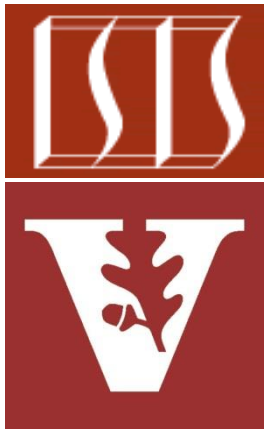
Java Monitor Objects: Synchronized Method Example



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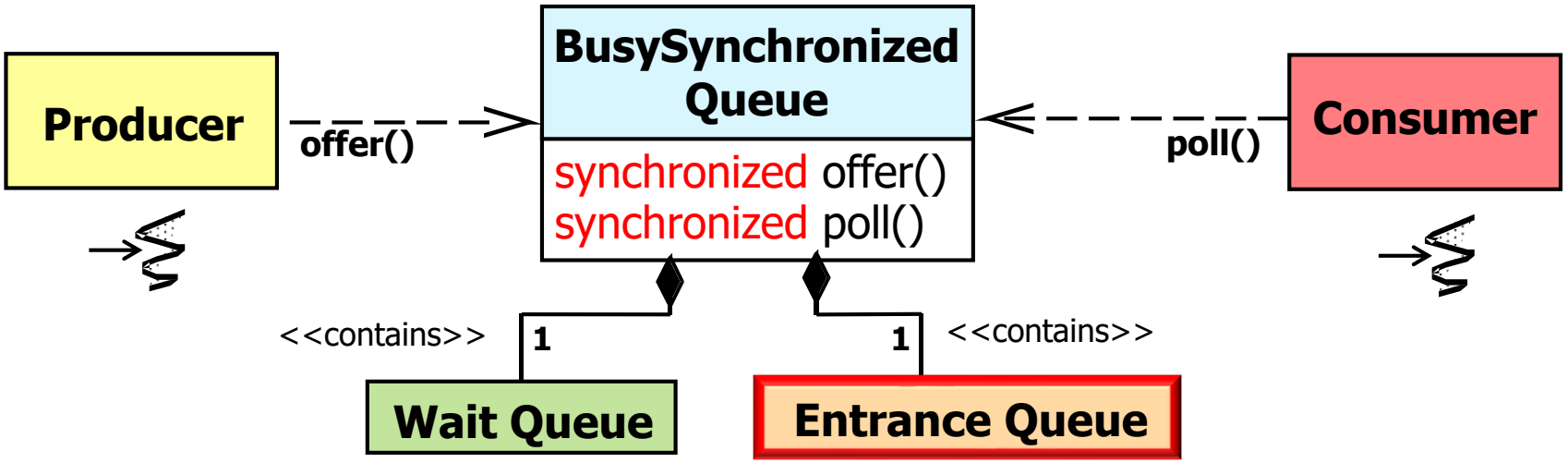
Learning Objectives in this Part of the Lesson

- Recognize the synchronized methods/statements provided by Java build-in monitor objects to support *mutual exclusion*
- Understand how to fix race conditions in the buggy concurrent Java app by using synchronized methods



The use of synchronized methods only provides a partial solution, however…

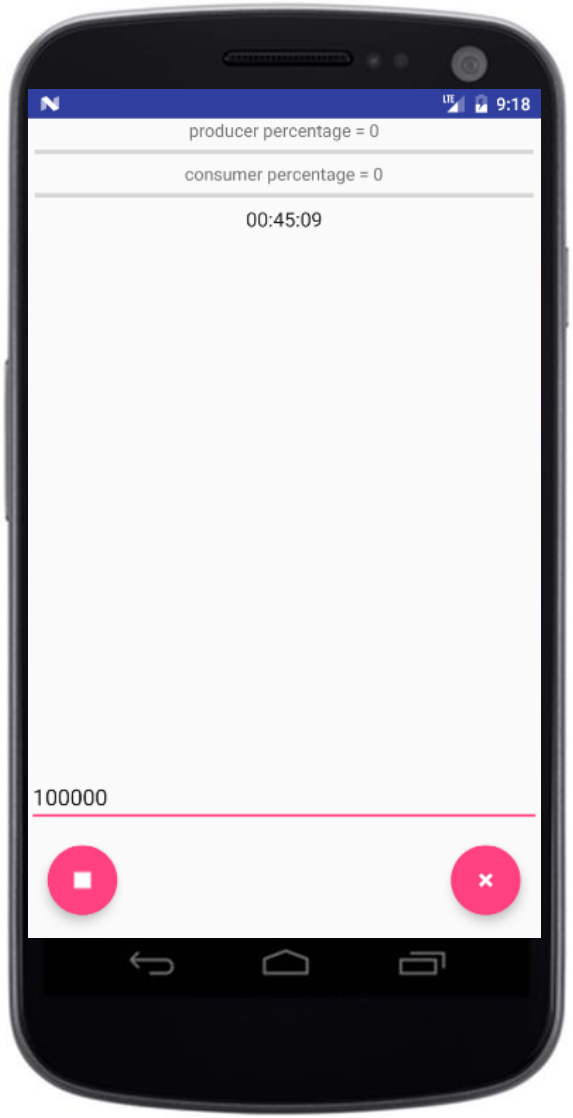
Partial Solution Using Java Synchronized Methods

