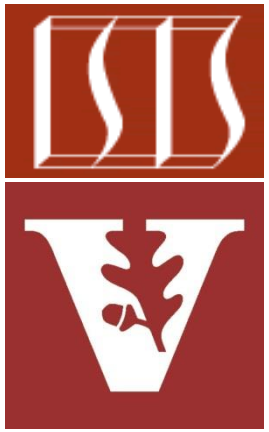
Java Concurrent Collections: Designing a Memoizer with ConcurrentHashMap

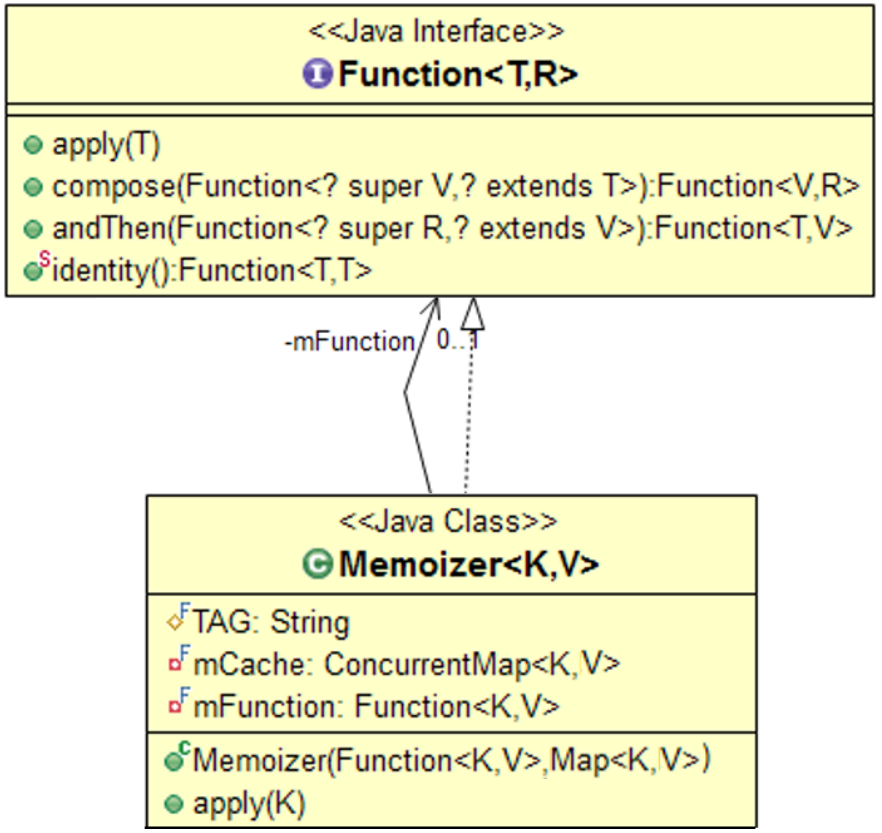


Douglas C. Schmidt
d.schmidt@vanderbilt.edu
www.dre.vanderbilt.edu/~schmidt

Institute for Software Integrated Systems
Vanderbilt University
Nashville, Tennessee, USA

Learning Objectives in this Lesson

- Understand the capabilities of Java's concurrent collections
- Recognize the capabilities of Java's ConcurrentHashMap & BlockingQueue
- Know how to apply the Java Concurrent HashMap class to design a "memoizer"



Memoizer caches function call results & returns cached results for same inputs

Overview of Memoizer

Overview of Memoization

- Memoization is optimization technique used to speed up programs

See en.wikipedia.org/wiki/Memoization

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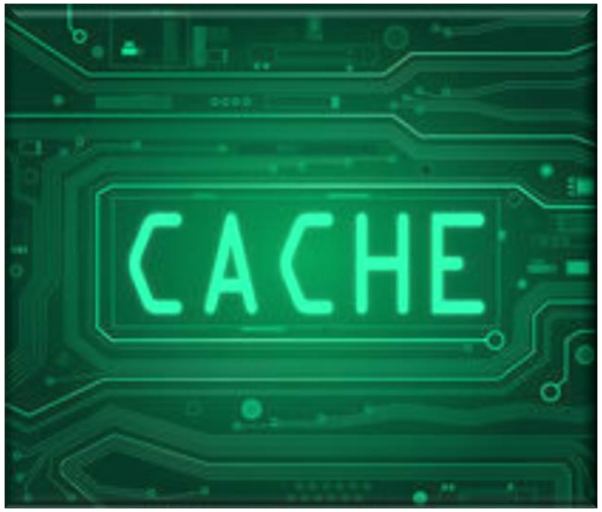
- Memoization is optimization technique used to speed up programs
  - It caches the results of expensive function calls

```
V computeIfAbsent(K key, Function func) {
   1. If key doesn't exist in cache perform a
      long-running function associated w/key
      & store the resulting value via the key
   2. Return value associated with key
}
```

Memoizer



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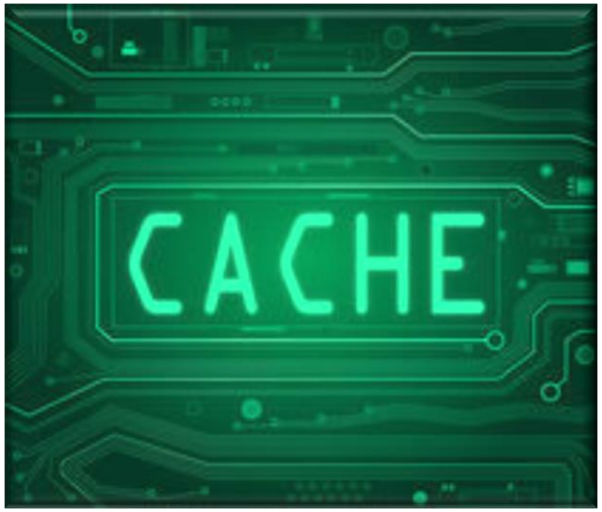
Memoizer



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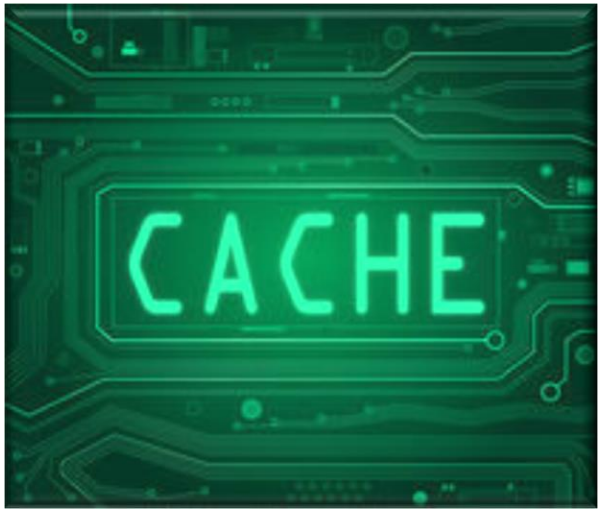

