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Producer-Consumer Problem

Documentation

➢ Pseudocode

Classes:

1.1 Main Function.

1.2 DataQueue Class.

1.3 Producer Class.

1.4 Consumer Class.

1.5 Message Class.

****

1.1 Main function

1. Start
2. Create new DataQueue object and pass queue maxSize.
3. Create Producer and Consumer threads as many as desired and pass the DataQueue object as parameter.
4. Start Producer and Consumer threads.
5. Start queue.
6. End.

***

1.2 DataQueue

class DataQueue

Attributes

private int maxSize

private boolean queueStartFlag := false

private Queue <Message> queue

private Semaphore producer_criticalSecLock

private Semaphore consumer_criticalSecLock

private int producerCount := 0

private boolean producerStartFlag := false

private Semaphore producerId_Lock

private Queue <Object> producer_queue

private int consumerCount :=0

private Boolean consumerStartFlag :=false

private Semaphore ConsumerId_Lock

private Queue <Object> consumer_queue

Constructors

- DataQueue(int size)

mazSize := size

end

*****

Methods

- function start()

    If Not queueStartFlag And (consumer_queue Not empty Or (producer_queue Not empty And maxSize <= 10000)) then

        print “queue started”

        queueStartFlag := true

        wake Next Producer

        wake Next Consumer

    end

    return queueStartFlag

    end

- function isProducerStarted()

    return producerStartFlag

end

- function isConsumerStarted()

    return ConsumerStartFlag

end

- function getProcucer_Id()

    integer id := 0

    acquire Semaphore producerId_Lock

    id := producerCount

    producerCount := producerCount + 1

    release producer Id section Lock

    return id

end

- function getProducerLock()

    return producer_criticalSecLock

end

- function getConsumerLock()end

    return consumer_criticalSecLock

end

- function getConsumer_Id()

    integer id := 0

    acquire consumer Id Lock to Create new id

    id := consumerCount

    consumerCount := consumerCount + 1

    release consumer Id section Lock

    return id

end

- function getProducerCount()

    integer count := 0

    acquire to get the producer id Lock

    count := producerCount;

    release the producer id section Lock

    return count

end

- function getConsumerCount()

    integer count := 0

    acquire to get the consumer id Lock

    count := consumerCount;

    release the consumer id section Lock

    return count

end

- function waitOnProducerQ() throws InterruptedException

    Create new object nextProducer of type Object class

    synchronized (producer_queue) {

      add nextProducer to producer_queue

    }

    synchronized(nextProd){

     wait on the nextProducer object

    }

end

- function waitOnProducerQ() throws InterruptedException

    Create new object nextConsumer of type Object class

    synchronized (consumer_queue) {

      add nextConsumer to consumer_queue

    }

    synchronized(nextProd){

     wait on the nextConsumer object

    }

end

- function wakeNextProducer() end

```
synchronized (producer_queue) {
    if  producer_queue Not empty   then
     poll head  of the  producer_queue
   assign the polled value to new object of type Object
      synchronized(nextProducer){
         wake all producers waiting on this object
         if  producerStartFlag  Not true   then
         print “producer queue is active"
                producerStartFlag  :=  true;
       end}
   end}
end
```

- function wakeNextConsumer()

```
synchronized (consumer_queue) {
    if consuemr_queue Not empty  then
          poll head of the consumer_queue
         assign the polled value to new object of type Object
           synchronized(nextConsumer){
              wake all consumers waiting on nextConsumer
              if  consumerStartFlag  Not true  then
              print “producer queue is active"
                     consumerStartFlag  :=  true;
            end}
   end}
end
```

- function isEmpty()

```
    synchronized (queue) {
      if queue size = zero then return true
      else  return false
      end
      }
end
```

- function isFull()

```
    synchronized (queue) {
      if queue size = maxSize then return true
      else  return false
      end
      }
end
```

- function add(Message message)

```
      synchronized (queue) {
         add message to queue
          if added then return true
          else   return false
          end
      }
end
```

