Java 8 Parallel Stream Internals

(Part 4)

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Learning Objectives in this Part of the Lesson

- Understand parallel stream internals, e.g.
  - Know what can change & what can't
  - Partition a parallel stream data source into "chunks"
  - Process chunks in parallel
  - Configure the Java 8 parallel stream common fork-join pool

```
int desiredThreads = 8;
System.setProperty
  ("java.util.concurrent."
   + "ForkJoinPool.common."
   + "parallelism",
   desiredThreads);
```

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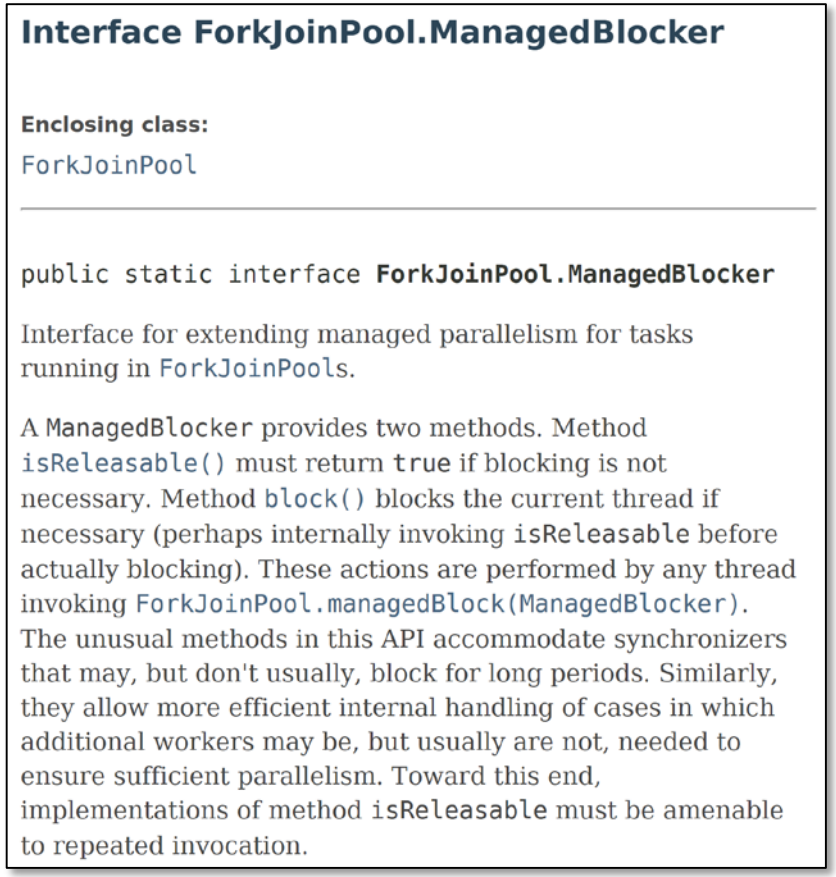
- Understand parallel stream internals, e.g.
  - Know what can change & what can't
  - Partition a parallel stream data source into "chunks"
  - Process chunks in parallel
  - Configure the Java 8 parallel stream common fork-join pool
  - Avoid pool starvation & improve performance w/ManagedBlocker



Interface ForkJoinPool.ManagedBlocker

Enclosing class:

ForkJoinPool

---

public static interface **ForkJoinPool.ManagedBlocker**

Interface for extending managed parallelism for tasks running in ForkJoinPools.

A ManagedBlocker provides two methods. Method isReleasable() must return true if blocking is not necessary. Method block() blocks the current thread if necessary (perhaps internally invoking isReleasable before actually blocking). These actions are performed by any thread invoking ForkJoinPool.managedBlock(ManagedBlocker). The unusual methods in this API accommodate synchronizers that may, but don't usually, block for long periods. Similarly, they allow more efficient internal handling of cases in which additional workers may be, but usually are not, needed to ensure sufficient parallelism. Toward this end, implementations of method isReleasable must be amenable to repeated invocation.

