Java Monitor Objects: Coordination Methods

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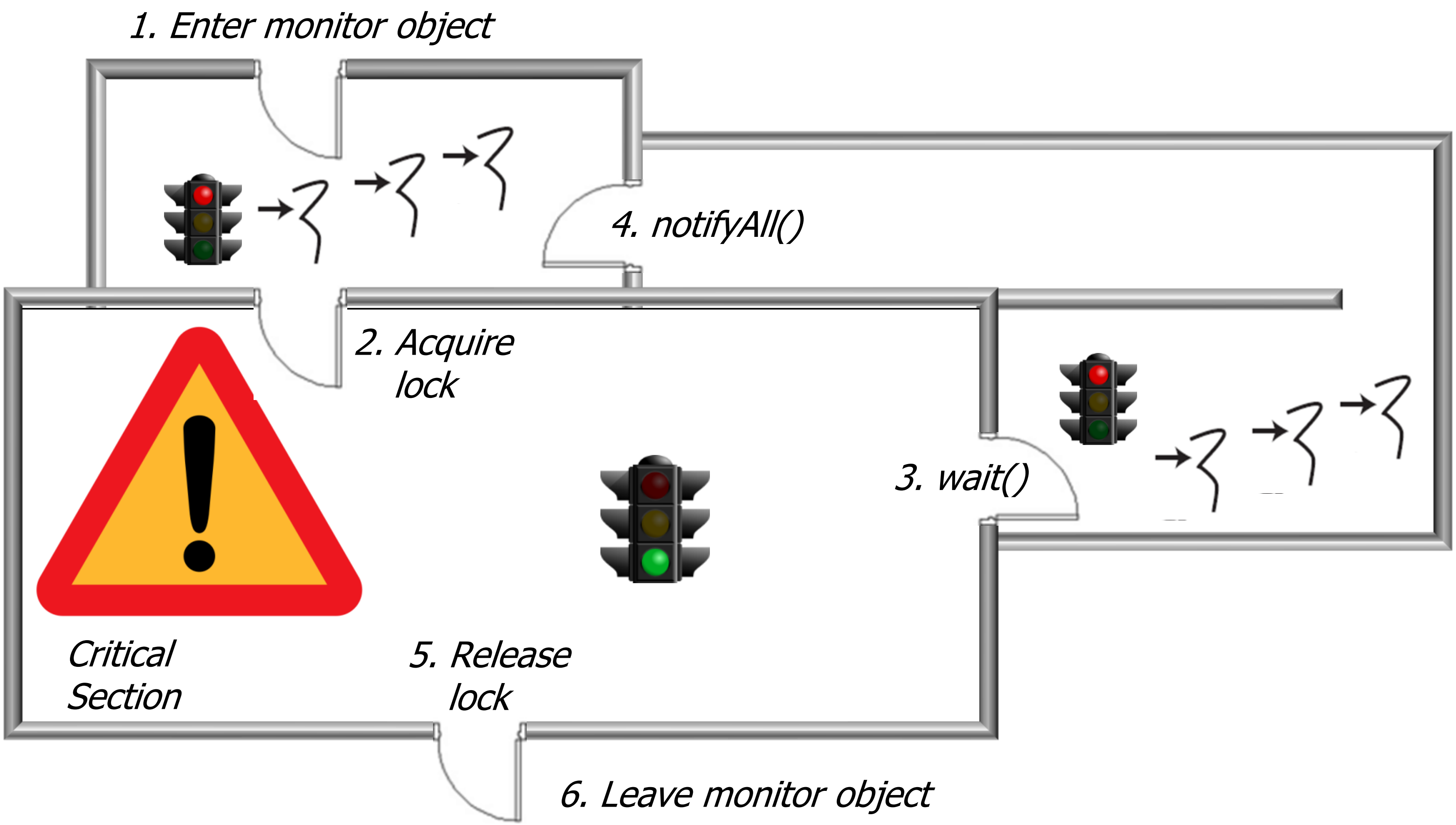
Learning Objectives in this Part of the Lesson

- Understand how Java built-in monitor objects provide waiting & notification mechanisms that coordinate threads running in a concurrent program



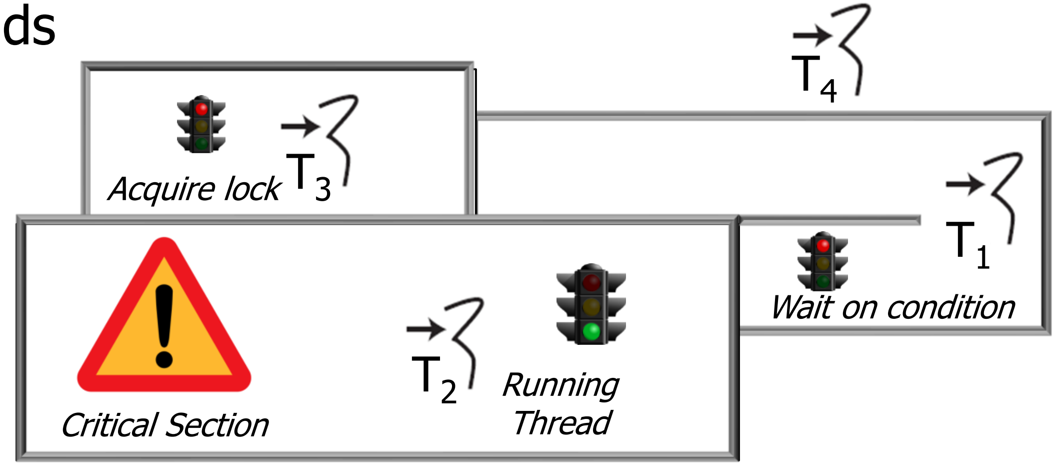
Java Built-in Waiting & Notification Mechanisms

