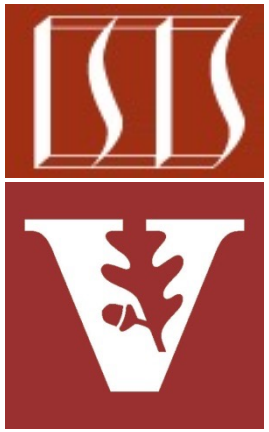
The Pervasiveness & Complexity of Java Synchronizers



Douglas C. Schmidt
d.schmidt@vanderbilt.edu
www.dre.vanderbilt.edu/~schmidt

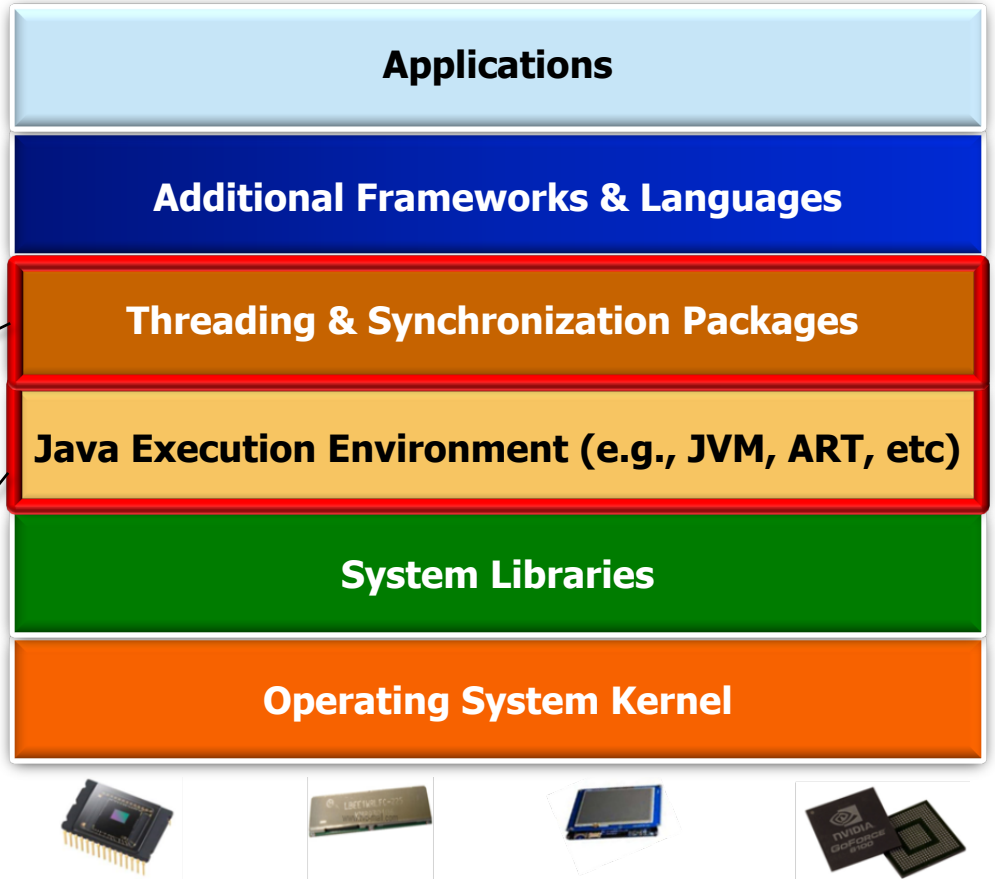
Institute for Software Integrated Systems
Vanderbilt University
Nashville, Tennessee, USA

Learning Objectives in this Part of the Lesson

- Be aware of the Java memory model
- Understand the purpose of Java synchronizers
- Recognize the pervasiveness of Java synchronizers

