Applying the Java ExecutorCompletion Service to the PrimeChecker App

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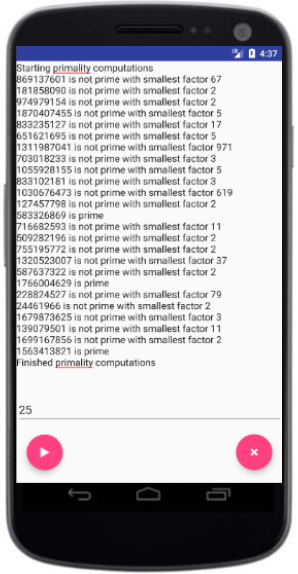
Learning Objectives in this Part of the Lesson

- Understand how the Java CompletionService interface defines a framework for handling the completion of asynchronous tasks
- Know how to instantiate the Java ExecutorCompletionService
- Recognize key methods in the Java CompletionService interface
- Visualize the ExecutorCompletionService in action
- Be aware of how the Java ExecutorCompletionService implements the CompletionService interface
- Know how to apply the Java ConcurrentHashMap class to design a "memoizer"

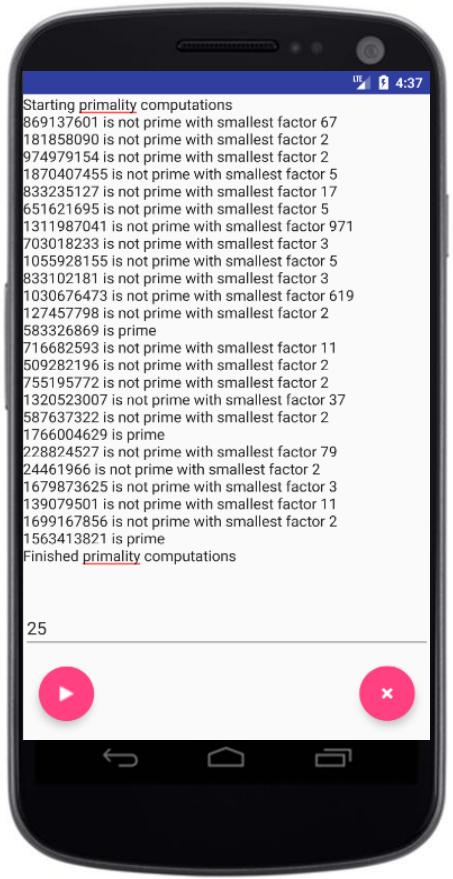


- Master how to implement the Memoizer class with Java ConcurrentHashMap
- See how Java ExecutorCompletionService & Memoizer are integrated into the "PrimeChecker" app

Applying Memoizer to Check for Prime #’s

Applying Memoizer to Check for Prime #'s

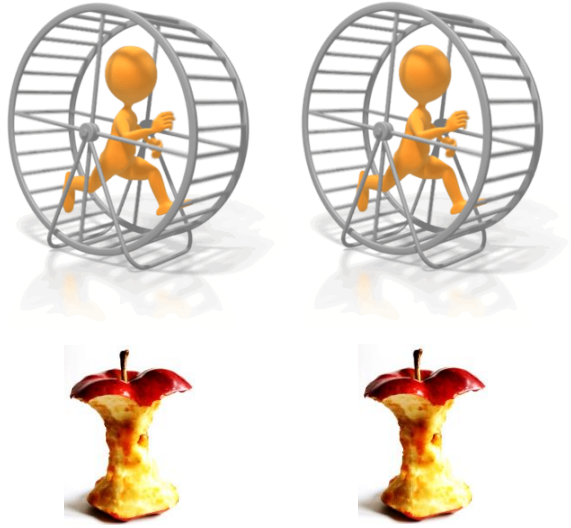
- This app shows how Java's ExecutorCompletionService framework & the modern Java-based Memoizer can be used to check if *N* random #'s are prime

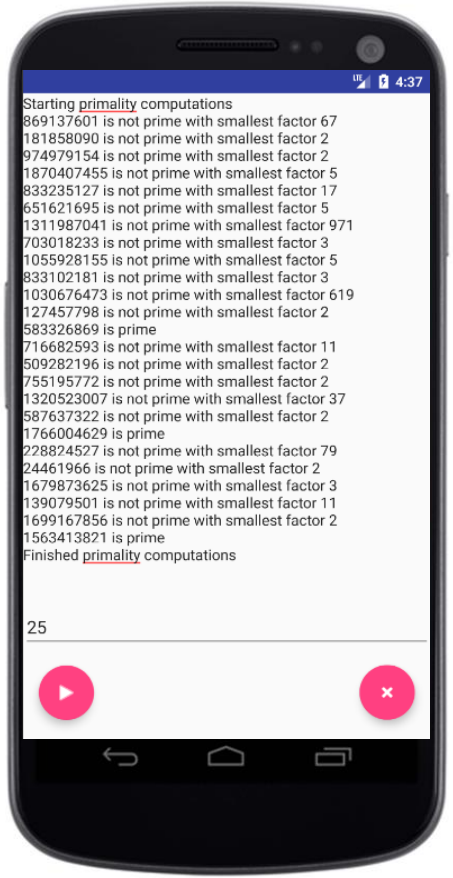


See ex/M4/Primes/PrimeExecutorCompletionService

Applying Memoizer to Check for Prime #'s

- This app shows how Java's ExecutorCompletionService framework & the modern Java-based Memoizer can be used 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

