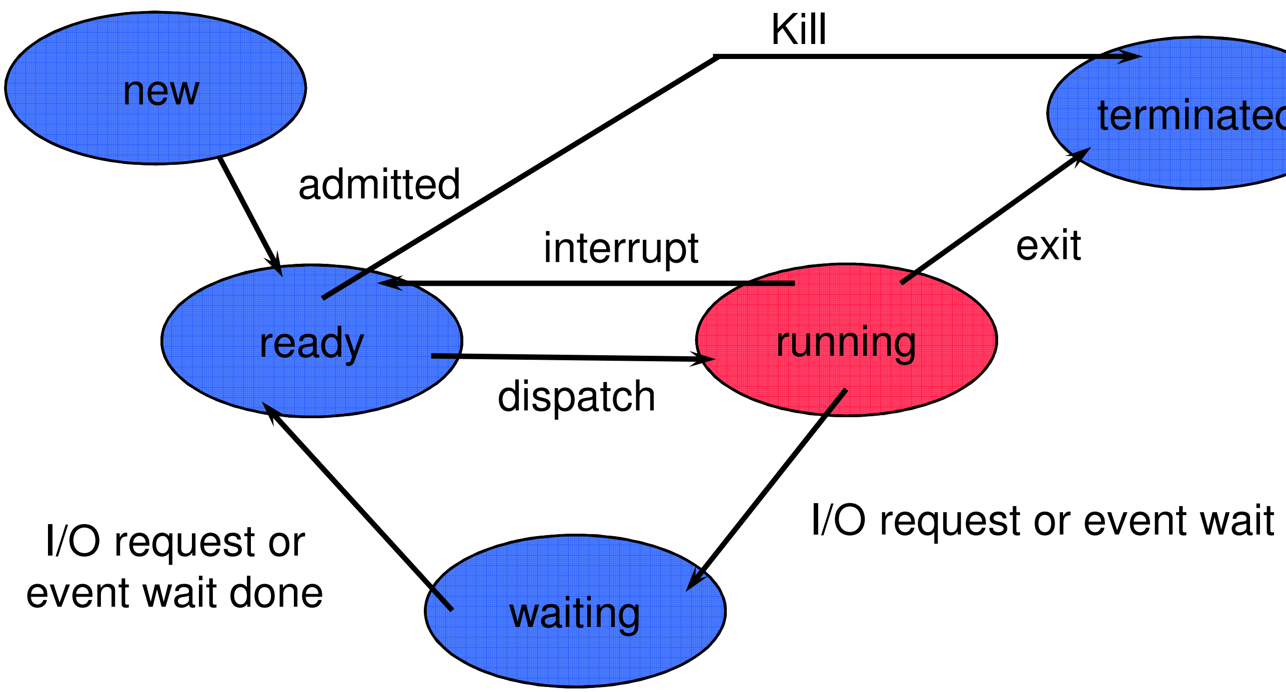
Announcements

- Program #1
  - Due February 16th
- Reading
  - Threads - Chapter 4 (ch 5, 6th Ed)