Partial Solution Using Java Synchronized Methods

See en.wikipedia.org/wiki/Crazy_Horse_Memorial

Partial Solution Using Java Synchronized Methods

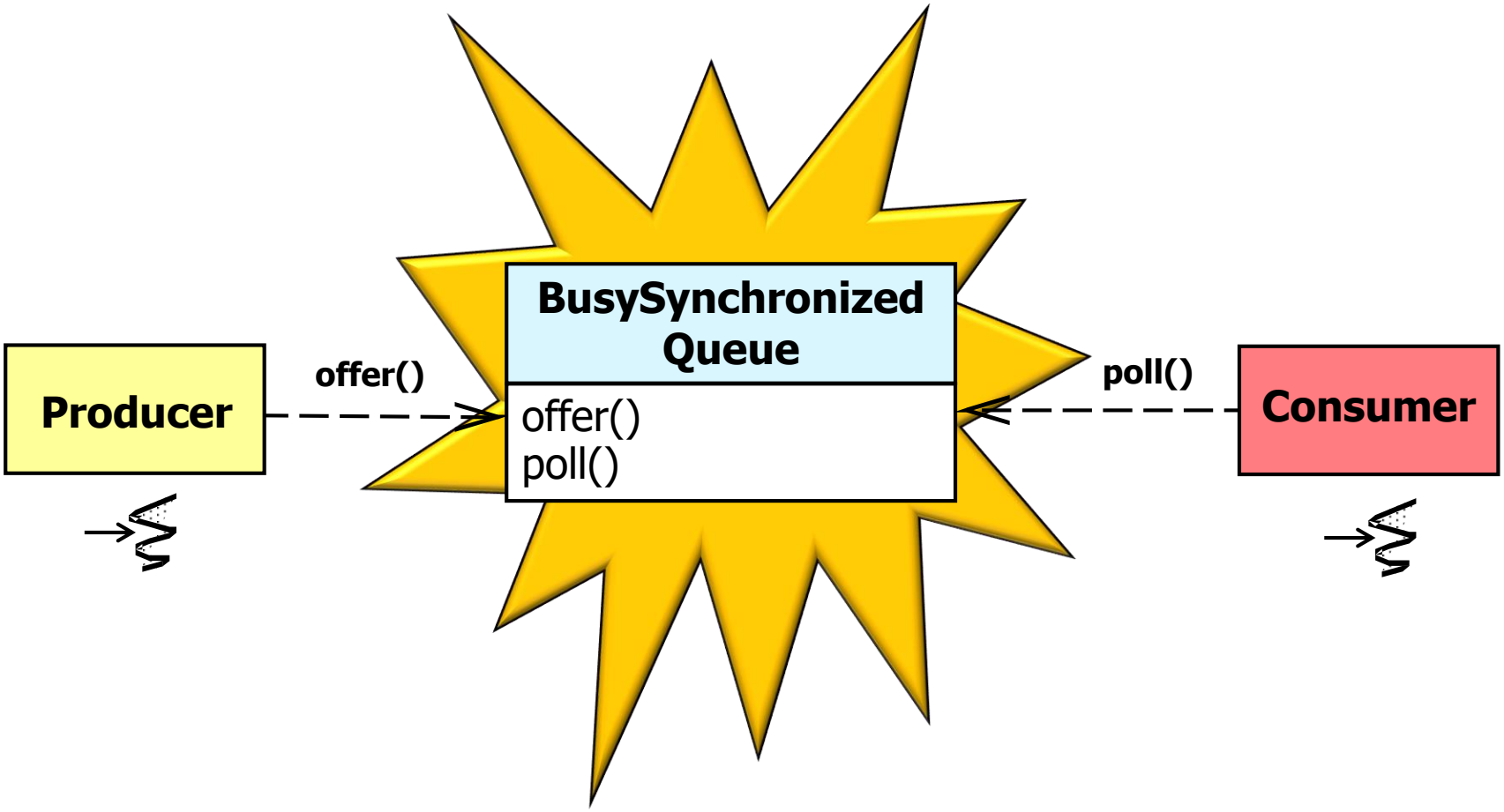
- A concurrent producer/consumer app that passes messages via the class "BusySynchronizedQueue"



