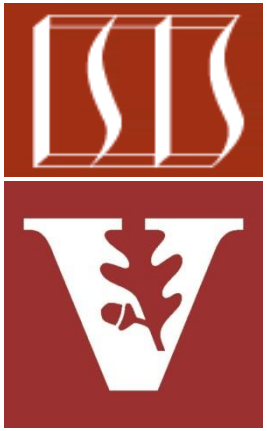
Java ReentrantReadWriteLock: Structure & Functionality



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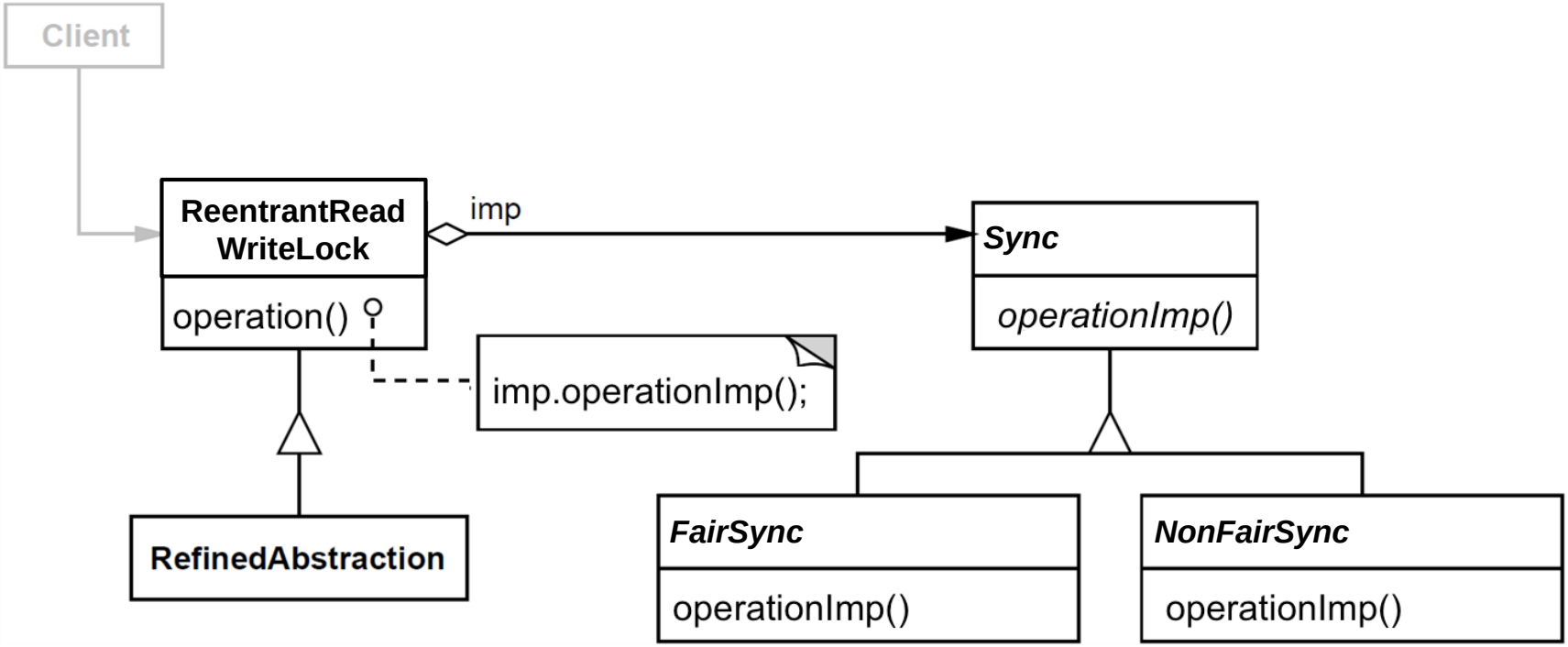
Learning Objectives in this Part of the Lesson

- Understand the structure & functionality of the Java ReentrantReadWriteLock class



Overview of ReentrantReadWriteLock

Overview of Java ReentrantReadWriteLock

- Provides a Java readers-writer lock implementation

```
class ReentrantReadWriteLock
      implements ReadWriteLock ... {
```

Class ReentrantReadWriteLock

java.lang.Object
    java.util.concurrent.locks.ReentrantReadWriteLock

All Implemented Interfaces:

Serializable, ReadWriteLock

```
public class ReentrantReadWriteLock
extends Object
implements ReadWriteLock, Serializable
```

An implementation of `ReadWriteLock` supporting similar semantics to `ReentrantLock`.

