Overview of Java Atomic Operations & Variables

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Learning Objectives in this Lesson

- Recognize Java programming language & library features that provide atomic operations & variables
Overview of Java Atomic Operations & Variables
Overview of Java Atomic Operations & Variables

- Java supports several types of atomicity
Overview of Java Atomic Operations & Variables

- Java supports several types of atomicity, e.g.
  - *Volatile variables*

See upcoming lesson on “Java Volatile Variables”
Overview of Java Atomic Operations & Variables

- Java supports several types of atomicity, e.g.
  - **Volatile variables**
    - Ensure a variable is read from & written to main memory & not cached

See [en.wikipedia.org/wiki/Volatile_variable#In_Java](en.wikipedia.org/wiki/Volatile_variable#In_Java)
Overview of Java Atomic Operations & Variables

- Java supports several types of atomicity, e.g.
  
  - **Volatile variables**
    - Ensure a variable is read from & written to main memory & not cached
    - e.g., sharing a field between two threads

```
class PingPongTest {
    private volatile int val = 0;
    private int MAX = ...;

    public void playPingPong() {
        new Thread(() -> { // T2 Listener.
            for (int lv = val; lv < MAX; )
                if (lv != val) {
                    print("pong(" + val + ")");
                    lv = val;
                }
        }).start();

        new Thread(() -> { // T1 Changer.
            for (int lv = val; val < MAX; ) {
                val = ++lv;
                print("ping(" + lv + ")");
                ... Thread.sleep(500); ...
            }
        }).start();

        ...
    }
}
```
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        ...
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```

This program alternates printing "ping" & "pong" between threads \( T_1 \) & \( T_2 \)

See [dzone.com/articles/java-volatile-keyword-0](dzone.com/articles/java-volatile-keyword-0)
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*If volatile’s omitted from val’s definition the program won’t terminate since val’s not visible*

*By defining val as volatile reads & writes bypass local caches*
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These reads from `val` are atomic

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Overview of Java Atomic Operations & Variables

- Java supports several types of atomicity, e.g.
  - **Volatile variables**
  - **Low-level atomic operations in the Java Unsafe class**

Concurrency

And few words about concurrency with `Unsafe.compareAndSwap` methods are atomic and can be used to implement high-performance lock-free data structures.

For example, consider the problem to increment value in the shared object using lot of threads.

First we define simple interface `Counter`:

```
interface Counter {
    void increment();
    long getCount();
}
```

Then we define worker thread `CounterClient`, that uses `Counter`:

```
class CounterClient implements Runnable {
    private Counter c;
    private int num;

    public CounterClient(Counter c, int num) {
        this.c = c;
        this.num = num;
    }

    @Override
    public void run() {
        for (int i = 0; i < num; i++) {
            c.increment();
        }
    }
}
```

See upcoming lesson on "Java Atomic Operations & Classes"
Overview of Java Atomic Operations & Variables

- Java supports several types of atomicity, e.g.
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- It’s designed for use only by the Java Class Library, not by normal app programs

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    }

    @Override
    public void run() {
        for (int i = 0; i < num; i++) {
            c.increment();
        }
    }
}
```

See [www.baeldung.com/java-unsafe](http://www.baeldung.com/java-unsafe)
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- Java supports several types of atomicity, e.g.
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  - **Low-level atomic operations in the Java Unsafe class**
    - It’s designed for use only by the Java Class Library, not by normal app programs
    - Its “compare & swap” (CAS) methods are quite useful

```java
int compareAndSwapInt
   (Object o, long offset,
    int expected, int updated) {
START_ATOMIC();
   int *base = (int *) o;
   int oldValue = base[offset];
   if (oldValue == expected)
      base[offset] = updated;
END_ATOMIC();
   return oldValue;
}
```

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    }
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```

Atomically compare the contents of memory with a given value & modify contents to a new given value iff they are the same.

See upcoming lesson on “Implementing Java Atomic Operations”
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    - Its “compare & swap” (CAS) methods are quite useful
    - CAS methods can be used to implement efficient “lock free” algorithms

