Java Tutorial

CS 131a

Fall 2014

Overview

- Classes and methods
- Interfaces, generics
- Input and output
- **Threads**
- Tips

- Slides online: http://rmarcus.info/slides.pdf

Classes

- All code is contained within a **class**
  - Has same name as file
- Classes can have **methods**

- Special method **main** is an entry point

Example

```
// Basics.java
public class Basics {
    public static void main(String[] args) {
        System.out.println(“Hello World!”);
    }
}
```

Example

```
// Basics.java
public class Basics {
    public static void main(String[] args) {
        System.out.println(“Hello World!”);
    }
}
```

Class name matches file name

Example

```
// Basics.java
public class Basics {
    public static void main(String[] args) {
        System.out.println(“Hello World!”);
    }
}
```

Entry point method

Example

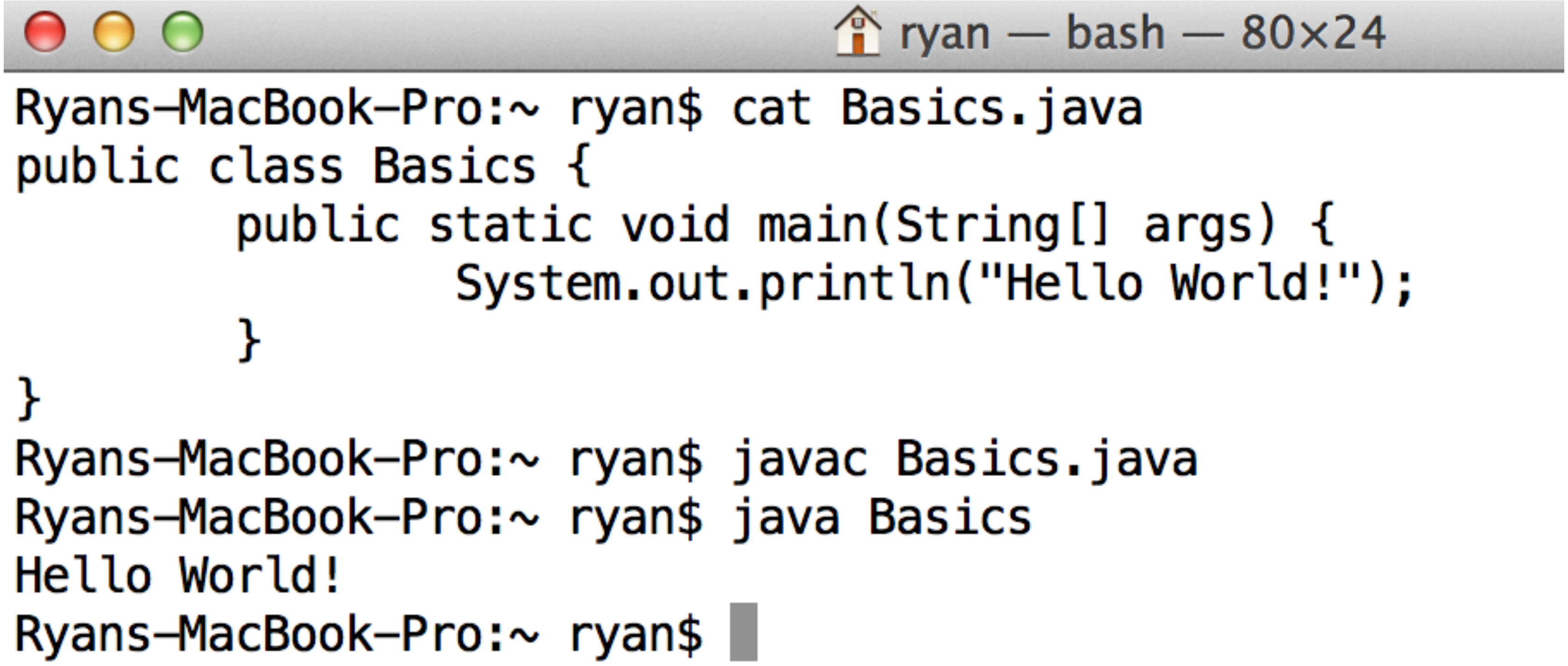
```
// Basics.java
public class Basics {
    public static void main(String[] args) {
        System.out.println(“Hello World!”);
    }
}
```