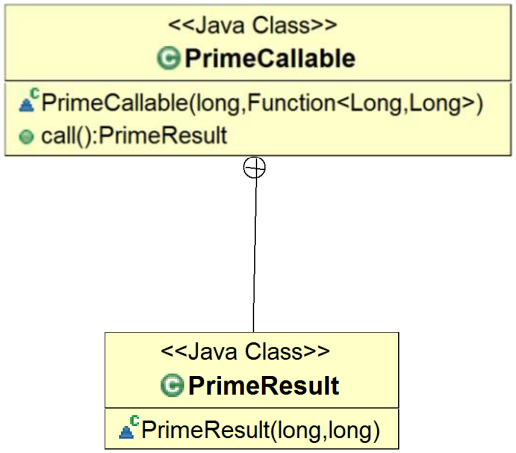
Applying Memoizer to Check for Prime #'s

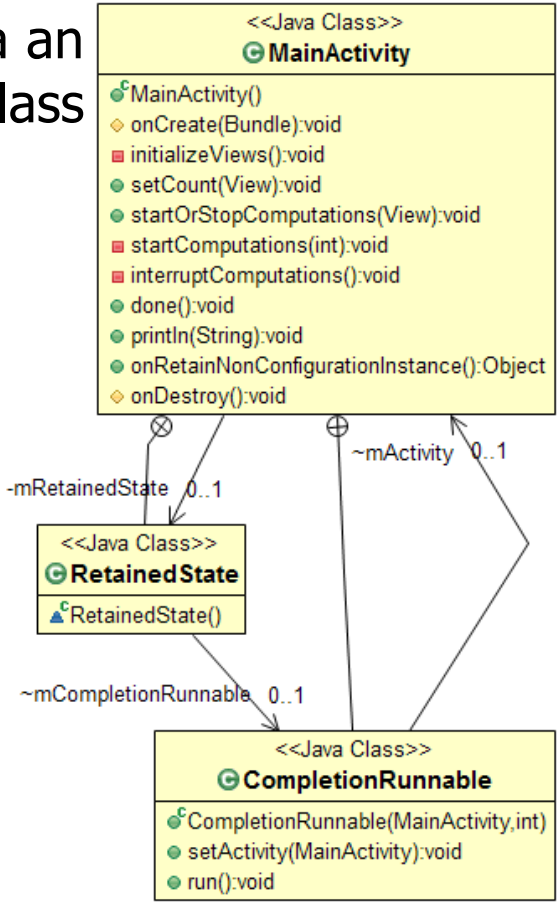
- MainActivity checks primality of "count" random #'s via an ExecutorService w/a thread pool & the PrimeCallable class

Cached (Variable-sized) Thread Pool


```
mExecutor = Executors
   .newCachedThreadPool();
```

The executor service uses a cached (variable-sized) pool of threads





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

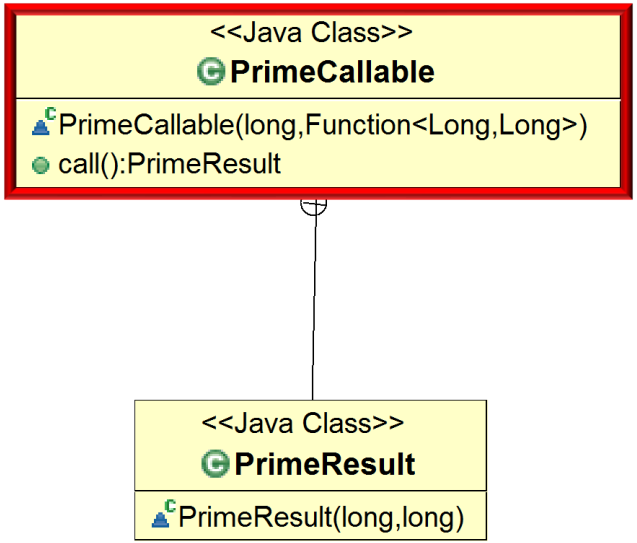
Applying Memoizer to Check for Prime #'s

- PrimeCallable defines a two-way means of determining whether a # is prime by calling a function that returns 0 if it's prime or smallest factor if it's not

```
class PrimeCallable implements Callable<PrimeResult> {
  Function<Long, Long> mPrimeChecker;
  ...


  PrimeCallable(Long primeCandidate,
                Function<Long, Long> pc)
  { mPrimeChecker = pc; }

  PrimeResult call() {
    return new PrimeResult
      (mPrimeCandidate, mPrimeChecker.apply(mPrimeCandidate));
}
```



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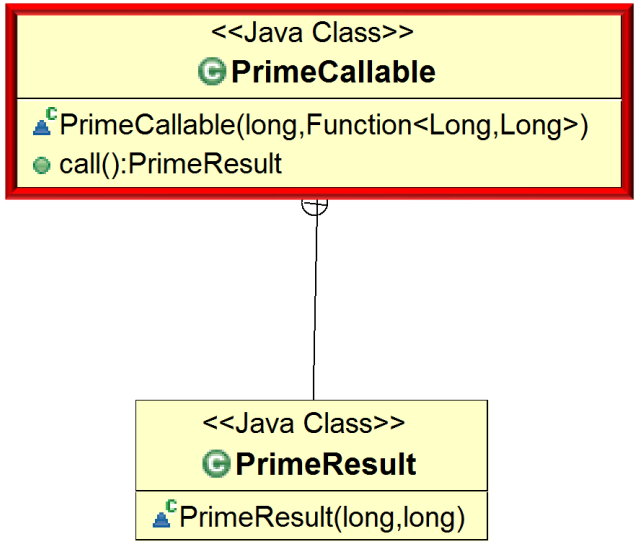
}
```

Implements Callable to run in a pool thread



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  PrimeResult call() {
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  }
```
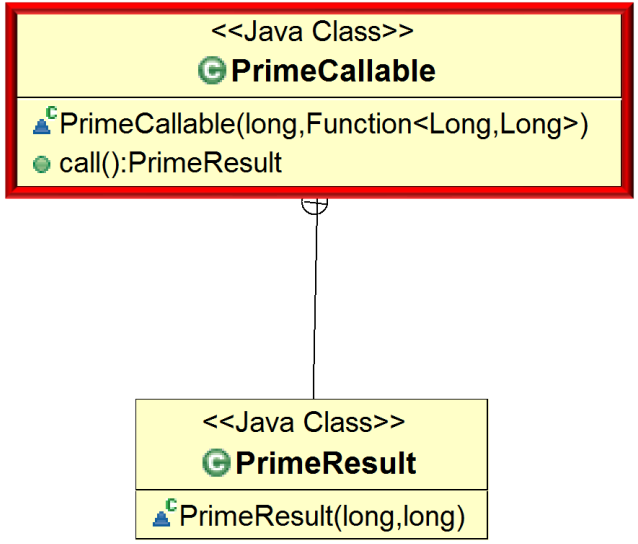

