Applying the Java FutureTask-based Memoizer to the PrimeChecker App

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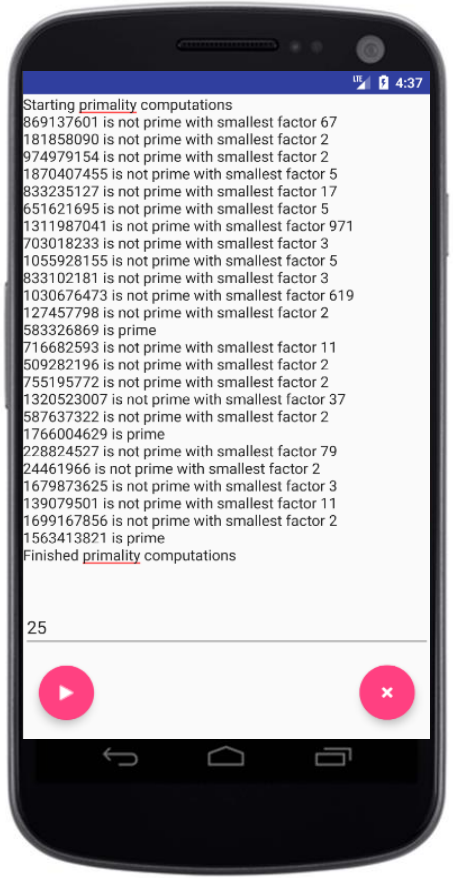
Learning Objectives in this Part of the Lesson

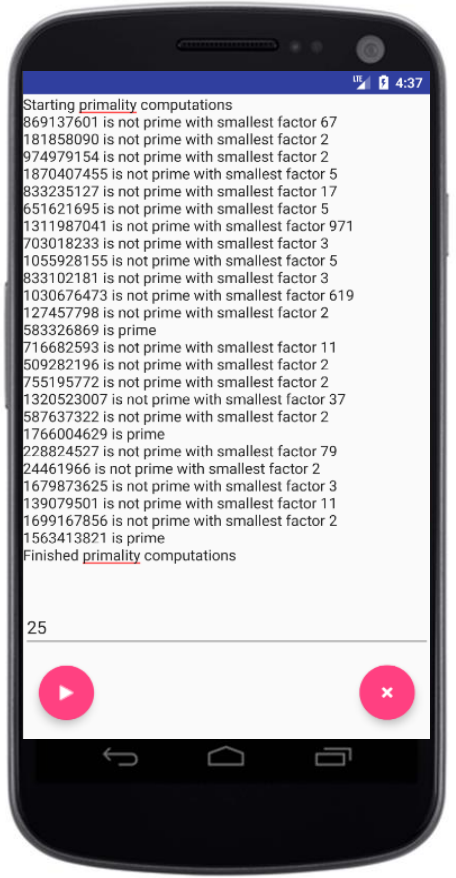
- Understand how Java FutureTask conveys a result from a computation running in a thread to thread(s) retrieving the result
- Recognize key methods in Java FutureTask
- Know what a Memoizer is & motivates how FutureTask can optimize its performance in concurrent programs
- Learn how to implement the Memoizer cache with FutureTask
- Recognize how the Memoizer class is applied to the PrimeChecker app to optimize prime # checking



Applying the Memoizer to Optimize Prime # Checking

Applying the Memoizer to Optimize Prime # Checking

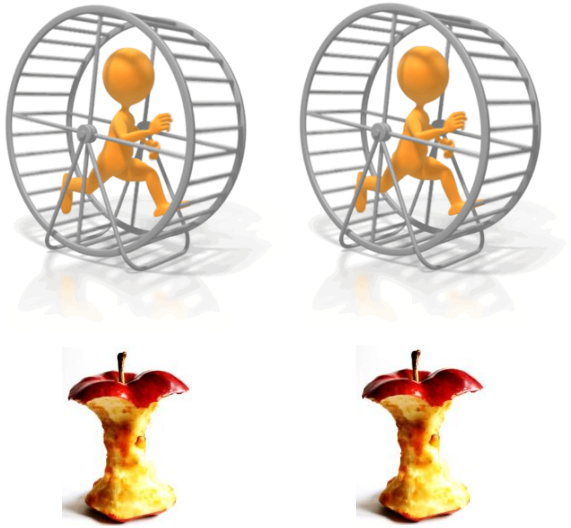
- This app applies the Java ExecutorCompletionService framework & the FutureTask-based Memoizer to check if *N* random #'s are prime

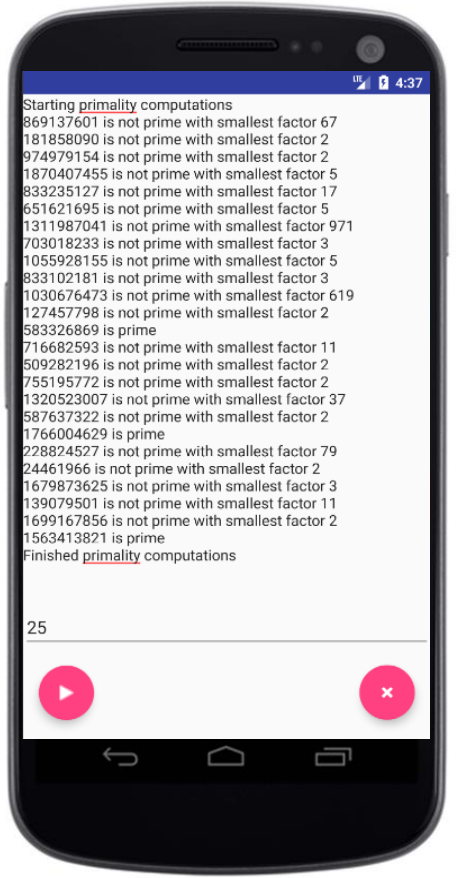


See github.com/douglascraigschmidt/POSA/tree/master/ex/M4/Primes/PrimeExecutorServiceFutureTask

Applying the Memoizer to Optimize Prime # Checking

- This app applies the Java ExecutorCompletionService framework & the FutureTask-based Memoizer to check if *N* random #'s are prime
  - This app is "embarrassingly parallel" & compute-bound