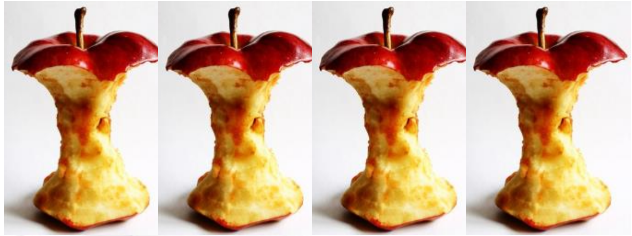
Java Built-in Waiting & Notification Mechanisms

Java synchronized methods & statements only provide a partial solution to concurrent programs

Java Built-in Waiting & Notification Mechanisms

- Java monitor objects allow threads to coordinate their interactions





Java Built-in Waiting & Notification Mechanisms

- Java monitor objects allow threads to coordinate their interactions
  - via the wait(), notify(), & notifyAll() methods

void	wait() – Causes the current thread to wait until another thread invokes the notify() method or the notifyAll() method for this object
void	notify() – Wakes up a single thread that is waiting on this object's monitor
void	notifyAll() – Wakes up all threads that are waiting on this object's monitor

See docs.oracle.com/javase/8/docs/api/java/lang/Object.html

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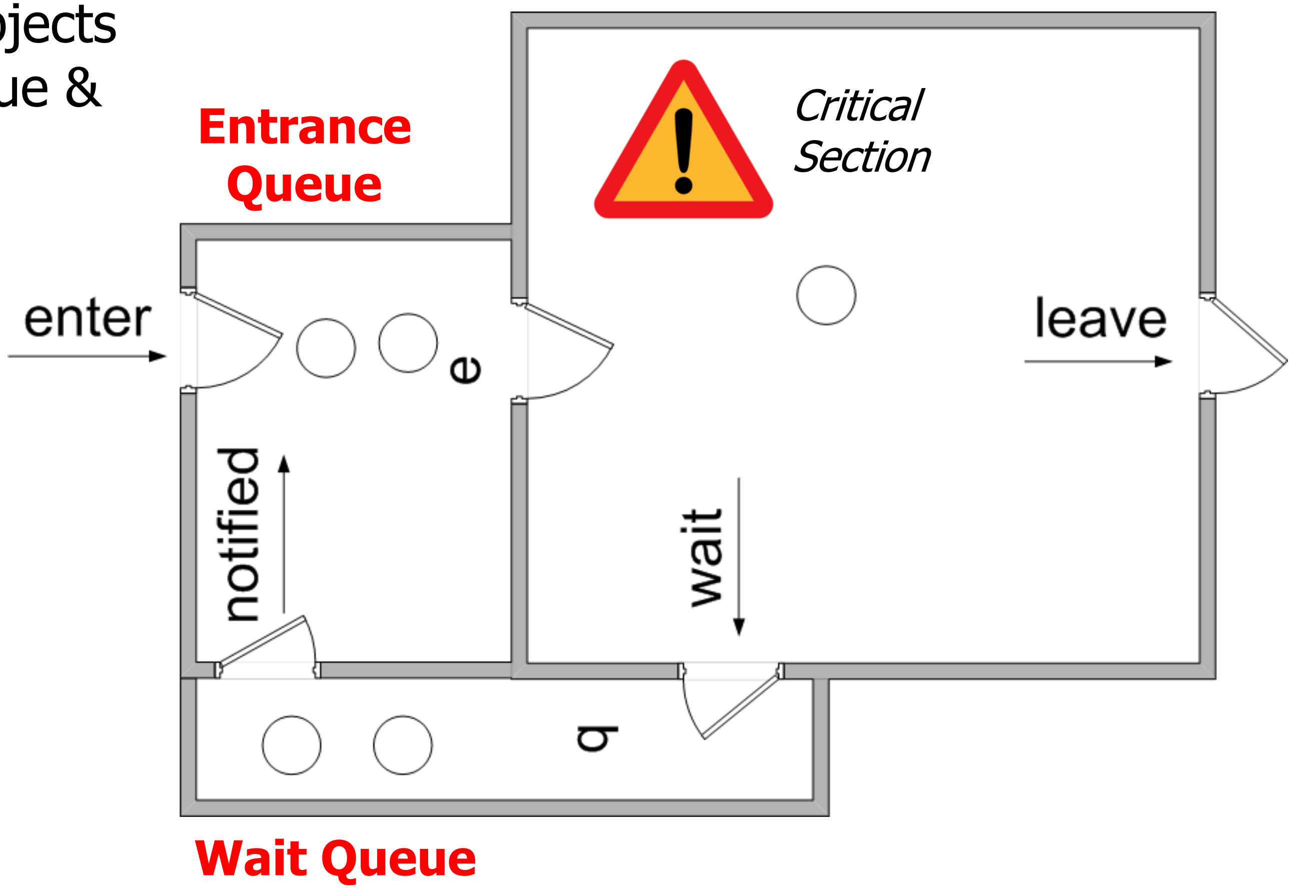
ADOLPH ZUKOR and JESSE L. LASKY PRESENT
ZANE GREY'S
THE THUNDERING HERD
with JACK HOLT, LOIS WILSON
NOAH BEERY, RAYMOND HATTON
SCREEN PLAY BY LUCIEN HUBBARD • • DIRECTED BY WILLIAM HOWARD

