Structure & Functionality of Java ConditionObject

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Learning Objectives in this Part of the Lesson

• Understand what condition variables are
• Note a human known use of condition variables
• Know what pattern they implement
• Recognize common use cases where condition variables are applied
• Recognize the structure & functionality of Java ConditionObject
Overview of Java
ConditionObject
Overview of Java ConditionObject

- ConditionObject provides the condition variable abstraction

```java
public class ConditionObject
    implements Condition,
    java.io.Serializable {
...
```

**Class AbstractQueuedSynchronizer.ConditionObject**

```java
java.lang.Object
    java.util.concurrent.locks.AbstractQueuedSynchronizer.ConditionObject
```

All Implemented Interfaces:

- Serializable, Condition

Enclosing class:

- AbstractQueuedSynchronizer

```java
public class AbstractQueuedSynchronizer.ConditionObject
    extends Object
    implements Object, Condition, Serializable
```

Condition implementation for a `AbstractQueuedSynchronizer` serving as the basis of a Lock implementation.

Method documentation for this class describes mechanics, not behavioral specifications from the point of view of Lock and Condition users. Exported versions of this class will in general need to be accompanied by documentation describing condition semantics that rely on those of the associated `AbstractQueuedSynchronizer`.

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

- ConditionObject provides the condition variable abstraction
- Implements Condition interface

```java
public class ConditionObject implements Condition, java.io.Serializable {
    ...
}
```

**Interface Condition**

All Known Implementing Classes:

- AbstractQueuedLongSynchronizer.ConditionObject, AbstractQueuedSynchronizer.ConditionObject

```
public interface Condition

Condition factors out the Object monitor methods (wait, notify and notifyAll) into distinct objects to give the effect of having multiple wait-sets per object, by combining them with the use of arbitrary Lock implementations. Where a Lock replaces the use of synchronized methods and statements, a Condition replaces the use of the Object monitor methods.

Conditions (also known as condition queues or condition variables) provide a means for one thread to suspend execution (to "wait") until notified by another thread that some state condition may now be true. Because access to this shared state information occurs in different threads, it must be protected, so a lock of some form is associated with the condition. The key property that waiting for a condition provides is that it atomically releases the associated lock and suspends the current thread, just like Object.wait.

A Condition instance is intrinsically bound to a lock. To obtain a Condition instance for a particular Lock instance use its newCondition() method.
```

See [docs.oracle.com/javase/8/docs/api/java/util/concurrent/locks/Condition.html](docs.oracle.com/javase/8/docs/api/java/util/concurrent/locks/Condition.html)
Overview of Java ConditionObject

- ConditionObject is nested within the AbstractQueuedSynchronizer class
- This framework is used by Java synchronizers that rely on FIFO wait queues

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/locks/AbstractQueuedSynchronizer.html
Overview of Java ConditionObject

- A ConditionObject provides a "wait queue" of nodes

See [gee.cs.oswego.edu/dl/papers/aqs.pdf](gee.cs.oswego.edu/dl/papers/aqs.pdf)
Overview of Java ConditionObject

- A ConditionObject provides a “wait queue” of nodes
- Enables a set of threads (i.e., the “wait set”) to coordinate their interactions

<<Java Class>>
**ConditionObject**
- firstWaiter: Node
- lastWaiter: Node
- ConditionObject()
- await(): void
- awaitUninterruptibly(): void
- await(long, TimeUnit): boolean
- signal(): void
- doSignal(Node): void
- doSignalAll(): void

<<Java Class>>
**Node**
- S EXCLUSIVE: Node
- S SHARED: Node
- prev: Node
- next: Node
- thread: Thread
- nextWaiter: Node
- Node()
Overview of Java ConditionObject

- A ConditionObject provides a “wait queue” of nodes
- Enables a set of threads (i.e., the “wait set”) to coordinate their interactions
- e.g., by selecting the order & conditions under which they run
Overview of Java ConditionObject

- A ConditionObject is *always* used with a lock

See earlier lessons on "Java ReentrantLock"
A ConditionObject is *always* used with a lock

This lock protects shared state in a condition expression from concurrent manipulation
A ConditionObject is *always* used with a lock

This lock protects shared state in a condition expression from concurrent manipulation.

```java
newCondition() is a factory method that returns a ConditionObject that can be used with this lock.
```

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

- Both ReentrantLock & ConditionObject have internal queues
Overview of Java ConditionObject

- Both ReentrantLock & ConditionObject have internal queues

Queues up threads that are waiting to acquire the lock
Overview of Java ConditionObject

- Both ReentrantLock & ConditionObject have internal queues

Queues up threads waiting for some condition(s) to become true
Overview of Java ConditionObject

- User-defined Java objects can have multiple ConditionObjects (COs)

![Diagram showing the relationship between Producer, Consumer, ArrayBlockingQueue, ConditionObject, and ReentrantLock]

Two COs: notEmpty & notFull

Producer

Consumer

ArrayBlockingQueue

- put()
- take()
- put()
- take()

Producer uses

ConditionObject

- await()
- signal()
- signalAll()

Consumer uses

ReentrantLock

- lock()
- unlock()
- newCondition()
Overview of Java ConditionObject

- User-defined Java objects can have multiple ConditionObjects (COs)
- Multiple COs enable more sophisticated & efficient ways to coordinate multiple threads

![Diagram of Java ConditionObject](image-url)
Overview of Java ConditionObject

- User-defined Java objects can have multiple ConditionObjects (COs)
- Multiple COs enable more sophisticated & efficient ways to coordinate multiple threads

Example:
- Multiple wait-sets per app object can share a lock & are notified on different conditions

See stackoverflow.com/questions/18490636/condition-give-the-effect-of-having-multiple-wait-sets-per-object
Overview of Java ConditionObject

- In contrast, Java’s built-in monitor objects only support one monitor condition

See github.com/douglascraigschmidt/LiveLessons/tree/master/SimpleBlockingQueue
Overview of Java ConditionObject

- In contrast, Java’s built-in monitor objects only support *one* monitor condition

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**THERE CAN BE**

*ONLY ONE*

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**Overview of Java ConditionObject**

- In contrast, Java’s built-in monitor objects only support *one* monitor condition

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**THERE CAN BE**

*ONLY ONE*

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See upcoming lesson on "Java Built-in Monitor Objects"
Overview of Java ConditionObject

- In contrast, Java’s built-in monitor objects only support one monitor condition.
- Yields inefficient programs that require excessive notifications & use of notifyAll().

See [www.dre.vanderbilt.edu/~schmidt/C++2Java.html#concurrency](www.dre.vanderbilt.edu/~schmidt/C++2Java.html#concurrency)
Overview of Java ConditionObject

• In contrast, Java’s built-in monitor objects only support one monitor condition
  • Yields inefficient programs that require excessive notifications & use of notifyAll()
    • e.g., producers & consumers must both wake up on every change to the queue, even if a given thread can’t proceed

```java
synchronized(this) {
    while (mList.isEmpty())
        wait();
    notifyAll();
    return mList.poll();
}
```

See stackoverflow.com/questions/18490636/condition-give-the-effect-of-having-multiple-wait-sets-per-object
End of Structure & Functionality of Java ConditionObject