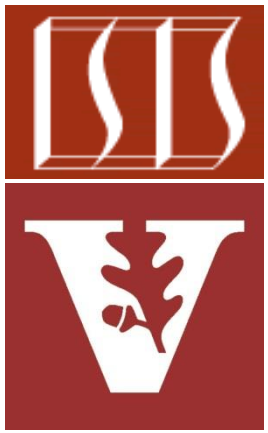
Overview of Java Threads (Part 3)



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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
- Know how to run a Java thread
- Recognize common thread mechanisms
- Appreciate Java thread "happens-before" orderings
- Understand the implementation of the GCD concurrent app

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- Understand the implementation of the GCD concurrent app
- Know the pros & cons of Java thread programming models

Runtime Behavior of the GCD Concurrent App

Runtime Behavior of the GCD Concurrent App

- Concurrently compute the greatest common divisor (GCD) of two #'s, which is the largest integer that divides two integers without a remainder

<<Java Class>>

Thread

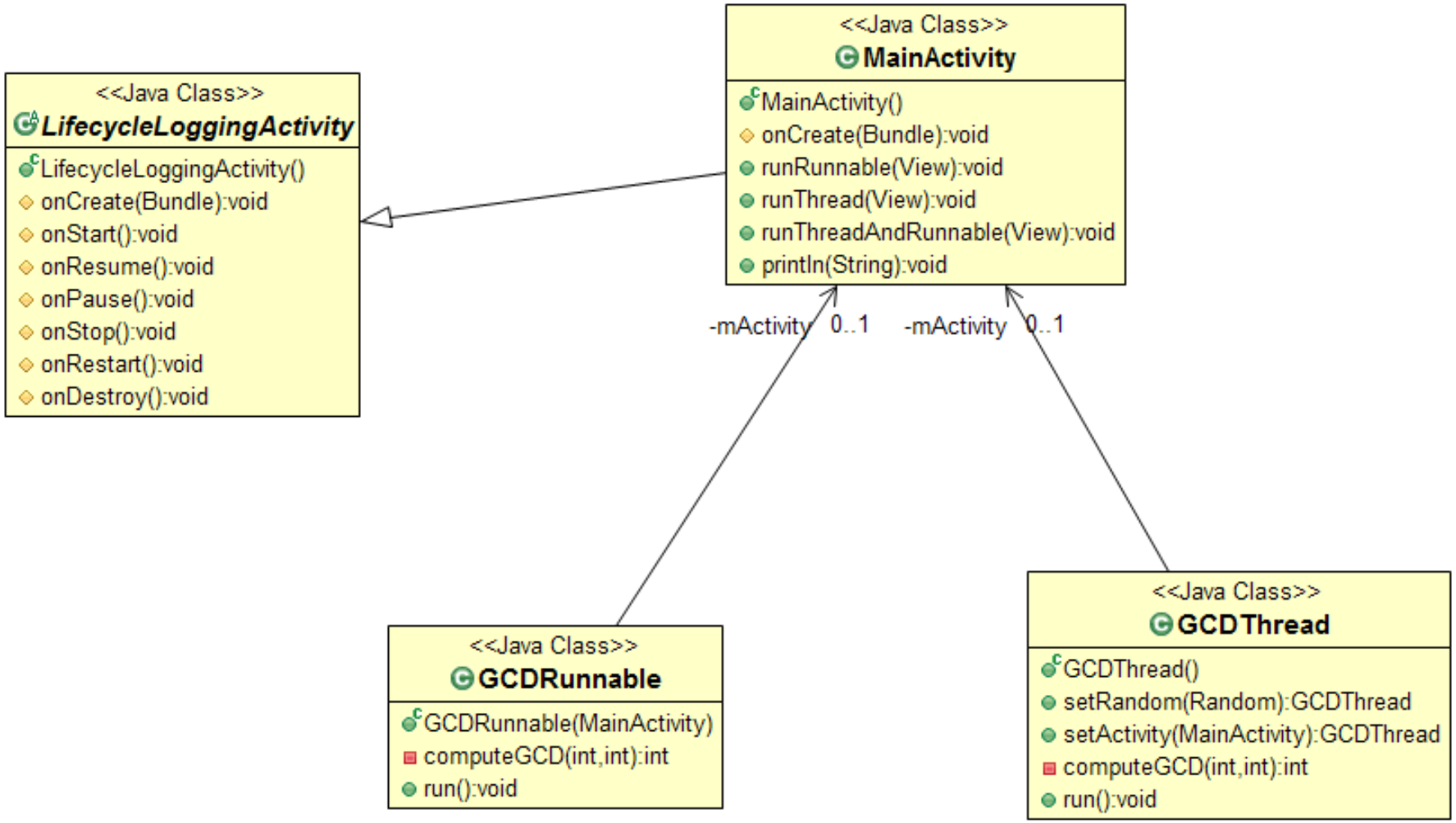
- yield():void
- currentThread():Thread
- sleep(long):void
- sleep(long,int):void
- Thread()
- Thread(Runnable)
- Thread(String)
- start():void
- run():void
- exit():void
- interrupt():void
- interrupted():boolean
- isInterrupted():boolean
- isAlive():boolean
- setPriority(int):void
- getPriority():int
- join(long):void
- join(long,int):void
- join():void
- setDaemon(boolean):void
- isDaemon():boolean