See en.wikipedia.org/wiki/Thundering_herd_problem

Java Built-in Waiting & Notification Mechanisms

- Java built-in monitor objects have one entrance queue & one wait queue



Entrance Queue

Critical Section

Wait Queue

See en.wikipedia.org/wiki/Monitor_(synchronization)#Implicit_condition_variable_monitors

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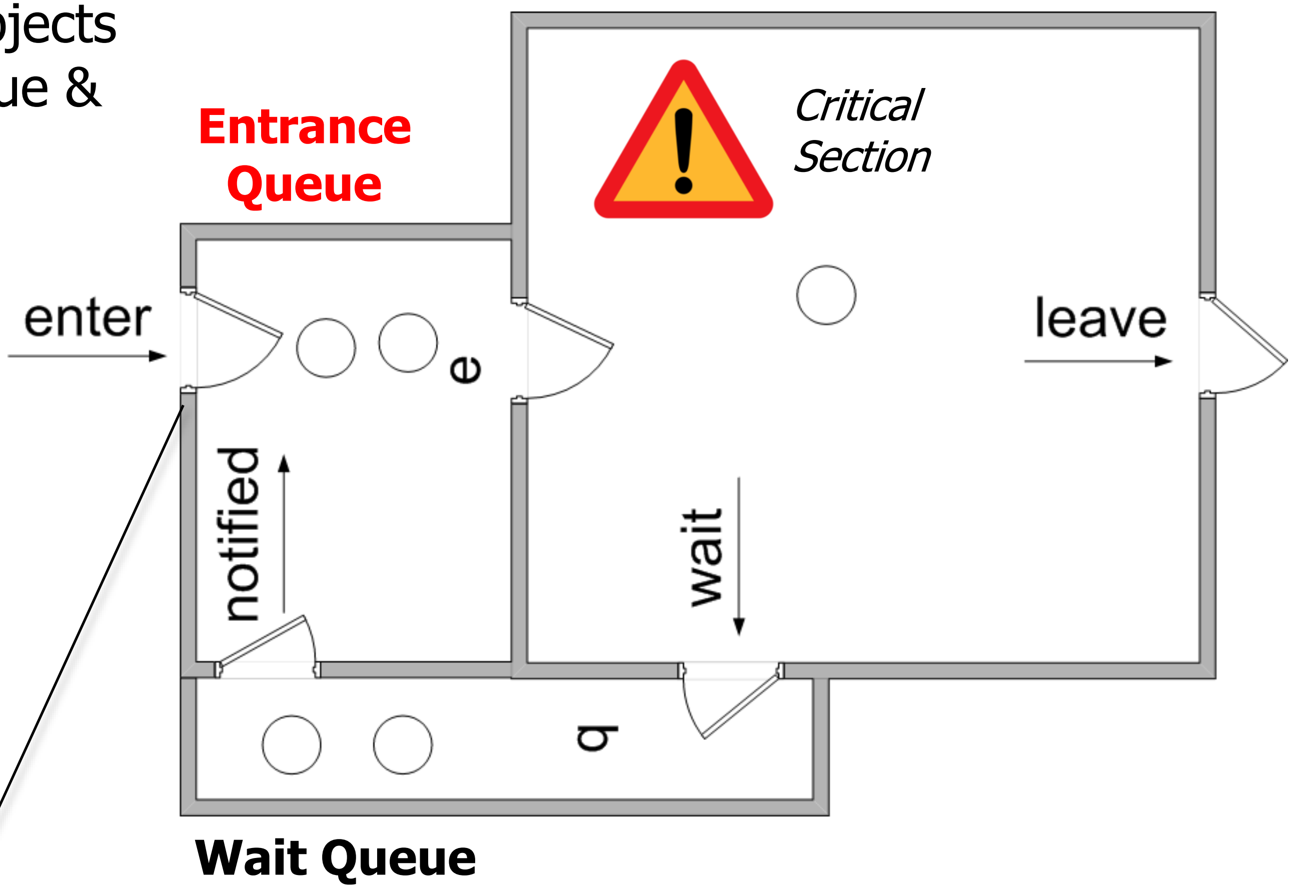

