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
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()`.

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

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

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

Interface Lock

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

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 ReentrantReadWriteLock.

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.
Applies the *Bridge* pattern

```java
class ReentrantLock implements Lock, java.io.Serializable {
    ...
    
    // Decouples an interface from its implementation(s) so fair & non-fair semantics can be supported uniformly
}
```

See [en.wikipedia.org/wiki/Bridge_pattern](http://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](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](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
public class ReentrantLock
    implements Lock, java.io.Serializable {
    ...
    /** 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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                sync = fair
                    ? new FairSync()
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            }

    ...
```

See upcoming lessons on “Java Semaphore” & “Java ReentrantReadWriteLock”
Overview of ReentrantLock

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```java
public class ReentrantLock implements Lock, java.io.Serializable {
    ...
    public ReentrantLock (boolean fair) {
        sync = fair
            ? new FairSync()
            : new NonfairSync();
    }
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    Ensures strict “FIFO” fairness, at the expense of performance
```
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```
public class ReentrantLock
    implements Lock,
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    |
    |
    |
    public ReentrantLock
            (boolean fair) {
        sync = fair
            ? new FairSync()
            : new NonfairSync();
    }

    Enables faster performance
    at the expense of fairness
```
Overview of ReentrantLock

- Applies the Bridge pattern
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- These models apply the same pattern used by Semaphore & ReentrantReadWriteLock

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

    ... 

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

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

    The default behavior favors performance over fairness
```
Overview of ReentrantLock

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class ReentrantLock implements Lock, java.io.Serializable {

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

    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

<table>
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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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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