See en.wikipedia.org/wiki/Greatest_common_divisor

Implementation of the GCD Concurrent App

Implementation of the GCD Concurrent App

- This app shows various Java Thread methods & alternative implementations



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

Implementation of the GCD Concurrent App

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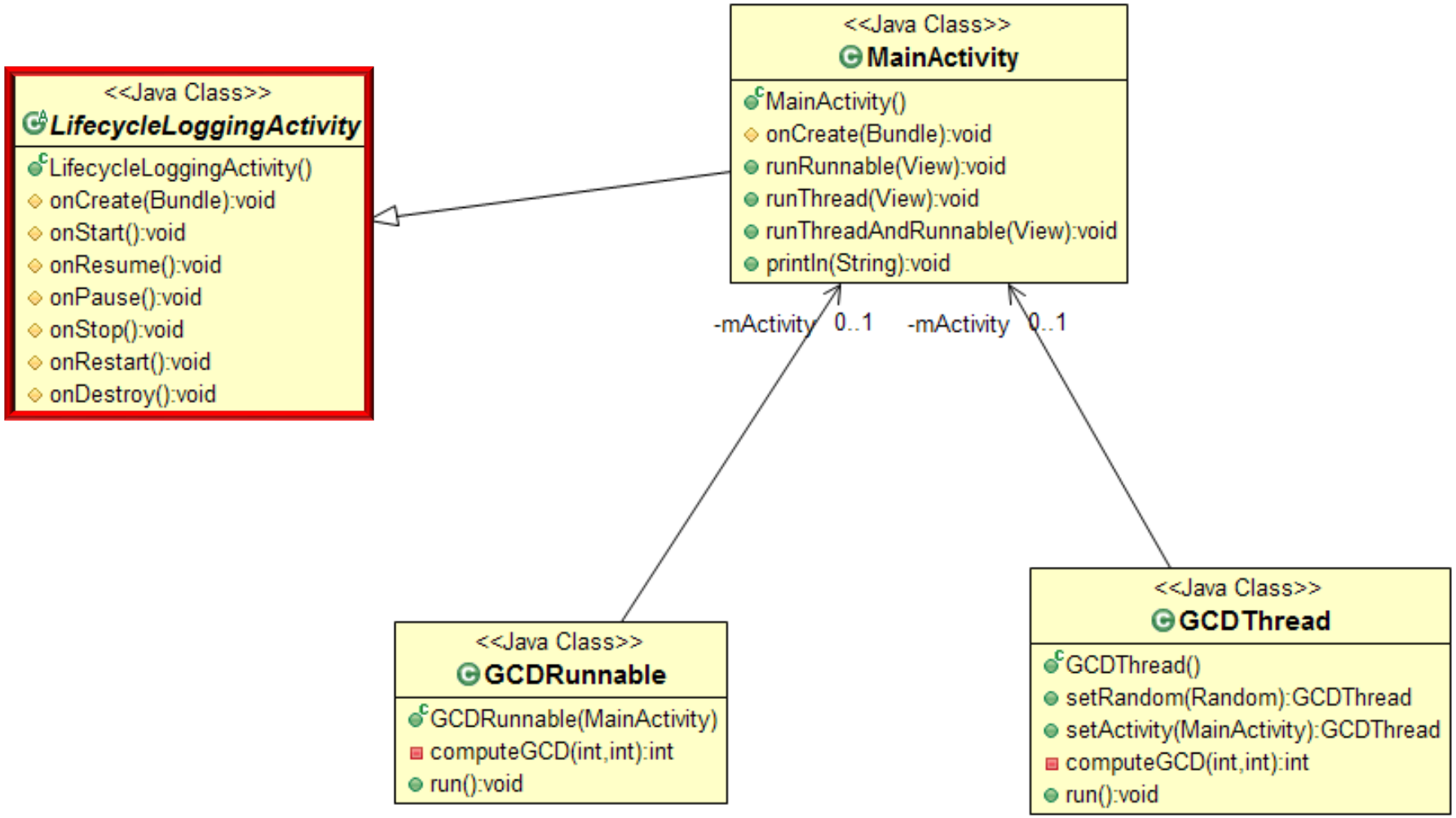
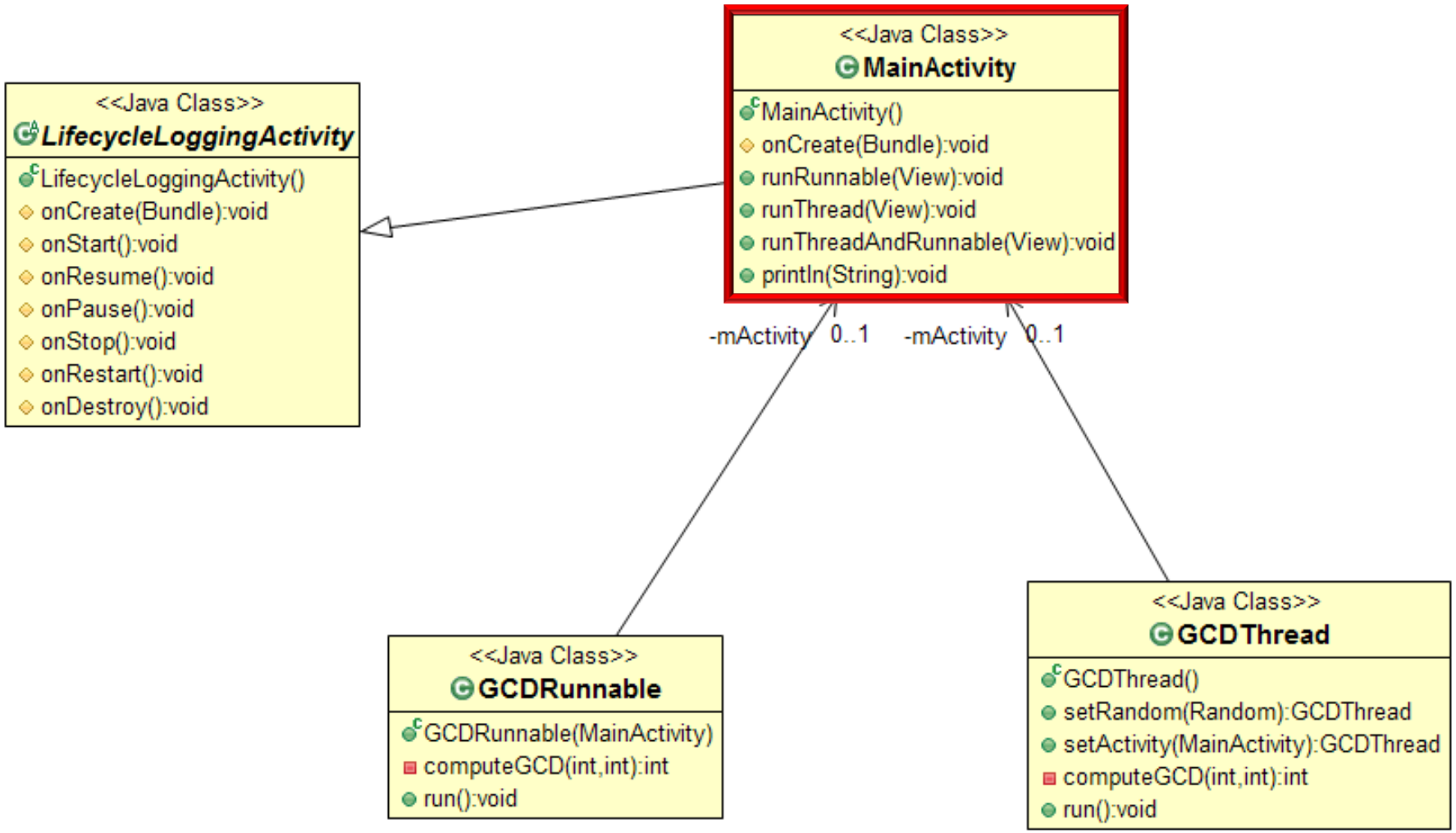


