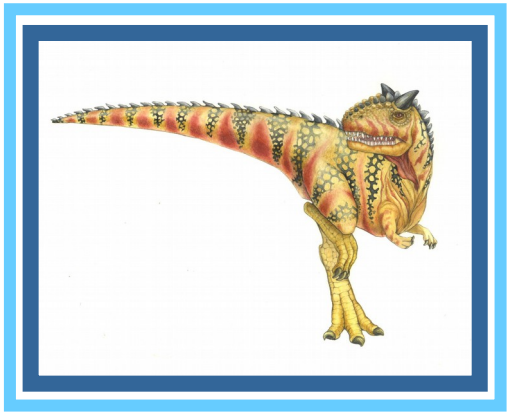
Chapter 7: Synchronization Examples



Chapter 7: Synchronization Examples

- Classic Problems of Synchronization
- Synchronization Examples
- Alternative Approaches

Objectives

- To examine several classical process-synchronization problems
- To explore several tools that are used to solve process 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
- We will present solutions using:
  - Semaphores.
  - Monitors
  - Various operating systems

Semaphore Solutions

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

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

Bounded Buffer Problem (Cont.)

- The structure of the consumer process

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

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
- Shared Data
  - 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

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

Readers-Writers Problem (Cont.)

- The structure of a reader process

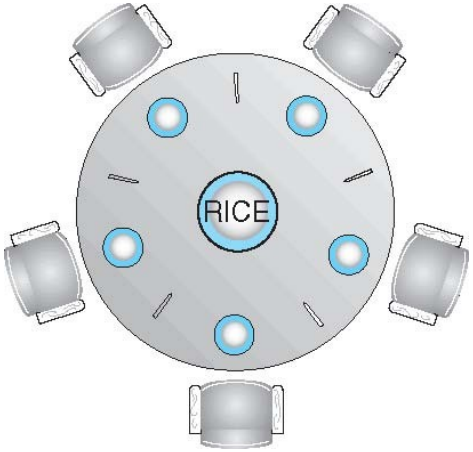
```
do {
        wait(mutex);
        read_count++;
        if (read_count == 1)
        wait(rw_mutex);
    signal(mutex);

        ...
        /* reading is performed */

        ...
    wait(mutex);
        read_count--;
        if (read_count == 0)
        signal(rw_mutex);
    signal(mutex);
} while (true);
```

Readers-Writers Problem Variations

- ***First*** variation – no reader kept waiting unless writer has permission to use shared object
- ***Second*** variation – once writer is ready, it performs the write ASAP
- Both may have starvation leading to even more variations
- Problem is solved on some systems by kernel providing reader-writer locks

Dining-Philosophers Problem

- Philosophers 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

- The structure of Philosopher *i*:

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

                // eat

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

                // think

} while (TRUE);
```

Dining-Philosophers Problem Algorithm (Cont.)

- This solution guarantees that no two neighbors are eating simultaneously.
- Possibility of a deadlock. Suppose that all five philosophers become hungry at the same time and each grabs the left chopstick.
- Solution:
  - Allow at most 4 philosophers to be sitting simultaneously at the table.
  - Allow a philosopher to pick up the forks only if both are available (picking must be done in a critical section.
  - Use an asymmetric solution -- an odd-numbered philosopher picks up first the left chopstick and then the right chopstick. Even-numbered philosopher picks up first the right chopstick and then the left chopstick.

End of Chapter 7