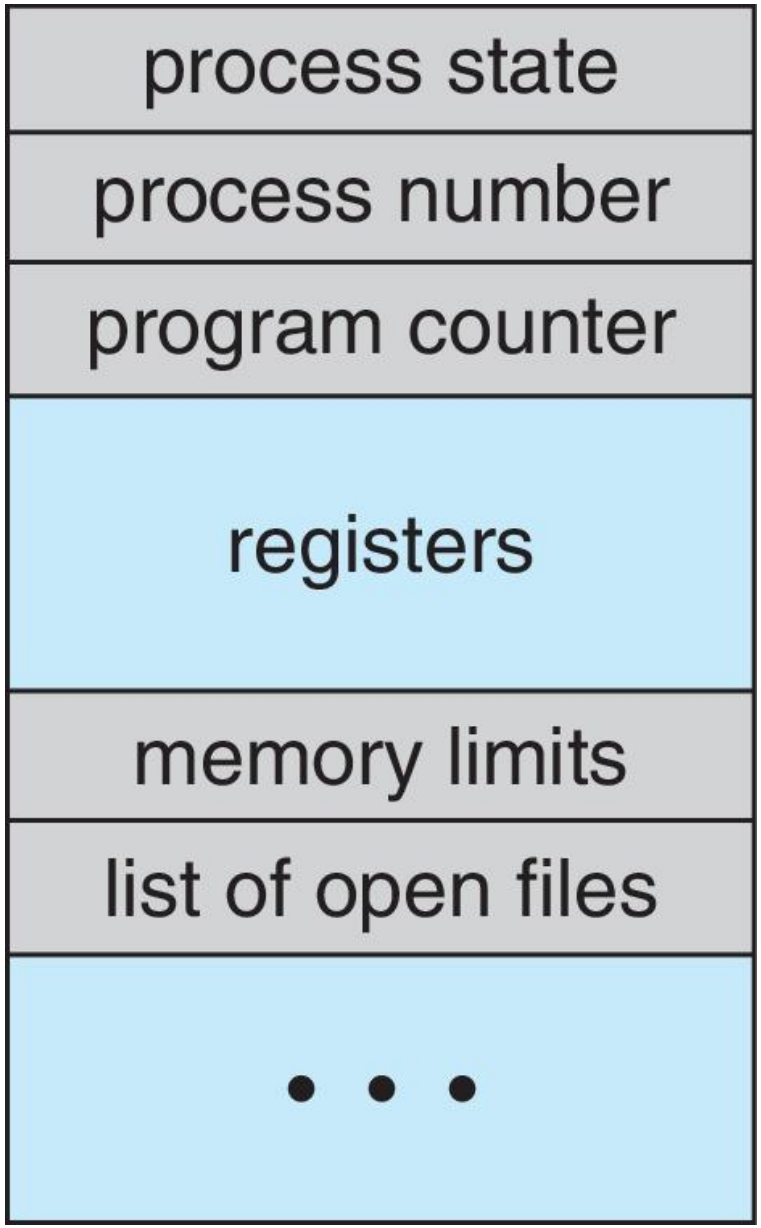
Transition of Process States



Process Control Block (PCB)

Information associated with each process (also called **task control block**)

- Process state – running, waiting, etc
- Program counter – location of instruction to next execute
- CPU registers – contents of all process-centric registers
- CPU scheduling information- priorities, scheduling queue pointers
- Memory-management information – memory allocated to the process
- Accounting information – CPU used, clock time elapsed since start, time limits
- I/O status information – I/O devices allocated to process, list of open files


process state
process number
program counter
registers
memory limits
list of open files
• • •

Threads

- So far, a process has a single thread of execution
- Consider having multiple program counters per process
  - Multiple locations can execute at once
    - Multiple threads of control -> **threads**
- Must then have storage for thread details, multiple program counters in PCB
- Explore in detail next week

Questions?