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

Partial Solution Using Java Synchronized Methods

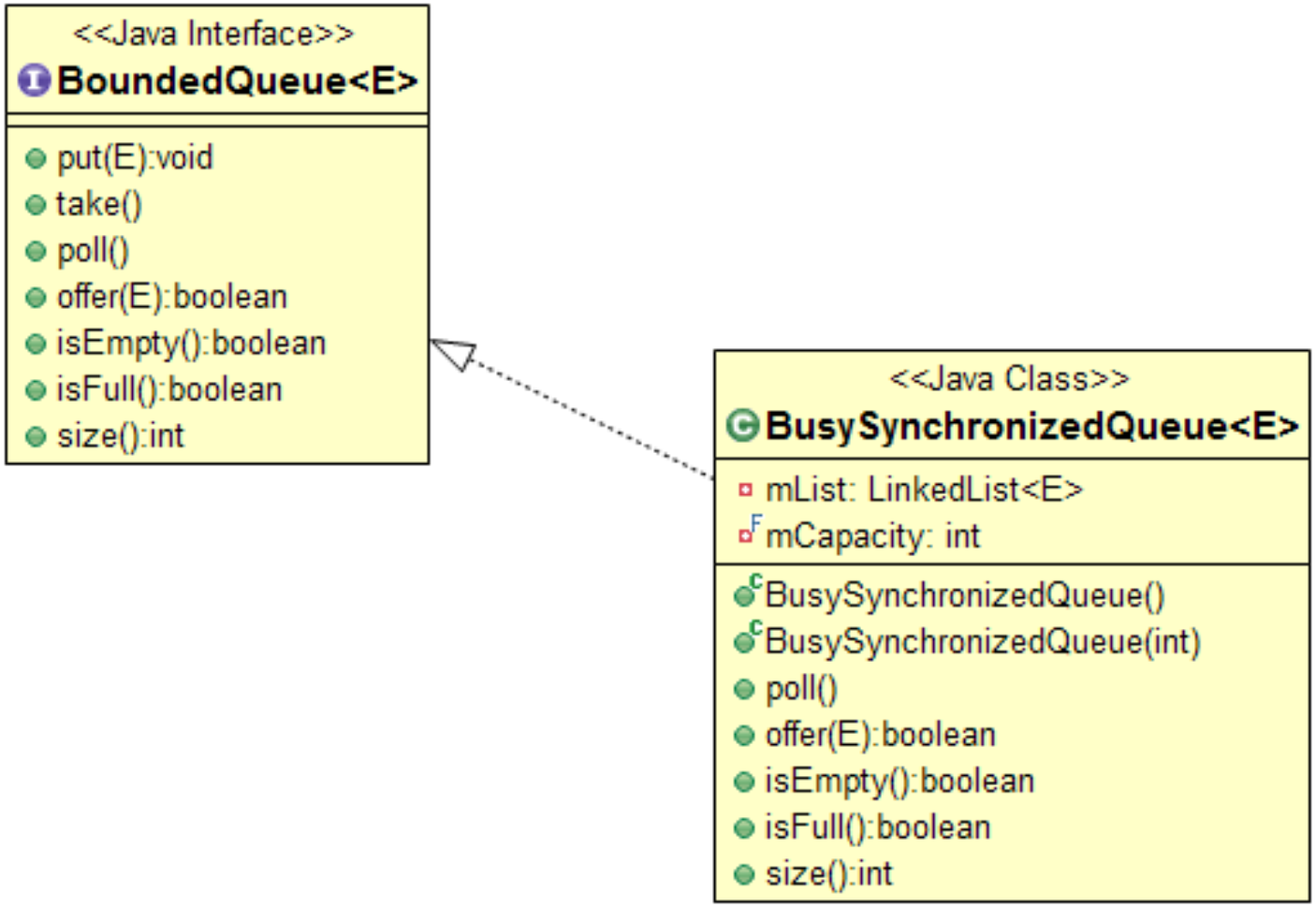
- The BusySynchronizedQueue is modeled on the Java ArrayBoundedQueue



