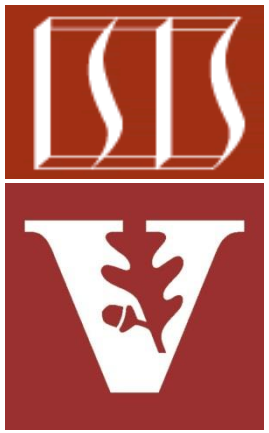
Overview of Java Threads (Part 1)



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Institute for Software Integrated Systems
Vanderbilt University
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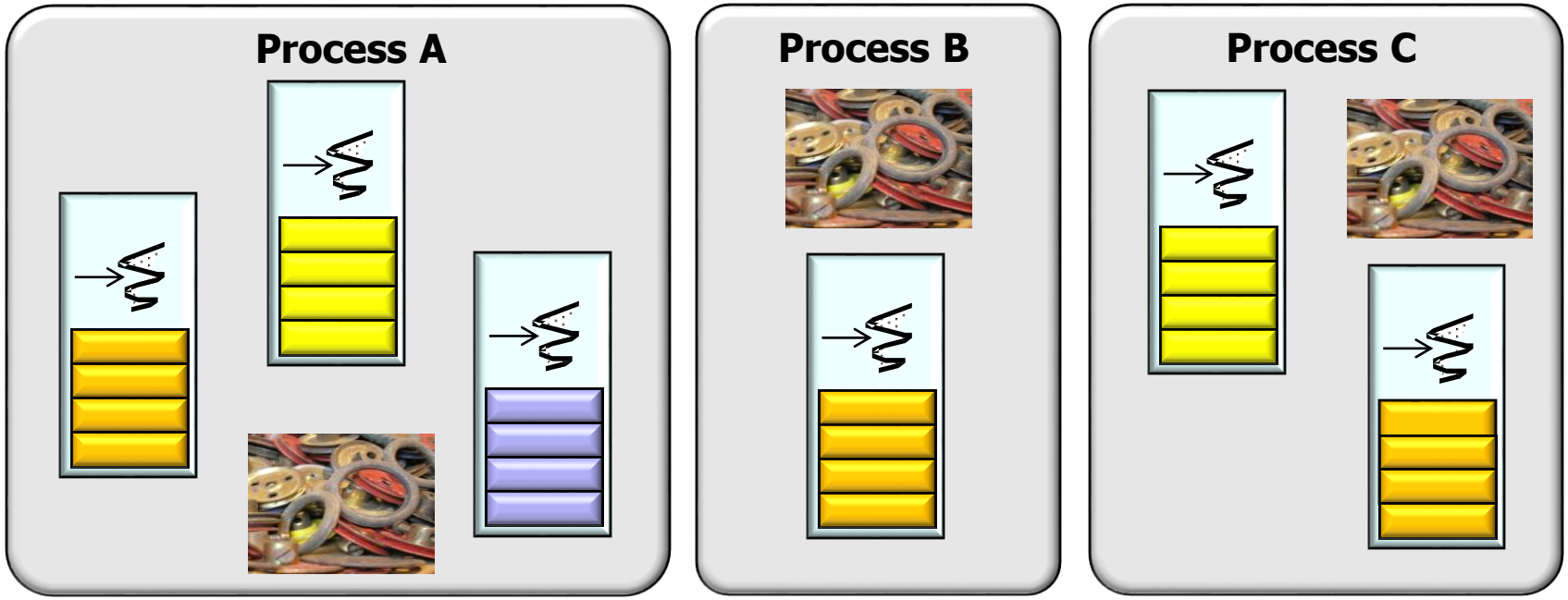
Learning Objectives in this Part of the Lesson

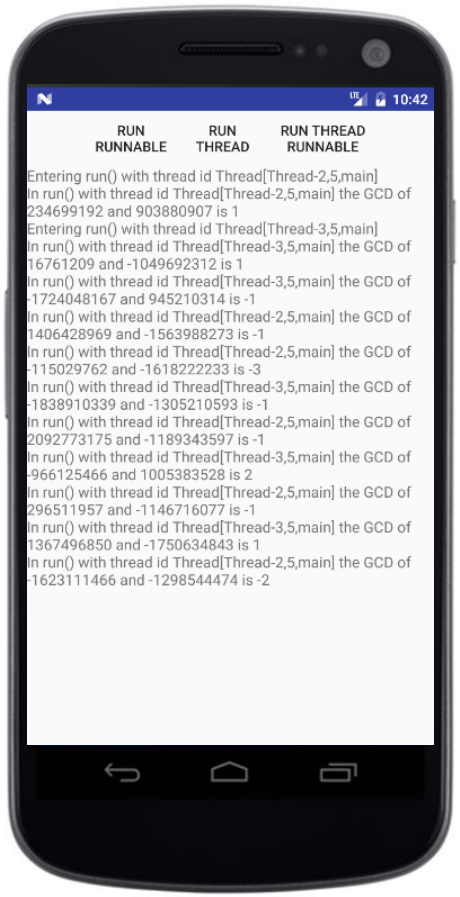
- Understand how Java threads support concurrency



Concurrent apps use threads to simultaneously run multiple computations that potentially interact with each other

Learning Objectives in this Part of the Lesson

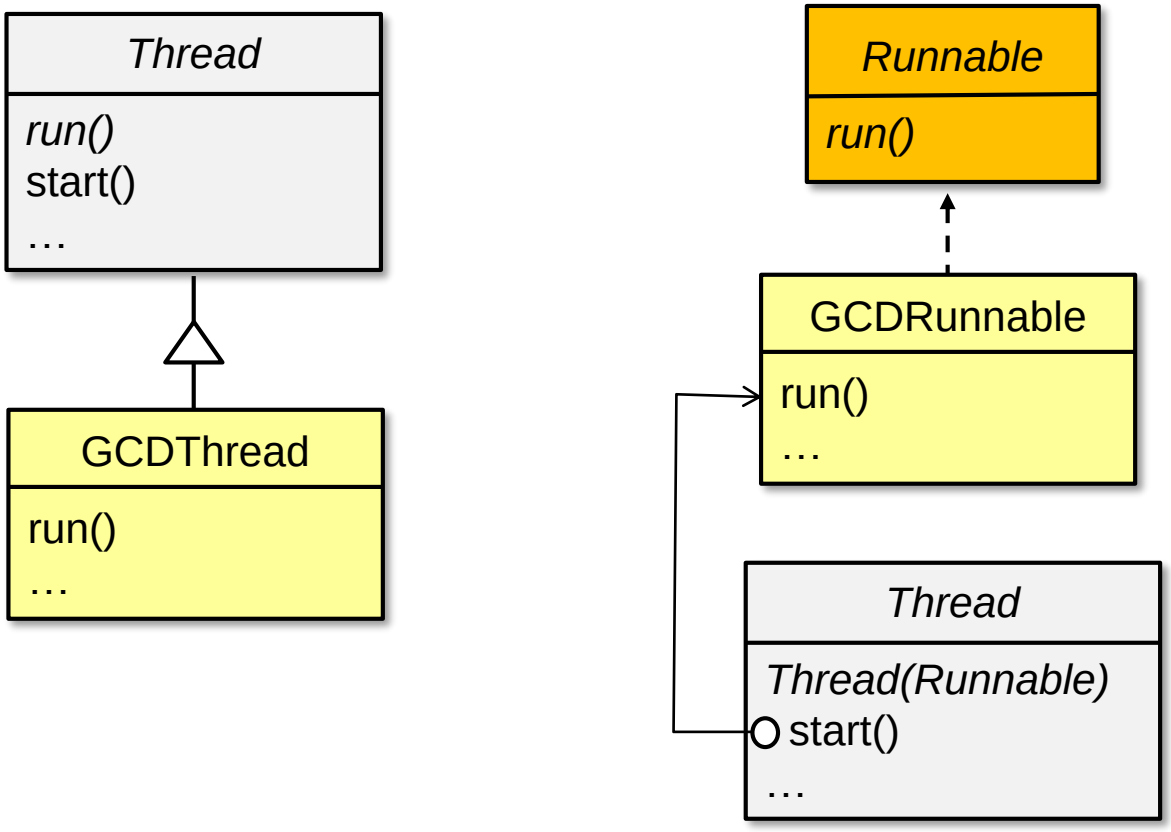
- Understand how Java threads support concurrency
- Learn how our case study app works



See github.com/douglascraigschmidt/POSA/tree/master/ex/M3/GCD/Concurrent

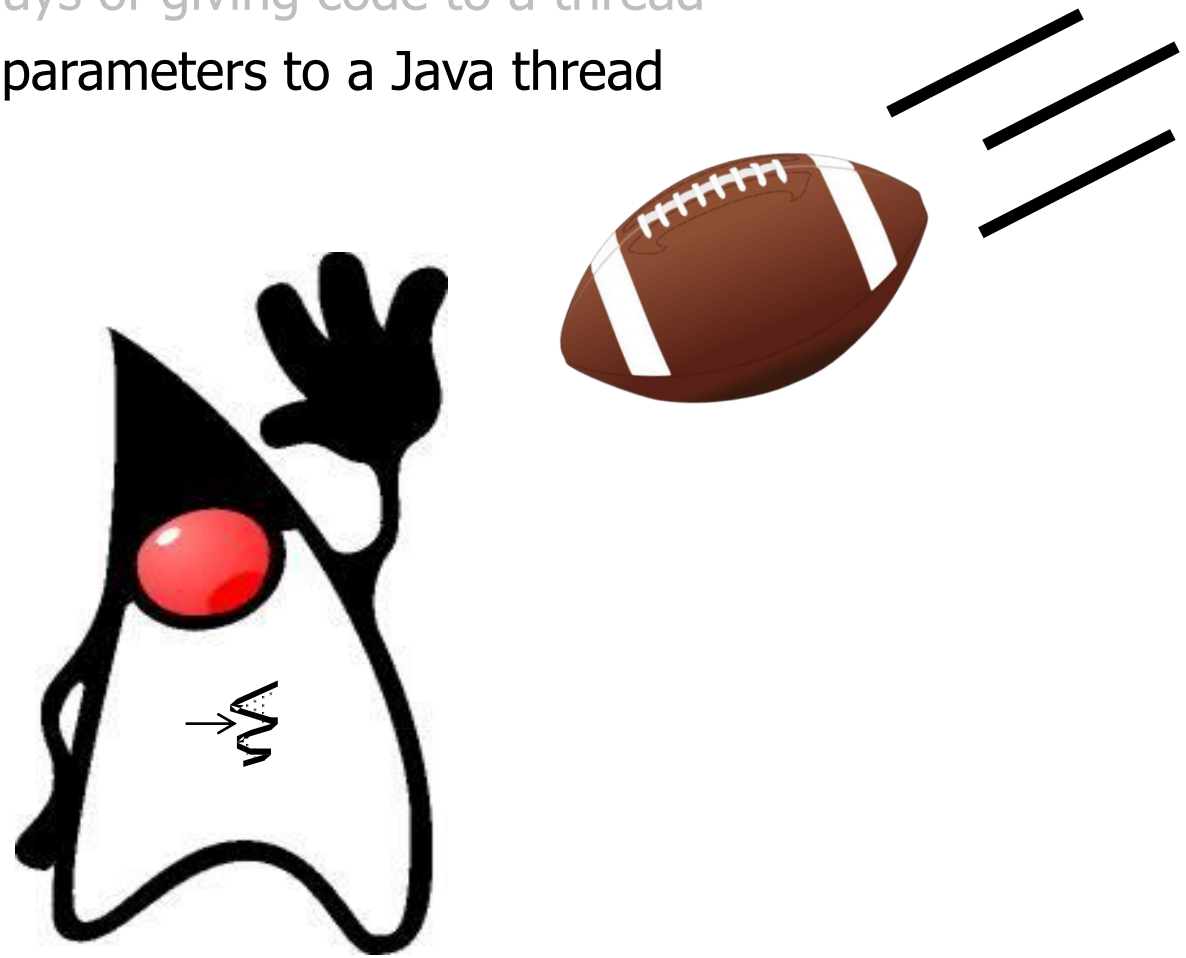
Learning Objectives in this Part of the Lesson

