

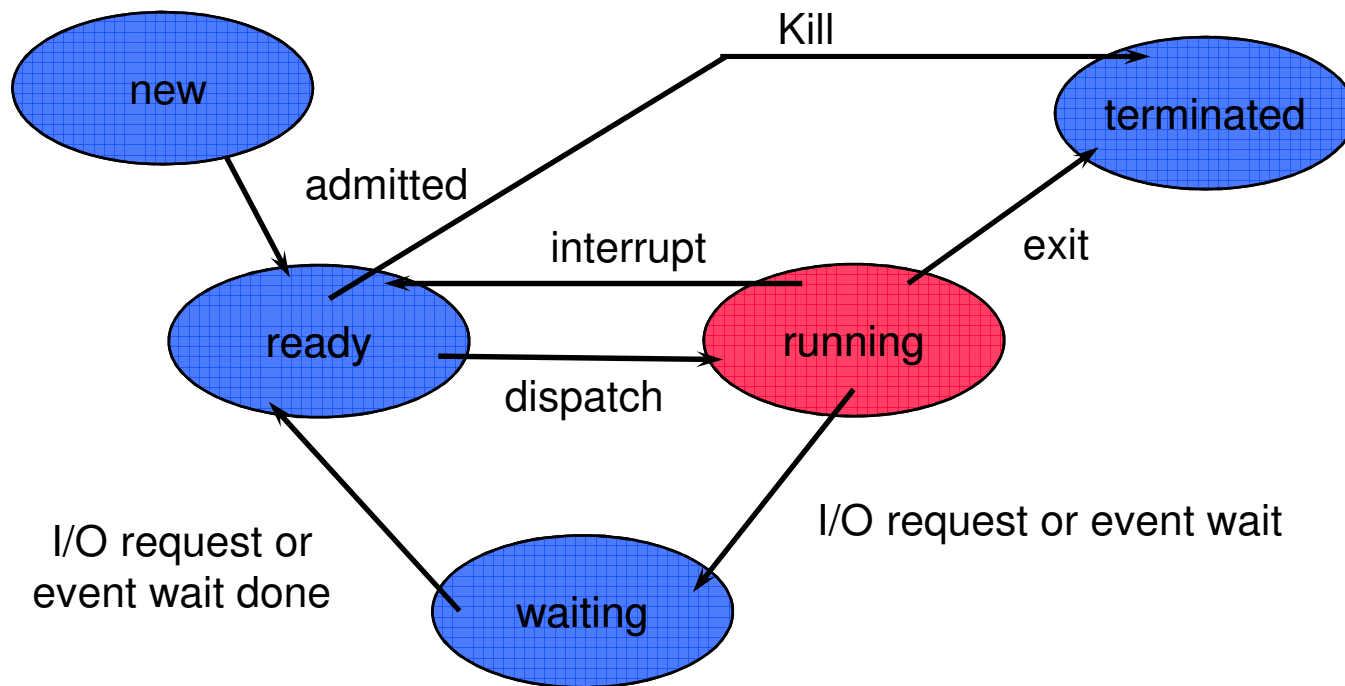
Announcements

- Program #0
 - Due on Friday
 - Limit should return 0 when called with correct parameters
 - Calling limit resets the counter, so a Limit(0,4) will be killed on the 5th system call after Limit.
- Reading
 - Today: Processes - Chapter 3 (ch 4, 6th Ed)
 - Thursday: Threads - Chapter 4 (ch 5, 6th Ed)

Multi-programming

- **Systems that permit more than one process at once**
 - virtually all computers today
- **Permits more efficient use of resources**
 - while one process is waiting another can run
- **Provides natural abstraction of different activities**
 - windowing system
 - editor
 - mail daemon
- **Preemptive vs. non-preemptive multi-programming**
 - preemptive means that a process can be forced off the processor by the OS
 - provides processor protection

Process State Transitions



Components of a Process

- **Memory Segments**

- Program - often called the text segment
- Data - global variables
- Stack - contains activation records

- **Processor Registers**

- program counter - next instruction to execute
- general purpose CPU registers
- processor status word
 - results of compare operations
- floating point registers

Process Control Block

- Stores all of the information about a process
- PCB contains
 - process state: new, ready, etc.
 - processor registers
 - Memory Management Information
 - page tables, and limit registers for segments
 - CPU scheduling information
 - process priority
 - pointers to process queues
 - Accounting information
 - time used (and limits)
 - files used
 - program owner
 - I/O status information
 - list of open files
 - pending I/O operations