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

Configuring the Parallel Stream Common Fork-Join Pool

Configuring the Parallel Stream Common Fork-Join Pool

- Java 8 parallel streams are intentionally designed with a limited # of “knobs” to configure their behavior

See www.infoq.com/presentations/tecniques-parallelism-java

Configuring the Parallel Stream Common Fork-Join Pool

- In particular, the common fork-join pool optimizes resource utilization since it's aware of what cores are being used globally

See dzone.com/articles/common-fork-join-pool-and-streams

Configuring the Parallel Stream Common Fork-Join Pool

- In particular, the common fork-join pool optimizes resource utilization since it's aware of what cores are being used globally
  - This "global" vs "local" resource management tradeoff is common in computing & other domains

See blog.tsia.com/blog/local-or-global-resource-management-which-model-is-better

Configuring the Parallel Stream Common Fork-Join Pool

- By default the common ForkJoinPool has one less thread than the # of cores

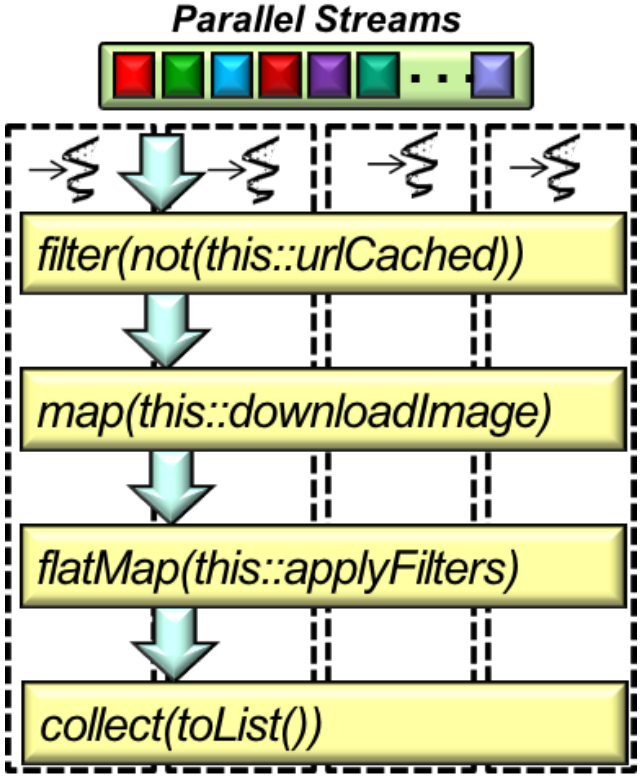
```
System.out.println
  ("The parallelism in the"
   + "common fork-join pool is "
   + ForkJoinPool
       .getCommonPoolParallelism());
```

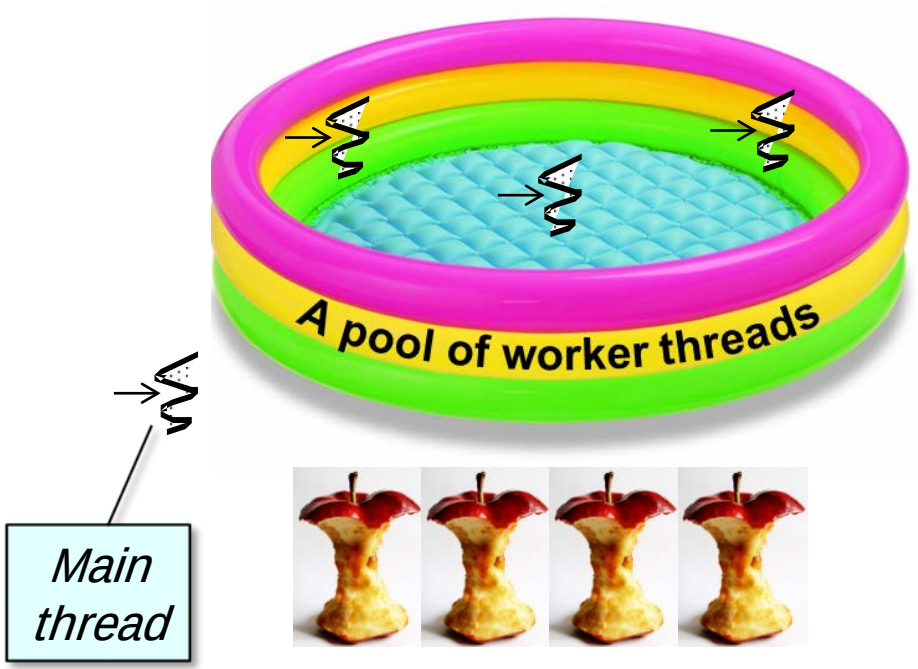
e.g., returns 7 on my quad-core hyper-threaded processor

See github.com/douglascraigschmidt/LiveLessons/tree/master/SearchStreamForkJoin/Java7

