

Java Monitor Objects: Synchronized Methods



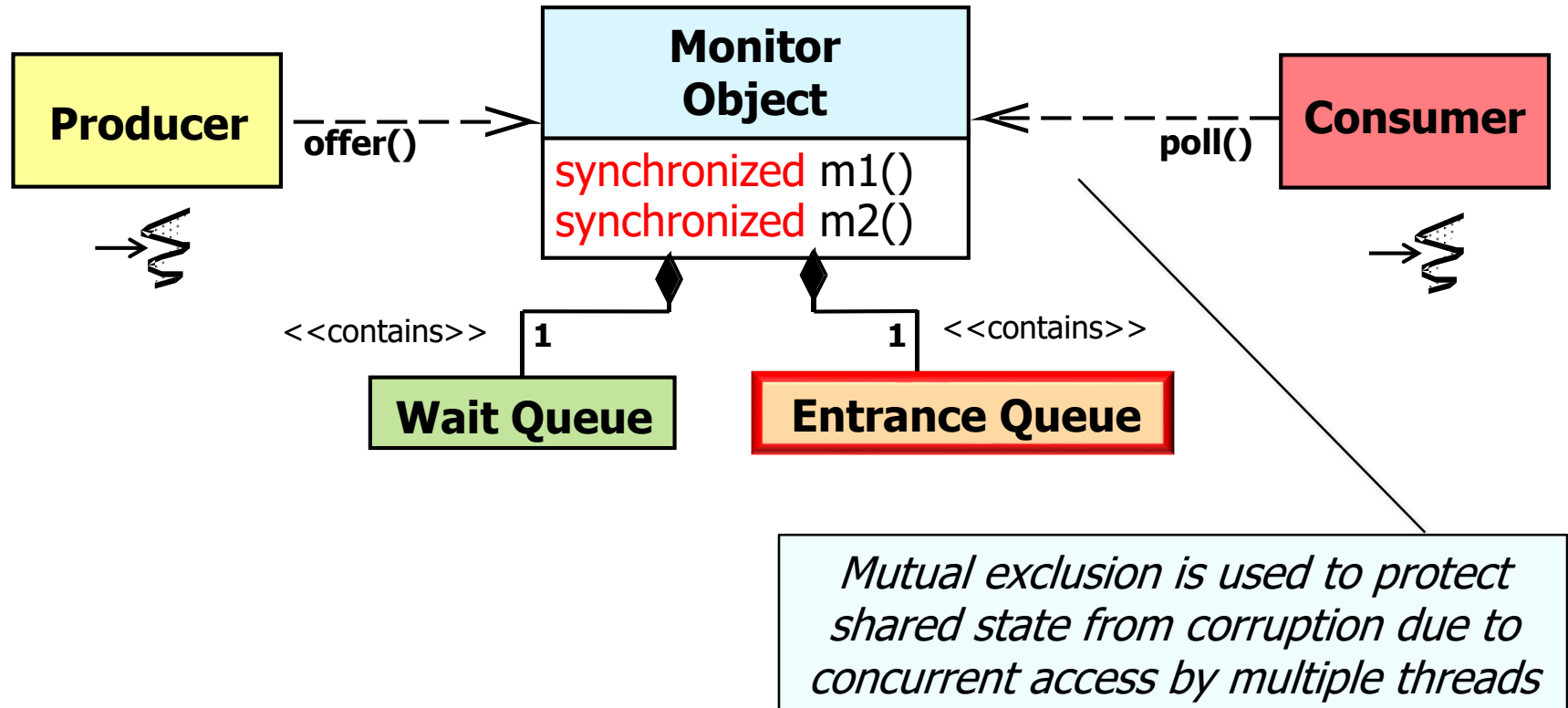
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Learning Objectives in this Part of the Lesson

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



See en.wikipedia.org/wiki/Mutual_exclusion

Java Synchronized Methods

Java Synchronized Methods

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

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

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

<<Java Class>>	
G BusySynchronizedQueue <E>	
▣	mList: LinkedList<E>
▣ ^F	mCapacity: int
● ^c	BusySynchronizedQueue()
● ^c	BusySynchronizedQueue(int)
●	poll()
●	offer(E):boolean
●	isEmpty():boolean
●	isFull():boolean
●	size():int

