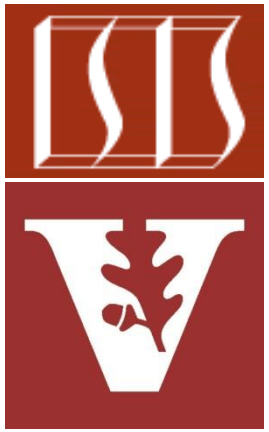
Java Monitor Object Usage Considerations



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Learning Objectives in this Lesson

- Appreciate Java monitor object usage considerations

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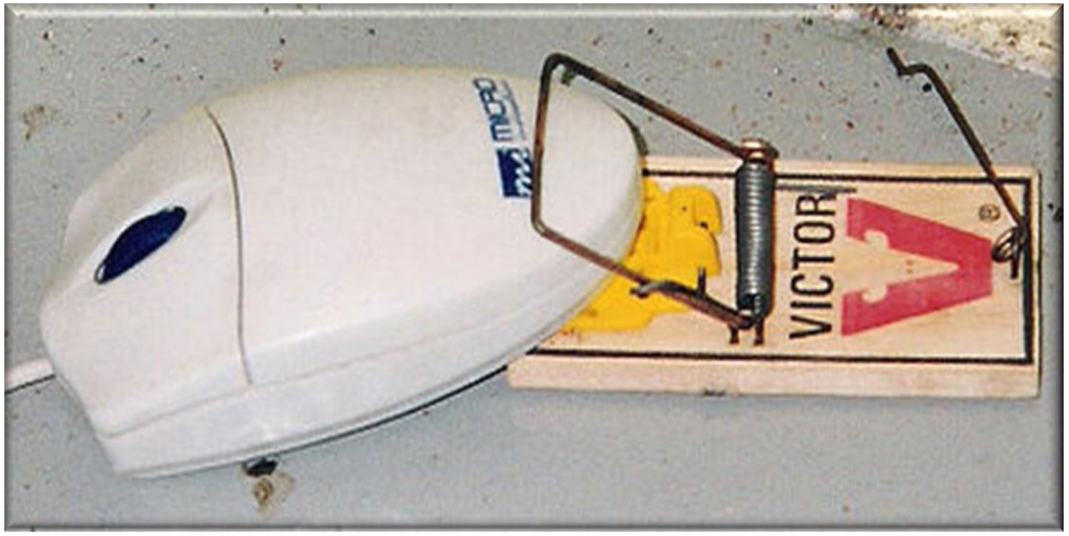
- Appreciate Java monitor object usage considerations
  - In particular, know common traps & pitfalls of Java's built-in monitor objects



Usage Considerations of Java Monitor Objects

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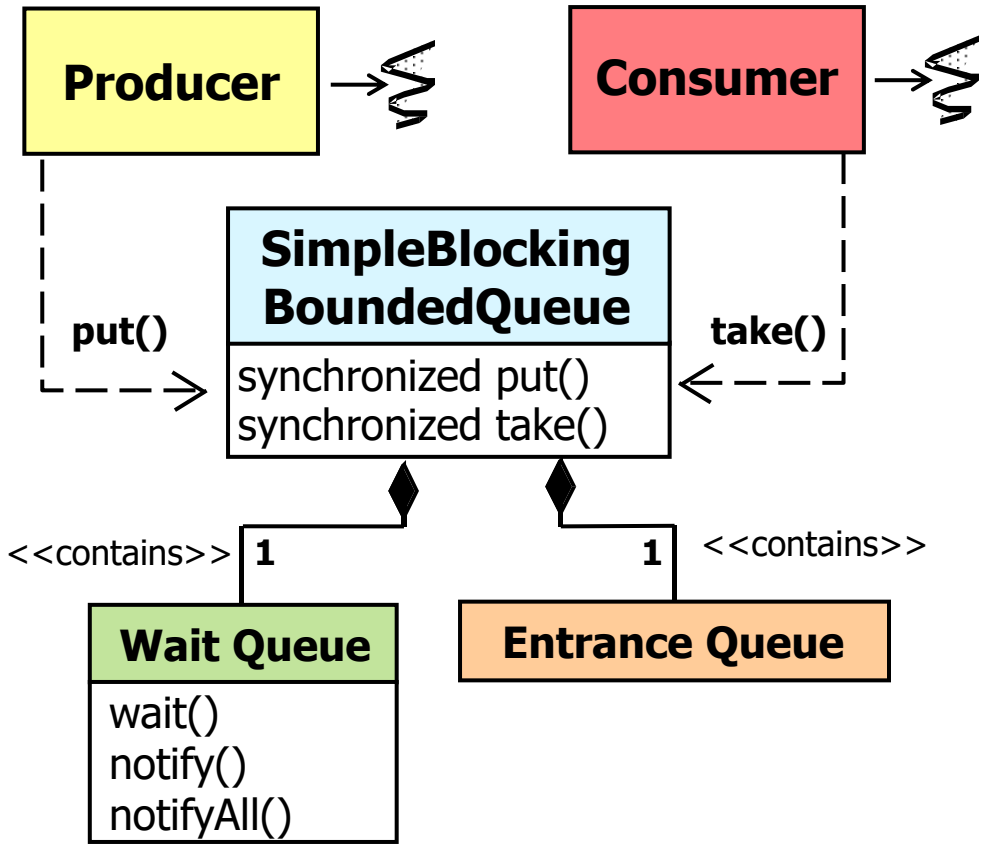
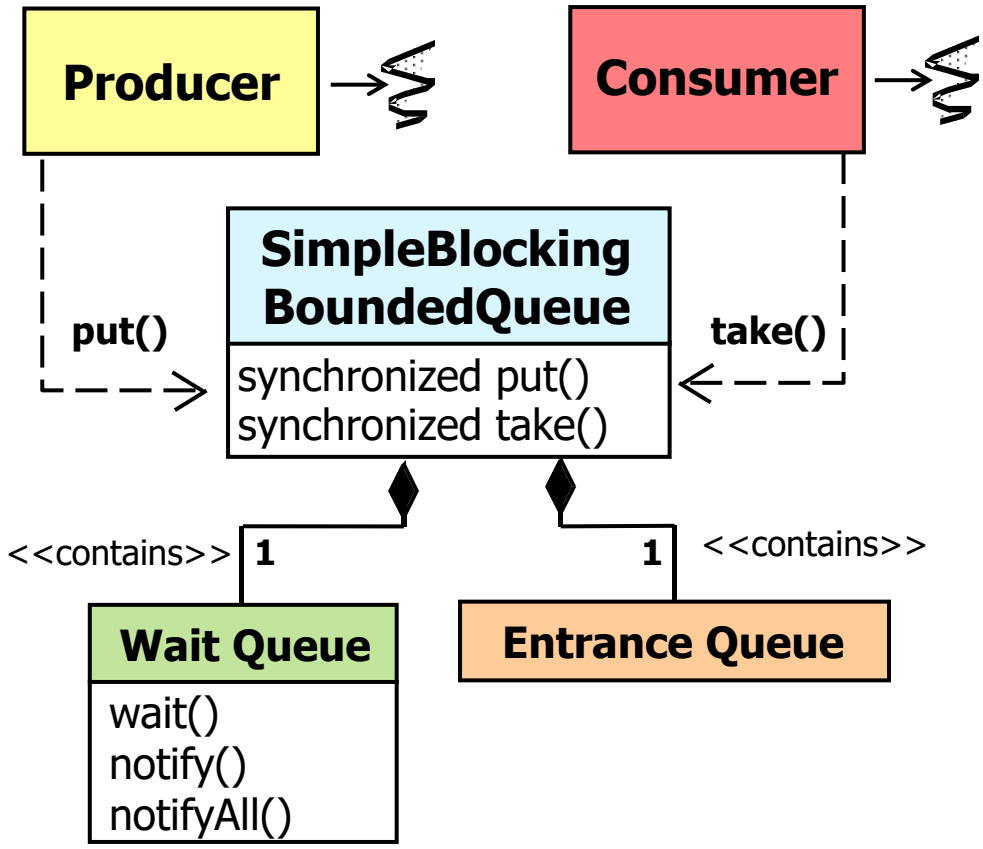
- Programmers must be aware of issues with Java monitor objects