The function computing primality is parameterized



This Function param is a new feature added since the earlier PrimeCheck example

Applying Memoizer to Check for Prime #'s

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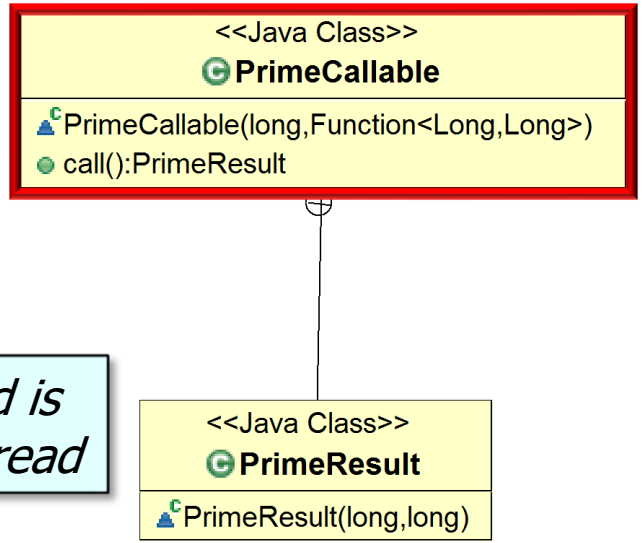
}
```



This hook method is called in a pool thread

Applying Memoizer to Check for Prime #'s

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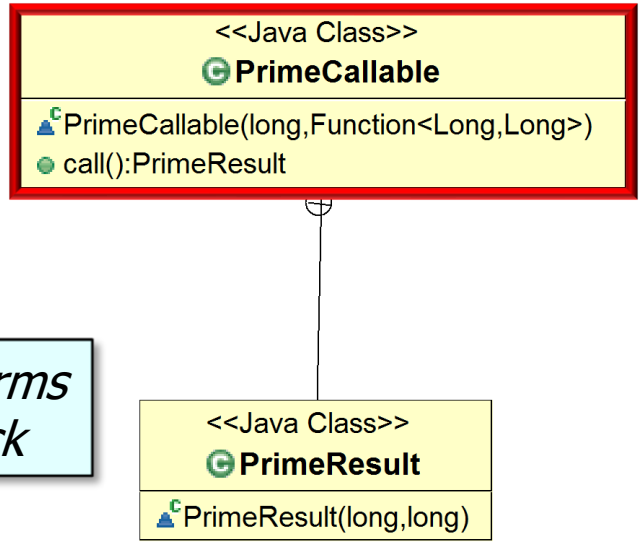


This function performs the prime # check

Applying Memoizer to Check for Prime #'s

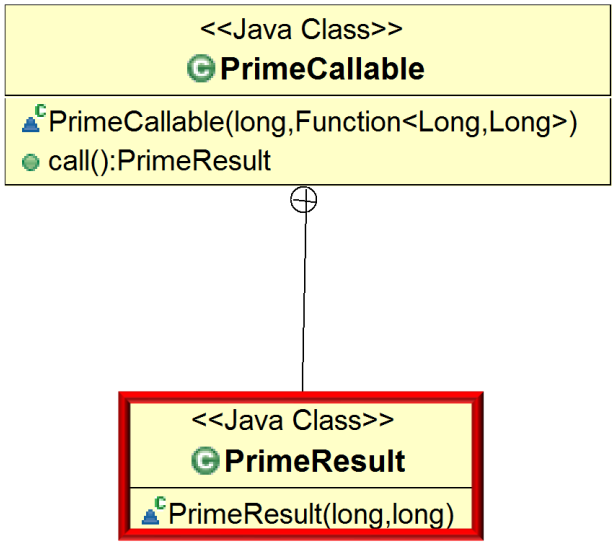
- PrimeCallable defines a two-way means of determining whether a # is prime by calling a function that returns 0 if it's prime or smallest factor if it's not

```
class PrimeCallable implements Callable<PrimeResult> {
  Function<Long, Long> mPrimeChecker;
  ...
```

Match prime # candidate with primality check result

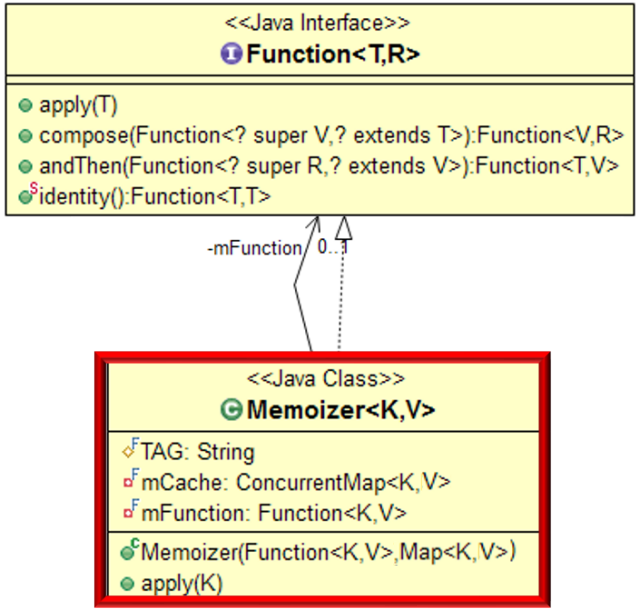
```
  PrimeCallable(Long primeCandidate,
                Function<Long, Long> pc)
  { mPrimeChecker = pc; }

