The Java Executor Interface (Part 2)

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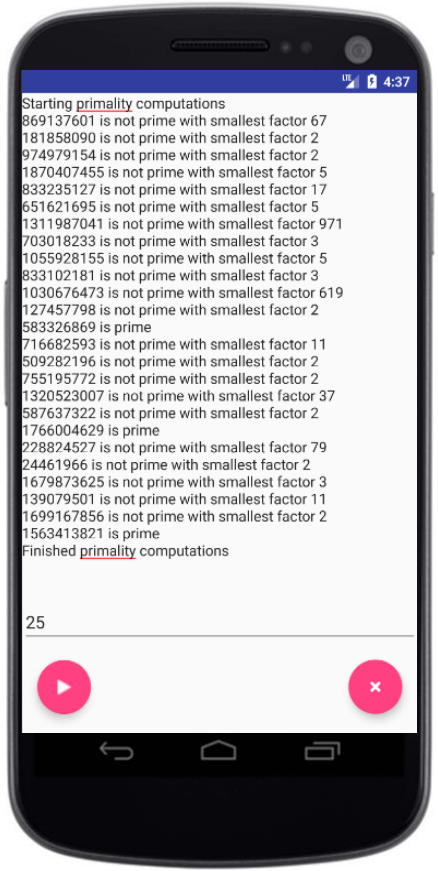
Learning Objectives in this Part of the Lesson

- Recognize the simple/single feature provided by the Java Executor interface
- Learn how to program a simple "prime checker" app using the Java Executor interface



Overview of the PrimeChecker App

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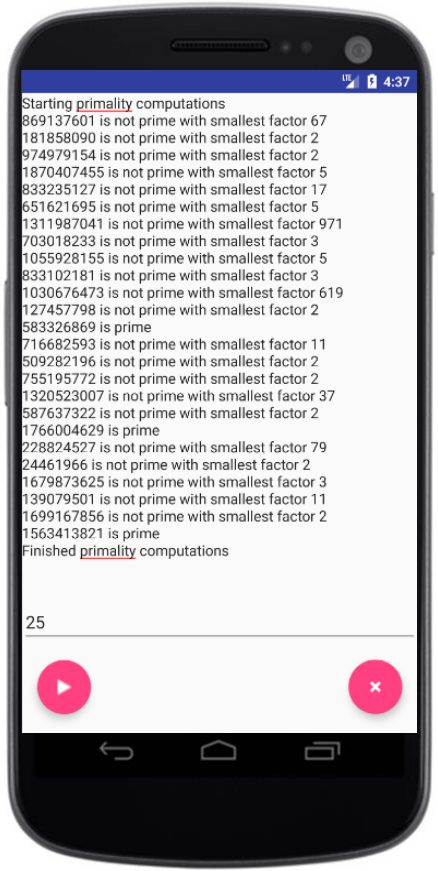
- This app shows how to use the Java Executor framework to check if *N* random #'s are prime

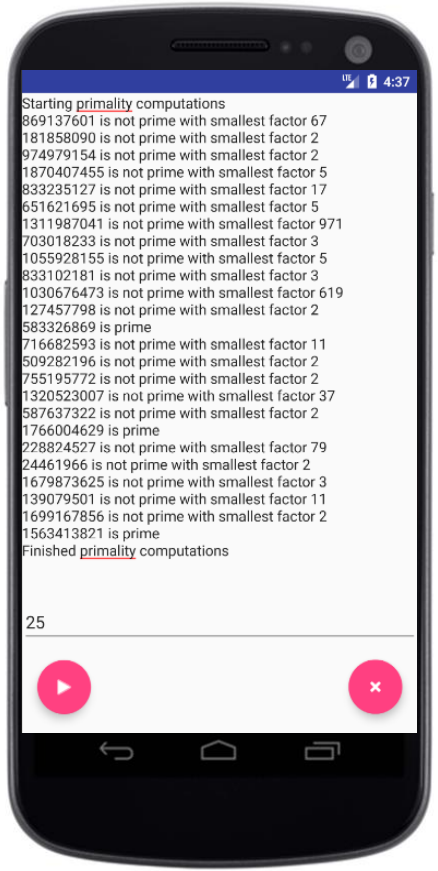


See github.com/douglascraigschmidt/POSA/tree/master/ex/M4/Primes/PrimeExecutor

Overview of the PrimeChecker App

- This app shows how to use the Java Executor framework to check if *N* random #'s are prime
  - Each natural # divisible only by 1 & itself is prime

2	3	5	7	11
13	17	19	23	29
31	37	41	43	47
53	59	61	67	71
73	79	83	89	97



See en.wikipedia.org/wiki/Prime_number

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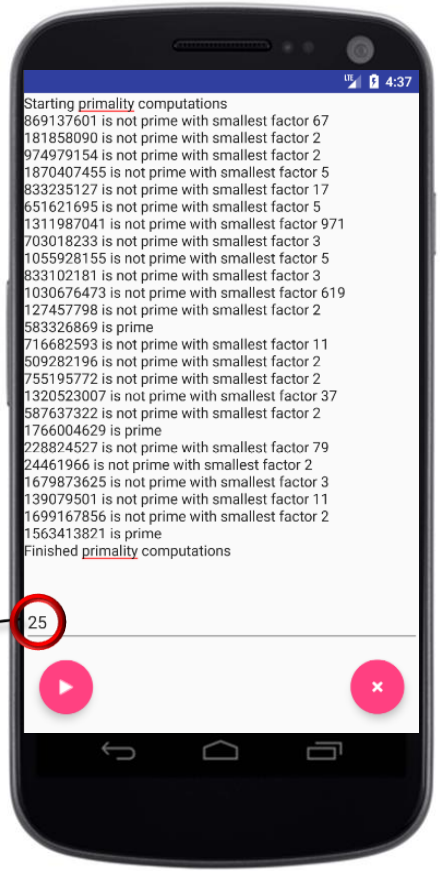