Configuring the Parallel Stream Common Fork-Join Pool

- By default the common ForkJoinPool has one less thread than the # of cores

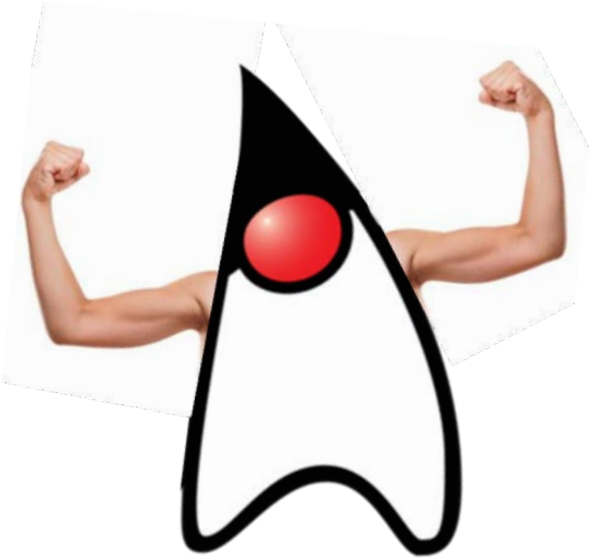


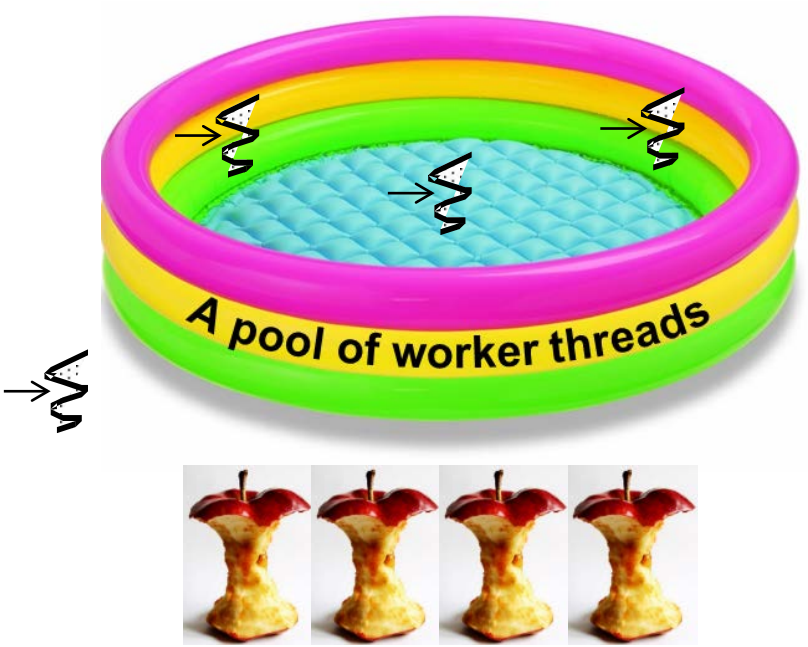


A parallel stream can thus use all cores since it also uses the main thread

Configuring the Parallel Stream Common Fork-Join Pool

- However, the default # of threads in the fork-join pool may be inadequate





Configuring the Parallel Stream Common Fork-Join Pool

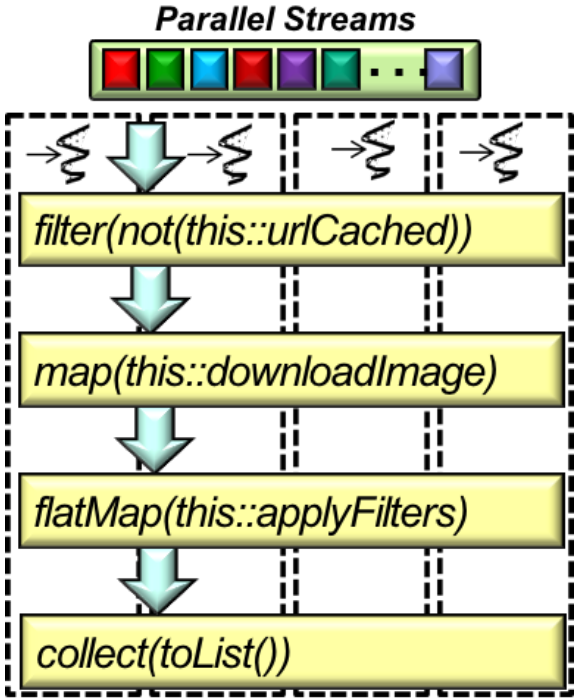
- However, the default # of threads in the fork-join pool may be inadequate
  - e.g., problems occur when blocking operations are used in a parallel stream

e.g., downloading more images than # of cores

These problems may range from underutilization of processor cores to deadlock..

