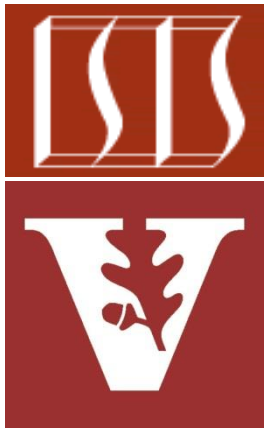
Java ConditionObject Usage Considerations



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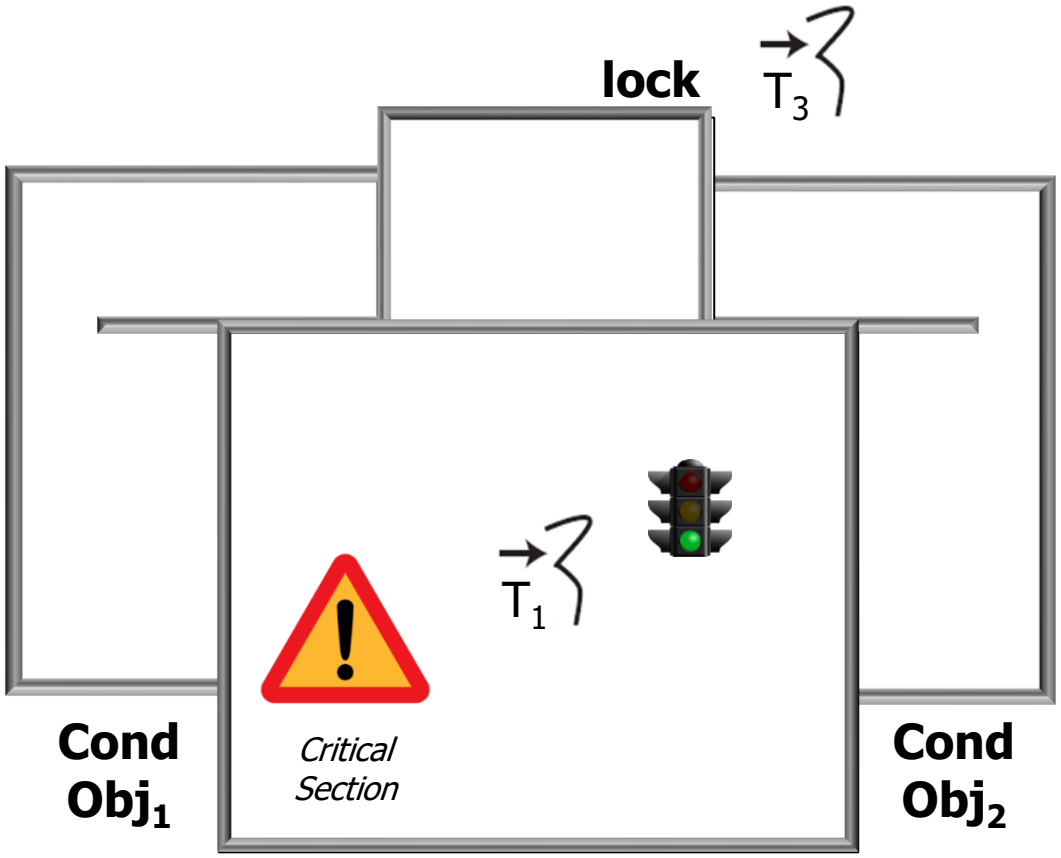
Learning Objectives in this Part of the Lesson

- Understand what condition variables are
- Note a human known use of condition variables
- Know what pattern they implement
- Recognize common use cases where condition variables are applied
- Recognize the structure & functionality of Java ConditionObject
- Know the key methods defined by the Java ConditionObject class
- Master the use of ConditionObjects in practice
- Appreciate ConditionObject usage considerations

Java ConditionObject Usage Considerations

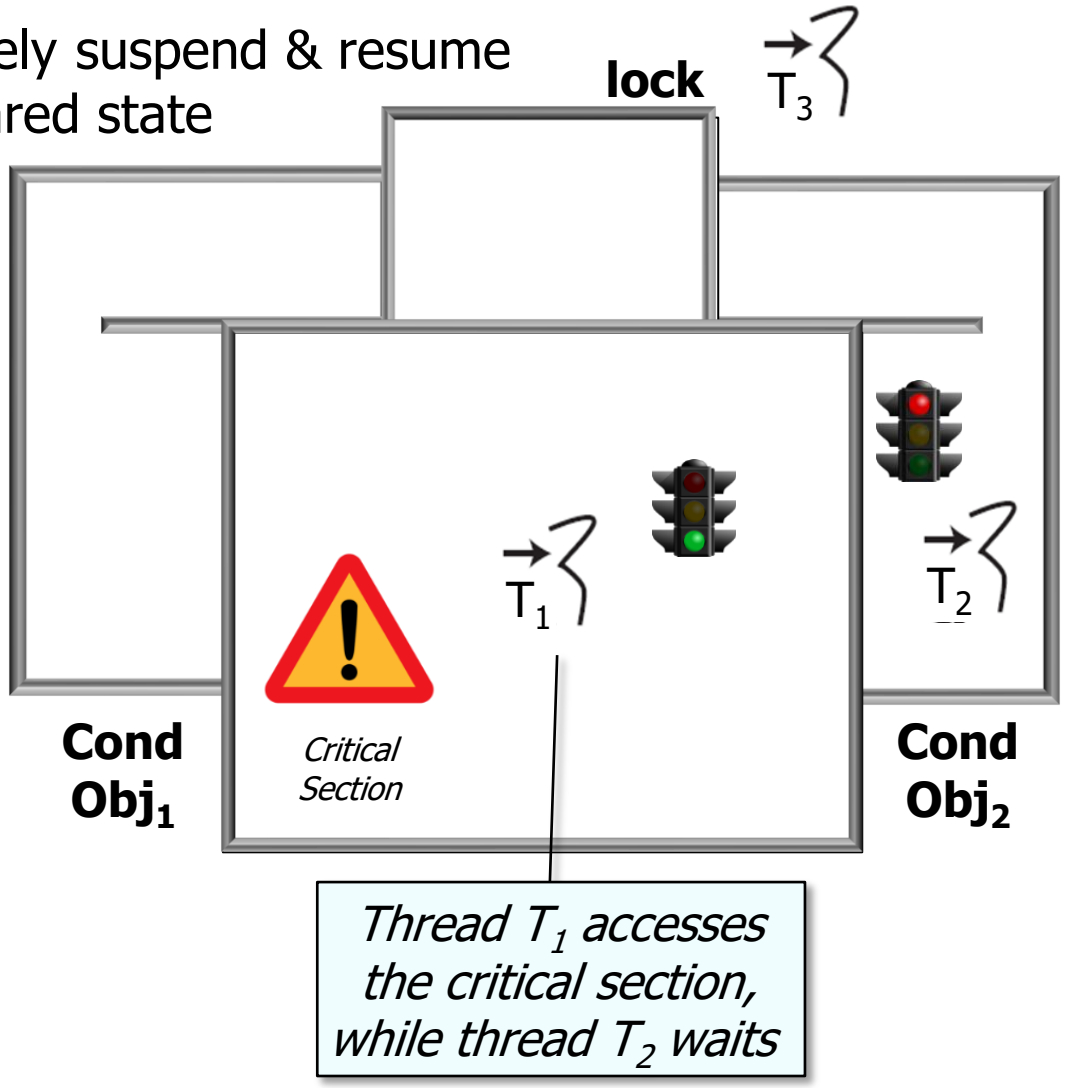
Java ConditionObject Usage Considerations