The user can select the # 'N'

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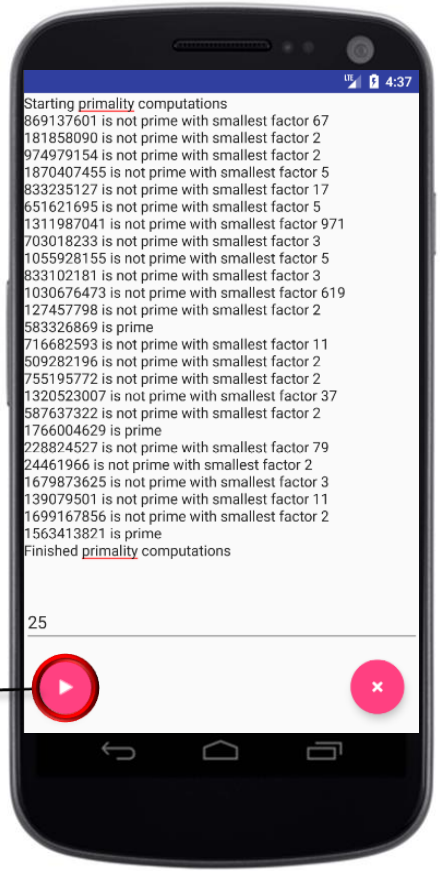
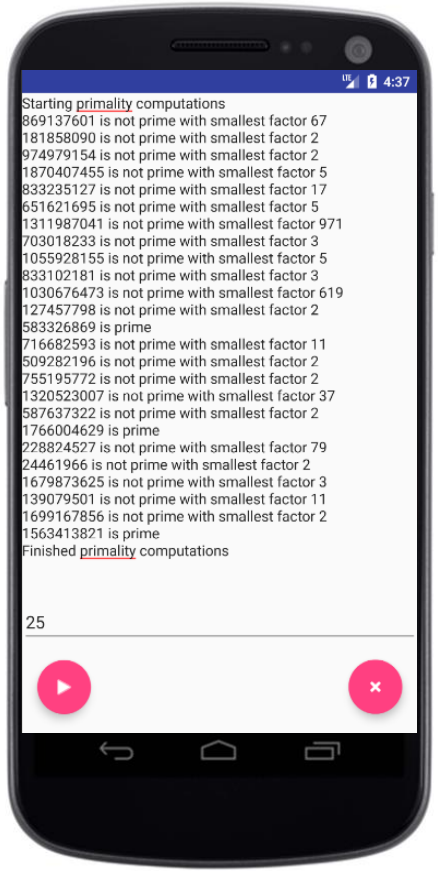


The user can also start running the app

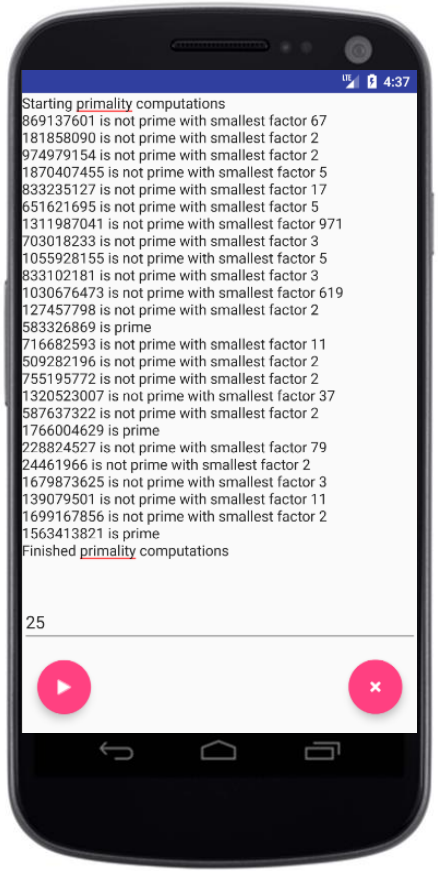
Overview of the PrimeChecker App

- This app has several notable properties



Overview of the PrimeChecker App

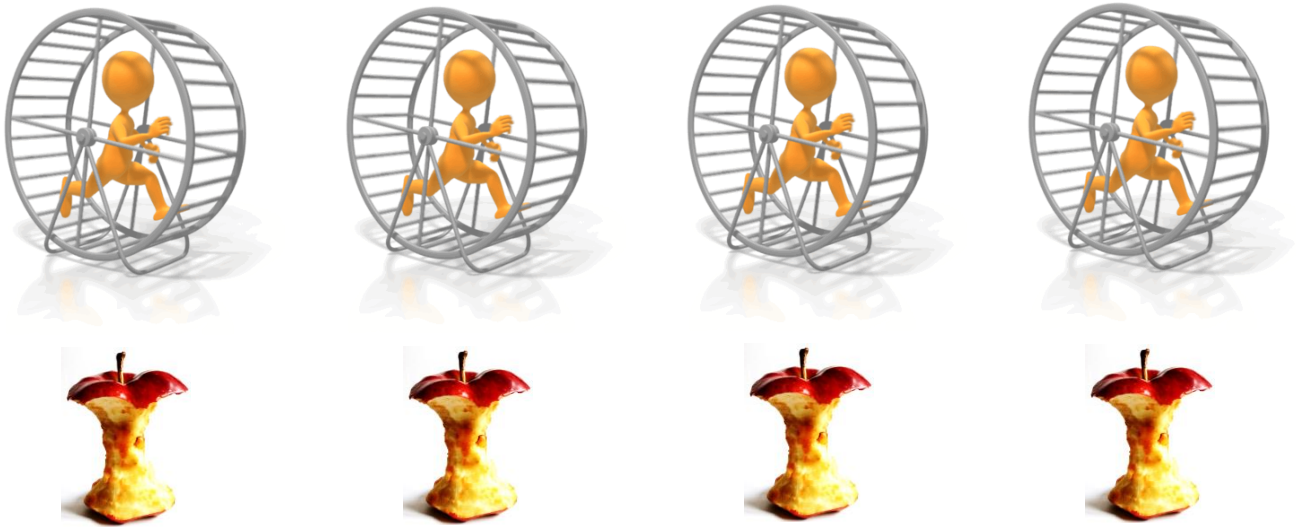
- This app has several notable properties
  - It is "embarrassingly parallel"
    - *i.e., no data dependencies between worker threads*