- function remove()

```
synchronized (queue) {
    remove the head element of queue
    if removed then  return true
    else   return false
    end
}
```

end

- function size()

```
synchronized(queue){  return queue size  }
```

end

end of class

****

1.3 Producer class

Import Semaphore class from java .util.concurrent

class Producer

Attributes

```
private   DataQueue   dataQueue
private  boolean  runFlag
private Boolean produced := false
private Semaphore criticalSecLock
private int id
private int  producerCount
```

*****

Constructors

- Public Producer(DataQueue queue)

    dataQueue := queue
    criticalSecLock := dataQueue.getProducerLock()
    id := dataQueue.getProd_id
    runFlag := true

end

*****

Methods

- function run ()

    produce ()

end

- function produce()

    wait on producers queue until notify
    create message, object of Message type
    while runFlag = true

        produced := false

        message := gererateMessage()

        if no one inside critical section Or producers count < 3 then
        acquire Lock to enter critical section
        else
            wait on producers queue until notify
            acquire lock to enter critical section
        end

```
            while Not produced
                if  dataQueue is not full   then
                    add message to the queue
                else if  consumer queue  Not started   then
                        wake next consumer
                else
                        produced := false
                end
            end
            release crititcal section lock
            if  producer count >2   then
                wake next producer
                wait on producers queue until notify
            else if  producers count = 2 then
                  wake new producer
                  get producers count

            else
                get producers count
            end
        end
end
```

- function generateMessage()

```
    create new object of Message type
    return the object
end
```

- function stop()

    runFlag = false

    wake next producer

end

****

1.4 Consumer class

Import Semaphore class from java .util.concurrent

class Consumer

Attributes

private DataQueue dataQueue

private boolean runFlag

private Semaphore criticalSecLock

private int id

private int consumersCount

***

Constructors

- Public Consumer(DataQueue queue)

    dataQueue := queue

    criticalSecLock := dataQueue.getConsumerLock()

    id := dataQueue.getConsumer_id()

    runFlag := true

end

***

Methods

- function run()

    consume()

end

- function consume()

    wait on consumers queue

    create new message object of Message type

    while runFlag = true

        message := null

        if no one inside critical section Or consumers count < 3 then
        acquire Lock to enter critical section
        else
            wait on consumers queue until notify
            acquire lock to enter critical section
        end

        while message = null

            if dataQueue is not empty then
                remove message from the queue
            else if producers queue Not started then
                wake next producer
            end
        end

        release crititcal section lock

```
            if  consumers count >2   then
                    wake next consumer
                    wait on consumers queue until notify
            else if  consumers count = 2 then
                     wake new consumers
                     get consumers count
            else
                    get consumers count
            end
        end
    end
```

- function stop()

```
        runFlag = false
        wake next consumer
    end
```

end of class

****

1.5 Message class

class Message

Attributes

private int id

private double data

****

- public Constructor (double userData)

        data := userData

        id := generate_id()

end

****

- Function getValue ()

        return data

end

- function int getId()

        return id

end

- function generate_id()