```java
void lock(Object o, long offset){
    while (compareAndSwapInt (o, offset, 0, 1) > 0);
}

void unlock(Object o, long offset){
    START_ATOMIC();
    int *base = (int *) o;
    base[offset] = 0;
    END_ATOMIC();
}
```

See [en.wikipedia.org/wiki/Non-blocking_algorithm](en.wikipedia.org/wiki/Non-blocking_algorithm)
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}

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    START_ATOMIC();
    int *base = (int *) o;
    base[offset] = 0;
    END_ATOMIC();
}
```

*Uses CAS to implement a simple “mutex” spin-lock*

See upcoming lesson on “Implementing Java Atomic Operations”
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  - *Volatile variables*
  - *Low-level atomic operations in the Java Unsafe class*
    - It’s designed for use only by the Java Class Library, not by normal app programs
    - Its “compare & swap” (CAS) methods are quite useful
    - CAS methods can be used to implement efficient “lock free” algorithms
  - Synchronizers in the Java Class Library use CAS methods extensively

See [www.youtube.com/watch?v=sq0MX3fHkro](http://www.youtube.com/watch?v=sq0MX3fHkro)
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- Java supports several types of atomicity, e.g.
  - **Volatile variables**
  - **Low-level atomic operations in the Java Unsafe class**
  - **Atomic classes**

### Package `java.util.concurrent.atomic`
A small toolkit of classes that support lock-free thread-safe programming on single variables.
See: Description

<table>
<thead>
<tr>
<th>Class Summary</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AtomicBoolean</td>
<td>A boolean value that may be updated atomically.</td>
</tr>
<tr>
<td>AtomicInteger</td>
<td>An int value that may be updated atomically.</td>
</tr>
<tr>
<td>AtomicIntegerArray</td>
<td>An int array in which elements may be updated atomically.</td>
</tr>
<tr>
<td>AtomicIntegerFieldUpdater&lt;T&gt;</td>
<td>A reflection-based utility that enables atomic updates to designated volatile int fields of designated classes.</td>
</tr>
<tr>
<td>AtomicLong</td>
<td>A long value that may be updated atomically.</td>
</tr>
<tr>
<td>AtomicLongArray</td>
<td>A long array in which elements may be updated atomically.</td>
</tr>
<tr>
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</tr>
<tr>
<td>AtomicMarkableReference&lt;V&gt;</td>
<td>An AtomicMarkableReference maintains an object reference along with a mark bit, that can be updated atomically.</td>
</tr>
<tr>
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<td>An object reference that may be updated atomically.</td>
</tr>
<tr>
<td>AtomicReferenceArray&lt;E&gt;</td>
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</tbody>
</table>

See upcoming lesson on “Java Atomic Operations & Classes”
Overview of Java Atomic Operations & Variables

- Java supports several types of atomicity, e.g.
  - **Volatile variables**
  - **Low-level atomic operations in the Java Unsafe class**
  - **Atomic classes**
    - Use Java Unsafe internally to implement “lock-free” methods

---

See [docs.oracle.com/javase/8/docs/api/java/util/concurrent/atomic/package-summary.html](docs.oracle.com/javase/8/docs/api/java/util/concurrent/atomic/package-summary.html)
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  - **Atomic classes**
    - Use Java Unsafe internally to implement "lock-free" methods
      - e.g., AtomicLong & AtomicBoolean

---

**Class AtomicBoolean**

```java
java.lang.Object
    java.util.concurrent.atomic.AtomicBoolean
```

All Implemented Interfaces:
- Serializable

```java
public class AtomicBoolean
extends Object
implements Serializable
```

A boolean value that may be updated atomically. See the

**Class AtomicLong**

```java
java.lang.Object
    java.lang.Number
        java.util.concurrent.atomic.AtomicLong
```

All Implemented Interfaces:
- Serializable

```java
public class AtomicLong
extends Number
implements Serializable
```

A long value that may be updated atomically. See the

---

See [docs.oracle.com/javase/8/docs/api/java/util/concurrent/atomic/AtomicBoolean.html](http://docs.oracle.com/javase/8/docs/api/java/util/concurrent/atomic/AtomicBoolean.html) & [docs.oracle.com/javase/8/docs/api/java/util/concurrent/atomic/AtomicLong.html](http://docs.oracle.com/javase/8/docs/api/java/util/concurrent/atomic/AtomicLong.html)
End of Overview of Java Atomic Operations & Variables