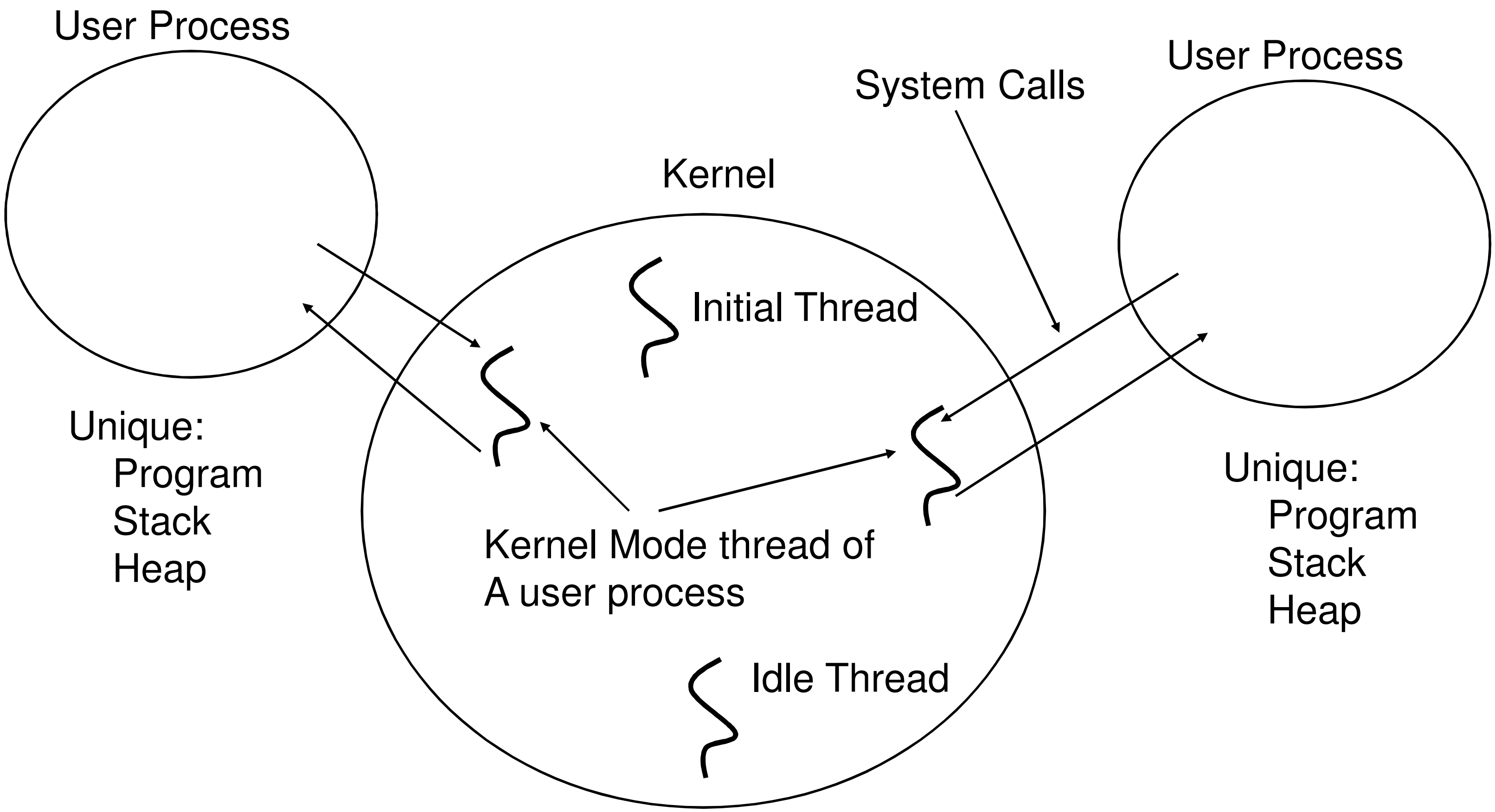
Announcements

- Reading
  - Project #1 – due in 1 week at 5:00 pm
  - Scheduling
    - Chapter 6 (6^{th} ed) or Chapter 5 (8^{th} ed)

Relationship between Kernel mod and User Mode



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

Dispatcher

- The inner most part of the OS that runs processes
- Responsible for:
  - saving state into PCB when switching to a new process
  - selecting a process to run (from the ready queue)
  - loading state of another process
- Sometimes called the short term scheduler
  - but does more than schedule
- Switching between processes is called context switching
- One of the most time critical parts of the OS
- Almost never can be written completely in a high level language

Selecting a process to run

- called scheduling
- can simply pick the first item in the queue
  - called round-robin scheduling
  - is round-robin scheduling fair?
- can use more complex schemes
  - we will study these in the future
- use alarm interrupts to switch between processes
  - when time is up, a process is put back on the end of the ready queue
  - frequency of these interrupts is an important parameter
    - typically 10-100ms on systems today
      - Time has been getting longer over past 30 years
  - need to balance overhead of switching vs. responsiveness

CPU Scheduling

- Manage CPU to achieve several objectives:
  - maximize CPU utilization
  - minimize response time
  - maximize throughput
  - minimize turnaround time
- Multiprogrammed OS
  - multiple processes in executable state at same time
  - scheduling picks the one that will run at any give time (on a uniprocessor)
- Processes use the CPU in bursts
  - may be short or long depending on the job

Types of Scheduling

- At least 4 types:
  - long-term - add to pool of processes to be executed
  - medium-term - add to number of processes partially or fully in main memory
  - short-term - which available process will be executed by the processor
  - I/O - which process's pending I/O request will be handled by an available I/O device
- Scheduling changes the ***state*** of a process

Scheduling criteria

- Per processor, or system oriented
  - CPU utilization
    - maximize, to keep as busy as possible
  - throughput
    - maximize, number of processes completed per time unit
- Per process, or user oriented
  - turnaround time
    - minimize, time of submission to time of completion.
  - waiting time
    - minimize, time spent in ready queue - affected solely by scheduling policy
  - response time
    - minimize, time to produce first output
    - most important for interactive OS

Scheduling criteria non-performance related

- Per process
  - predictability
    - job should run in about the same amount of time, regardless of total system load
- Per processor
  - fairness
    - don't starve any processes, treat them all the same
  - enforce priorities
    - favor higher priority processes
  - balance resources
    - keep all resources busy