Command line arguments

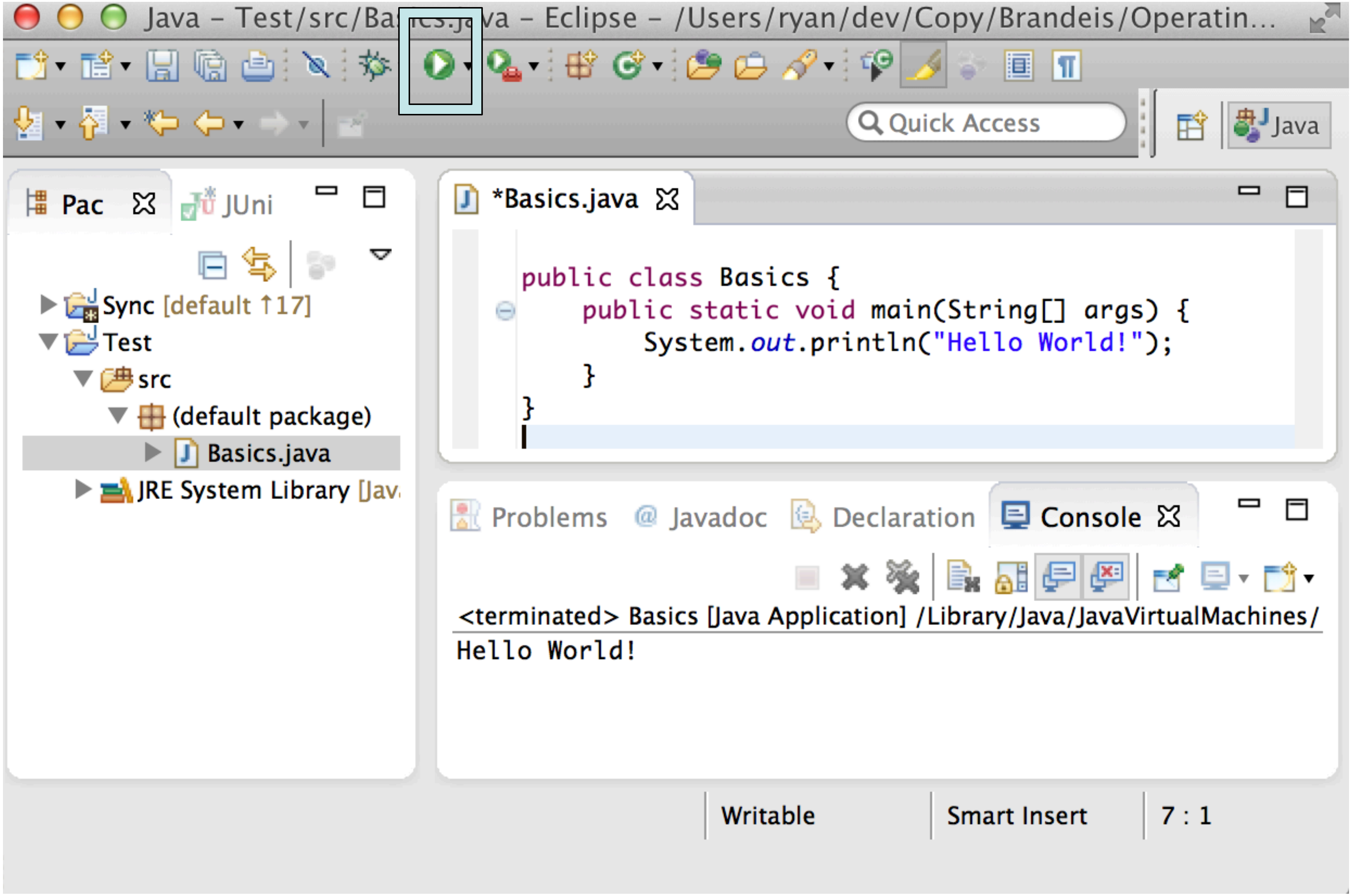
Example

```
// Basics.java
public class Basics {
    public static void main(String[] args) {
        System.out.println(“Hello World!”);
    }
}
```

Prints “Hello World!”



```
Ryans-MacBook-Pro:~ ryan$ cat Basics.java
public class Basics {
        public static void main(String[] args) {
                System.out.println("Hello World!");
        }
}
Ryans-MacBook-Pro:~ ryan$ javac Basics.java
Ryans-MacBook-Pro:~ ryan$ java Basics
Hello World!
Ryans-MacBook-Pro:~ ryan$ 
```



Java – Test/src/Basics.java – Eclipse – /Users/ryan/dev/Copy/Brandeis/Operatin...

*Basics.java

```java
public class Basics {
    public static void main(String[] args) {
        System.out.println("Hello World!");
    }
}
```

<terminated> Basics [Java Application] /Library/Java/JavaVirtualMachines/

```
Hello World!
```

```
// Sample.java
public class Sample {
    private int sampleSize;

    public Sample(int n) {
        this.sampleSize = n;
    }

    public void printReport() {
        System.out.println(“n = “ + sampleSize);
    }
}
```

```
// Sample.java
public class Sample {
    private int sampleSize;

    public Sample(int n) {
        this.sampleSize = n;
    }

    public void printReport() {
        System.out.println(“n = “ + sampleSize);
    }
}
```

Class and file name match

```
// Sample.java
public class Sample {
    private int sampleSize;

    public Sample(int n) {
        this.sampleSize = n;
    }

    public void printReport() {
        System.out.println(“n = “ + sampleSize);
    }
}
```

Class field

```
// Sample.java
public class Sample {
    private int sampleSize;

    public Sample(int n) {
        this.sampleSize = n;
    }

    public void printReport() {
        System.out.println(“n = “ + sampleSize);
    }
}
```