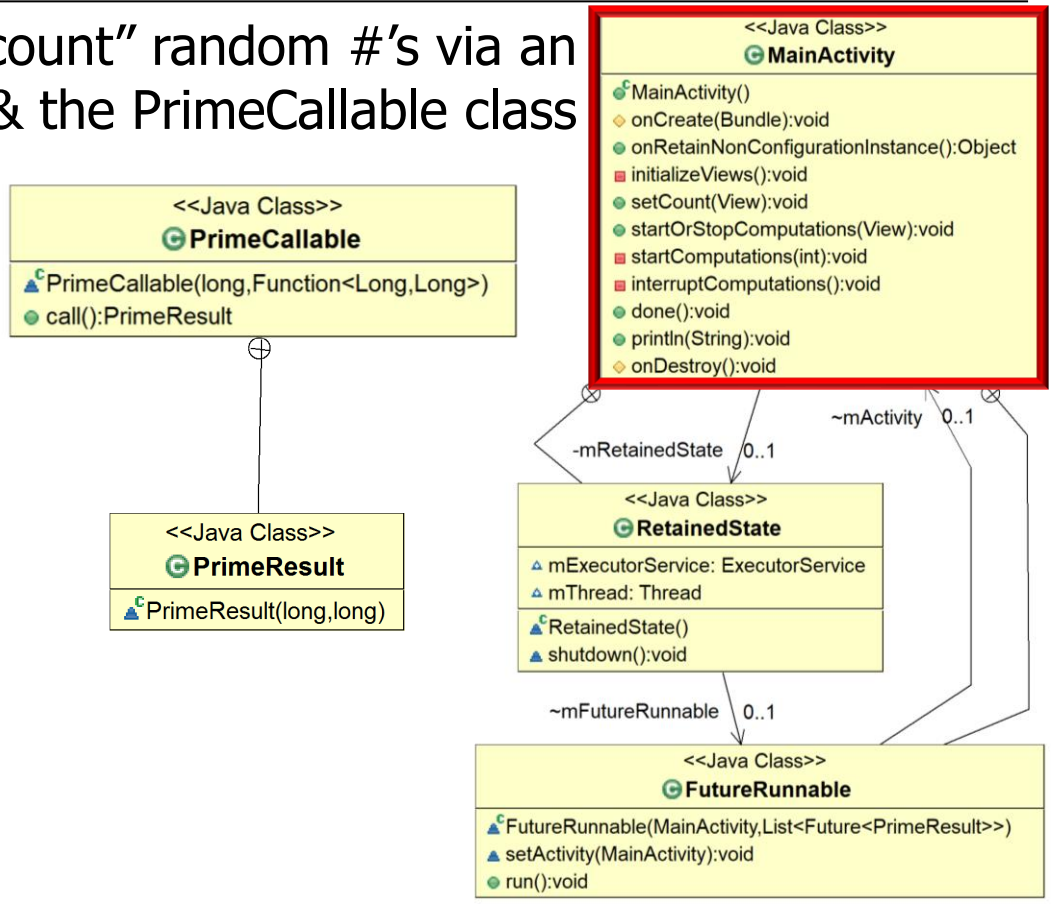




See en.wikipedia.org/wiki/Embarrassingly_parallel & en.wikipedia.org/wiki/CPU-bound

Applying the Memoizer to Optimize Prime # Checking

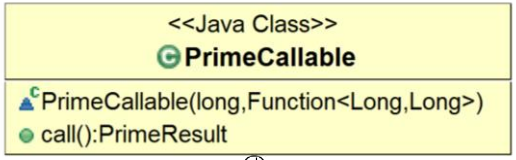
- MainActivity checks primality of "count" random #'s via an ExecutorService w/a thread pool & the PrimeCallable class

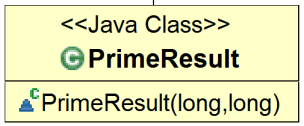


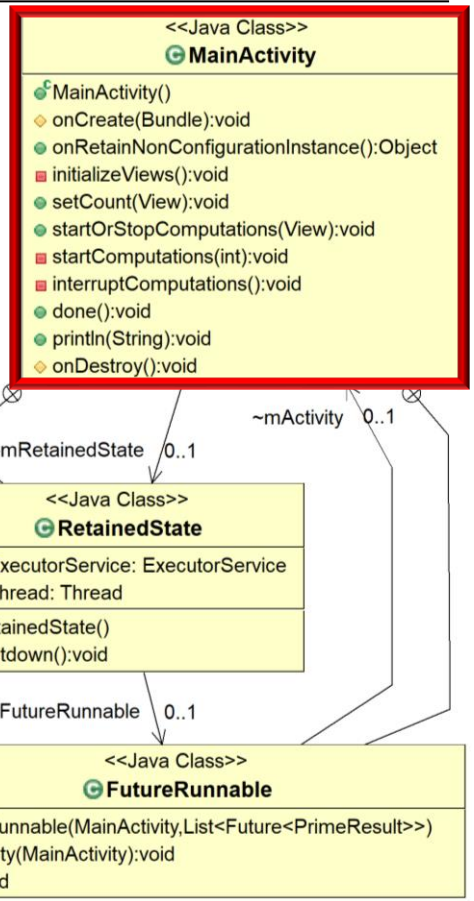
See PrimeExecutorServiceFutureTask/app/src/main/java/vandy/mooc/prime/activities/MainActivity.java

Applying the Memoizer to Optimize Prime # Checking

- MainActivity checks primality of "count" random #'s via an ExecutorService w/a thread pool & the PrimeCallable class








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

The executor service uses a fixed-sized thread pool

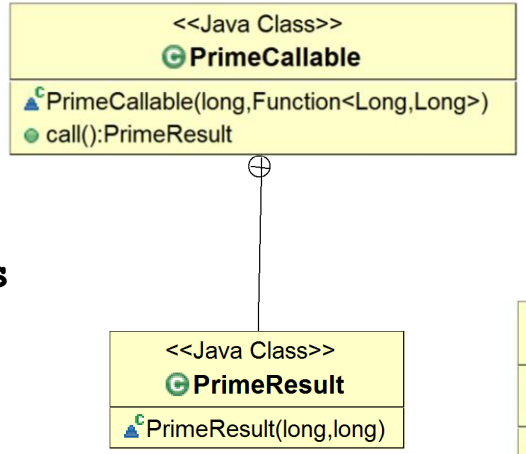
See docs.oracle.com/javase/8/docs/api/java/util/concurrent/Executors.html#newFixedThreadPool

