Process

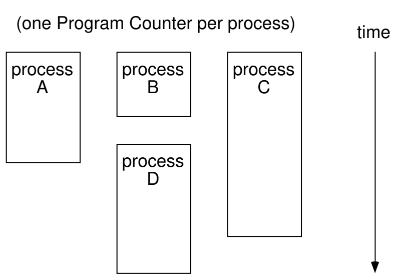
- A *process* (sometimes called a *task,* or a *job*) is, informally, a program in execution
- “Process” is not the same as “program”
  - We distinguish between a passive program stored on disk, and an actively executing process
    - Multiple people can run the same program; each running copy corresponds to a distinct process
  - The program is only part of a process; the process also contains the execution state
- List processes (HP UNIX):
  - ps — my processes, little detail
  - ps -fl — my processes, more detail
  - ps -efl — all processes, more detail
- Note user processes and OS processes

Process Creation / Termination

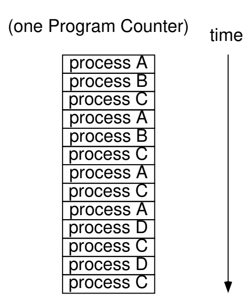
- Reasons for process creation
  - User logs on
  - User starts a program
  - OS creates process to provide a service (e.g., printer daemon to manage printer)
  - Program starts another process (e.g., netscape calls xv to display a picture)
- Reasons for process termination
  - Normal completion
  - Arithmetic error, or data misuse (e.g., wrong type)
  - Invalid instruction execution
  - Insufficient memory available, or memory bounds violation
  - Resource protection error
  - I/O failure

Process Execution

- Conceptual model of 4 processes executing:

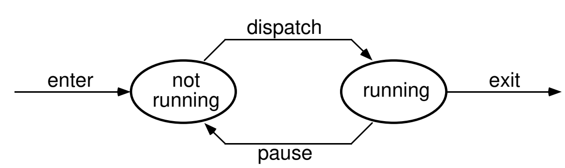


- Actual interleaved execution of the 4 processes:

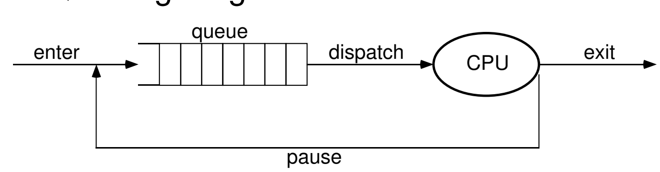


A Two-State Process Model

- This process model says that either a process is *running*, or it is *not running*
- State transition diagram:



- Queuing diagram:



- CPU scheduling (round-robin)
  - Queue is first-in, first-out (FIFO) list
  - CPU scheduler takes process at head of queue, runs it on CPU for one time slice, then puts it back at tail of queue

Process Transitions in the Two-State Process Model

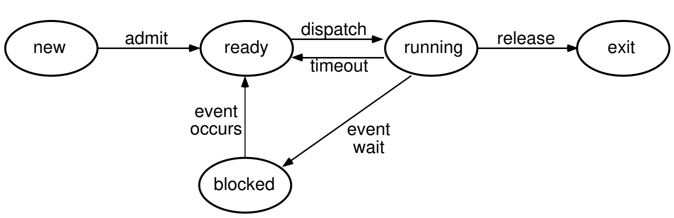
- When the OS creates a new process, it is initially placed in the **not-running** state
  - It's waiting for an opportunity to execute
- At the end of each time slice, the *CPU scheduler* selects a new process to run
  - The previously running process is *paused* — moved from the **running** state into the **not-running** state (at tail of queue)
  - The new process (at head of queue) is *dispatched* — moved from the **not-running** state into the **running** state
    - If the running process completes its execution, it exits, and the CPU scheduler is invoked again
    - If it doesn't complete, but its time is up, it gets moved into the **not-running** state anyway, and the CPU scheduler chooses a new process to execute

Waiting on Something to Happen…

- Some reasons why a process that might otherwise be running needs to wait:
  - Wait for user to type the next key
  - Wait for output to appear on the screen
  - Program tried to read a file — wait while OS decides which disk blocks to read, and then actually reads the requested information into memory
  - Netscape tries to follow a link (URL) — wait while OS determines address, requests data, reads packets, displays requested web page
- OS must distinguish between:
  - Processes that are ready to run and are waiting their turn for another time slice
  - Processes that are waiting for something to happen (OS operation, hardware event, etc.)

A Five-State Process Model

- The *not-running* state in the two-state model has now been split into a *ready* state and a *blocked* state
  - *Running* — currently being executed
  - *Ready* — prepared to execute
  - *Blocked* — waiting for some event to occur (for an I/O operation to complete, or a resource to become available, etc.)
  - *New* — just been created
  - *Exit* — just been terminated
- State transition diagram:



State Transitions in Five-State Process Model

- new → ready
  - Admitted to ready queue; can now be considered by CPU scheduler
- ready → running
  - CPU scheduler chooses that process to execute next, according to some scheduling algorithm
- running → ready
  - Process has used up its current time slice
- running → blocked
  - Process is waiting for some event to occur (for I/O operation to complete, etc.)
- blocked → ready
  - Whatever event the process was waiting on has occurred

Process State

- The *process state* consists of (at least):
  - Code for the program
  - Program's static and dynamic data
  - Program's procedure call stack
  - Contents of general purpose registers
  - Contents of Program Counter (PC) —address of next instruction to be executed
  - Contents of Stack Pointer (SP)
  - Contents of Program Status Word (PSW) — interrupt status, condition codes, etc.
  - OS resources in use (e.g., memory, open files, connections to other programs)
  - Accounting information

↪ Everything necessary to resume the process' execution if it is somehow put aside temporarily

Process Control Block (PCB)

- For every process, the OS maintains a *Process Control Block* (*PCB*), a data structure that represents the process and its state:
  - Process id number
  - Userid of owner
  - Memory space (static, dynamic)
  - Program Counter, Stack Pointer, general purpose registers
  - Process state (running, not-running, etc.)
  - CPU scheduling information (e.g., priority)
  - List of open files
  - I/O states, I/O in progress
  - Pointers into CPU scheduler's state queues (e.g., the waiting queue)
  - …