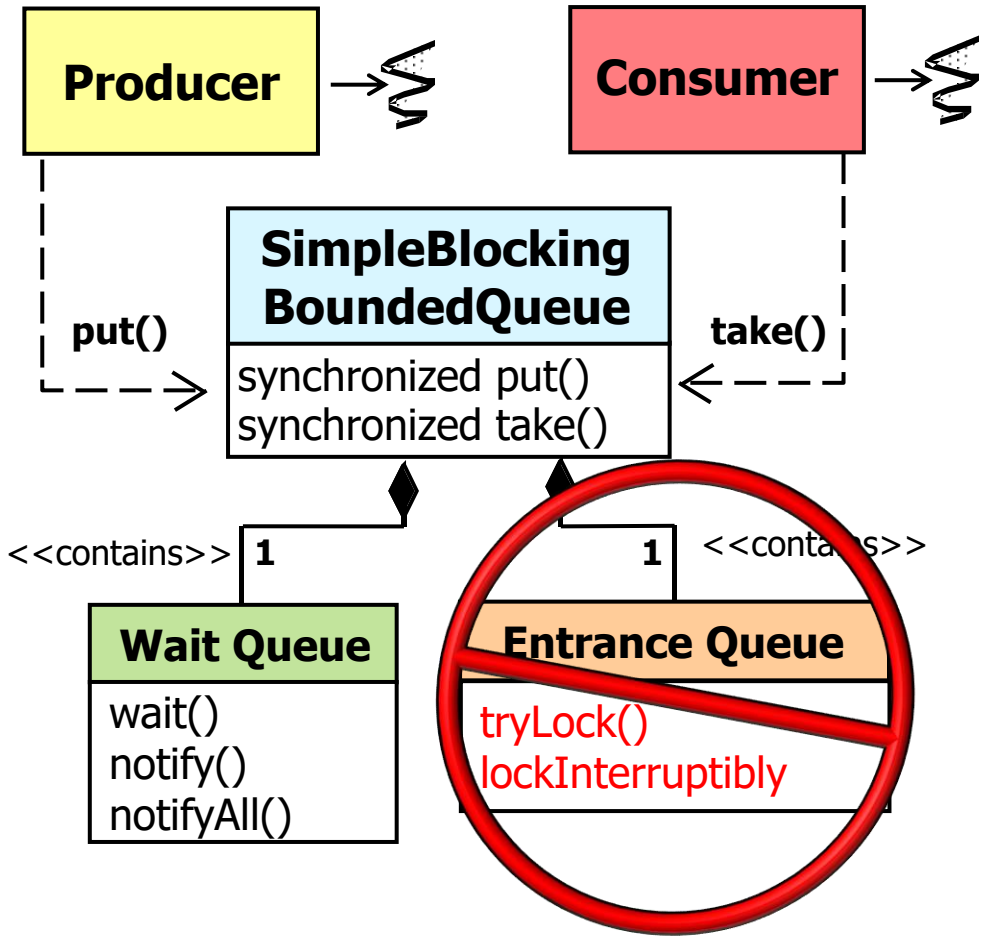
Usage Considerations of Java Monitor Objects