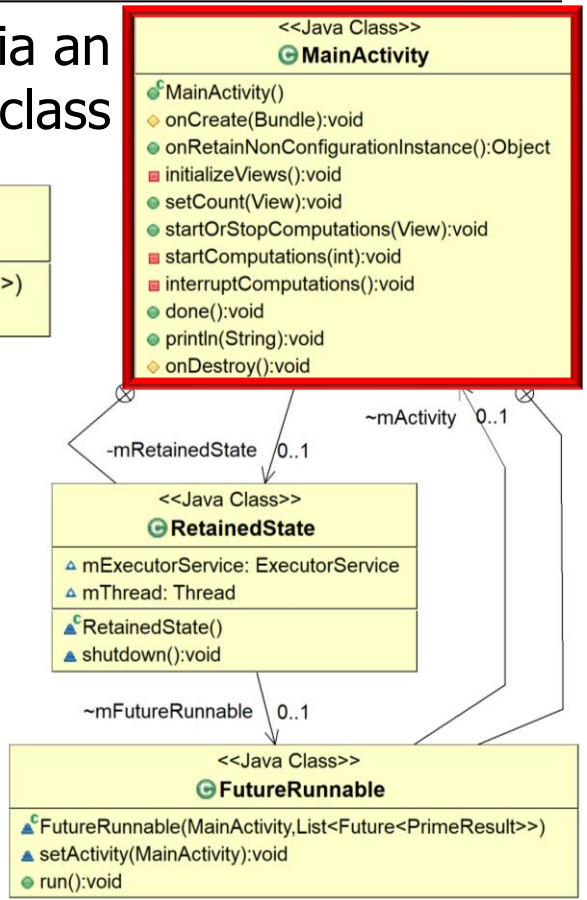
Applying the Memoizer to Optimize Prime # Checking

- MainActivity checks primality of "count" random #'s via an ExecutorService w/a thread pool & the PrimeCallable class


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

Pool size tuned to # of processor cores

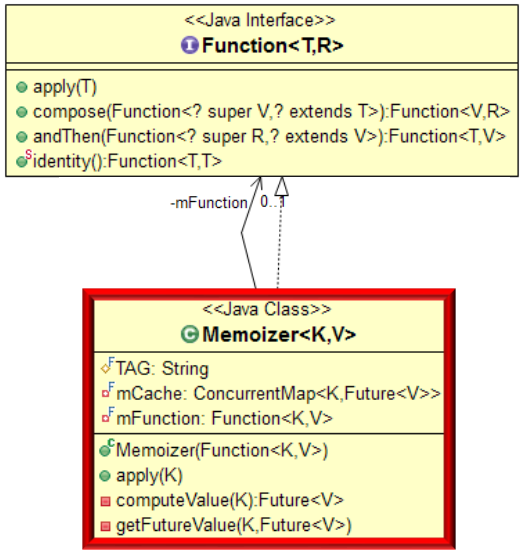


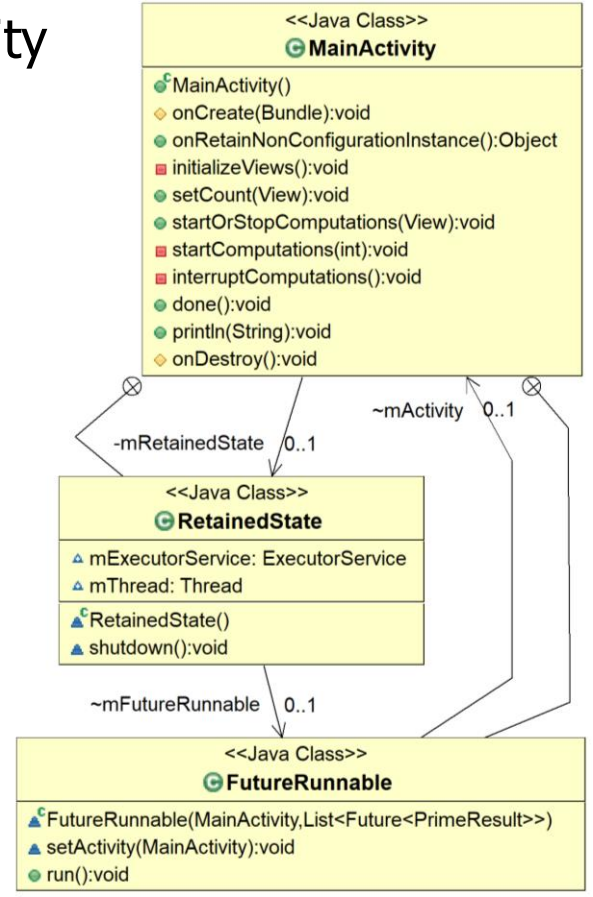


See docs.oracle.com/javase/8/docs/api/java/lang/Runtime.html#availableProcessors

Applying the Memoizer to Optimize Prime # Checking

- MainActivity also uses a memoizer to optimize primality checking of the random #'s





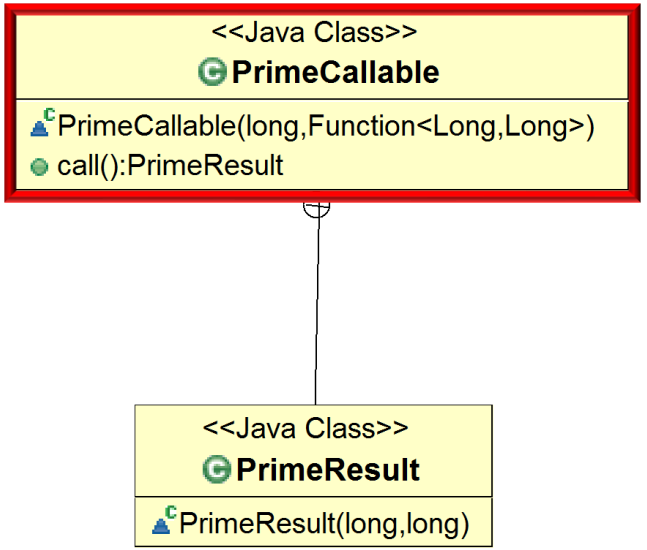
See earlier parts of this lesson on "*Application to Memoizer*" & "*Implementing a Memoizer*"

Applying the Memoizer to Optimize Prime # Checking

- PrimeCallable uses a Function object to extensibly determine if a # is prime

```
class PrimeCallable
      implements Callable<PrimeResult> {
  long mPrimeCandidate;
  mFunction<Long, Long> mPrimeChecker;

  PrimeCallable(Long primeCandidate,
                Function<Long, Long>
                   primeChecker) {
    mPrimeCandidate = primeCandidate;
    mPrimeChecker = primeChecker;
  }
```



See PrimeExecutorServiceFutureTask/app/src/main/java/vandy/mooc/prime/activities/PrimeCallable.java