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

Partial Solution Using Java Synchronized Methods

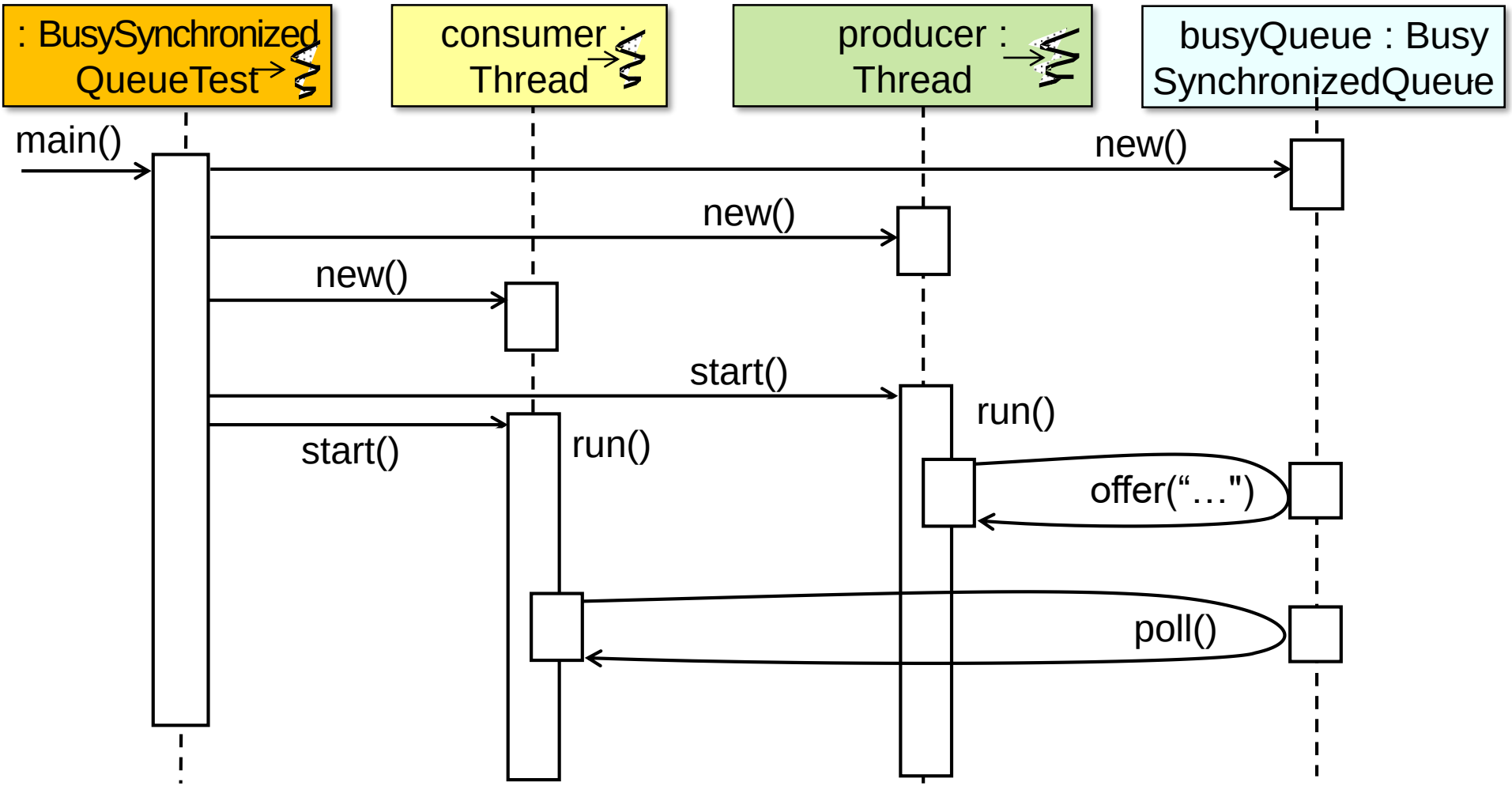
- UML class diagram showing the design of the BusySynchronizedQueue