This class has the following properties:

- **Acquisition order**

  This class does not impose a reader or writer preference ordering for lock access. However, it does support an optional *fairness* policy.

  Non-fair mode (default)

  When constructed as non-fair (the default), the order of entry to the read and write lock is unspecified, subject to reentrancy constraints. A nonfair lock that is continuously contended may indefinitely postpone one or more reader or writer threads, but will normally have higher throughput than a fair lock.

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

Overview of Java ReentrantReadWriteLock

- Provides a Java readers-writer lock implementation
  - Implements the ReadWriteLock interface

```
class ReentrantReadWriteLock
      implements ReadWriteLock ... {
  ...
```

Interface ReadWriteLock

All Known Implementing Classes:

ReentrantReadWriteLock

`public interface` **`ReadWriteLock`**

A `ReadWriteLock` maintains a pair of associated `locks`, one for read-only operations and one for writing. The `read lock` may be held simultaneously by multiple reader threads, so long as there are no writers. The `write lock` is exclusive.

All `ReadWriteLock` implementations must guarantee that the memory synchronization effects of `writeLock` operations (as specified in the `Lock` interface) also hold with respect to the associated `readLock`. That is, a thread successfully acquiring the read lock will see all updates made upon previous release of the write lock.

A read-write lock allows for a greater level of concurrency in accessing shared data than that permitted by a mutual exclusion lock. It exploits the fact that while only a single thread at a time (a *writer* thread) can modify the shared data, in many cases any number of threads can concurrently read the data (hence *reader* threads). In theory, the increase in concurrency permitted by the use of a read-write lock will lead to performance improvements over the use of a mutual exclusion lock. In practice this increase in concurrency will only be fully realized on a multi-processor, and then only if the access patterns for the shared data are suitable.

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

Overview of Java ReentrantReadWriteLock

- Provides a Java readers-writer lock implementation
  - Implements the ReadWriteLock interface
  - Nested ReadLock & WriteLock classes implement Lock interface

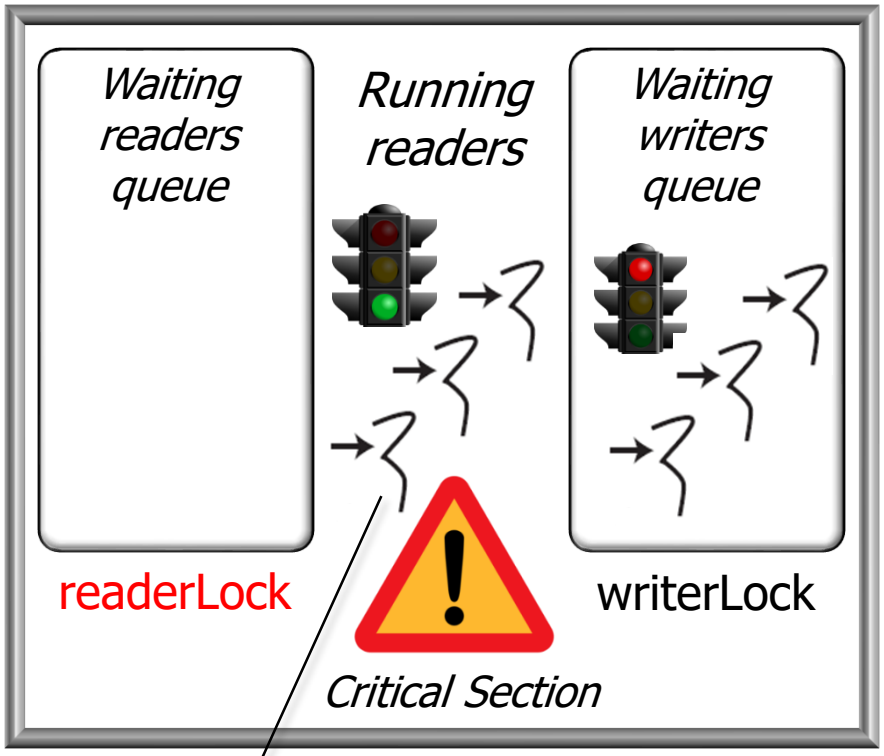
```
class ReentrantReadWriteLock
    implements ReadWriteLock ... {
  ...
  /** Inner class providing
      readlock */
  ReentrantReadWriteLock.ReadLock
    readerLock;

  /** Inner class providing
      writelock */
  ReentrantReadWriteLock.WriteLock
    writerLock;
  ...
```