Applying the Memoizer to Optimize Prime # Checking

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```
class PrimeCallable
      implements Callable<PrimeResult> {
  long mPrimeCandidate;
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  PrimeCallable(Long primeCandidate,
                Function<Long, Long>
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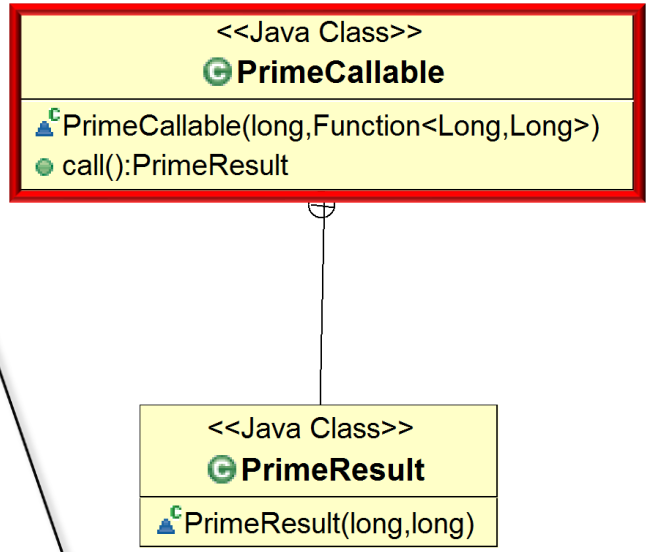
    mPrimeCandidate = primeCandidate;
    mPrimeChecker = primeChecker;
  }
```



PrimeCallable implements Callable so it can be submitted & run by the Java ExecutorCompletionService framework

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/Callable.html

Applying the Memoizer to Optimize Prime # Checking

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```
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  PrimeCallable(Long primeCandidate,
                Function<Long, Long>
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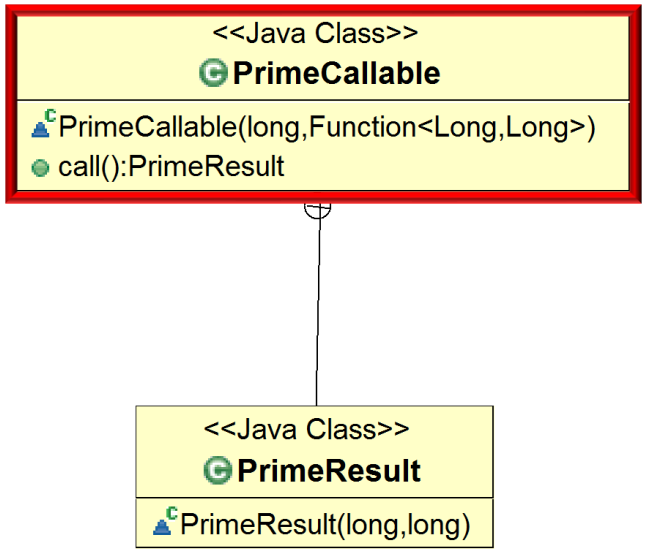
    mPrimeCandidate = primeCandidate;
    mPrimeChecker = primeChecker;
  }
```



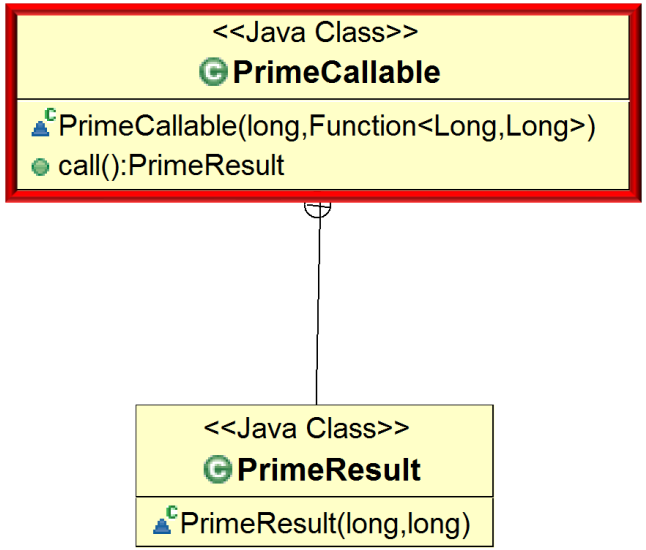
The function that checks primes is passed as a param & stored in a field

Applying the Memoizer to Optimize Prime # Checking

- PrimeCallable uses a Function object to extensibly determine if a # is prime

```
class PrimeCallable
      implements Callable<PrimeResult> {
   ...
  PrimeResult call() {
    return new PrimeResult
      (mPrimeCandidate,
       mPrimeChecker
         .apply(mPrimeCandidate));
  }
  ...
```

The call() hook method applies the function



This method runs in the context of a thread in the fixed-sized thread pool

Applying the Memoizer to Optimize Prime # Checking

- PrimeCallable uses a Function object to extensibly determine if a # is prime

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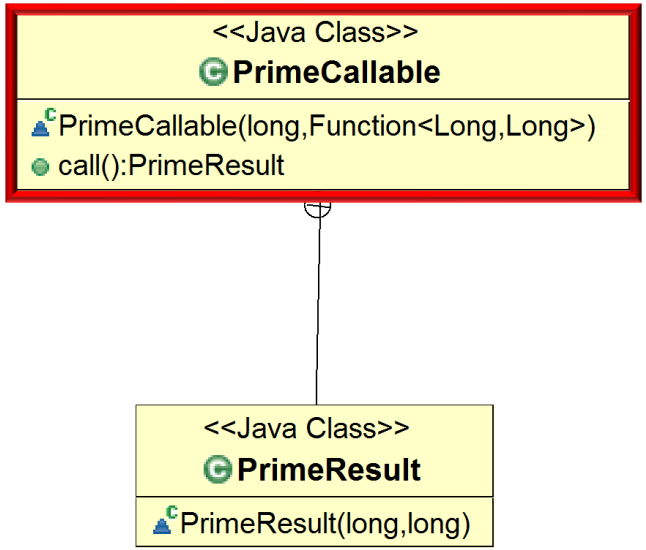
         .apply(mPrimeCandidate));
  }
  ...
```



apply() returns 0 if the # is prime or smallest factor if it's not

The apply() method call can be transparently optimized via the Memoizer

Applying the Memoizer to Optimize Prime # Checking

- PrimeCallable uses a Function object to extensibly determine if a # is prime