See gM3/Queues/BusySynchronizedQueue/app/src/main/java/edu/vandy/busysynchronizedqueue/model

Partial Solution Using Java Synchronized Methods

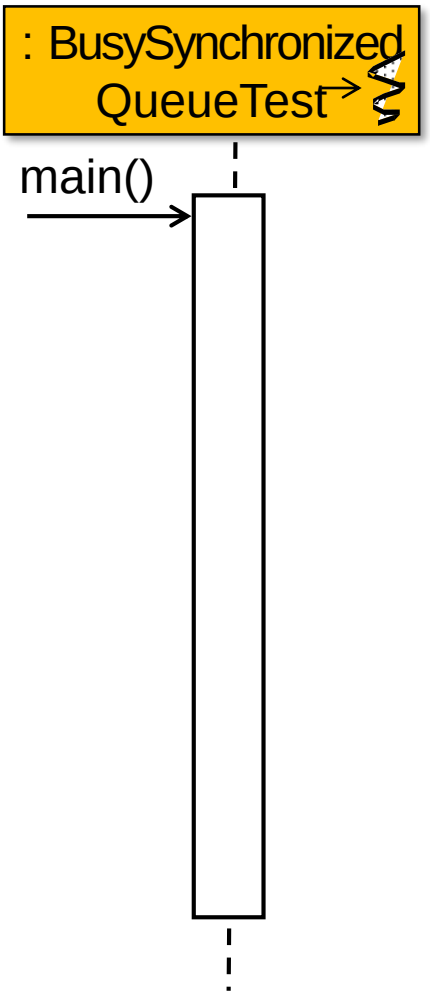
- UML sequence diagram of the BusySynchronizedQueue unit test



See github.com/douglascraigschmidt/POSA/tree/master/ex/M3/Queues/BusySynchronizedQueue/app/src/test/java/edu/vandy/busysynchronizedqueue

Partial Solution Using Java Synchronized Methods

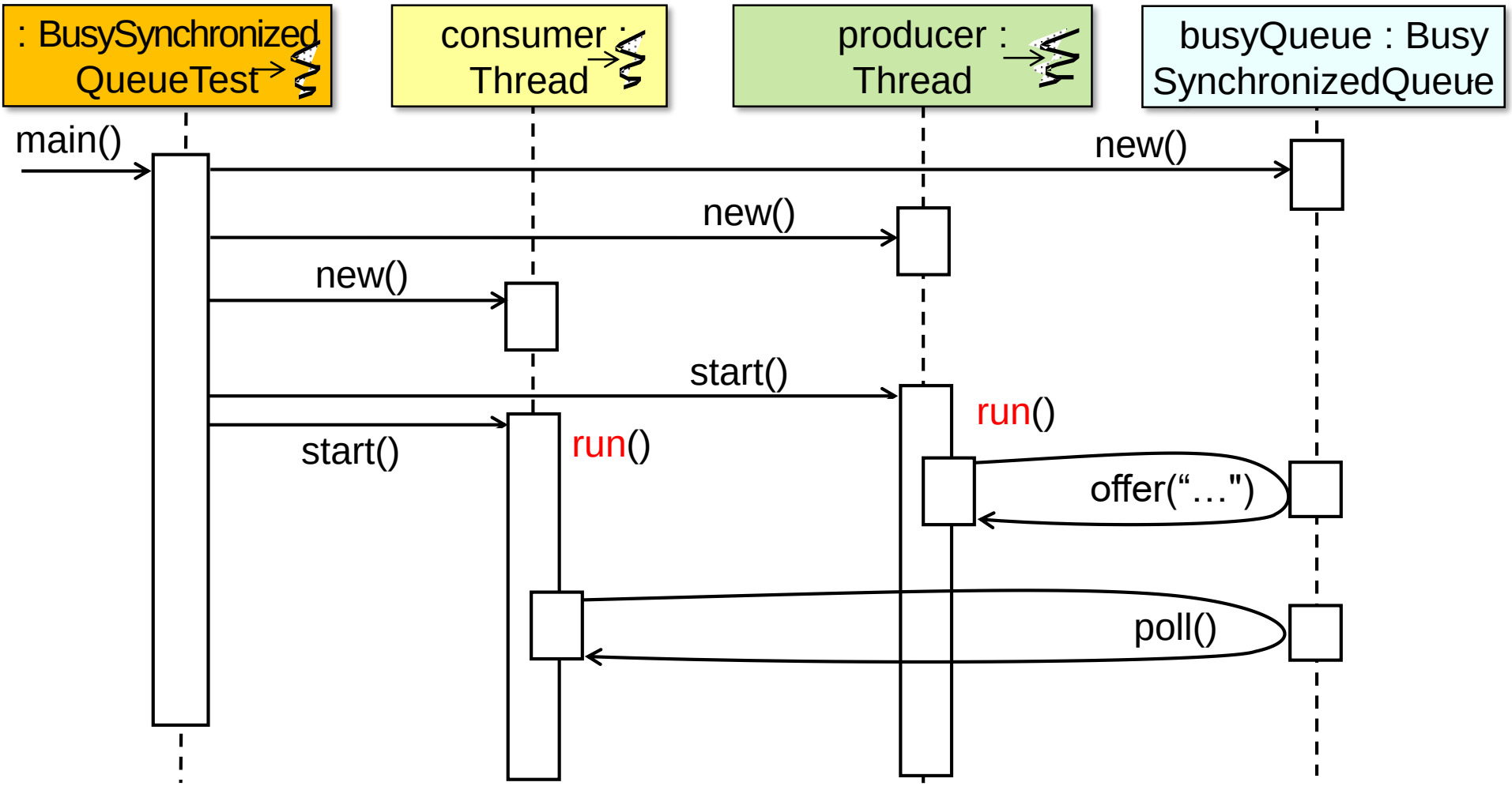
- UML sequence diagram of the BusySynchronizedQueue unit test