Constructor

```
// Sample.java
public class Sample {
    private int sampleSize;

    public Sample(int n) {
        this.sampleSize = n;
    }

    public void printReport() {
        System.out.println(“n = “ + sampleSize);
    }
}
```

“this” refers to current instance

```
// Sample.java
public class Sample {
    private int sampleSize;

    public Sample(int n) {
        this.sampleSize = n;
    }

    public void printReport() {
        System.out.println(“n = “ + sampleSize);
    }
}
```

Method signature

```
// Sample.java
public class Sample {
    private int sampleSize;

    public Sample(int n) {
        this.sampleSize = n;
    }

    public void printReport() {
        System.out.println(“n = “ + sampleSize);
    }
}
```

Field access

```
// Scope.java
public class Scope {
    private int n;
    public Scope() {
        n = 5;
    }
    public void printN() {
        int n = 1000;
        System.out.println(n);
        System.out.println(this.n);
    }
}
```

Scope

```
// Scope.java
public class Scope {
    private int n;
    public Scope() {
        n = 5;
    }
    public void printN() {
        int n = 1000;
        System.out.println(n);
        System.out.println(this.n);
    }
}
```

Scope

```java
// Scope.java
public class Scope {
    private int n;
    public Scope() {
        n = 5;
    }
    public void printN() {
        int n = 1000;
        System.out.println(n);
        System.out.println(this.n);
    }
}
```

Output:

```
5
1000
```

Scope

Interfaces

- An **interface** is a contract
- Set of methods that a class will implement
- Also a **type**

```
// Blog.java
public interface Blog {
    public String getBlogName();
    public String getAuthorName();
}
```

```java
// Blog.java
public interface Blog {
    public String getBlogName();
    public String getAuthorName();
}
```

Same name as the file

```
// Blog.java
public interface Blog {
    public String getBlogName();
    public String getAuthorName();
}
```

“interface” instead of class

```
// Blog.java
public interface Blog {
    public String getBlogName();
    public String getAuthorName();
}
```

Signature only! No body!

```
// HuffPost.java
public class HuffPost implements Blog {
    @Override
    public String getBlogName() {
        return “The Huffington Post”;
    }

    @Override
    public String getAuthorName() {
        return “A bunch of liberals”;
    }
}
```

```
// HuffPost.java
public class HuffPost implements Blog {
    @Override
    public String getBlogName() {
        return “The Huffington Post”;
    }

    @Override
    public String getAuthorName() {
        return “A bunch of liberals”;
    }
}
```

Class name and file name match

```
// HuffPost.java
public class HuffPost implements Blog {
    @Override
    public String getBlogName() {
        return “The Huffington Post”;
    }

    @Override
    public String getAuthorName() {
        return “A bunch of liberals”;
    }
}
```

“implements” clause

```
// HuffPost.java
public class HuffPost implements Blog {
    @Override
    public String getBlogName() {
        return “The Huffington Post”;
    }

    @Override
    public String getAuthorName() {
        return “A bunch of liberals”;
    }
}
```

Optional annotation

```
// HuffPost.java
public class HuffPost implements Blog {
    @Override
    public String getBlogName() {
        return “The Huffington Post”;
    }

    @Override
    public String getAuthorName() {
        return “A bunch of liberals”;
    }
}
```

Matching signature with bodies

```
// HuffPost.java
public class HuffPost implements Blog {
    @Override
    public String getBlogName() {
        return “The Huffington Post”;
    }

    @Override
    public String getAuthorName() {
        return “A bunch of liberals”;
    }
}
```

Methods implemented

```
// GG.java
public class GG implements Blog {
    @Override
    public String getBlogName() {
        return “Gossip Girl”;
    }

    @Override
    public String getAuthorName() {
        return “One secret I’ll never tell”;
    }
}
```

Another implementing class

```
public void test() {
    Blog b1 = new HuffPost();
    Blog b2 = new GG();

    ArrayList<Blog> br = new ArrayList<Blog>();
    br.add(b1);
    br.add(b2);

    System.out.println(br.get(0).getBlogName());
    System.out.println(br.get(1).getAuthorName());
}
```

```
public void test() {
    Blog b1 = new HuffPost();
    Blog b2 = new GG();

    ArrayList<Blog> br = new ArrayList<Blog>();
    br.add(b1);
    br.add(b2);

    System.out.println(br.get(0).getBlogName());
    System.out.println(br.get(1).getAuthorName());
}
```

Implementing classes are typed

```
public void test() {
    Blog b1 = new HuffPost();
    Blog b2 = new GG();

    ArrayList<Blog> br = new ArrayList<Blog>();
    br.add(b1);
    br.add(b2);

    System.out.println(br.get(0).getBlogName());
    System.out.println(br.get(1).getAuthorName());
}
```

Can be added to collections

```
public void test() {
    Blog b1 = new HuffPost();
    Blog b2 = new GG();

    ArrayList<Blog> br = new ArrayList<Blog>();
    br.add(b1);
    br.add(b2);

    System.out.println(br.get(0).getBlogName());
    System.out.println(br.get(1).getAuthorName());
}
```