```
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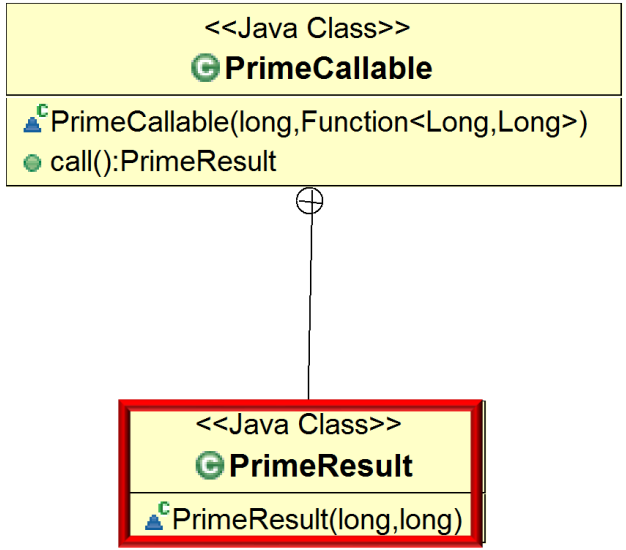
  }
  ...
```



The PrimeResult tuple matches the prime # candidate with result of checking for primality

Applying the Memoizer to Optimize Prime # Checking

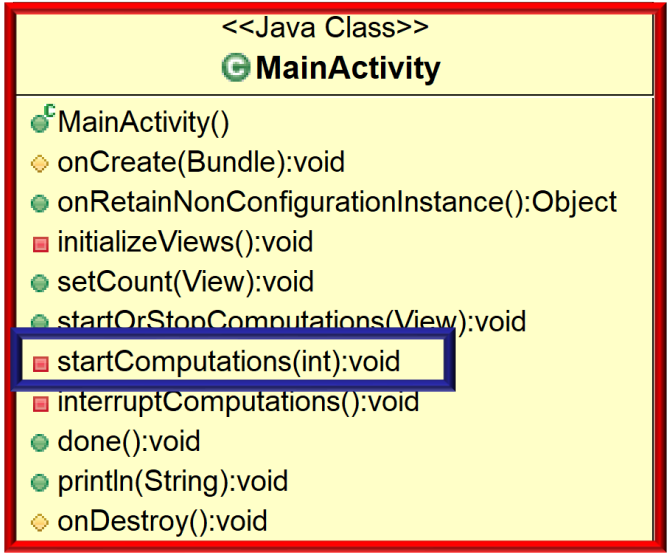
- Memoizer caches results when processing a stream of PrimeCallables

```
mMemoizer = new Memoizer<>
     (PrimeCheckers::bruteForceChecker);



new Random()
     .longs(count,
            sMAX_VALUE - count,
            sMAX_VALUE)
     .mapToObj(ranNum ->
        new PrimeCallable(ranNum, mMemoizer))

     .forEach(callable ->
              mRetainedState.mExecutorCompService::submit); ...
```



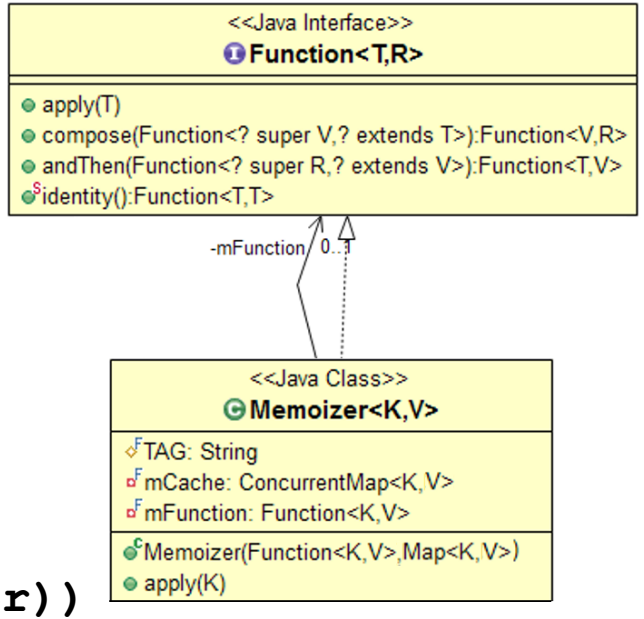
See PrimeExecutorServiceFutureTask/app/src/main/java/vandy/mooc/prime/activities/MainActivity.java

Applying the Memoizer to Optimize Prime # Checking

- Memoizer caches results when processing a stream of PrimeCallables

```
mMemoizer = new Memoizer<>
      (PrimeCheckers::bruteForceChecker);
```

This memoizer caches prime # results




```
new Random()
      .longs(count,
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             sMAX_VALUE)
      .mapToObj(ranNum ->
         new PrimeCallable(ranNum, mMemoizer))

      .forEach(callable ->
               mRetainedState.mExecutorCompService::submit); ...
```

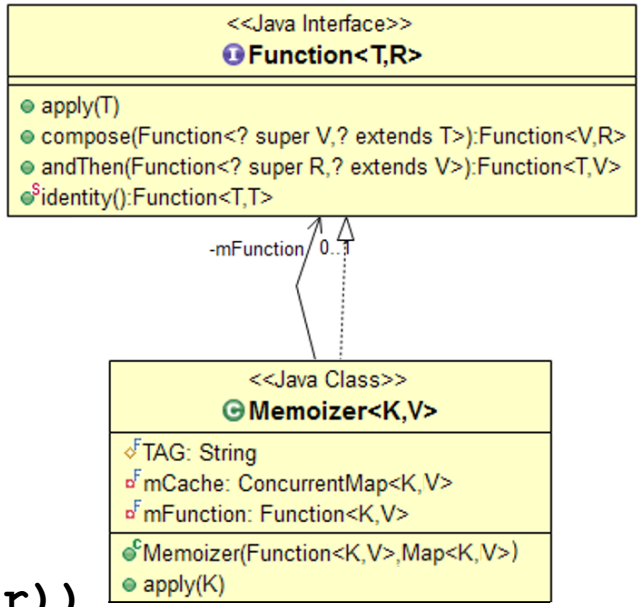
See PrimeExecutorServiceFutureTask/app/src/main/java/vandy/mooc/prime/utils/Memoizer.java

Applying the Memoizer to Optimize Prime # Checking

- Memoizer caches results when processing a stream of PrimeCallables

```
mMemoizer = new Memoizer<>
      (PrimeCheckers::bruteForceChecker);
```

It's easy to change the prime # checker from this..




```
new Random()
      .longs(count,
             sMAX_VALUE - count,
             sMAX_VALUE)
      .mapToObj(ranNum ->
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      .forEach(callable ->
               mRetainedState.mExecutorCompService::submit); ...
```

Applying the Memoizer to Optimize Prime # Checking

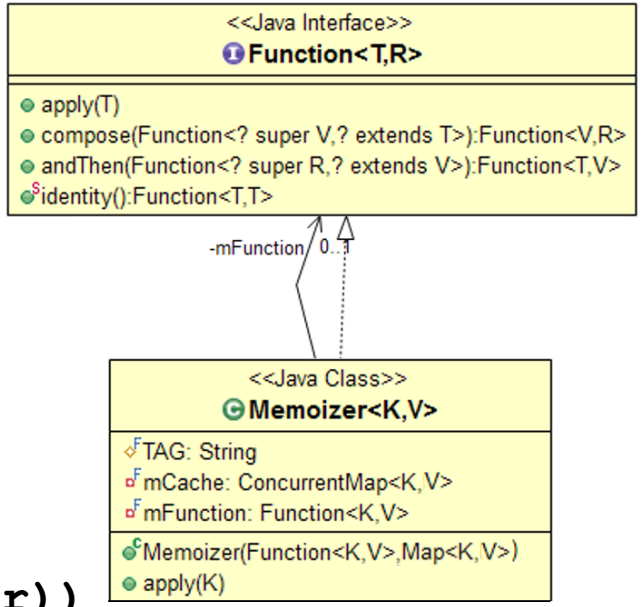
- Memoizer caches results when processing a stream of PrimeCallables

```
mMemoizer = new Memoizer<>
      (PrimeCheckers::efficientChecker);
```

..to this..