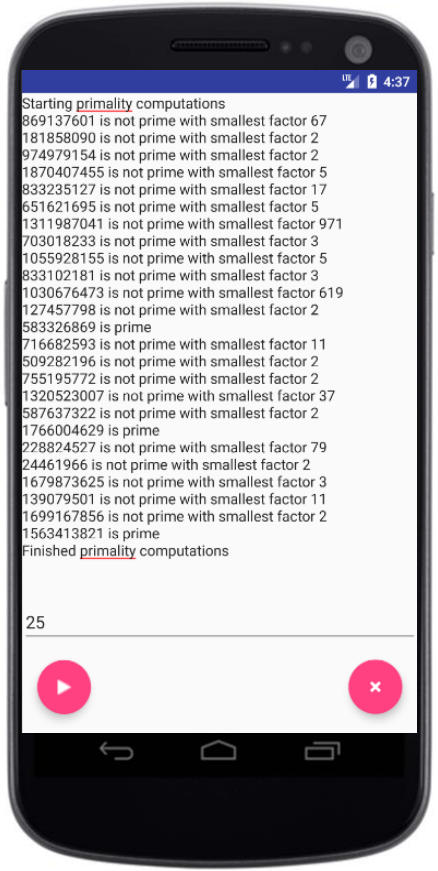


See en.wikipedia.org/wiki/Embarrassingly_parallel

Overview of the PrimeChecker App

- This app has several notable properties
  - It is "embarrassingly parallel"
  - It is compute-bound
    - i.e., time to complete a task is dictated by CPU speed





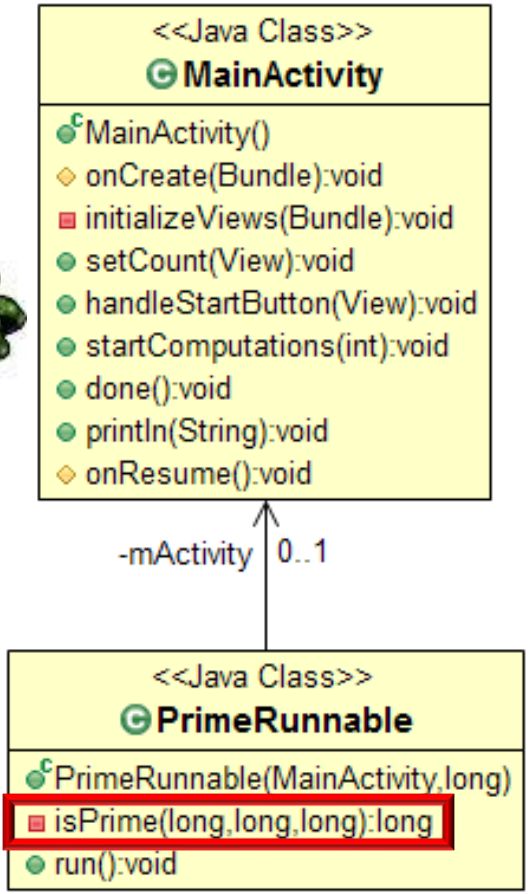
See en.wikipedia.org/wiki/CPU-bound

Overview of the PrimeChecker App

- PrimeRunnable defines a brute-force means to check if a # is prime

```
long isPrime(long n) {
  if (n > 3)
    for (long factor = 2;
         factor <= n / 2;
         ++factor)
      if (n / factor * factor
          == n)
        return factor;

  return 0;
}
```



See www.mkyong.com/java/how-to-determine-a-prime-number-in-java

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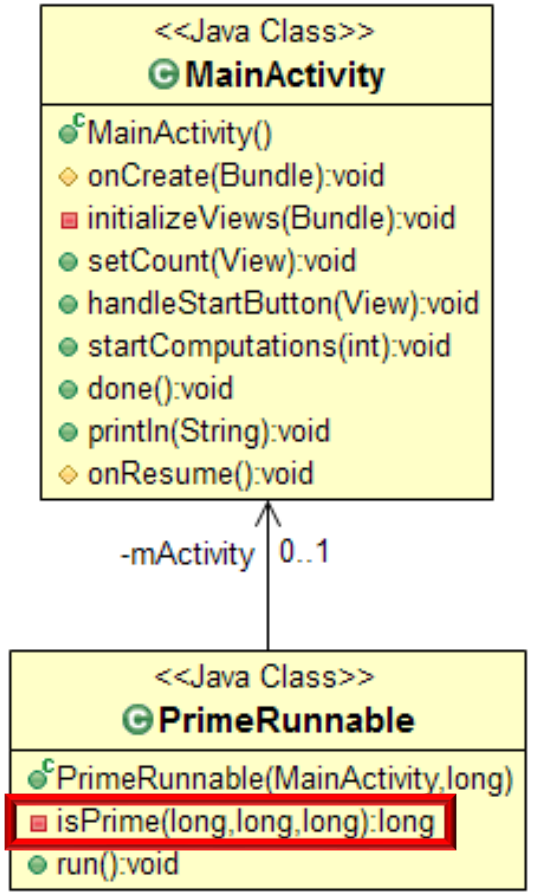
Note how this algorithm is "compute-bound"