- Understand how Java threads support concurrency
- Learn how our case study app works
- Know alternative ways of giving code to a thread



Learning Objectives in this Part of the Lesson

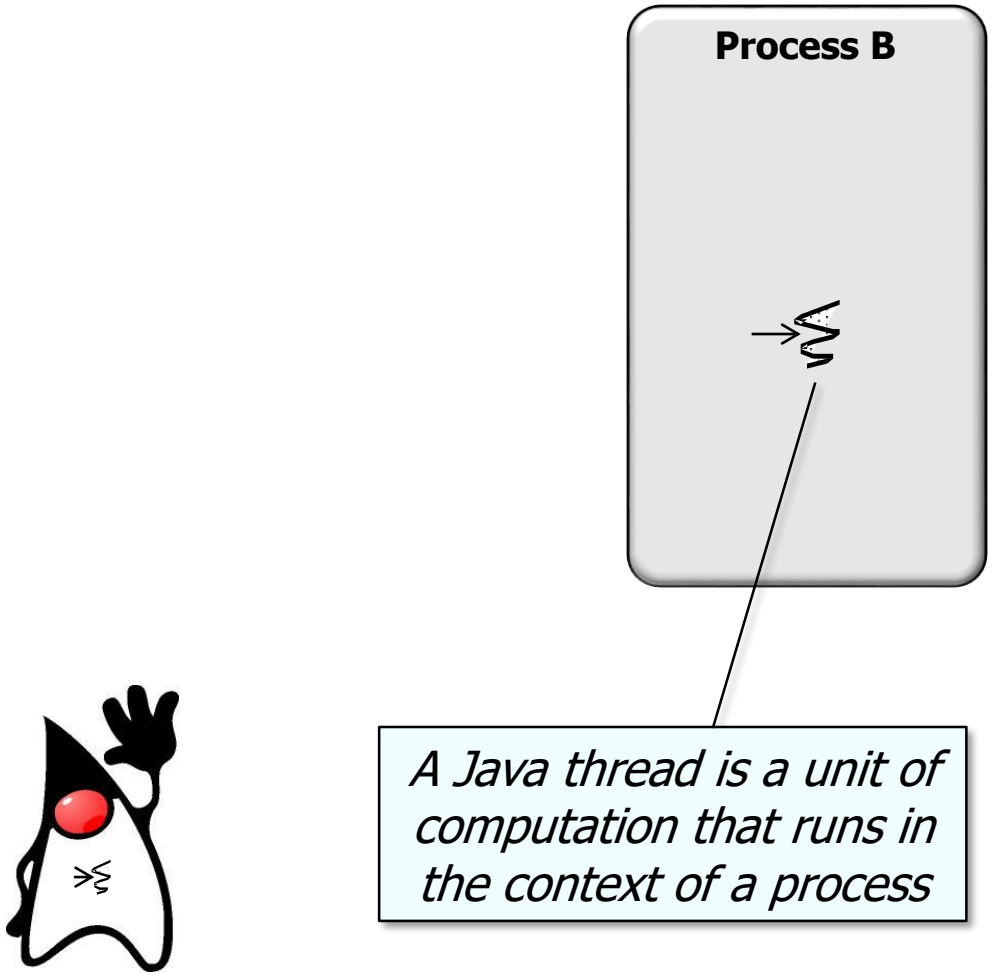
- Understand how Java threads support concurrency
- Learn how our case study app works
- Know alternative ways of giving code to a thread
- Learn how to pass parameters to a Java thread



Introduction to Java Threads

Introduction to Java Threads

- Threads are the most basic way of obtaining concurrency in Java



See en.wikipedia.org/wiki/Thread_(computing)

Introduction to Java Threads

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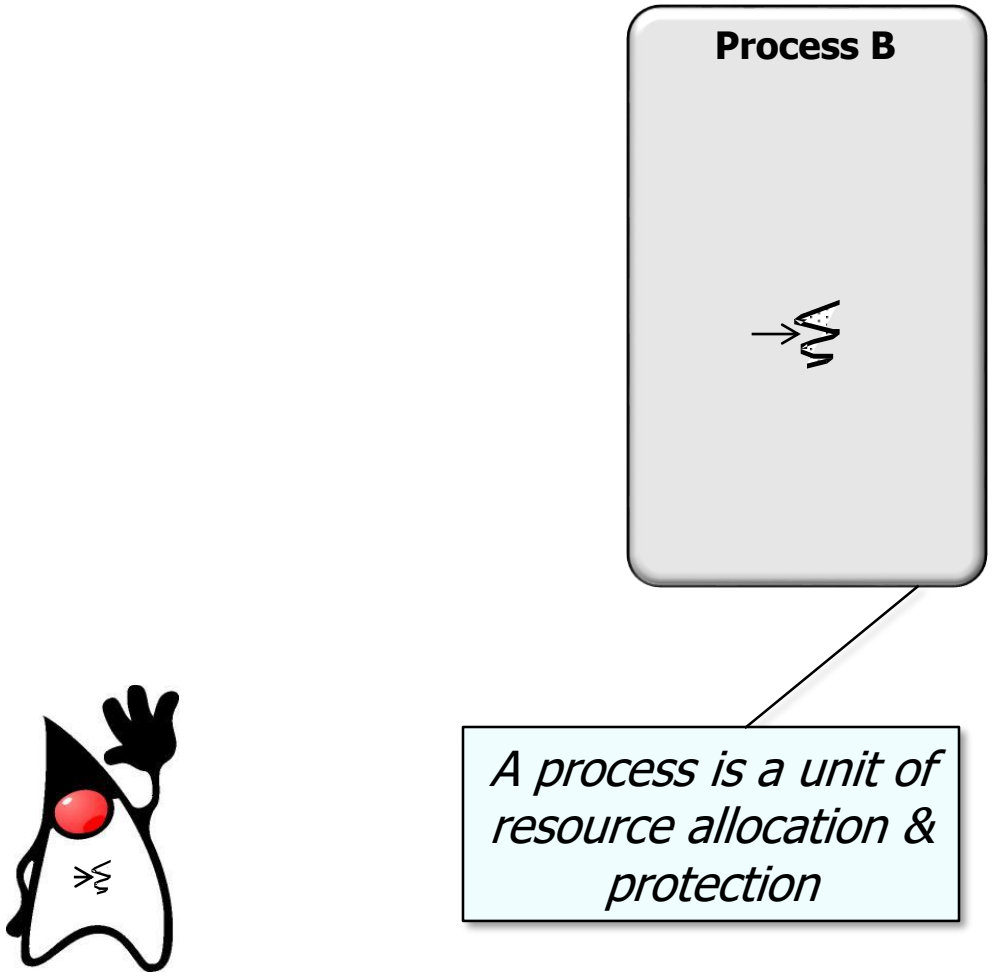

See en.wikipedia.org/wiki/Process_(computing)

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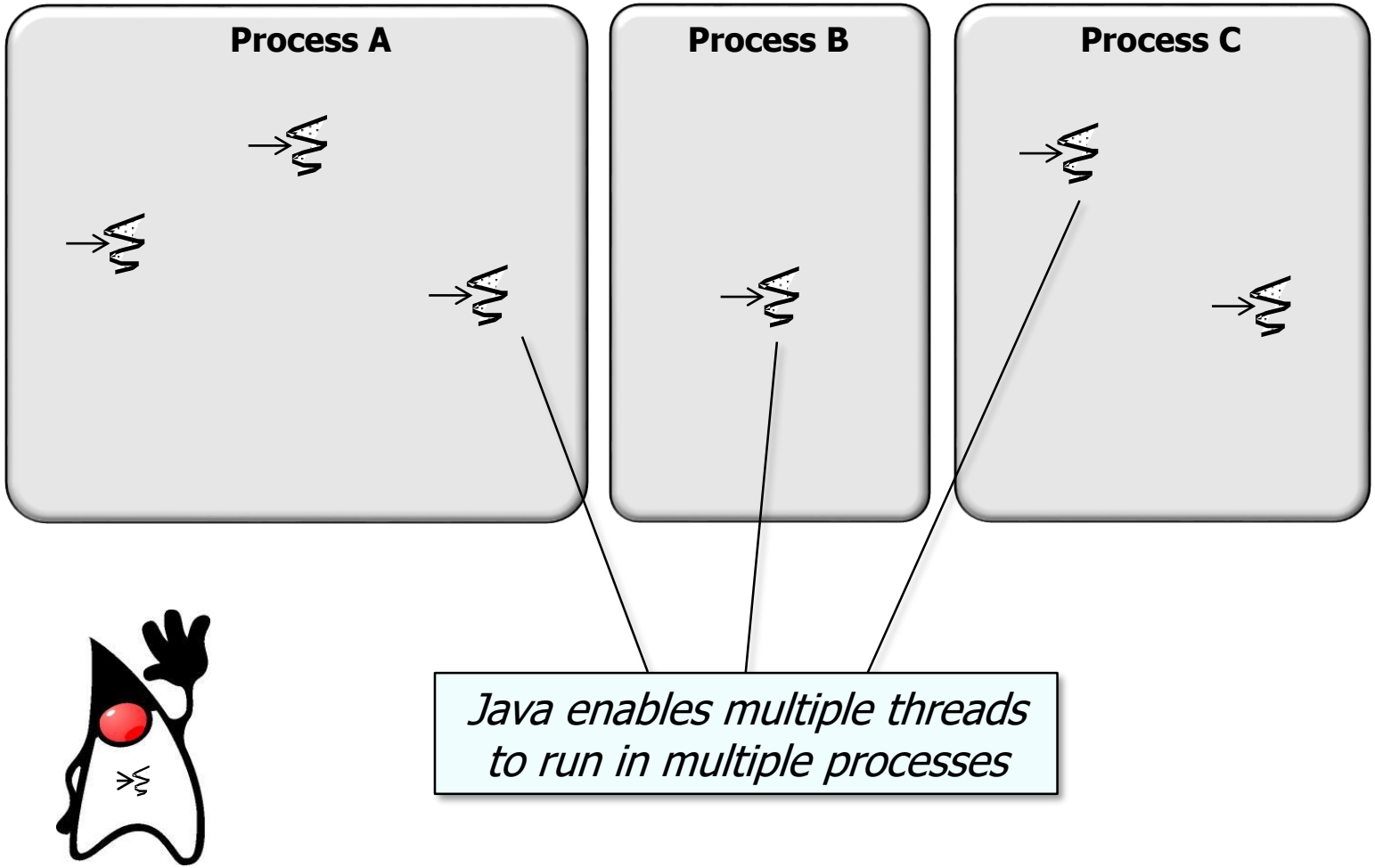

