Java Monitor Object
Synchronized Methods

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Learning Objectives in this Part of the Lesson

- Recognize how the synchronized methods/statements provided by Java built-in monitor objects support *mutual exclusion*

```
Producer
```

```
Consumer
```

```
Monitor Object

synchronized m1()
synchronized m2()
```

```
Wait Queue

<<contains>> 1

Entrance Queue

<<contains>> 1
```

Mutual exclusion is used to protect shared state from corruption due to concurrent access by multiple threads

See [en.wikipedia.org/wiki/Mutual_exclusion](en.wikipedia.org/wiki/Mutual_exclusion)
Java Synchronized Methods
The BusySynchronizedQueue class showcases Java built-in synchronization mechanisms.

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

    BusySynchronizedQueue(int capacity) {
        mList = new LinkedList<E>();
        mCapacity = capacity;
    }
    ...
```

See [github.com/douglascraigschmidt/POSA/tree/master/ex/M3/Queues/BusySynchronizedQueue](https://github.com/douglascraigschmidt/POSA/tree/master/ex/M3/Queues/BusySynchronizedQueue)
Java Synchronized Methods

- The BusySynchronizedQueue class showcases Java built-in synchronization mechanisms.

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

    BusySynchronizedQueue(int capacity) {
        mList = new LinkedList<E>();
        mCapacity = capacity;
    }
    ...
}
```

This interface is a variant of what’s available in Java’s BlockingQueue interface.
The BusySynchronizedQueue class showcases Java built-in synchronization mechanisms.

The state in this class must be protected against race conditions.

Java Synchronized Methods

• The BusySynchronizedQueue class showcases Java built-in synchronization mechanisms

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

        BusySynchronizedQueue(int capacity) {
            mList = new LinkedList<E> ();
            mCapacity = capacity;
        }
        ...
    }
}
```

The constructor initializes the state

A constructor is called once by a single thread, so synchronization isn’t needed
Java Synchronized Methods

• Methods in a built-in monitor object can be marked with the synchronized keyword

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

    public synchronized boolean offer(E e)
    {
        ...
    }

    public synchronized E poll()
    {
        ...
    }

    public synchronized boolean isFull()
    {
        ...
    }

    ...
```

See [docs.oracle.com/javase/tutorial/essential/concurrency/syncmeth.html](docs.oracle.com/javase/tutorial/essential/concurrency/syncmeth.html)
Java Synchronized Methods

- Methods in a built-in monitor object can be marked with the synchronized keyword.
- A synchronized method is serialized wrt other synchronized methods in an object.

```java
class BusySynchronizedQueue<E> implements SimpleBlockingQueue<E> {
    ...
    public synchronized boolean offer(E e) {
        ...
    }
    public synchronized E poll() {
        ...
    }
    public synchronized boolean isFull() {
        ...
    }
    ...
```
Methods in a built-in monitor object can be marked with the `synchronized` keyword.

A synchronized method is serialized wrt other synchronized methods in an object.

```java
class BusySynchronizedQueue<E> implements SimpleBlockingQueue<E> {
    public synchronized boolean offer(E e) {
        ... }

    public synchronized E poll() {
        ... }

    public synchronized boolean isFull() {
        ... }

    ...}
```

See earlier lesson on “Java ReentrantLock”
Java Synchronized Methods

- Methods in a built-in monitor object can be marked with the synchronized keyword
- A synchronized method is serialized wrt other synchronized methods in an object
- When used in the method declaration, the entire body of the method is serialized

```java
class BusySynchronizedQueue<E> implements SimpleBlockingQueue<E> {
    ...
    public synchronized boolean offer(E e) {
        if (!isFull()) {
            mList.add(e);
            return true;
        } else
            return false;
    }

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

    public synchronized boolean isFull() {
        return mList.size() == mCapacity;
    }

    ...
```
Java Synchronized Methods

- The synchronized keyword is not considered to be part of a method's signature.

```java
class BusySynchronizedQueue<E>
    implements SimpleBlockingQueue<E>
{
    ... 
    public synchronized boolean offer(E e)
    {
        ... 
    }

    public synchronized E poll()
    {
        ... 
    }

    public synchronized boolean isFull()
    {
        ... 
    }

    ...
}
```