- ConditionObject is a highly flexible synchronization mechanism



Java ConditionObject Usage Considerations

- ConditionObject is a highly flexible synchronization mechanism
  - Allows threads to cooperatively suspend & resume their execution based on shared state



e.g., threads T_1 & T_2 can take turns sharing a critical section

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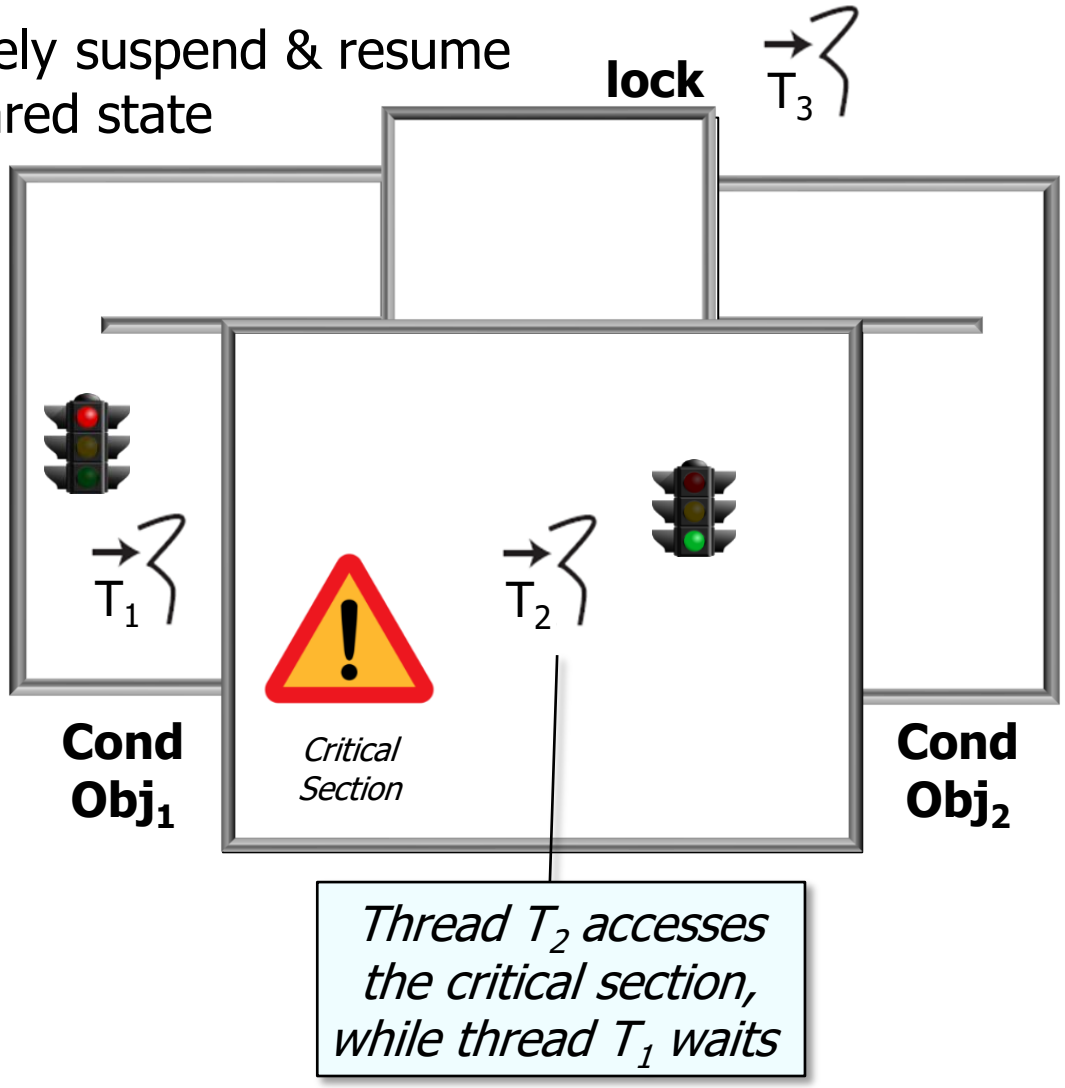