See docs.oracle.com/javase/tutorial/essential/concurrency/procthread.html

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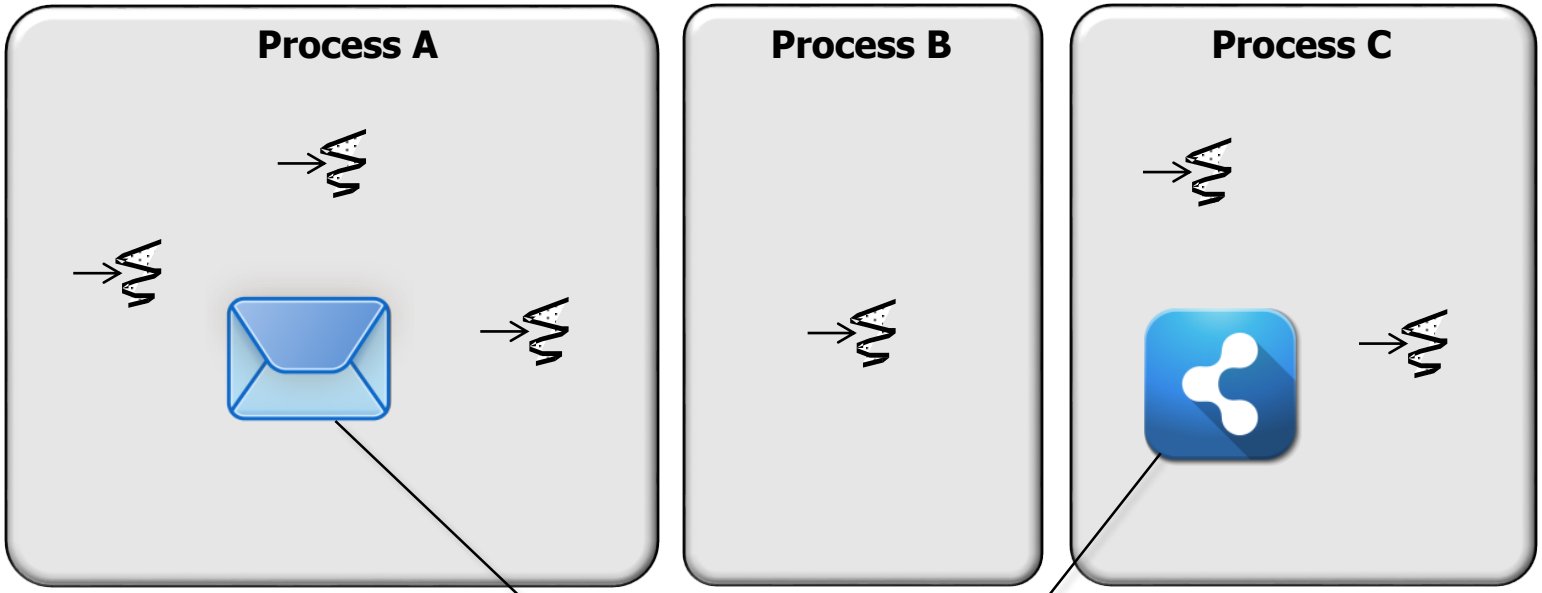

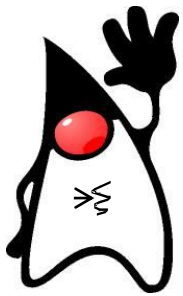

Java threads running in the same process can communicate with each other via shared objects or message passing

See www.javatpoint.com/inter-thread-communication-example & web.mit.edu/6.005/www/fa14/classes/20-queues-locks/message-passing

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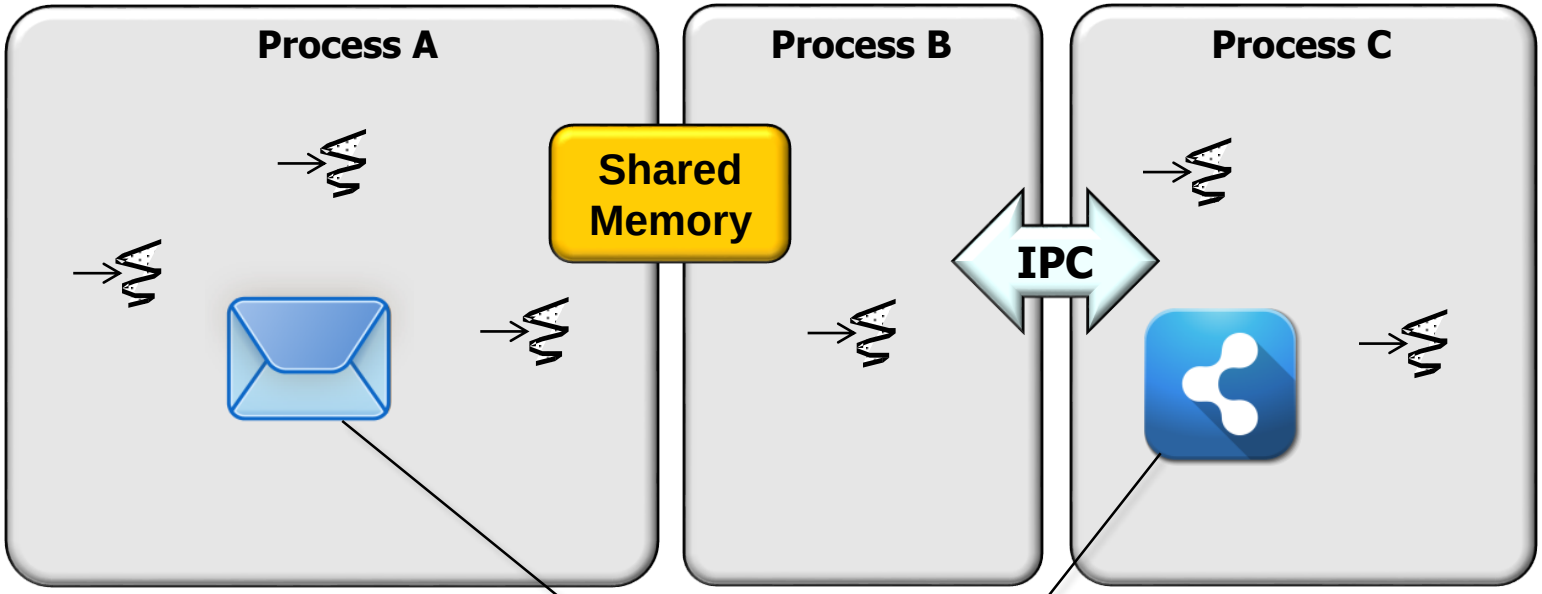

Java threads running in different processes can communicate with each other via shared memory or inter-process communication (IPC) mechanisms

We'll focus later on Android-centric forms of shared memory & IPC

Introduction to Java Threads

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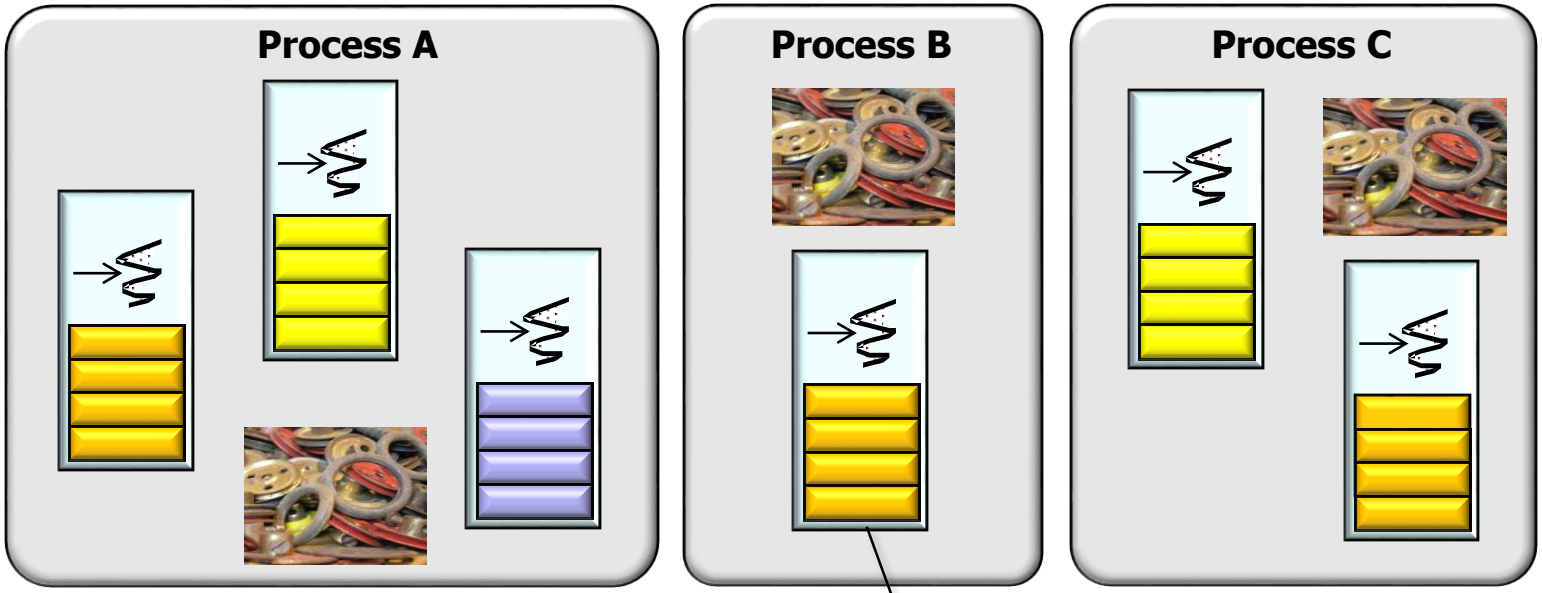

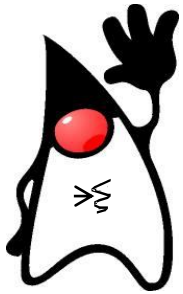

Each Java thread leverages unique "state" from the underlying operating system thread, e.g., a runtime stack, an instruction counter, & other registers