Super class that logs various activity lifecycle hook methods to aid debugging

Implementation of the GCD Concurrent App

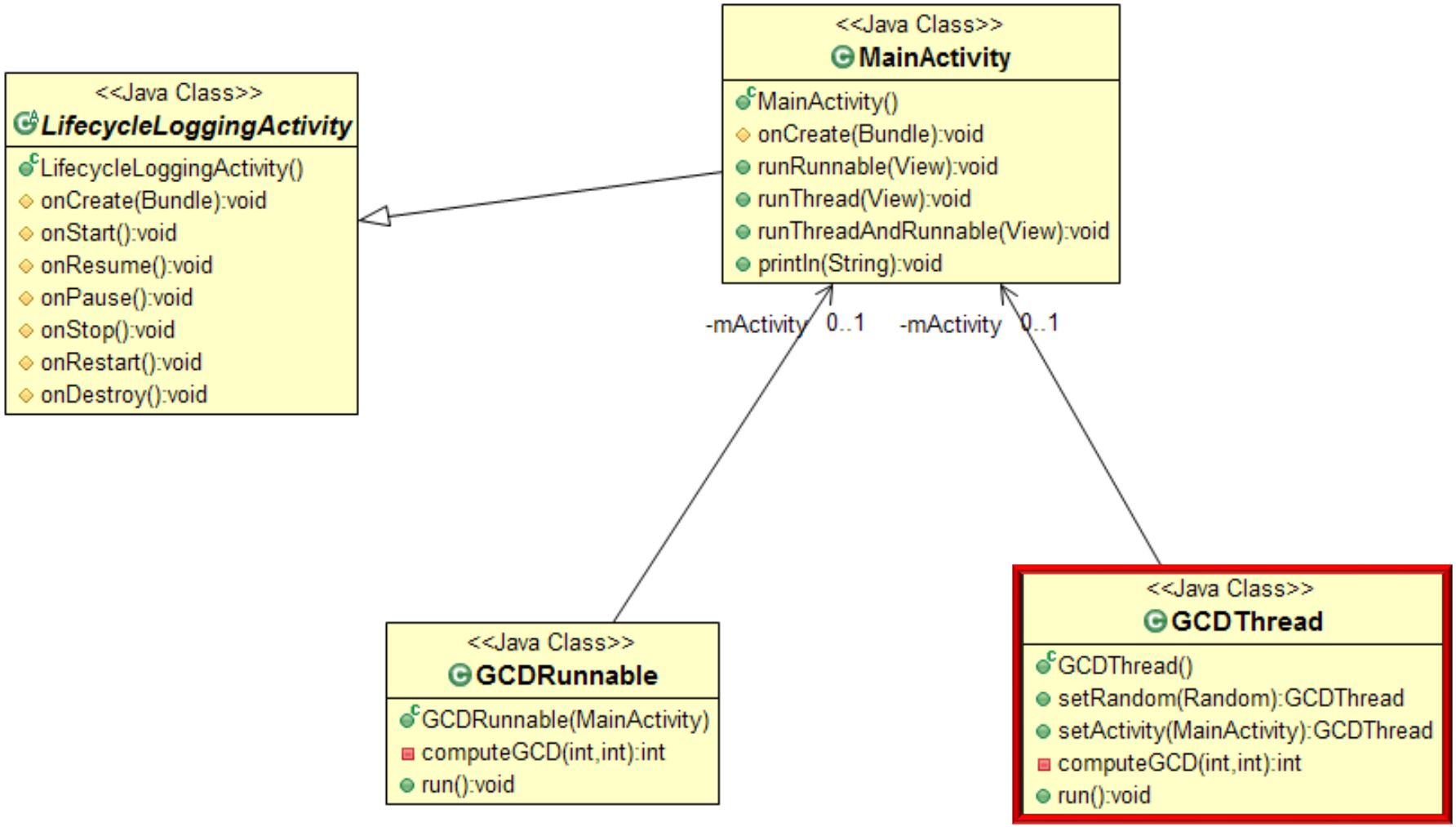
- This app shows various Java Thread methods & alternative implementations