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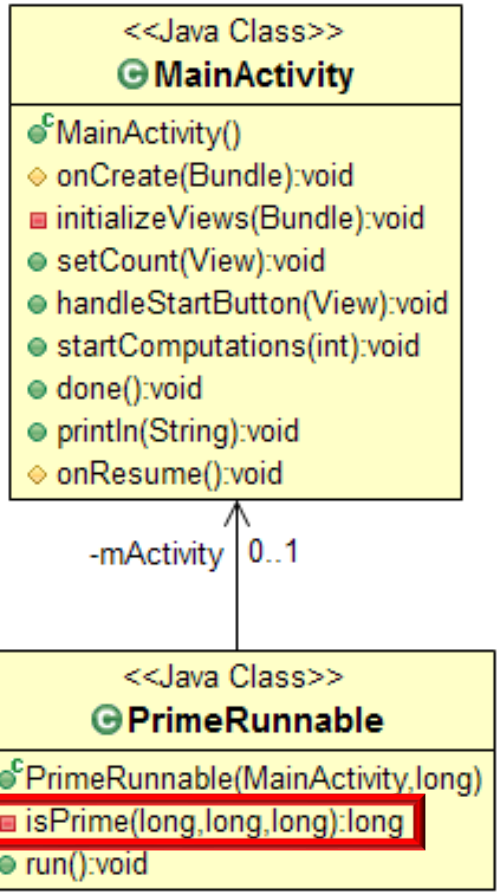
Return 0 if # is prime or smallest factor if not



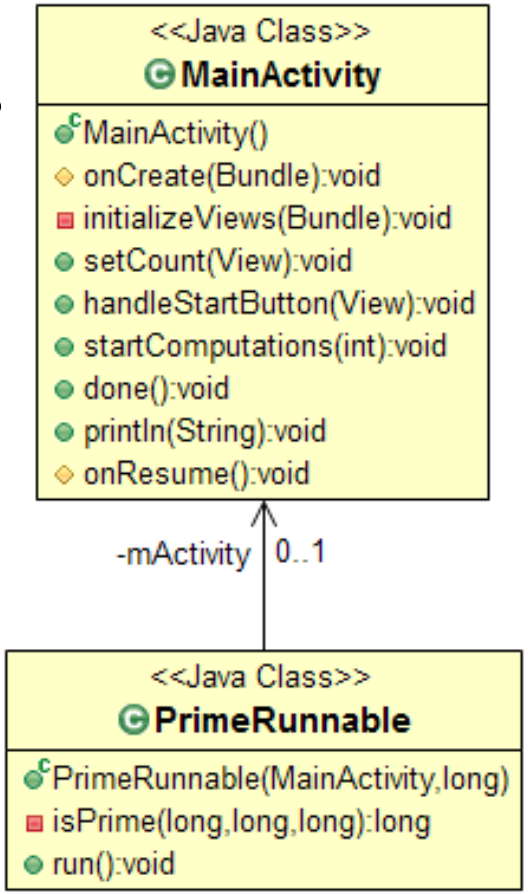
The goal is to burn non-trivial CPU time!!

Overview of the PrimeChecker App

- This app uses a Java Executor that's implemented w/a fixed-size thread pool tuned to the # of processor cores in the computing device

```
mExecutor = Executors.newFixedThreadPool
              (Runtime.getRuntime().
               availableProcessors());
```

Creates a thread pool that reuses a fixed # of threads operating off a shared unbounded queue



See docs.oracle.com/javase/8/docs/api/java/util/concurrent/Executors.html#newFixedThreadPool

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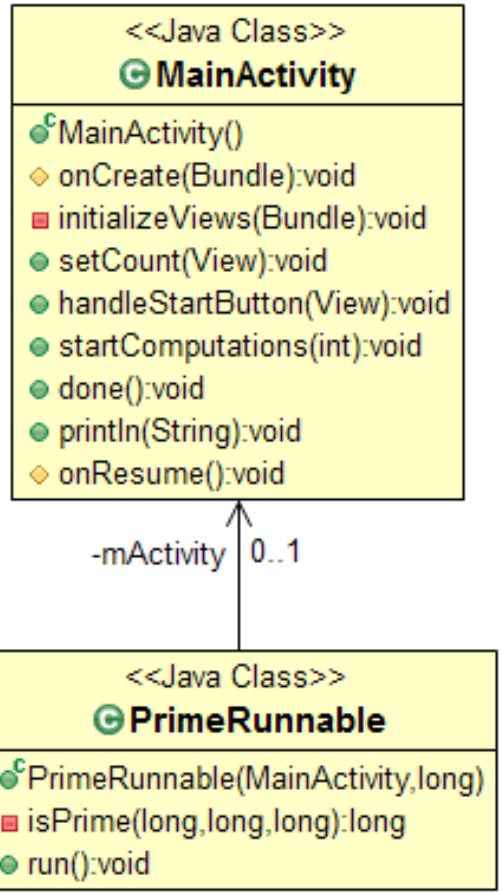
Returns # of processors available to the Java execution environment



See docs.oracle.com/javase/8/docs/api/java/lang/Runtime.html#availableProcessors

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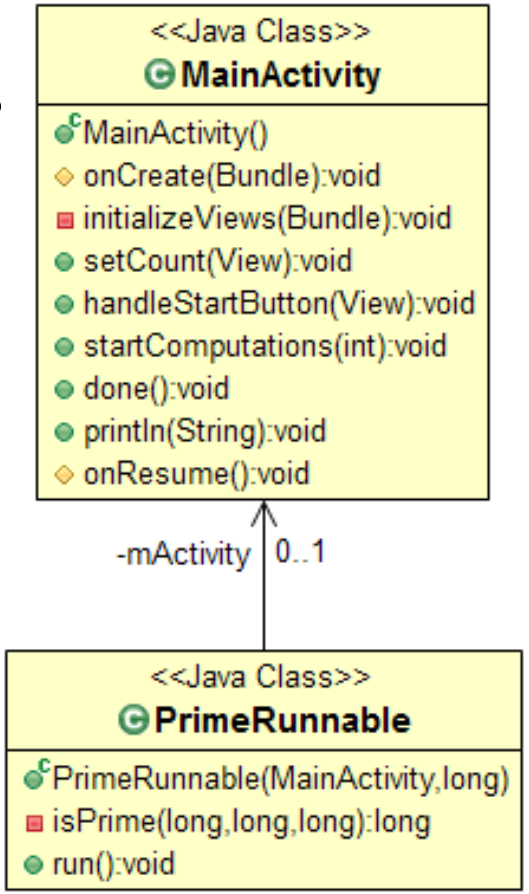
This value is suitable since isPrime() is inherently a "compute-bound" task