See en.wikipedia.org/wiki/Thread_(computing)#Processes.2C_kernel_threads.2C_user_threads.2C_and_fibers

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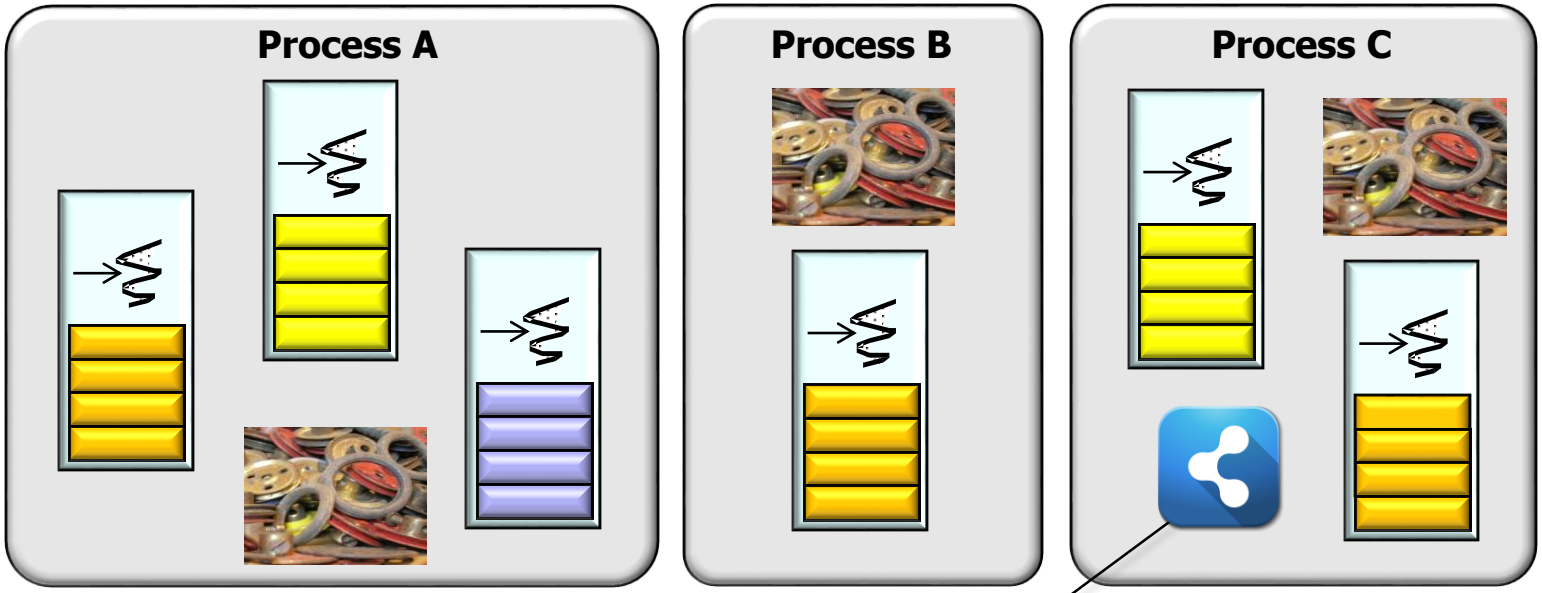

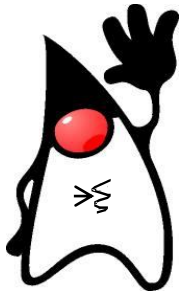

Java dynamic & static objects can be shared across Java threads (i.e., this "state" is common)

See en.wikipedia.org/wiki/Thread_(computing)#Processes.2C_kernel_threads.2C_user_threads.2C_and_fibers

The GCD Concurrent App Case Study

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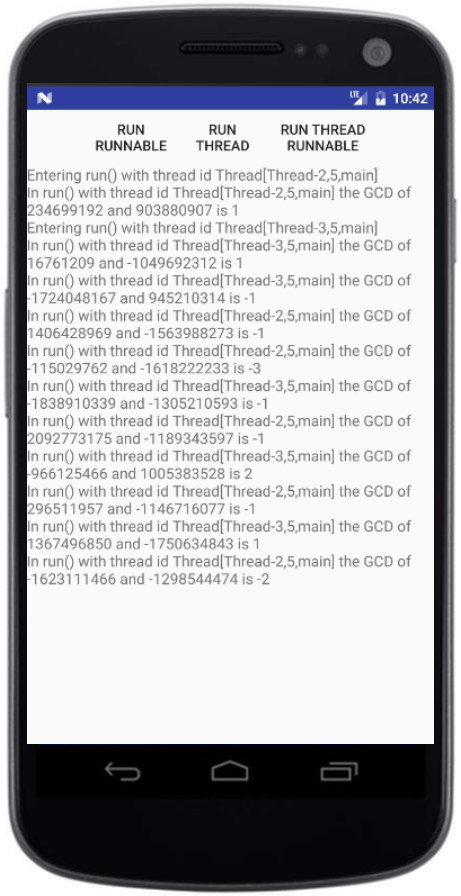
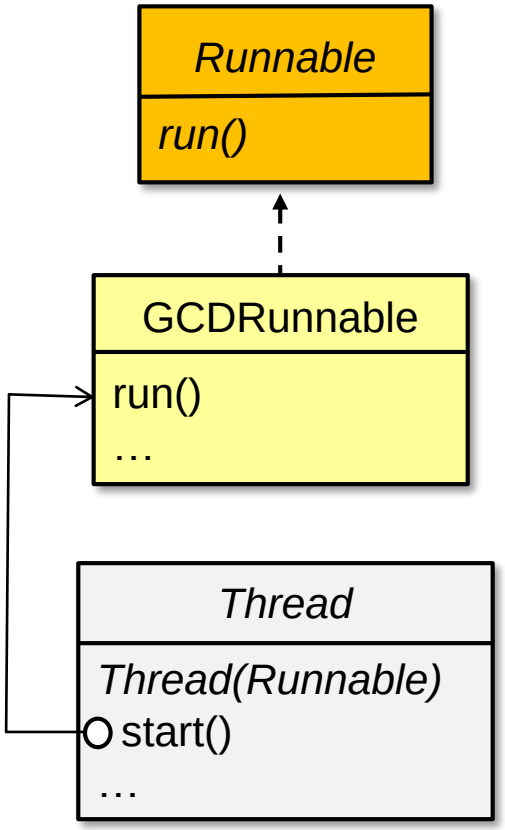
- This app shows various methods in Java's Thread class & alternative ways of giving code to a Java thread

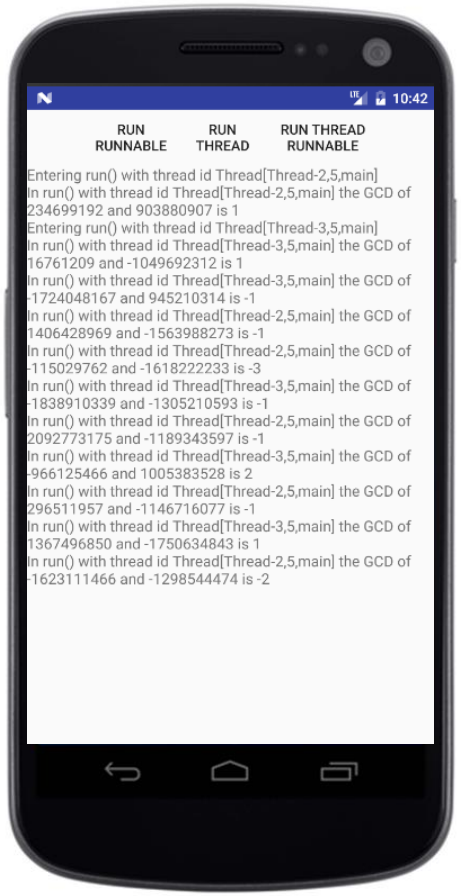


See github.com/douglascraigschmidt/POSA/tree/master/ex/M3/GCD/Concurrent

The GCD Concurrent App Case Study

- This app shows various methods in Java's Thread class & alternative ways of giving code to a Java thread, e.g.
  - By implementing the Runnable interface

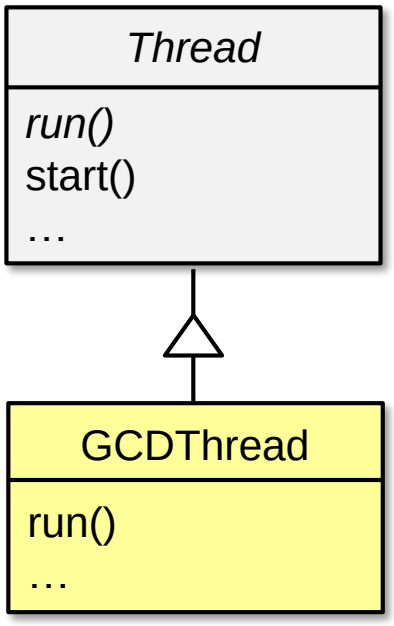


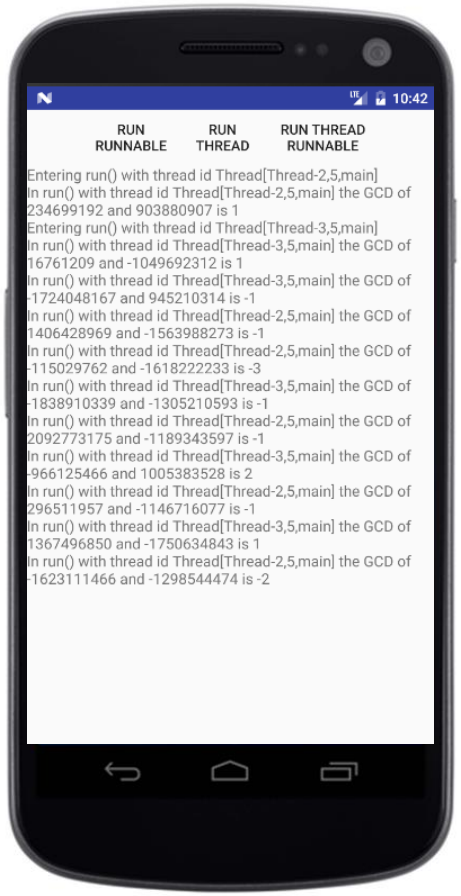


See github.com/douglascraigschmidt/POSA/tree/master/ex/M3/GCD/Concurrent/app/src/main/java/vandy/mooc/gcd/activities/GCDRunnable.java

The GCD Concurrent App Case Study

- This app shows various methods in Java's Thread class & alternative ways of giving code to a Java thread, e.g.
  - By implementing the Runnable interface
  - By inheriting from the Thread class