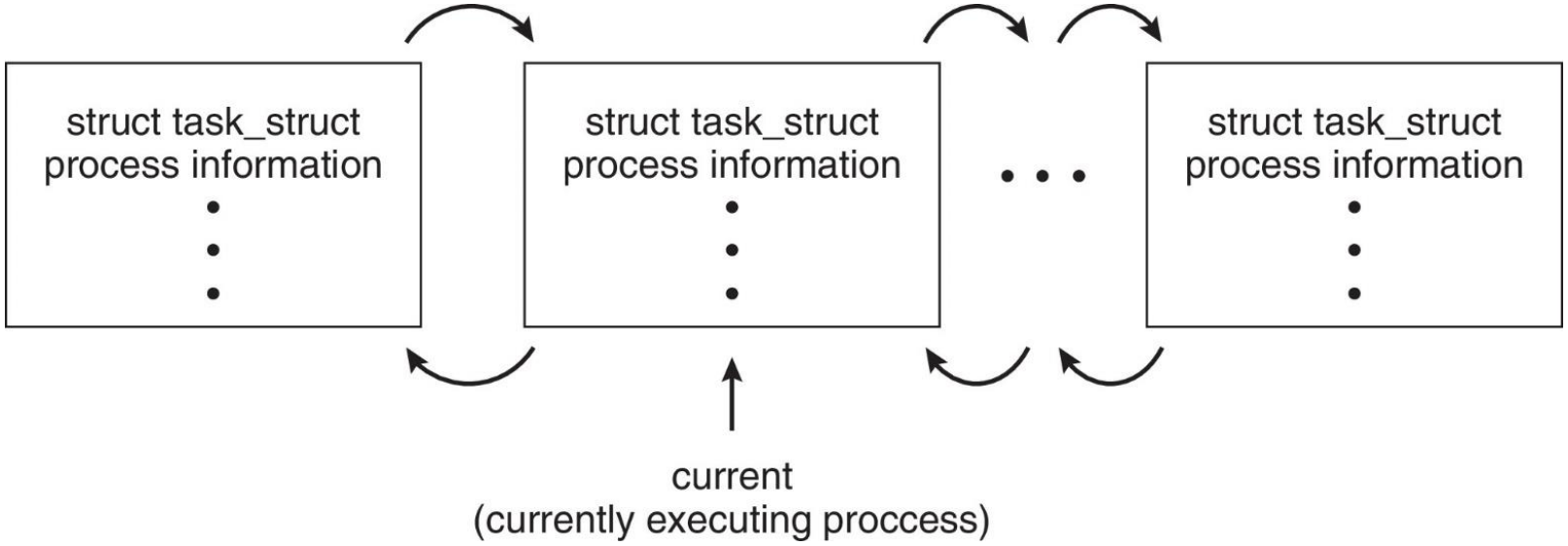
- Concept of process state
- Concept of process state transition
- Data structure for managing and representing process
- Concepts of thread of control/execution and thread.

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
*/
```

Process Representation in Linux: Task List

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```

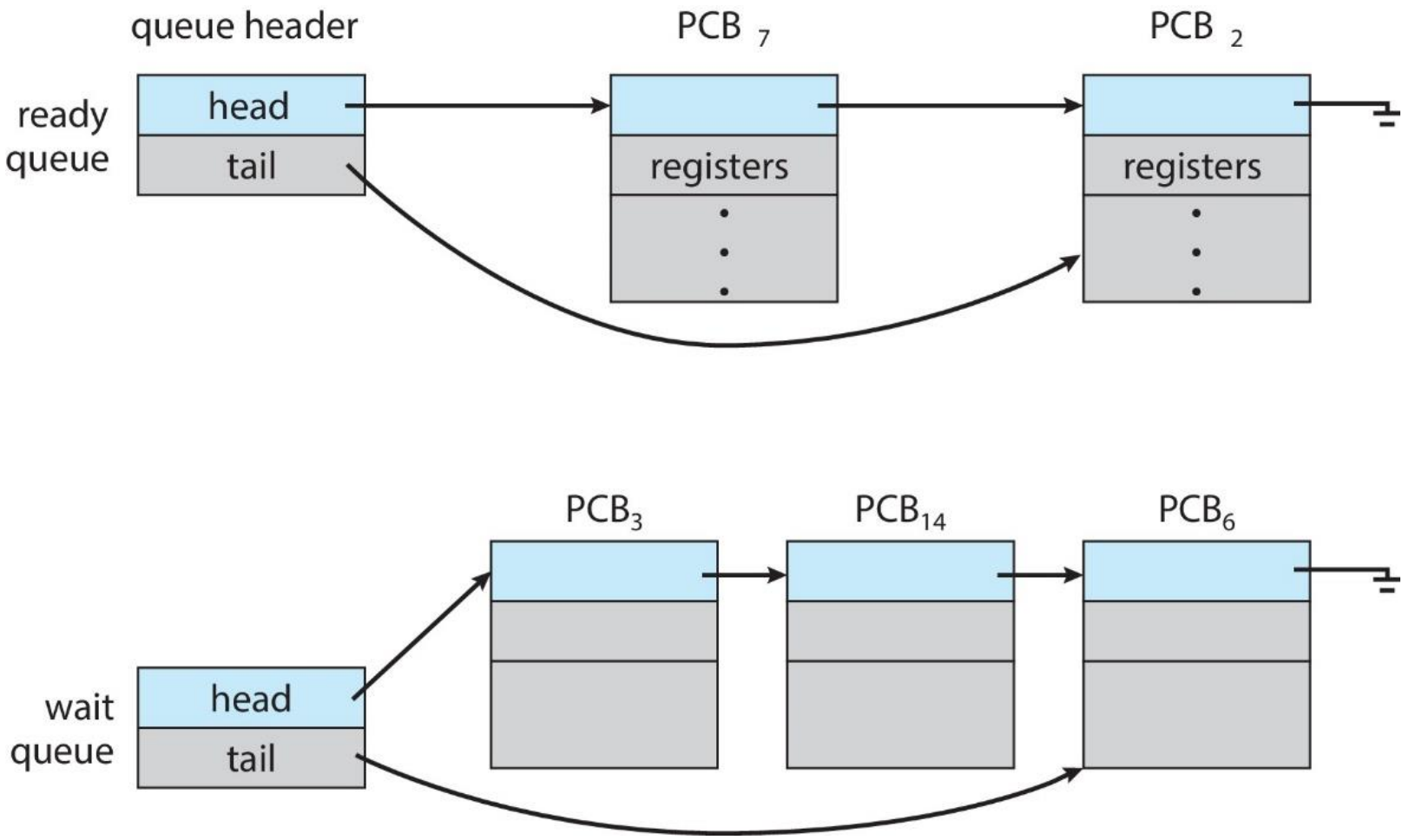
Questions?

- Process representation in Linux?

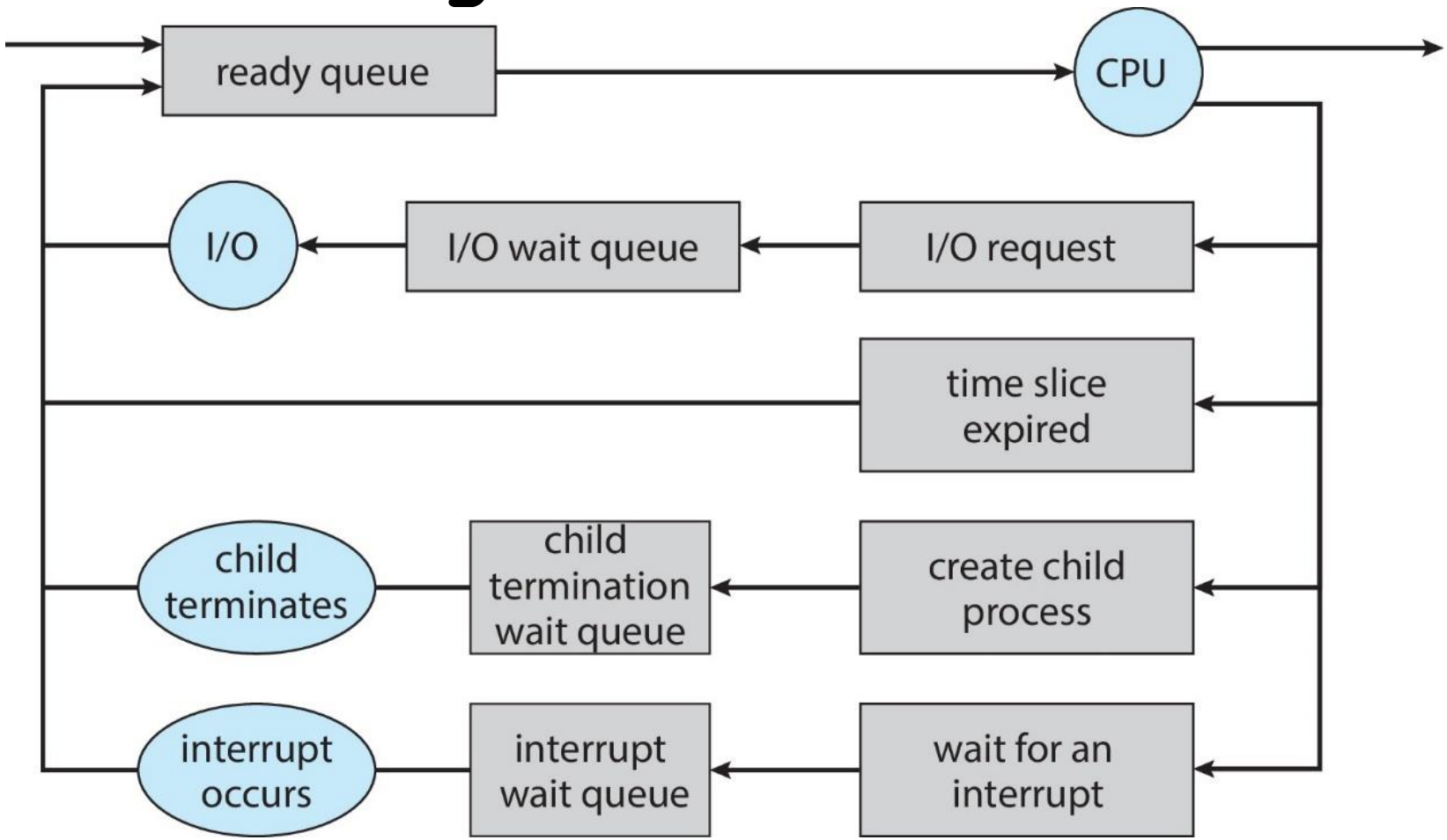
Process Scheduling

- Maximize CPU use, quickly switch processes onto CPU core
- **Process scheduler** selects among available processes for next execution on CPU core