Serializes thread access to monitor object's critical section

Java Built-in Waiting & Notification Mechanisms

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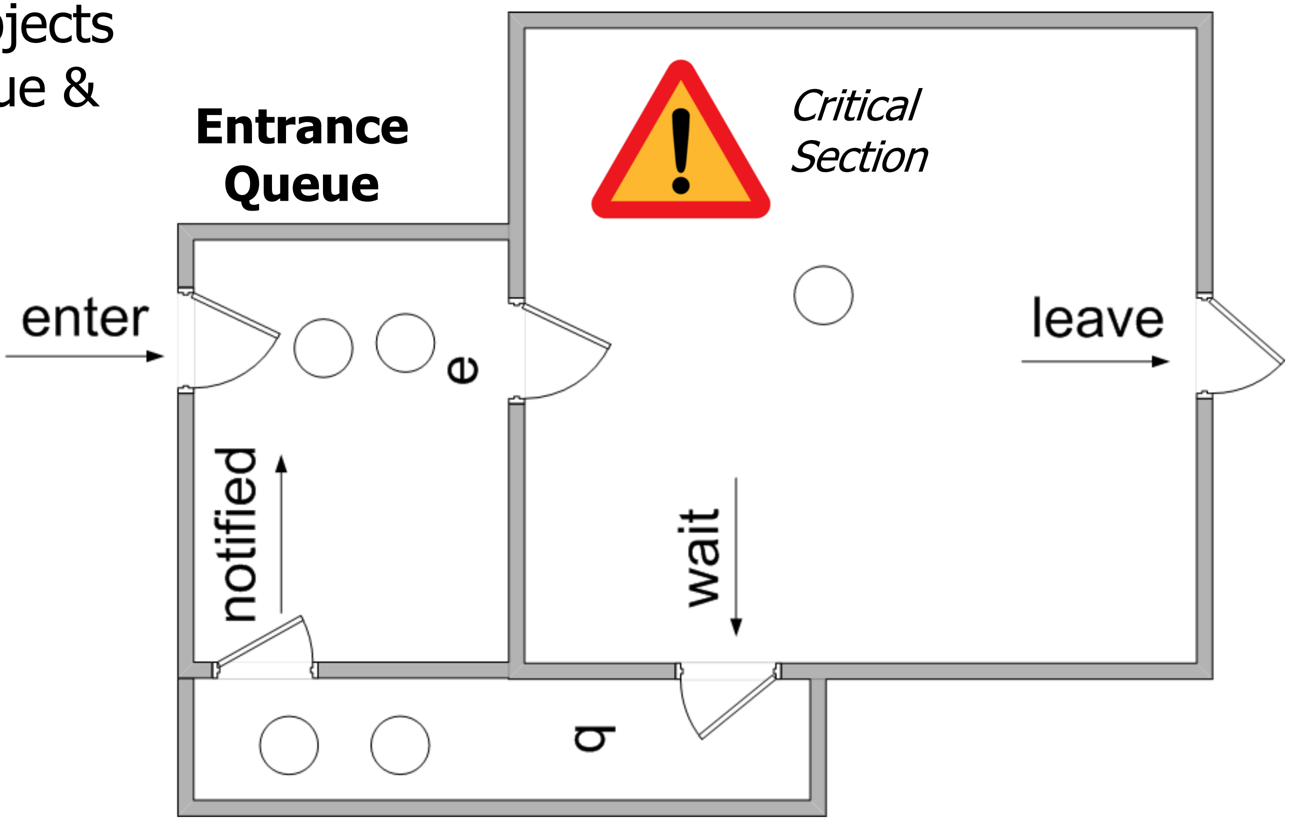

Wait Queue

All threads that call wait() are parked on the wait queue

Java Built-in Waiting & Notification Mechanisms

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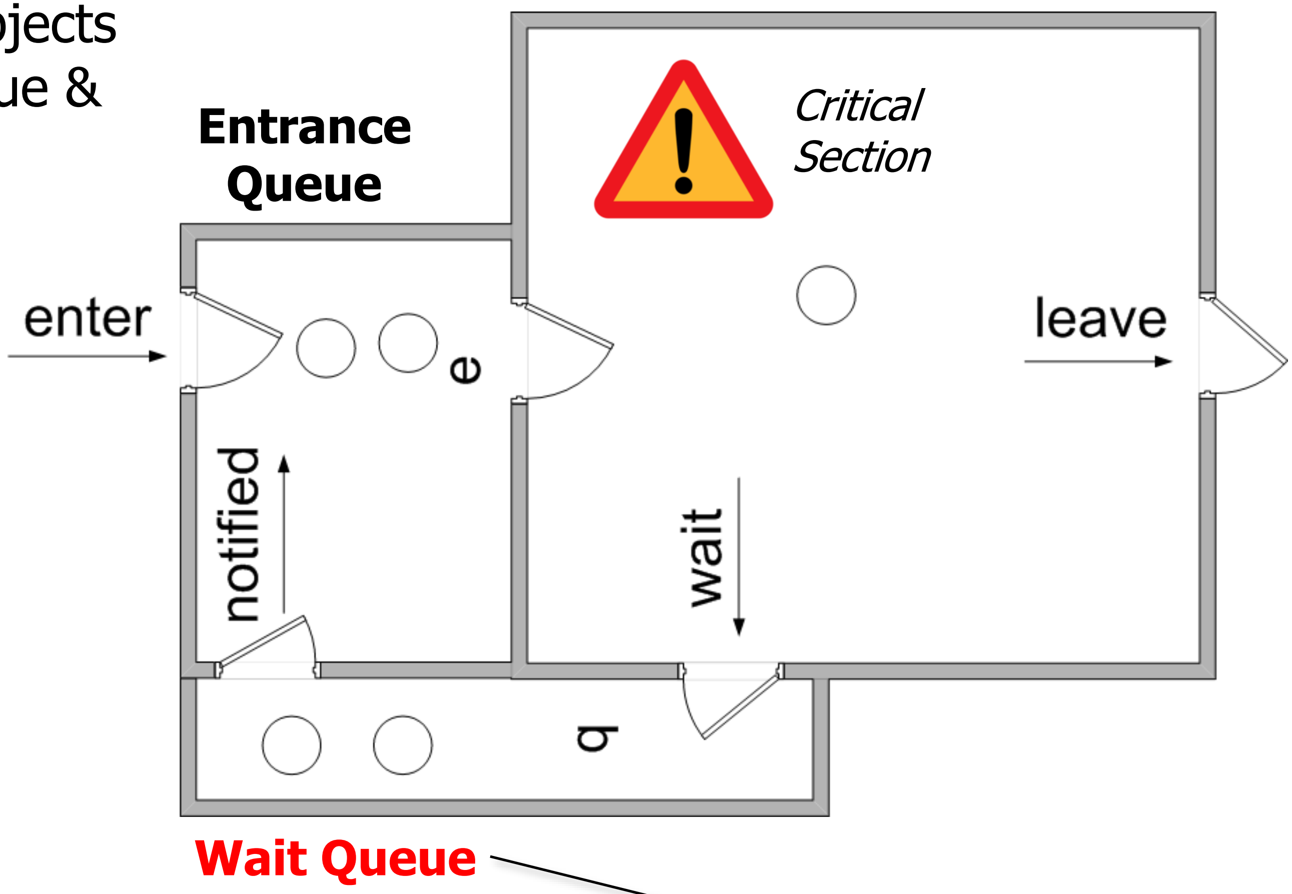