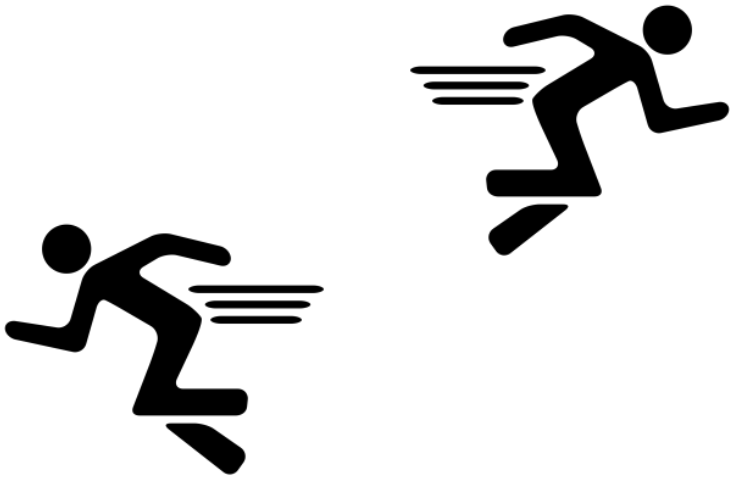


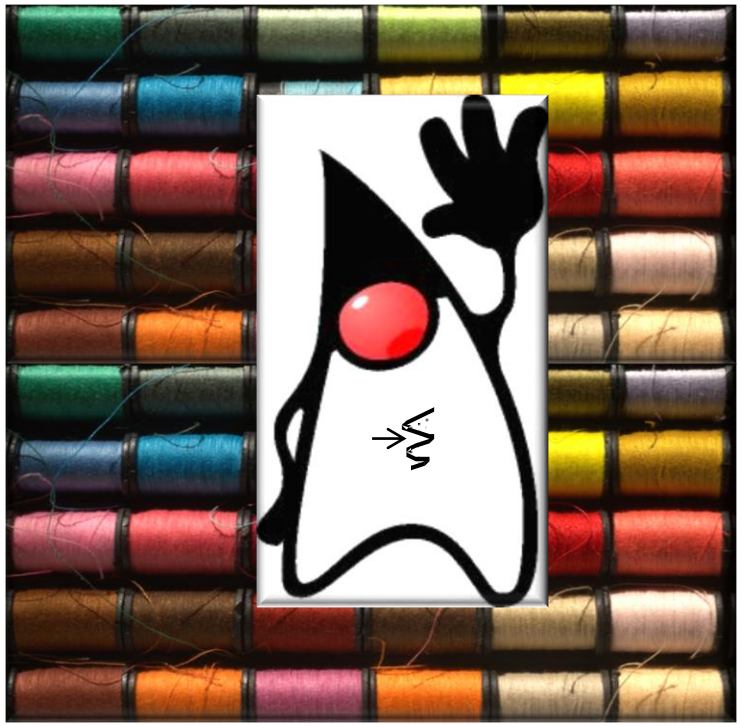
See github.com/douglascraigschmidt/POSA/tree/master/ex/M3/GCD/Concurrent/app/src/main/java/vandy/mooc/gcd/activities/GCDThread.java

Ways of Giving Code to Java Threads

Ways of Giving Code to Java Threads

- Java threads *must* be given code to run





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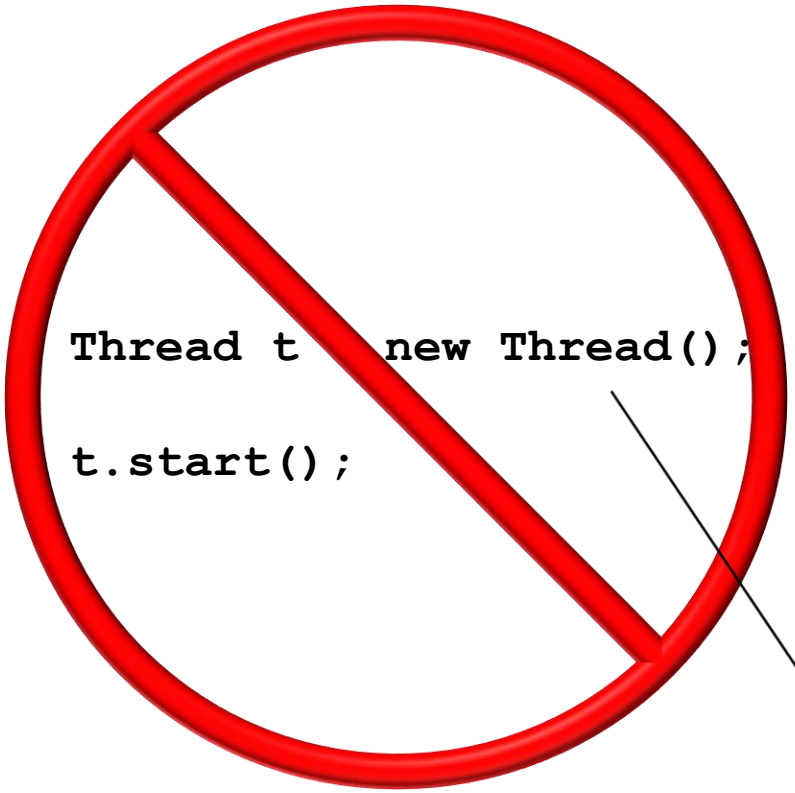

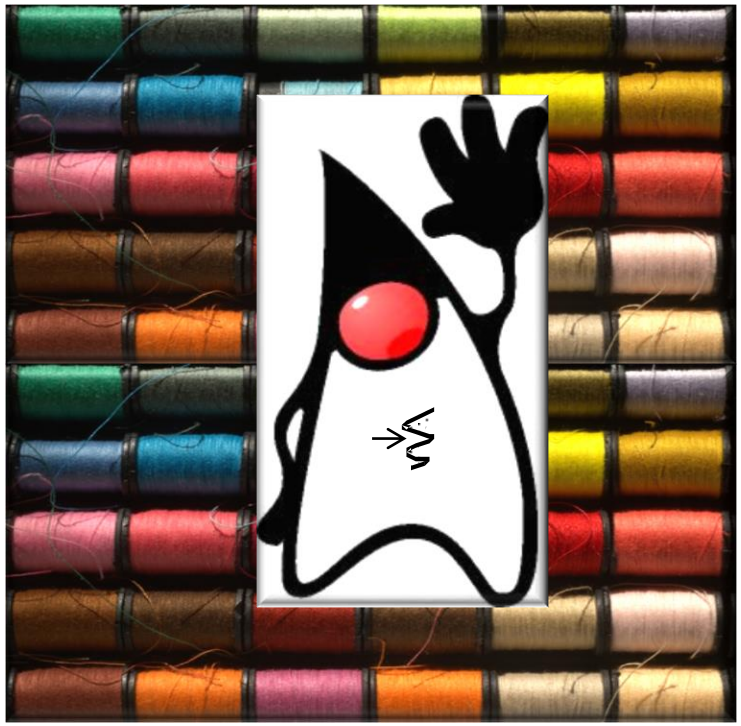

Do not use the "no argument" Thread constructor directly!!!

See stackoverflow.com/questions/7572527/why-would-anyone-ever-use-the-java-thread-no-argument-constructor

Ways of Giving Code to Java Threads

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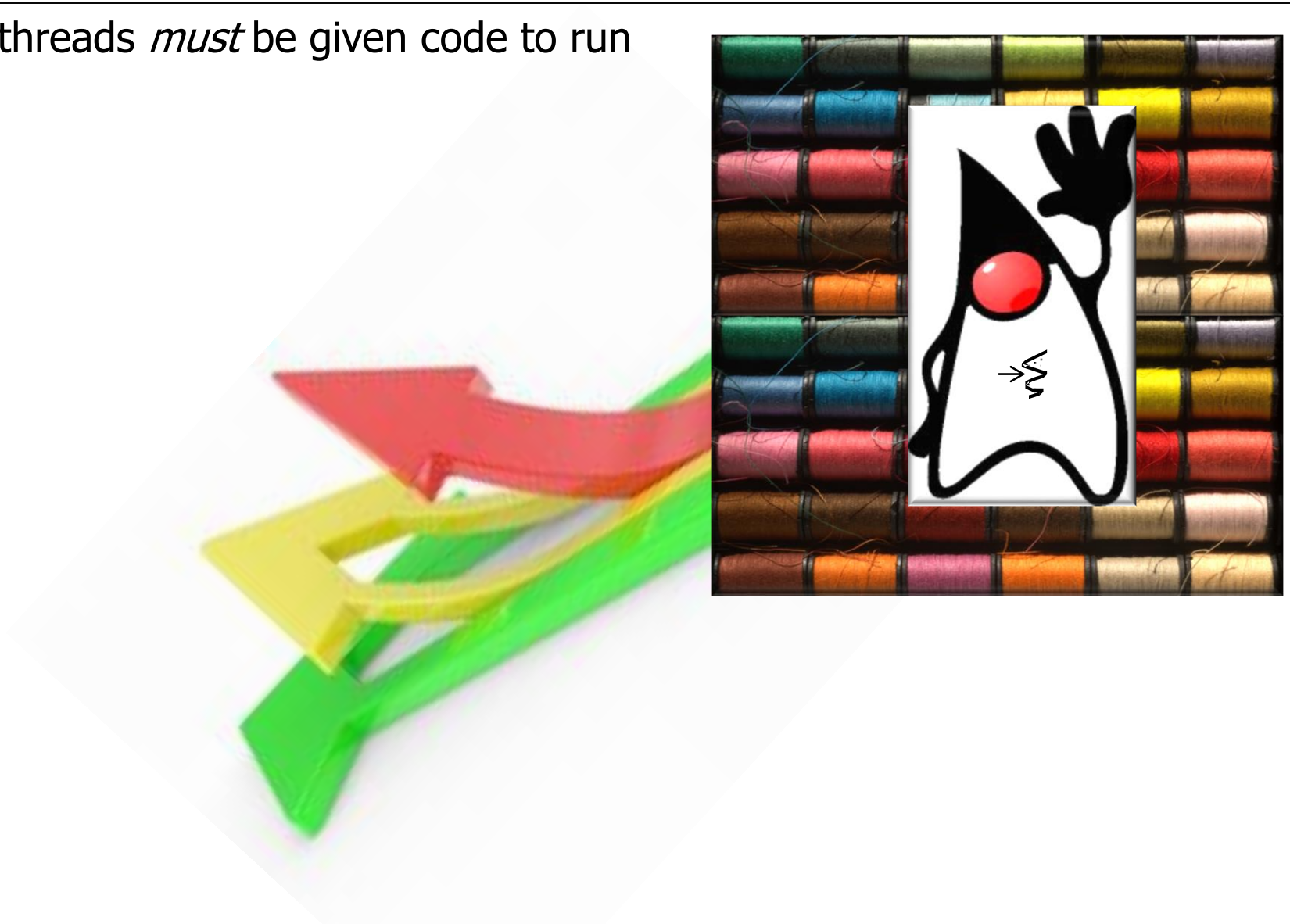
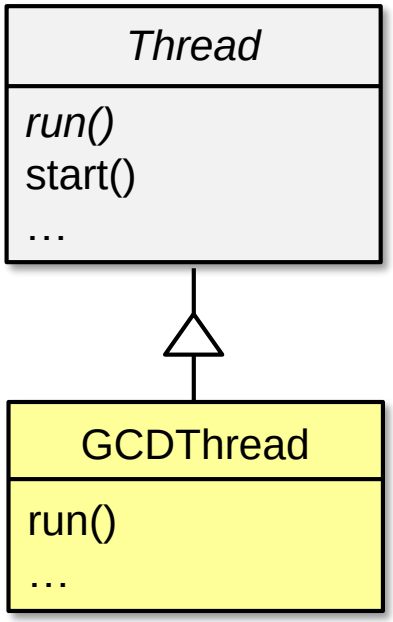