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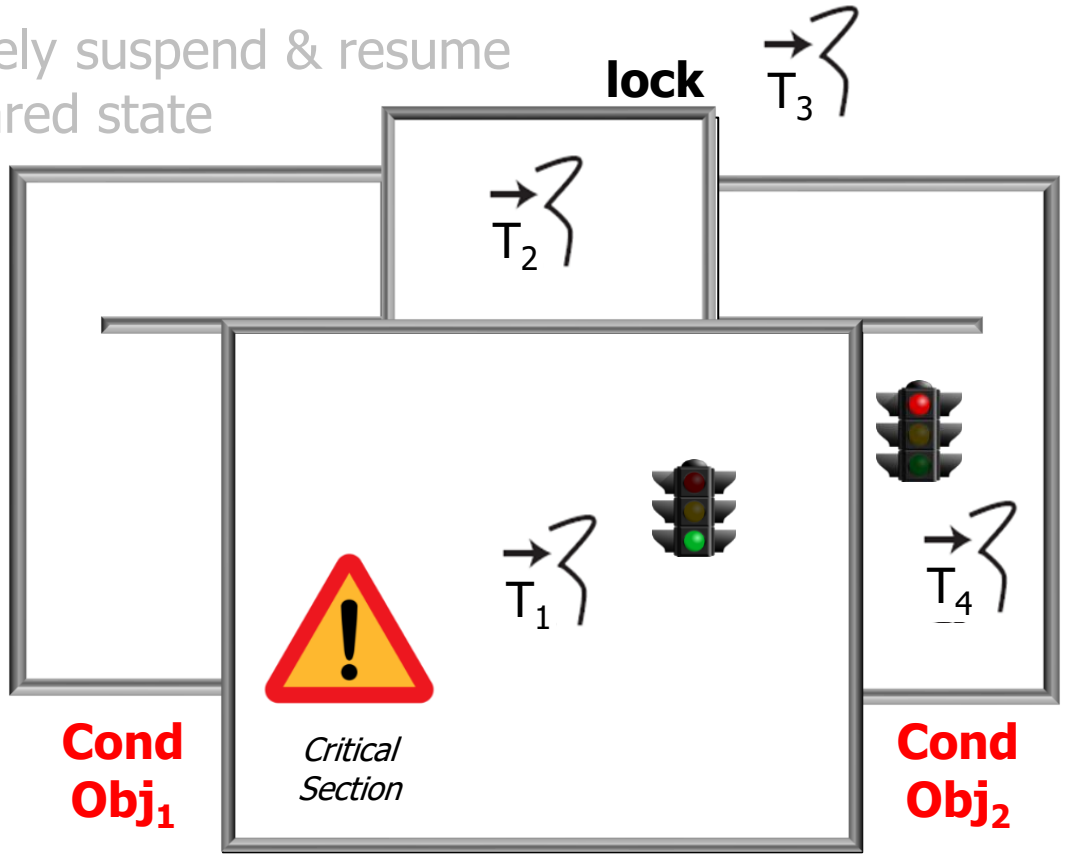
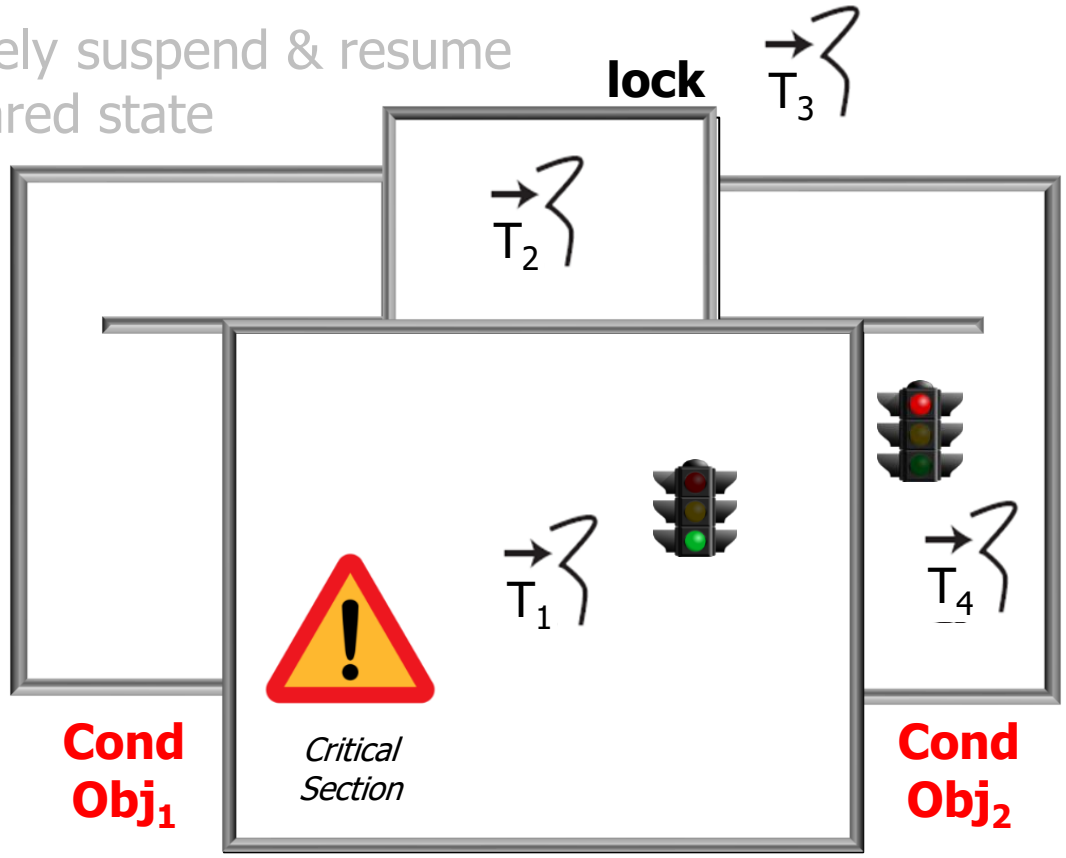
  - A user object can define multiple ConditionObjects



Java ConditionObject Usage Considerations

- ConditionObject is a highly flexible synchronization mechanism
  - Allows threads to cooperatively suspend & resume their execution based on shared state
  - A user object can define multiple ConditionObjects
    - Each ConditionObject can provide a separate "wait set"



Java ConditionObject Usage Considerations

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- However, a ConditionObject must be used carefully to avoid problems
  - It should (almost) always be waited upon in a loop

```
public class
       ArrayBlockingQueue<E>
                                ... {
  ...
  public E take() ... {
    final ReentrantLock lock =
      this.lock;
    lock.lockInterruptibly();
    try {
      while (count == 0)
        notEmpty.await();
      return extract();
    } finally {
      lock.unlock();
    }
  }
```

Java ConditionObject Usage Considerations

- However, a ConditionObject must be used carefully to avoid problems
  - It should (almost) always be waited upon in a loop
    - (Re)test state that's being waited for since it may change due to non-determinism of concurrency

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public class
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```

See docs.oracle.com/javase/tutorial/essential/concurrency/guardmeth.html

Java ConditionObject Usage Considerations

- However, a ConditionObject must be used carefully to avoid problems
  - It should (almost) always be waited upon in a loop
    - (Re)test state that's being waited for since it may change due to non-determinism of concurrency
  - Guard against spurious wakeups

```
public class
       ArrayBlockingQueue<E>
                                  ... {
  ...
  public E take() ... {
    final ReentrantLock lock =
      this.lock;
    lock.lockInterruptibly();
    try {
      while (count == 0)
        notEmpty.await();
      return extract();
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      lock.unlock();
    }
  }
```

A thread might be awoken from its waiting state even though no thread signaled the CO