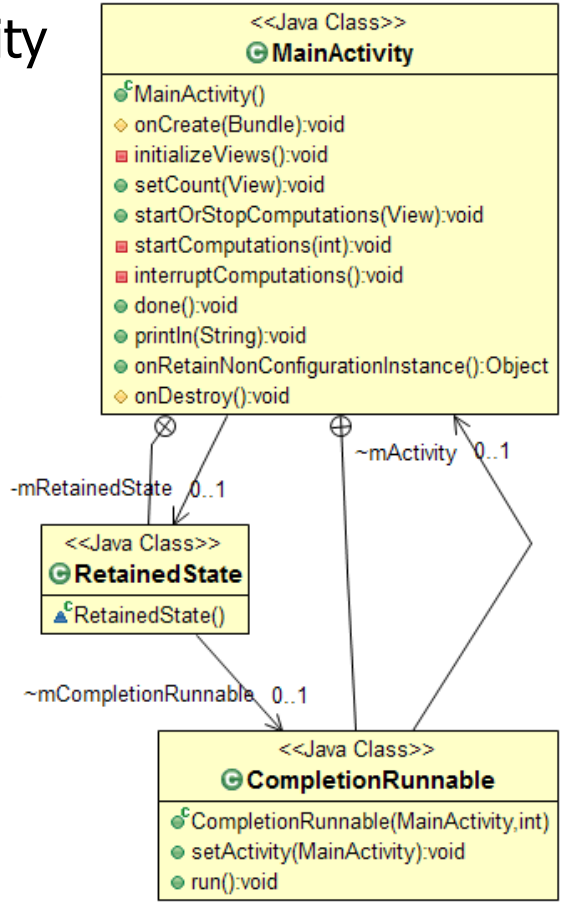
  PrimeResult call() {
    return new PrimeResult
      (mPrimeCandidate, mPrimeChecker.apply(mPrimeCandidate));
  }
```



Applying Memoizer to Check for Prime #'s

- MainActivity creates a Memoizer that optimizes primality checking of "count" random #'s





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

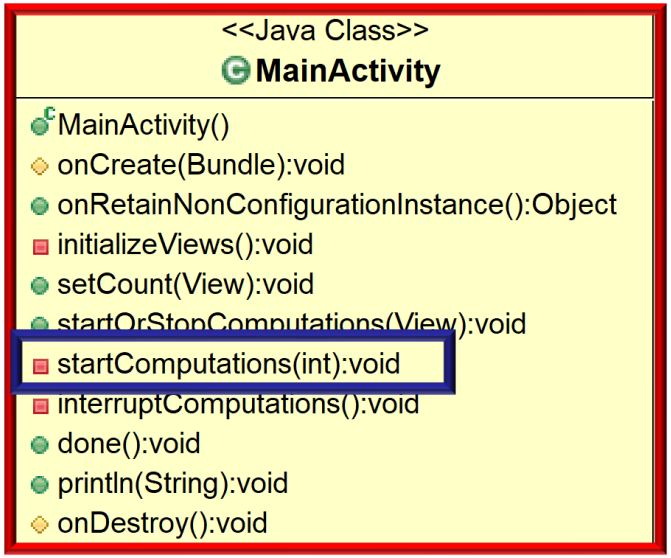
Applying Memoizer to Check for Prime #'s

- Memoizer caches results when processing a stream of PrimeCallables

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


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

     .forEach(mRetainedState.mExecutorCompService::submit); ...
```



Applying Memoizer to Check for Prime #'s

- Memoizer caches results when processing a stream of PrimeCallables

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mMemoizer = new Memoizer<>
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       new ConcurrentHashMap());
```

This memoizer caches prime # results

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

      .forEach(mRetainedState.mExecutorCompService::submit); ...
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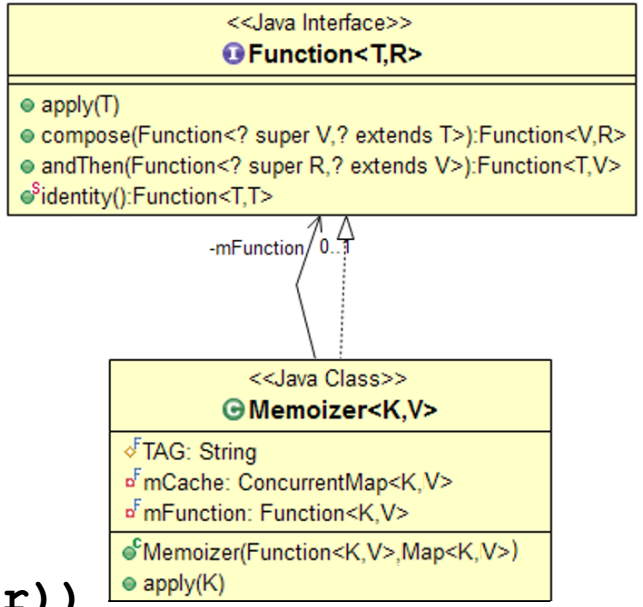


Applying Memoizer to Check for Prime #'s

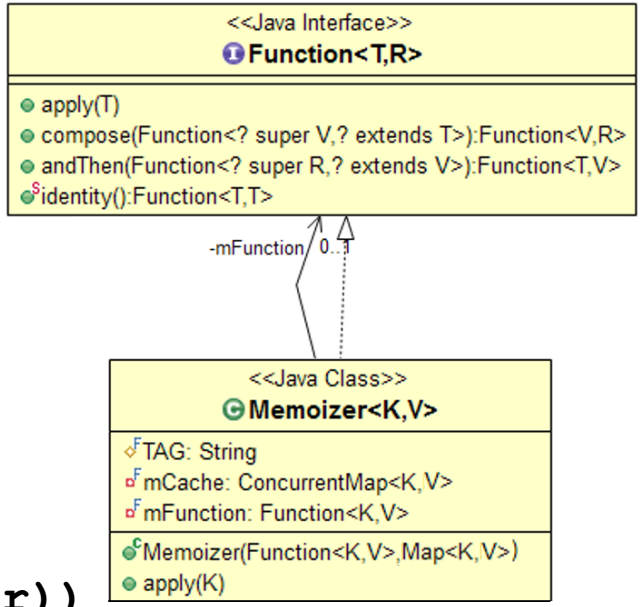
- Memoizer caches results when processing a stream of PrimeCallables

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

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

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

      .forEach(mRetainedState.mExecutorCompService::submit); ...
```



