Java Concurrency

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Staring a New Thread

```
public class HelloRunnable implements Runnable {
    @Override
    public void run() {
        System.out.println("Hello from a thread!");
    }

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

or

```
 public class HelloThread extends Thread {
     @Override
     public void run() {
         System.out.println("Hello from a thread!");
     }

     public static void main(String args[]) {
         (new HelloThread()).start();
     }
 }
```

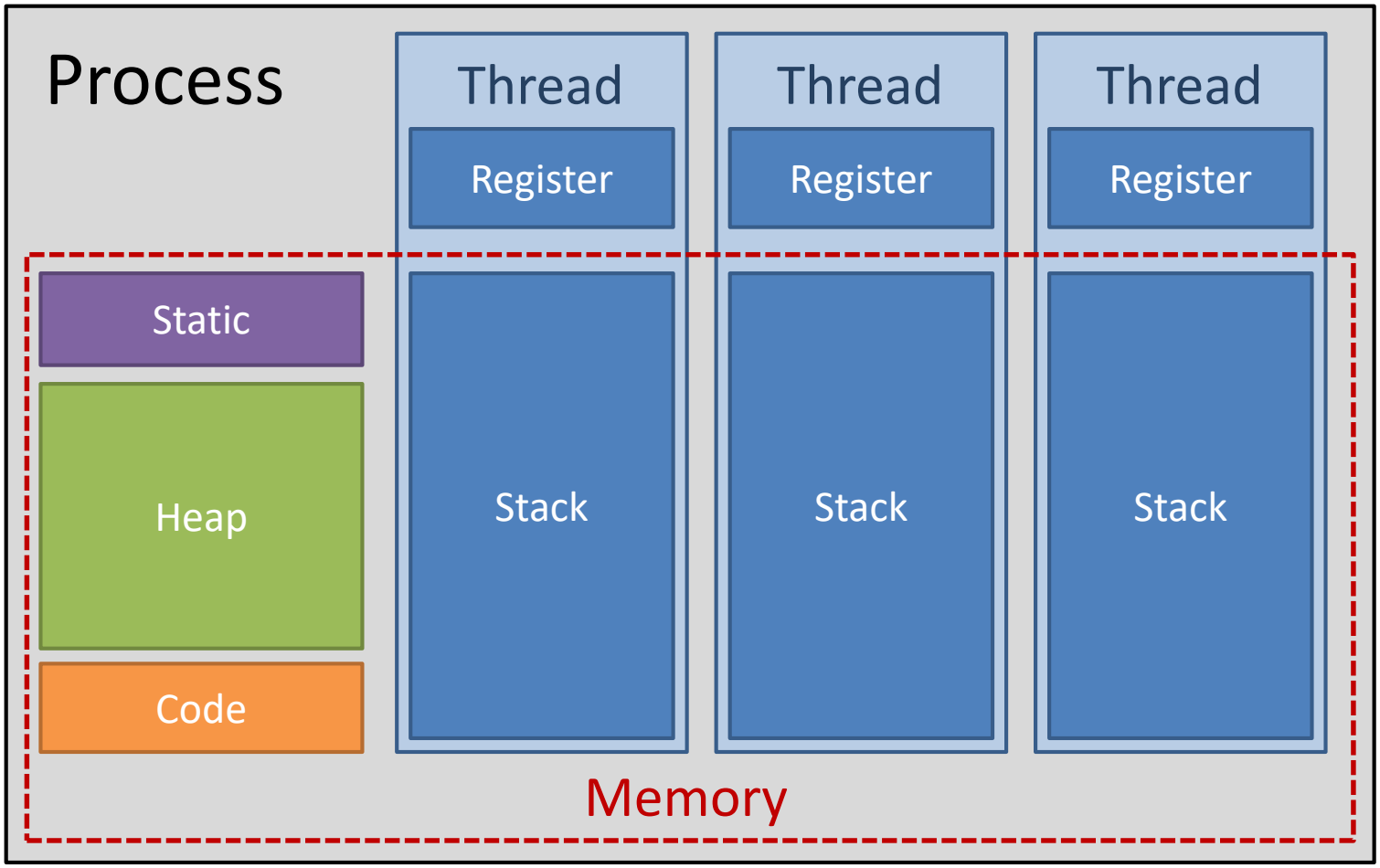
What Happened?

```
public class HelloRunnable implements Runnable {
    @Override
    public void run() {
        System.out.println("Hello from a thread!");
    }

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

- A new stack is allocated for `run()`, in addition to that of `main()`
- Your CPU spends time on executing `run()` ***in parallel with*** `main()`

Memory Scheme in a Process



Multiple Stacks, Single Heap

- The heap in memory scheme?
  - Stores objects
  - ***Shared by all threads***
- Can two threads access the same object? Yes
- How? Passing the same object to their constructors

```
public static void main(String args[]) {
    Counter counter = ...;
    (new Thread(new HelloRunnableA(counter))).start(); // thread A
    (new Thread(new HelloRunnableB(counter))).start(); // thread B
}
```

Concurrent Access

- Given the same object `counter`
- Suppose both threads execute in `run()`:

```
int c = counter.get();
c++; // c--;
counter.set(c);
```

```
class Counter {
    private int c = 0;
    Public void set(int c) {
        This.c = c;
    }
    public int get() {
        return c;
    }
}
```

- Thread A's result will be lost if
  1. Thread A: Get c
  2. Thread B: Get c
  3. Thread A: Increment retrieved value; result is 1
  4. Thread B: Decrement retrieved value; result is -1
  5. Thread A: Set result in c; c is now 1.
  6. Thread B: Set result in c; c is now -1.