See en.wikipedia.org/wiki/Spurious_wakeup

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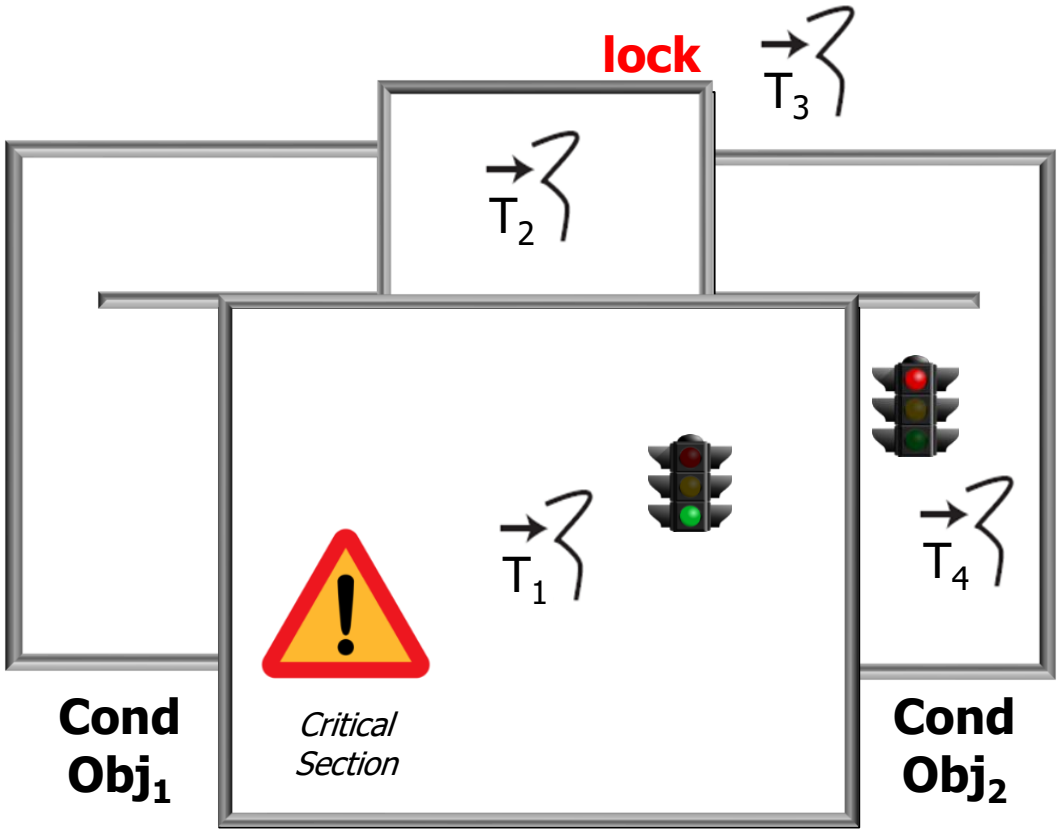

Java ConditionObject Usage Considerations

- However, a ConditionObject must be used carefully to avoid problems
  - It should (almost) always be waited upon in a loop
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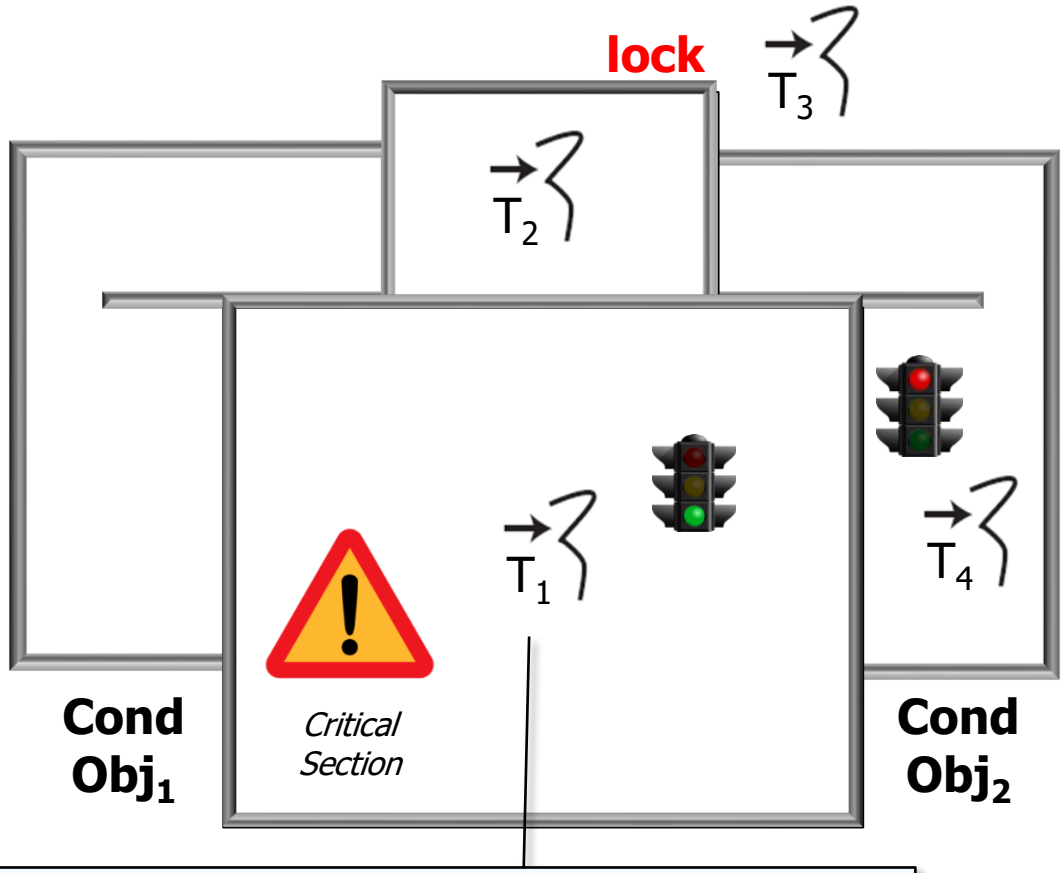
    - Needed to avoid the "lost wakeup problem"