- Programmers must be aware of issues with Java monitor objects
  - Monitor objects are limited



Usage Considerations of Java Monitor Objects

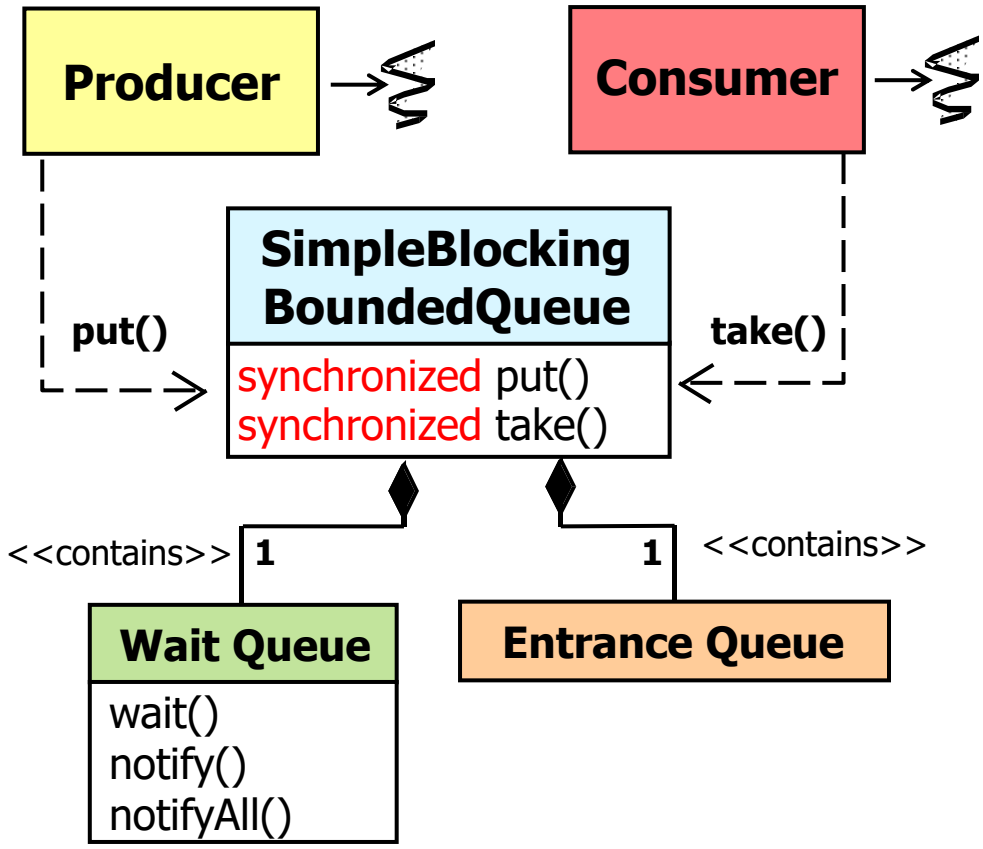
- Programmers must be aware of issues with Java monitor objects
  - Monitor objects are limited, e.g.
    - No non-blocking, timed, or interruptible synchronizers



See lessons on "*Java ReentrantLocks*" for examples of these capabilities

Usage Considerations of Java Monitor Objects

- Programmers must be aware of issues with Java monitor objects
  - Monitor objects are limited, e.g.
    - No non-blocking, timed, or interruptible synchronizers
    - Only one wait queue & one entrance queue



See www.dre.vanderbilt.edu/~schmidt/C++2Java.html#concurrency

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- Programmers must be aware of issues with Java monitor objects
  - Monitor objects are limited, e.g.
    - No non-blocking, timed, or interruptible synchronizers
    - Only one wait queue & one entrance queue
      - May yield "nested monitor lockout"

```
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(); }
  } ...
```

lock() is a synchronized method

See tutorials.jenkov.com/java-concurrency/nested-monitor-lockout.html

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    { mMonObj.notify(); }
  } ...
```

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

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- Programmers must be aware of issues with Java monitor objects
  - Monitor objects are limited, e.g.
    - No non-blocking, timed, or interruptible synchronizers
    - Only one wait queue & one entrance queue
      - May yield "nested monitor lockout"
    - Doesn't support "two lock queue" optimizations

```
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 src/share/classes/java/util/concurrent/LinkedBlockingQueue.java