```
new Random()
      .longs(count,
             sMAX_VALUE - count,
             sMAX_VALUE)
      .mapToObj(ranNum ->
         new PrimeCallable(ranNum, mMemoizer))

      .forEach(callable ->
               mRetainedState.mExecutorCompService::submit); ...
```



Applying the Memoizer to Optimize Prime # Checking

- Memoizer caches results when processing a stream of PrimeCallables

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     .longs(count,
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            sMAX_VALUE)
     .mapToObj(ranNum ->
        new PrimeCallable(ranNum, mMemoizer))

     .forEach(callable ->
              mRetainedState.mExecutorCompService::submit); ...
```

Generates "count" random #'s between sMAX_VALUE – count & sMAX_VALUE

Applying the Memoizer to Optimize Prime # Checking

- Memoizer caches results when processing a stream of PrimeCallables

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mMemoizer = new Memoizer<>
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     .mapToObj(ranNum ->
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     .forEach(callable ->
              mRetainedState.mExecutorCompService::submit); ...
```

Transforms random #'s into PrimeCallables

Applying the Memoizer to Optimize Prime # Checking

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     .longs(count,
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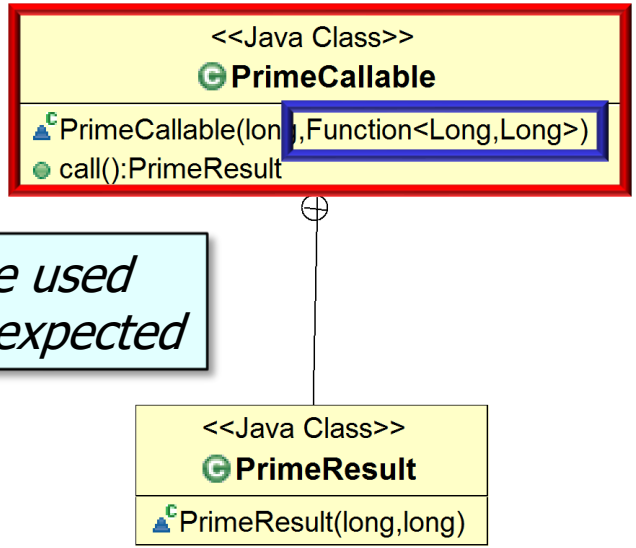
     .forEach(callable ->
              mRetainedState.mExecutorCompService::submit); ...
```



See blog.indrek.io/articles/java-8-behavior-parameterization

Applying the Memoizer to Optimize Prime # Checking

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     .mapToObj(ranNum ->
        new PrimeCallable(ranNum, mMemoizer))

     .forEach(callable ->
              mRetainedState.mExecutorCompService::submit); ...
```

Submit a value-returning task for execution for each prime callable

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/ExecutorCompletionService.html#submit

Applying the Memoizer to Optimize Prime # Checking

- Memoizer caches results when processing a stream of PrimeCallables

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```

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     .mapToObj(ranNum ->
        new PrimeCallable(ranNum, mMemoizer))

     .forEach(callable ->
              mRetainedState.mExecutorCompService::submit); ...
```

There's no need for a list of futures due to the ExecutorCompletionService

Applying the Memoizer to Optimize Prime # Checking

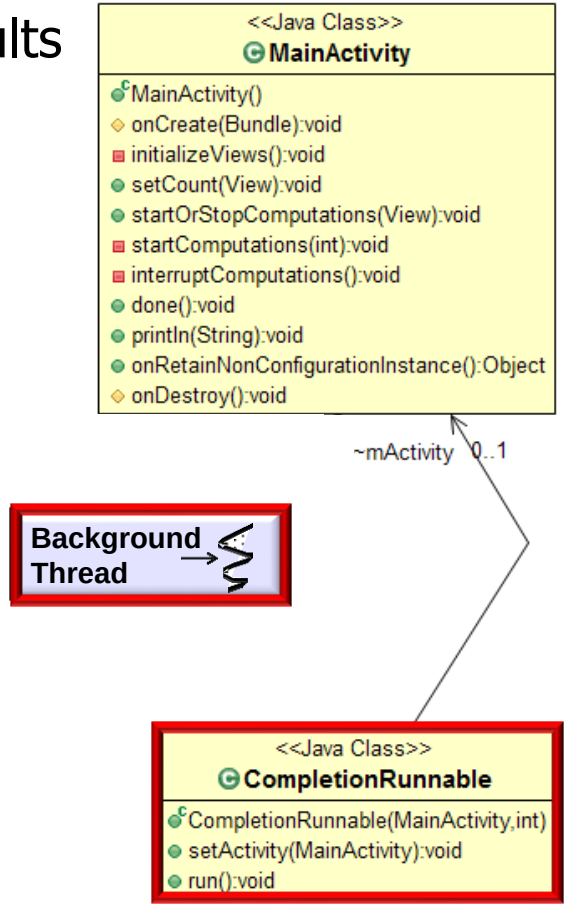
- MainActivity creates a thread to wait for all future results in the background so the UI thread doesn't block

```
...
mRetainedState.mCompletionRunnable =
   new CompletionRunnable(this, count);
```

CompletionRunnable is stored in a field so it can be updated during a runtime configuration change

```
mRetainedState.mThread = new Thread
   (mRetainedState.mCompletionRunnable);

mRetainedState.mThread.start();
```



Applying the Memoizer to Optimize Prime # Checking

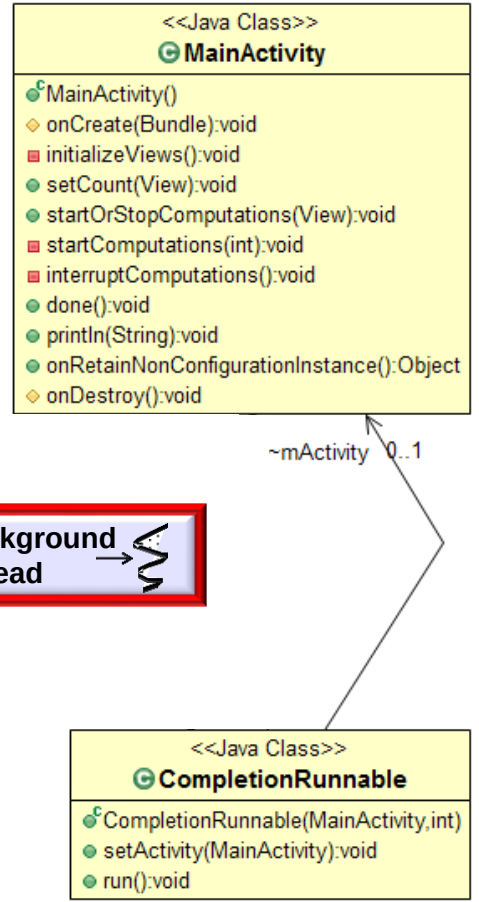
- MainActivity creates a thread to wait for all future results in the background so the UI thread doesn't block

```
...
mRetainedState.mCompletionRunnable =
   new CompletionRunnable(this, count);
```