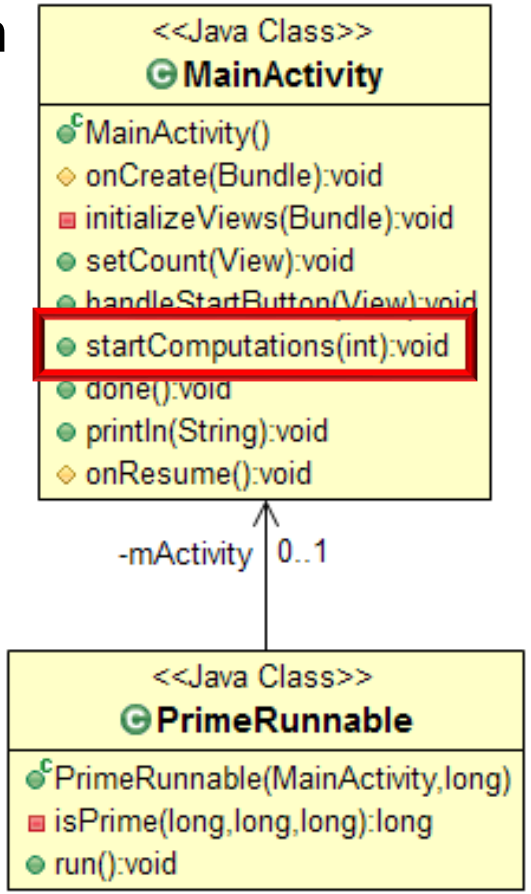
See en.wikipedia.org/wiki/CPU-bound

Overview of the PrimeChecker App

- MainActivity creates/executes a PrimeRunnable for each of the "count" random #

```
new Random()
   .longs(count,
          sMAX_VALUE - count, sMAX_VALUE)

   .forEach(randomNumber ->
            mExecutor.execute
               (new PrimeRunnable
                     (this, randomNumber)));
```