Main entry point into the app that handles button presses from the user

Implementation of the GCD Concurrent App

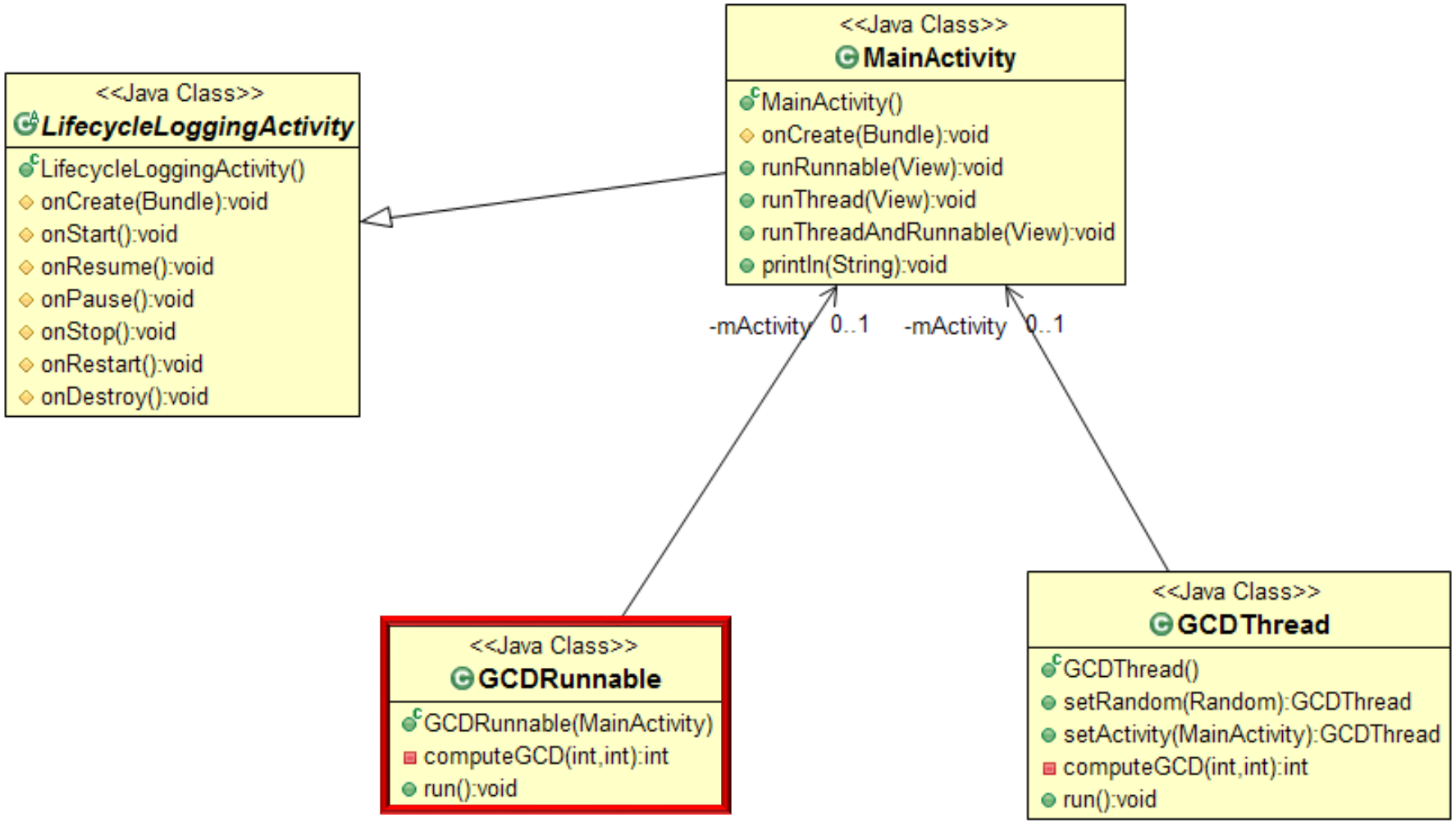
- This app shows various Java Thread methods & alternative implementations