Synchronization is considered an "implementation detail"

See [gee.cs.oswego.edu/dl/cpj/mechanics.html#synchronization](gee.cs.oswego.edu/dl/cpj/mechanics.html#synchronization)
Java Synchronized Methods

- The synchronized keyword is not considered to be part of a method's signature.
- synchronized is not inherited when subclasses override superclass methods.

```java
class SynchronizedQueue<E> extends BusySynchronizedQueue<E> {
    public boolean offer(E e) {
        ... }

    public E poll() {
        ... }

    public boolean isFull() {
        ... }

    ... \n
    These methods will not be synchronized unless the implementation decides to synchronize them explicitly.
• Pros of synchronized methods
Java Synchronized Methods

- **Pros of synchronized methods**
  - Synchronized methods can be identified by examining the method interfaces

```java
class BusySynchronizedQueue<E>
    implements SimpleBlockingQueue<E>
{
    ...
    public synchronized boolean offer(E e)
    {
        ...
    }

    public synchronized E poll()
    {
        ...
    }

    public synchronized boolean isFull()
    {
        ...
    }
    ...
```

Java Synchronized Methods

• Pros of synchronized methods
  • Synchronized methods can be identified by examining the method interfaces
  • The “method” is the unit of synchronization

```java
class BusySynchronizedQueue<E>
    implements SimpleBlockingQueue<E>
{
    ...
    public synchronized boolean offer(E e)
    {
        ...
    }
    public synchronized E poll()
    {
        ...
    }
    public synchronized boolean isFull()
    {
        ...
    }
    ...
```

It’s easier to reason about method-oriented synchronization

See www.dre.vanderbilt.edu/~schmidt/PDF/monitor.pdf
Java Synchronized Methods

• Pros of synchronized methods
  • Synchronized methods can be identified by examining the method interfaces
  • The “method” is the unit of synchronization
  • The syntax is compact

The code is more legible since there are no explicit synchronization statements

```java
class BusySynchronizedQueue<E> implements SimpleBlockingQueue<E> {
    ... 
    public synchronized boolean offer(E e) {
        if (!isFull()) {
            mList.add(e); 
            return true;
        } else 
            return false;
    }
    public synchronized E poll() {
        return mList.poll();
    }
    public synchronized boolean isFull() {
        return mList.size() == mCapacity;
    }
    ...
```
Java Synchronized Methods

- Pros of synchronized methods
  - Synchronized methods can be identified by examining the method interfaces
  - The “method” is the unit of synchronization
  - The syntax is compact
  - Support reentrant mutex semantics

```java
class BusySynchronizedQueue<E>
    implements SimpleBlockingQueue<E>
{
    ...
    public synchronized boolean offer(E e)
    {
        if (!isFull()) {
            mList.add(e);
            return true;
        } else
            return false;
    }

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

    public synchronized boolean isFull()
    {
        return mList.size() == mCapacity;
    }
    ...
```

See [en.wikipedia.org/wiki/Reentrant_mutex](en.wikipedia.org/wiki/Reentrant_mutex)

*isFull() reacquires the intrinsic lock when called from offer()*
Java Synchronized Methods

- Cons of synchronized methods

See stackoverflow.com/questions/574240/is-there-an-advantage-to-use-a-synchronized-method-instead-of-a-synchronized-blo/574525#574525
Java Synchronized Methods

- **Cons of synchronized methods**
  - Synchronizes on the “intrinsic lock” (this), so it is possible for other objects to synchronize with it too

```java
BusySynchronizedQueue<Long> q = new BusySynchronizedQueue<>();

// Thread T1
while (q.isEmpty())
    ...

// Thread T2
synchronized (q) {
    ...
}
```

*T2 will keep Thread T1 from accessing q’s critical section*
Java Synchronized Methods

- Cons of synchronized methods
  - Synchronizes on the “intrinsic lock” (this), so it is possible for other objects to synchronize with it too
  - The granularity of synchronization is “coarse-grained”
End of Java Monitor Object Synchronized Methods