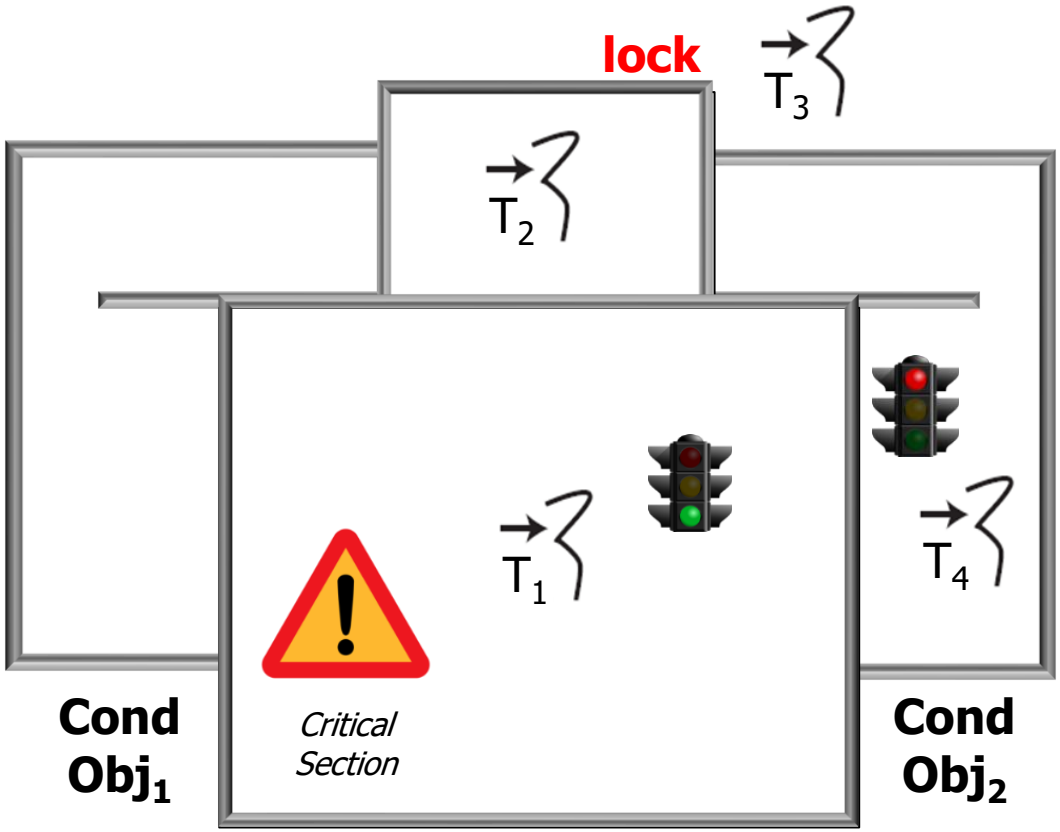


- *A thread calls signal() or signalAll()*
- *Another thread is between the test of the condition & the call to await()*
- *No threads are waiting*

See docs.oracle.com/cd/E19253-01/816-5137/sync-30

Java ConditionObject Usage Considerations

- However, a ConditionObject must be used carefully to avoid problems
  - It should (almost) always be waited upon in a loop
  - It is always used in conjunction with a lock
    - Needed to avoid the "lost wakeup problem"
    - await() internally releases & reacquires its associated lock!



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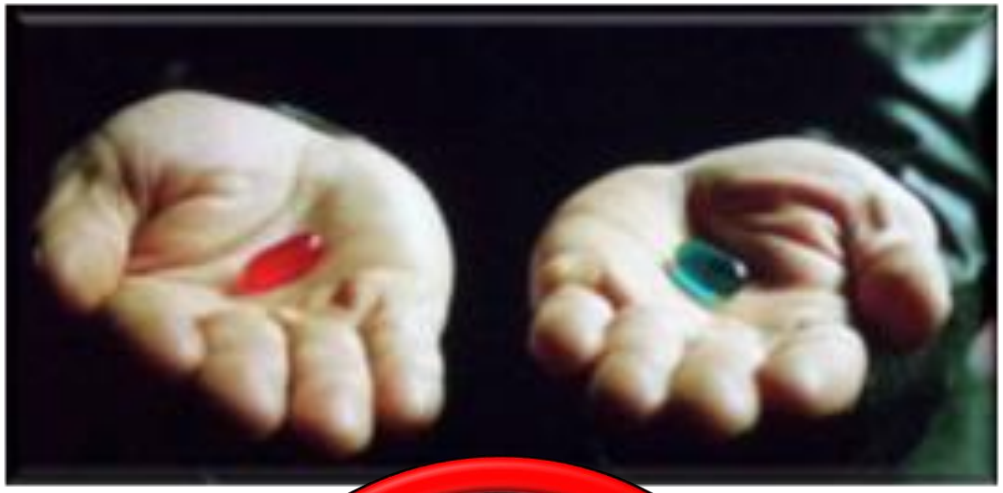
  - Choosing between signal() & signalAll() can be subtle
    - Using signal() is more efficient & avoids the "Thundering Herd" problem..



See en.wikipedia.org/wiki/Thundering_herd_problem

Java ConditionObject Usage Considerations

- However, a ConditionObject must be used carefully to avoid problems
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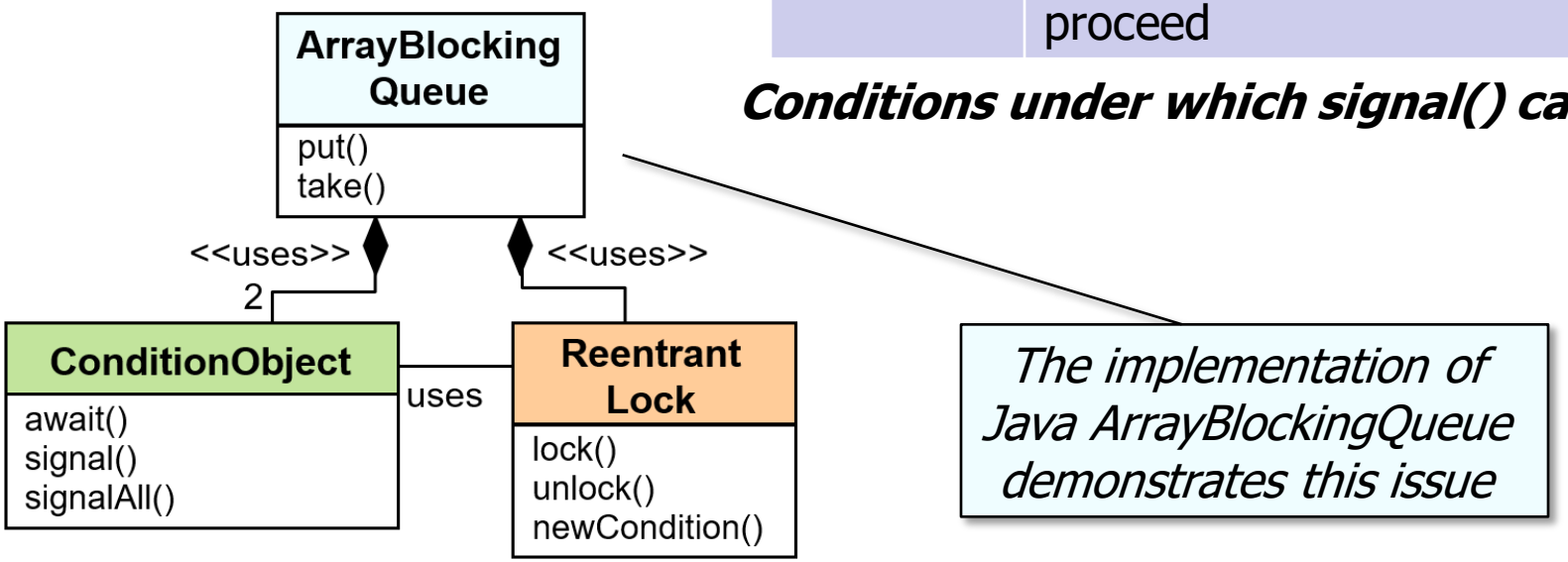
Uniform waiters	Only one condition expression that await() is waiting for is associated with the ConditionObject wait set & each thread executes the same logic when returning from await()
One-in & one-out	A signal() on the ConditionObject enables at most one thread to proceed