The main thread coordinates the other threads in the test

Partial Solution Using Java Synchronized Methods

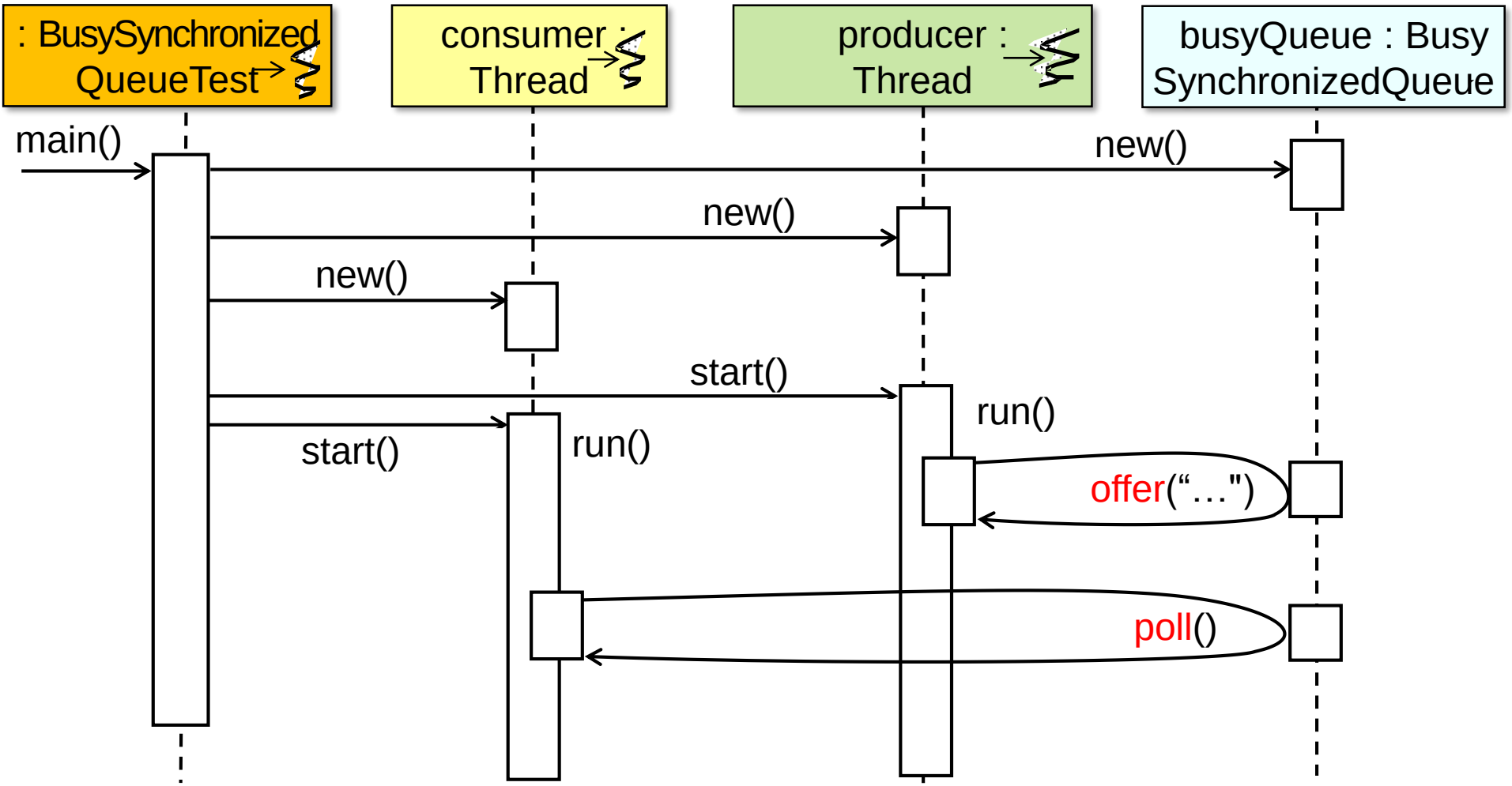
- UML sequence diagram of the BusySynchronizedQueue unit test



