Operating Systems

Isfahan University of Technology
Electrical and Computer Engineering Department
1400-1 semester

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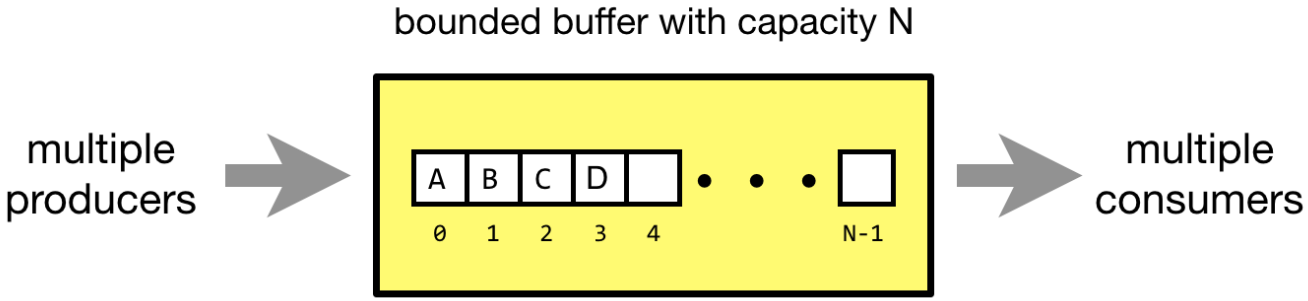
Session 16: Classical Problems of Synchronization

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 */

        ...
        /* add next produced to the buffer */
        ...

}
```

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) {

    ...
  /* remove an item from buffer to next_consumed */
    ...

    /* consume the item in next consumed */
    ...
}
```

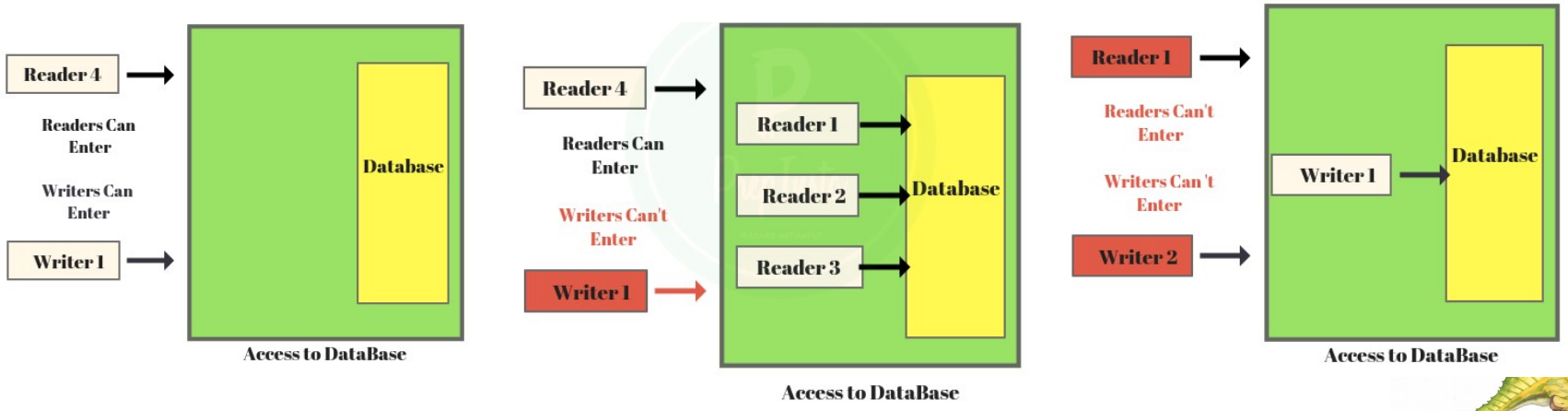
Bounded Buffer Problem (Cont.)

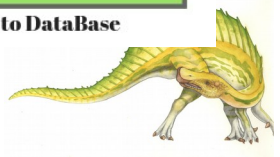
- The structure of the consumer process

```
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) {

}
```

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){

}
```

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.
  - **Once a reader is ready to read, no "newly arrived writer" is allowed to read.**
- 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