Computes the GCD of two numbers by extending the Thread super class

Implementation of the GCD Concurrent App

- This app shows various Java Thread methods & alternative implementations



Computes the GCD of two numbers by implementing the Runnable interface

Implementation of the GCD Concurrent App

- This app shows various Java Thread methods & alternative implementations

```
/**
 * Computes the greatest common divisor (GCD) of two numbers, which is
 * the largest positive integer that divides two integers without a
 * remainder.  This implementation extends Random and implements the
 * Runnable interface's run() hook method.
 */
public class GCDRunnable
       extends Random // Inherits random number generation capabilities.
       implements Runnable {
    /**
     * A reference to the MainActivity.
     */
    private final MainActivity mActivity;

    /**
     * Number of times to iterate, which is 100 million to ensure the
     * program runs for a while.
     */
    private final int MAX_ITERATIONS = 100000000;

    /**
     * Number of times to iterate before calling print, which is 10
     * million to ensure the program runs for a while.
     */
    private final int MAX_PRINT_ITERATIONS = 10000000;

    /**
     * Hook method that runs for MAX_ITERATIONs computing the GCD of
     * randomly generated numbers.
     */
    public void run() {
        final String threadString = " with thread id " + Thread.currentThread();

        mActivity.println("Entering run()" + threadString);

        // Generate random numbers and compute their GCDs.

        for (int i = 0; i < MAX_ITERATIONS; ++i) {
            // Generate two random numbers.
            int number1 = nextInt();
            int number2 = nextInt();

            // Print results every 10 million iterations.
            if ((i % MAX_PRINT_ITERATIONS) == 0)
                mActivity.println("In run()"
                                  + threadString
                                  + " the GCD of "
                                  + number1
                                  + " and "
                                  + number2
                                  + " is "
                                  + computeGCD(number1,
                                               number2));
        }

        mActivity.println("Leaving run() " + threadString);
    }
```

```
/**
* Computes the greatest common divisor (GCD) of two numbers, which is
* the largest positive integer that divides two integers without a
* remainder.  This implementation extends Thread and overrides its
* run() hook method.
*/
public class GCDThread
       extends Thread {
    /**
     * A reference to the MainActivity.
     */
    private MainActivity mActivity;

    /**
     * Generate random numbers.
     */
    private Random mRandom;

    /**
     * Number of times to iterate, which is 100 million to ensure the
     * program runs for a while.
     */
    private final int MAX_ITERATIONS = 100000000;

    /**
     * Number of times to iterate before calling print, which is 10
     * million to ensure the program runs for a while.
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    /**
     * Hook method that runs for MAX_ITERATIONs computing the GCD of
     * randomly generated numbers.
     */
    public void run() {
        final String threadString = " with thread id " + Thread.currentThread();

        mActivity.println("Entering run()" + threadString);

        // Generate random numbers and compute their GCDs.

        for (int i = 0; i < MAX_ITERATIONS; ++i) {
            // Generate two random numbers.
            int number1 = mRandom.nextInt();
            int number2 = mRandom.nextInt();

            // Print results every 10 million iterations.
            if ((i % MAX_PRINT_ITERATIONS) == 0)
                mActivity.println("In run()"
                                  + threadString + " the GCD of "
                                  + number1 + " and " + number2 + " is "
                                  + computeGCD(number1,
                                               number2));
        }

        mActivity.println("Leaving run() " + threadString);
    }
```

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

Pros & Cons of Java Thread Programming Models

Pros & Cons of Java Thread Programming Models

- Now that we've examined the source code for the GCD concurrent app we'll summarize the pros & cons of the various Java thread programming models

Pros & Cons of Java Thread Programming Models

- Pros with extending Thread

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

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

  private int computeGCD
     (int number1, number2) {
    ...
  }

  public void run()
  { ... }
  ...
}
```

Pros & Cons of Java Thread Programming Models

- Pros with extending Thread
  - It's straightforward to extend the Thread super class

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

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

  private int computeGCD
     (int number1, number2) {
    ...
  }

  public void run()
  { ... }
  ...
}
```

Pros & Cons of Java Thread Programming Models

- Pros with extending Thread
  - It's straightforward to extend the Thread super class
    - Just override the run() hook method!