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

Applying Memoizer to Check for Prime #'s

- Memoizer caches results when processing a stream of PrimeCallables

```
mMemoizer = new Memoizer<>
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```

..to this..

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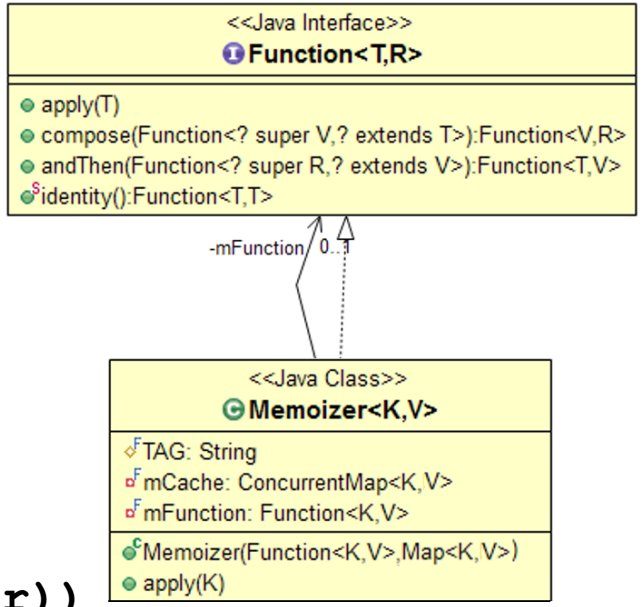
      .forEach(mRetainedState.mExecutorCompService::submit); ...
```



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```
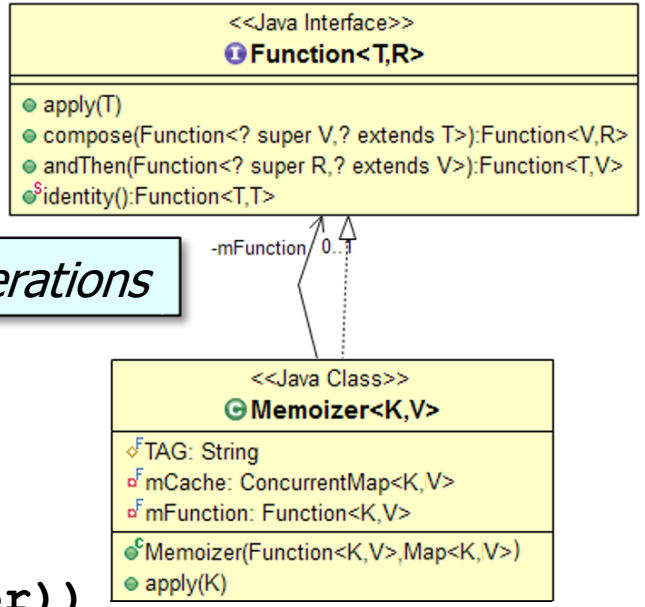

Ensure efficient thread-safe map operations



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

Applying Memoizer to Check for Prime #'s

- Memoizer caches results when processing a stream of PrimeCallables

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

     .forEach(mRetainedState.mExecutorCompService::submit); ...
```

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

Applying Memoizer to Check for Prime #'s

- Memoizer caches results when processing a stream of PrimeCallables

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

     .forEach(mRetainedState.mExecutorCompService::submit); ...
```

Transforms random #'s into PrimeCallables

Applying Memoizer to Check for Prime #'s

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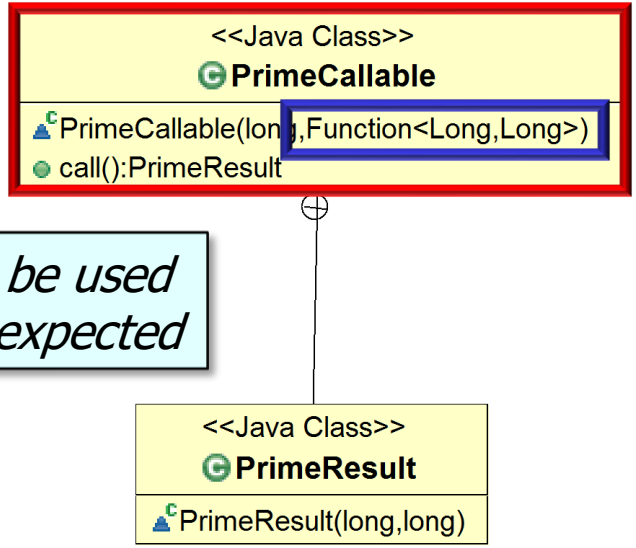
```



A Memoizer object can be used wherever a Function is expected

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

Applying Memoizer to Check for Prime #'s

- Memoizer caches results when processing a stream of PrimeCallables

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     .forEach(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

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- Memoizer caches results when processing a stream of PrimeCallables

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

     .forEach(mRetainedState.mExecutorCompService::submit); ...
```