All notify() & notifyAll() calls also apply to the wait queue

Java Built-in Waiting & Notification Mechanisms

- Java built-in monitor objects have one entrance queue & one wait queue

```
class SimpleBoundedBlockingQueue<E>
      implements BlockingQueue<E> {
  ...
  public void put(E msg){
    synchronized(this) {
      while (isFull()) wait();
      mList.add(msg);
      notifyAll();
    }
  }

  public E take() ... {
    synchronized(this) {
      while (isEmpty()) wait();
      notifyAll();
      return mList.poll();
    }
  }
  ...
```

This class fixes the "busy waiting" problem with BusySynchronizedQueue

See github.com/douglascraigschmidt/POSA/tree/master/ex/M3/BoundedBuffers/SimpleBoundedBlockingQueue

Java Built-in Waiting & Notification Mechanisms

- Java built-in monitor objects have one entrance queue & one wait queue, e.g.
  - put() calls wait() when the queue is full

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class SimpleBoundedBlockingQueue<E>
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Atomically releases the intrinsic lock & sleeps on the wait queue

See en.wikipedia.org/wiki/Guarded_suspension

Java Built-in Waiting & Notification Mechanisms

- Java built-in monitor objects have one entrance queue & one wait queue, e.g.
  - put() calls wait() when the queue is full
    - It also calls notifyAll() after adding an item

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class SimpleBoundedBlockingQueue<E>
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      notifyAll();
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    }
  }
  ...
```

Must wake up all the threads blocked on the wait queue since waiters are non-uniform

See upcoming lesson on "*Java Monitor Objects: Usage Considerations*"

Java Built-in Waiting & Notification Mechanisms

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  }
  ...
```

notifyAll() is required due to a Java monitor object only having one wait queue

LIMITED

See stackoverflow.com/questions/37026/java-notify-vs-notifyall-all-over-again/3186336#3186336

Java Built-in Waiting & Notification Mechanisms

- Java built-in monitor objects have one entrance queue & one wait queue, e.g.
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Java Built-in Waiting & Notification Mechanisms

- Java built-in monitor objects have one entrance queue & one wait queue, e.g.
  - put() calls wait() when the queue is full
  - take() calls wait() when the queue is empty
    - It also calls notifyAll() after removing an item

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```

Must wake up all the threads blocked on the wait queue since waiters are non-uniform

Again, notifyAll() is required here due to the limitations of Java monitor objects, which only have one wait queue

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```
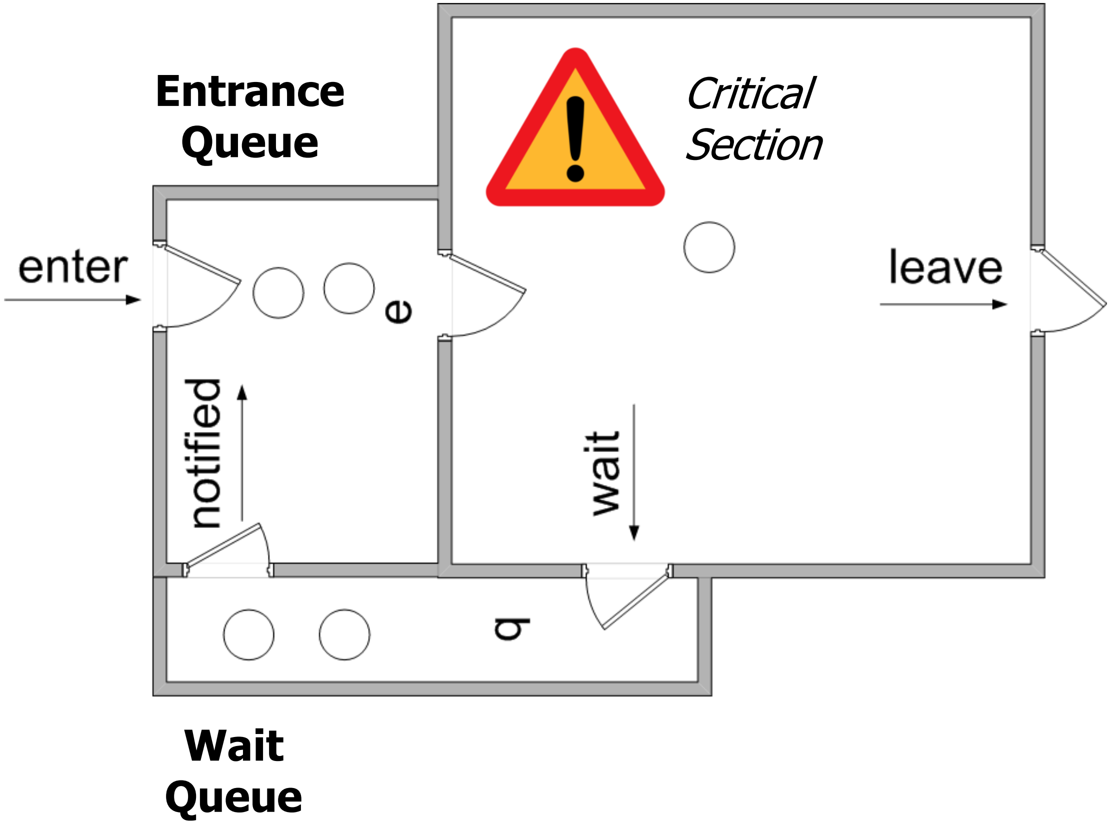

