CS 3204 Operating Systems

Lecture 14

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Announcements

- Project 1 is due Feb 27, 11:59pm
  - Should have finished alarm clock by now
  - Basic priority by this weekend
    - priority-change, -preempt, -fifo, -sema, -condvar
  - Priority donation & advanced scheduler will likely take more time than alarm clock & priority scheduling
- Use forum & office hours
- Check website for reading assignments: Stallings Chapter 6 & some of 9

Monitors in C

- POSIX Threads & Pintos
  - are Mesa-style, so must always use "while()"
  - See also book Chapter 5 on discussion of Hoare vs Mesa-style
- No compiler support, must do everything manually
  - must declare locks & condition vars
  - must call lock_acquire/lock_release when entering&leaving the monitor
  - must use cond_wait/cond_signal to wait for/signal condition
- Upside: more flexibility

Monitors in Java

- synchronized *block* means
  - enter monitor
  - *execute block*
  - leave monitor
- wait()/notify() use condition variable associated with receiver
  - Every object in Java can function as a condition var

```
class buffer {
  private char buffer[];
  private int head, tail;
  public synchronized produce(item i) {
    while (buffer_full())
      this.wait();
    buffer[head++] = i;
    this.notify();
  }
  public synchronized item consume() {
    while (buffer_empty())
      this.wait();
    buffer[tail++] = i;
    this.notify();
  }
}
```


Per Brinch Hansen's Criticism

- See *Java's Insecure Parallelism* [Brinch Hansen 1999]
- Says Java abused concept of monitors because Java does not *require* all accesses to shared variables to be within monitors
- Why did designers of Java not follow his lead?
  - Performance: compiler can't easily decide if object is local or not - conservatively, would have to make all public methods synchronized – pay at least cost of atomic instruction on entering every time

Readers/Writer w/ Monitor

```
struct lock mlock; // protects rdrs & wrtrs
int readers = 0, writers = 0;
struct condvar canread, canwrite;
void read_lock_acquire() {
  lock_acquire(&mlock);
  while (writers > 0)
    cond_wait(&canread, &mlock);
  readers++;
  lock_release(&mlock);
}
void read_lock_release() {
  lock_acquire(&mlock);
  if (--readers == 0)
    cond_signal(&canwrite, &mlock);
  lock_release(&mlock);
}
```

```
void write_lock_acquire() {
  lock_acquire(&mlock);
  while (readers > 0 || writers > 0)
    cond_wait(&canwrite, &mlock);
  writers++;
  lock_release(&mlock);
}

void write_lock_release() {
  lock_acquire(&mlock);
  writers--;
  ASSERT(writers == 0);
  cond_signal(&canread, &mlock);
  cond_signal(&canwrite, &mlock);
  lock_release(&mlock);
}
```

Q.: does this implementation prevent starvation?

Optimistic Concurrency Control

Optimistic Concurrency Control

- Alternative to locks: instead of serializing access, detect when bad interleaving occurred, retry if so

```
void increment_counter(int *counter) {
  do {
    int oldvalue = *counter;
    int newvalue = oldvalue + 1;
    [ BEGIN ATOMIC COMPARE-AND-SWAP INSTRUCTION ]
    if (*counter == oldvalue) { *counter = newvalue; success = true; }
    else { success = false; }
    [ END CAS ]
  } while (!success);
}
```

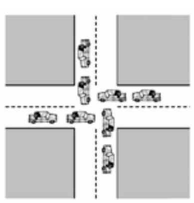

Optimistic Concurrency Control (2)

- Other names:
  - lock-free synchronization
  - wait-free synchronization
  - non-blocking synchronization
- x86 supports this via cmpxchg instruction
- Advantages:
  - Less overhead for uncontended locks (faster, and need no storage for lock queue)
  - Synchronizes with IRQ handler
  - Easier to clean up when killing a thread
- Disadvantages
  - Can requires lots of retries (more inefficient that even a hot lock since no thread might make progress)

Deadlock

Deadlock (Definition)

- A situation in which two or more threads or processes are blocked and cannot proceed
- “blocked” either on a resource request that can’t be granted, or waiting for an event that won’t occur
  - Possible causes: resource-related or communication-related
- Cannot easily back out

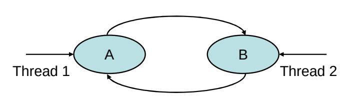


(b) Deadlock

Deadlock Canonical Example (1)

```
pthread_mutex_t A;
pthread_mutex_t B;
…
pthread_mutex_lock(&A);
pthread_mutex_lock(&B);
…
pthread_mutex_unlock(&B);
pthread_mutex_unlock(&A);
```

```
pthread_mutex_lock(&B);
pthread_mutex_lock(&A);
…
pthread_mutex_unlock(&A);
pthread_mutex_unlock(&B);
```



Canonical Example (2)

```
class account {
  pthread_mutex_t lock;
  int amount;  const char *name;
public:
  account(int amount, const char *name) :
      amount(amount), name(name)  { pthread_mutex_init(&this->lock, NULL); }
  void transferTo(account *that, int amount) {
    pthread_mutex_lock(&this->lock);
    pthread_mutex_lock(&that->lock);
    cout << "Transfering $" << amount << " from "
         << this->name << " to " << that->name << endl;
    this->amount -= amount;
    that->amount += amount;
    pthread_mutex_unlock(&that->lock);
    pthread_mutex_unlock(&this->lock);
  }
};
```

```
account acc1(10000, "acc1");
account acc2(10000, "acc2");

// Thread 1:
 for (int i = 0; i < 100000; i++)
     acc2.transferTo(&acc1, 20);
// Thread 2:
 for (int i = 0; i < 100000; i++)
     acc1.transferTo(&acc2, 20);
```

Q.: How to fix?