Can use methods declared in interface

```
public void test() {
    Blog b1 = new HuffPost();
    Blog b2 = new GG();

    ArrayList<Blog> br = new ArrayList<Blog>();
    br.add(b1);
    br.add(b2);

    System.out.println(br.get(0).getBlogName());
    System.out.println(br.get(1).getAuthorName());
}
```

Output:

```
The Huffington Post
One secret I’ll never tell
```

Input and Output

- "Standard" in and out
  - `System.out` and `System.in`
- File input and output
  - For refresher, go here:
  - http://docs.oracle.com/javase/tutorial/essential/io/

```
public void test() {
    Scanner in = new Scanner(System.in);
    String name = in.nextLine();
    System.out.println(“Hello, ” + name + “!”);
}
```

```
public void test() {
    Scanner in = new Scanner(System.in);
    String name = in.nextLine();
    System.out.println(“Hello, ” + name + “!”);
}
```

Create a new scanner on stdin

```
public void test() {
    Scanner in = new Scanner(System.in);
    String name = in.nextLine();
    System.out.println(“Hello, ” + name + “!”);
}
```

Can be any InputStream

```
public void test() {
    Scanner in = new Scanner(System.in);
    String name = in.nextLine();
    System.out.println(“Hello, ” + name + “!”);
}
```

Block until user hits “enter”

```
public void test() {
    Scanner in = new Scanner(System.in);
    String name = in.nextLine();
    System.out.println(“Hello, ” + name + “!”);
}
```

Greet the user

Threads

- Running two things at once
- Many classes provided to make your life easier
- Synchronization issues

Threads

- Running two things at once
  - Sort of
- Many classes provided to make your life easier
- Synchronization issues

Creating Threads

- `Thread` class, requires a `Runnable`
- `Runnable` (interface) requires one method, `run()`

Creating Threads

- `Thread` class, requires a `Runnable`
- `Runnable` (interface) requires one method, `run()`

1. Create a new Runnable **r**
2. Create a new thread **t**, `new Thread(r)`
3. Start the thread, `t.start()`
4. Wait for it, `t.join()`

```
public class GG implements Runnable {
    @Override
    public void run() {
        System.out.print(“Welcome back,”);
        System.out.println(“Upper East Siders…”);

        // make some bad puns, process data, etc.

        System.out.println(“XOXO GG”);
    }
}
```

```
public class GG implements Runnable {
    @Override
    public void run() {
        System.out.print(“Welcome back,”);
        System.out.println(“Upper East Siders…”);

        // make some bad puns, process data, etc.

        System.out.println(“XOXO GG”);
    }
}
```

Implementing Runnable

```
public class GG implements Runnable {
    @Override
    public void run() {
        System.out.print(“Welcome back,”);
        System.out.println(“Upper East Siders…”);

        // make some bad puns, process data, etc.

        System.out.println(“XOXO GG”);
    }
}
```

Optional annotation

```
public class GG implements Runnable {
    @Override
    public void run() {
        System.out.print(“Welcome back,”);
        System.out.println(“Upper East Siders…”);

        // make some bad puns, process data, etc.

        System.out.println(“XOXO GG”);
    }
}
```

As required by Runnable

```
public class GG implements Runnable {
    @Override
    public void run() {
        System.out.print(“Welcome back,”);
        System.out.println(“Upper East Siders…”);

        // make some bad puns, process data, etc.

        System.out.println(“XOXO GG”);
    }
}
```

Code that will execute in the thread

```
public class HuffPost implements Runnable {
    @Override
    public void run() {
        System.out.print(“Blah blah blah ”);
        System.out.println(“Obama.”);

        // be insightful but kinda cheeky

        System.out.println(“MITT ROMNEY”);
    }
}
```

Another Runnable

```
public void runThread() {
    Runnable r1 = new GG();
    Runnable r2 = new HuffPost();

    Thread t1 = new Thread(r1);
    Thread t2 = new Thread(r2);

    t1.start();
    t2.start();

    t1.join();
    t2.join();
}
```

```
public void runThread() {
    Runnable r1 = new GG();
    Runnable r2 = new HuffPost();

    Thread t1 = new Thread(r1);
    Thread t2 = new Thread(r2);

    t1.start();
    t2.start();

    t1.join();
    t2.join();
}
```

Create two blogs (Runnable)

```
public void runThread() {
    Runnable r1 = new GG();
    Runnable r2 = new HuffPost();

    Thread t1 = new Thread(r1);
    Thread t2 = new Thread(r2);

    t1.start();
    t2.start();

    t1.join();
    t2.join();
}
```

Create two threads

```
public void runThread() {
    Runnable r1 = new GG();
    Runnable r2 = new HuffPost();

    Thread t1 = new Thread(r1);
    Thread t2 = new Thread(r2);

    t1.start();
    t2.start();

    t1.join();
    t2.join();
}
```

Start both threads

```
public void runThread() {
    Runnable r1 = new GG();
    Runnable r2 = new HuffPost();

    Thread t1 = new Thread(r1);
    Thread t2 = new Thread(r2);

    t1.start();
    t2.start();

    t1.join();
    t2.join();
}
```