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  - When the same inputs occur again the cached results are simply returned

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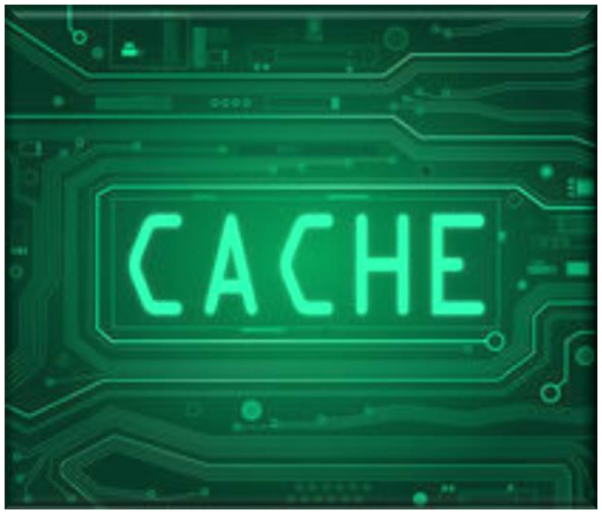
Memoizer



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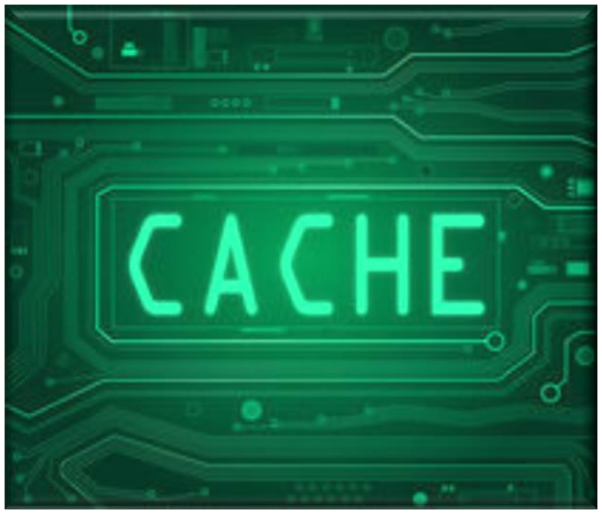
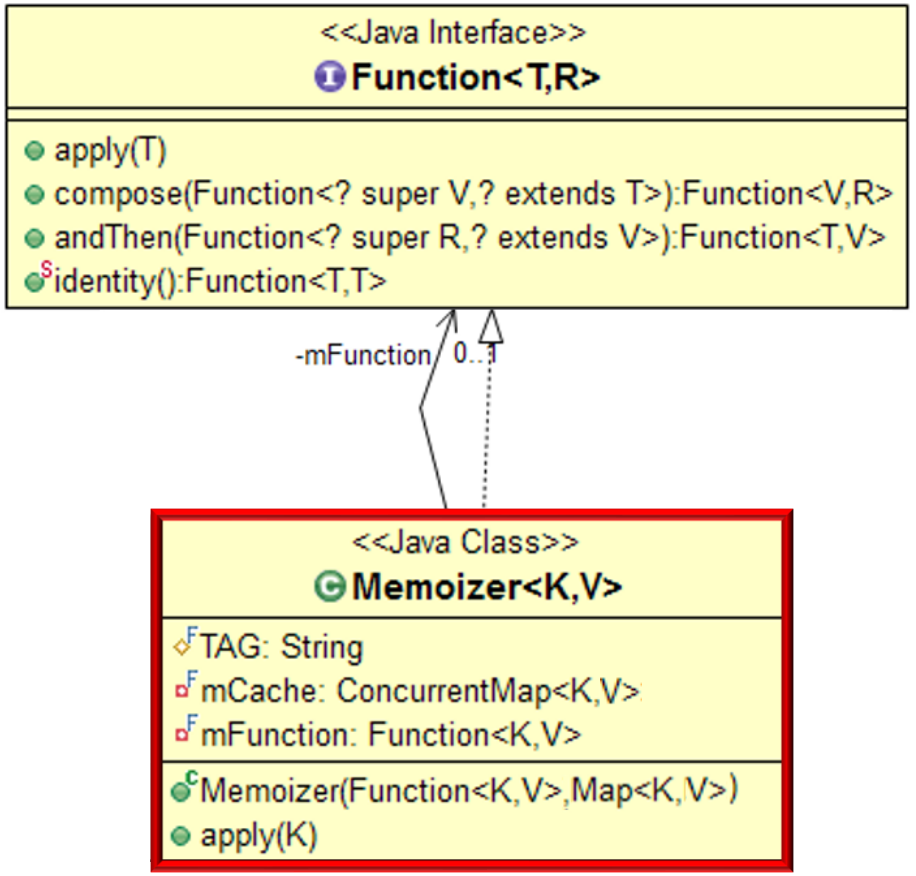
Memoizer



Designing a Memoizer with ConcurrentHashMap

Designing a Memoizer with ConcurrentHashMap

- Memoizer defines a cache that returns a value produced by applying a (long-running) function to a key