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

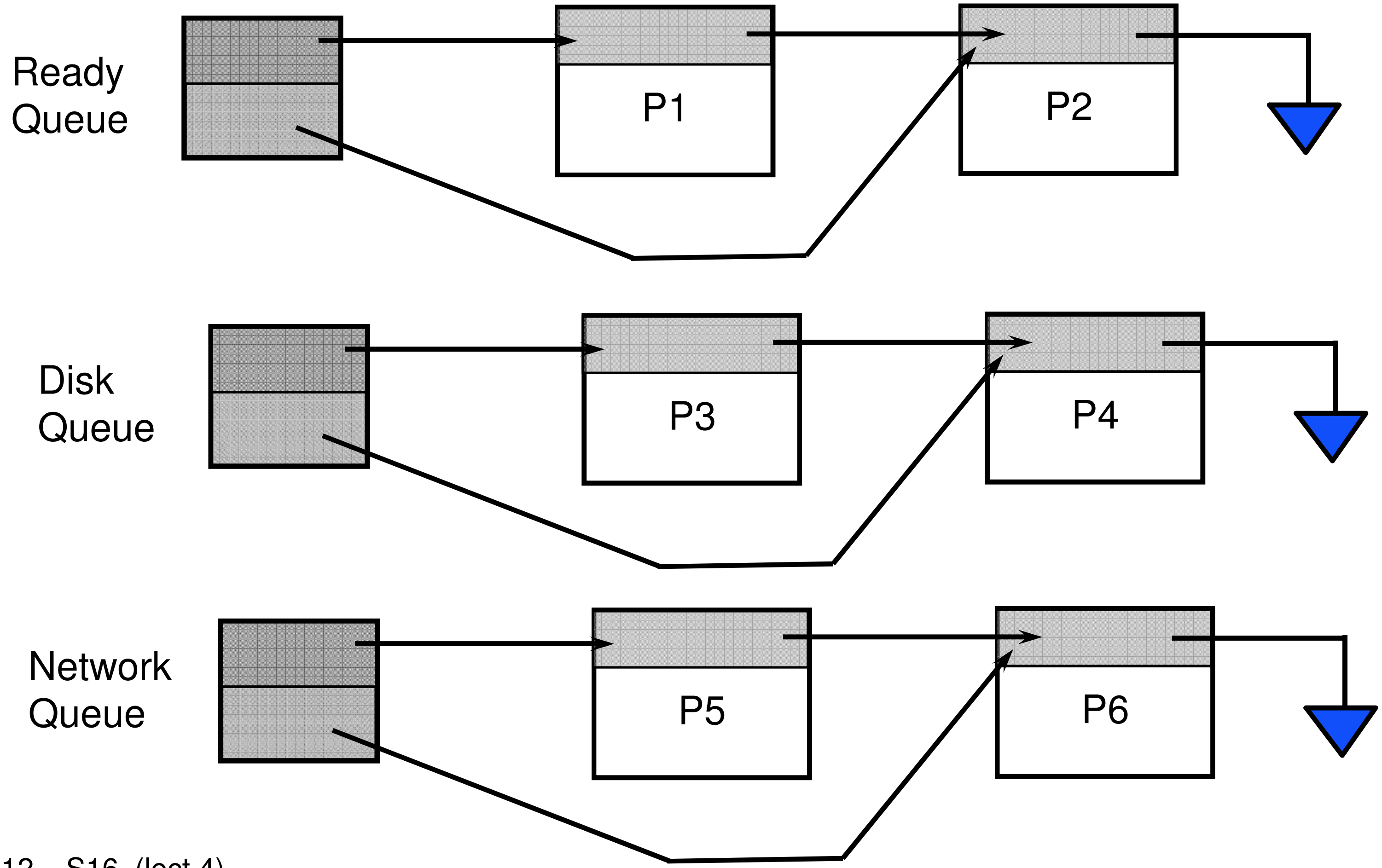
- Need to keep track of the different processes in the system
- Collection of PCBs is called a process table
- How to store the process table?
- First Option:

P1 Ready	P2 Waiting	P2 New	P3 Term	P4 Waiting	P5 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