Wait for `t1` to finish

```
public void runThread() {
    Runnable r1 = new GG();
    Runnable r2 = new HuffPost();

    Thread t1 = new Thread(r1);
    Thread t2 = new Thread(r2);

    t1.start();
    t2.start();

    t1.join();
    t2.join();
}
```

Wait for `t2` to finish

Many possible outputs

Output 1
Welcome back, Upper East Siders
Blah blah blah Obama.
XOXO GG
MITT ROMNEY

Output 2
Blah blah blah Obama.
Welcome back, Upper East Siders
XOXO GG
MITT ROMNEY

Output 3
Blah blah blah Obama.
Welcome back, Upper East Siders
MITT ROMNEY
XOXO GG

Output 4
Blah blah blah Upper East Siders.
Welcome back, Obama.
MITT ROMNEY
XOXO GG

… and many more …

Problems from Threads

- Race conditions
- Unstable ordering
- Starvation
- Deadlocks

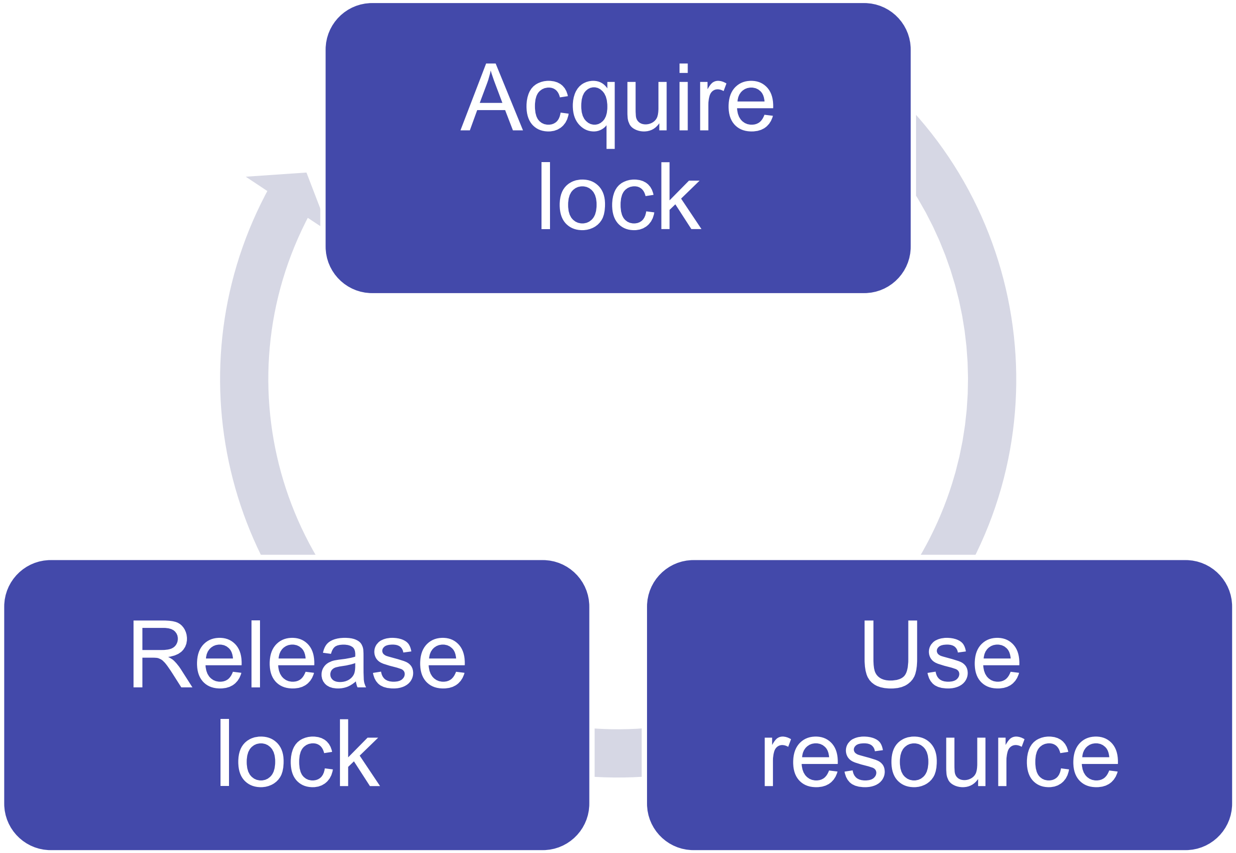
But, we have a partial solution!

- Locks!