The put() & take() methods are examined later in this lesson

See upcoming lesson on "*Java Monitor Objects: Coordination Example Implementation*"

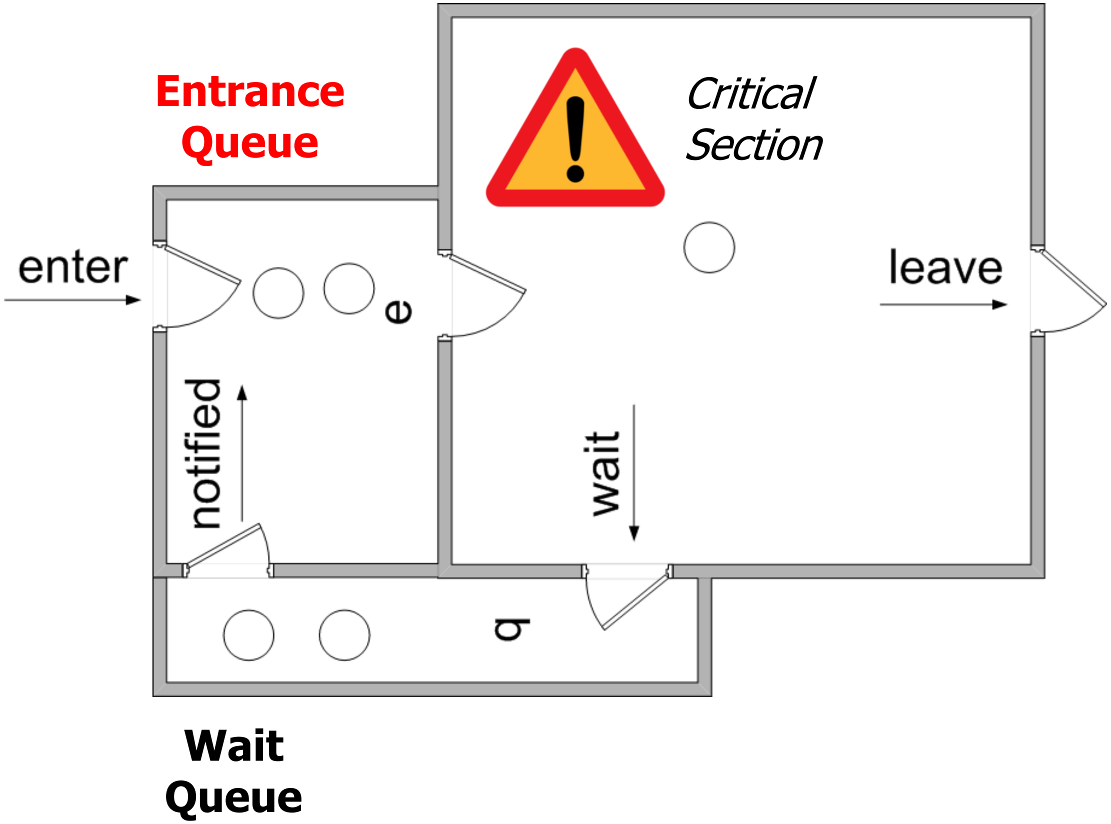
Java Built-in Waiting & Notification Mechanisms

- Java built-in monitor object synchronizers can be implemented w/POSIX-like synchronizers