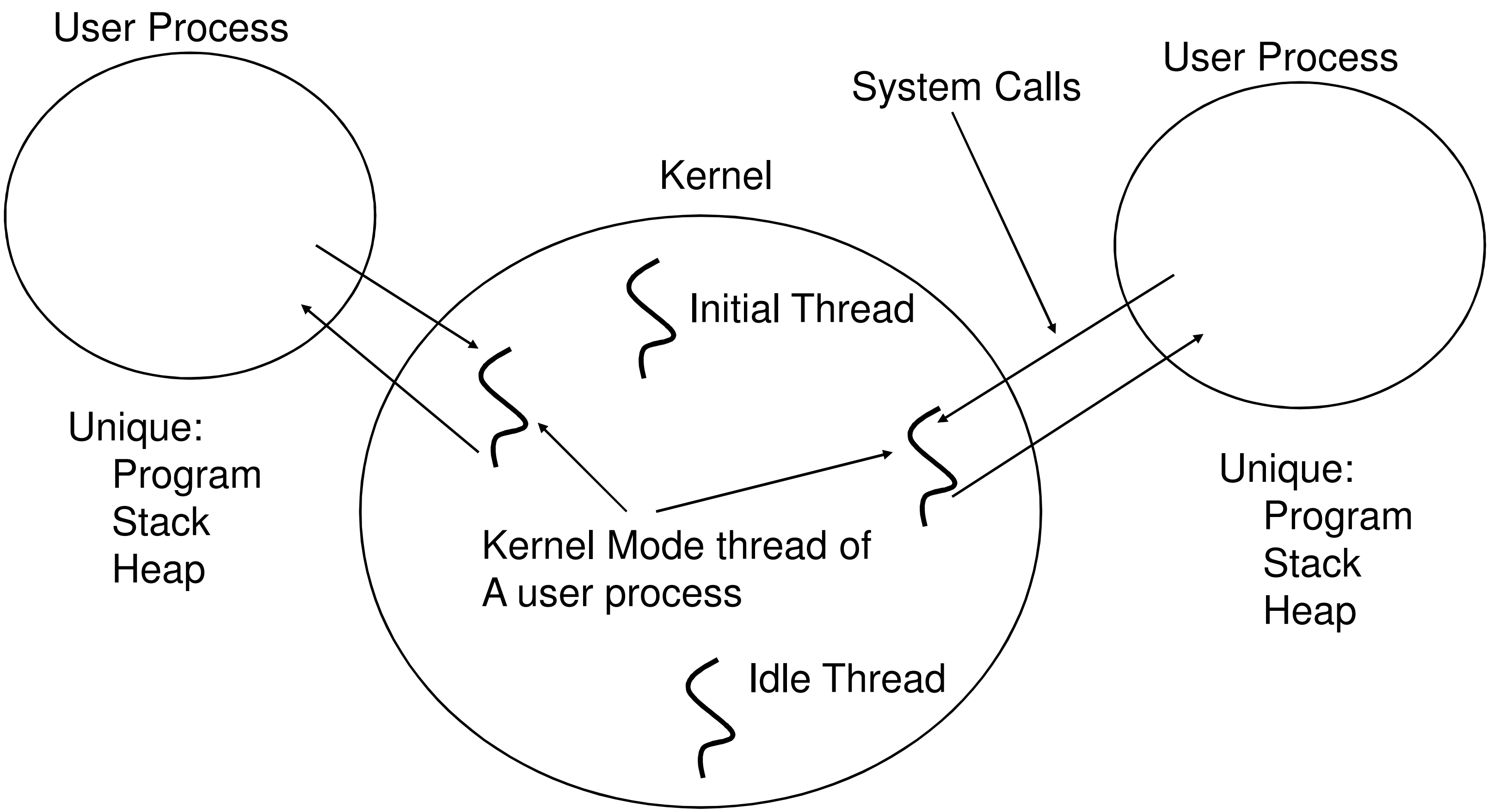
Process Termination

- 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 (SIGCHILD)
  - 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

Relationship between Kernel mod and User Mode



User Process

System Calls

User Process

Kernel

Initial Thread

Unique:
    Program
    Stack
    Heap

Kernel Mode thread of
A user process

Unique:
    Program
    Stack
    Heap

Idle Thread

Kernel Threads:

- Each has own stack (separate from user mode)
- Share heap with other kernel threads
- Run same program (kernel) as other kernel threads

Threads

- processes can be a heavy (expensive) object
- threads are like processes but generally a collection of threads will share
  - memory (except stack)
  - open files (and buffered data)
  - signals
- can be user or system level
  - user level: kernel sees one process
    - + easy to implement by users
    - - I/O management is difficult
    - - in an multi-processor can't get parallelism
  - system level: kernel schedules threads

Important Terms

- Threads
  - An execution context sharing an address space
- Kernel Threads
  - Threads running with kernel privileges
- User Threads
  - Threads running in user space
- Processes
  - An execution context with an address space
  - Visible to and scheduled by the kernel
- Light-Weight Processes
  - An execution context sharing an address space
  - Visible to and scheduled by the kernel