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

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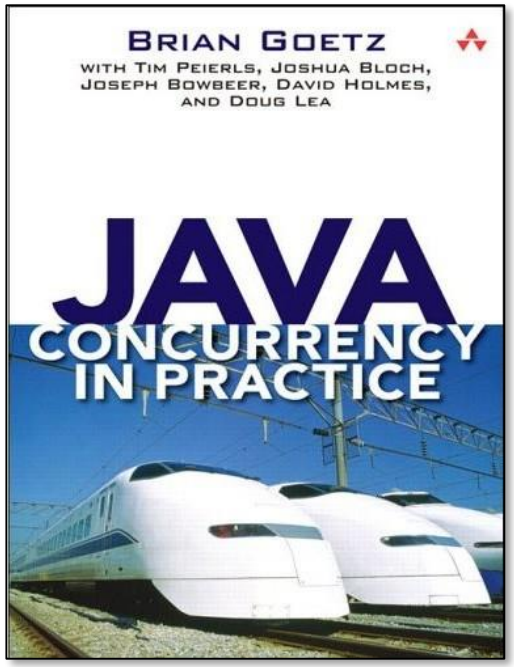
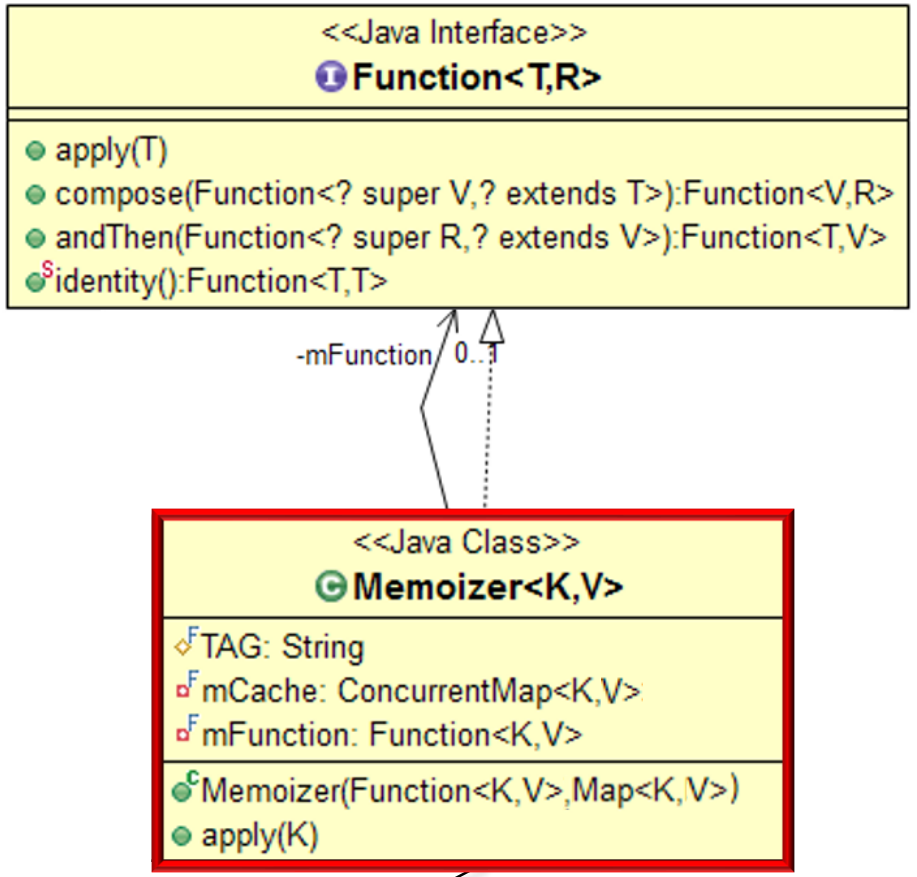


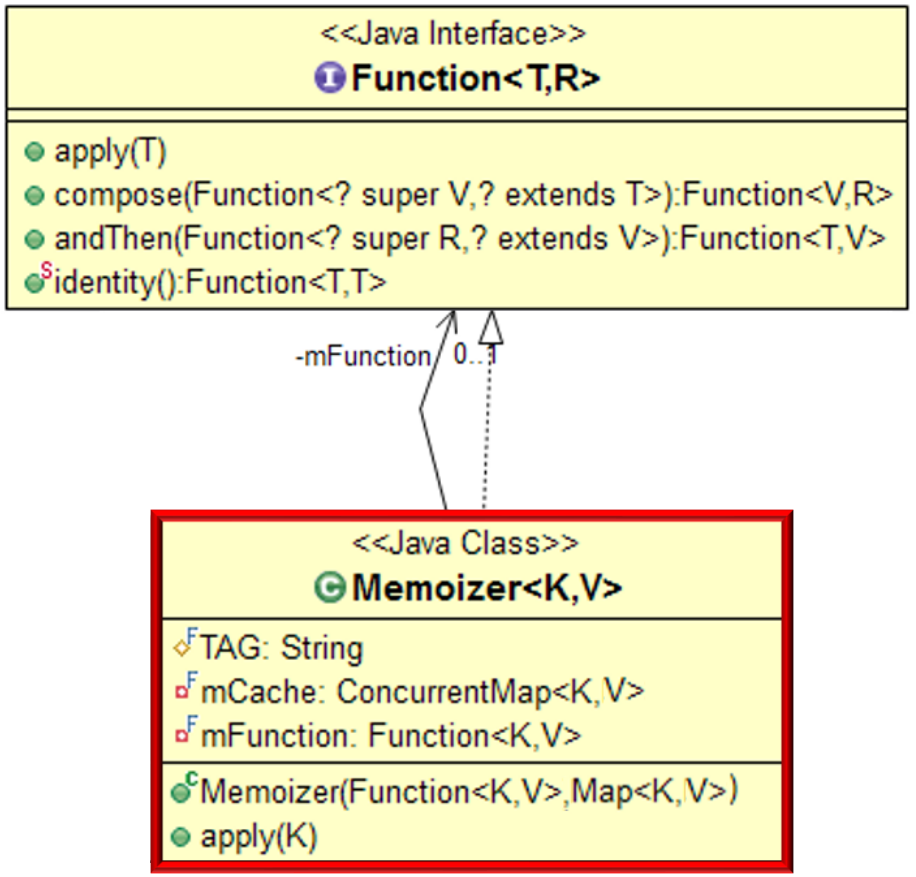


This class is based on "Java Concurrency in Practice" by Brian Goetz et al.