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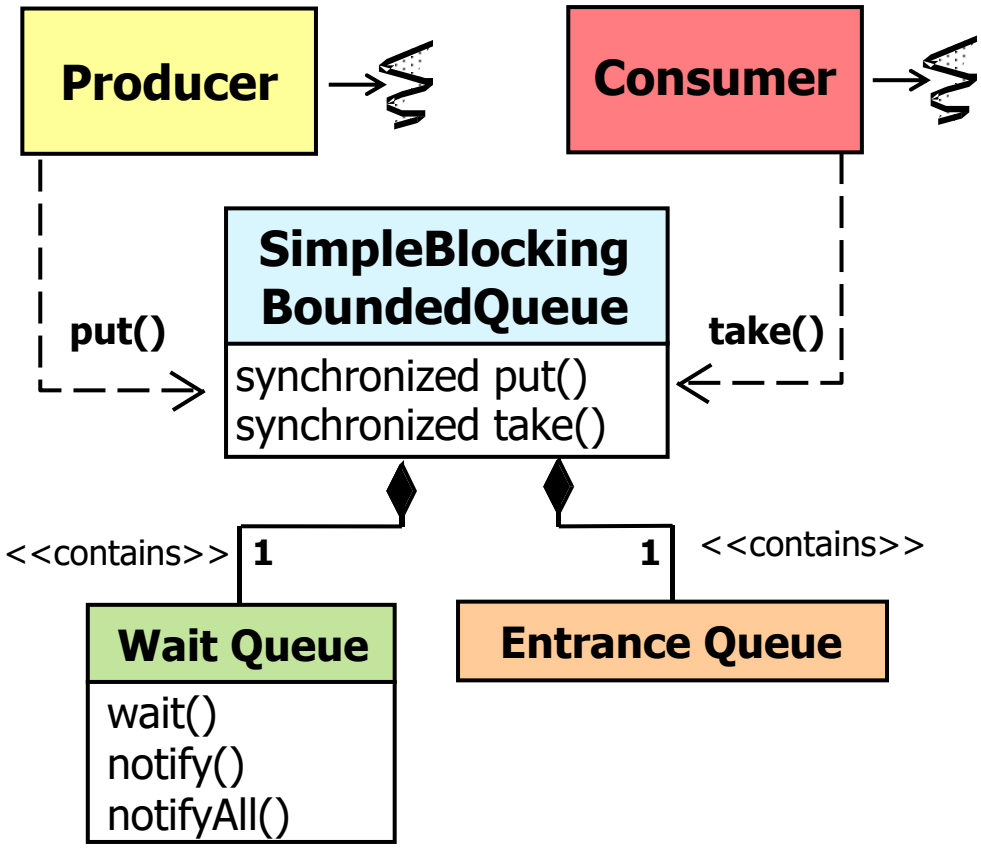
- Programmers must be aware of issues with Java monitor objects
  - Monitor objects are limited, e.g.
    - No non-blocking, timed, or interruptible synchronizers
    - Only one wait queue & one entrance queue
    - Synchronized statements *only* support scoped locking

```
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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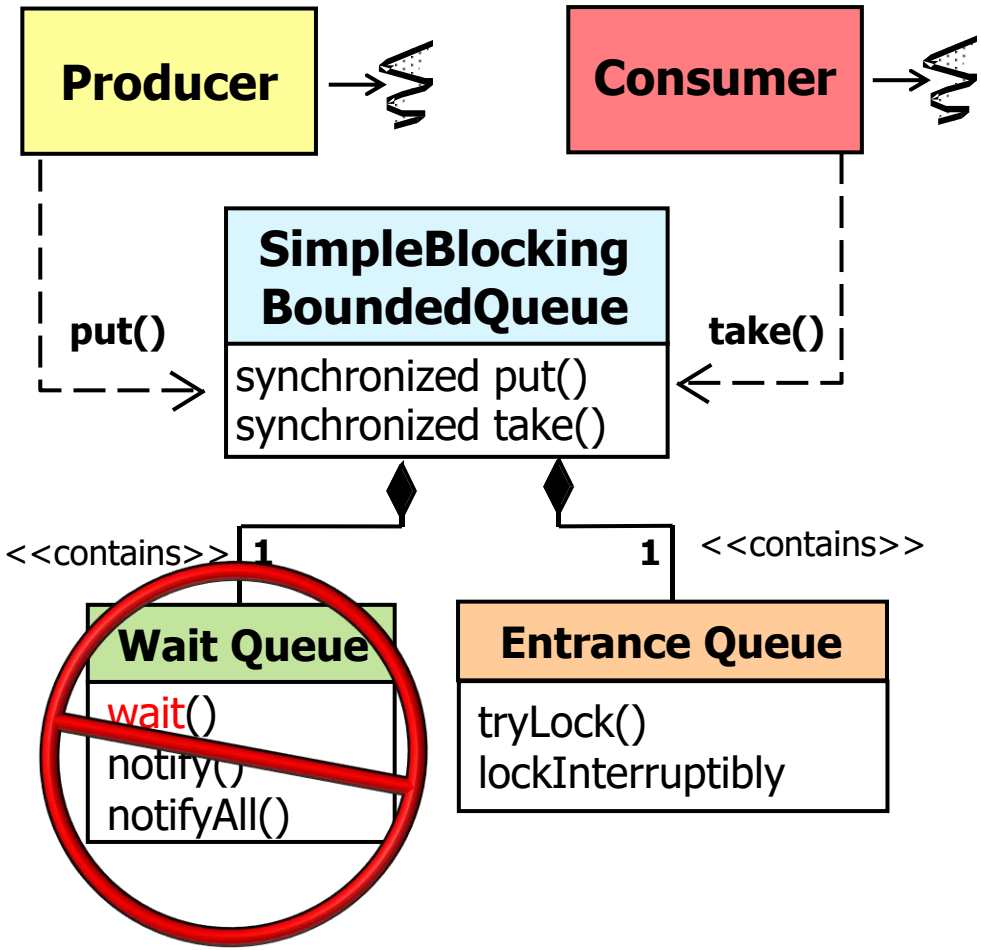
  - Monitor objects are limited, e.g.
    - No non-blocking, timed, or interruptible synchronizers
    - Only one wait queue & one entrance queue
    - Synchronized statements *only* support scoped locking
  - No support for sensible timed waits…



See stackoverflow.com/questions/3397722/how-to-differentiate-when-waitlong-timeout-exit-for-notify-or-timeout

Usage Considerations of Java Monitor Objects

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

See stackoverflow.com/questions/37026/java-notify-vs-notifyall-all-over-again