Configuring the Parallel Stream Common Fork-Join Pool

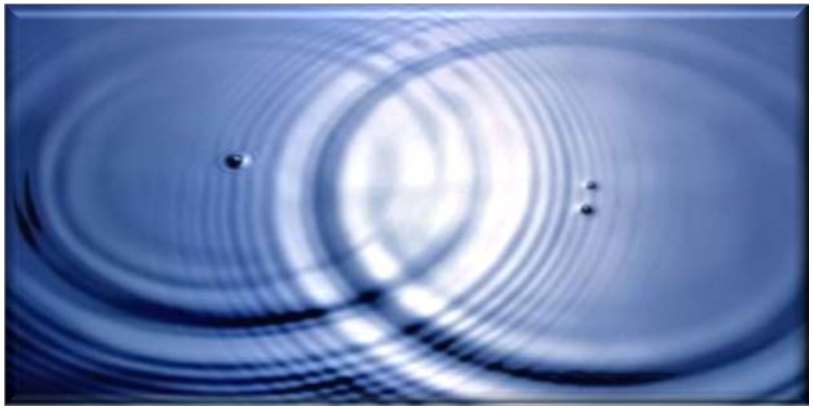
- The common pool size can be controlled programmatically




```
int numberOfDownloads = 10;
System.setProperty
  ("java.util.concurrent."
   + "ForkJoinPool.common."
   + "parallelism",
   numberOfDownloads);
```

Configuring the Parallel Stream Common Fork-Join Pool

- The common pool size can be controlled programmatically
  - Setting this property affects all parallel streams in a process



```
int numberOfDownloads = 10;
System.setProperty
  ("java.util.concurrent."
   + "ForkJoinPool.common."
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   numberOfDownloads);
```

It's hard to estimate the total # of threads to set in the common fork-join pool

Configuring the Parallel Stream Common Fork-Join Pool

- The common pool size can be controlled programmatically
  - Setting this property affects all parallel streams in a process
  - The ManagedBlocker class can be used to temporarily add worker threads to common fork-join pool


```
SupplierManagedBlocker<T> mb =
  new SupplierManagedBlocker<>
   (supplier);
...
ForkJoinPool.managedBlock(mb);
...
return mb.getResult();
```

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

Configuring the Parallel Stream Common Fork-Join Pool

- The common pool size can be controlled programmatically
  - Setting this property affects all parallel streams in a process
  - The ManagedBlocker class can be used to temporarily add worker threads to common fork-join pool
    - This is useful for behaviors that block on I/O and/or synchronizers

```
SupplierManagedBlocker<T> mb =
  new SupplierManagedBlocker<>
   (supplier);
...
ForkJoinPool.managedBlock(mb);
...
return mb.getResult();
```

See github.com/douglascraigschmidt/LiveLessons/tree/master/ImageStreamGang

Overview of the ManagedBlocker Interface

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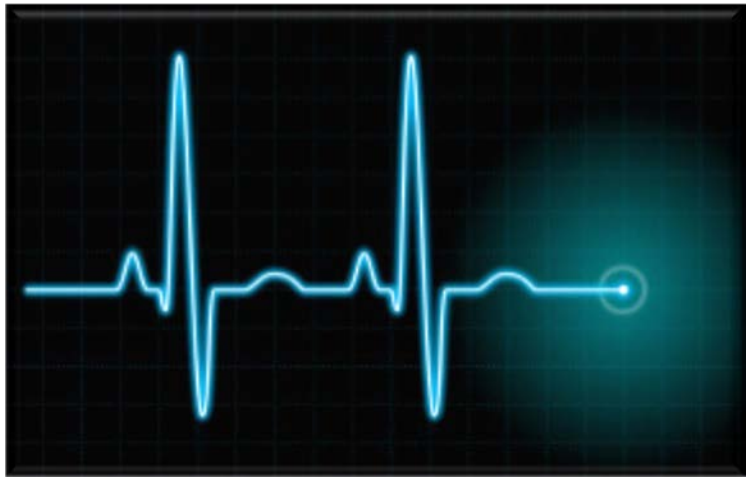
- ManagedBlocker handles cases where more worker threads may be needed to ensure liveness/responsiveness



Interface ForkJoinPool.ManagedBlocker

Enclosing class:

`ForkJoinPool`

`public static interface ForkJoinPool.ManagedBlocker`

Interface for extending managed parallelism for tasks running in `ForkJoinPools`.

