JAC444 - Lecture 5

Threads

Segment 2 - Synchronization

Threads

In this section you will be learning about:

- Synchronization
- Synchronized Methods
- Deadlock
- Starvation and Livelock

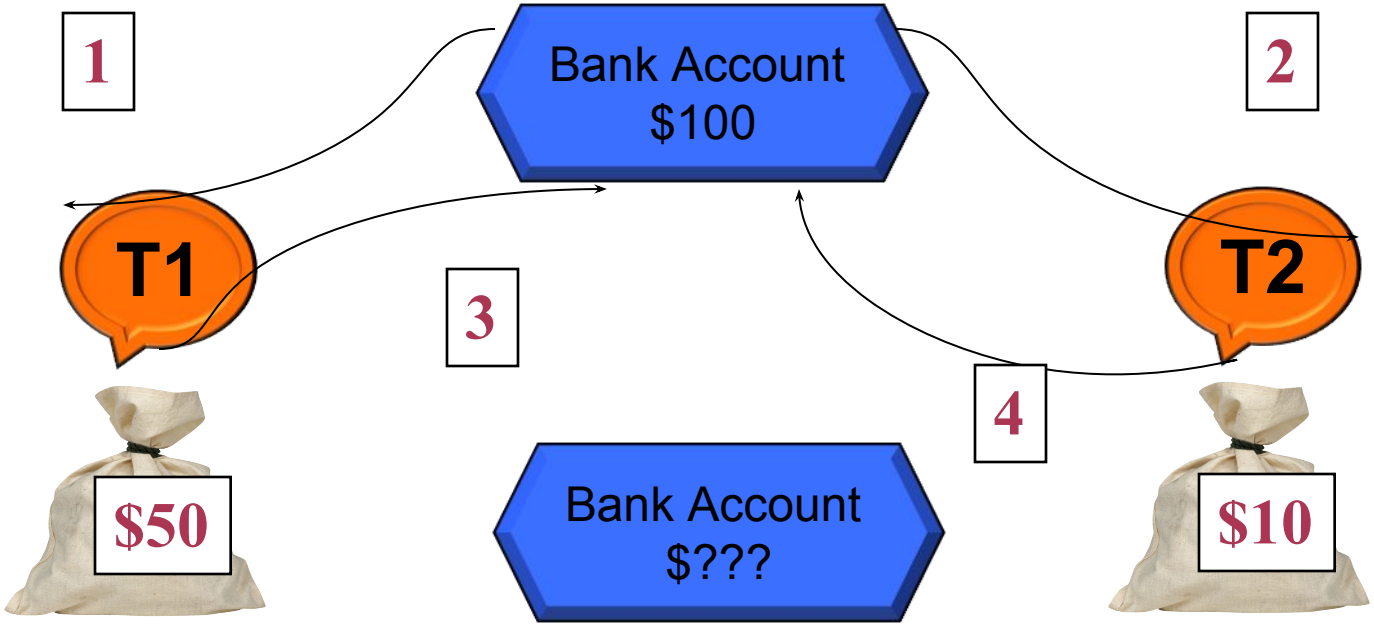
Bank Account – Race Condition

Race Condition

```
getResource();
modifyResource();
setResource();
```

Example: Bank Account

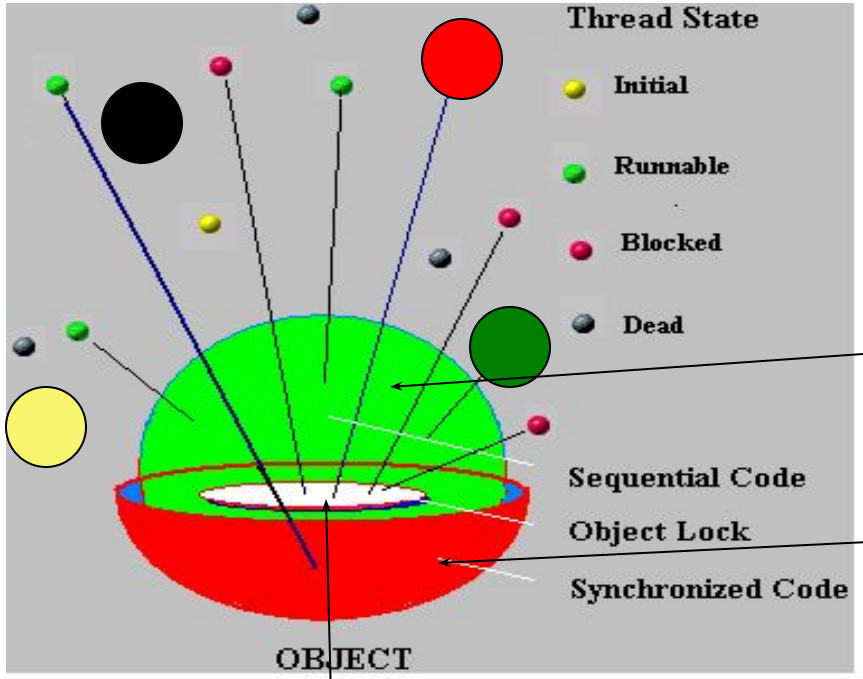
```
I.   x = account.getBalance();
II.  x = x + deposit;
III. account.setBalance(x);
```



Synchronization Concepts

- Synchronization is built around the concept known as the *intrinsic lock*
- Every object has an intrinsic lock associated with it
- A thread that needs access to an object's fields has to *acquire* the object's intrinsic lock
- A thread has to *release* the intrinsic lock when it's done with an object
- A thread is said to *own the intrinsic lock* since acquires until releases the object's intrinsic lock
- Any *other thread will block* when it attempts to acquire the object's intrinsic lock, if the lock is owned by another thread

Thread State and Intrinsic Lock



Unsynchronized Code

Synchronized Code

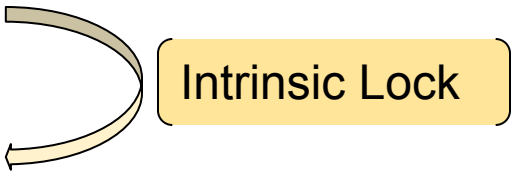
Object Intrinsic Lock

1. Initial
2. Runnable
3. Blocked
4. Dead

Synchronized Methods

- When a thread invokes a synchronized method, it automatically acquires the intrinsic lock for that method's object
- In a synchronized method, the thread releases the acquired lock when the method returns

```
class X extends Thread {
...
  synchronized void method(...) {
    ...
    return;
  }
  public static void main(...) {
    Thread t = new X();
    t.method();
  }
}
```



Synchronized Statements

- Synchronized statements <u>must specify the object that provides the intrinsic lock</u>
