CS 5204
Operating Systems
Lecture 3

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Announcements

- Send me your paper preferences if you haven't already

Topic VII: Reliability

- Metal
- SFI
- Nooks
- Rx

Topic VIII: Virtual Machines

- KaffeOS
- Xen

Topic I: Concurrency

- Review of basic concepts
- Process Management as OS responsibility
  - process vs thread abstraction
- Synchronization Issues:
  - mutual exclusion & race conditions
  - deadlock & starvation
- Implementing processes & threads
- Programming models for communication
  - threads vs events

Definition: Process/Thread

- Process
  - "program in execution"
  - resources: CPU context, memory maps, open files, privileges, ….; *isolated*
- Threads
  - CPU context (state + stack); *not isolated*
- "thread" is a historically recent term
  - Threads used to be called "processes"
- Q: what primitives does an OS need to provide?

User View

- Unix/C:
  – fork()/wait() vs pthread_create()/pthread_join()
- Java:
  – new Thread()
  – Thread.start()/join()

```
Runnable r = new Runnable() {
  public void run() {
     /* body */
  }
};

Thread t = new Thread(r);
t.start();  // concurrent execution starts
// main
t.join();   // concurrent execution ends
```

- See also [Boehm PLDI 2005]

Aside: Hybrid Models

- The “threads share everything” + “processes share nothing” mantra does not always hold
- Hybrids:
  – WEAVES allows groups of threads to define their own namespace, so they only share data they want
  – Java multitasking systems (KaffeOS, MVM): multiple “processes” may share same address space

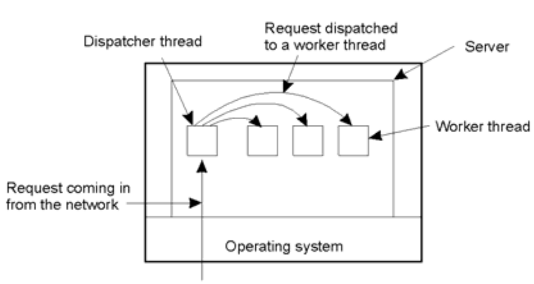
Why use Concurrency?

Why use Concurrency?

- Overlap I/O and computation
  – Hide latency
- Reduce latency
  – If thread system supports preemption
- Exploit multiprocessors
  – CPU concurrency
- Software engineering reasons
  – Separation of concerns

- Q: What are non-reasons to use threads?

Example Use: Threads in Servers



Resource Access

- Access to resources must be protected
- Race Condition problem
  – Definition
  – Approaches for detecting them
  – Static vs dynamic

Critical Section Problem

- Many algorithms known
  - purely software-based (Dekker's, Peterson's algorithm) vs. hardware-assisted (disable irqs, test-and-set instructions)
- Criteria for good algorithm:
  - mutual exclusion
  - progress
  - bounded waiting

```
while (application hasn't exited) {
    enter critical section
    inside critical section
    exit critical section
    in remainder section
}
```


Synchronization Abstractions

- Atomic primitives
  - e.g. Linux kernel "atomic_inc()"
- Dijkstra's semaphores
  - P(s) := atomic { while (s<=0) /* no op */; s--; }
  - V(s) := atomic { s++; }
  - Q: what's wrong with this implementation?
- Binary semaphores, locks, mutexes
  - Difference between mutex & semaphore

Expressing Critical Sections

```
pthread_mutex_t m;
…
pthread_mutex_lock(&m);
/* in critical section */

if (*) {
   pthread_mutex_unlock(&m);
   return;
}

pthread_mutex_unlock(&m);
```

```
synchronized (object) {
   /* in critical section */

   if (*) {

      return;
   }

}
```

Pthreads/C vs Java

Summary

- Review of concurrency issues:
  - Purposes
  - Abstractions
  - Critical Sections