Structure & Functionality of Java ReentrantLock

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Learning Objectives in this Part of the Lesson

- Understand the concept of mutual exclusion in concurrent programs
- Note a human-known use of mutual exclusion
- Recognize the structure & functionality of Java ReentrantLock
Overview of ReentrantLock
Overview of ReentrantLock

• Provide mutual exclusion to concurrent Java programs

```java
public class ReentrantLock
    implements Lock,
    java.io.Serializable {
...
```

Class ReentrantLock

java.lang.Object
    java.util.concurrent.locks.ReentrantLock

All Implemented Interfaces:
    Serializable, Lock

```java
public class ReentrantLock
extends Object
implements Lock, Serializable
```

A reentrant mutual exclusion Lock with the same basic behavior and semantics as the implicit monitor lock accessed using synchronized methods and statements, but with extended capabilities.

A ReentrantLock is owned by the thread last successfully locking, but not yet unlocking it. A thread invoking lock will return, successfully acquiring the lock, when the lock is not owned by another thread. The method will return immediately if the current thread already owns the lock. This can be checked using methods isHeldByCurrentThread(), and getHoldCount().
Overview of ReentrantLock

- Provide mutual exclusion to concurrent Java programs
- Implements Lock interface

```java
public class ReentrantLock implements Lock, java.io.Serializable {
    ...
```

Interface Lock

All Known Implementing Classes:
- ReentrantLock, ReentrantReadWriteLock.ReadLock, ReentrantReadWriteLock.WriteLock

```java
public interface Lock
```

Lock implementations provide more extensive locking operations than can be obtained using synchronized methods and statements. They allow more flexible structuring, may have quite different properties, and may support multiple associated Condition objects.

A lock is a tool for controlling access to a shared resource by multiple threads. Commonly, a lock provides exclusive access to a shared resource: only one thread at a time can acquire the lock and all access to the shared resource requires that the lock be acquired first. However, some locks may allow concurrent access to a shared resource, such as the read lock of a ReadWriteLock.

The use of synchronized methods or statements provides access to the implicit monitor lock associated with every object, but forces all lock acquisition and release to occur in a block-structured way: when multiple locks are acquired they must be released in the opposite order, and all locks must be released in the same lexical scope in which they were acquired.

See [docs.oracle.com/javase/8/docs/api/java/util/concurrent/locks/Lock.html](docs.oracle.com/javase/8/docs/api/java/util/concurrent/locks/Lock.html)
Applies the *Bridge* pattern

see en.wikipedia.org/wiki/Bridge_pattern

The `ReentrantLock` class implements the `Lock` interface and is serializable. It decouples an interface from its implementation(s) so fair and non-fair semantics can be supported uniformly.

```java
class ReentrantLock implements Lock, java.io.Serializable {
    ...
    imp.operationImp();
}
```

Decouples an interface from its implementation(s) so fair & non-fair semantics can be supported uniformly.

See en.wikipedia.org/wiki/Bridge_pattern
Overview of ReentrantLock

- Applies the Bridge pattern
- Locking handled by Sync Implementor hierarchy

```java
public class ReentrantLock
    implements Lock,
    java.io.Serializable {

    ...

    /** Performs sync mechanics */
    final Sync sync;
```
Overview of ReentrantLock

• Applies the *Bridge* pattern
• Locking handled by Sync Implementor hierarchy
• Inherits functionality from AbstractQueuedSynchronizer

```java
public class ReentrantLock
    implements Lock,
    java.io.Serializable {
    ...
    /** Performs sync mechanics */
    final Sync sync;

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

See [docs.oracle.com/javase/8/docs/api/java/util/concurrent/locks/AbstractQueuedSynchronizer.html](http://docs.oracle.com/javase/8/docs/api/java/util/concurrent/locks/AbstractQueuedSynchronizer.html)
Overview of ReentrantLock

• 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

```java
public class ReentrantLock
    implements Lock,
    java.io.Serializable {
    ...
    /** Performs sync mechanics */
    final Sync sync;
    
    /** Sync implementation for ReentrantLock */
    abstract static class Sync extends
        AbstractQueuedSynchronizer
    {
        ... 
    }
    ...
}
```

See gee.cs.oswego.edu/dl/papers/aqs.pdf
Overview of ReentrantLock

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

```java
class ReentrantLock implements Lock, java.io.Serializable {
    final Sync sync;

    static final class NonfairSync extends Sync {
    }

    static final class FairSync extends Sync {
    }

    /** Performs sync mechanics */
    final Sync sync;

    /** Sync implementation for ReentrantLock */
    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/ReentrantLock.java
Overview of ReentrantLock

• Applies the *Bridge* pattern
• Locking handled by Sync Implementor hierarchy
• Constructor enables fair vs. non-fair lock acquisition model

```java
public class ReentrantLock
    implements Lock,
    java.io.Serializable {
    ...

    public ReentrantLock
        (boolean fair) {
        sync = fair
            ? new FairSync()
            : new NonfairSync();
    }
    ...
```

*This param determines whether FairSync or NonfairSync is used*
Overview of ReentrantLock

- 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 Semaphore & ReentrantReadWriteLock

```java
public class ReentrantLock
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See upcoming lessons on “Java Semaphore” & “Java ReentrantReadWriteLock”
Overview of ReentrantLock

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    ...;

    Ensures strict “FIFO” fairness, at the expense of performance
```
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    implements Lock, java.io.Serializable {

    ... public ReentrantLock
        (boolean fair) {

            sync = fair
                ? new FairSync()
                : new NonfairSync();

        }

    ...

    Enables faster performance at the expense of fairness
```
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        (boolean fair) {
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            ? new FairSync()
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    }

    public ReentrantLock() {
        sync = new NonfairSync();
    }

    ... 

    The default behavior favors performance over fairness
```
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        sync = fair
        ? new FairSync()
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    }

    public ReentrantLock() {
        sync = new NonfairSync();
    }

    ...

    FairSync is generally much slower than NonfairSync, so use it accordingly
```
Overview of ReentrantLock

- ReentrantLock is similar to the monitor lock provided by Java’s built-in monitor objects

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See upcoming lessons on “Java Built-in Monitor Object”
Overview of ReentrantLock

- ReentrantLock is similar to the monitor lock provided by Java’s built-in monitor objects
- But also provides extended capabilities

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## Overview of ReentrantLock

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- But also provides extended capabilities.

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In contrast, Java’s synchronized methods/statements are not interruptible
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Likewise, Java’s synchronized methods/statements aren’t non-blocking
End of Structure & Functionality of Java ReentrantLock