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

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

  private int computeGCD
     (int number1, number2) {
    ...
  }

  public void run()
  { ... }
  ...
}
```

Pros & Cons of Java Thread Programming Models

- Pros with extending Thread
  - It's straightforward to extend the Thread super class
  - It also consolidates all state & methods in one place

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

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

// Main app
Thread thread = new GCDThread()
  .setActivity(this)...;

thread.start();

...
```

Pros & Cons of Java Thread Programming Models

- Pros with extending Thread
  - It's straightforward to extend the Thread super class
  - It also consolidates all state & methods in one place
    - Enables central allocation & management of the thread

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

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

// Main app
Thread thread = new GCDThread()
  .setActivity(this)...;

thread.start();

...
```

Pros & Cons of Java Thread Programming Models

- Pros with extending Thread
  - It's straightforward to extend the Thread super class
  - It also consolidates all state & methods in one place
    - Enables central allocation & management of the thread
    - This design is useful when the thread must be updated during runtime configuration changes

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

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

// Main app
Thread thread = new GCDThread()
  .setActivity(this)...;

thread.start();

...
```

Pros & Cons of Java Thread Programming Models

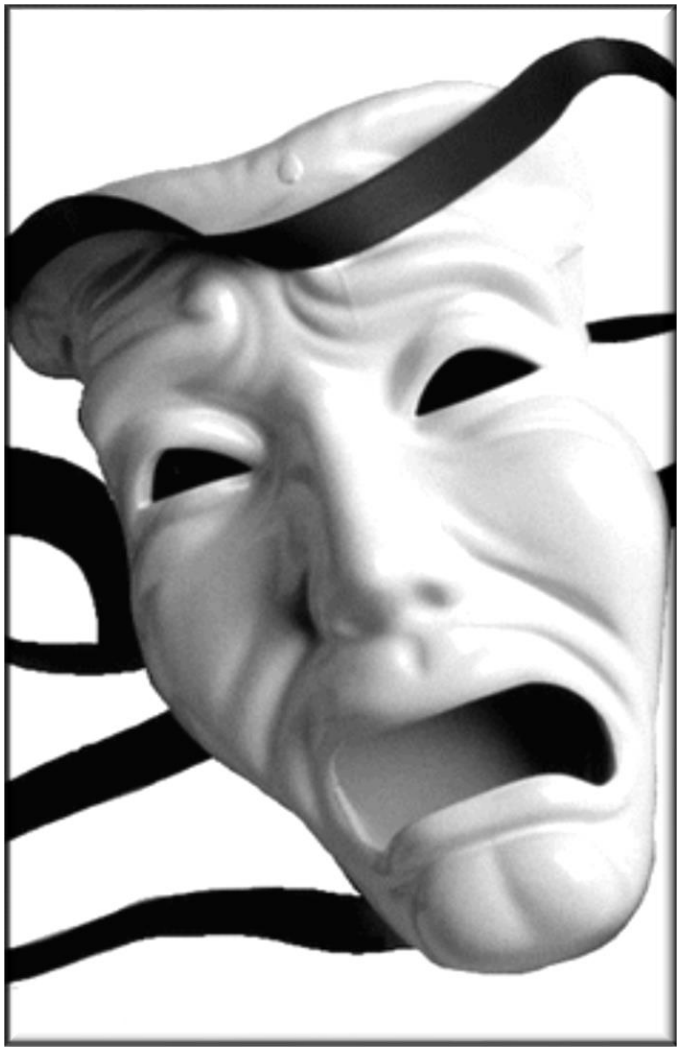
- Pros with extending Thread
  - It's straightforward to extend the Thread super class
  - It also consolidates all state & methods in one place
    - Enables central allocation & management of the thread
    - This design is useful when the thread must be updated during runtime configuration changes
      - e.g., interrupting/restarting a running thread & reading/ writing its state

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

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

// Main app
Thread thread = new GCDThread()
  .setActivity(this)...;

thread.start();

...
```

See the upcoming lessons on "Managing the Java Lifecycle" & "Managing Multi-threaded Activity State"

Pros & Cons of Java Thread Programming Models

- Cons with extending Thread



```
public class GCDThread
        extends Thread {
   ...
   private int computeGCD
       (int number1, number2) {
      ...
   }

   public void run() {
      ...
   }
   ...
}
```

Pros & Cons of Java Thread Programming Models

- Cons with extending Thread
  - A subclass must extend the Thread superclass

```
public class GCDThread
        extends Thread {
   ...
   private int computeGCD
       (int number1, number2) {
      ...
   }

   public void run() {
      ...
   }
   ...
}
```

Pros & Cons of Java Thread Programming Models

- Cons with extending Thread
  - A subclass must extend the Thread superclass
    - This is restrictive since Java only allows one superclass per subclass!