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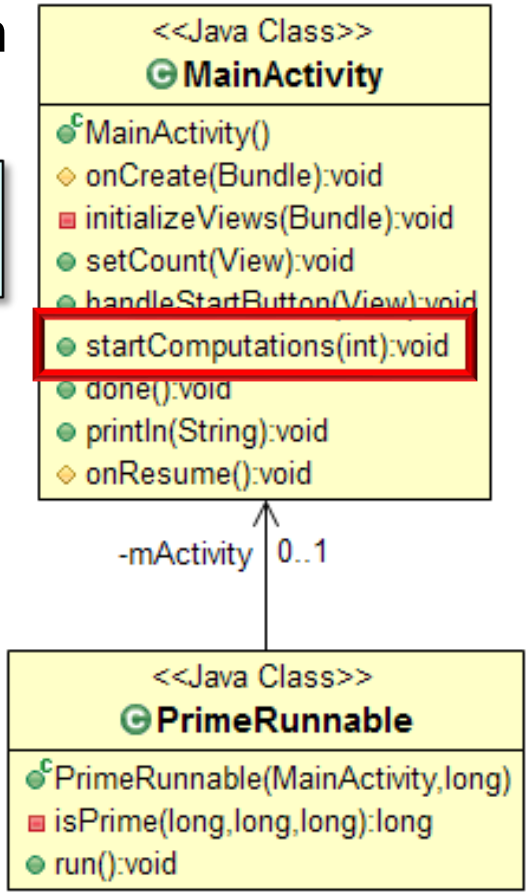
```

These random longs are in the range sMAX_VALUE – count & sMAX_VALUE



sMAX_VALUE is set to a large #, e.g., 1,000,000,000

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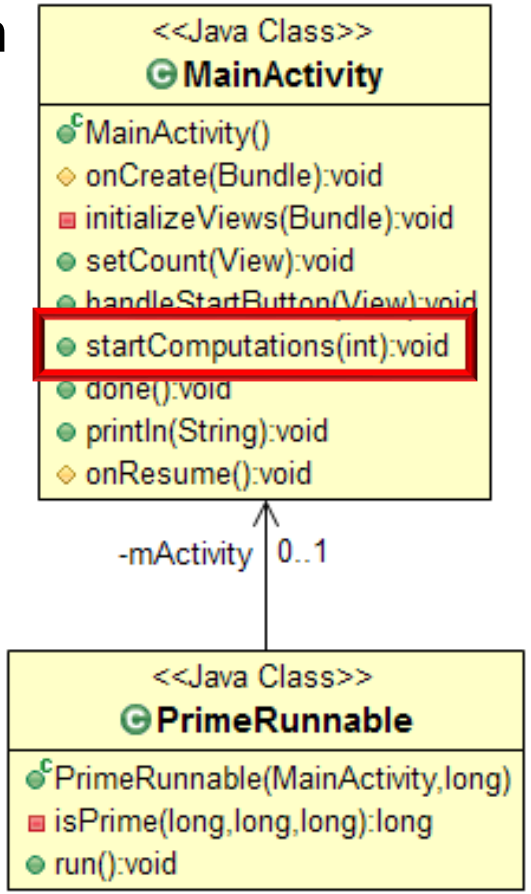
Each random long is queued for execution by a thread in the pool



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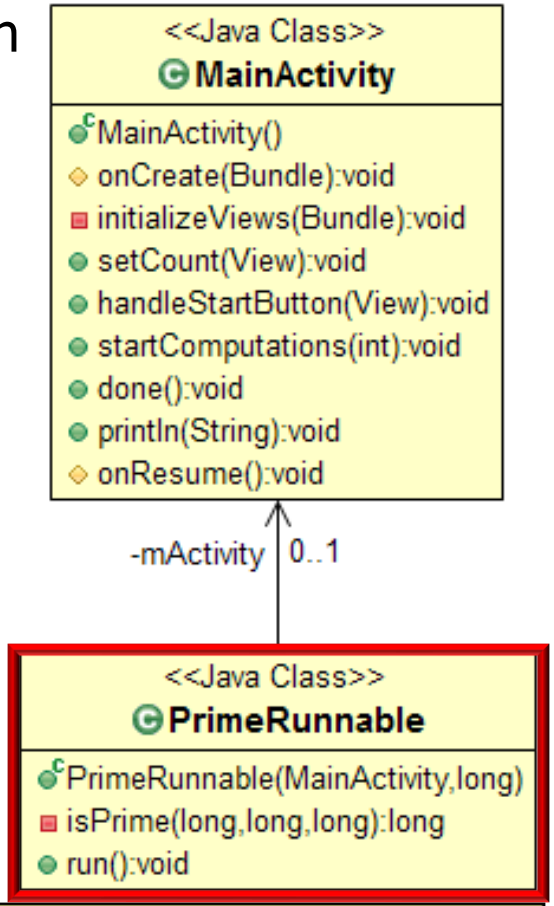

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Overview of the PrimeChecker App

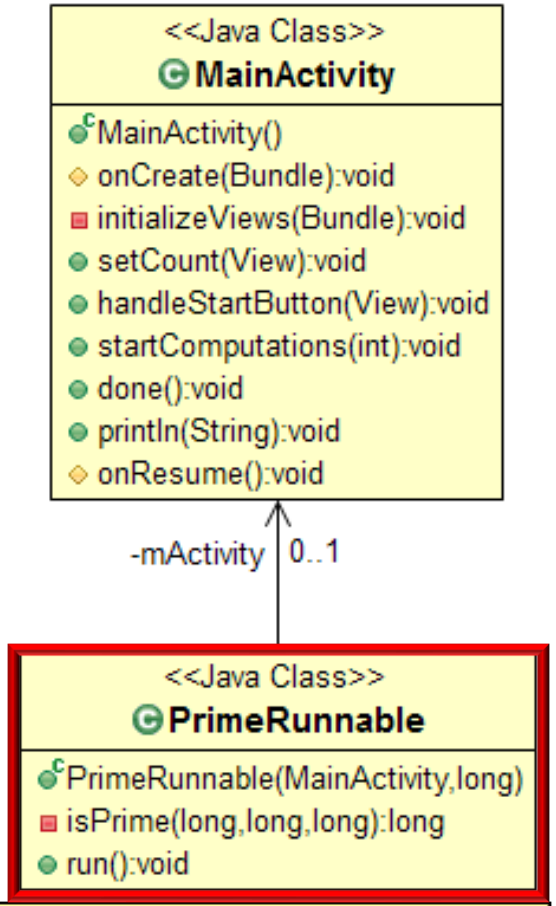
- PrimeRunnable determines if a # is prime

```
class PrimeRunnable implements Runnable {
  long mPrimeCandidate;
  private final MainActivity mActivity;
  ...

  PrimeRunnable(MainActivity a, Long pc)
  { mActivity = a; mPrimeCandidate = pc; }