Conditions under which signal() can be used



The implementation of Java ArrayBlockingQueue demonstrates this issue

See earlier discussion in "*Java ConditionObject: Example Application*"

Java ConditionObject Usage Considerations

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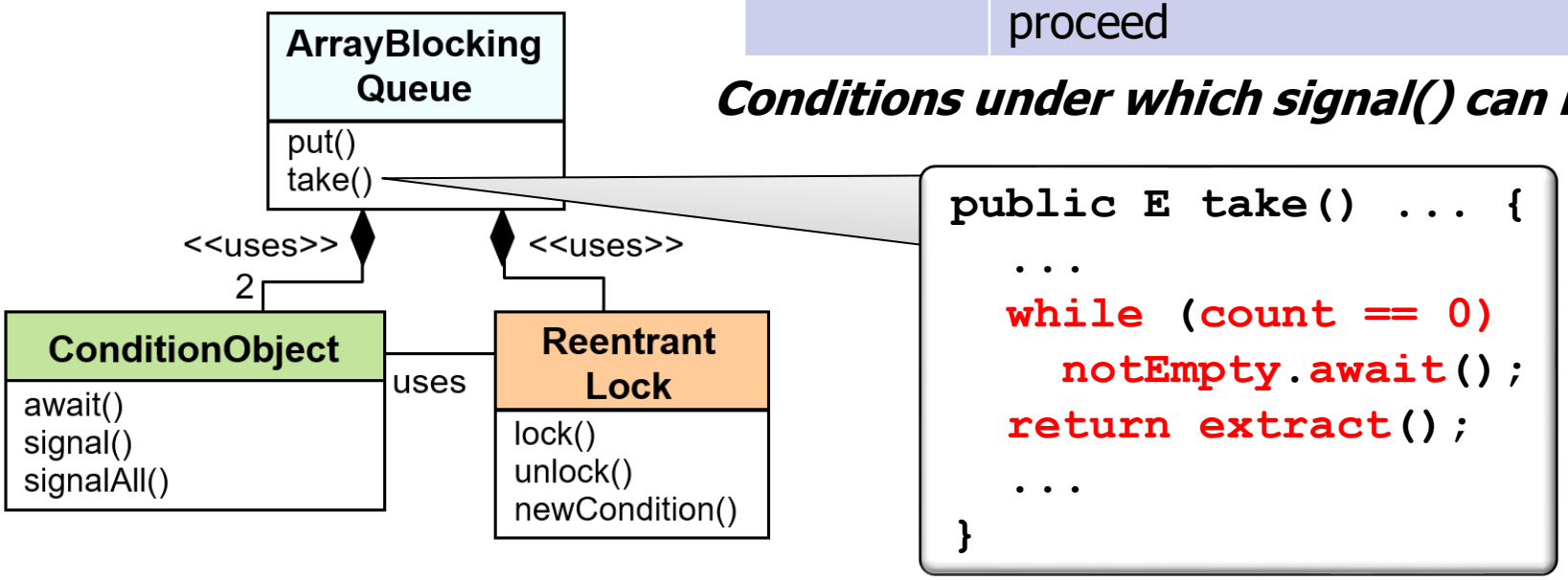

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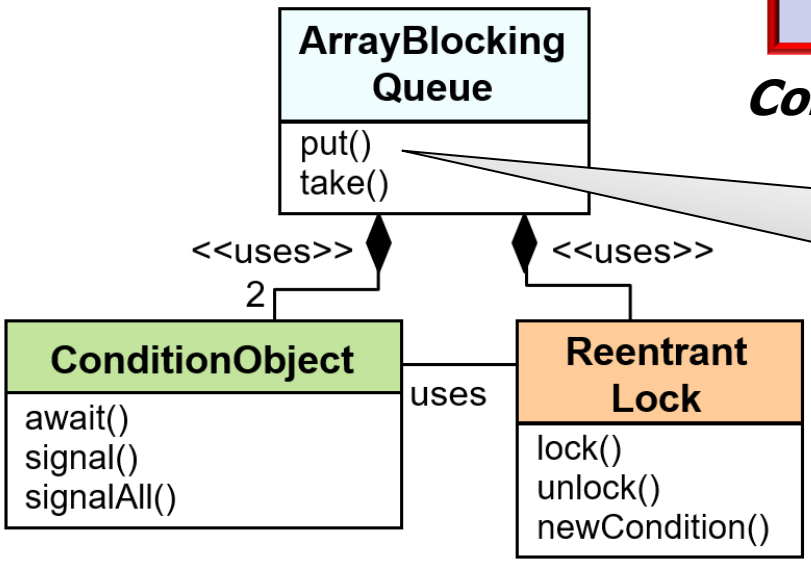


```
private void insert(E x) {
  items[putIndex] = x;
  putIndex = inc(putIndex);
  ++count;
  notEmpty.signal();
}
```

See earlier discussion in "*Java ConditionObject: Example Application*"