        generate new message id

        return new id

end

end of class

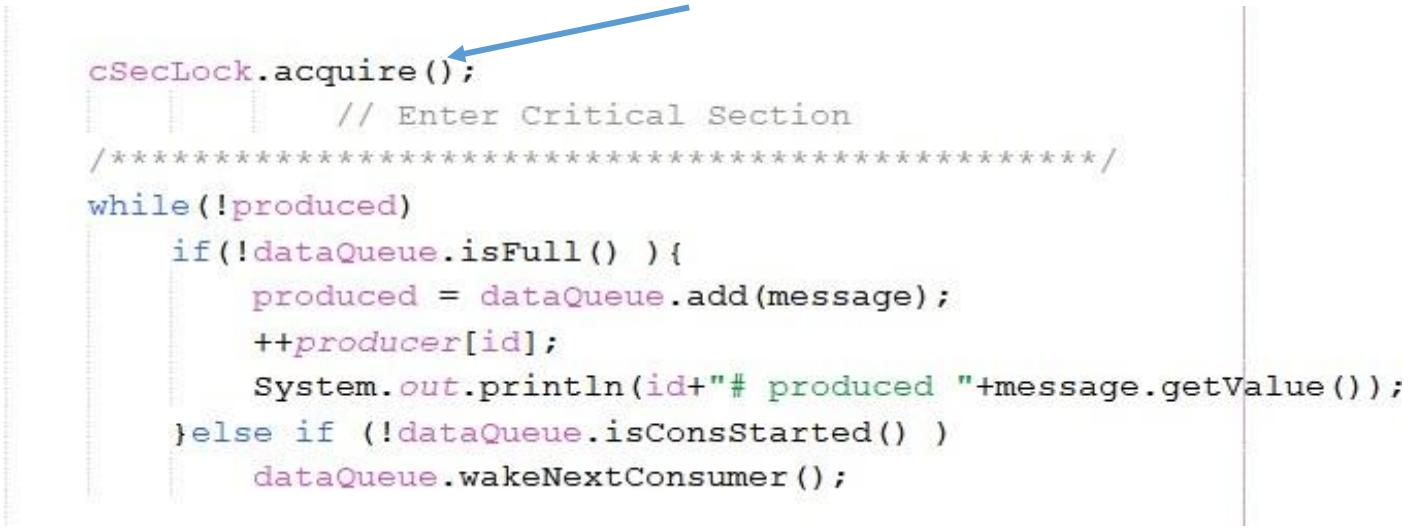
****

➢ Deadlock

Example to explain where Deadlock can take place

- In this example, we'll create two threads, producer1 and consumer1.
- Thread producer1 calls produce, and consumer1 calls consume.
- To complete their operations, thread producer needs to acquire first_mutex first and then second_mutex, whereas thread consume needs to acquire second_mutex first and then first_mutex.
- So, basically, both threads are trying to acquire the locks in the opposite order.
- Deadlock is possible if producer1 acquires first_mutex and consumer1 acquires second_mutex.
- Producer1 then waits for second_mutex and Consumer waits for first_mutex.
- Obviously no one gets the lock to enter their critical section and they remain stuck forever.

  - Solution of this situation is to either acquire locks in same order or to use only one lock and that should be enough same as the code mentioned below :



```
cSecLock.acquire();
            // Enter Critical Section
/************************************************/
while(!produced)
    if(!dataQueue.isFull() ){
        produced = dataQueue.add(message);
        ++producer[id];
        System.out.println(id+"# produced "+message.getValue());
    }else if (!dataQueue.isConsStarted() )
        dataQueue.wakeNextConsumer();
```

****

➢ Starvation

Example to explain where Starvation can take place

- In this example, we'll create N thread, producer1 to producerN.
- each thread has priority value assigned to it.
- all threads call produce method.
- To complete their operations, threads need to acquire produce_lock.
- So, if there is a very low priority thread it won't be able to acquire the lock and complete its task if there are many other threads with high priority.

- Possible solution for this situation is to create queue for threads to wait in until the thread inside critical finishes and releases the lock then wakes the first thread in the queue.
- As we can see in this code

```
cSecLock.acquire();
            // Enter Critical Section
/*************************************************/

    while(!produced)
        if(!dataQueue.isFull() ){
            produced = dataQueue.add(message);
            ++producer[id];
            System.out.println(id+"# produced "+message.getValue());
        }else if (!dataQueue.isConsStarted() )
            dataQueue.wakeNextConsumer();

/*************************************************/
            // Leave Critical Section
cSecLock.release();
dataQueue.wakeNextProducer();
```

****

- Explanation for real world application

The application is an application that provides services to people with daily nutritional needs and for each person a certain number is available to him, the number should not exceed in the event that the goods are not available or insufficient, and in the event that the number is available, the person is allowed to take what he wants, and every time the person takes it, the worker asks the user Does he want, even if he wants to do business, he checks the number of goods and the number of users, and in the event that there is no one and the goods are available, the person is allowed to take, and if it is not available, the user cannot take and the user leaves.

Real world

The application is an application that provides services to people with daily nutritional needs and for each person a certain number is available to him, the number should not exceed in the event that the goods are not available or insufficient, and in the event that the number is available, the person is allowed to take what he wants, and every time the person takes it, the worker asks the user Does he want, even if he wants to do business, he checks the number of goods and the number of users, and in the

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