Locks

- Mutual exclusion
- `acquire()`
- `release()`

Acquire-Use-Release Loop



```
public class GG implements Runnable {
  @Override
  public void run() {
      synchronized (System.out) {
          System.out.print(“Welcome back,”);
          System.out.println(“Upper East Siders…”);

          // make some bad puns, process data, etc.

          System.out.println(“XOXO GG”);
      }
    }
}
```

```
public class GG implements Runnable {
  @Override
  public void run() {
      synchronized (System.out) {
          System.out.print(“Welcome back,”);
          System.out.println(“Upper East Siders…”);

          // make some bad puns, process data, etc.

          System.out.println(“XOXO GG”);
      }
    }
}
```

“synchronized” block

```
public class GG implements Runnable {
  @Override
  public void run() {
      synchronized (System.out) {
          System.out.print(“Welcome back,”);
          System.out.println(“Upper East Siders…”);

          // make some bad puns, process data, etc.

          System.out.println(“XOXO GG”);
      }
    }
}
```

Object to lock on (acquire)

```
public class GG implements Runnable {
  @Override
  public void run() {
      synchronized (System.out) {
          System.out.print(“Welcome back,”);
          System.out.println(“Upper East Siders…”);

          // make some bad puns, process data, etc.

          System.out.println(“XOXO GG”);
      }
    }
}
```

“Critical section”

```
public class HuffPost implements Runnable {
  @Override
  public void run() {
    synchronized(System.out) {
        System.out.print(“Blah blah blah ”);
        System.out.println(“Obama.”);

        // be insightful but kinda cheeky

        System.out.println(“MITT ROMNEY”);
    }
  }
}
```

Another Runnable

```
public void runThread() {
    Runnable r1 = new GG();
    Runnable r2 = new HuffPost();

    Thread t1 = new Thread(r1);
    Thread t2 = new Thread(r2);

    t1.start();
    t2.start();

    t1.join();
    t2.join();
}
```

Two possible outputs

Output 1

```
Welcome back, Upper East Siders
XOXO GG
Blah blah blah Obama.
MITT ROMNEY
```

← **`t1` gets lock first**

`t2` gets lock first →

Output 2

```
Blah blah blah Obama.
MITT ROMNEY
Welcome back, Upper East Siders
XOXO GG
```

Locking Multiple Objects

- What if you need more than just `System.out`?
- Need to `acquire()` and `release()` multiple resources

```
public class ReadWrite1 implements Runnable {
  @Override
  public void run() {
    synchronized (System.out) {
      synchronized (System.in) {
        Scanner sc = new Scanner(System.in);
        String name = sc.nextLine();
        System.out.println(“Hello “ + name);
      }
    }
  }
}
```

```
public class ReadWrite1 implements Runnable {
  @Override
  public void run() {
    synchronized (System.out) {
      synchronized (System.in) {
        Scanner sc = new Scanner(System.in);
        String name = sc.nextLine();
        System.out.println(“Hello “ + name);
      }
    }
  }
}
```

Named ReadWrite1

```
public class ReadWrite1 implements Runnable {
  @Override
  public void run() {
    synchronized (System.out) {
      synchronized (System.in) {
        Scanner sc = new Scanner(System.in);
        String name = sc.nextLine();
        System.out.println(“Hello “ + name);
      }
    }
  }
}
```

Acquire System.out

```
public class ReadWrite1 implements Runnable {
   @Override
   public void run() {
      synchronized (System.out) {
         synchronized (System.in) {
            Scanner sc = new Scanner(System.in);
            String name = sc.nextLine();
            System.out.println(“Hello “ + name);
         }
      }
   }
}
```

Acquire System.in

```
public class ReadWrite1 implements Runnable {
  @Override
  public void run() {
    synchronized (System.out) {
      synchronized (System.in) {
        Scanner sc = new Scanner(System.in);
        String name = sc.nextLine();
        System.out.println(“Hello ” + name);
      }
    }
  }
}
```

Greet the user

```
public class ReadWrite2 implements Runnable {
  @Override
  public void run() {
    synchronized (System.in) {
      synchronized (System.out) {
        Scanner sc = new Scanner(System.in);
        String name = sc.nextLine();
        System.out.println(“Salve “ + name);
      }
    }
  }
}
```

```
public class ReadWrite2 implements Runnable {
  @Override
  public void run() {
    synchronized (System.in) {
      synchronized (System.out) {
        Scanner sc = new Scanner(System.in);
        String name = sc.nextLine();
        System.out.println(“Salve “ + name);
      }
    }
  }
}
```

Named ReadWrite2

```
public class ReadWrite2 implements Runnable {
  @Override
  public void run() {
    synchronized (System.in) {
      synchronized (System.out) {
        Scanner sc = new Scanner(System.in);
        String name = sc.nextLine();
        System.out.println(“Salve “ + name);
      }
    }
  }
}
```

Acquire System.in

```
public class ReadWrite2 implements Runnable {
  @Override
  public void run() {
    synchronized (System.in) {
      synchronized (System.out) {
        Scanner sc = new Scanner(System.in);
        String name = sc.nextLine();
        System.out.println(“Salve “ + name);
      }
    }
  }
}
```

Acquire System.out

```
public class ReadWrite2 implements Runnable {
   @Override
   public void run() {
      synchronized (System.in) {
         synchronized (System.out) {
            Scanner sc = new Scanner(System.in);
            String name = sc.nextLine();
            System.out.println(“Salve “ + name);
         }
      }
   }
}
```

Greet the user (in Latin!)