Synchronization

```
public class SynchronizedCounter {
    private int c = 0;
    public synchronized void set(int c) {
        this.c = c;
    }
    public synchronized int get() {
        return c;
    }
}
```

- Only one thread can enter sync. block of an obj. at a time
- Problem solved?

- Same as…

```
public class SynchronizedCounter {
    private int c = 0;
    public void set(int c) {
        synchronized (this) {
            this.c = c;
        }
    }
    public int get() {
        synchronized (this) {
            return c;
        }
    }
}
```

Still Wrong!

- Two threads in `run()`:

```
... // counter is a SynchronizedCounter instance
int c = counter.get();
c++; // c--;
counter.set(c);
```

- Thread A's result will still be lost if
  1. Thread A: Get c
  2. Thread B: Get c
  3. Thread A: Increment retrieved value; result is 1
  4. Thread B: Decrement retrieved value; result is -1
  5. Thread A: Set result in c; c is now 1.
  6. Thread B: Set result in c; c is now -1.

Synchronization at Right Place

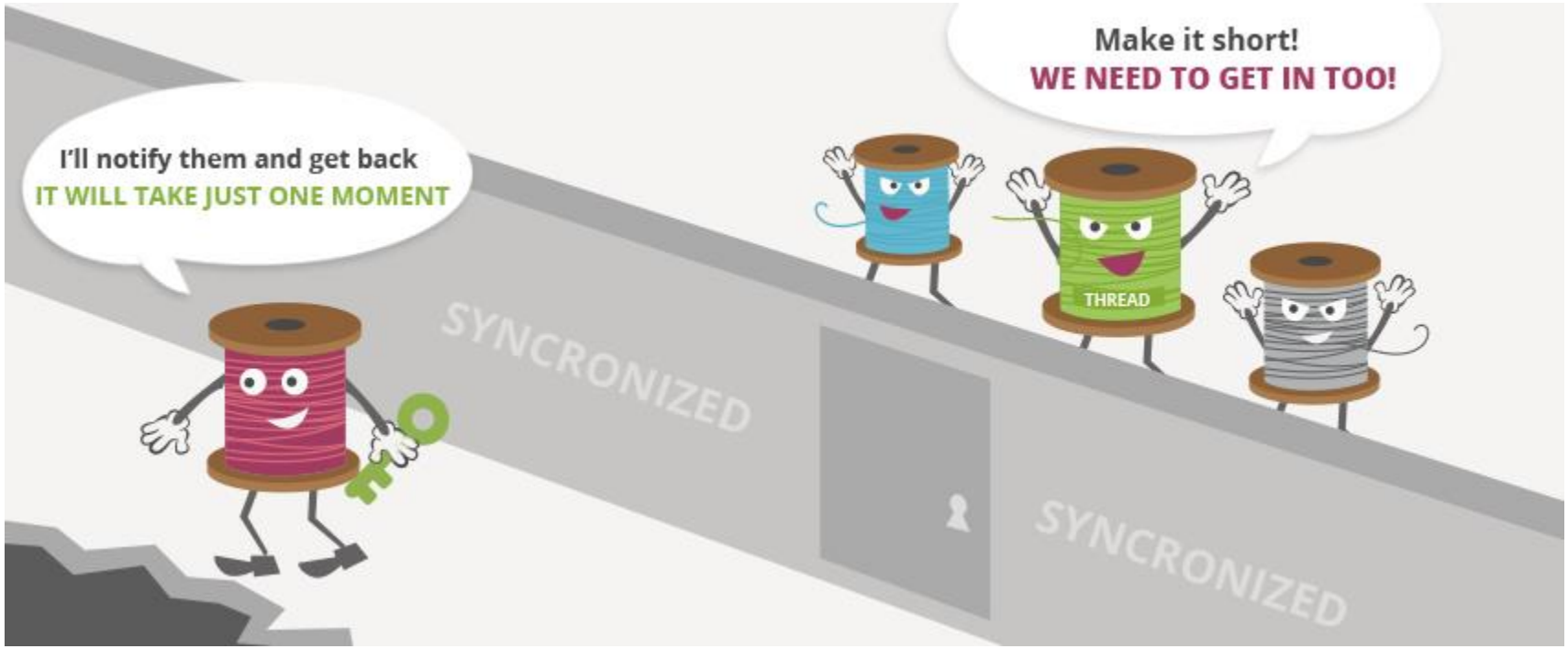
- Solution1: callers lock `counter` during the entire increment/decrement period:

```
synchronized(counter){
    int c = counter.get();
    c++; // or c--;
    counter.set(c);
}
```

- Solution2: callee provides atomic methods

```
public class SynchronizedCounter {
    private int c = 0;
    public void synchronized increment() {
        c++;
    }
    public int get() {
        return c;
    }
}
```

Synchronization



Source

Blocking and Waiting States

- Threads are ***blocked*** outside a critical section if someone is in
- Thread *A* in a critical section of `o` can stop and enter the ***waiting*** state by calling `o.wait()`
  - Gives up the lock, so some other blocking thread *B* can enter the critical section
  - If *B* calls `o.notifyAll()`, *A* competes for the lock again and resume

Wrap `wait()` in a Loop

- It's a good practice to warp `wait()` in a loop to prevent bugs
- Queue length: 10

Threads A, B:

```
// enqueue
synchronized(queue) {
    while(queue.size() == 10) {
        queue.wait();
    }
    queue.add(...);
    queue.notifyAll();
}
```

Threads C, D:

```
// dequeue
synchronized(queue) {
    while (queue.size() == 0) {
        queue.wait();
    }
    ... = queue.remove();
    queue.notifyAll();
}
```

Assigned Reading

- Java Concurrency Tutorial