There are alternative programming models for giving code to Java threads

Ways of Giving Code to Java Threads

- Java threads *must* be given code to run, e.g.
  1. Extend the Thread class




```
public class GCDThread
                extends Thread {
    public void run() {
        // code to run goes here
    }
}
```

See docs.oracle.com/javase/8/docs/api/java/lang/Thread.html

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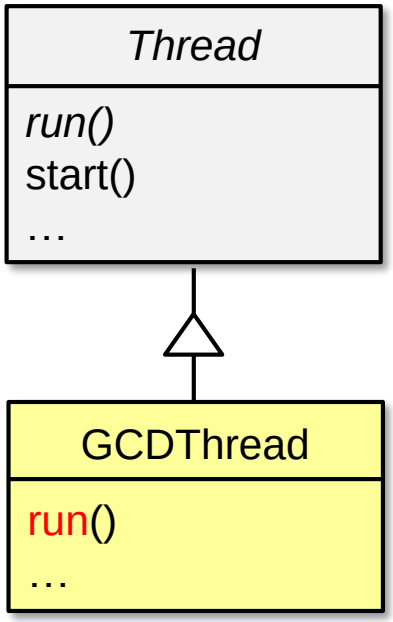


```
public class GCDThread
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    public void run() {
        // code to run goes here
    }
}
```

Override the run() hook method in the subclass & define the thread's computations

See wiki.c2.com/?HookMethod

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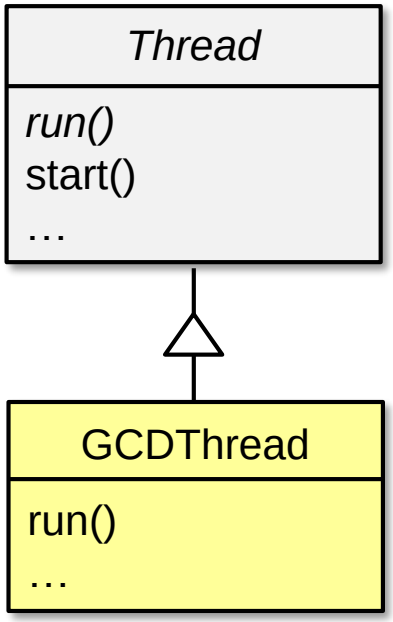


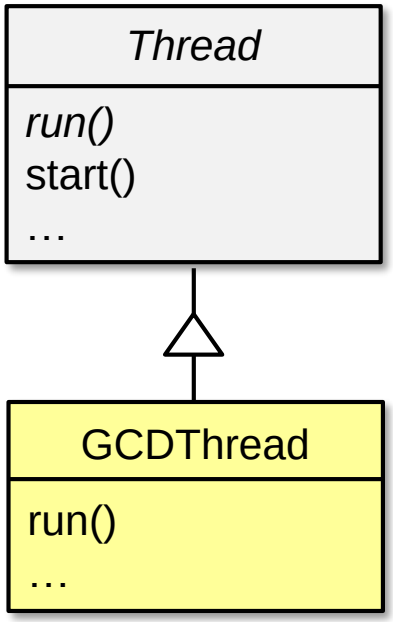

```
public class GCDThread
                extends Thread {
    public void run() {
        // code to run goes here
    }
}

Thread gCDThread =
  new GCDThread();
gCDThread.start();
```

Create & start a thread using a named subclass of Thread

Ways of Giving Code to Java Threads

- Java threads *must* be given code to run, e.g.

  1. Extend the Thread class

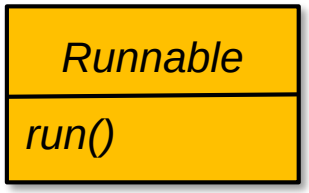



```
public class GCDThread
                  extends Thread {
    public void run() {
        // code to run goes here
    }
}

new GCDThread().start();
```

You can also write a one-liner to create & start an anonymous thread

Ways of Giving Code to Java Threads

- Java threads *must* be given code to run, e.g.
  1. Extend the Thread class
  2. Implement the Runnable interface



See docs.oracle.com/javase/8/docs/api/java/lang/Thread.html

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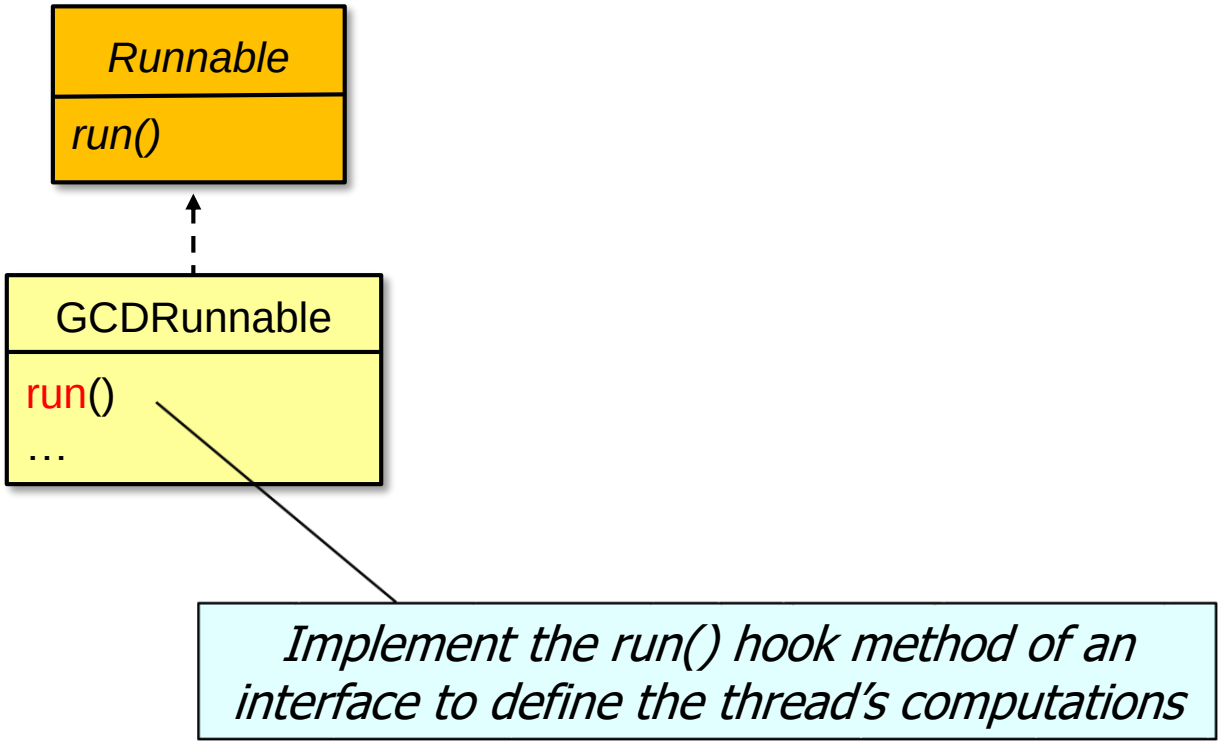

See docs.oracle.com/javase/8/docs/api/java/lang/Runnable.html

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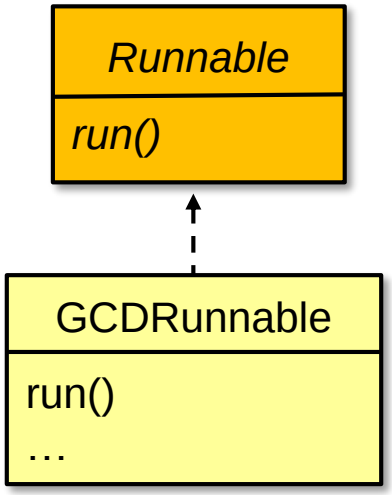

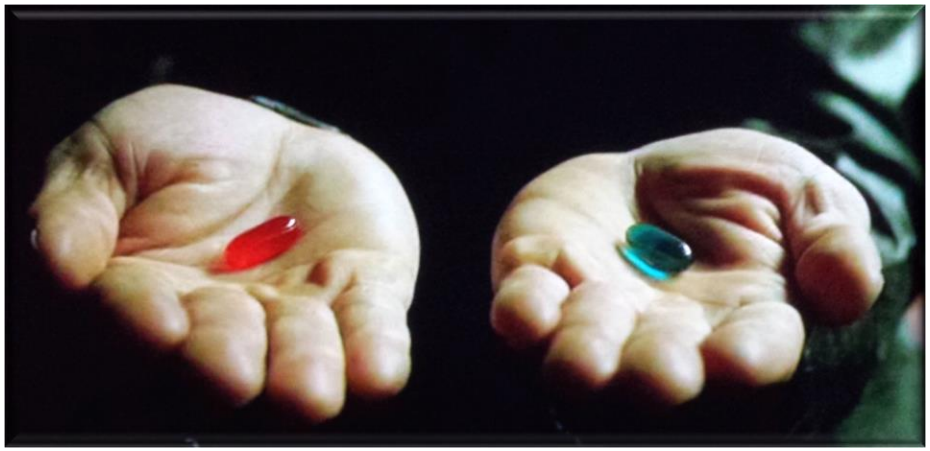

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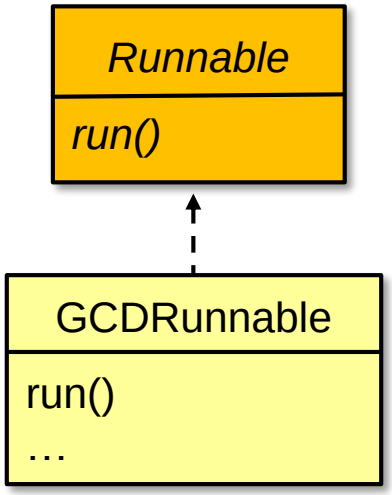