See jcip.net

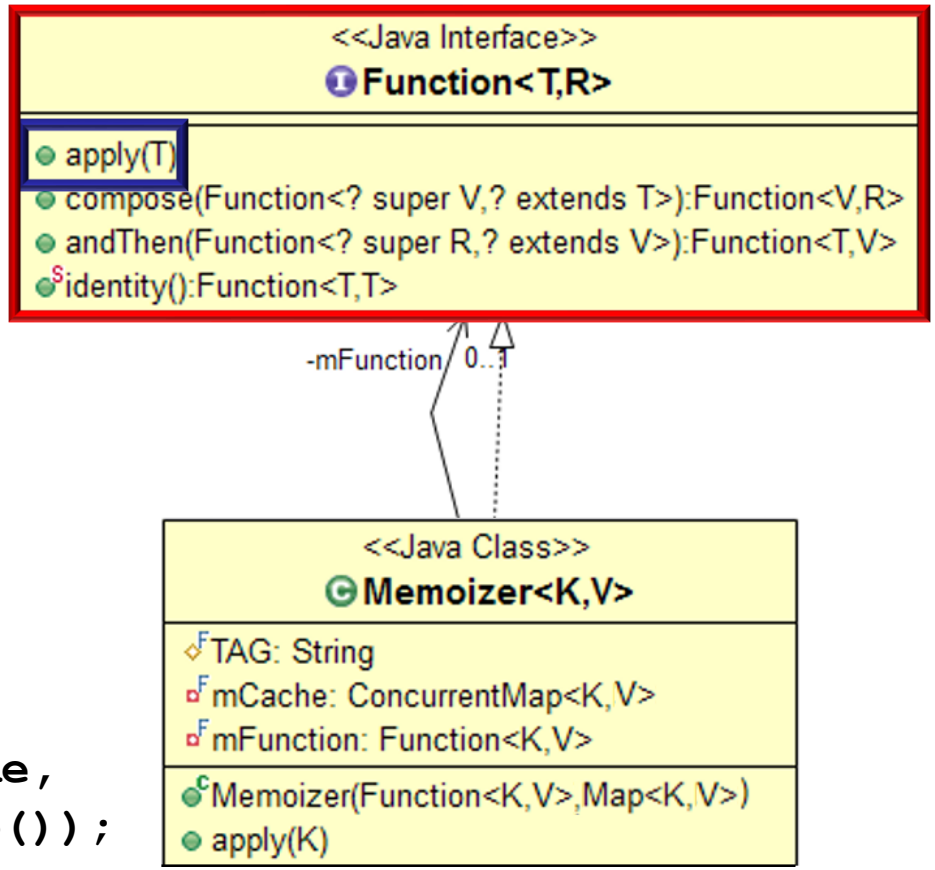
Designing a Memoizer with ConcurrentHashMap

- Memoizer defines a cache that returns a value produced by applying a (long-running) function to a key
  - A value that's been computed for a key is returned, rather than applying the function to recompute it



Designing a Memoizer with ConcurrentHashMap

- Memoizer defines a cache that returns a value produced by applying a (long-running) function to a key
  - A value that's been computed for a key is returned, rather than applying the function to recompute it
  - A memoizer can be used whenever a Function is expected




```
Function<Long, Long> func =
  doMemoization
    ? new Memoizer<>
        (PrimeCheckers::isPrime,
         new ConcurrentHashMap());
    : PrimeCheckers::isPrime;


...
new PrimeCallable(randomNumber, func));
```

See docs.oracle.com/javase/8/docs/api/java/util/function/Function.html

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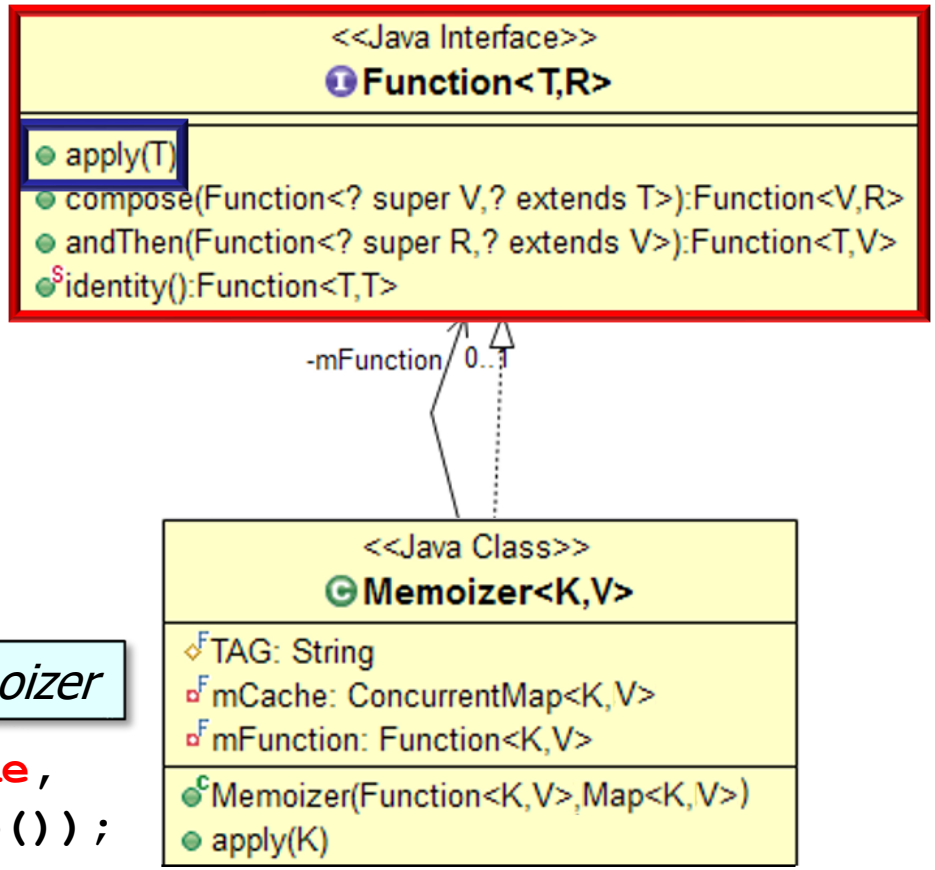


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Function<Long, Long> func =
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```

