Chapter 6
Synchronization

Images from Silberschatz

Processes

- Multiple processes accessing the same data
  - Could be threads

- Producer/Consumer
  - Section 3.4.1

```
while (true) {

      /*  produce an item and put in nextProduced  */
       while (count == BUFFER_SIZE)
                ; // do nothing
            buffer [in] = nextProduced;
            in = (in + 1) % BUFFER_SIZE;
            count++;
}
```

```
while (true)  {
     while (count == 0)
          ; // do nothing
          nextConsumed =  buffer[out];
           out = (out + 1) % BUFFER_SIZE;
           count--;

             /*  consume the item in nextConsumed
}
```

- What's the problem?

Race Condition

- How can count++ be executed?

- How can count-- be execute?

- Why is this a problem?
  - Why else is it a problem?

- Atomic

Critical Section Problem

- Critical Section

- Mutual Exclusion

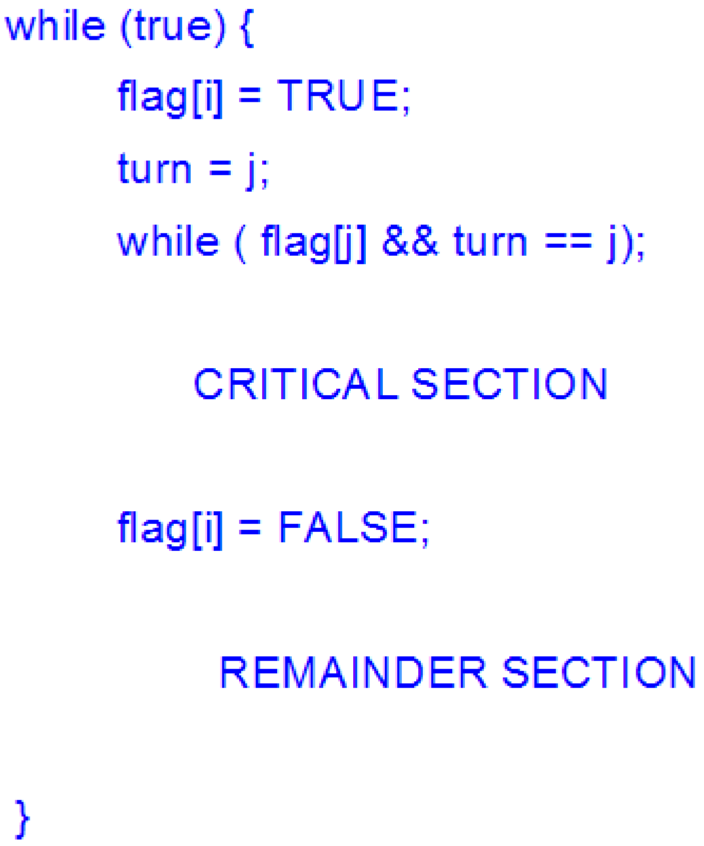
- Progress

- Bounded Waiting

- Preemptive vs non-preemptive kernels

Peterson's Solution

- Assumptions:



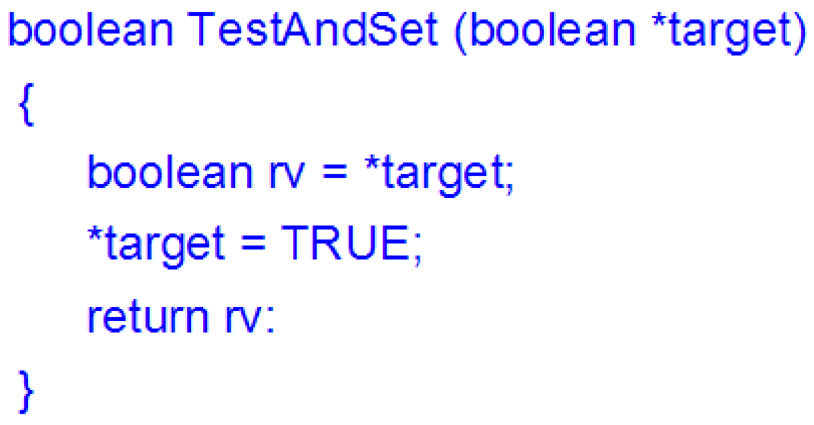
```
while (true) {
        flag[i] = TRUE;
        turn = j;
        while ( flag[j] && turn == j);

              CRITICAL SECTION

        flag[i] = FALSE;

                REMAINDER SECTION

}
```

- Are the 3 properties preserved?