Java Built-in Waiting & Notification Mechanisms

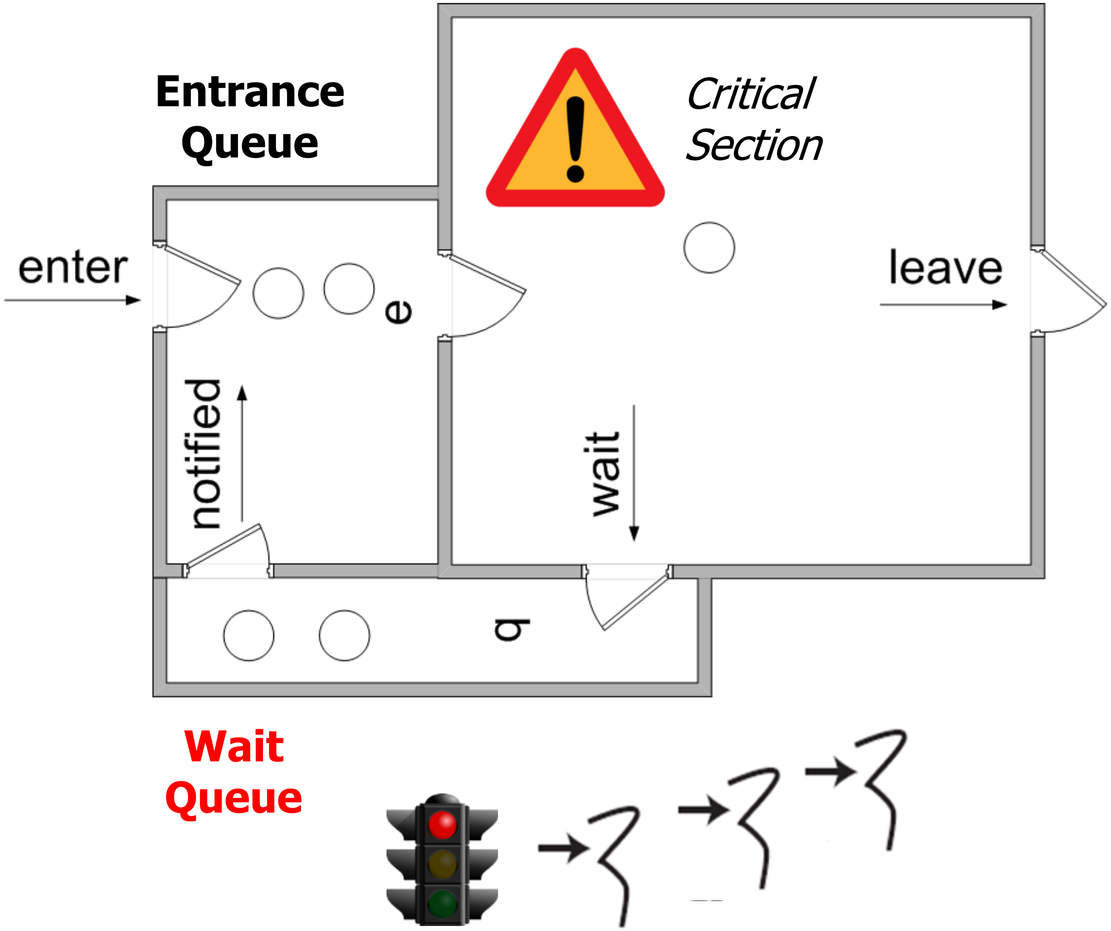
- Java built-in monitor object synchronizers can be implemented w/POSIX-like synchronizers, e.g.
  - Entrance queue is akin to a POSIX recursive mutex



See computing.llnl.gov/tutorials/pthreads/#Mutexes

Java Built-in Waiting & Notification Mechanisms

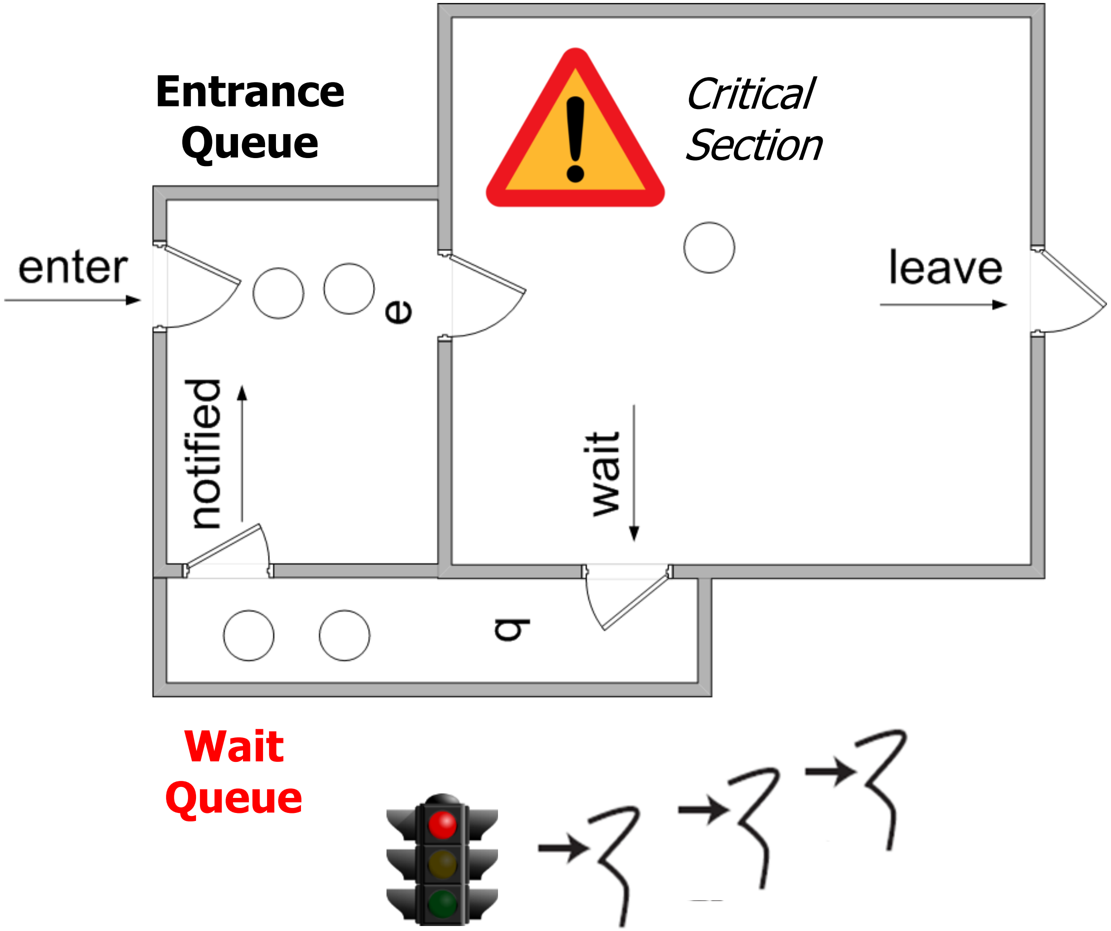
- Java built-in monitor object synchronizers can be implemented w/POSIX-like synchronizers, e.g.
  - Entrance queue is akin to a POSIX recursive mutex
  - Wait queue is akin to a POSIX condition variable