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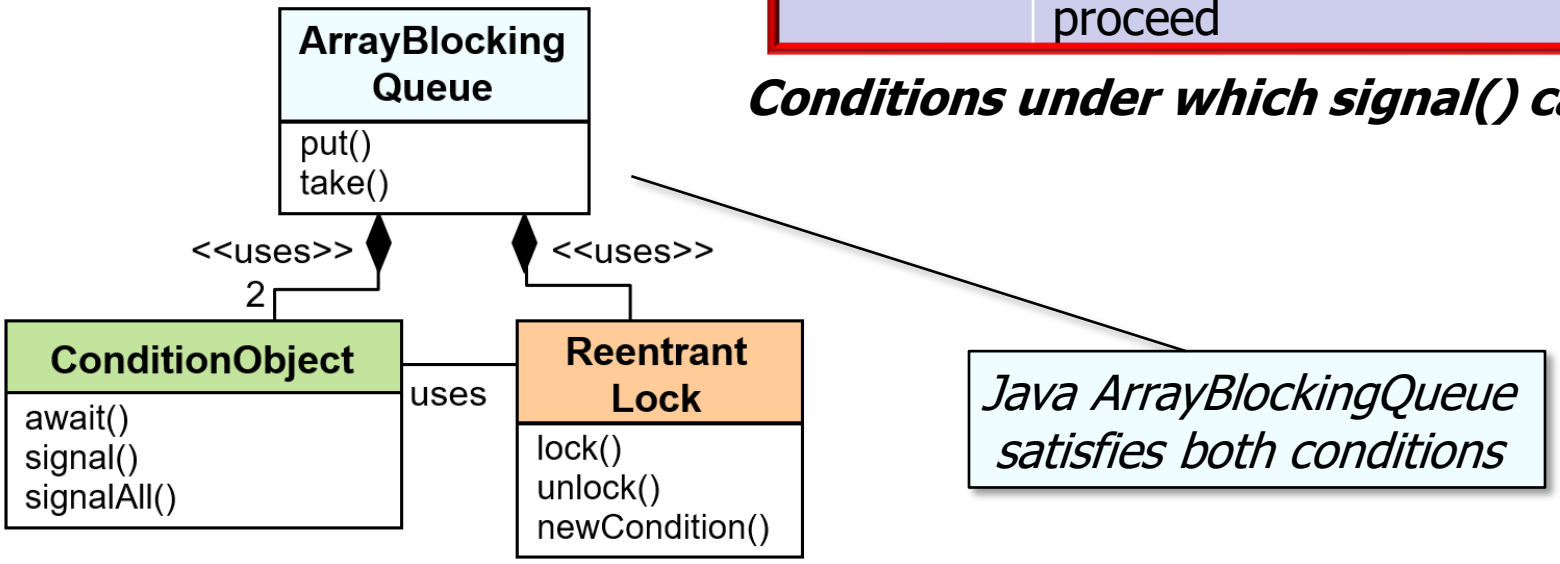

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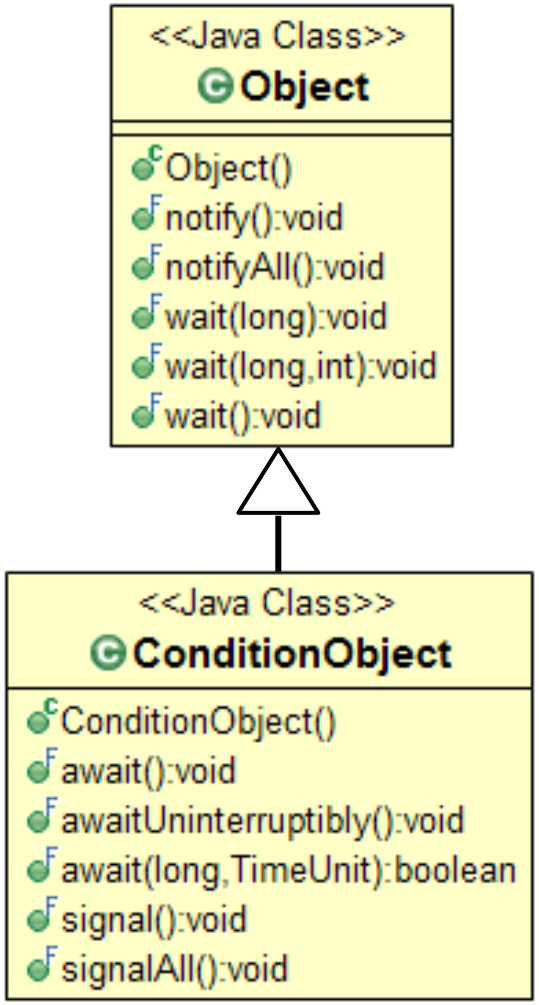
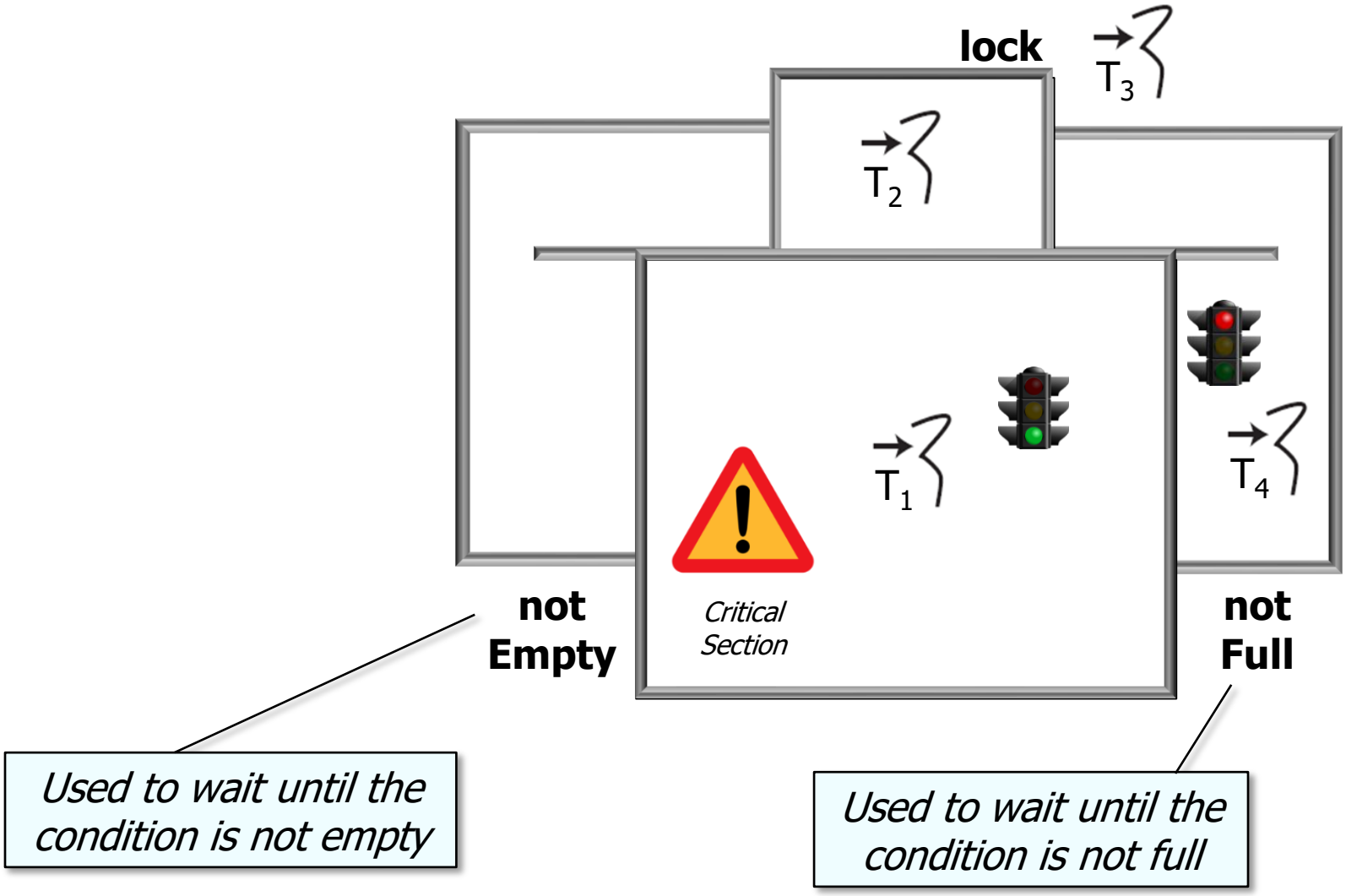
- However, a ConditionObject must be used carefully to avoid problems
  - It should (almost) always be waited upon in a loop
  - It is always used in conjunction with a lock
  - Choosing between signal() & signalAll() can be subtle
  - ConditionObject inherits the wait(), notify(), & notifyAll() methods from Java Object!!