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

Applying Memoizer to Check for Prime #'s

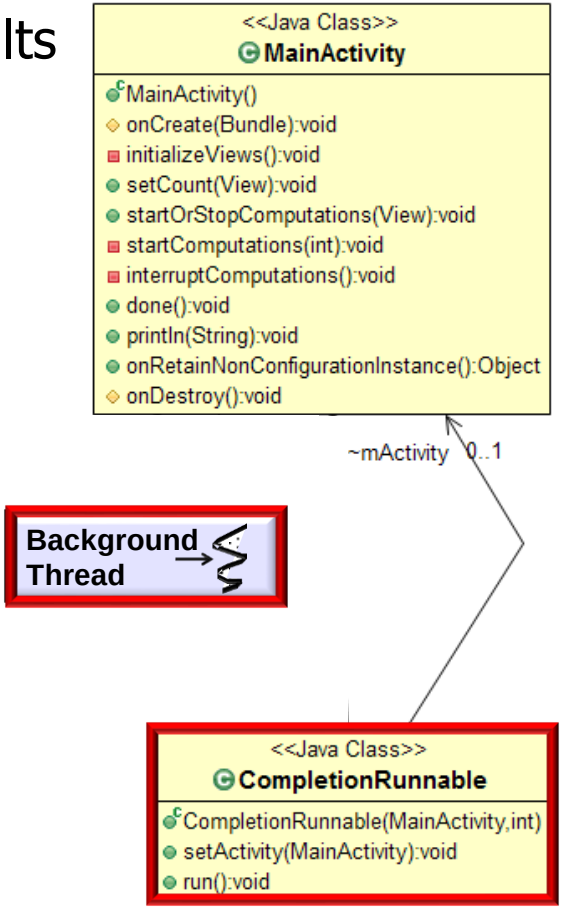
- MainActivity creates a thread to wait for all future results in the background so the UI thread doesn't block

```
...
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 Memoizer to Check for Prime #'s

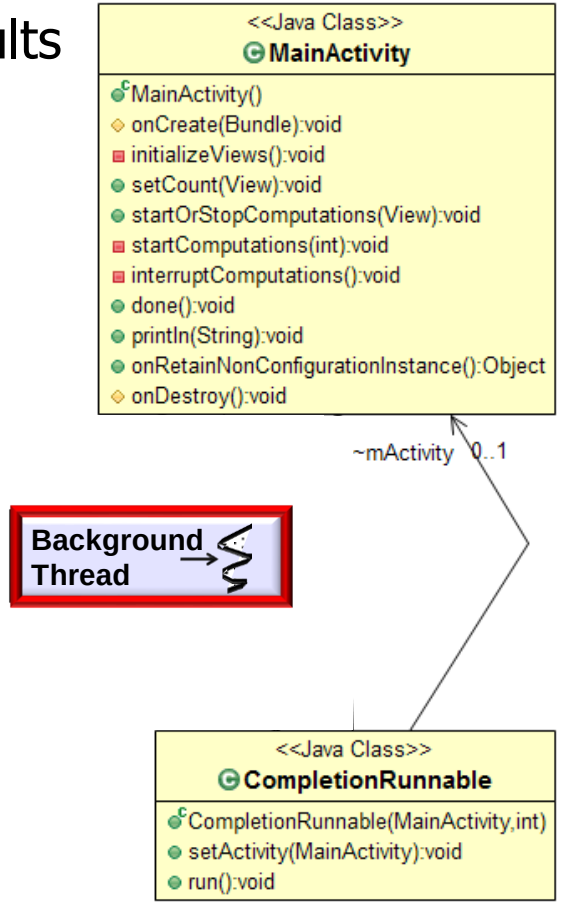
- MainActivity creates a thread to wait for all future results in the background so the UI thread doesn't block

```
...
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();
```



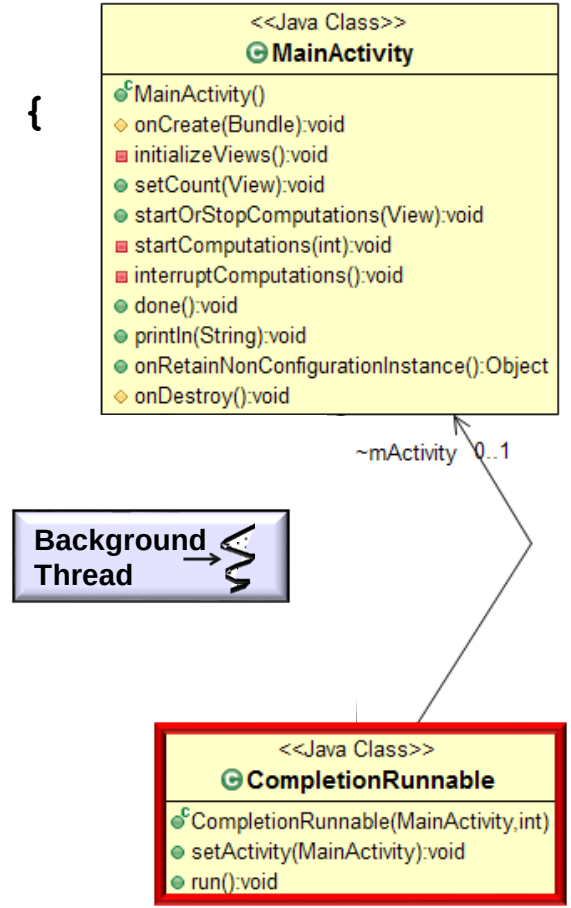
Applying Memoizer to Check for Prime #'s

- 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(); ...
```