  long isPrime(long n) { ... }

  PrimeResult run() {
    long smallestFactor =
      isPrime(mPrimeCandidate);
  } ...
```



See PrimeExecutor/app/src/main/java/vandy/mooc/prime/activities/PrimeRunnable.java

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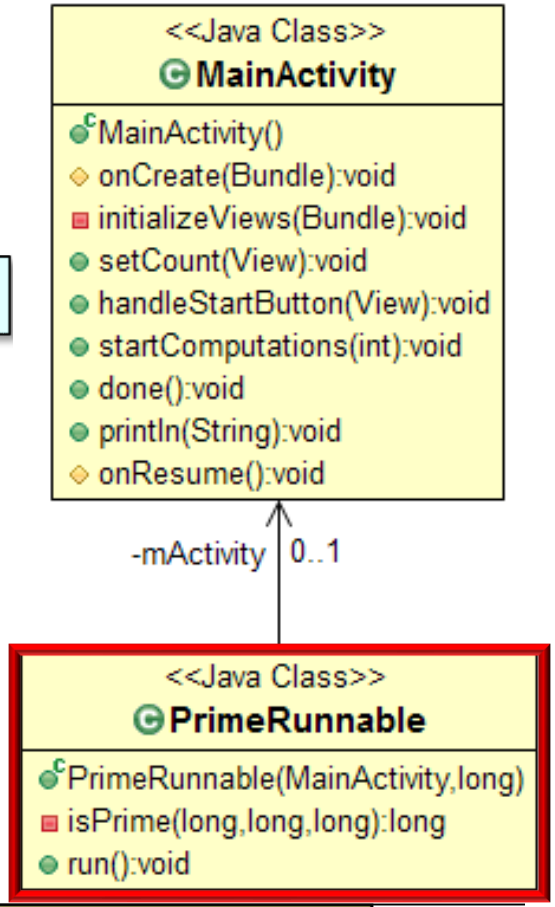
Implements Runnable



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  PrimeResult run() {
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```
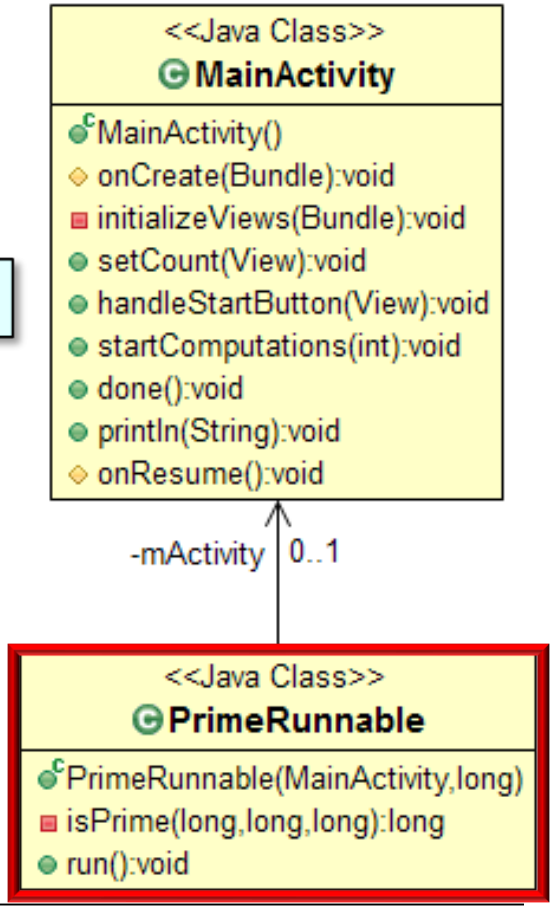

Constructor stores prime # candidate & activity



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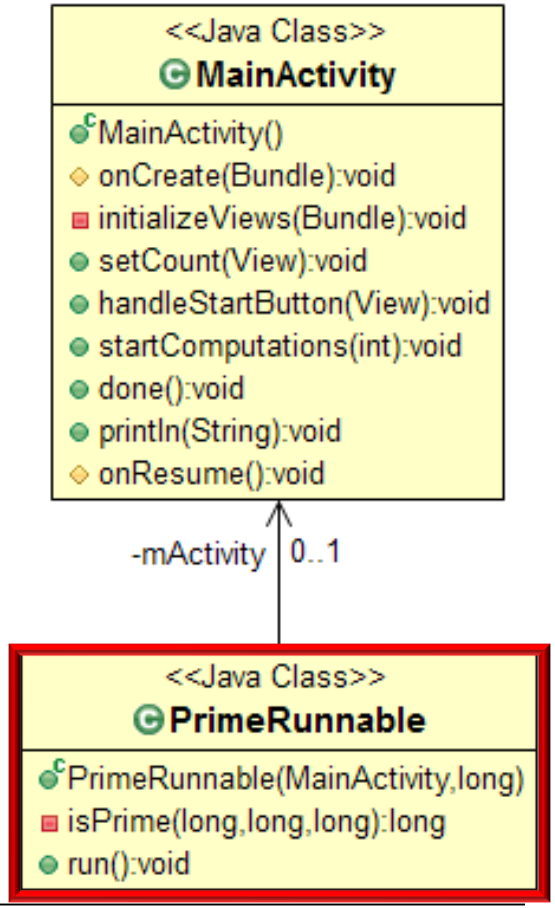
Returns 0 if n is prime or smallest factor if it's not



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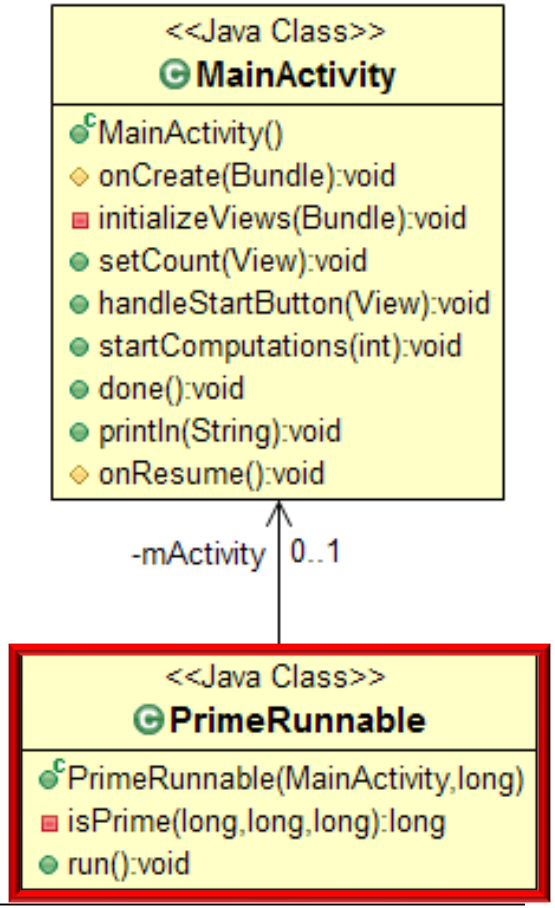
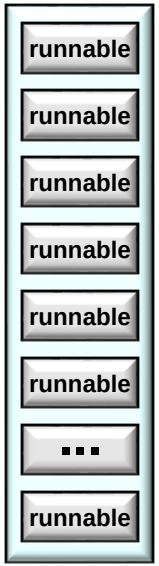
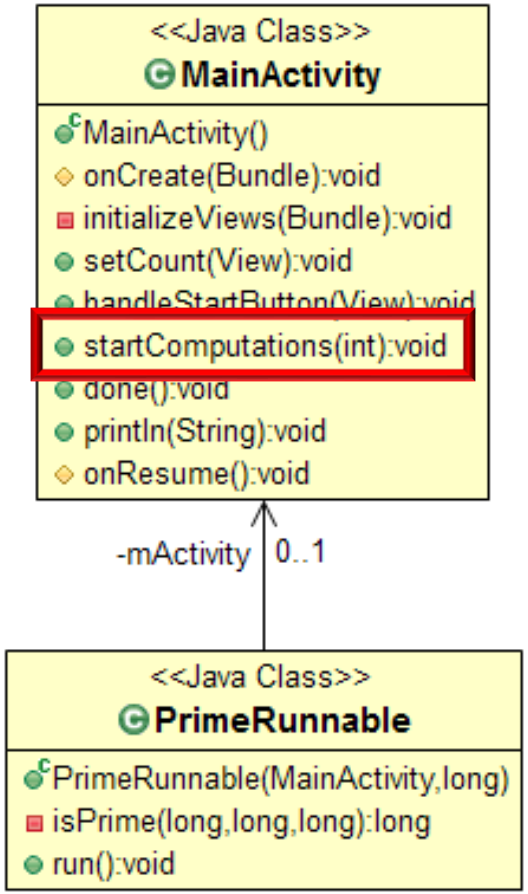


The run() hook method invokes isPrime()

Overview of the PrimeChecker App

- Although there may be many PrimeRunnable instances, they will run on a (much) smaller # of threads, which can be tuned transparently





Evaluating the PrimeChecker App

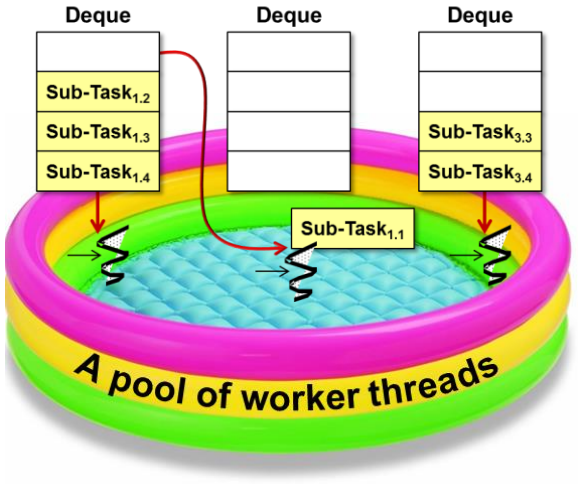
Evaluating the PrimeChecker App

- The Java Executor interface enables the # & type of threads to be tuned transparently wrt the prime checker app logic