- 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

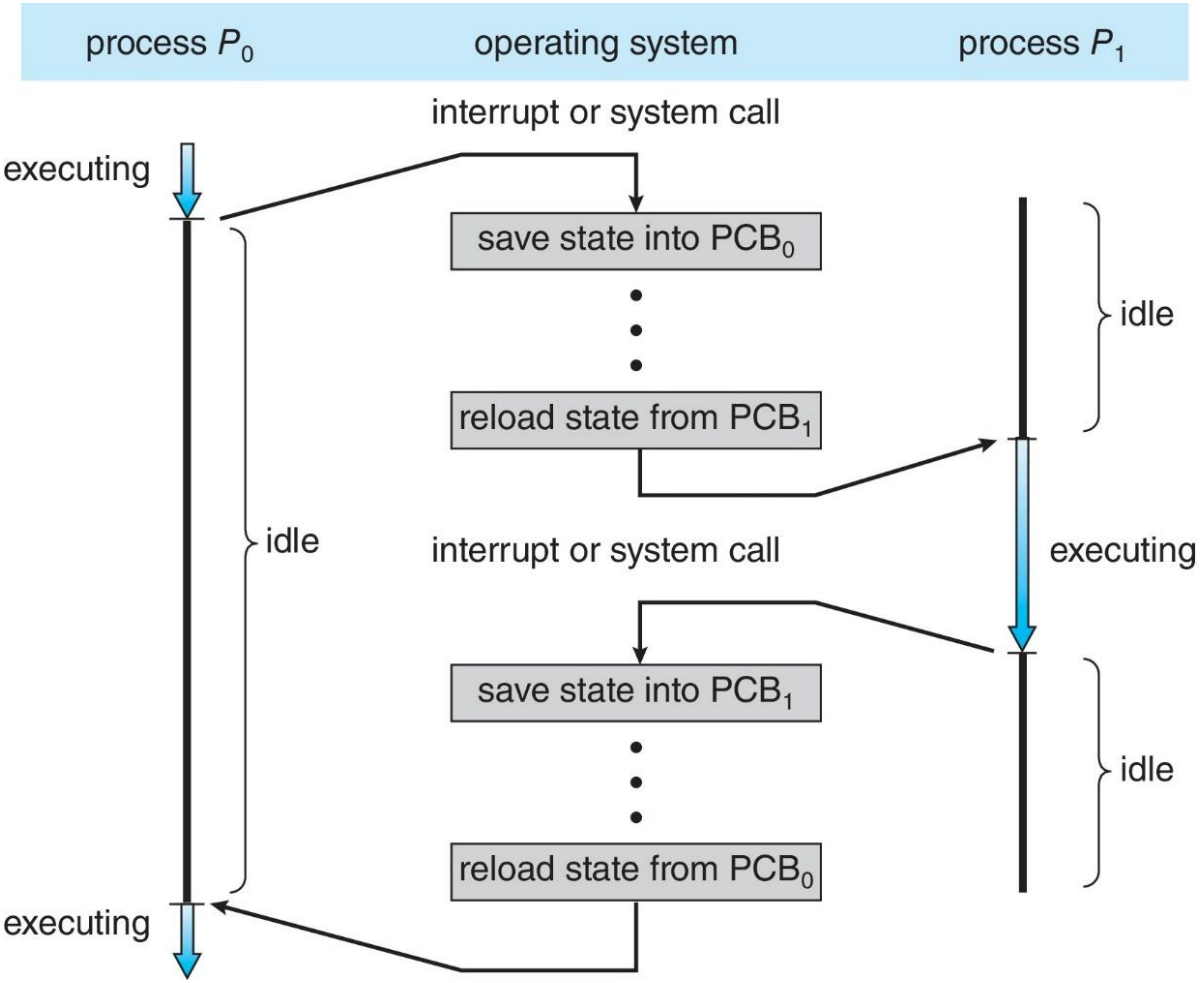
Ready and Wait Queues



Representation of Process Scheduling



CPU Switch From Process to Process



Context Switch

- A context switch occurs when the CPU switches from one process to another.

Context Switch: What must Happen?

- 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.
- **Context** of a process represented in the PCB
- Context-switch time is 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

Questions?

- Concept of process scheduling
- Concept of context switch
- When must happen during a context switch?

Multitasking in Mobile Systems