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

Overview of Java ReentrantReadWriteLock

- Implements readers-writer semantics



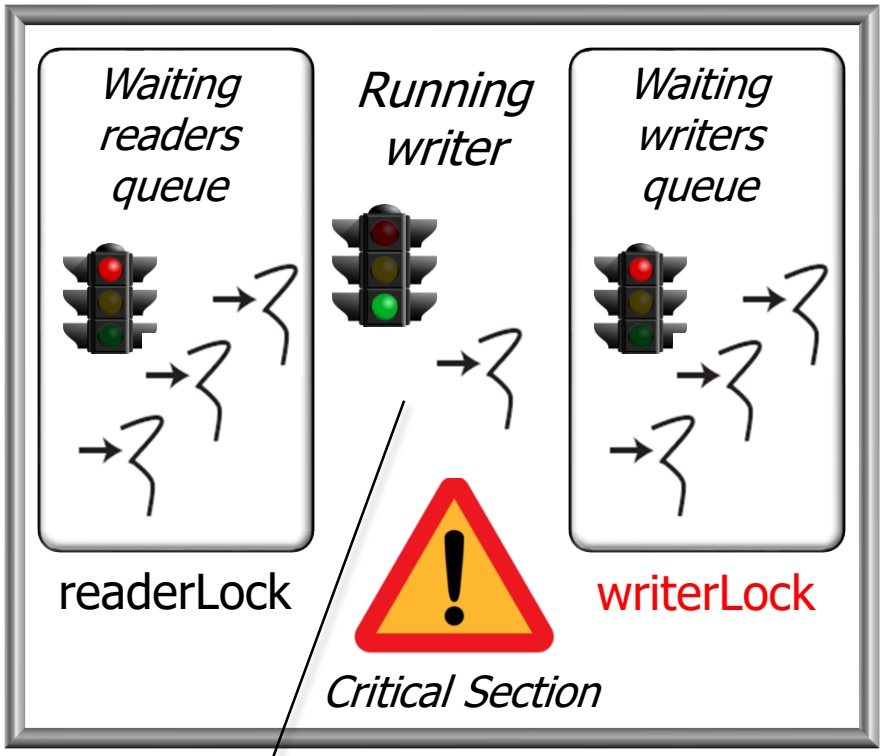

```
class ReentrantReadWriteLock
      implements ReadWriteLock ... {
...
/** Inner class providing
    readlock */
ReentrantReadWriteLock.ReadLock
  readerLock;

/** Inner class providing
    writelock */
ReentrantReadWriteLock.WriteLock
  writerLock;
...
```

Multiple reader threads can run concurrently within a critical section

Overview of Java ReentrantReadWriteLock

- Implements readers-writer semantics



Only one writer thread can run at a time within a critical section

```
class ReentrantReadWriteLock
      implements ReadWriteLock ... {
...
/** Inner class providing
    readlock */
ReentrantReadWriteLock.ReadLock
  readerLock;

/** Inner class providing
    writelock */
ReentrantReadWriteLock.WriteLock
  writerLock;
...
```

