# Lecture 18

CprE 308

February 21, 2013

# Intro

# Review

- Producer Consumer using Semaphores
- Condition Variables

# Today's Topics

- Dining Philosophers

# Review

# Review: Producer Consumer using Semaphores

## Shared Variables

- count (number of items in buffer)
- buffer
- N (maximum size of buffer)

## Semaphores

- Empty - semaphore initialized to N (number of free slots in buffer)
- Full - semaphore initialized to zero (number of items in buffer)

# Review: Producer Consumer using Semaphores (Example)

## Producer

```
while(TRUE) {
  item = produce();
  down(Empty);
  lock(mutex);
  insert(item,buffer);
  count++;
  unlock(mutex);
  up(Full);
```

## Consumer

```
while(TRUE) {
  down(Full);
  lock(mutex);
  item = remove(buffer);
  count--;
  unlock(mutex);
  up(Empty);
  consume(item);
}
```

# Review: Taking Multiple Locks

## Thread A

```
proc1() {
    pthread_mutex_lock(&m1);
    /* use object 1 */
    pthread_mutex_lock(&m2);
    /* use objects 1 and 2 */
    pthread_mutex_unlock(*m2);
    pthread_mutex_unlock(*m1);
}
```

## Thread B

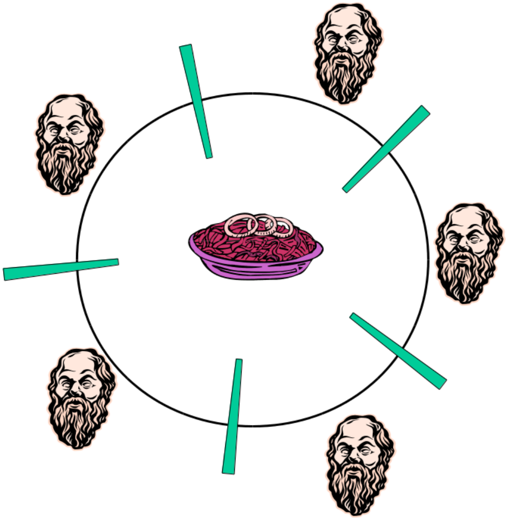
```
proc2() {
    pthread_mutex_lock(&m2);
    /* use object 2 */
    pthread_mutex_lock(&m1);
    /* use objects 1 and 2 */
    pthread_mutex_unlock(*m1);
    pthread_mutex_unlock(*m2);
}
```

# Dining Philosophers

# Dining Philosophers

- Classic Synchronization Problem
- Philosopher
    - eat, think, sleep
    - eat, think, sleep
    - ......
- Philosopher = Process
- Eating needs two resources (chopsticks)

# Dining Philosophers



# First Pass at a Solution

One Mutex for each chopstick

- Philosopher i:

```
while(1) {
  Think();
  lock(Left_Chopstick);
  lock(Right_Chopstick);
  Eat();
  unlock(Left_Chopstick);
  unlock(Right_Chopstick);
}
```

# First Pass at a Solution

One Mutex for each chopstick

- Philosopher i:

```
while(1) {
  Think();
  lock(Left_Chopstick);
  lock(Right_Chopstick);
  Eat();
  unlock(Left_Chopstick);
  unlock(Right_Chopstick);
}
```

**Deadlock!**

# One Possible Solution

Use a mutex for the whole dinner table

- Philosopher i:

```
lock(table);
EAT();
unlock(table);
```

# One Possible Solution

Use a mutex for the whole dinner table

- Philosopher i:

```
lock(table);
EAT();
unlock(table);
```

**Performance Problem!**

# Another Solution

- Philosopher i:

```
Think();
unsuccessful = 1;
while(unsuccessful) {
  lock(left_chopstick);
  if(try_lock(right_chopstick))
    unsuccessful = 0;
  else unlock(left_chopstick);
}
Eat();
unlock(left_chopstick);
unlock(right_chopstick);
```

# Another Solution

- Philosopher i:

```
Think();
unsuccessful = 1;
while(unsuccessful) {
  lock(left_chopstick);
  if(try_lock(right_chopstick))
    unsuccessful = 0;
  else unlock(left_chopstick);
}
Eat();
unlock(left_chopstick);
unlock(right_chopstick);
```

**Starvation if unfavorable scheduling**

# In Practice

- Starvation will probably not occur
- We can ensure this by adding randomization to the system:
  - Add a random delay before retrying
  - Unlikely that our random delays will be in sync too many times

## Solution with Random Delays

- Philosopher i:

```
Think();
while(unsuccessful) {
  wait(random());
  lock(left_chopstick);
  if(try_lock(right_chopstick))
    unsuccessful = 0;
  else unlock(left_chopstick);
}
Eat();
unlock(left_chopstick);
unlock(right_chopstick);
}
```

# Another Solution?

Suppose two philosophers

**Philosopher 1:**

```
lock(left_chopstick);
lock(right_chopstick);
```

**Philosopher 2:**

```
lock(right_chopstick);
lock(left_chopstick);
```

## Yet Another Solution Idea

- Do not try to take forks one after another
  - Don't have each fork protected by a different mutex
- Try to grab both forks at the same time
- Text has details (pg. 166)