- Some mobile systems (e.g., early version of iOS) allow only one process to run, others suspended
- Due to screen real estate, user interface limits iOS provides for a
  - Single **foreground** process- controlled via user interface
  - Multiple **background** processes– in memory, running, but not on the display, and with limits
  - Limits include single, short task, receiving notification of events, specific long-running tasks like audio playback
- Android runs foreground and background, with fewer limits
  - Background process uses a **service** to perform tasks
  - Service can keep running even if background process is suspended
  - Service has no user interface, small memory use

Questions?

- Multitasking in mobile systems?
- Why?

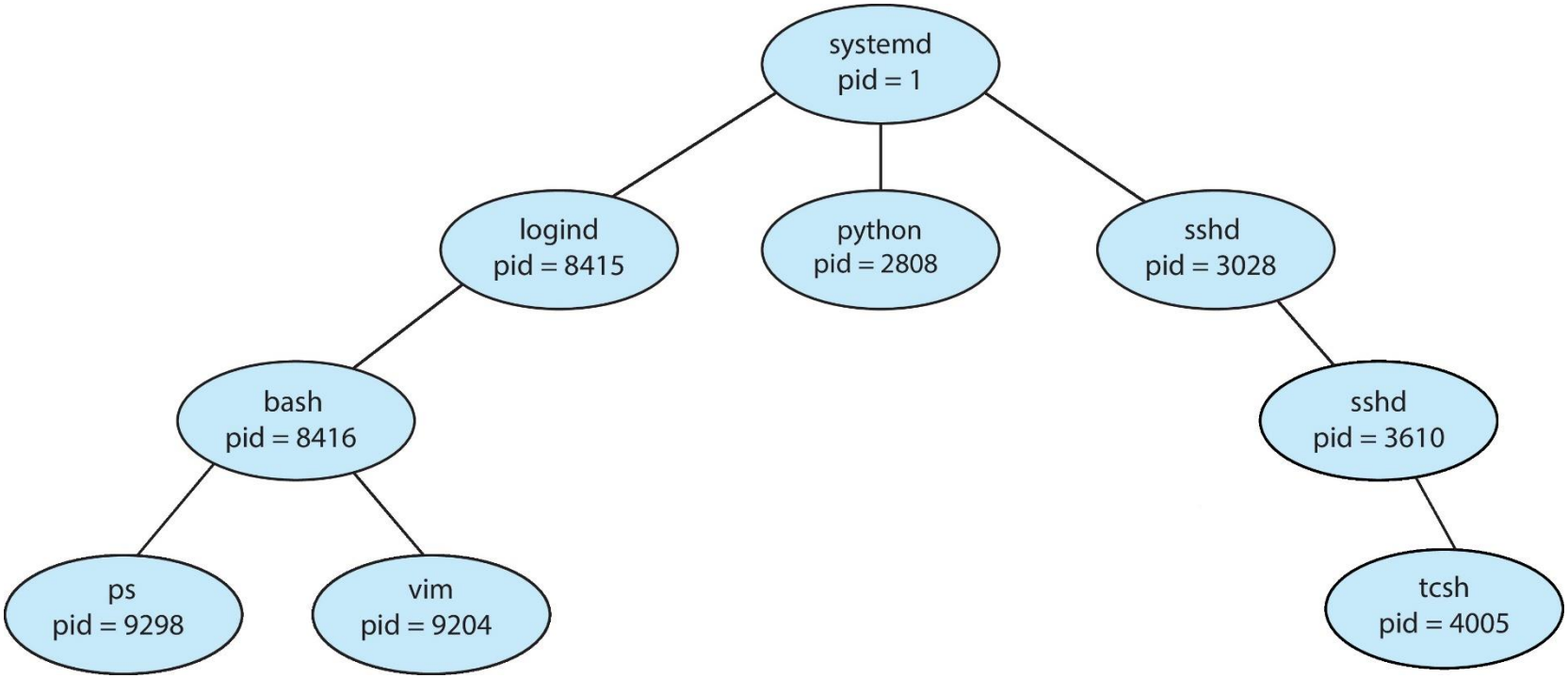
Operations on Processes

- System must provide mechanisms for:
  - process creation
  - process termination

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 options
  - Parent and children share all resources
  - Children share subset of parent's resources
  - Parent and child share no resources
- Execution options
  - Parent and children execute concurrently
  - Parent waits until children terminate

A Tree of Processes in Linux



Process Creation: Design Consideration

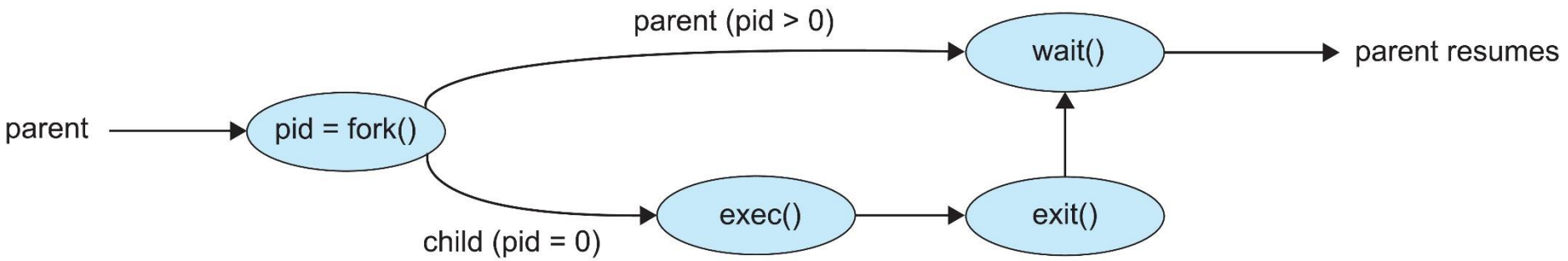
- Physical and logical resources
  - CPU time, memory, files, I/O devices
  - Child obtains from the OS
  - Child is constrained to a subset of the parent process's resources
- Program data
  - Parent process may pass initialization data to child process
- Address space
  - Child duplicate of parent
  - Child has a program loaded into it

Process Creation in UNIX

- **`fork()`** system call creates new process
- **`exec()`** system call used after a **`fork()`** to replace the process' memory space with a new program
- Parent process calls **`wait()`** for the child to terminate

Example Application in Linux

- See the example program



Example Application in Windows

- See the example program

Questions?