A `ManagedBlocker` provides two methods. Method `isReleasable()` must return `true` if blocking is not necessary. Method `block()` blocks the current thread if necessary (perhaps internally invoking `isReleasable` before actually blocking). These actions are performed by any thread invoking `ForkJoinPool.managedBlock(ManagedBlocker)`. The unusual methods in this API accommodate synchronizers that may, but don't usually, block for long periods. Similarly, they allow more efficient internal handling of cases in which additional workers may be, but usually are not, needed to ensure sufficient parallelism. Toward this end, implementations of method `isReleasable` must be amenable to repeated invocation.

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

Overview of the ManagedBlocker Interface

- ManagedBlocker handles cases where more worker threads may be needed to ensure liveness/responsiveness
  - e.g., to automatically/temporarily increase common fork/join pool size

Interface ForkJoinPool.ManagedBlocker

Enclosing class:

`ForkJoinPool`

`public static interface ForkJoinPool.ManagedBlocker`

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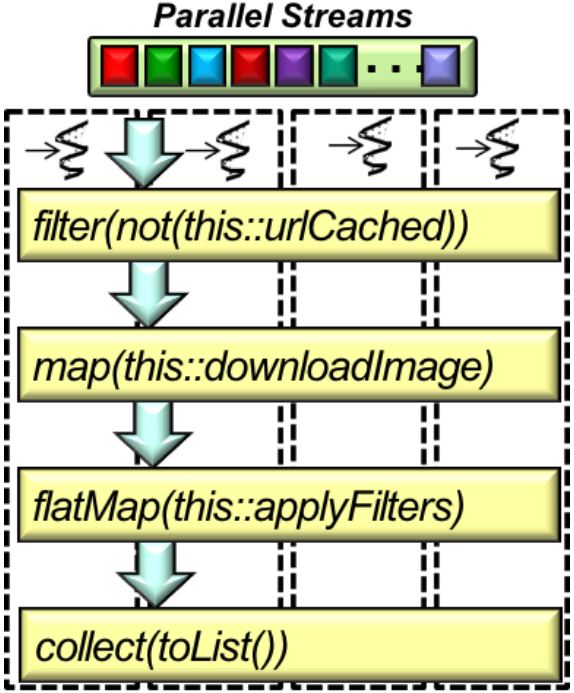
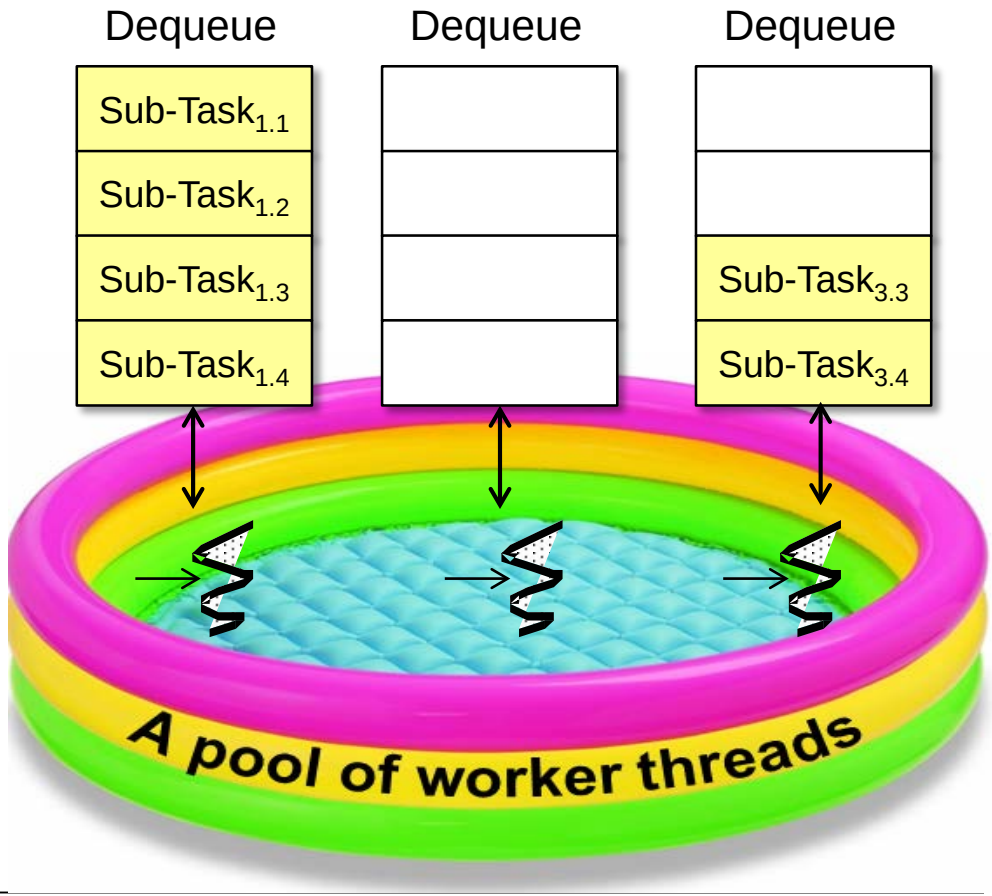
Overview of the ManagedBlocker Interface