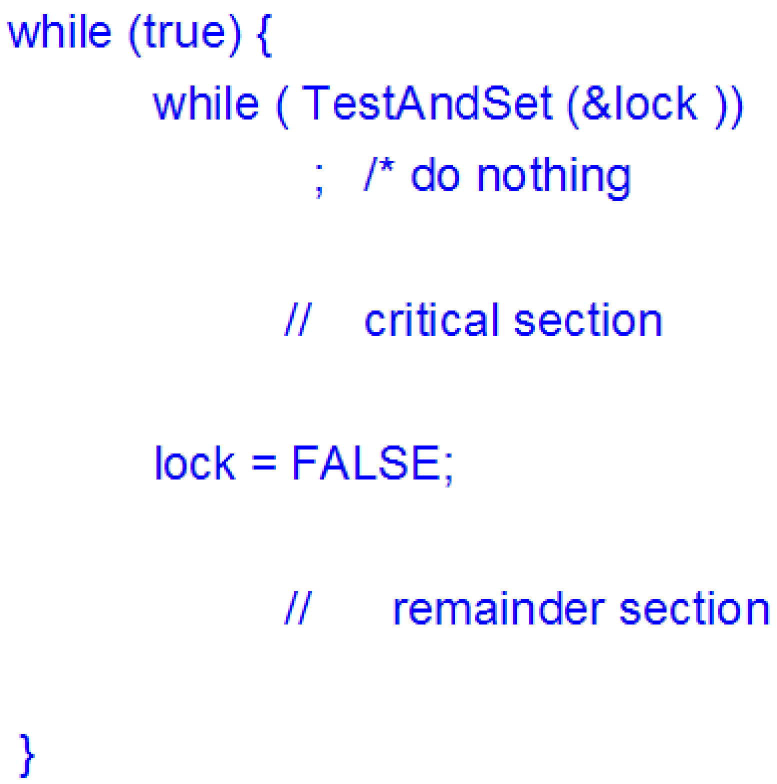
- How might we implement this?
    - Think about system calls....

Hardware support

- Implement this on the processor
  - Machine instructions



```
boolean TestAndSet (boolean *target)
{
     boolean rv = *target;
     *target = TRUE;
     return rv:
}
```



```
while (true) {
          while ( TestAndSet (&lock ))
                    ;   /* do nothing

                  //    critical section

          lock = FALSE;

                  //      remainder section

}
```

More hardware solutions

```
while (true)  {
        key = TRUE;
        while ( key == TRUE)
                Swap (&lock, &key );

                   //    critical section

         lock = FALSE;

                  //      remainder section

 }
```

```
void Swap (boolean *a, boolean *b)
{
        boolean temp = *a;
        *a = *b;
        *b = temp:
}
```

Semaphore

- Counting
- Binary
    - ??
- Spin lock
- Problems?
    - solutions?
- What can we say about Critical Sections?

```
wait (S) {
           while S <= 0
                 ; // no-op
              S--;
      }
signal (S) {
        S++;
     }
```