Overview of Java ReentrantReadWriteLock

- Implements readers-writer semantics


```
class ReentrantReadWriteLock
      implements ReadWriteLock ... {
  ...
  /** Inner class providing
      readlock */
  ReentrantReadWriteLock.ReadLock
    readerLock;

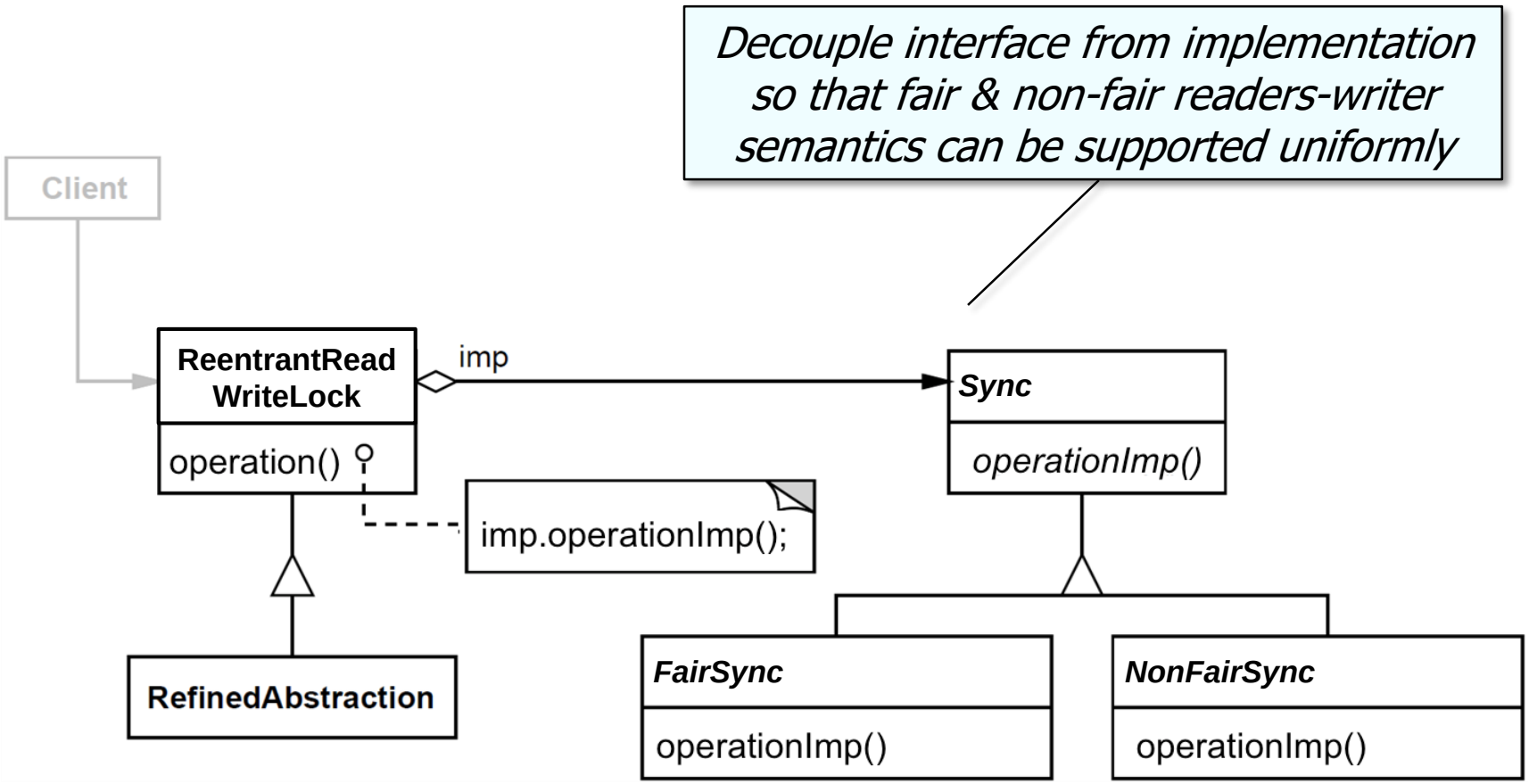
  /** Inner class providing
      writelock */
  ReentrantReadWriteLock.WriteLock
    writerLock;
  ...
```

ReentrantReadWriteLock is "pessimistic", i.e., it assumes contention may occur

Overview of Java ReentrantReadWriteLock

- Applies the *Bridge* pattern

```
class ReentrantReadWriteLock
      implements ReadWriteLock ... {
  ...
```



See en.wikipedia.org/wiki/Bridge_pattern

Overview of Java ReentrantReadWriteLock

- Applies the *Bridge* pattern
  - Locking handled by Sync implementor hierarchy

```
class ReentrantReadWriteLock
      implements ReadWriteLock ... {
  ...
  /** Performs sync mechanics */
  final Sync sync;
  ...
```

