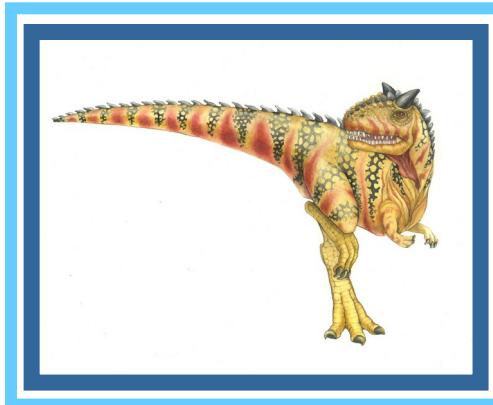


Synchronization Examples

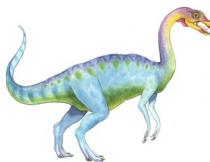




Classical Problems of Synchronization

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

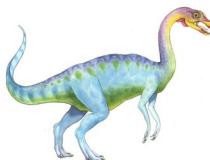




Bounded-Buffer Problem

- n buffers, each can hold one item
- Semaphore **mutex** initialized to the value 1
- Semaphore **full** initialized to the value 0 (empty buffer)
- Semaphore **empty** initialized to the value n (no. of free slots)





Bounded Buffer Problem (Cont.)

- The structure of the producer process

```
while (true) {  
    ...  
    /* produce an item in next_produced */  
    ...  
    wait(empty); /*wait until there is an empty  
                   slot in the buffer*/  
    wait(mutex); /*enter CS*/  
    ...  
    /* add next produced to the buffer */  
    ...  
    signal(mutex); /* leaves CS*/  
    signal(full); /*signal that there is a new full  
                   slot an item availbale*/  
}
```



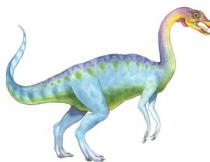


Bounded Buffer Problem (Cont.)

- The structure of the consumer process

```
while (true) {  
    wait(full); /*wait until there is at least one  
    full slot*/  
    wait(mutex); /* enter CS*/  
    ...  
    /* remove an item from buffer to next_consumed */  
    ...  
    signal(mutex); /*leave CS*/  
    signal(empty); /*Signal that one empty slot is  
    free now*/  
    ...  
    /* consume the item in next consumed */  
    ...  
}
```

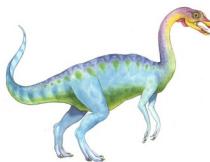




Readers-Writers Problem

- 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



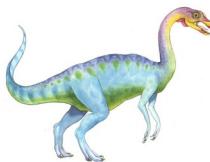


Readers-Writers Problem (Cont.)

- The structure of a writer process

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





Readers-Writers Problem (Cont.)

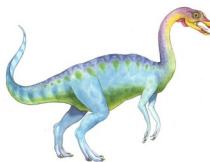
- The structure of a reader process

```
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

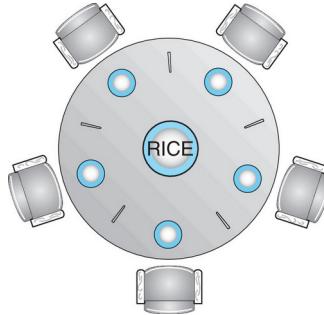
- The solution in previous slide can result in a situation where a writer process never writes. It is referred to as the “First reader-writer” problem. (no reader kept waiting unless writer has permission to use shared object)
- The “Second reader-writer” problem is a variation the first reader-writer 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**





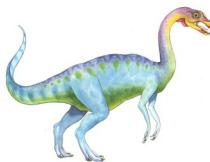
Dining-Philosophers Problem

- 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





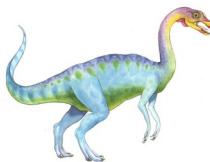
Dining-Philosophers Problem Algorithm

- 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?





Monitor Solution to Dining Philosophers

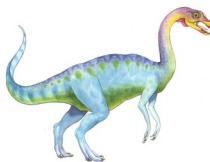
```
monitor DiningPhilosophers
{
    enum { THINKING, HUNGRY, EATING} state [5] ;
    condition self [5];

    void pickup (int i) {
        state[i] = HUNGRY; //philosopher is hungry//
        test(i); //try to get both chopsticks//
        if (state[i] != EATING)
            self[i].wait; //wait if not allowed to eat//
    }

    void putdown (int i) {
        state[i] = THINKING; //philosopher stops eating//
        // test left and right neighbors
        test((i + 4) % 5); //left neighbor//
        test((i + 1) % 5); //right neighbor//

    }
}
```

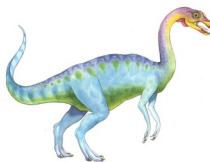




Solution to Dining Philosophers (Cont.)

```
void test (int i) {  
    if ((state[(i + 4) % 5] != EATING) && //left not eating//  
        (state[i] == HUNGRY) && //I is hungry//  
        (state[(i + 1) % 5] != EATING) ) { //right not eating//  
        state[i] = EATING ; //allow philosopher i to eat//  
        self[i].signal () ; // wake up I if waiting//  
    }  
}  
  
initialization_code() {  
    for (int i = 0; i < 5; i++)  
        state[i] = THINKING;  
}  
}
```





Solution to Dining Philosophers (Cont.)

- Each philosopher “i” invokes the operations **pickup ()** and **putdown ()** in the following sequence:

```
DiningPhilosophers.pickup(i) ;
```

```
    /** EAT **/
```

```
DiningPhilosophers.putdown(i) ;
```

- No deadlock, but starvation is possible



End of Chapter