A new thread is created/started to execute the CompletionRunnable

```
mRetainedState.mThread = new Thread
   (mRetainedState.mCompletionRunnable);

mRetainedState.mThread.start();
```



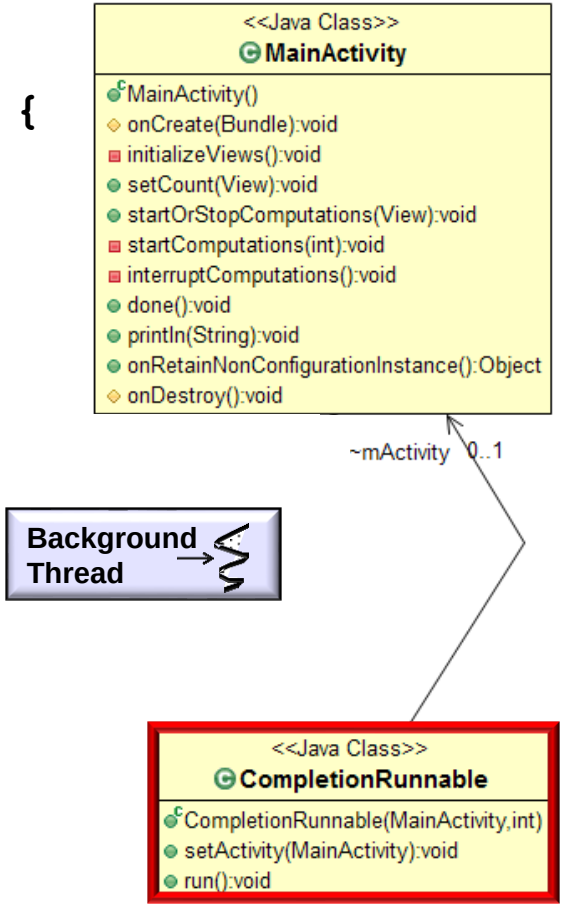
Applying the Memoizer to Optimize Prime # Checking

- CompletionRunnable gets results as futures complete

```
class CompletionRunnable implements Runnable {
  int mCount;
  MainActivity mActivity; ...

 public void run() {
   for (int i = 0; i < mCount; ++i) {
     PrimeResult pr = ...
       mExecutorCompService
         .take().get();

     if (pr.mSmallestFactor != 0) ...
     else ...
   ...
   mActivity.done(); ...
```



Applying the Memoizer to Optimize Prime # Checking

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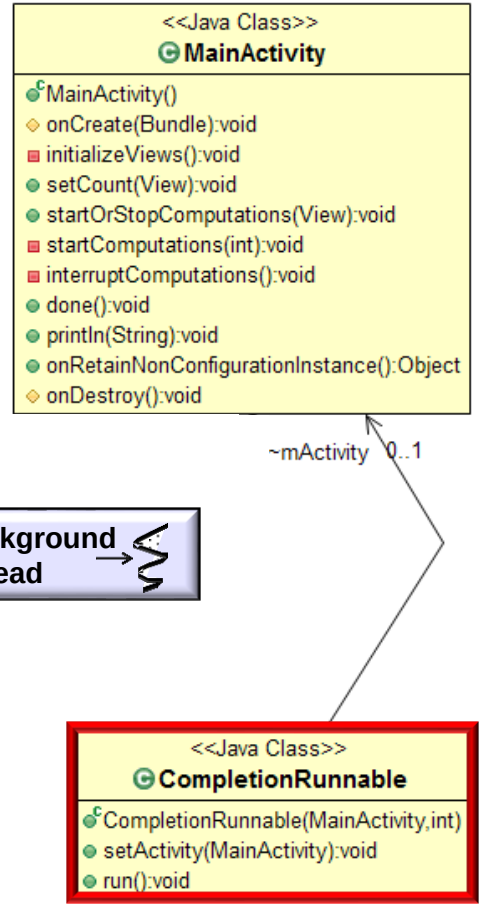
 public void run() {
   for (int i = 0; i < mCount; ++i) {
     PrimeResult pr = ...
       mExecutorCompService
         .take().get();

     if (pr.mSmallestFactor != 0) ...
     else ...
   ...
   mActivity.done(); ...
```

Iterate thru all results



Applying the Memoizer to Optimize Prime # Checking

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 public void run() {
   for (int i = 0; i < mCount; ++i) {
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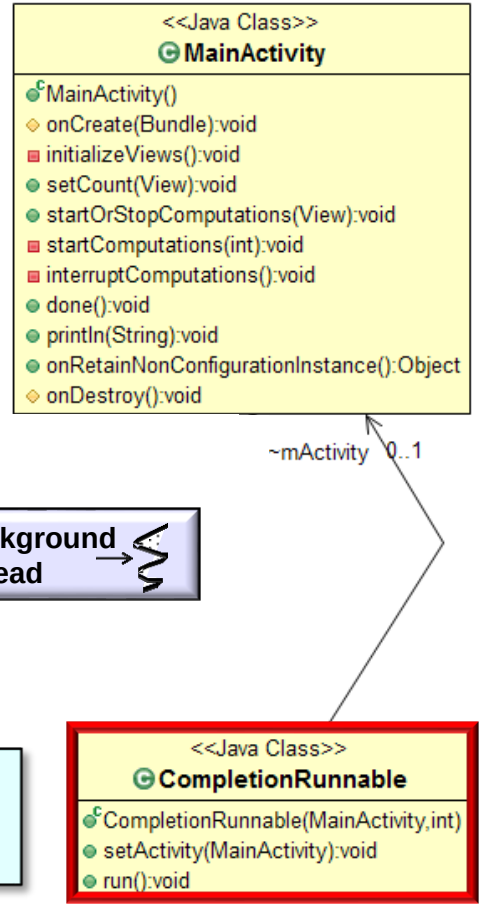
       mExecutorCompService
         .take().get();

     if (pr.mSmallestFactor != 0) ...
     else ...
   ...
   mActivity.
```



get() doesn't block, though take() may block if completed futures aren't yet available