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

Applying Memoizer to Check for Prime #'s

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 public void run() {
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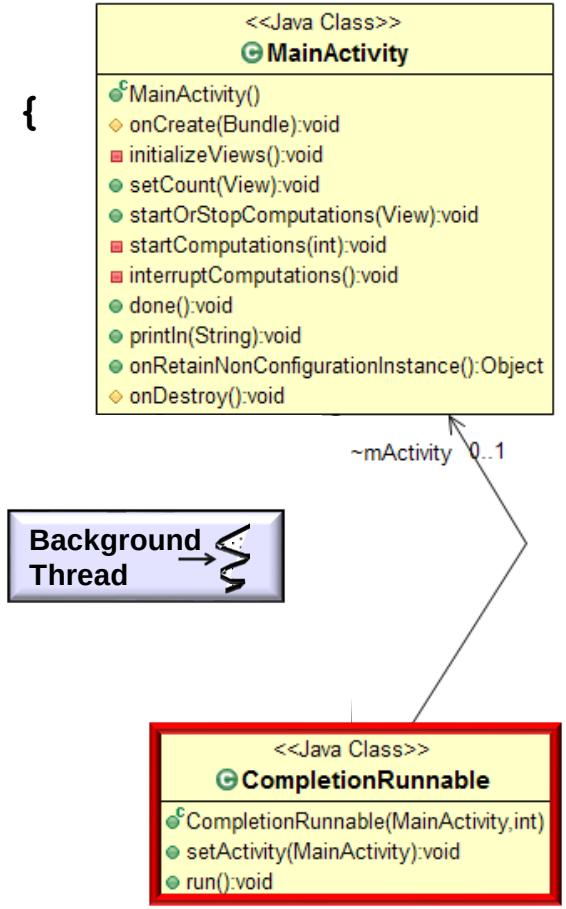

See docs.oracle.com/javase/8/docs/api/java/lang/Runnable.html

Applying Memoizer to Check for Prime #'s

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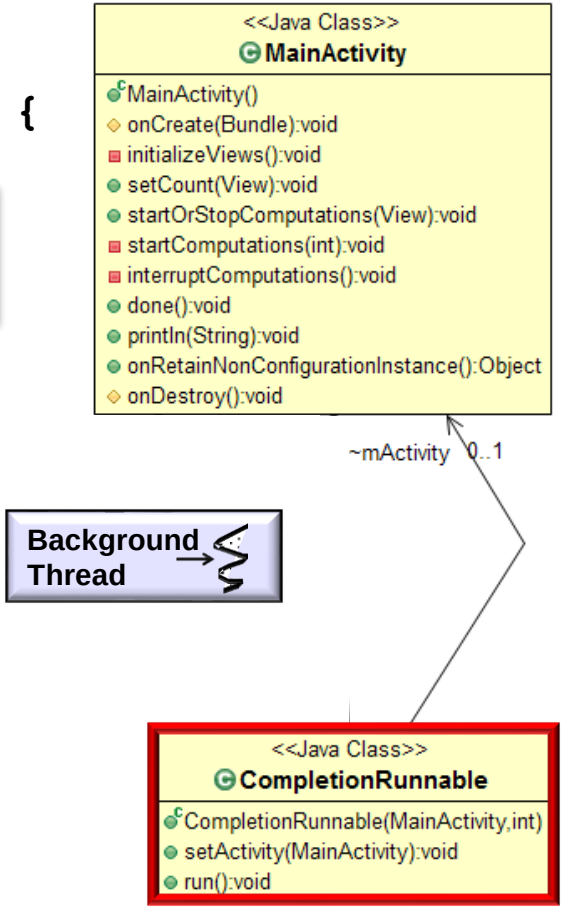

Iterate thru all results



Applying Memoizer to Check for Prime #'s

- CompletionRunnable gets results as futures complete

```
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  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.
```
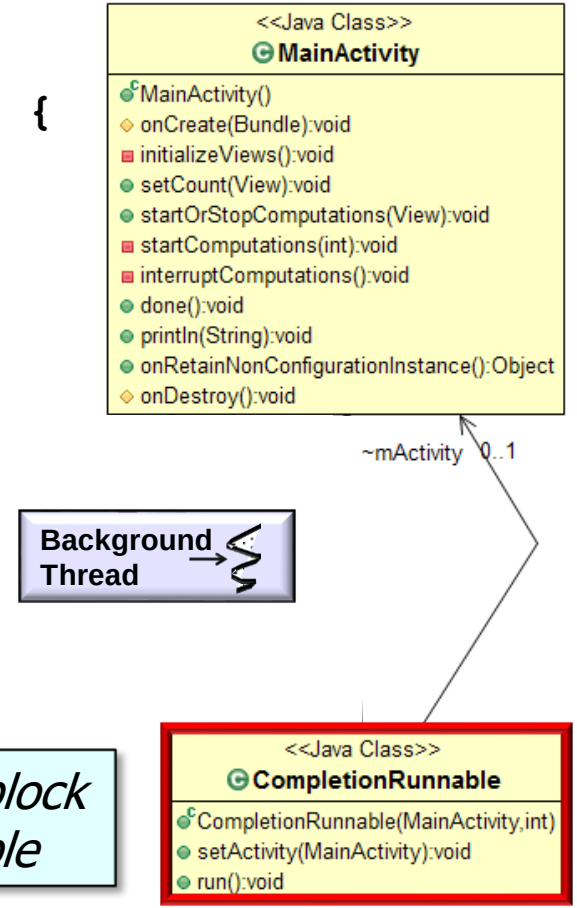

get() doesn't block, though take() may block if no completed futures are yet available