See computing.llnl.gov/tutorials/pthreads/#ConditionVariables

Java Built-in Waiting & Notification Mechanisms

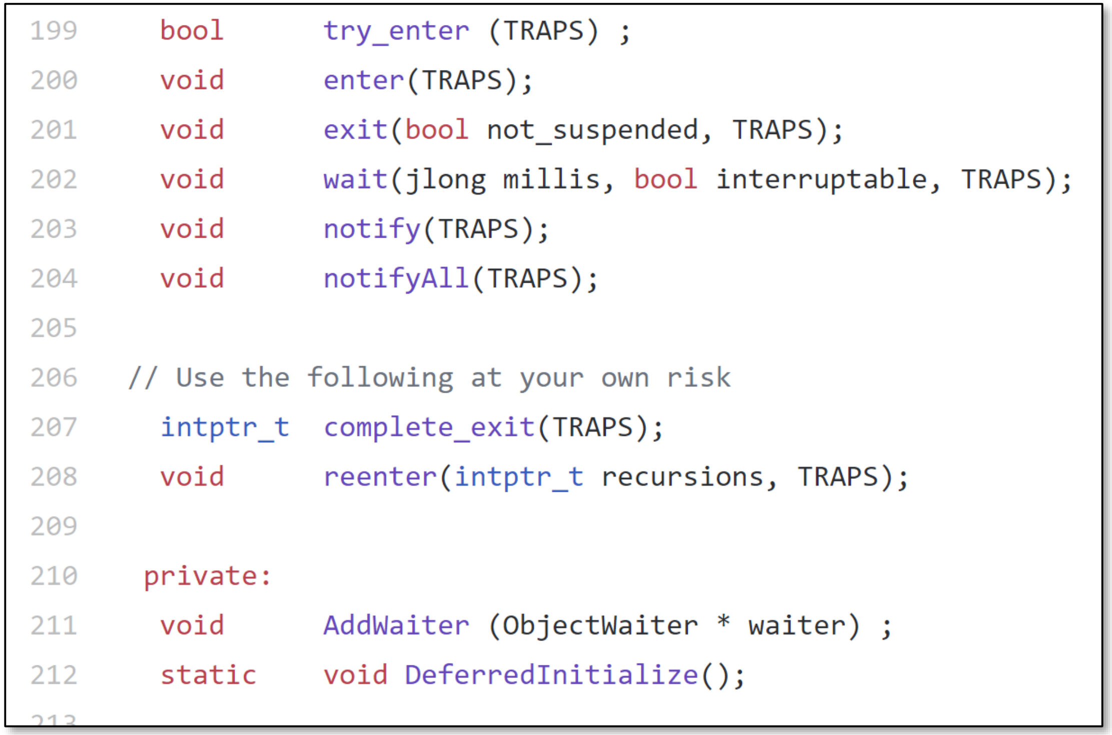
- Java built-in monitor object synchronizers can be implemented w/POSIX-like synchronizers, e.g.
  - Entrance queue is akin to a POSIX recursive mutex
  - Wait queue is akin to a POSIX condition variable
    - Similar to Java ConditionObjects



See earlier lessons on "*Java ConditionObjects*"

Java Built-in Waiting & Notification Mechanisms

- Java built-in monitor object synchronizers can be implemented w/POSIX-like synchronizers, e.g.
  - Entrance queue is akin to a POSIX recursive mutex
  - Wait queue is akin to a POSIX condition variable
  - The implementation in the Oracle JDK uses lower-level locking primitives



```
  bool        try_enter (TRAPS) ;
  void        enter(TRAPS);
  void        exit(bool not_suspended, TRAPS);
  void        wait(jlong millis, bool interruptable, TRAPS);
  void        notify(TRAPS);
  void        notifyAll(TRAPS);

// Use the following at your own risk
  intptr_t    complete_exit(TRAPS);
  void        reenter(intptr_t recursions, TRAPS);

 private:
  void        AddWaiter (ObjectWaiter * waiter) ;
  static      void DeferredInitialize();
```

See github.com/JetBrains/jdk8u_hotspot/blob/master/src/share/vm/runtime/objectMonitor.cpp

End of Java Monitor Object: Coordination Methods