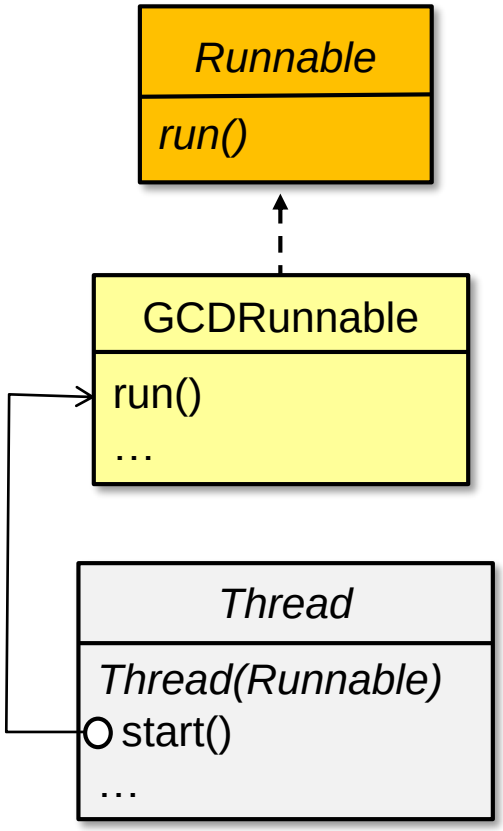

```
public class GCDRunnable
        implements Runnable {
  public void run() {
    // code to run goes here
  }
}

Runnable gCDRunnable =
  new GCDRunnable();
```

Create an instance of a named class as the runnable

Ways of Giving Code to Java Threads

- Java threads *must* be given code to run, e.g.
  1. Extend the Thread class
  2. Implement the Runnable interface




```
public class GCDRunnable
        implements Runnable {
  public void run() {
    // code to run goes here
  }
}

Runnable gCDRunnable =
  new GCDRunnable();
new Thread(gCDRunnable).start();
```

Pass that runnable to a new thread object & start it

Ways of Giving Code to Java Threads

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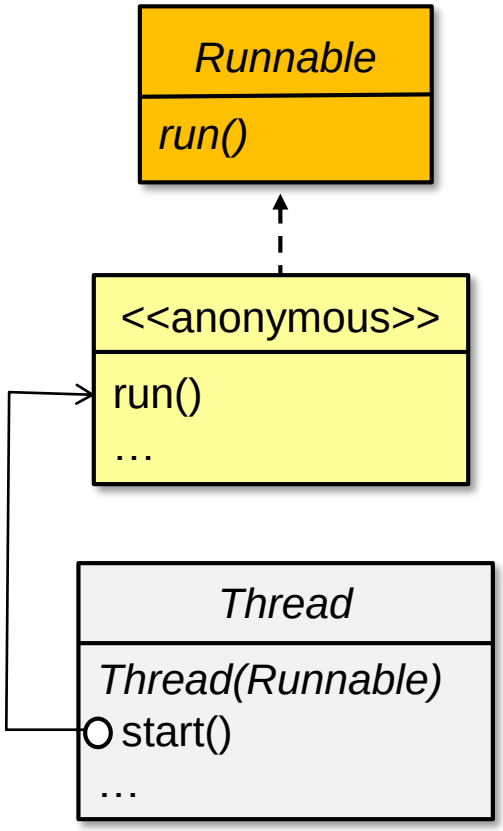
  2. Implement the Runnable interface




```
new Thread(new Runnable() {
    public void run(){
      // code to run goes here
  }
}).start();
```

Create & start a thread using an anonymous inner class as the runnable

Ways of Giving Code to Java Threads

- Java threads *must* be given code to run, e.g.
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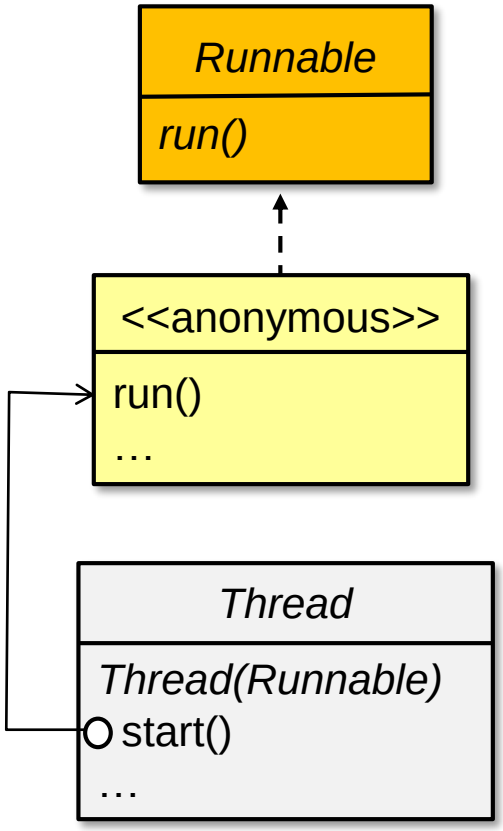
  2. Implement the Runnable interface




```
new Thread(new Runnable() {
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  }
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```
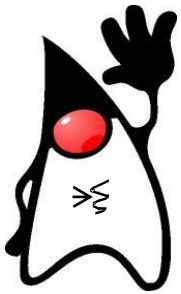
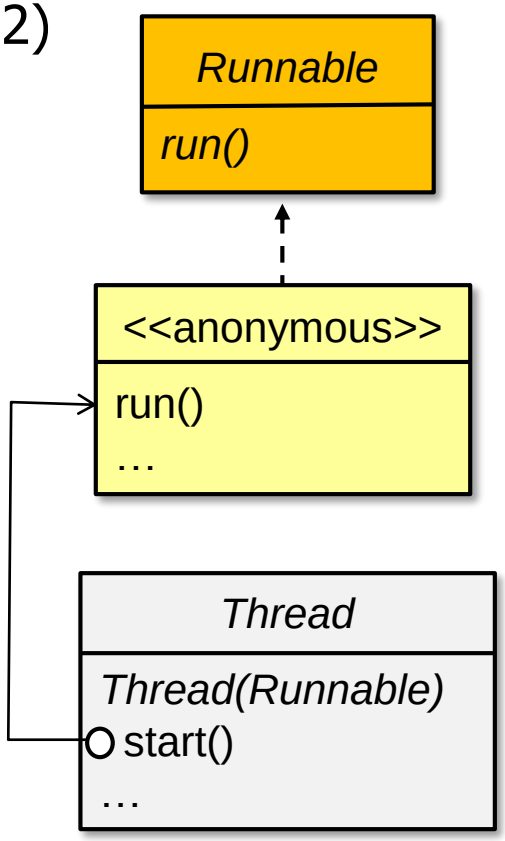



This anonymous inner class idiom is used extensively in older Java & Android code

Ways of Giving Code to Java Threads

- Java threads *must* be given code to run, e.g.
  1. Extend the Thread class
  2. Implement the Runnable interface
  3. Use Java 8 lambda expressions (variant of #2)




```
new Thread(() -> {
        // code to run goes here
}).start();
```

A lambda expression is an unnamed block of code (with optional parameters) that can be passed around & executed later

See www.drdobbs.com/jvm/lambda-expressions-in-java-8/240166764

Ways of Giving Code to Java Threads

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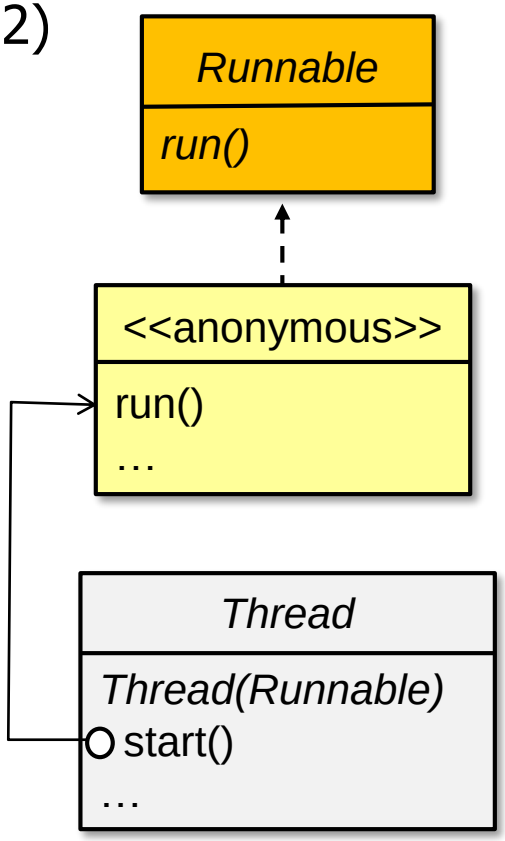


```
new Thread(() -> {
        // code to run goes here
}).start();
```

This approach is unwieldy if the code to run is long, complex, or needs to be used multiple times!

Ways of Giving Code to Java Threads

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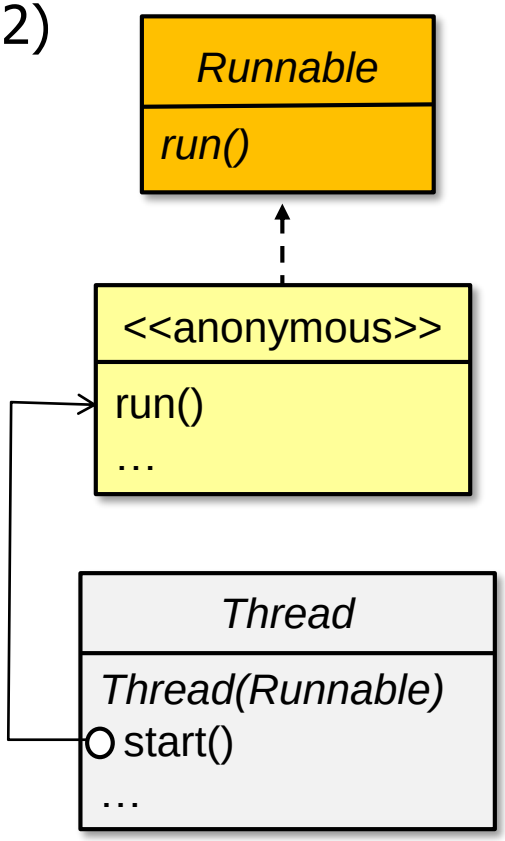


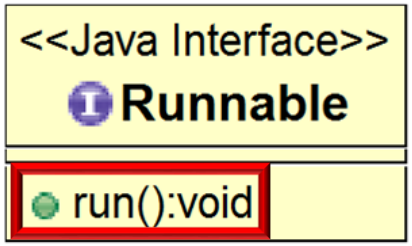