- ManagedBlocker can be used for both conventional fork-join & parallel stream use-cases



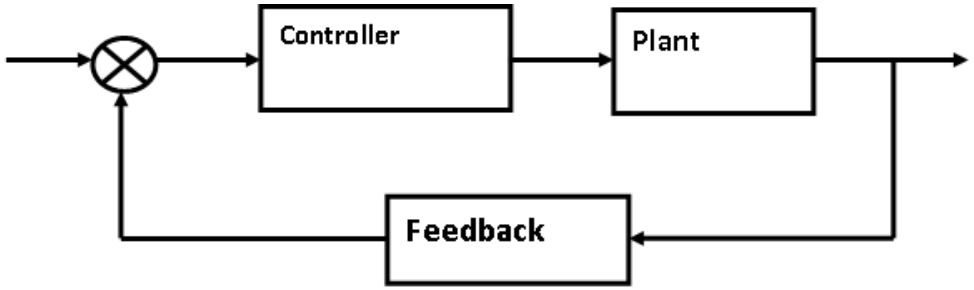


Overview of the ManagedBlocker Interface

- ManagedBlocker can be used for both conventional fork-join & parallel stream use-cases
  - ForkJoinPool reclaims threads during periods of non-use & reinstates them on later use

Overview of the ManagedBlocker Interface

- ManagedBlocker can be used for both conventional fork-join & parallel stream use-cases
  - ForkJoinPool reclaims threads during periods of non-use & reinstates them on later use
  - ForkJoinPool also tries to create or activate threads to ensure the target parallelism level is met



Overview of the ManagedBlocker Interface

- ManagedBlocker defines two methods


```
interface ManagedBlocker {
  boolean isReleasable();

  boolean block();
}
```

Overview of the ManagedBlocker Interface

- ManagedBlocker defines two methods
  - Returns true if blocking is unnecessary

```
interface ManagedBlocker {
  boolean isReleasable();

  boolean block();
}
```

e.g., was able to acquire a lock without blocking

Overview of the ManagedBlocker Interface

- ManagedBlocker defines two methods
  - Returns true if blocking is unnecessary
  - Possibly blocks the calling thread

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interface ManagedBlocker {
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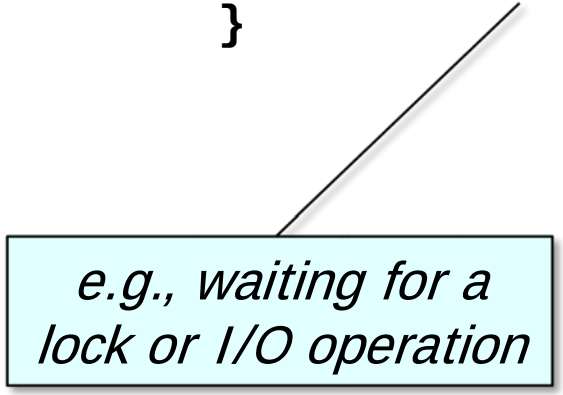
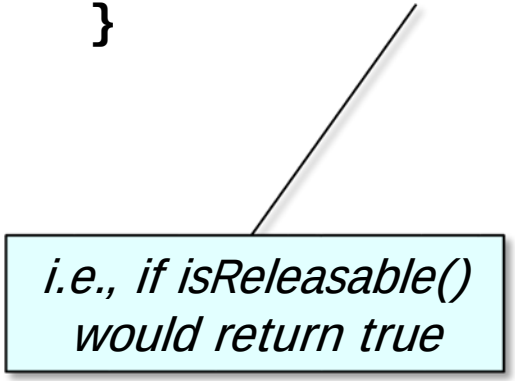