Use memoizer

```
...
new PrimeCallable(randomNumber, func)); ...
```

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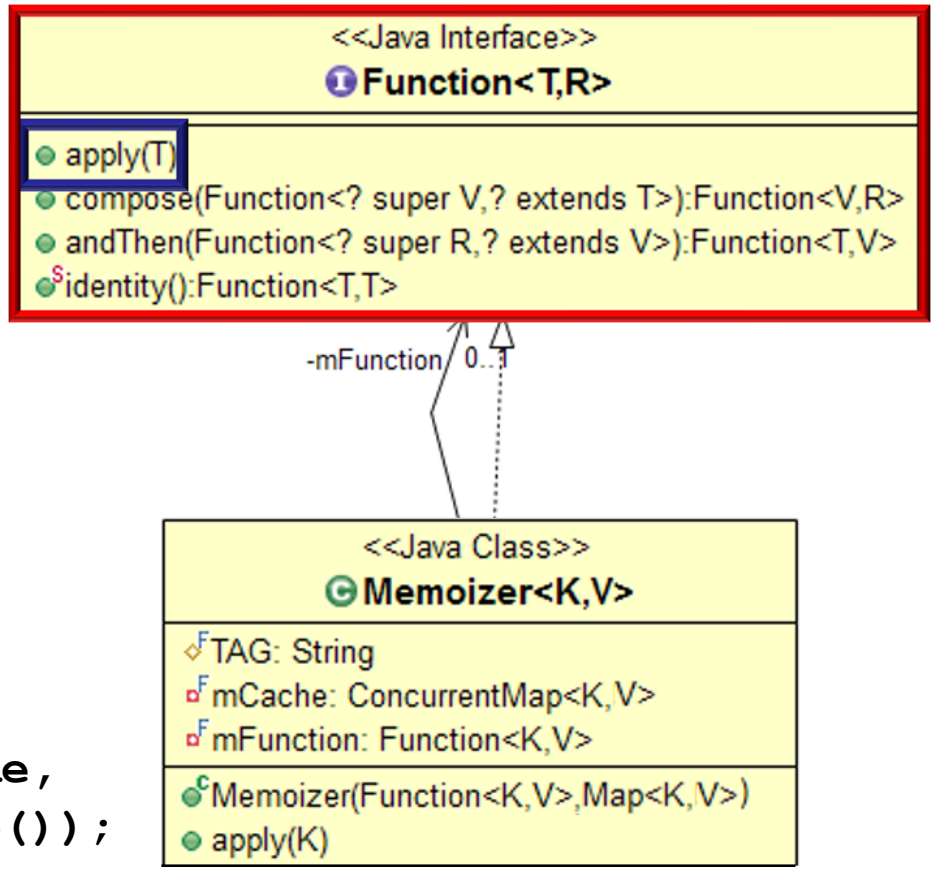


```
Function<Long, Long> func =
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```

Don't use memoizer

```
...
new PrimeCallable(randomNumber, func)); ...
```

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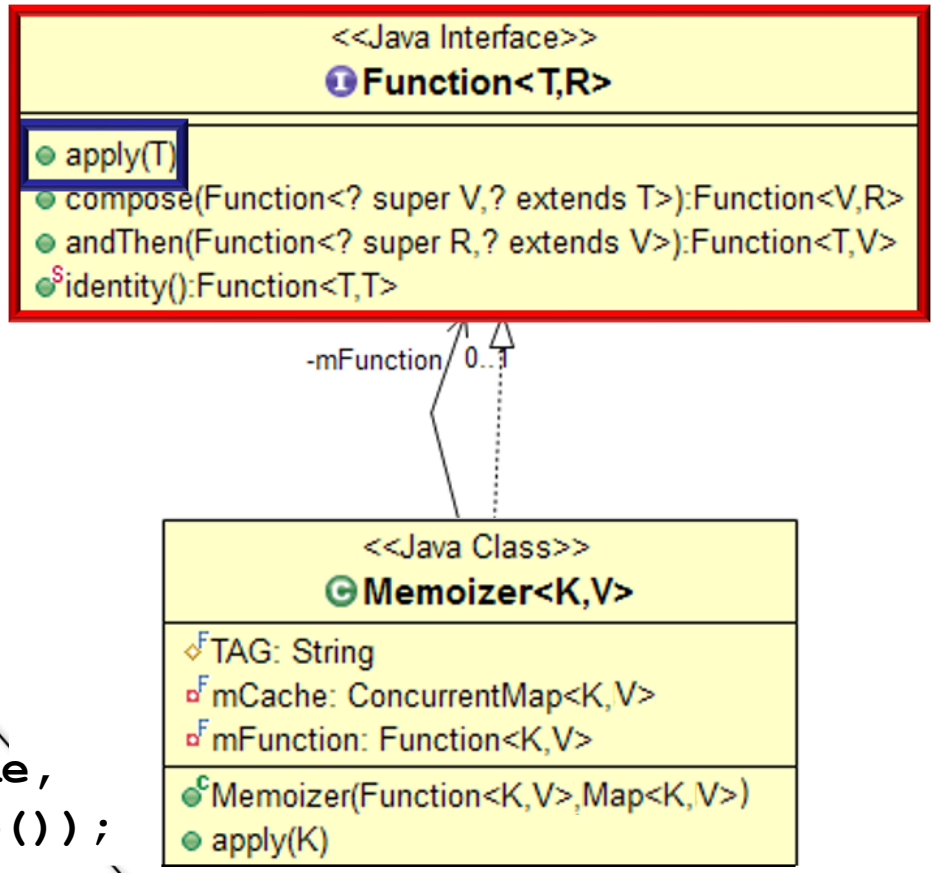


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...
new PrimeCallable(randomNumber, func)); ...
```
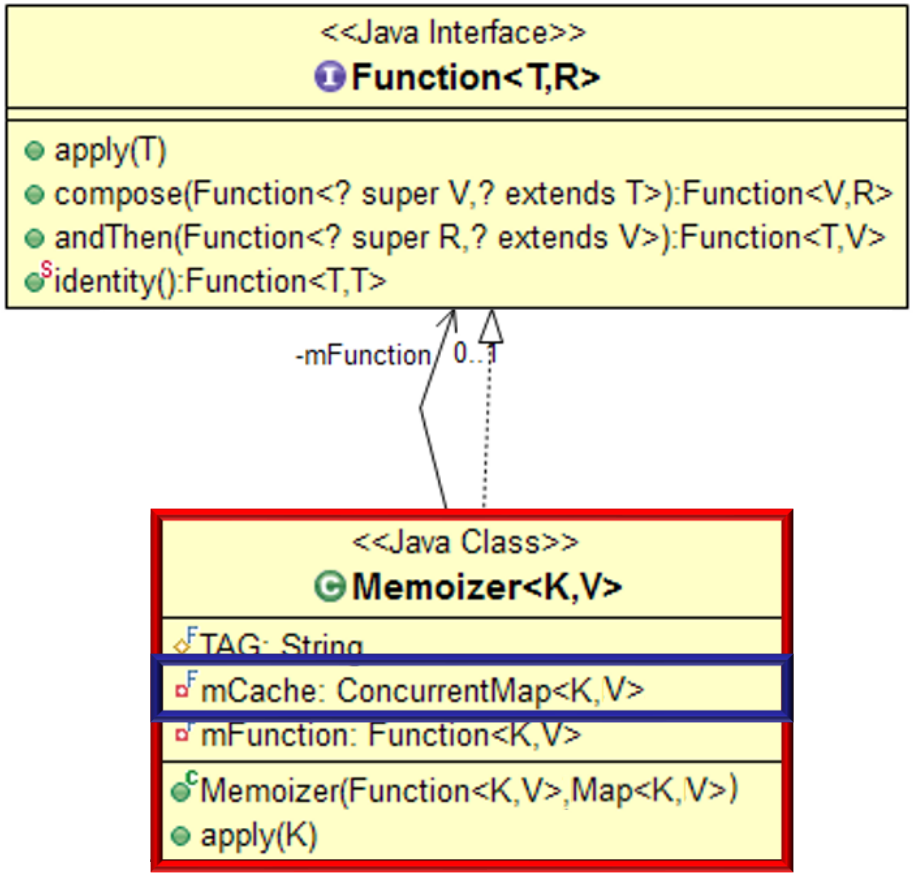