```
public class GCDThread
        extends Thread {
   ...
   private int computeGCD
      (int number1, number2) {
     ...
   }

   public void run() {
     ...
   }
   ...
}
```

See docs.oracle.com/javase/tutorial/java/IandI/subclasses.html

Pros & Cons of Java Thread Programming Models

- Pros of implementing Runnable

```
public class GCDRunnable
       implements Runnable,
       implements Serializable,
       extends Random {
   ...
   private int computeGCD
       (int number1, number2) {
      ...
   }

   public void run() {
      ...
   }
   ...
```

Pros & Cons of Java Thread Programming Models

- Pros of implementing Runnable
  - A subclass can implement multiple interfaces

```
public class GCDRunnable
       implements Runnable,
       implements Serializable,
       extends Random {
   ...
   private int computeGCD
       (int number1, number2) {
      ...
   }

   public void run() {
      ...
   }
   ...
```

See docs.oracle.com/javase/tutorial/java/concepts/interface.html

Pros & Cons of Java Thread Programming Models

- Pros of implementing Runnable
  - A subclass can implement multiple interfaces
    - Which enables it to extend a different superclass

```
public class GCDRunnable
       implements Runnable,
       implements Serializable,
       extends Random {
   ...
   private int computeGCD
       (int number1, number2) {
      ...
   }

   public void run() {
      ...
   }
   ...
```

See docs.oracle.com/javase/tutorial/java/concepts/interface.html

Pros & Cons of Java Thread Programming Models

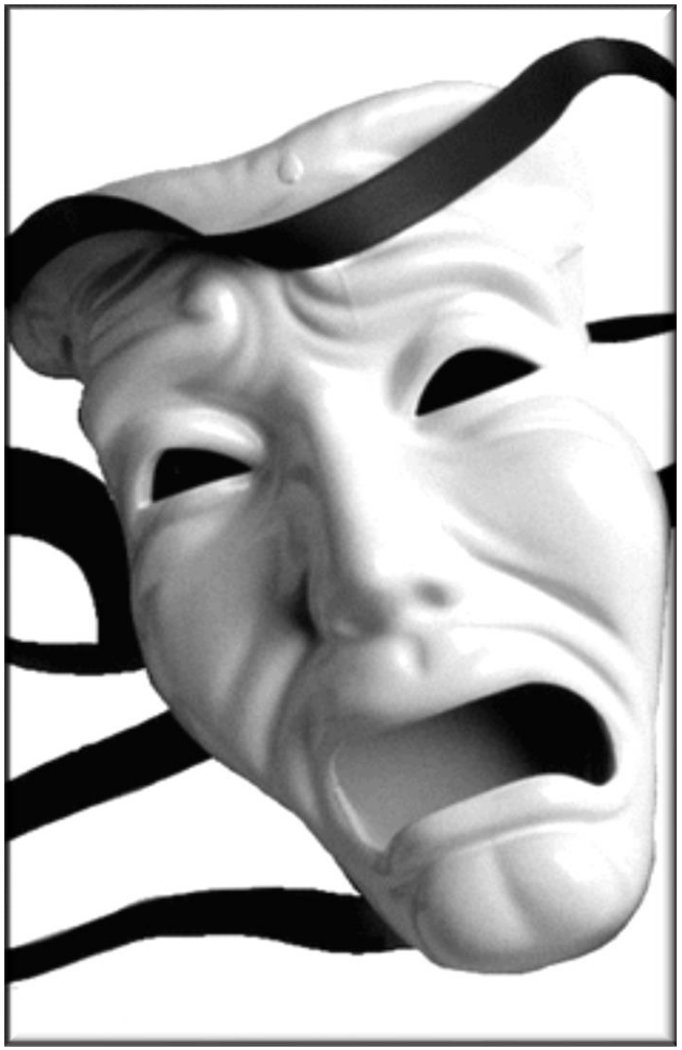
- Pros of implementing Runnable
  - A subclass can implement multiple interfaces
  - Runnables are flexible since they can be reused in other contexts

```
public class GCDRunnable
       implements Runnable,
       ... {
  ...
}
...

GCDRunnable runnableCommand =
  new GCDRunnable(...);

ExecutorService executor =
   Executors.newFixedThreadPool
                          (POOL_SIZE);
 ...
 executor.execute
   (runnableCommand);
```

See upcoming lesson on "the Java Executor framework"

Pros & Cons of Java Thread Programming Models

- Cons of implementing Runnable



```
public class GCDRunnable
        implements Runnable,
        ... {
   ...
}
...

GCDRunnable runnableCommand =
  new GCDRunnable(...);

Thread thr =
  new Thread(runnableCommand);
...
thr.start();
```

Pros & Cons of Java Thread Programming Models

- Cons of implementing Runnable
  - Yields more "moving parts"


```
public class GCDRunnable
        implements Runnable,
        ... {
   ...
}
...

GCDRunnable runnableCommand =
  new GCDRunnable(...);