- Process creation
- Using system calls to create processes

Process Termination

- Processes executes last statement (normal process termination)
- Parent terminates child process (abort the child process)

Normal Process Termination

- Process executes last statement and then asks the operating system to delete it
  - e.g., in UNIX, using the **`exit()`** system call.
  - Returns status data from child to parent (e.g., via **`wait()` in UNIX**)
  - Process' resources are deallocated by operating system

Abort Child Process

- Parent may terminate the execution of children processes.
  - e.g., using the **`abort()`** system call
  - Some reasons for doing so:
    - Child has exceeded allocated resources
    - Task assigned to child is no longer required
    - The parent is exiting and the operating systems does not allow a child to continue if its parent terminates

Terminate Children or Wait for Children?

- Allow child process to exist without the existence of the parent?
- Allow parent to wait for child to complete?

Terminate All Children

- Some operating systems do not allow child to exists if its parent has terminated.
- If a process terminates, then all its children must also be terminated.
  - **cascading termination.** All children, grandchildren, etc. are terminated.
  - The termination is initiated by the operating system.

Wait for Children

- The parent process may wait for termination of a child process
  - e.g., in UNIX, by using the **`wait()`** system call. The call returns status information and the pid of the terminated process

```
pid = wait(&status);
```

Zombie Process

- A process that has terminated, but whose parent has not yet called wait(), is known as a zombie process.
- All processes transition to this state when they terminate, but generally they exist as zombies only briefly.
- Once the parent calls wait(), the process identifier of the zombie process and its entry in the process table are released.

Orphan Process

- A parent did not invoke wait() and instead terminated, thereby leaving its child processes as orphans.
- In UNIX, assign new parent (initd/systemd)

Questions?

- Process termination?
- Process termination in UNIX?
- Zombie?
- Orphan?

Mobile Systems: Design Consideration

- Mobile operating systems often have to terminate processes to reclaim system resources such as memory.

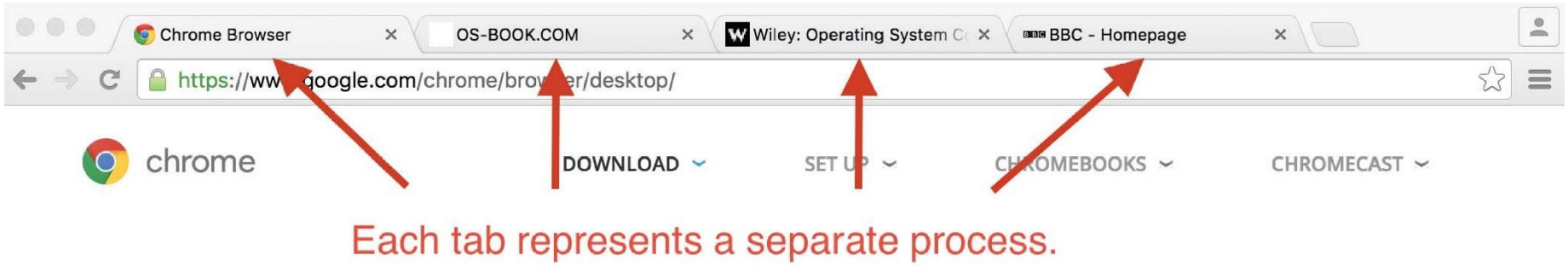
Android Process Importance Hierarchy

- In Android, process are ranked from most to least important:
  - Foreground process
  - Visible process
  - Service process
  - Background process
  - Empty process
- Android will begin terminating processes that are least important.

Multiprocess Architecture in Chrome Browser

- Some Web browsers ran as single process
  - If one web site causes trouble, entire browser can hang or crash
- Google Chrome Browser is multiprocess with 3 different types of processes:
  - **Browser** process manages user interface, disk and network I/O
  - **Renderer** process renders web pages, deals with HTML, Javascript. A new renderer created for each website opened
    - Runs in **sandbox** restricting disk and network I/O, minimizing effect of security exploits
  - **Plug-in** process for each type of plug-in

New Renderer Created for Each Website Opened



Questions?

- Some design consideration for Android?
- Some design consideration for Web browsers