Computer Science 162
Discussion Section
Week 2

Agenda

- Recap “What is an OS?” and Why?
- Process vs. Thread
- “THE” System

Note: Many slides are modifications of slides from Matei Zaharia

Who referenced slides from Steve Gribble, Ed Lazowska, Hank Levy, and John Zahorian

Why do we want an OS?

- **Isolation**
  - Fault: "if my program crashes yours shouldn't"
  - Performance: "if my program starts to do some massive computation, it shouldn't starve yours from running"
- **Mediation (multiplexing/sharing + protection)**
  - Manage the sharing of hardware resources (CPU, NIC, RAM, disk, keyboard, sound card, etc),
- **Abstractions and Primitives**
  - Set of constructs and well-defined interfaces to simplify application development: "all the code you didn't write" in order to implement your application
    - Because hardware changes faster than applications!
    - Because some concepts are useful across applications

Why bother with an OS?

- **User benefits**
  - Efficiency (cost and performance)
    - share one computer across many users
    - concurrent execution of multiple programs
  - Safety
    - OS protects programs from each other
    - OS fairly multiplexes resources across programs
- **Application benefits**
  - Simplicity
    - sockets instead of ethernet cards
  - Portability
    - device independence: 3COM card or Intel card?

Concurrency and Parallelism

- Concurrency means multiple threads of computation can make progress, but possibly by sharing the same processor
  - Like doing homework while chatting on IM

- Parallelism means leveraging multiple processors to compute a result faster
  - Like dividing a pile of work among people

Why Concurrency?

- Consider a web server: while it's waiting for a response from one client, it could read a request for another client
- Consider a browser: while it's waiting for a response from a web server, it wants to react to mouse or keyboard input

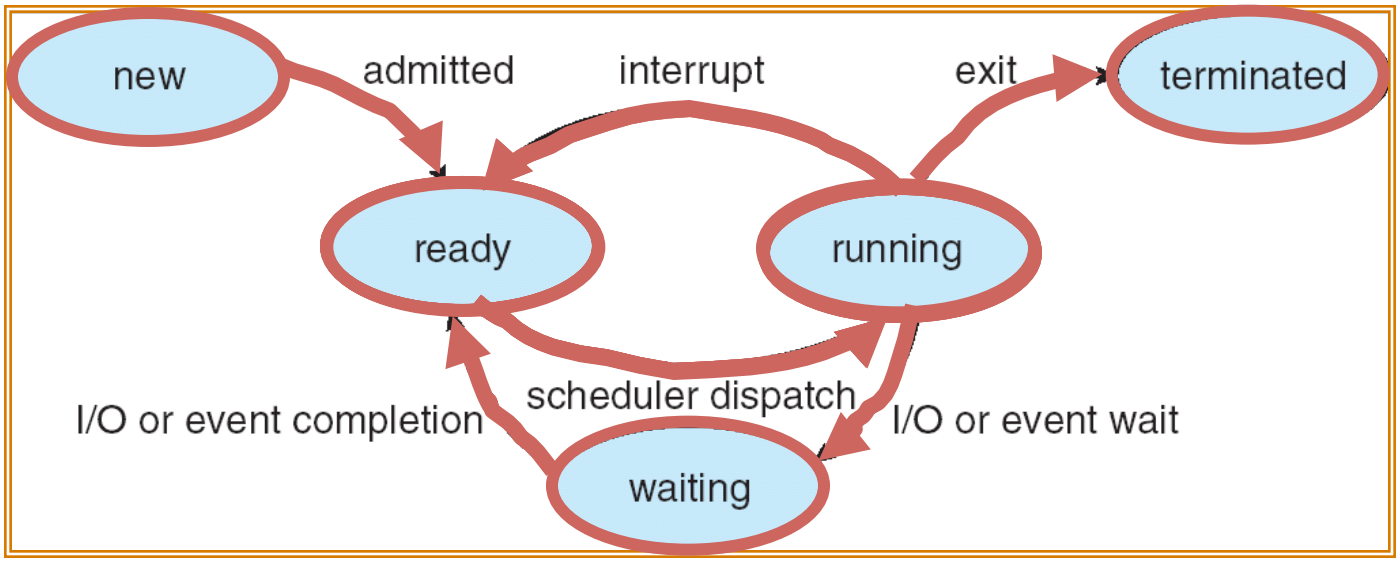
Concurrency increases/enables responsiveness

Why Parallelism?

- Because we actually have multiple CPUs!
- Because matrix multiply goes so much faster!

NOTE: Parallelism requires multiple processors, while concurrency also helps on a uniprocessor

Lifecycle of a Thread (or Process)



- As a thread executes, it changes state:
  - new: The thread is being created
  - ready: The thread is waiting to run
  - running: Instructions are being executed
  - waiting: Thread waiting for some event to occur
  - terminated: The thread has finished execution
- "Active" threads are represented by their TCBs
  - TCBs organized into queues based on their state

How does OS do it?