Do *not* mix & match these methods!!!

Java ConditionObject Usage Considerations

- Name condition object fields to reflect their usage



Java ConditionObject Usage Considerations

- ConditionObject is used in 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.

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- ConditionObject is used in java.util.concurrent & java.util.concurrent.locks
  - However, it's typically hidden within higher-level abstractions

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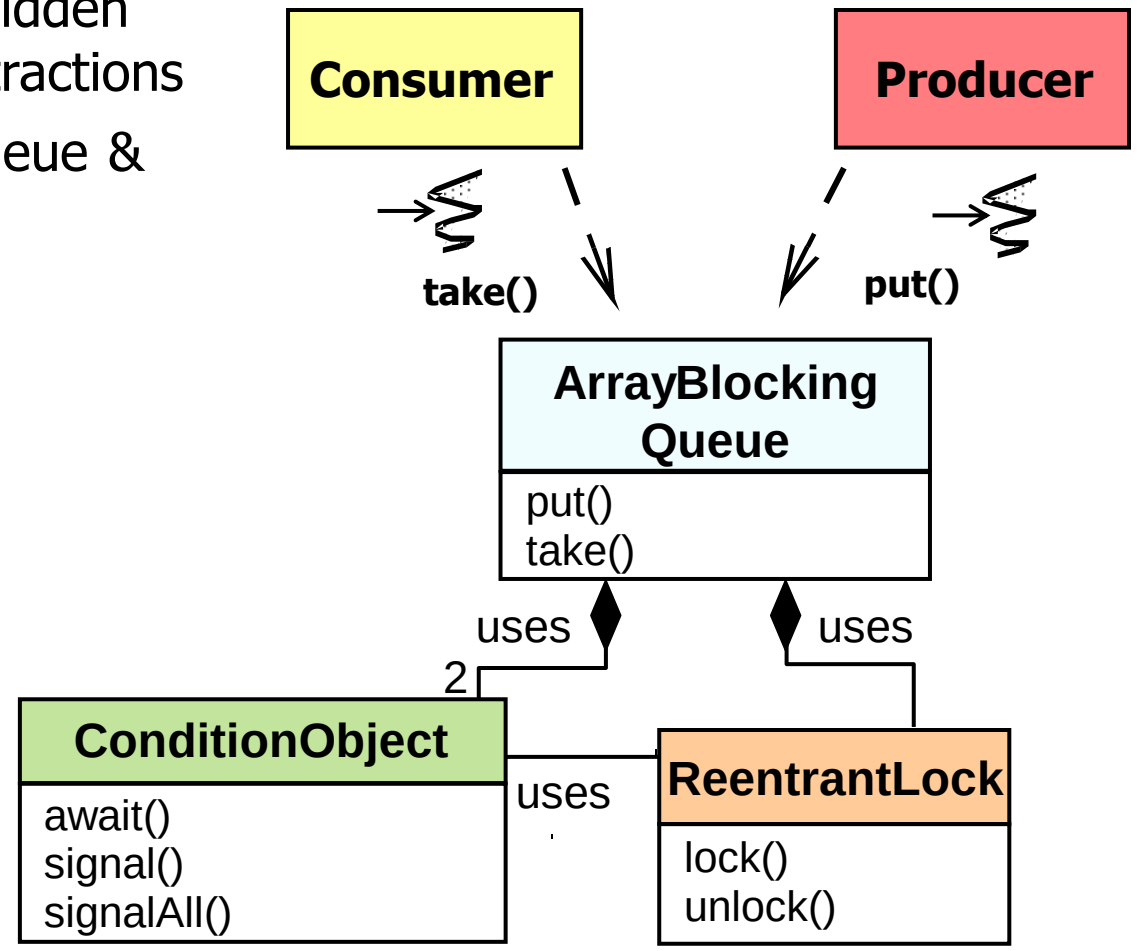
- ConditionObject is used in java.util.concurrent & java.util.concurrent.locks
  - However, it's typically hidden within higher-level abstractions
    - e.g., ArrayBlockingQueue & LinkedBlockingQueue



See docs.oracle.com/javase/8/docs/api/java/util/concurrent/ArrayBlockingQueue.html

End of Java ConditionObject Usage Considerations