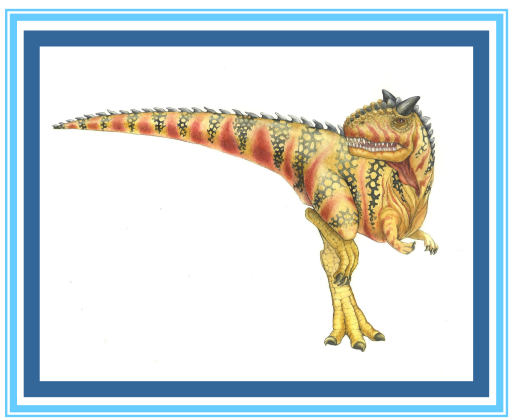
Chapter 7: Synchronization Examples



Outline

- Explain the bounded-buffer synchronization problem
- Explain the readers-writers synchronization problem
- Explain and dining-philosophers synchronization problems

Classical Problems of Synchronization

- Classical problems used to test newly-proposed synchronization schemes
  - Bounded-Buffer Problem
  - Readers and Writers Problem
  - Dining-Philosophers Problem

Bounded-Buffer Problem

- ***n*** buffers, each can hold one item
- Semaphore **`mutex`** initialized to the value 1
- Semaphore **`full`** initialized to the value 0
- Semaphore **`empty`** initialized to the value n

Bounded Buffer Problem (Cont.)

- The structure of the producer process

```
while (true) {
        ...
        /* produce an item in next_produced */
        ...
    wait(empty);
    wait(mutex);
        ...
        /* add next produced to the buffer */
        ...
    signal(mutex);
    signal(full);
}
```

Bounded Buffer Problem (Cont.)

- The structure of the consumer process

```
while (true) {
   wait(full);
   wait(mutex);
      ...
    /* remove an item from buffer to next_consumed */
      ...
   signal(mutex);
   signal(empty);
      ...
     /* consume the item in next consumed */
      ...
  }
```

Readers-Writers Problem

- A data set is shared among a number of concurrent processes
  - **Readers** – only read the data set; they do ***not*** perform any updates
  - **Writers** – can both read and write
- Problem – allow multiple readers to read at the same time
  - Only one single writer can access the shared data at the same time
- Several variations of how readers and writers are considered – all involve some form of priorities

Readers-Writers Problem (Cont.)

- Shared Data
  - Data set
  - Semaphore **`rw_mutex`** initialized to 1
  - Semaphore **`mutex`** initialized to 1
  - Integer **`read_count`** initialized to 0

Readers-Writers Problem (Cont.)

- The structure of a writer process

```
while (true) {
        wait(rw_mutex);
            ...
        /* writing is performed */
            ...
    signal(rw_mutex);
}
```

Readers-Writers Problem (Cont.)

- The structure of a reader process

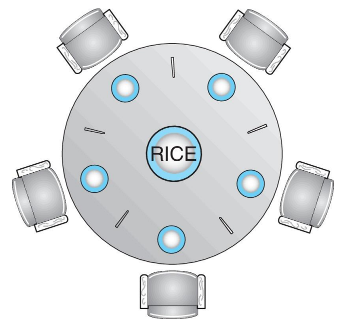
```
while (true){
     wait(mutex);
     read_count++;
     if (read_count == 1) /* first reader */
      wait(rw_mutex);
          signal(mutex);
         ...
         /* reading is performed */
         ...
     wait(mutex);
         read_count--;
         if (read_count == 0) /* last reader */
         signal(rw_mutex);
     signal(mutex);
}
```

Readers-Writers Problem Variations

- The solution in previous slide can result in a situation where a writer process never writes. It is referred to as the “First reader-writer” problem.
- The “Second reader-writer” problem is a variation the first reader-writer problem that state:
  - Once a writer is ready to write, no “newly arrived reader” is allowed to read.
- Both the first and second may result in starvation. leading to even more variations
- Problem is solved on some systems by kernel providing reader-writer locks

Dining-Philosophers Problem

- N philosophers' sit at a round table with a bowel of rice in the middle.



- They spend their lives alternating thinking and eating.
- They do not interact with their neighbors.
- Occasionally try to pick up 2 chopsticks (one at a time) to eat from bowl
  - Need both to eat, then release both when done
- In the case of 5 philosophers, the shared data
  - Bowl of rice (data set)
  - Semaphore chopstick [5] initialized to 1

Dining-Philosophers Problem Algorithm

- Semaphore Solution
- The structure of Philosopher i :

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

      /* eat for awhile */

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

      /* think for awhile */

}
```

- What is the problem with this algorithm?

End of Chapter 7