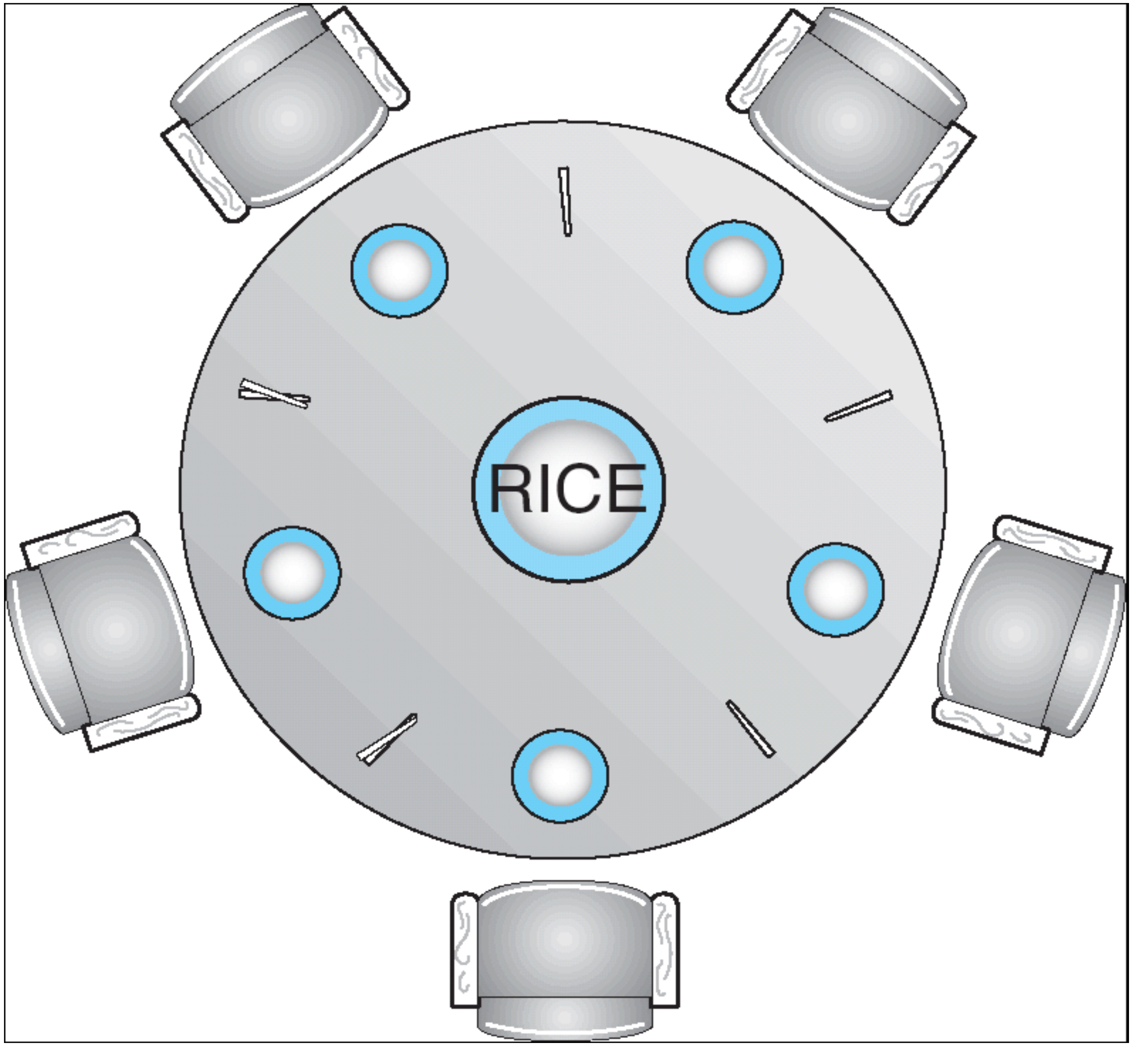
```
Semaphore S;    //  initialized to 1
wait (S);
            Critical Section
signal (S);
```

Deadlock & Starvation

Classic Problems of Synchronization

- Used to test new synchronization methods
- Bounded Buffer
- Readers-Writers
- Dining Philosophers
  - or, why you should never eat at a table full of computer scientists