Overview of the ManagedBlocker Interface

- ManagedBlocker defines two methods
  - Returns true if blocking is unnecessary
  - Possibly blocks the calling thread
    - Returns true if no additional blocking is necessary

```
interface ManagedBlocker {
  boolean isReleasable();

  boolean block();
}
```



Applying the Managed Blocker Interface

Applying the ManagedBlocker Interface

- The ForkJoinPool class uses a ManagedBlocker internally

```
class ForkJoinPool extends AbstractExecutorService {
  ...
  static void managedBlock(ManagedBlocker blocker) {
    ...
    while (!blocker.isReleasable()) {
      if (p.tryCompensate(p.ctl)) {
        ...
        do {}
        while (!blocker.isReleasable()
               && !blocker.block());
        ...
}
...
```

See openjdk/7-b147/java/util/concurrent/ForkJoinPool.java

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        ...
  }
  ...
```

This method activates a spare thread to ensure sufficient parallelism while calling thread is blocked

See openjdk/7-b147/java/util/concurrent/ForkJoinPool.java

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        ...
  }
  ...
```

If there aren't enough live threads, create or re-activate a spare thread to compensate for blocked joiners 'til they unblock

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        ...
}
...
```

Potentially block the calling thread

Applying the ManagedBlocker Interface

- Here is a ManagedBlocker based on a ReentrantLock (from Java docs)

```
class ManagedLocker implements ManagedBlocker {
  final ReentrantLock mLock;
  boolean mHasLock = false;

  ManagedLocker(ReentrantLock lock) { mLock = lock; }

  public boolean isReleasable()
  { return mHasLock || (mHasLock = mLock.tryLock()); }

  public boolean block() {
    if (!mHasLock)
      mLock.lock();
    return true;
  }
}
```

Handles a blocking synchronizer

Applying the ManagedBlocker Interface

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```

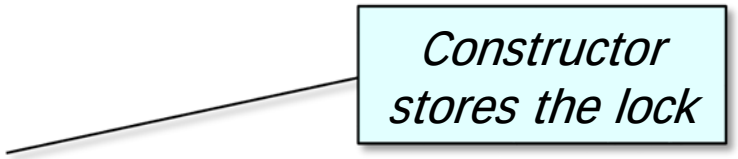

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```

Tries to acquire the lock (non-blocking)

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    return true;
  }
}
```

Performs a blocking lock operation

Applying the ManagedBlocker Interface

- This class possibly blocks waiting for an item on a queue (from Java docs)

```
class QueueTaker<E> implements ManagedBlocker {
  final BlockingQueue<E> mQueue;
  volatile E mItem = null;

  QueueTaker(BlockingQueue<E> q) { mQueue = q; }

  public boolean isReleasable()
  { return mItem != null || (mItem = mQueue.poll()) != null; }

  public boolean block() throws InterruptedException
  { if (mItem == null) mItem = mQueue.take(); return true; }

  public E getItem()
  { return mItem; }
}
```

Handles a blocking queue

Applying the ManagedBlocker Interface

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}
```

Try to get an item (non-blocking)

Applying the ManagedBlocker Interface

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  public boolean block() throws InterruptedException
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  { return mItem; }
}
```

Block until an item is available

Applying the ManagedBlocker Interface

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  public E getItem()
  { return mItem; }
}
```

Call after pool.managedBlock() completes

Using ManagedBlocker via the BlockingTask Class

Using ManagedBlocker via the BlockingTask Class

- BlockingTask integrates blocking Suppliers with the common fork/join pool

```
public class BlockingTask {
  ...
  public static<T> T callInManagedBlocker(Supplier<T> supplier){



    SupplierManagedBlocker<T> managedBlocker =
      new SupplierManagedBlocker<T>(supplier);
    ...
    ForkJoinPool.managedBlock(managedBlocker);
    ...
    return managedBlocker.getResult();
  }
  ...
```

See github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex20

Using ManagedBlocker via the BlockingTask Class

- BlockingTask integrates blocking Suppliers with the common fork/join pool

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public class BlockingTask {
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      new SupplierManagedBlocker<T>(supplier);
    ...
    ForkJoinPool.managedBlock(managedBlocker);
    ...
    return managedBlocker.getResult();
  }
  ...
```