Applying the Memoizer to Optimize Prime # Checking

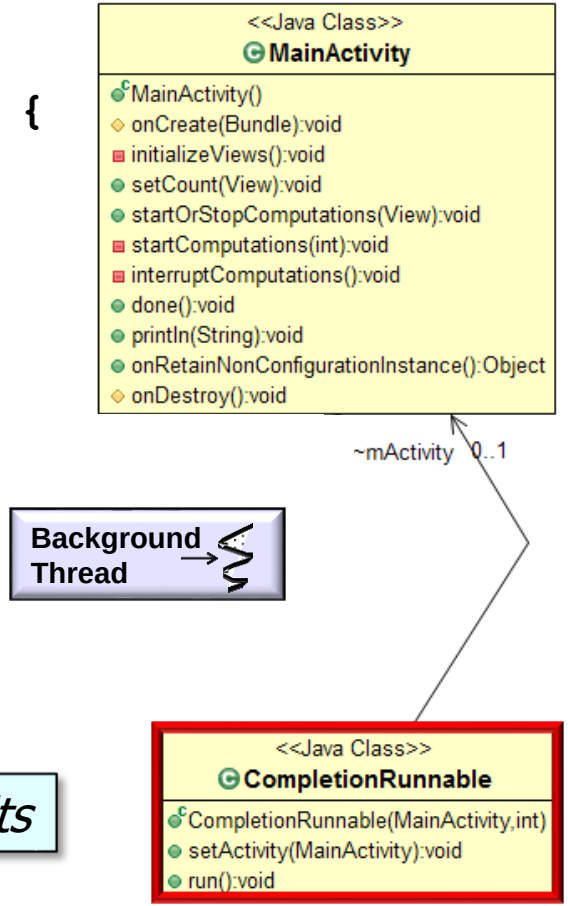
- CompletionRunnable gets results as futures complete

```
class CompletionRunnable implements Runnable {
  int mCount;
  MainActivity mActivity; ...

 public void run() {
   for (int i = 0; i < mCount; ++i) {
     PrimeResult pr = ...
       mExecutorCompService
         .take().get();

     if (pr.mSmallestFactor != 0) ...
     else ...
   ...
   mActivity.done(); ...
```

Process & output results



Applying the Memoizer to Optimize Prime # Checking

- RetainedState maintains key concurrency state across runtime configuration changes

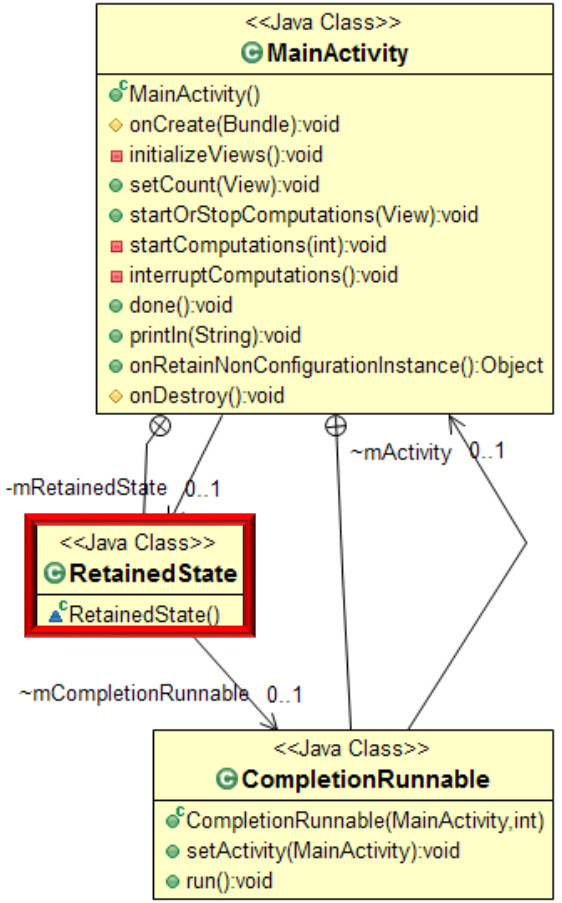
```
class RetainedState {
  ExecutorCompletionService
    mExecutorCompService;

  ExecutorService mExecutorService;

  CompletionRunnable mCompletionRunnable;

  Thread mThread;

  Memoizer<Long, Long> mMemoizer;
}
```



See android.jlelse.eu/handling-orientation-changes-in-android-7072958c442a

Applying the Memoizer to Optimize Prime # Checking

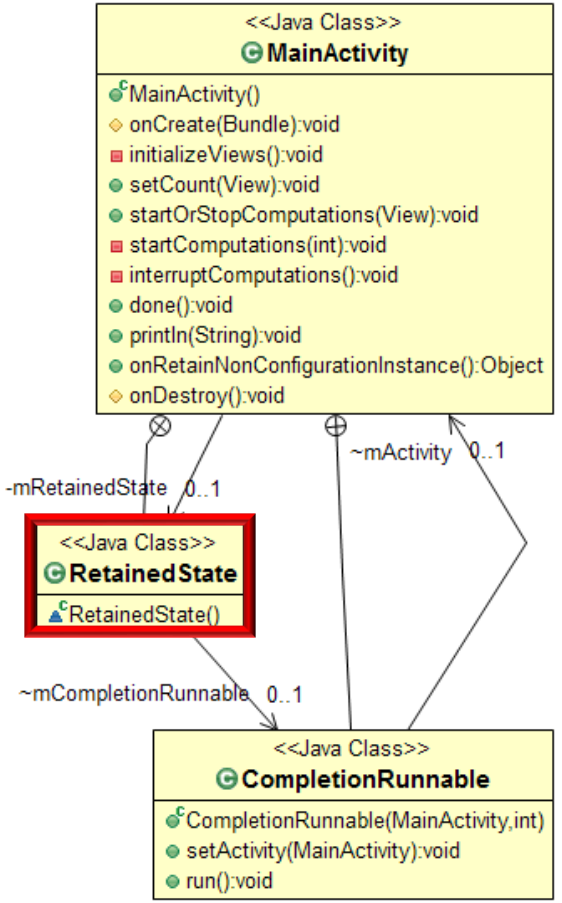
- RetainedState maintains key concurrency state across runtime configuration changes

```
void onCreate(...) {
  mRetainedState = (RetainedState)
    getLastNonConfigurationInstance();

  if (mRetainedState != null) {
    ... // update configurations
  }
}

Object onRetainNonConfigurationInstance()
{ return mRetainedState; }
```

Android's activity framework dispatches these hook methods to save & restore state when runtime configuration changes occur



See android.jlelse.eu/handling-orientation-changes-in-android-7072958c442a

End of Applying the Java FutureTask-based Memoizer to the PrimeChecker App