`func` is identical, regardless of which branch is chosen

See upcoming lesson on "*Java ExecutorCompletion Service: Application to PrimeChecker App*"

Designing a Memoizer with ConcurrentHashMap

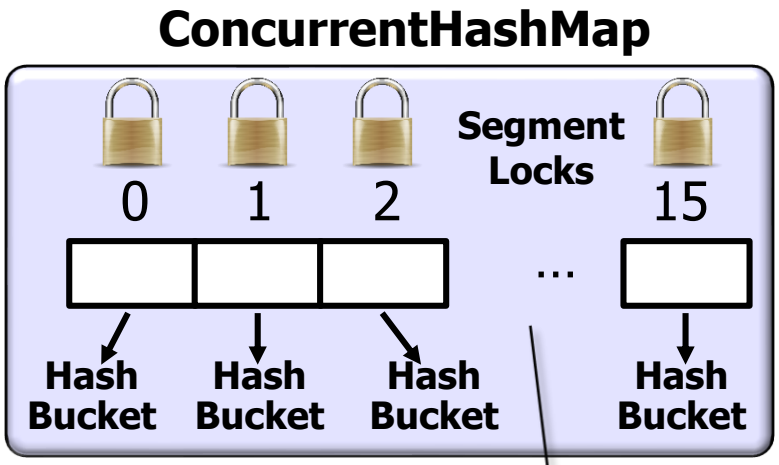
- Memoizer uses a ConcurrentHashMap to minimize synchronization overhead

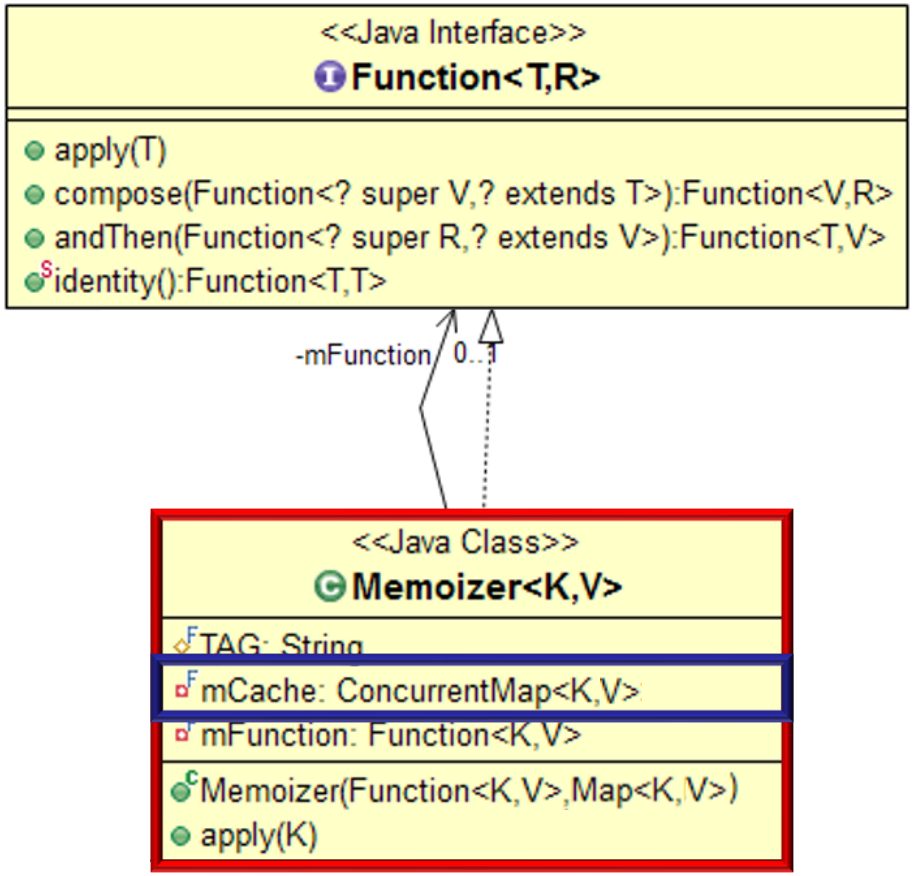


See docs.oracle.com/javase/8/docs/api/java/util/concurrent/ConcurrentHashMap.html

Designing a Memoizer with ConcurrentHashMap

- Memoizer uses a ConcurrentHashMap to minimize synchronization overhead
  - A group of locks guard different subsets of the hash buckets