Dining Philosophers

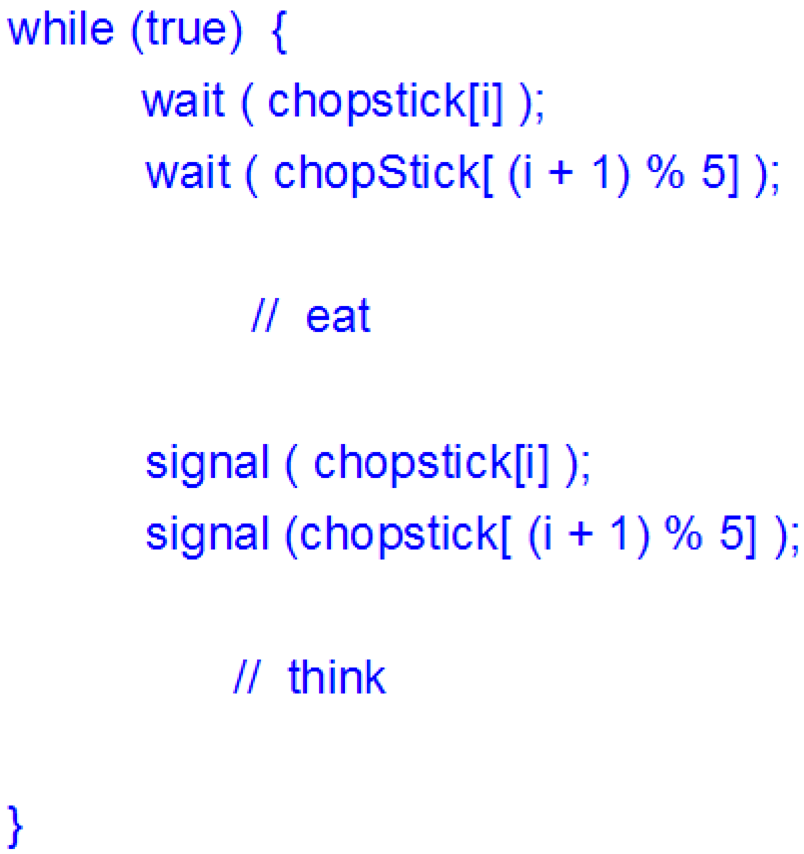


Dining Philosophers Solution

- Using semaphores

- Problems?

- Solutions?



```
while (true)  {
        wait ( chopstick[i] );
        wait ( chopStick[ (i + 1) % 5] );

              //  eat

        signal ( chopstick[i] );
        signal (chopstick[ (i + 1) % 5] );

             //  think

}
```

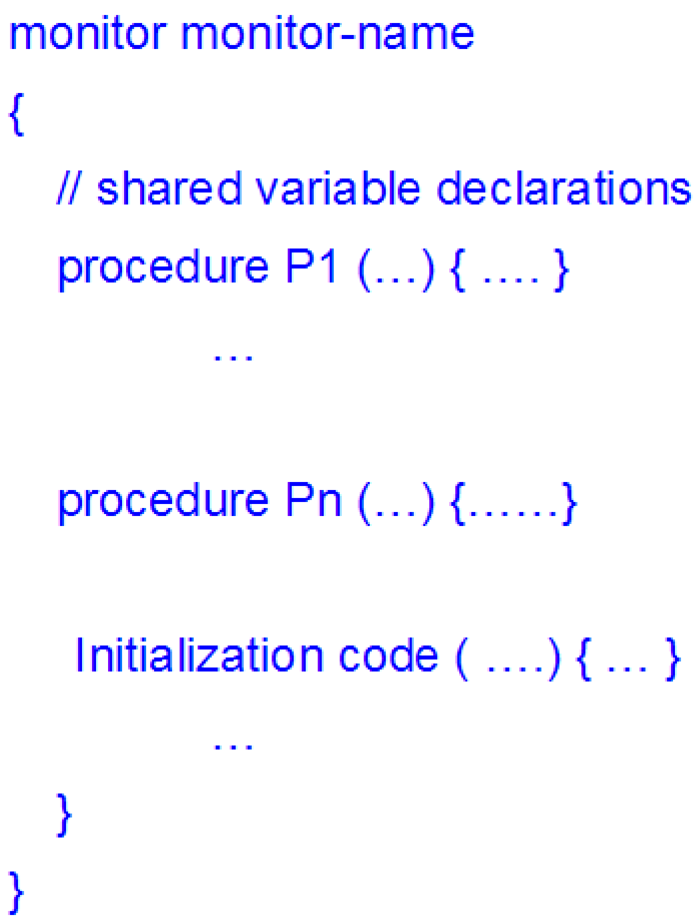
Problems with Semaphores

- What can you think of?

- Why are these problems bad?
  - Really, really, really bad?
    - Evil even.

Monitors

- High level coding practice
  - *design pattern*
  - Sometimes part of the language
    - Java: *synchronized*
    - C#: *Monitor* class
    - C++ .NET: *Monitor* class
  - Sometimes you code it yourself
    - C
- Only one process can be in a monitor at a time
- Why is this useful?



```
monitor monitor-name
{
   // shared variable declarations
   procedure P1 (…) { …. }
           …

   procedure Pn (…) {……}


    Initialization code ( ….) { … }
           …
   }
}
```

Log-Based Recovery

- Ensure atomicity
  - In case of a crash
  - Databases
  - Long running computations
    - Weather simulations
    - Nuclear reaction simulations
- Write-ahead logging
  - Start
  - Commit
  - Undo
  - Redo
- Problems?

Checkpoints