Thread thr =
  new Thread(runnableCommand);
...
thr.start();
```

Pros & Cons of Java Thread Programming Models

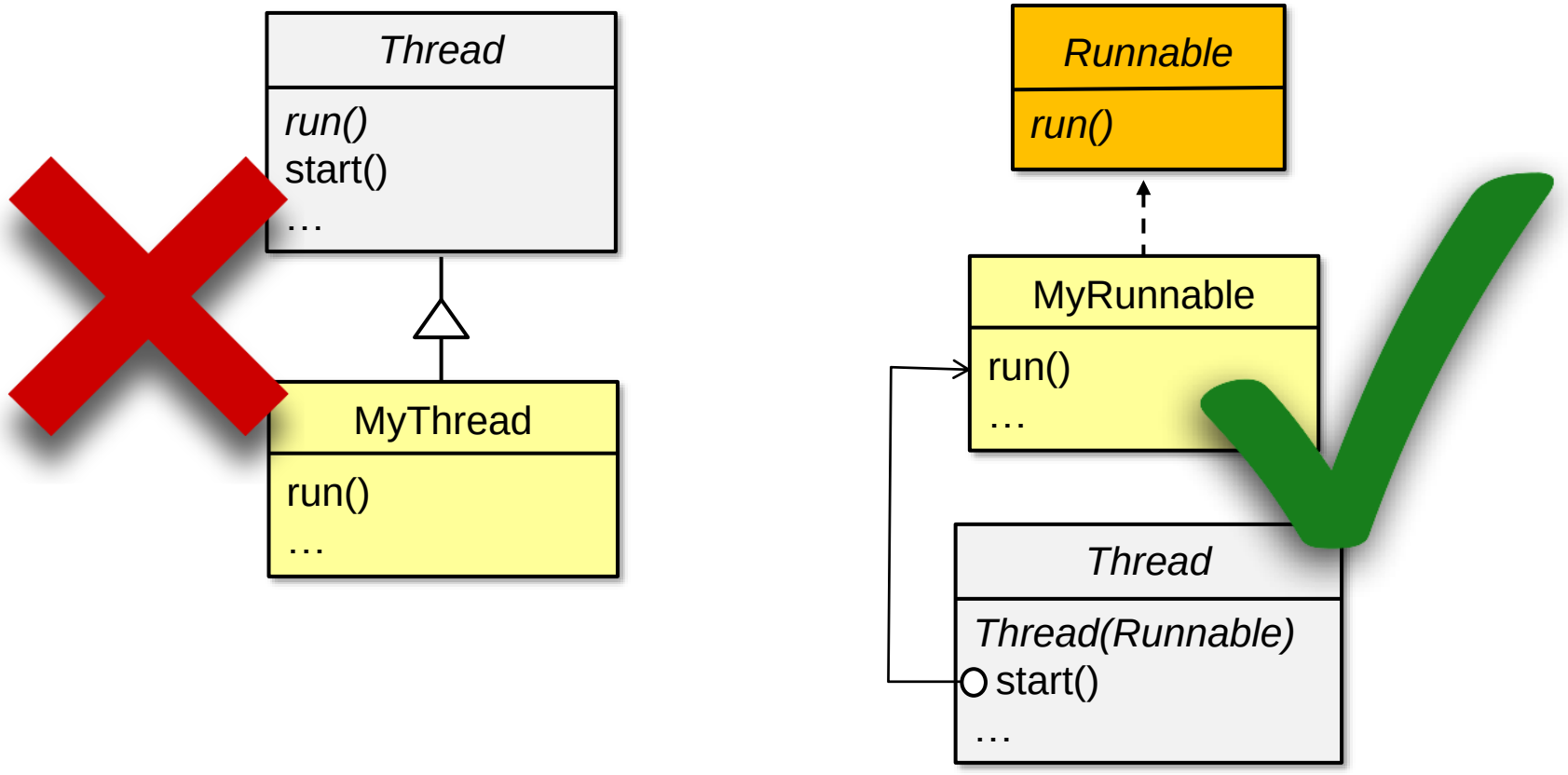
- Cons of implementing Runnable
  - Yields more "moving parts"
    - e.g., Runnable & Thread are separate entities & must be managed/accessed separately

```
public class GCDRunnable
        implements Runnable,
        ... {
   ...
}
...

GCDRunnable runnableCommand =
  new GCDRunnable(...);

Thread thr =
  new Thread(runnableCommand);
...
thr.start();
```

This decoupling get complicated if a program needs to access the state of a runnable, but only holds a reference to the thread object..

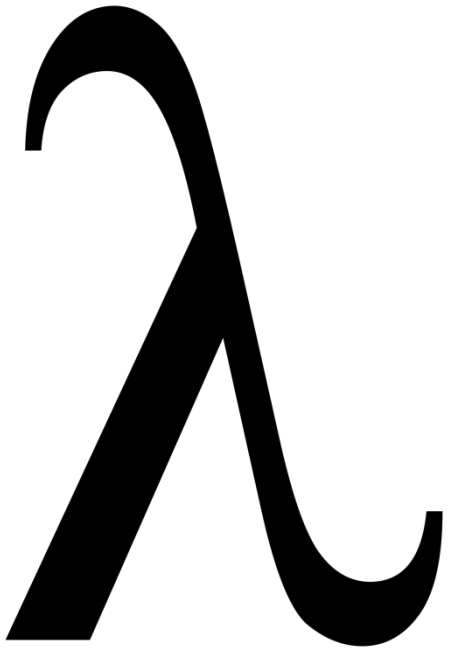
Pros & Cons of Java Thread Programming Models

- In practice, Java & Android software often implements Runnable rather than extending Thread



Pros & Cons of Java Thread Programming Models

- In practice, Java & Android software often implements Runnable rather than extending Thread
  - Lambda expressions are becoming popular with Java 8-based platforms



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

End of Overview of Java Threads (Part 3)