See github.com/douglasraigschmidt/POSA/tree/master/ex/M3/Queues/BusySynchronizedQueue

Java Synchronized Methods

- The BusySynchronizedQueue class showcases Java built-in synchronization mechanisms

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

<<Java Interface>>	
I BoundedQueue<E>	
●	put(E):void
●	take()
●	poll()
●	offer(E):boolean
●	isEmpty():boolean
●	isFull():boolean
●	size():int

Java Synchronized Methods

- The BusySynchronizedQueue class showcases Java built-in synchronization mechanisms

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

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

The state in this class must be protected against race conditions

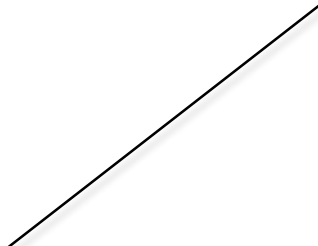
See en.wikipedia.org/wiki/Race_condition

Java Synchronized Methods

- The BusySynchronizedQueue class showcases Java built-in synchronization mechanisms

```
class BusySynchronizedQueue<E>
    implements BoundedQueue<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

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

    public synchronized E poll()
    { ... }

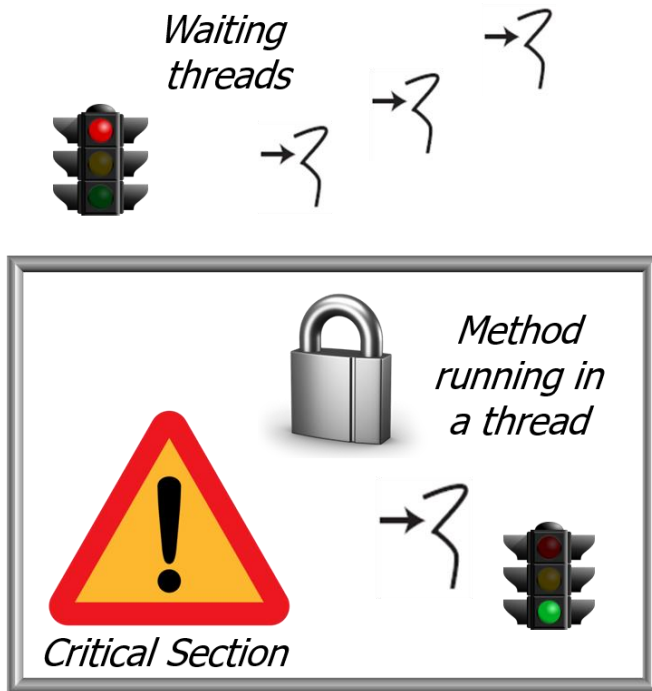
    public synchronized boolean isEmpty()
    { ... }

    ...
}
```

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

```
class BusySynchronizedQueue<E>  
    implements BoundedQueue<E> {  
    ...  
    public synchronized boolean  
        offer(E e)  
    { ... }  
  
    public synchronized E poll()  
    { ... }  
  
    public synchronized boolean isEmpty()  
    { ... }  
  
    ...  
}
```



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



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

    public synchronized E poll()
    { ... }

    public synchronized boolean isEmpty()
    { ... }

    ...
}
```

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

```
class BusySynchronizedQueue<E>
    implements BoundedQueue<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 isEmpty()
    { return mList.size() == 0; }

    ...
}
```

Java Synchronized Methods

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

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

    public synchronized E poll()
    { ... }

    public synchronized boolean isEmpty()
    { ... }

    ...
}
```

*Synchronization is considered
an "implementation detail"*

See 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

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

    public E poll()
    { ... }

    public boolean isEmpty()
    { ... }

    ...
}
```

These methods will not be synchronized unless the implementation decides to synchronize them explicitly

Java Synchronized Methods

- **Pros 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

- **Pros of synchronized methods**

- Synchronized methods can be identified by examining the method interfaces

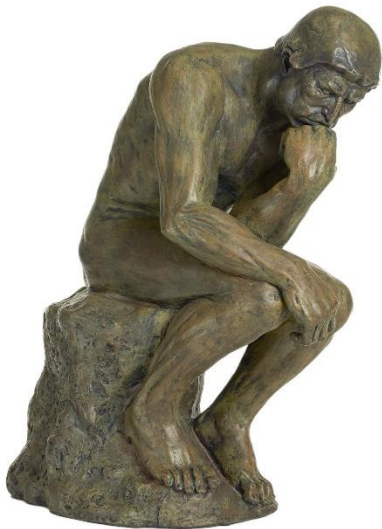
```
class BusySynchronizedQueue<E>  
    implements BoundedQueue<E> {  
  