Usage Considerations of Java Monitor Objects

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Uniform waiters	Only one condition expression that wait() is waiting for is associated with the monitor object & each thread executes the same logic when returning from wait()
One-in & one-out	A notify() on the monitor object enables at most one thread to proceed

Conditions under which notify() can be used

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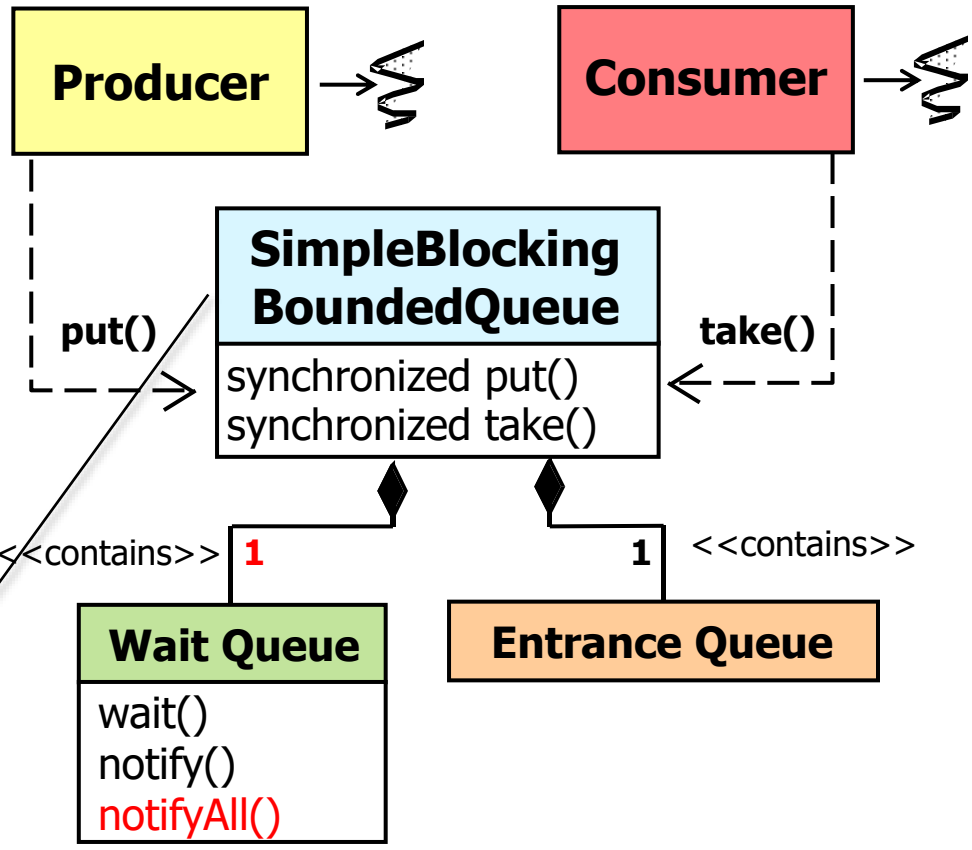
Usage Considerations of Java Monitor Objects

- Programmers must be aware of issues with Java 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

Usage Considerations of Java Monitor Objects

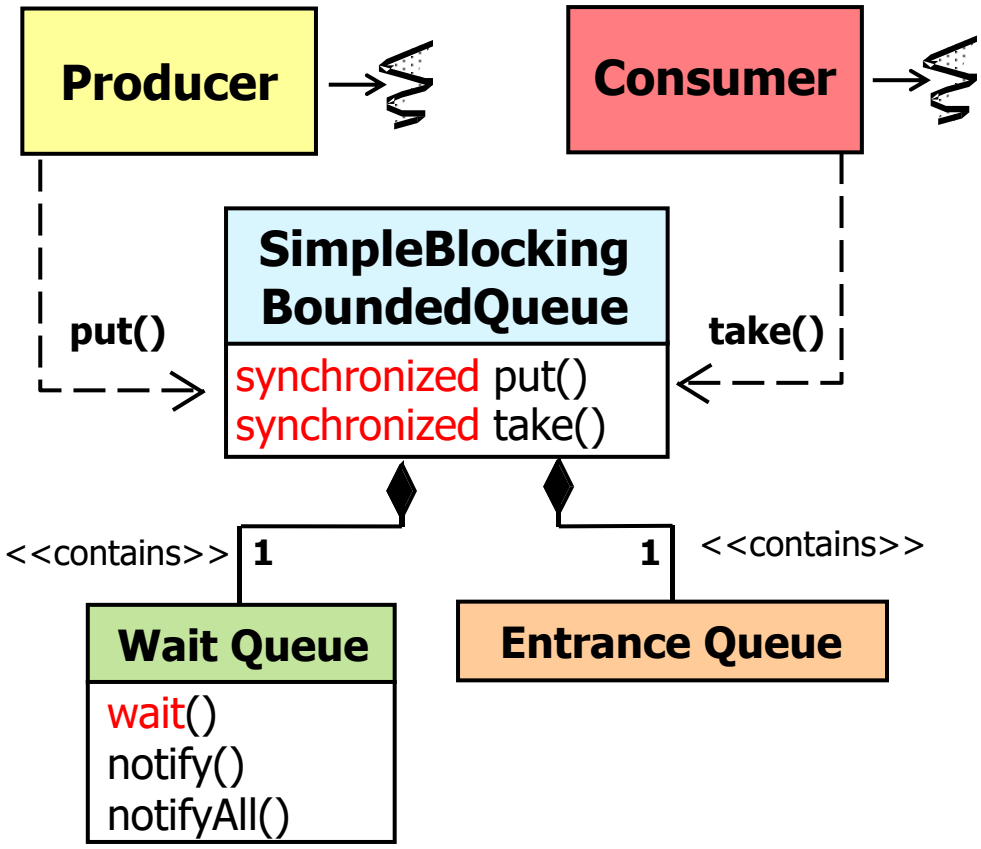
- Programmers must be aware of issues with Java monitor objects
  - Monitor objects are limited
  - Choosing between notify() & notifyAll() is tricky
    - Use notify() when possible since it's more efficient & avoids the "Thundering Herd" problem..
    - However, notifyAll() is often needed since there's just one wait queue..