Contention is low due to use of multiple locks

See www.ibm.com/developerworks/java/library/j-jtp08223

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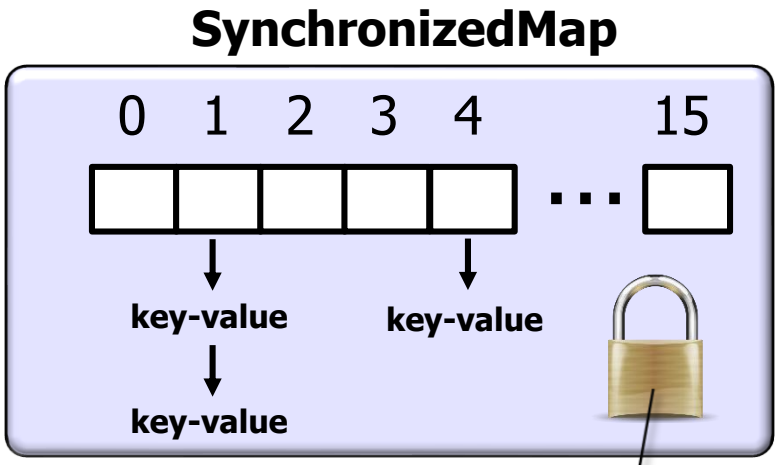
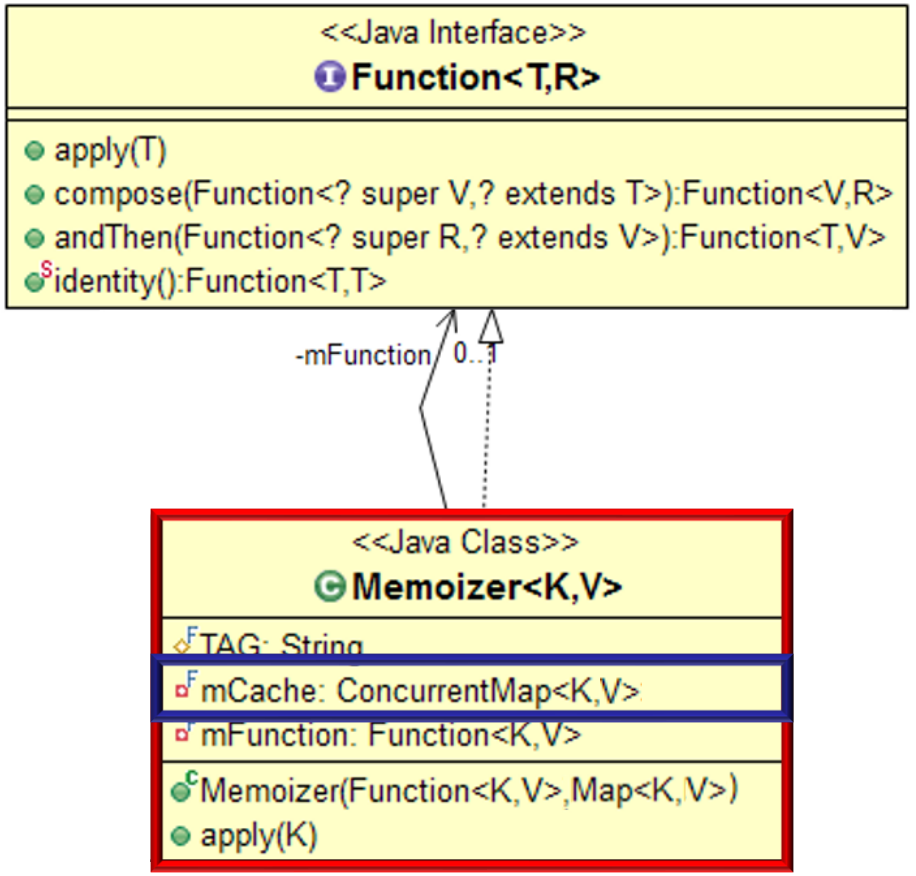


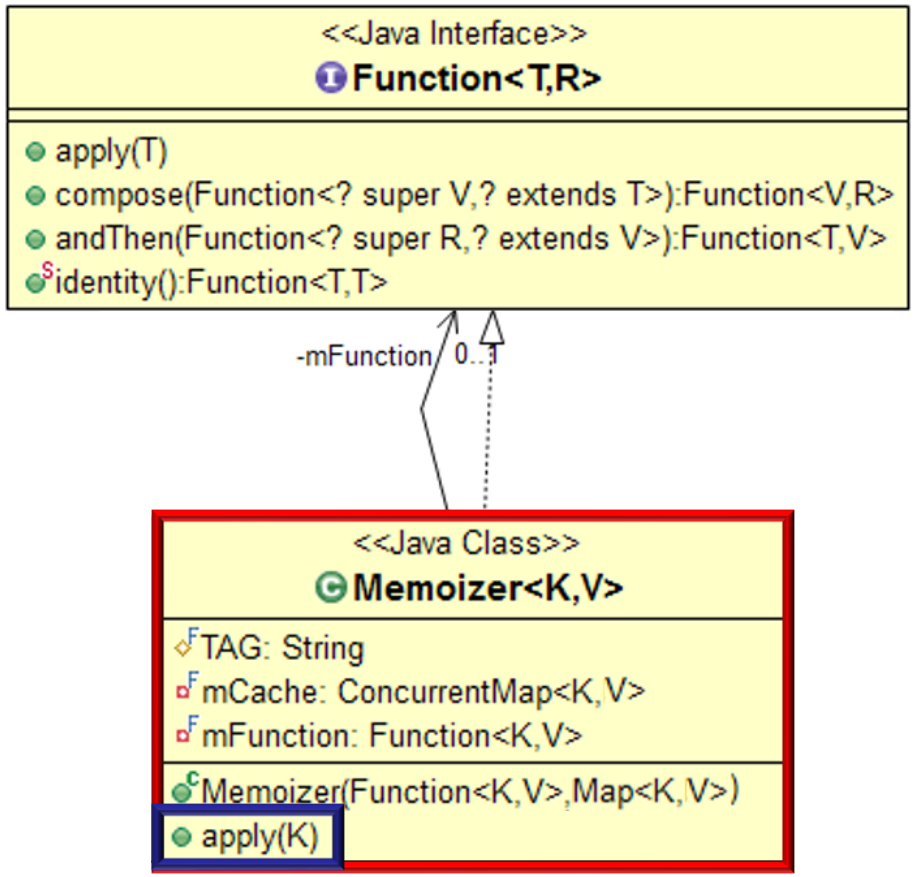


In contrast, a SynchronizedMap uses a single lock

See codepumpkin.com/hashtable-vs-synchronizedmap-vs-concurrenthashmap

Designing a Memoizer with ConcurrentHashMap

- Memoizer uses a ConcurrentHashMap to minimize synchronization overhead
  - A group of locks guard different subsets of the hash buckets
  - apply() uses computeIfAbsent() to ensure a function only runs when key/value pair is added to cache