    ...  
    public synchronized boolean  
        offer(E e)  
  
        { ... }  
  
    public synchronized E poll()  
        { ... }  
  
    public synchronized boolean  
        isEmpty()  
  
        { ... }  
  
    ...  
}
```

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

Java Synchronized Methods

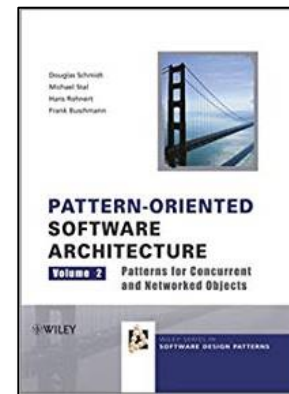
- **Pros of synchronized methods**

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



*It's easier to reason about
method-oriented synchronization*

```
class BusySynchronizedQueue<E>  
    implements BoundedQueue<E> {  
  
    ...  
    public synchronized boolean  
        offer(E e)  
  
    { ... }  
  
    public synchronized E poll()  
    { ... }  
  
    public synchronized boolean  
        isEmpty()  
  
    { ... }  
  
    ...  
}
```



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*

```
class BusySynchronizedQueue<E>  
    implements BoundedQueue<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  
        isEmpty()  
    { return mList.size() == 0; }  
  
    ...  
}
```

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



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

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

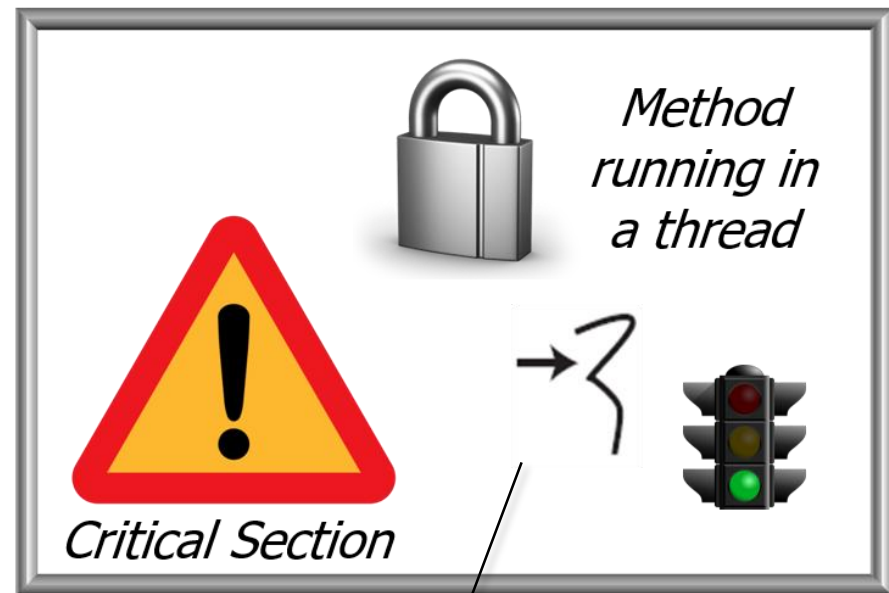
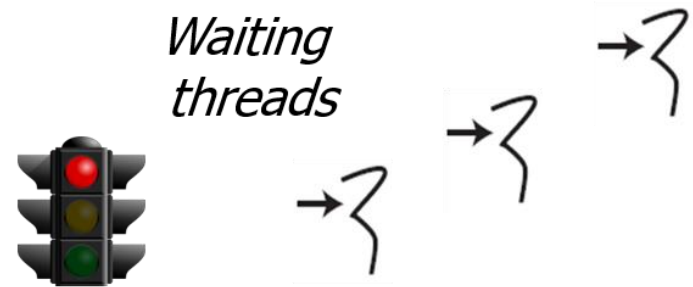
```
// Thread T2  
synchronized(q) {  
    ...  
}
```

*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”



Synchronization is a per-object & per-method basis

End of Java Monitor Objects: Synchronized Methods