What happens?

- Write a driver that starts ReadWrite1, then starts ReadWrite2.
- Run the code, type my name, press enter.
- What happens?

What happens?

- Write a driver that starts ReadWrite1, then starts ReadWrite2.
- Run the code, type my name, press enter.
- What happens?

- Nothing! What went wrong?

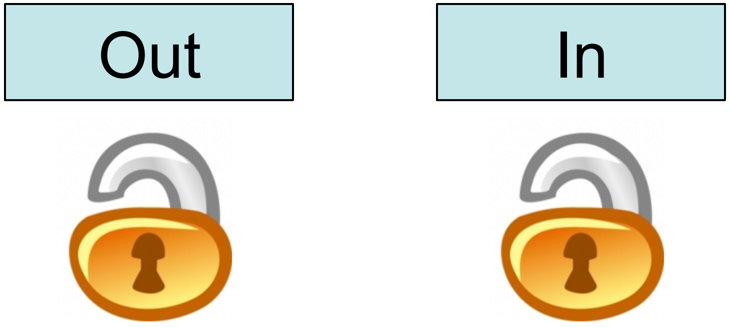
What’s going on?

ReadWrite1

- Acquire System.out
- Acquire System.in
- Greet user
- Release System.in
- Release System.out

ReadWrite2

- Acquire System.in
- Acquire System.out
- Greet user
- Release System.out
- Release System.in



Out

In

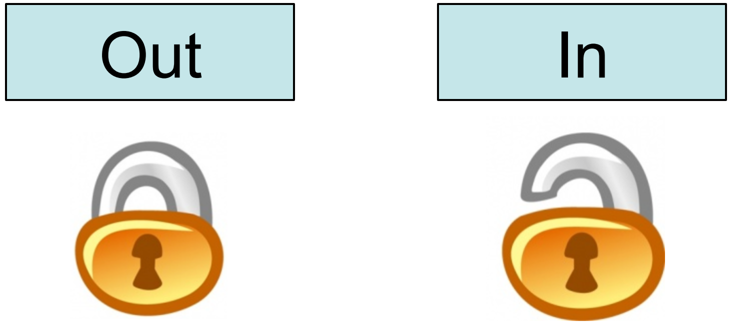
What’s going on?

ReadWrite1

- Acquire System.out
- Acquire System.in
- Greet user
- Release System.in
- Release System.out

ReadWrite2

- Acquire System.in
- Acquire System.out
- Greet user
- Release System.out
- Release System.in



Out

In

What’s going on?

CONTEXT SWITCH!

ReadWrite1

- Acquire System.out
- Acquire System.in
- Greet user
- Release System.in
- Release System.out

ReadWrite2

- Acquire System.in
- Acquire System.out
- Greet user
- Release System.out
- Release System.in

Out	In
🔒	🔓

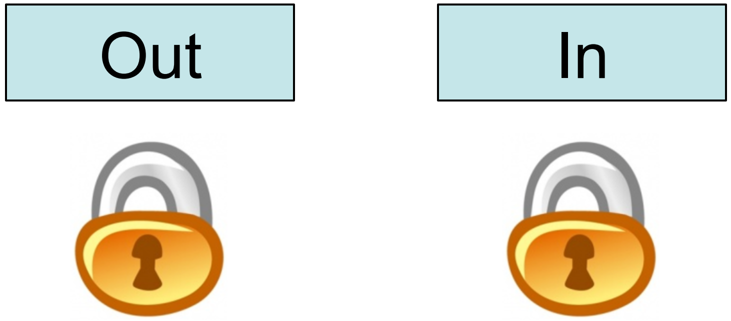
What’s going on?

ReadWrite1

- Acquire System.out
- Acquire System.in
- Greet user
- Release System.in
- Release System.out

ReadWrite2

- Acquire System.in
- Acquire System.out
- Greet user
- Release System.out
- Release System.in



Out

In

What's going on?

ReadWrite1

- Acquire System.out
- Acquire System.in
- Greet user
- Release System.in
- Release System.out

ReadWrite2

- Acquire System.in
- *Acquire System.out*
- Greet user
- Release System.out
- Release System.in

Out

In

What’s going on?

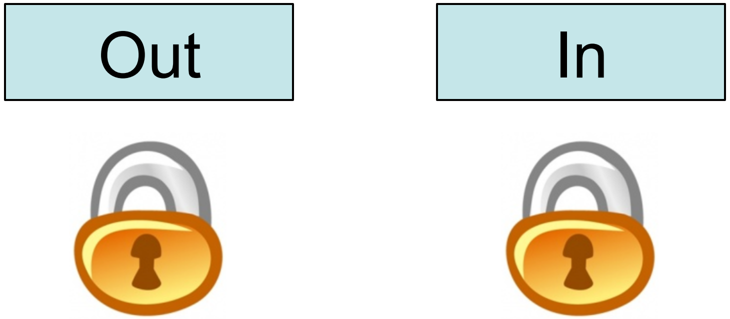
CONTEXT SWITCH!