Overview of Java ReentrantReadWriteLock

- Applies the *Bridge* pattern
  - Locking handled by Sync implementor hierarchy
    - Inherits functionality from AbstractQueuedSynchronizer

```
class ReentrantReadWriteLock
    implements ReadWriteLock ... {
  ...
  /** Performs sync mechanics */
  final Sync sync;

  /** Sync implementation for
      ReentrantReadWriteLock */
  abstract static class Sync extends
    AbstractQueuedSynchronizer
    { ... }
  ...
```

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

Overview of Java ReentrantReadWriteLock

- Applies the *Bridge* pattern
  - Locking handled by Sync implementor hierarchy
    - Inherits functionality from AbstractQueuedSynchronizer
      - Many Java synchronizers based on FIFO wait queues use this framework

```
class ReentrantReadWriteLock
    implements ReadWriteLock ... {
  ...
  /** Performs sync mechanics */
  final Sync sync;

  /** Sync implementation for
      ReentrantReadWriteLock */
  abstract static class Sync extends
    AbstractQueuedSynchronizer
    { ... }
  ...
```

See gee.cs.oswego.edu/dl/papers/aqs.pdf

Overview of Java ReentrantReadWriteLock

- Applies the *Bridge* pattern
  - Locking handled by Sync implementor hierarchy
    - Inherits functionality from AbstractQueuedSynchronizer
    - Defines NonFairSync & FairSync subclasses with non-FIFO & FIFO semantics

```
class ReentrantReadWriteLock
    implements ReadWriteLock ... {
  ...
  /** Performs sync mechanics */
  final Sync sync;

  /** Sync implementation for
      ReentrantReadWriteLock */
  abstract static class Sync extends
    AbstractQueuedSynchronizer
    { ... }

  static final class NonFairSync
    extends Sync { ... }

  static final class FairSync
    extends Sync { ... }
```

See src/share/classes/java/util/concurrent/locks/ReentrantReadWriteLock.java

Overview of Java ReentrantReadWriteLock

- Applies the *Bridge* pattern
  - Locking handled by Sync implementor hierarchy
  - Constructor enables fair vs. non-fair lock acquisition model
    - These models apply the same pattern used by ReentrantLock & Semaphore

```
class ReentrantReadWriteLock
      implements ReadWriteLock ... {
  ...
  public ReentrantReadWriteLock
                      (boolean fair) {
    sync = fair ? new FairSync()
                : new NonfairSync();
    readerLock =
      new ReadLock(this);
    writerLock =
      new WriteLock(this);
  }
  ...
```

See earlier lessons on "*Java ReentrantLock*" & "*Java Semaphore*"

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```
class ReentrantReadWriteLock
    implements ReadWriteLock ... {
  ...
  public ReentrantReadWriteLock
                      (boolean fair) {
    sync = fair ? new FairSync()
                : new NonfairSync();
    readerLock =
      new ReadLock(this);
    writerLock =
      new WriteLock(this);
  }
  ...
```

This param determines whether FairSync or NonfairSync is used

See earlier lessons on "*Java Semaphore*" & "*Java ReentrantLock*"

Overview of Java ReentrantReadWriteLock

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class ReentrantReadWriteLock
      implements ReadWriteLock ... {
  ...
  public ReentrantReadWriteLock
                        (boolean fair) {
    sync = fair ? new FairSync()
                : new NonfairSync();
    readerLock =
      new ReadLock(this);
    writerLock =
      new WriteLock(this);
  }
  ...
```

