Concurrency 2

Shared Memory

Catuscia Palamidessi
INRIA Futurs and LIX - Ecole Polytechnique

The other lecturers for this course:

Jean-Jacques Lévy (INRIA Rocquencourt)
James Leifer (INRIA Rocquencourt)
Eric Goubault (CEA)

http://pauillac.inria.fr/~leifer/teaching/mpri-concurrency-2005/

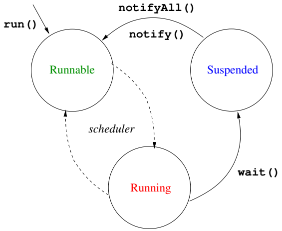
Outline

1. Solution to some of the exercises in previous lecture
   - Semaphores in Java
   - Readers and Writers
2. Verification of Concurrent Software (by Jean-Jacques Lévy)
   - A case study: Ariane

A few facts about Java (1/2)

Threads in Java

- A thread is a single sequential line of control. It may be execute in parallel/interleaving with other threads.
- The states of a live thread in Java:



A few facts about Java (2/2)

Classes with synchronized methods

- Class whose objects may be shared by different threads need synchronized methods
- Example: A bank account with two or more owners

Bank account

```
class Account {
    private int balance;
    public Account(int initialDeposit) {
        balance = initialDeposit;
    }
    public synchronized void deposit(int amount) {
        balance = balance + amount;
    }
    ...
}
```

- Synchronized methods are handled using a lock mechanism. *A lock is per object*.
- When a thread suspends inside a synchronized method, it releases the lock.

Definition of Semaphore (from previous lecture)

A generalized semaphore s is an integer variable with two operations:

- $acquire(s)$: If $s > 0$ then $s := s - 1$, otherwise suspend on s. (atomically)
- $release(s)$: If some process is suspended on s, wake it up, otherwise $s := s + 1$. (atomically)

Example of use: At beginning, $s = max$. Then

$[\cdots; acquire(s);\ C_1;\ release(s); \cdots] \ || \ [\cdots; acquire(s);\ C_2;\ release(s); \cdots]$

Use of a semaphore in Java

Creation of a Semaphore s

s.Semaphore(*max*);

Thread 1

...
s.acquire();
C_1;
s.release();
...

Thread 2

...
s.acquire();
C_2;
s.release();
...

Declaration of class Semaphore in Java

Use *sus* to indicate the number of suspended threads on the semaphore

Semaphore

```
class Semaphore {
    private int value, sus;
    public Semaphore(int initial) {
        value = initial; sus = 0;
    }
    public synchronized void acquire() {
        if (value == 0) { sus = sus + 1;  wait(); sus = sus - 1; }
        else value = value - 1;
    }
    public synchronized void release() {
        if (sus > 0) {  notify(); }
        else { value = value + 1; }
    }
}
```

However, this is not efficient (why?) and it is not in the typical “Java style”.

Semaphore in Java (typical Java solution)

Semaphore

```
class Semaphore {
    private int value;
    public Semaphore(int initial) {
        value = initial;
    }
    public synchronized void acquire() {
        while (value == 0)  wait();
        value = value - 1;
    }
    public synchronized void release() {
        value = value + 1;
        notify();
    }
}
```

Problem: A certain resource (for instance a file) is shared by some readers and some writers. The readers cannot modify the resource, while the writers can.

We want that only one writer can access the resource at a time, while the readers are allowed to do it concurrently.

Readers and Writers in Java

Reader

...
r.acquireShared();
use r ;
r.releaseShared();
...

Writer

...
r.acquireExclusive();
use r;
r.releaseExclusive();
...

The class Resource

Resource

```
class Resource {
    private int readers, writers;
    public Resource() {
        readers = 0;
        writers = 0;
    }
    public synchronized void acquireShared() { ... }
    public synchronized void releaseShared() { ... }
    public synchronized void acquireExclusive() { ... }
    public synchronized void releaseExclusive() { ... }
}
```

The methods of Resource

acquireShared()

```
{
   while (writers == 1) {
      wait();
   }
   readers = readers + 1;
}
```

acquireExclusive()

```
{
   while (writers == 1 || readers > 0)  {
      wait();
   }
   writers = 1;
}
```

releaseShared()

```
{
    readers = readers - 1;
    notify();
}
```

releaseExclusive()

```
{
    writers = 0;
    notifyAll();
}
```

However, this solution is not efficient. (Why?)

A more efficient solution

- Use suspension conditions *cR*, *cW*
- Use *sR* to indicate the number of readers suspended.

acquireShared()

```
{
   while (writers == 1) {
      sR = sR + 1;
      wait(cR);
      sR = sR - 1;
   }
   readers = readers + 1;
}
```

releaseShared()

```
{
    readers = readers - 1;
    notify(cW);
}
```

acquireExclusive()

```
{
   while (writers == 1 || readers > 0)   {
      wait(cW);
   }
   writers = 1;
}
```

releaseExclusive()

```
{
    writers = 0;
    if ( sR > 0) {  notifyAll(cR); }
    else {  notify(cW); }
}
```

Exercises

- The "more efficient solution" for the Readers and Writers problem that we presented in this lecture is not starvation-free, because it always gives priority to the readers. Modify the solution so to ensure that neither the writers nor the readers will starve.
- About the first solution we presented for the Readers and Writers problem: it that one starvation-free? Justify your answer.

A case study: Ariane