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

Designing a Memoizer with ConcurrentHashMap

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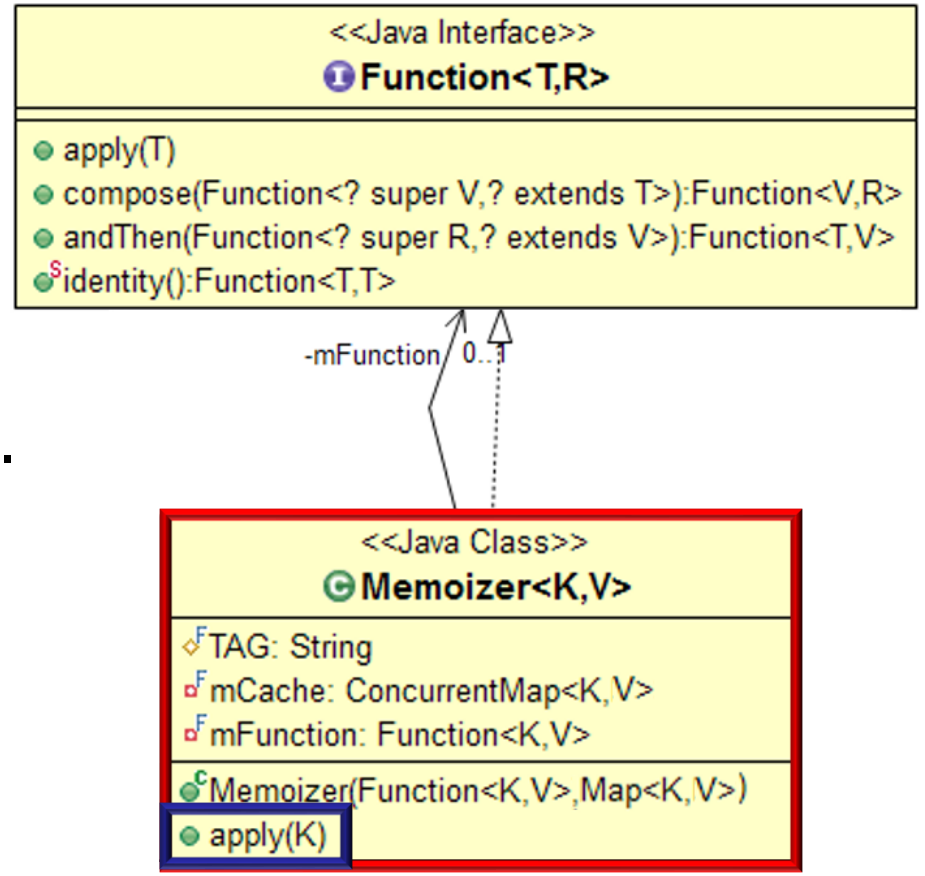
  - apply() uses computeIfAbsent() to ensure a function only runs when key/value pair is added to cache, e.g.
    - This method implements "atomic check-then-act" semantics

```
return map.computeIfAbsent
   (key,
    k -> mappingFunc(k));
```



See dig.cs.illinois.edu/papers/checkThenAct.pdf

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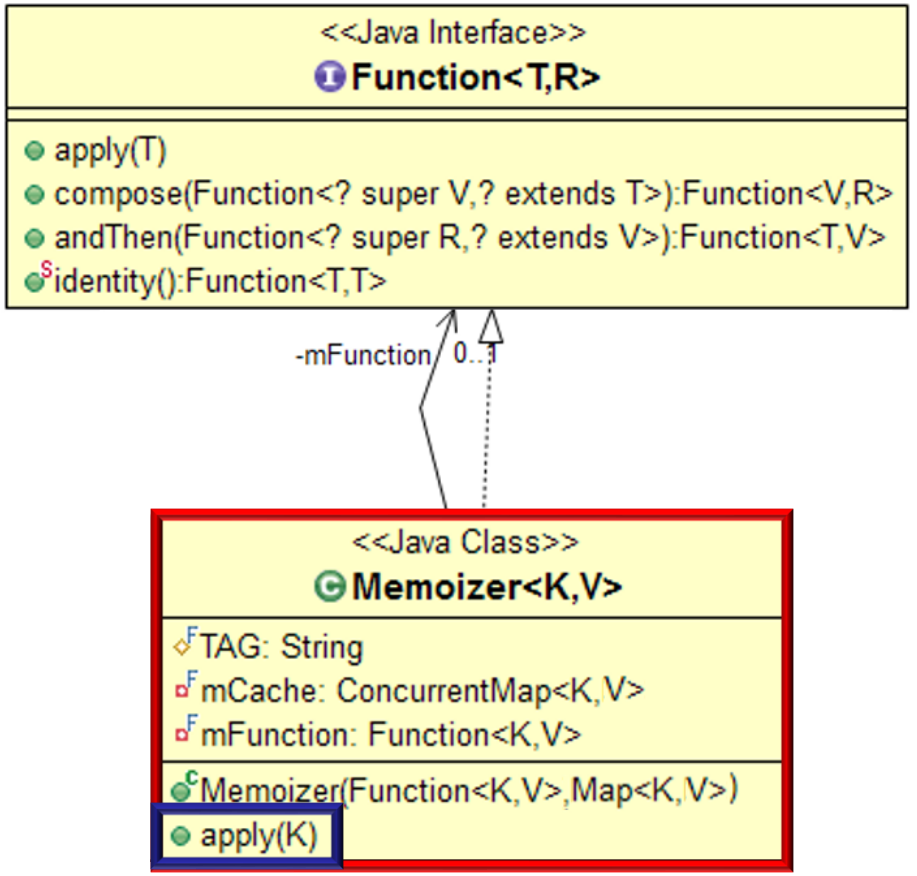
  - apply() uses computeIfAbsent() to ensure a function only runs when key/value pair is added to cache, e.g.
    - This method implements "atomic check-then-act" semantics
    - Here's the equivalent sequence of non-atomic/-optimized Java code




```
V value = map.get(key);
if (value == null) {
  value = mappingFunc.apply(key);
  if (value != null) map.put(key, value);
}
return value;
```

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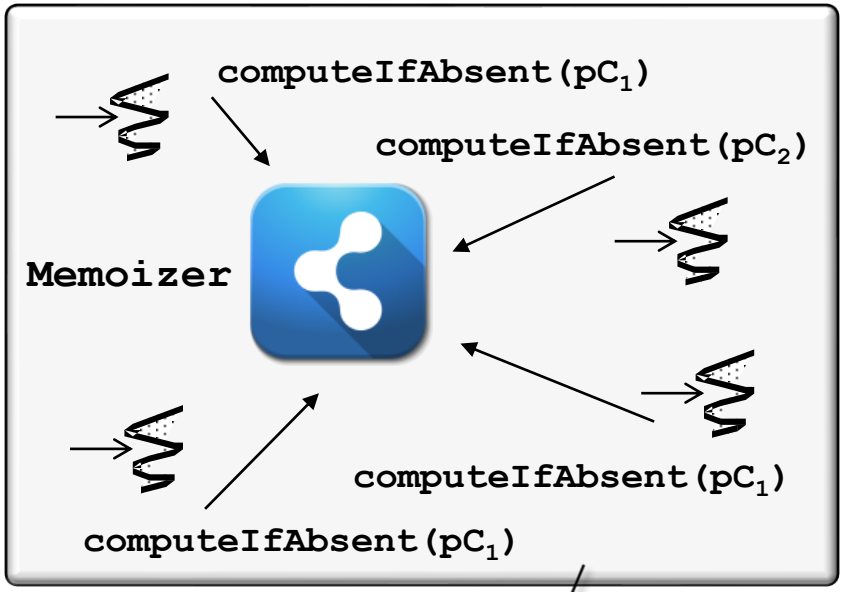

Only one computation per key is performed even if multiple threads simultaneously call computeIfAbsent() using the same key

End of Java Concurrent Collections: Designing a Memoizer with ConcurrentHashMap