ReadWrite1

- Acquire System.out
- Acquire System.in
- Greet user
- Release System.in
- Release System.out

ReadWrite2

- Acquire System.in
- *Acquire System.out*
- Greet user
- Release System.out
- Release System.in



Out

In

What’s going on?

ReadWrite1

- Acquire System.out
- *Acquire System.in*
- Greet user
- Release System.in
- Release System.out

ReadWrite2

- Acquire System.in
- *Acquire System.out*
- Greet user
- Release System.out
- Release System.in

Out 🔒

In 🔒

What's going on?

ReadWrite1

- Acquire System.out
- *Acquire System.in*
- Greet user
- Release System.in
- Release System.out

ReadWrite2

- Acquire System.in
- *Acquire System.out*
- Greet user
- Release System.out
- Release System.in

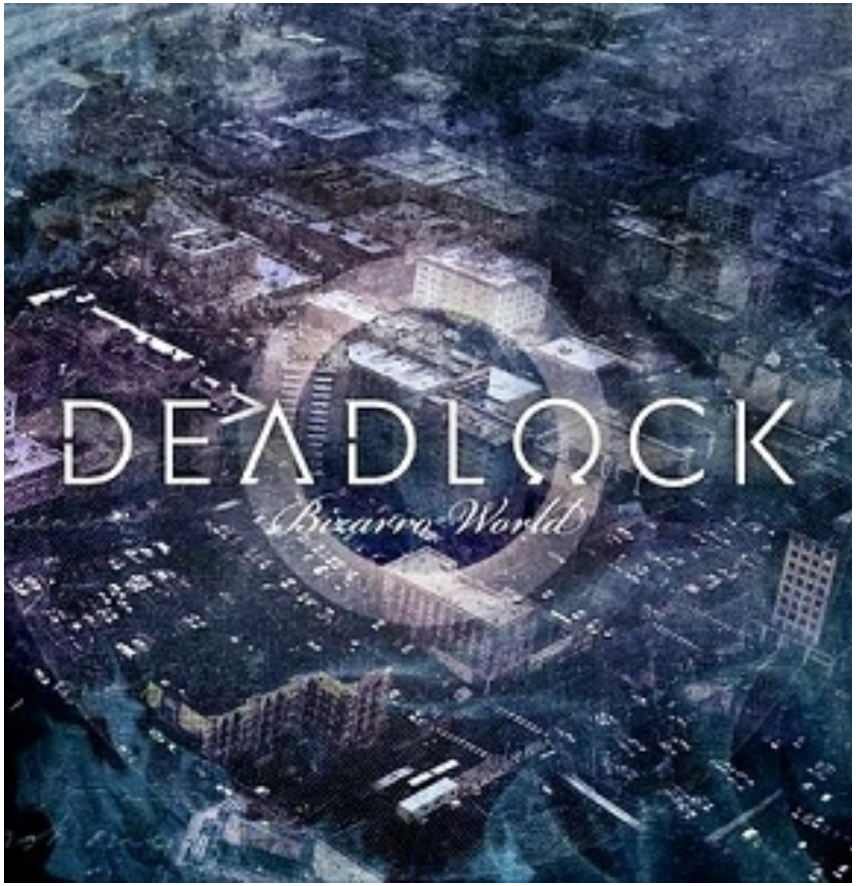
Out

In

DEAD LOCK! 🔒 🔒

Deadlock

“A deadlock is a situation in which two or more competing actions are each waiting for the other to finish, and thus neither ever does. “



(not the German metal band)

How can we fix it?

ReadWrite1

- Acquire System.out
- Acquire System.in
- Greet user
- Release System.in
- Release System.out

ReadWrite2

- Acquire System.in
- Acquire System.out
- Greet user
- Release System.out
- Release System.in

How can we fix it?

ReadWrite1

- Acquire System.out
- Acquire System.in
- Greet user
- Release System.in
- Release System.out

ReadWrite2

- Acquire System.in
- Acquire System.out
- Greet user
- Release System.out
- Release System.in

How can we fix it?

ReadWrite1

- Acquire System.out
- Acquire System.in
- Greet user
- Release System.in
- Release System.out

ReadWrite2

- Acquire System.out
- Acquire System.in
- Greet user
- Release System.in
- Release System.out

Lesson: always lock objects in the same order

Special Synchronized Methods

- You can also use “synchronized” in a method signature

```
public synchronized void myMethod() {
    // code
}
```

- Same as:

```
Object myMethodLockObj;
public void myMethod() {
    synchronized (myMethodLockObj) {

    }
}
```

Special Java Concurrent Classes

- Take a look at `java.util.concurrent`
- For PA1, you must not use `synchronized` and must use ONLY `ArrayBlockingQueue`.
- PA2, you must use ONLY `synchronized` and must NOT use `java.util.concurrent.*`

Godspeed

- PA1 Tutorial TOMORROW (9/16) at 7pm HERE.
  - **Highly recommended**
- Program early, program often
  - **Do not put it off. You will regret it and we will show no mercy.**
- Concurrency is **hard**
  - Utilize us (TA’s) and your peers during office hours or via LATTE forums.