The Java Monitor Object
Synchronized Method Example

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Learning Objectives in this Part of the Lesson

- Recognize the synchronized methods/statements provided by Java build-in monitor objects to support *mutual exclusion*
- Understand how to fix race conditions in the buggy concurrent Java app by using synchronized methods

The use of synchronized methods only provides a partial solution, however...
Partial Solution Using Java Synchronized Methods
Partial Solution Using Java Synchronized Methods

See en.wikipedia.org/wiki/Crazy_Horse_Memorial
Partial Solution Using Java Synchronized Methods

- A concurrent producer/consumer app that passes messages via the class “BusySynchronizedQueue”

See github.com/douglascraigschmidt/POSA/tree/master/ex/M3/Queues/BusySynchronizedQueue
Partial Solution Using Java Synchronized Methods

- The BusySynchronizedQueue is modeled on the Java ArrayBlockingQueue

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/ArrayBlockingQueue.html
Partial Solution Using Java Synchronized Methods

- UML class diagram showing the design of the BusySynchronizedQueue

See [gM3/Queues/BusySynchronizedQueue/app/src/main/java/edu/vandy/busysynchronizedqueue/model](gM3/Queues/BusySynchronizedQueue/app/src/main/java/edu/vandy/busysynchronizedqueue/model)
Partial Solution Using Java Synchronized Methods

- UML sequence diagram of the BusySynchronizedQueue unit test

![UML sequence diagram]

Partial Solution Using Java Synchronized Methods

- UML sequence diagram of the BusySynchronizedQueue unit test

The main thread coordinates the other threads in the test
Partial Solution Using Java Synchronized Methods

- UML sequence diagram of the BusySynchronizedQueue unit test

The consumer & producer threads generate & process messages sent via the BusySynchronizedQueue, respectively.
Partial Solution Using Java Synchronized Methods

- UML sequence diagram of the BusySynchronizedQueue unit test

Although the test runs correctly (since offer() & poll() are synchronized) it is inefficient due to the “busy waiting”!!
Implementation of the BusySynchronizedQueue
Implementation of the BusySynchronizedQueue

- Java synchronized methods protect critical sections from concurrent access

```java
public class BusySynchronizedQueue<E> implements SimpleBlockingQueue<E> {
    private List<E> mList;
    private int mCapacity;

    public BusySynchronizedQueue(int capacity) {
        mCapacity = capacity; mList = new LinkedList<>();
    }

    public synchronized boolean offer(E e) {
        if (!isFull()) { mList.add(e); return true; }
        return false;
    }

    public synchronized E poll() { return mList.poll(); }
    ...
```

See [github.com/douglascraigschmidt/POSA/tree/master/ex/M3/Queues/BusySynchronizedQueue](https://github.com/douglascraigschmidt/POSA/tree/master/ex/M3/Queues/BusySynchronizedQueue)
Implementation of the BusySynchronizedQueue

• Java synchronized methods protects critical sections from concurrent access.

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        else
            return false;
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    ...
```

A constructor is only called once in one thread so there won’t be race conditions.
Implementation of the BusySynchronizedQueue

- Java synchronized methods protects critical sections from concurrent access

```java
class BusySynchronizedQueue<E> {
    private List<E> mList;
    private int mCapacity;

    public BusySynchronizedQueue(int capacity) {
        mCapacity = capacity; mList = new LinkedList<>;
    }

    public synchronized boolean offer(E e) {
        if (!isFull()) mLList.add(e); return true;
        else
            return false;
    }

    public synchronized E poll() { return mLList.poll(); }
    ...
```

Only one synchronized method at a time can be active in any given object

CAUTION
STOP
GATE WILL ALLOW ONLY ONE VEHICLE AT A TIME
DO NOT TAILGATE

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Implementation of the BusySynchronizedQueue

- Java synchronized methods protects critical sections from concurrent access

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        return false;
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    ...
}
```

May be a liability for concurrently accessed objects, e.g., a double-ended queue implemented as a linked list

See [cs.nyu.edu/courses/fall07/G22.2631-001/lists.slides2.pdf](cs.nyu.edu/courses/fall07/G22.2631-001/lists.slides2.pdf)
Implementation of the BusySynchronizedQueue

• Adding the synchronized keyword has two effects

```java
class BusySynchronizedQueue<E>
    implements SimpleBlockingQueue<E> {
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```

See [docs.oracle.com/javase/tutorial/essential/concurrency/syncmeth.html](http://docs.oracle.com/javase/tutorial/essential/concurrency/syncmeth.html)
Implementation of the BusySynchronizedQueue

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```

**Invocations of offer() & poll() on the same object can’t interleave**

i.e., each synchronized method is “atomic”
Implementation of the BusySynchronizedQueue

• Adding the synchronized keyword has two effects

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    public synchronized boolean offer(E e) {  
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        else  
            return false;  
    }  

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...
```

Establishes a "happens-before" relation to ensure visibility of state changes to all threads

See en.wikipedia.org/wiki/Happened-before
End of the Java Monitor
Object Synchronized Method Example