- In a synchronized statements , the <u>thread releases</u> the acquired lock <u>when the last statement is executed</u>

```
public void addName(String studentName) {
    synchronized(this) {
        lastName = studentName;
        nameCount++;
    }
    studentList.add(studentName);
}
```

Intrinsic Lock

Example Synchronized Method

```
public class SynThread implements Runnable {
  private String holdA = "This is ";
  private int[] holdB = {1,2,3,4,5,6,7,8,9,10};

  //without synchronized keyword
  public void run() {
    for(int w = 0; w < 10; w++) {
      System.out.println(holdA + holdB[w] + ".");
    }
  }

  public static void main(String args[]) {
    SynThread z = new SynThread();
    new Thread(z).start();
    new Thread(z).start();
  }
}
```

Run this code twice: 1. as is, and 2. add **`synchronized`** keyword to **`run`** method.
Can you see the difference?

Liveness

Liveness is the property of a concurrent application to execute in a timely manner.

Liveness Problems:

1. *Deadlock*
   Deadlock occurs when multiple threads need the same locks but obtain them in different order

2. *Starvation*
   Starvation occurs when a thread is unable to gain regular access to shared resources and is unable

Deadlock Example

The threads `t1` and `t2` are blocked forever, waiting for each other - this problem is defined as being a *deadlock*

```
public class Deadlock {
  public static void main(String[] args) {

    final Object r1 = "r1";
    final Object r2 = "r2";

    Thread t1 = new Thread(() -> {synchronized(r1){
                                    synchronized(r2){}
                                  } });

    Thread t2 = new Thread(() -> {synchronized(r2){
                                    synchronized(r1){}
                                  } });
    t1.start();
    t2.start();
  }
}
```