The consumer & producer threads generate & process messages sent via the BusySynchronizedQueue, respectively

Partial Solution Using Java Synchronized Methods

- UML sequence diagram of the BusySynchronizedQueue unit test



Although the test runs correctly (since offer() & poll() are synchronized) it is inefficient due to the "busy waiting"!!

Implementation of the BusySynchronizedQueue

Implementation of the BusySynchronizedQueue

- Java synchronized methods protects critical sections from concurrent access

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

  public BusySynchronizedQueue(int capacity) {
    mCapacity = capacity; mList = new LinkedList<>();
  }

  public synchronized boolean offer(E e) {
      if (!isFull()) { mList.add(e); return true; }
      else
         return false;
    }



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

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

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```

Only one synchronized method at a time can be active in any given object

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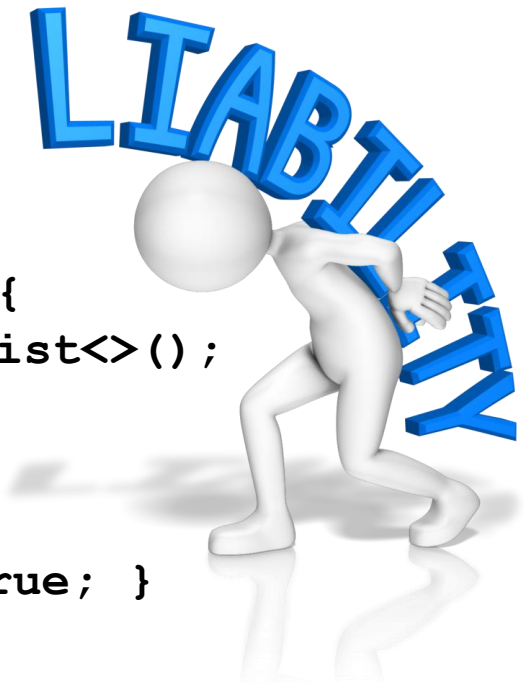

May be a liability for concurrently accessed objects, e.g., double-ended queues implemented as linked lists

See cs.nyu.edu/courses/fall07/G22.2631-001/lists.slides2.pdf

Implementation of the BusySynchronizedQueue

- Adding the synchronized keyword has two effects


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

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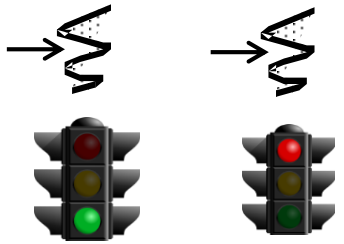

Invocations of offer() & poll() on the same object can't interleave

i.e., each synchronized method is "atomic"

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```

Establishes a "happens-before" relation to ensure visibility of state changes to all threads

See en.wikipedia.org/wiki/Happened-before

End of Java Monitor Objects: Synchronized Method Example