- Kernel: The highly privileged code that carries out lowest level OS functions

- Use multiple processes, OS schedules them (i.e. multiplexes resources between them)
  - Each process has its own address space
  - Each process maintains a list of open files, open network connections …

- Use multiple threads within a process, either OS *or* user schedules them
  - Threads share the process's address space

  Threads are cheaper than processes and can more easily share state! But have no isolation.

Recall, an OS needs to mediate access to resources: how do we share the CPU?

- Strategy 1: force everyone to cooperate
  - a thread willingly gives up the CPU by calling **`yield()`** which calls into the scheduler, which context-switches to another thread
  - what if a thread never calls **`yield()`**?

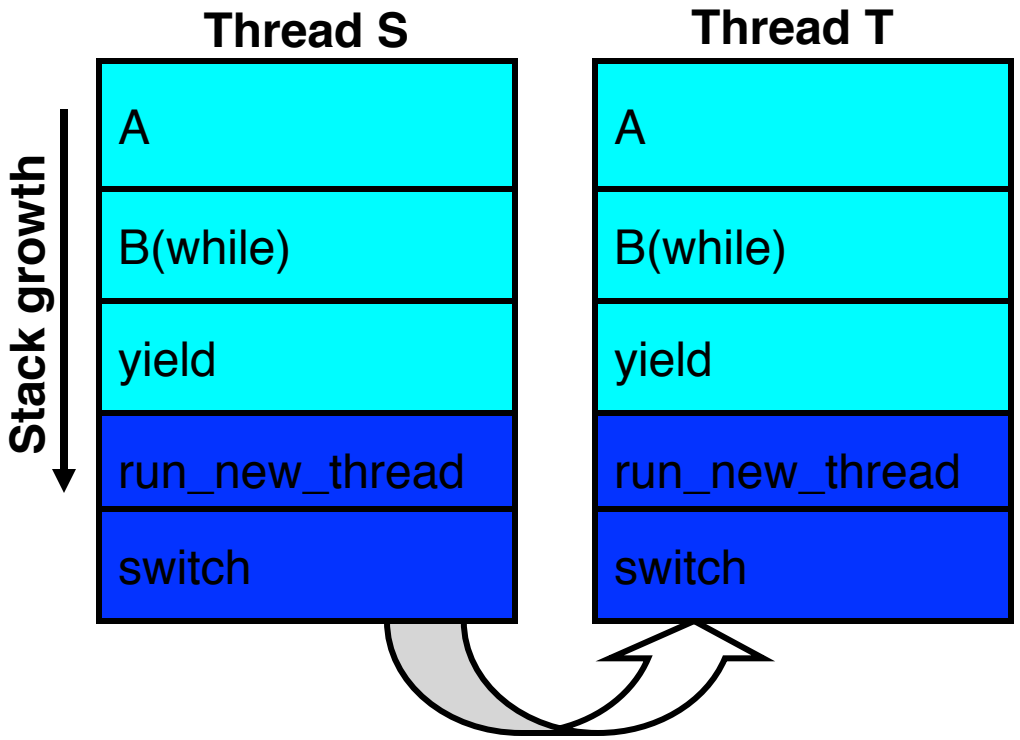
- Strategy 2: use preemption
  - at timer interrupt, scheduler gains control and context switches as appropriate

Review: Two Thread Yield Example

- Consider the following code blocks:

```
proc A() {
    B();
}
proc B() {
    while(TRUE) {
        yield();
    }
}
```

- Suppose we have 2 threads:
  - Threads S and T



“THE” System

- Dijkstra
  - Algorithm (shortest path)
  - OS (“THE”)
  - Software Engineering (“GOTO Considered Harmful”)
  - Programming Language and Formal Verification

“THE” Multiprogramming System

- Why Multiprogramming?
  - A Reduction in turnaround time for short programs
  - Economic use of peripheral devices
  - Automatic control of backing store and efficient use of CPU
  - Need general processor but not all the power

Storage

- Core ->RAM, Drum ->Disk
- Separation of Virtual and Physical location
- Page Swap, the content of the page can be written to a different location on the Drum.
- No need for consecutive physical locations

Processor

- A Collection of Sequential Processes Working Together
- Process State
- Mutual Synchronization

Hierarchy

- Level 0 – Present a virtual processor
- Level 1 – Present virtual segments
- Level 2 – Present a virtual console
- Level 3 – Present a buffered IO interface to devices
- Level 4 – User Programs

Benefit of Layering

- Limited Interface
- Fewer Bugs
- Easier to Test
- Easier to Communicate

Semaphore

- Found in Appendix, but so Important!
- Shared between sequential processes for synchronization
- P -> decrease ->Possibly lock (if value <0)
- V -> increase ->unlock
- P, V are indivisible (atomic)