Enables the use of blocking Suppliers with the common Java fork/join thread pool

See stackoverflow.com/q/37512662 for pros & cons of this approach

Using ManagedBlocker via the BlockingTask Class

- BlockingTask integrates blocking Suppliers with the common fork/join pool

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public class BlockingTask {
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    ...
    ForkJoinPool.managedBlock(managedBlocker);
    ...
    return managedBlocker.getResult();
  }
  ...
```

Create a helper object to encapsulate the supplier

Using ManagedBlocker via the BlockingTask Class

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      new SupplierManagedBlocker<T>(supplier);
    ...
    ForkJoinPool.managedBlock(managedBlocker);
    ...
    return managedBlocker.getResult();
  }
  ...
```

Submit managedBlock to common ForkJoin thread pool

Using ManagedBlocker via the BlockingTask Class

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```
public class BlockingTask {
  ...
  public static<T> T callInManagedBlocker(Supplier<T> supplier){



    SupplierManagedBlocker<T> managedBlocker =
      new SupplierManagedBlocker<T>(supplier);
    ...
    ForkJoinPool.managedBlock(managedBlocker);
    ...
    return managedBlocker.getResult();
  }
  ...
```

Return the result of the blocking call

Using ManagedBlocker via the BlockingTask Class

- BlockingTask integrates blocking Suppliers with the common fork/join pool

```
public class BlockingTask {
  ...
  private static class SupplierManagedBlocker<T>
                  implements ForkJoinPool.ManagedBlocker {
    /** The blocking supplier. */
    private final Supplier<T> mSupplier;
    /** Keeps track of whether blocking supplier is done. */
    private boolean mDone = false;
    /** Result obtained from supplier. */
    private T mResult;

    /** Constructor initializes the field. */
    private SupplierManagedBlocker(final Supplier supplier)
    { mSupplier = supplier; } ...
```

Blocking Supplier work w/common fork/join pool

Using ManagedBlocker via the BlockingTask Class

- BlockingTask integrates blocking Suppliers with the common fork/join pool

```
public class BlockingTask {
   ...
   private static class SupplierManagedBlocker<T>
                  implements ForkJoinPool.ManagedBlocker {
     ...
     public boolean block()
     { mResult = mSupplier.get(); mDone = true; return true; }

     public boolean isReleasable()
     { return mDone; }

     public T getResult()
     { return mResult; }
}
```

Sets result via the blocking Supplier's get() method

Using ManagedBlocker via the BlockingTask Class

- BlockingTask integrates blocking Suppliers with the common fork/join pool

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public class BlockingTask {
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     public boolean isReleasable()
     { return mDone; }

     public T getResult()
     { return mResult; }
}
```

True if blocking supplier has finished, else false

Using ManagedBlocker via the BlockingTask Class

- BlockingTask integrates blocking Suppliers with the common fork/join pool

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public class BlockingTask {
   ...
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     public boolean isReleasable()
     { return mDone; }

     public T getResult()
     { return mResult; }
}
```

Returns the supplier's result

Using ManagedBlocker via the BlockingTask Class

- This app uses BlockingTask to ensure there are enough threads in the common thread pool

```
Image blockingDownload(URL url) {
  return BlockingTask
    .callInManagedBlocker
      (()-> downloadImage(url));
}
```

See github.com/douglascraigschmidt/LiveLessons/tree/master/Java8/ex20

Using ManagedBlocker via the BlockingTask Class

- This app uses BlockingTask to ensure there are enough threads in the common thread pool

```
Image blockingDownload(URL url) {
  return BlockingTask
    .callInManagedBlocker
      (()-> downloadImage(url));
}
```

Transform a URL to an Image by downloading each image via its URL

Using ManagedBlocker via the BlockingTask Class

- This app uses BlockingTask to ensure there are enough threads in the common thread pool

```
Image blockingDownload(URL url) {
  return BlockingTask
    .callInManagedBlocker
      (()-> downloadImage(url));
}
```

This call ensures the common fork/join thread pool is expanded to handle the blocking image download

Using ManagedBlocker via the BlockingTask Class

- This app uses BlockingTask to ensure there are enough threads in the common thread pool

```
Image blockingDownload(URL url) {
  return BlockingTask
    .callInManagedBlocker
      (()-> downloadImage(url));
}
```

Extra threads in the common fork-join pool are automatically terminated later

End of Java 8 Parallel Stream Internals (Part 4)