```
Runnable r = () -> {
   // code to run goes here
};

new Thread(r).start();
```

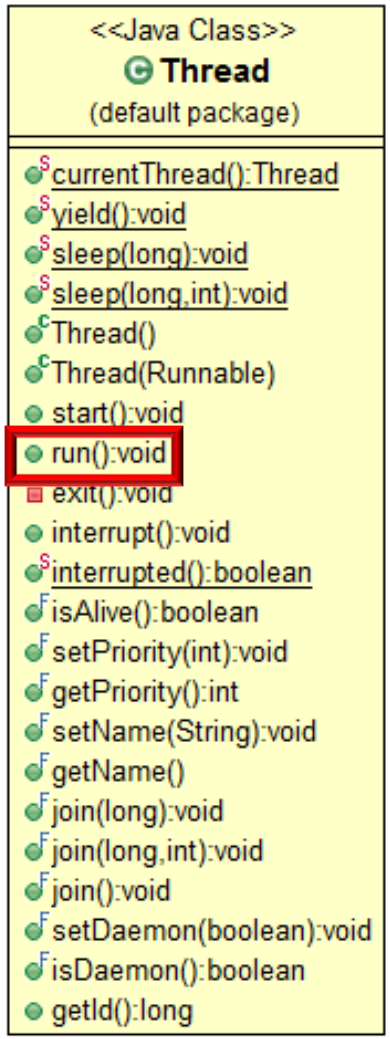
You can therefore store the runnable in a variable & pass it to the Thread constructor

Passing Parameters to a Java Thread

Passing Parameters to a Java Thread

- The run() methods defined in Java Thread & Runnable take no parameters

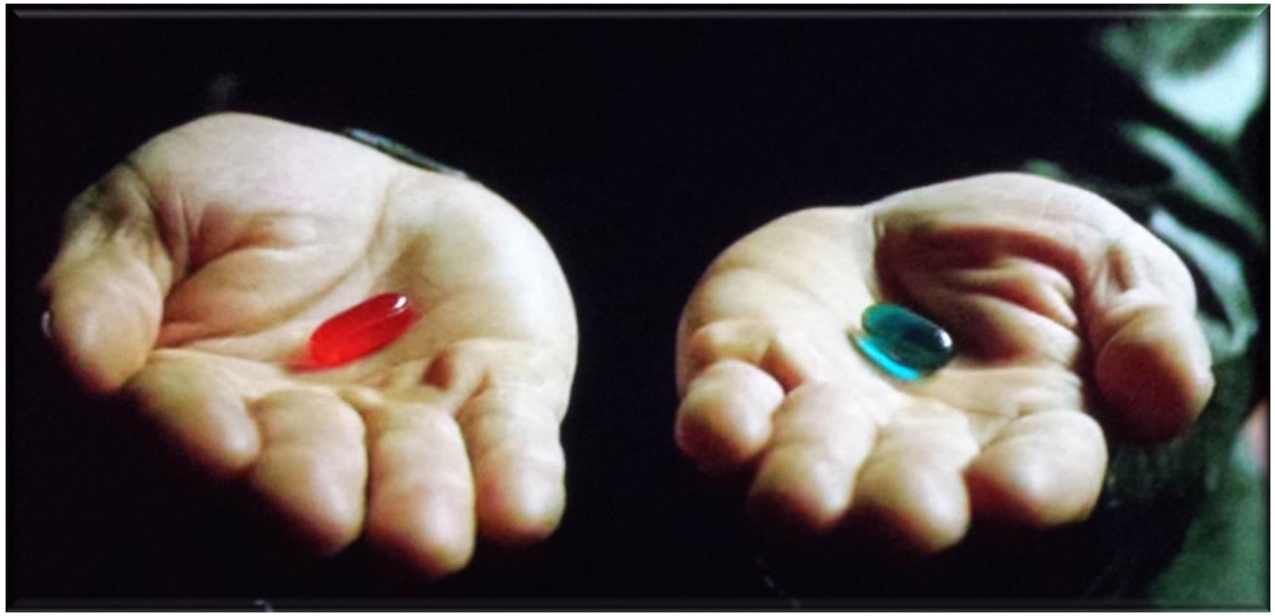




This raises the question of how to pass parameters to a Java thread!

Passing Parameters to a Java Thread

- Parameters passed to run() can be supplied via one of two other means



Passing Parameters to a Java Thread

- Parameters passed to run() can be supplied via one of two other means, e.g.
  - As parameters to a class constructor

```
public class GCDRunnable extends Random implements Runnable {
```

See github.com/douglascraigschmidt/POSA/tree/master/ex/M3/GCD/Concurrent/app/src/main/java/vandy/mooc/gcd/activities/GCDRunnable.java

Passing Parameters to a Java Thread

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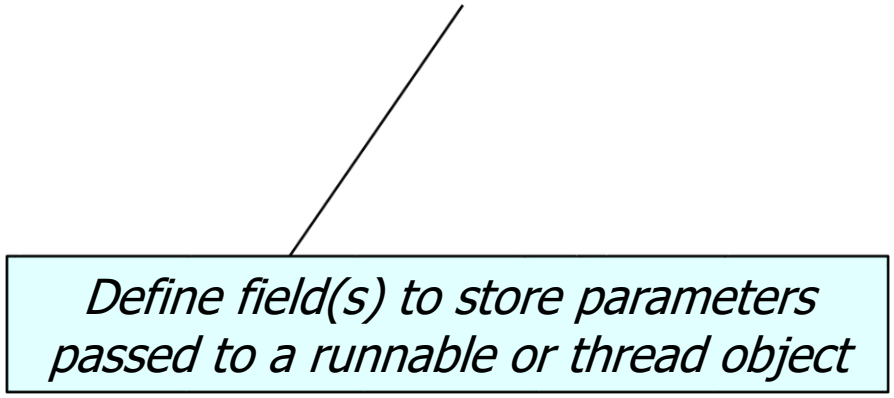
```
public class GCDRunnable extends Random implements Runnable {
  private final MainActivity mActivity;
  ...
```



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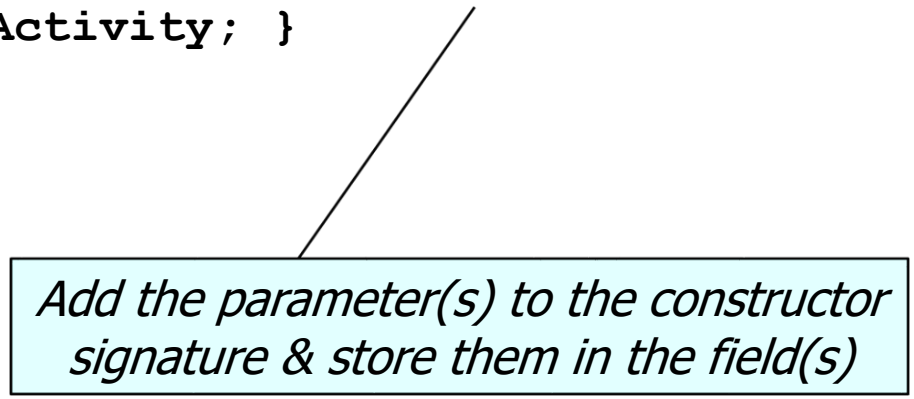
```
public class GCDRunnable extends Random implements Runnable {
  private final MainActivity mActivity;

  public GCDRunnable(MainActivity mainActivity)
  { mActivity = mainActivity; }
  ...
```



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```
public class GCDRunnable extends Random implements Runnable {
  private final MainActivity mActivity;

  public GCDRunnable(MainActivity mainActivity)
  { mActivity = mainActivity; }

  public void run() {
    final String threadString =
      " with thread id " + Thread.currentThread();
    mActivity.println("Entering run()" + threadString);
    ...
```

Use the field(s) within the thread's run() hook method to customize its behavior

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public class GCDRunnable extends Random implements Runnable {
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  public GCDRunnable(MainActivity mainActivity)
  { mActivity = mainActivity; }

  public void run() {
    final String threadString =
      " with thread id " + Thread.currentThread();
    mActivity.println("Entering run()" + threadString);
    ...
```

```
public class MainActivity ... { ...
  public void runRunnable(View v) { ...
     new Thread(new GDCRunnable(this));
  ...
```

Pass the parameter(s) when the runnable or thread is created

Passing Parameters to a Java Thread

- Parameters passed to run() can be supplied via one of two other means, e.g.
  - As parameters to a class constructor
  - As parameters to "setter" methods

```
public class GCDThread extends Thread {
```

See github.com/douglascraigschmidt/POSA/tree/master/ex/M3/GCD/Concurrent/app/src/main/java/vandy/mooc/gcd/activities/GCDThread.java

Passing Parameters to a Java Thread

- Parameters passed to run() can be supplied via one of two other means, e.g.
  - As parameters to a class constructor
  - As parameters to "setter" methods

```
public class GCDThread extends Thread {
  private MainActivity mActivity; private Random mRandom;
  ...
```

Define field(s) to store parameters passed to a runnable or thread object

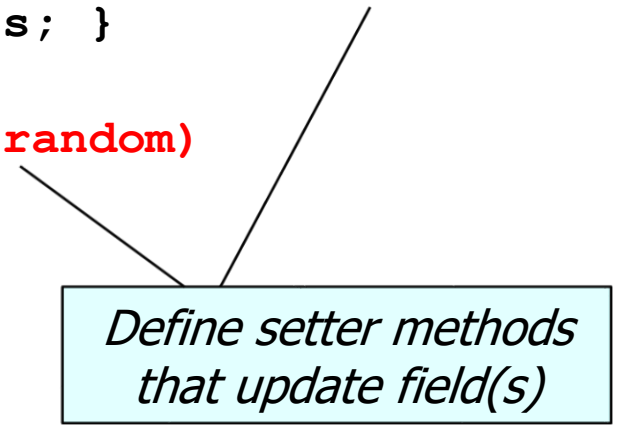
Passing Parameters to a Java Thread

- Parameters passed to run() can be supplied via one of two other means, e.g.
  - As parameters to a class constructor
  - As parameters to "setter" methods

```
public class GCDThread extends Thread {
  private MainActivity mActivity; private Random mRandom;

  public GCDThread setActivity(MainActivity activity)
  { mActivity = activity; return this; }

  public GCDThread setRandom(Random random)
  { mRandom = random; return this; }
  ...
```



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  private MainActivity mActivity; private Random mRandom;

  public GCDThread setActivity(MainActivity activity)
  { mActivity = activity; return this; }

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  { mRandom = random; return this; }
  ...
```

Note use of "fluent interfaces"

See en.wikipedia.org/wiki/Fluent_interface

Passing Parameters to a Java Thread

- Parameters passed to run() can be supplied via one of two other means, e.g.
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```
public class GCDThread extends Thread {
  private MainActivity mActivity; private Random mRandom;

  public GCDThread setActivity(MainActivity activity)
  { mActivity = activity; return this; }

  public GCDThread setRandom(Random random)
  { mRandom = random; return this; }
  ...

  public void run() { ...
    mActivity.println("Entering run()" + threadString);
    ...
       int number1 = mRandom.nextInt();
       int number2 = mRandom.nextInt(); ...
```

Use the fields within the thread's run() hook method to customize its behavior

Passing Parameters to a Java Thread

- Parameters passed to run() can be supplied via one of two other means, e.g.
  - As parameters to a class constructor
  - As parameters to "setter" methods

```
public class GCDThread extends Thread {
   ...

public class MainActivity ... { ...
  public void runThread(View v) { ...
    Thread thread =
      new GCDThread()
       .setActivity(this)
       .setRandom(new Random());
   ...
```

Use the fluent interface to pass parameter(s) when the runnable or thread is created

End of Overview of Java Threads (Part 1)