Ensures strict "FIFO" fairness, at the expense of performance

Overview of Java ReentrantReadWriteLock

- Applies the *Bridge* pattern
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```
class ReentrantReadWriteLock
      implements ReadWriteLock ... {
  ...
  public ReentrantReadWriteLock
                        (boolean fair) {
    sync = fair ? new FairSync()
                : new NonfairSync();
    readerLock =
      new ReadLock(this);
    writerLock =
      new WriteLock(this);
  }
  ...
```

Enables faster performance at the expense of fairness

Overview of Java ReentrantReadWriteLock

- Applies the *Bridge* pattern
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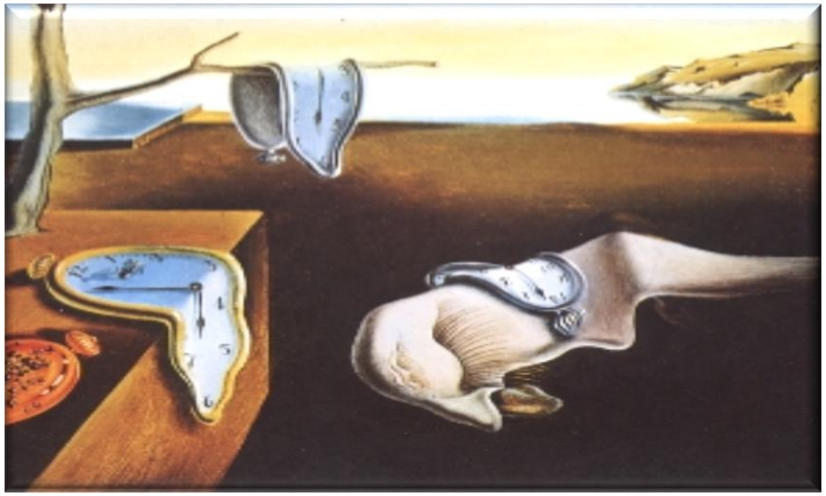
```
class ReentrantReadWriteLock
      implements ReadWriteLock ... {
  ...
  public ReentrantReadWriteLock
                        (boolean fair) {
    sync = fair ? new FairSync()
                : new NonfairSync();
    readerLock =
      new ReadLock(this);
    writerLock =
      new WriteLock(this);
  }
  ...
```

FairSync is generally much slower than NonfairSync, so use it accordingly



Overview of Java ReentrantReadWriteLock

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  - Constructor enables fair vs. non-fair lock acquisition model
    - These models apply the same pattern used by ReentrantLock & Semaphore

```
class ReentrantReadWriteLock
    implements ReadWriteLock ... {
  ...
  public ReentrantReadWriteLock
                      (boolean fair) {
    sync = fair ? new FairSync()
                : new NonfairSync();
    readerLock =
      new ReadLock(this);
    writerLock =
      new WriteLock(this);
  }

  public ReentrantReadWriteLock() {
    sync = new NonfairSync();
  }
  ...
```

The default constructor therefore uses the faster non-fair semantics

Overview of Java ReentrantReadWriteLock

- Applies the *Bridge* pattern
  - Locking handled by Sync implementor hierarchy
  - Constructor enables fair vs. non-fair lock acquisition model
    - These models apply the same pattern used by ReentrantLock & Semaphore
    - Initializes the readerLock & writerLock field

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class ReentrantReadWriteLock
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  public ReentrantReadWriteLock
                        (boolean fair) {
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See docs.oracle.com/javase/8/docs/api/java/util/concurrent/locks/Lock.html

Overview of Java ReentrantReadWriteLock

- Applies the *Bridge* pattern
  - Locking handled by Sync implementor hierarchy
  - Constructor enables fair vs. non-fair lock acquisition model
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    - Initializes the readerLock & writerLock field
      - WriteLock & ReadLock use "shared" mode of Abstract QueuedSynchronizer

```
class ReentrantReadWriteLock
    implements ReadWriteLock ... {
  ...
  public ReentrantReadWriteLock
                    (boolean fair) {
    sync = fair ? new FairSync()
                : new NonfairSync();
    readerLock =
      new ReadLock(this);
    writerLock =
      new WriteLock(this);
  }
  ...

  public static class WriteLock
    implements Lock ... { ... }

  public static class ReadLock
    implements Lock ... { ... }
```

Overview of Java ReentrantReadWriteLock

- Applies the *Bridge* pattern
  - Locking handled by Sync implementor hierarchy
  - Constructor enables fair vs. non-fair lock acquisition model
    - These models apply the same pattern used by ReentrantLock & Semaphore
    - Initializes the readerLock & writerLock field
      - WriteLock & ReadLock use "shared" mode of Abstract QueuedSynchronizer
        - Also implement the Lock interface w/methods like lock(), tryLock(), & unlock()

```
class ReentrantReadWriteLock
    implements ReadWriteLock ... {
  ...
  public ReentrantReadWriteLock
                      (boolean fair) {
    sync = fair ? new FairSync()
                : new NonfairSync();
    readerLock =
      new ReadLock(this);
    writerLock =
      new WriteLock(this);
  }
  ...

  public static class WriteLock
    implements Lock ... { ... }

  public static class ReadLock
    implements Lock ... { ... }
```

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

End of Java ReentrantReadWriteLock: Structure & Functionality