Storing PCBs

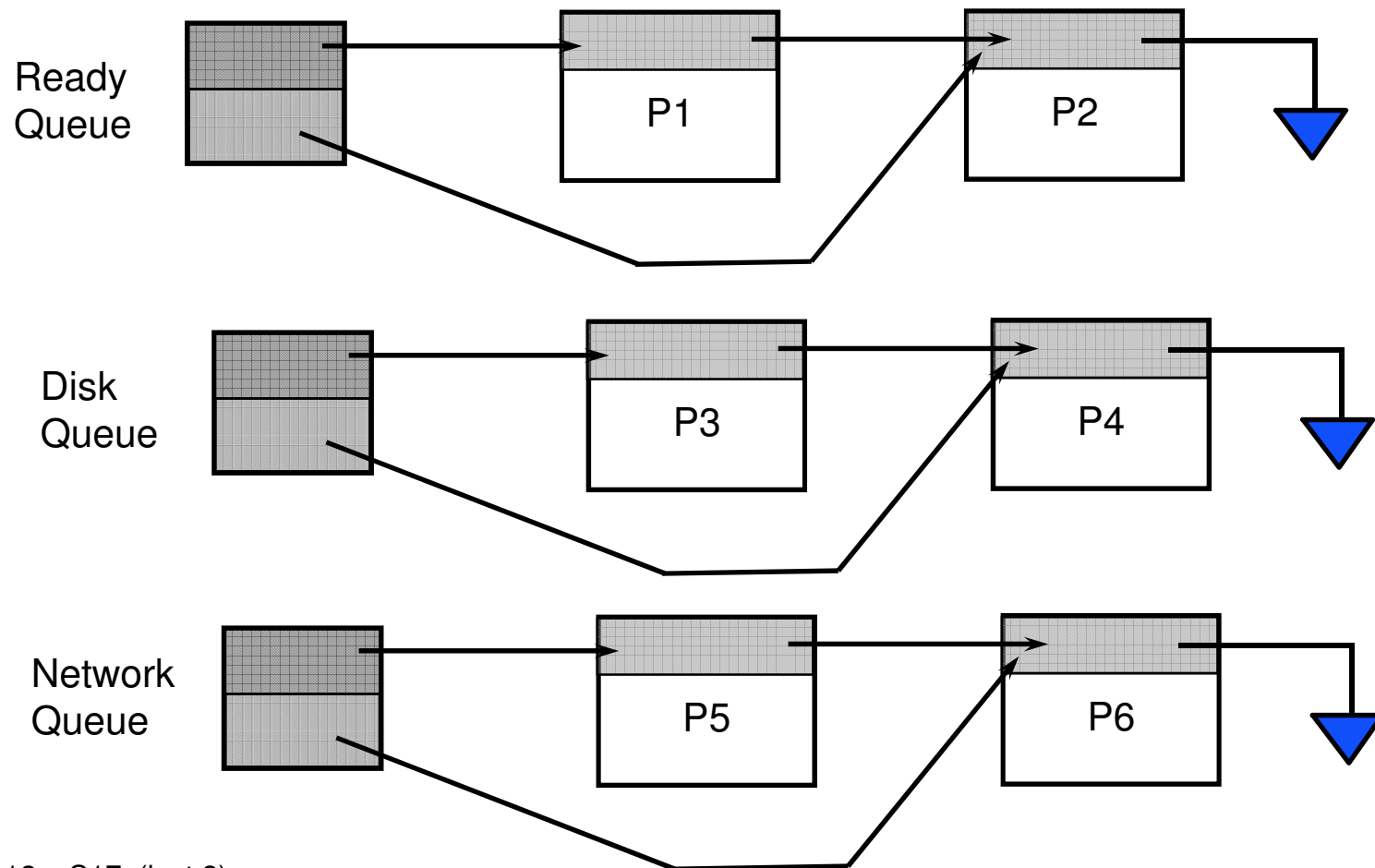
- Need to keep track of the different processes in the system
- Collection of PCBs is called a process table
- How to store the process table?
- First Option:

P1	P2	P2	P3	P4	P5
Ready	Waiting	New	Term	Waiting	Ready

- Problems with Option 1:
 - hard to find processes
 - how to fairly select a process

Queues of Processes

- Store processes in queues based on state



forking a new process

- create a PCB for the new process
 - copy most entries from the parent
 - clear accounting fields
 - buffered pending I/O
 - allocate a pid (process id for the new process)
- allocate memory for it
 - could require copying all of the parents segments
 - however, text segment usually doesn't change so that could be shared
 - might be able to use memory mapping hardware to help
 - will talk more about this in the memory management part of the class
- add it to the ready queue

Variations on Creating a Process

- **Fork()** [often used with exec too]
 - Create a new process with new address space
 - Parent address space copied into child
 - Child resumes at return of fork
- **Spawn(program)**
 - Create a new process with a new address space
 - Child starting running the passed program
 - Parent returns from spawn and continues executionn
- **Clone(func, stack)**
 - Creates a new process that **shares** parents address space
 - Child starts running func using the passed stack for locals
 - Parent returns from clone and continues execution

Process Termination

- Process can terminate self
 - via the exit system call
- One process can terminate another process
 - use the kill system call
 - can any process kill any other process?
 - No, that would be bad.
 - Normally an ancestor can terminate a descendant
- OS kernel can terminate a process
 - exceeds resource limits
 - tries to perform an illegal operation
- What if a parent terminates before the child
 - called an orphan process
 - in UNIX becomes child of the root process
 - in VMS - causes all descendants to be killed

Termination (cont.) - UNIX example

- Kernel

- frees memory used by the process
- moved process control block to the terminated queue

- Terminated process

- signals parent of its death (SIGCHLD)
- is called a zombie in UNIX
- remains around waiting to be reclaimed

- parent process

- wait system call retrieves info about the dead process
 - exit status
 - accounting information
- signal handler is generally called the reaper
 - since its job is to collect the dead processes