```
new Random().longs(count, sMAX_VALUE - count, sMAX_VALUE)
            .forEach(randomNumber ->  mExecutor.execute
               (new PrimeRunnable(this, randomNumber)));
```

Fixed-sized Thread Pool

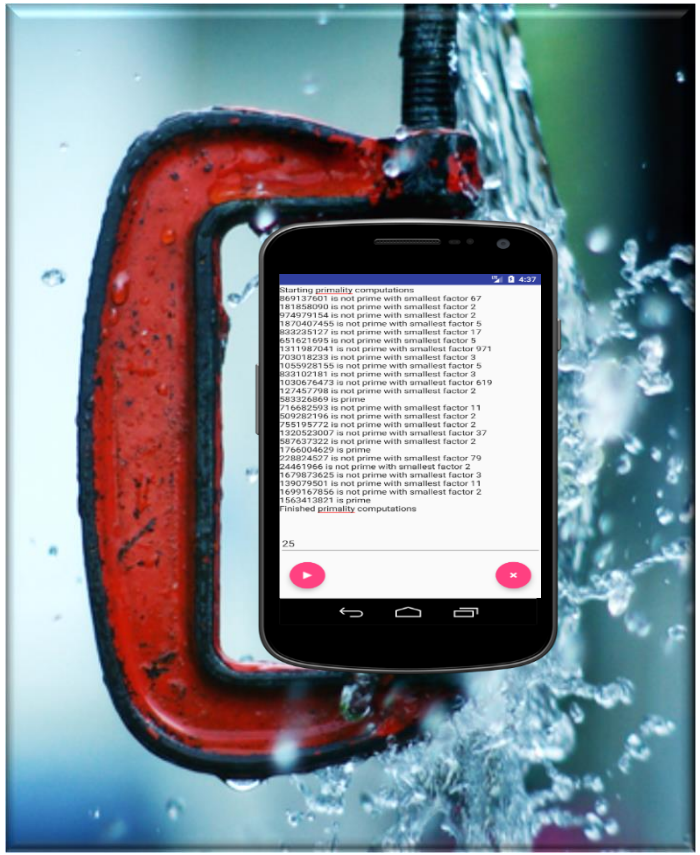
Variable-sized Thread Pool



Work-stealing Thread Pool

Evaluating the PrimeChecker App

- However, Java Executor has some restrictions



Evaluating the PrimeChecker App

- However, Java Executor has some restrictions, e.g.
  - One-way semantics of runnables tightly couple PrimeRunnable with MainActivity


```
class PrimeRunnable implements Runnable {
   ...
   private final MainActivity mActivity;
   ...
   public PrimeRunnable(MainActivity activity)
   { mActivity = activity; ... }

   public void run() {
      ... mActivity.done(); ...
   }
}
```

This tight coupling complicates runtime configuration changes

Evaluating the PrimeChecker App

- However, Java Executor has some restrictions, e.g.
  - One-way semantics of runnables tightly couple PrimeRunnable with MainActivity
  - isPrime() tightly coupled w/PrimeRunnable

```
class PrimeRunnable implements Runnable {
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  long isPrime(long n) {
    if (n > 3)
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          return factor;
    return 0;
  } ...
```

e.g., primality check is applied even if results are computed & complicates improvements

Evaluating the PrimeChecker App

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  - One-way semantics of runnables tightly couple PrimeRunnable with MainActivity
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  - The lack of lifecycle operations on Java Executor

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  - One-way semantics of runnables tightly couple PrimeRunnable with MainActivity
  - isPrime() tightly coupled w/PrimeRunnable
  - The lack of lifecycle operations on Java Executor, e.g.
    - Can't interrupt/cancel running tasks
    - Can't handle runtime configuration changes gracefully
      - e.g., must restart processing from the beginning

End of Overview of Java Executor Interface (Part 2)