A monitor object may need to wait for different condition expression

Usage Considerations of Java Monitor Objects

- Programmers must be aware of issues with Java 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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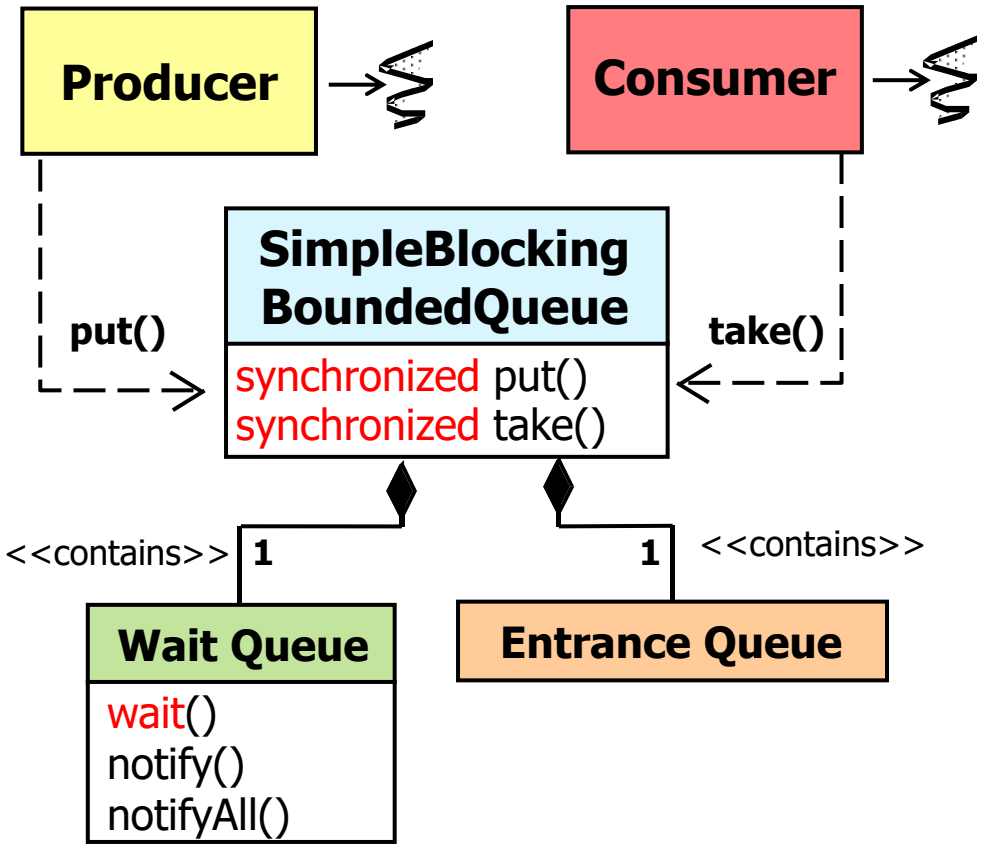
    - Monitor object's implement "haphazard notification" to optimize performance



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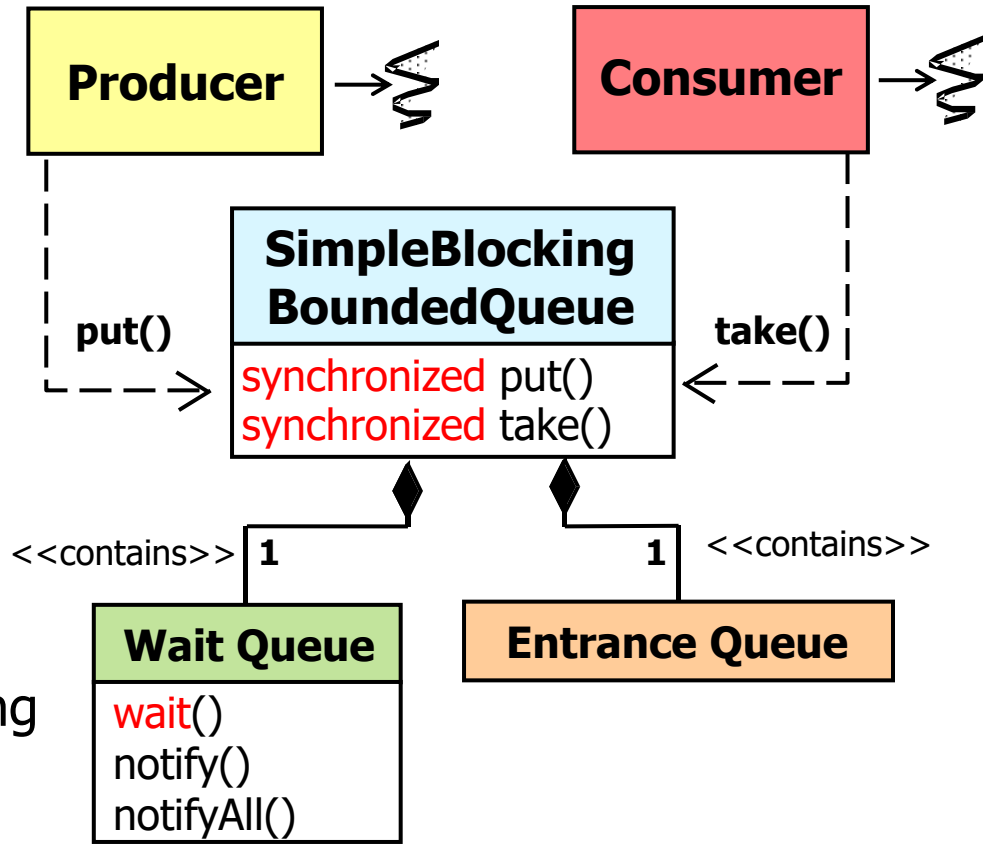
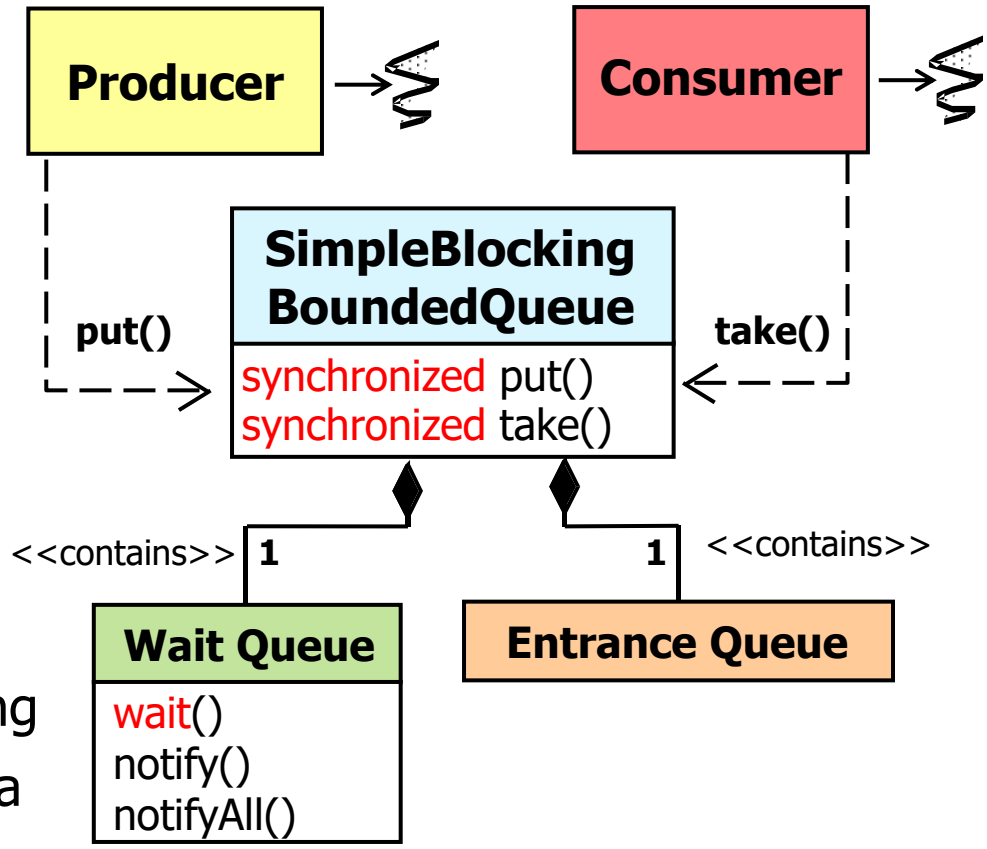
    - The *Specific Notification* pattern can be applied to control ordering



See www.dre.vanderbilt.edu/~schmidt/PDF/specific-notification.pdf

Usage Considerations of Java Monitor Objects

- Programmers must be aware of issues with Java 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
    - 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 family of waiting threads



Usage Considerations of Java Monitor Objects

- In practice, you often need more than Java's monitor object mechanisms
  - java.util.concurrent & java.util.concurrent.locks

package **Added in API level 1**

java.util.concurrent.locks

Interfaces and classes providing a framework for locking and waiting for conditions that is distinct from built-in synchronization and monitors. The framework permits much greater flexibility in the use of locks and conditions, at the expense of more awkward syntax.
The `Lock` interface supports locking disciplines that differ in semantics (reentrant, fair, etc), and that can be used in non-block-structured contexts including hand-over-hand and lock reordering algorithms. The main implementation is `ReentrantLock`.

package **Added in API level 1**

java.util.concurrent

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.

See developer.android.com/reference/java/util/concurrent/package-summary.html

Usage Considerations of Java Monitor Objects

- In practice, you often need more than Java's monitor object mechanisms
  - java.util.concurrent & java.util.concurrent.locks
    - e.g., ReentrantLock & ConditionObject