Applying Memoizer to Check for Prime #'s

- CompletionRunnable gets results as futures complete

```
class CompletionRunnable implements Runnable {
  int mCount;
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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(); ...
```
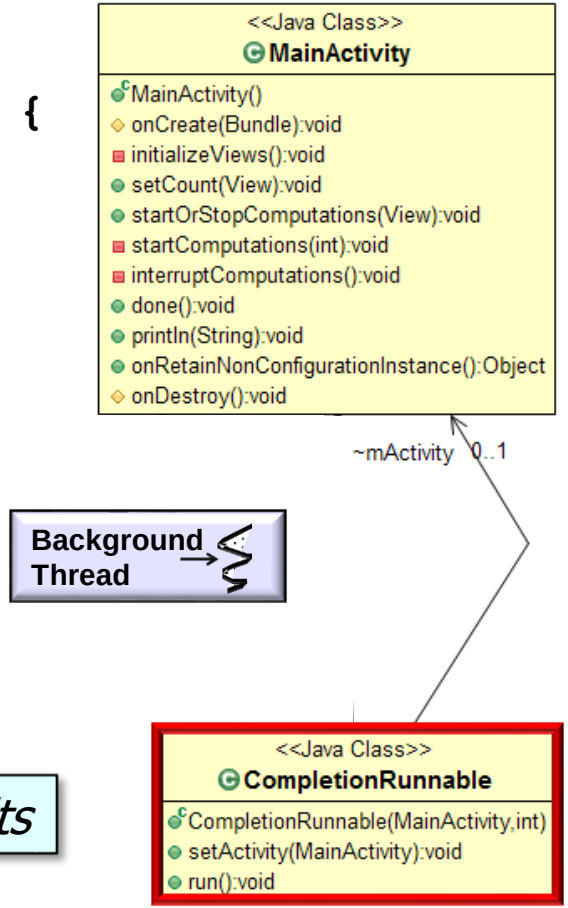
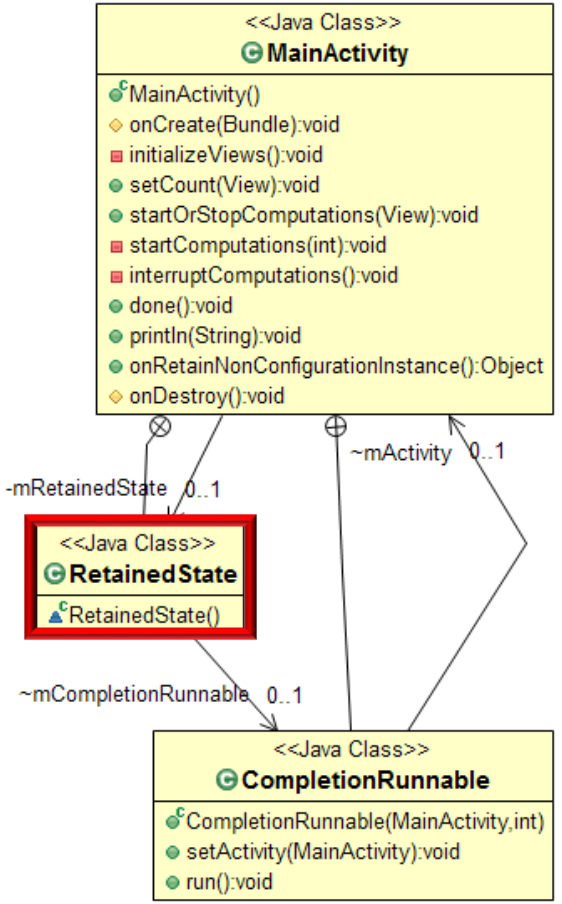

Process & output results



Applying Memoizer to Check for Prime #'s

- RetainedState maintains key concurrency state across runtime configuration changes

```
class RetainedState {
  ExecutorCompletionService
    mExecutorCompService;

  ExecutorService mExecutorService;

  CompletionRunnable mCompletionRunnable;

  Thread mThread;

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



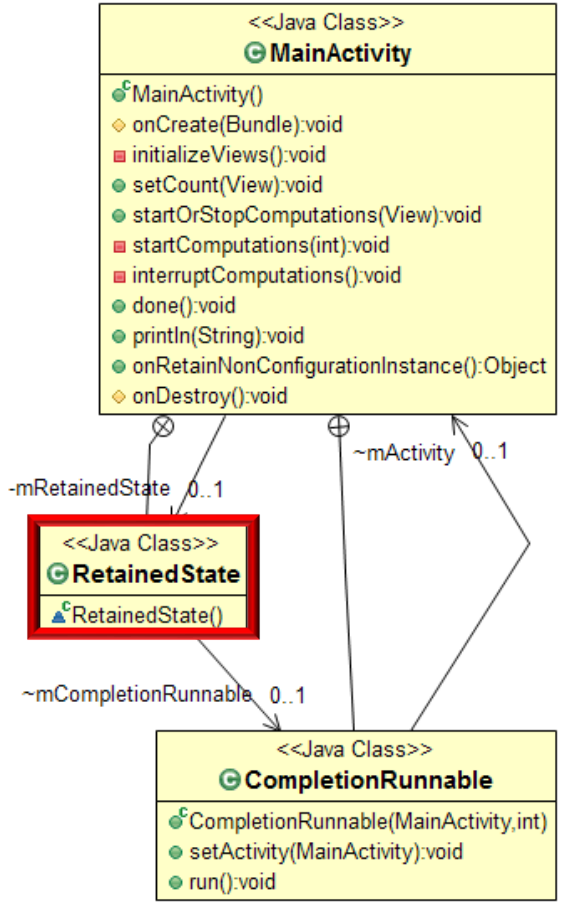
See android.jlelse.eu/handling-orientation-changes-in-android-7072958c442a

Applying Memoizer to Check for Prime #'s

- 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 ExecutorCompletionService to the PrimeChecker App