Part IV
Other Systems: I
Java Threads

C is quirky, flawed, and an enormous success.

Fall 2017
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Java Threads: 1/6

- Java has two ways to create threads:
  - Create a new class derived from the `Thread` class and overrides its `run()` method. This is similar to that of `ThreadMentor`.
  - Define a class that implements the `Runnable` interface.
Java Threads: 2/6

- **Method #1**: Use the Thread class

```java
public class HelloThread extends Thread {
    public void run() {
        System.out.println("Hello World");
    }
    public static void main(String[] args) {
        HelloThread t = new HelloThread();
        t.start();
    }
}
```
Java Threads: 3/6

- **Method #2:** Use the `Runnable` interface defined as follows:

```java
public interface Runnable {
    public abstract void run();
}
```
class Foo {
    String name;
    public Foo(String s) { name = s; }
    public void setName(String s) { name = s; }
    public String getName() { return name; }
}

class FooBar extends Foo implements Runnable {
    public FooBar(String s) { super(s); }
    public void run() {
        for (int i = 0; i < 10; i++)
            System.out.println(getName() +": Hello World");
    }
}

public static void main(String[] args) {
    FooBar f1 = new FooBar("Romeo");
    Thread t1 = new Thread(f1);   t1.start();
    FooBar f2 = new FooBar("Juliet");
    Thread t2 = new Thread(f2);   t2.start();
}
public class Fibonacci extends Thread {
    int n, result;
    public Fibonacci(int n) { this.n = n; }
    public void run() {
        if ((n == 0) || (n == 1))
            result = 1;
        else {
            Fibonacci f1 = new Fibonacci(n-1);
            Fibonacci f2 = new Fibonacci(n-2);
            f1.start(); f2.start();
            try {
                f1.join(); f2.join();
            } catch (InterruptedException e) {};
            result = f1.getResult()+f2.getResult();
        }
    }
    public int getResult() { return result; }
}
public static void main(String[] args) {
    Fibonacci f1 =
        new Fibonacci(Integer.parseInt(args[0]));
    f1.start();
    try {
        f1.join();
    } catch (InterruptedException e) {
    };
    System.out.println("Ans = "+f1.getResult());
}
The synchronized Keyword

- The synchronized keyword of a block implements mutual exclusion.

```java
public class Counter{
    private int count = 0;
    public int inc()
    {
        synchronized(this)
        {
            return ++count;
        }
    }
}
```

this is a critical section
A lock provides exclusive access to a shared resource: only one thread at a time can acquire the lock and all access to the shared resource requires that the lock be acquired first.

A **ReentrantLock** is similar to the **synchronized** keyword.

You may use `lock()` to acquire a lock and `unlock()` to release a lock.

There are other methods (e.g., `tryLock()`).
The following is a typical use of locks in Java.

```java
Lock myLock = new ReentrantLock();

myLock.lock();  // acquire a lock
try {
    // in critical section now
    // catch exceptions and
    // restore invariants if needed
} finally {
    myLock.unlock();
}
```
Java `wait()` and `notify()`: 1/7

- Method `wait()` causes a thread to release the lock it is holding on an object, allowing another thread to run.
- `wait()` should always be wrapped in a `try` block because it throws `IOException`.
- `wait()` can only be invoked by the thread that owns the lock on the object.
- The thread that calls `wait()` becomes inactive until it is notified. Note that actual situation can be more complex than this.
Java \texttt{wait()} and \texttt{notify()} \( : 2/7 \)

- A thread uses the \texttt{notify()} method of an object to release a waiting thread or the \texttt{notifyAll()} method to release all waiting threads.
- After \texttt{notify()} or \texttt{notifyAll()}, a thread may be picked by the thread scheduler and resumes its execution.
- Then, this thread regains its lock automatically.
- Using \texttt{notify()} and \texttt{notifyAll()} as the last statement can avoid many potential problems.
Java wait() and notify(): 3/7

```java
public class Counter implements BoundedCounter {
    protected long count = MIN;
    public synchronized long value() { return count; }
    public synchronized long inc() {
        awaitINC(); setCount(count+1);
    }
    public synchronized long dec() {
        awaitDEC(); setCount(count-1);
    }
    protected synchronized void setCount(long newVal) {
        count = newVal; notifyAll();
    }
    protected synchronized void awaitINC() {
        while (count >= MAX)
            try { wait(); } catch(InterruptedException e) {
            }
    }
    protected synchronized void awaitDEC() {
        while (count <= MIN)
            try { wait(); } catch(InterruptedException e) {
            }
    }
}
```
public final class CountingSemaphore {
    private int count = 0;
    public CountingSemaphore(int initVal) {
        count = initVal;
    }

    public synchronized void P() // semaphore wait
    {
        count--;
        while (count < 0)
        {
            try { wait();} catch (InterruptedException e){} 
        }
    }

    public synchronized void V() // semaphore signal
    {
        count++;
        notify();
    }
}
Java \texttt{wait()} and \texttt{notify()} : 5/7

```java
public class Buffer implements BoundedBuffer {
    protected Object[] buffer;
    protected int in;
    protected int out;
    protected int count;
    public Buffer(int size)
        throws IllegalArgumentException {
            if (size <= 0)
                throw new IllegalArgumentException();
            buffer = new Object[size];
        }
    public int GetCount() { return count; }
    public int capacity() { return Buffer.length; }
    // methods put() and get()
}
```

Part 1/3
Java `wait()` and `notify()`: 6/7

```java
public synchronized void put(Object x)
{
    while (count == Buffer.length)
        try { wait(); } 
          catch(InterruptedException e){};
    Buffer[in] = x;
    in = (in + 1) % Buffer.length;
    if (count++ == 0)
        notifyAll();
}
```

Part 2/3
Java `wait()` and `notify()`: 7/7

```java
public synchronized void get(Object x) {
    while (count == 0)
        try { wait(); }
        catch(InterruptedException e){};
    Object x = Buffer[out];
    Buffer[out] = null;
    out = (out + 1) % Buffer.length;
    if (count-- == Buffer.length) 
        notifyAll();
    return x;
}
```

Part 3/3
The End