Java Monitor Objects: Usage Considerations

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Learning Objectives in this Lesson

- Appreciate Java built-in monitor object usage considerations
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- Appreciate Java built-in monitor object usage considerations
- In particular, know common traps & pitfalls of Java’s built-in monitor objects
Usage Considerations of Java Monitor Objects
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  - Monitor objects are limited, e.g.
    - No non-blocking, timed, or interruptible synchronizers

See lesson on “Java ReentrantLocks” for examples of these capabilities
Usage Considerations of Built-in Monitor Objects

- Programmers must be aware of issues with Java built-in monitor objects
  - Monitor objects are limited, e.g.
    - No non-blocking, timed, or interruptible synchronizers
    - Synchronized statements **only** support scoped locking

```java
synchronized(this) {
    ...
    // this lock is always released at the end of this block
}
```

Scoped locking is inefficient for certain concurrent algorithms, e.g., it may require redundant checks for internal state(s)
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    - No non-blocking, timed, or interruptible synchronizers
    - Synchronized statements only support scoped locking
    - No support for sensible timed waits...

See [stackoverflow.com/questions/3397722/how-to-differentiate-when-waitlong-timeout-exit-for-notify-or-timeout](https://stackoverflow.com/questions/3397722/how-to-differentiate-when-waitlong-timeout-exit-for-notify-or-timeout)
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    - No support for sensible timed waits...
  - Only one wait queue & one entrance queue

See [www.dre.vanderbilt.edu/~schmidt/C++2Java.html#concurrency](http://www.dre.vanderbilt.edu/~schmidt/C++2Java.html#concurrency)
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    - Only one wait queue & one entrance queue
    - May yield “nested monitor lockout”

```java
public class BuggyLock {
    Object mMonObj = new Object();
    boolean mLocked;

    synchronized void lock() {
        while (mLocked)
            synchronized (mMonObj)
                { mMonObj.wait(); }
        mLocked = true;
    }

    synchronized void unlock() {
        mLocked = false;
        synchronized (mMonObj)
            { mMonObj.notify(); }
    }
}
```

BuggyLock monitor lock is still held here, so unlock() never runs!

See tutorials.jenkov.com/java-concurrency/nested-monitor-lockout.html
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• Programmers must be aware of issues with Java built-in monitor objects
  • Monitor objects are limited, e.g.
    • No non-blocking, timed, or interruptible synchronizers
    • Synchronized statements only support scoped locking
    • No support for sensible timed waits…
    • Only one wait queue & one entrance queue
    • May yield “nested monitor lockout”
    • Doesn’t support “two lock queue” optimizations

```java
class LinkedBlockingQueue<E>
    extends AbstractQueue<E>
    implements BlockingQueue<E>, ...

/** Lock held by take, poll, etc */
private final ReentrantLock takeLock =
    new ReentrantLock();

/** Lock held by put, offer, etc */
private final ReentrantLock putLock =
    new ReentrantLock();
```

See kickjava.com/src/java/util/concurrent/LinkedBlockingQueue.java.htm
Usage Considerations of Built-in Monitor Objects

- Programmers must be aware of issues with Java built-in monitor objects
  - Monitor objects are limited
  - Choosing between notify() & notifyAll() is tricky

See [stackoverflow.com/questions/37026/java-notify-vs-notifyall-all-over-again](https://stackoverflow.com/questions/37026/java-notify-vs-notifyall-all-over-again)
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*Conditions under which `notify()` can be used*
Usage Considerations of Built-in Monitor Objects

• Programmers must be aware of issues with Java built-in monitor objects
  • Monitor objects are limited
  • Choosing between `notify()` & `notifyAll()` is tricky
  • Use `notify()` when possible since it’s more efficient & avoids the “Thundering Herd” problem..

See [en.wikipedia.org/wiki/Thundering_herd_problem](en.wikipedia.org/wiki/Thundering_herd_problem)
Usage Considerations of Built-in Monitor Objects

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  • Monitor objects are limited
  • Choosing between notify() & notifyAll() is tricky
    • Use notify() when possible since it’s imore efficient & avoids the “Thundering Herd” problem.
    • However, notifyAll() is often needed since there’s just one wait queue.

A monitor object may need to wait for different condition expression
Usage Considerations of Built-in Monitor Objects

• Programmers must be aware of issues with Java built-in monitor objects
  • Monitor objects are limited
  • Choosing between notify() & notifyAll() is tricky
  • Fairness issues arise due to the order in which waiting threads are notified
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    - Monitor object's implement “haphazard notification” to optimize performance
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    - Monitor object’s implement “haphazard notification” to optimize performance
  - The **Specific Notification** pattern can be applied to control ordering

See [www.dre.vanderbilt.edu/~schmidt/PDF/specific-notification.pdf](http://www.dre.vanderbilt.edu/~schmidt/PDF/specific-notification.pdf)
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- Fairness issues arise due to the order in which waiting threads are notified
  - Monitor object's implement "haphazard notification" to optimize performance
- The *Specific Notification* pattern can be applied to control ordering
  - i.e., programmatically choose a particular thread to run from a set of waiting threads
Usage Considerations of Built-in Monitor Objects

In practice, you often need more than Java’s built-in monitor mechanisms

- `java.util.concurrent` & `java.util.concurrent.locks`

Utility classes commonly useful in concurrent programming. This package includes a few small standardized extensible frameworks, as well as some classes that provide useful functionality and are otherwise tedious or difficult to implement. Here are brief descriptions of the main components. See also the `java.util.concurrent.locks` and `java.util.concurrent.atomic` packages.

Usage Considerations of Built-in Monitor Objects

- In practice, you often need more than Java’s built-in monitor mechanisms
  - `java.util.concurrent & java.util.concurrent.locks`
  - e.g., `ReentrantLock & ConditionObject`

```java
public class ArrayBlockingQueue<E>
  extends AbstractQueue<E>
  implements BlockingQueue<E>,
  java.io.Serializable {

  final ReentrantLock lock;

  private final Condition notEmpty;

  private final Condition notFull;

  ...  
```

*Used to protect the object state from race conditions*
Usage Considerations of Built-in Monitor Objects

- In practice, you often need more than Java’s built-in monitor mechanisms
  - java.util.concurrent & java.util.concurrent.locks
- Android concurrency frameworks

See developer.android.com/guide/components/processes-and-threads.html#Threads
In practice, you often need more than Java’s built-in monitor mechanisms:

- `java.util.concurrent` and `java.util.concurrent.locks`
- Android concurrency frameworks

Message passing may avoid need for monitor objects & synchronization altogether.
End of Java Monitor Objects: Usage Considerations