```
public class ArrayBlockingQueue<E>
             extends AbstractQueue<E>
          implements BlockingQueue<E>,
                  java.io.Serializable {
...
/** Main lock guarding access */
final ReentrantLock lock;

/** Condition for waiting takes */
private final Condition notEmpty;

/** Condition for waiting puts */
private final Condition notFull;
...
```

Used to protect the object state from race conditions

Usage Considerations of Java Monitor Objects

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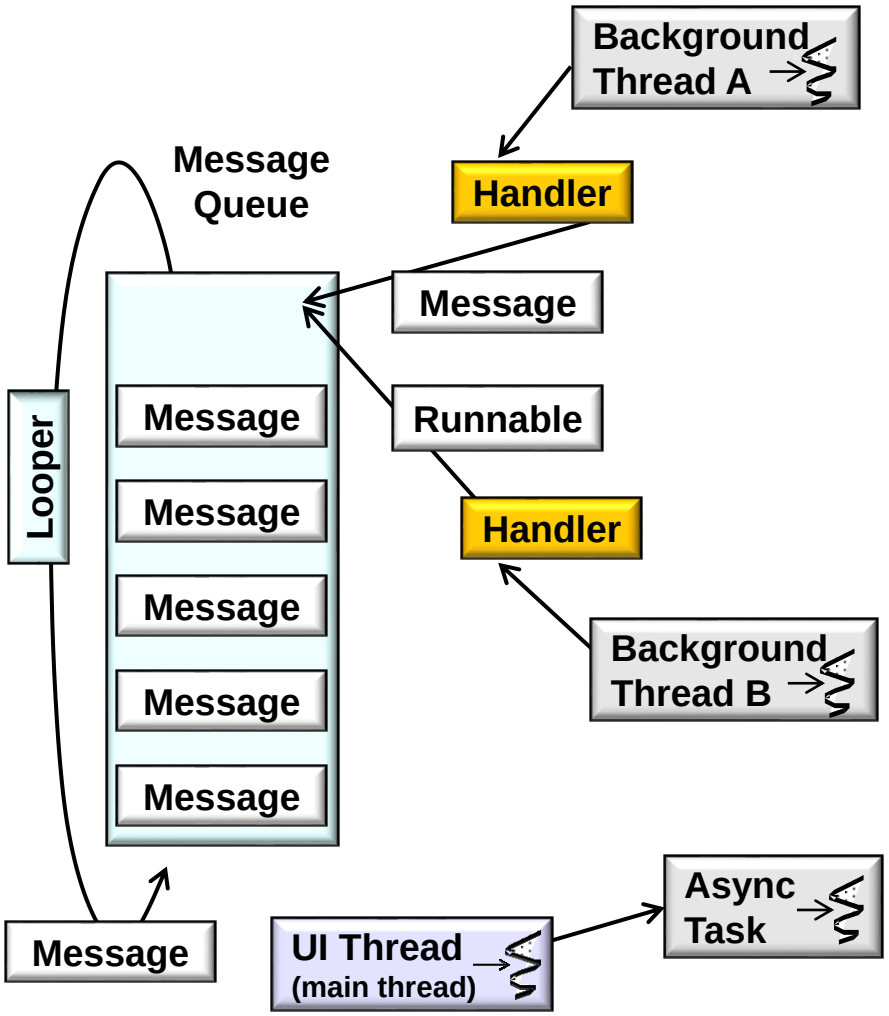
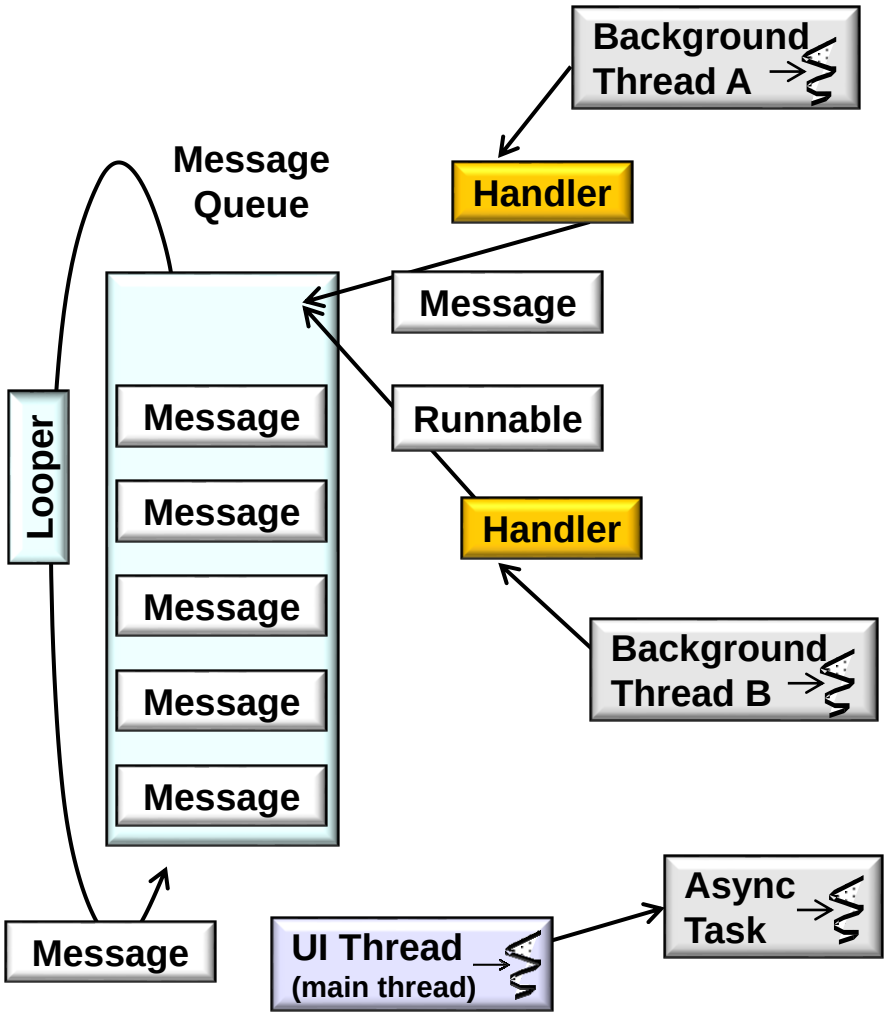
  - java.util.concurrent & java.util.concurrent.locks
  - Android concurrency frameworks



See developer.android.com/guide/components/processes-and-threads.html#Threads

Usage Considerations of Java Monitor Objects

- In practice, you often need more than Java's monitor object mechanisms
  - java.util.concurrent & java.util.concurrent.locks
  - Android concurrency frameworks
    - Message passing may avoid need for monitor objects & synchronization altogether



See www.oreilly.com/library/view/efficient-android-threading/9781449364120/ch04.html

End of Java Monitor Object Usage Considerations