e.g., Java atomics, locks, & other synchronizers

e.g., volatile variables & built-in monitor objects



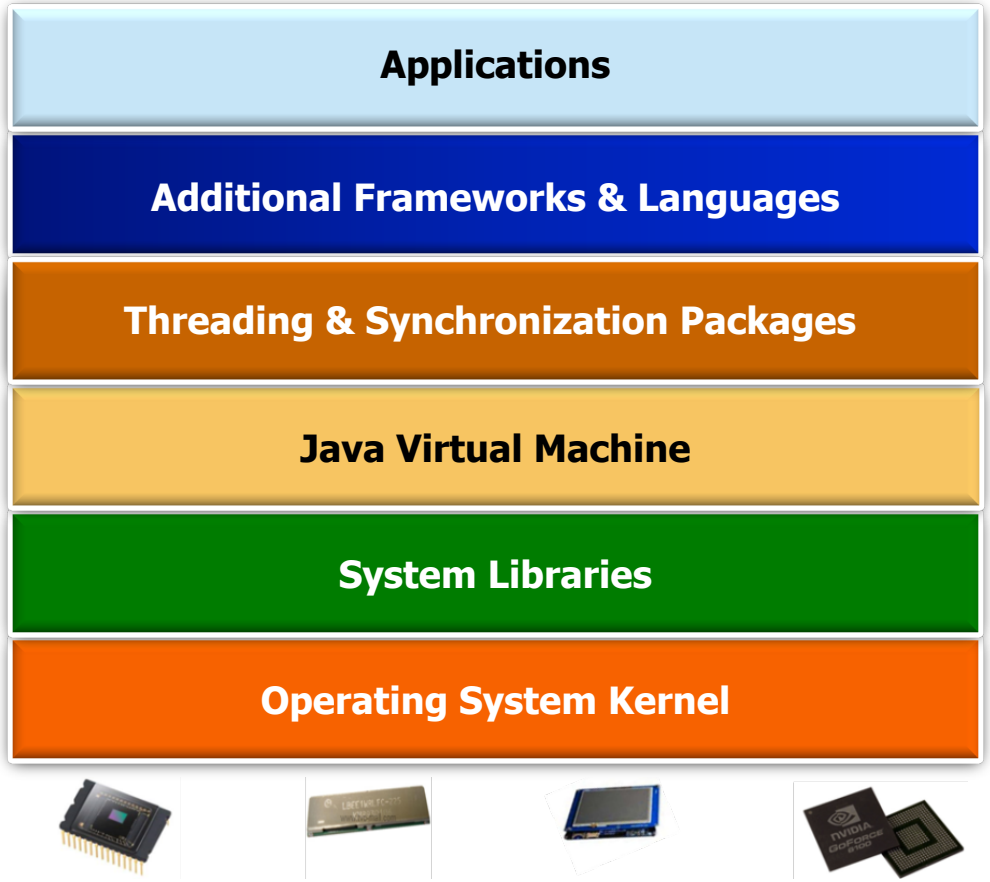
Learning Objectives in this Part of the Lesson

- Be aware of the Java memory model
- Understand the purpose of Java synchronizers
- Recognize the pervasiveness of Java synchronizers
  - As well as their complexities

The Pervasiveness of Synchronizers in Java

The Pervasiveness of Java Synchronizer Classes

- Multiple layers of synchronizers are provided on the Java platform

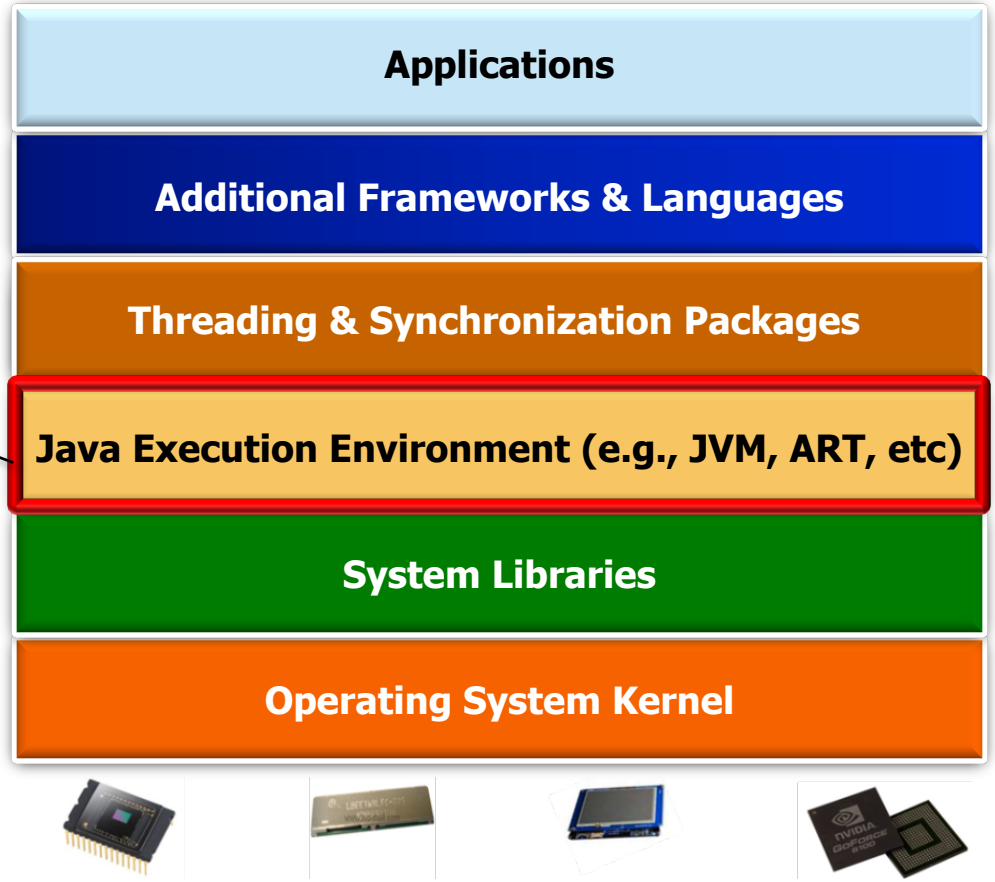


See en.wikipedia.org/wiki/Java_(software_platform)

The Pervasiveness of Java Synchronizer Classes

- Multiple layers of synchronizers are provided on the Java platform, e.g.
  - The Java language contains some features that synchronize threads

e.g., volatile variables & built-in monitor objects

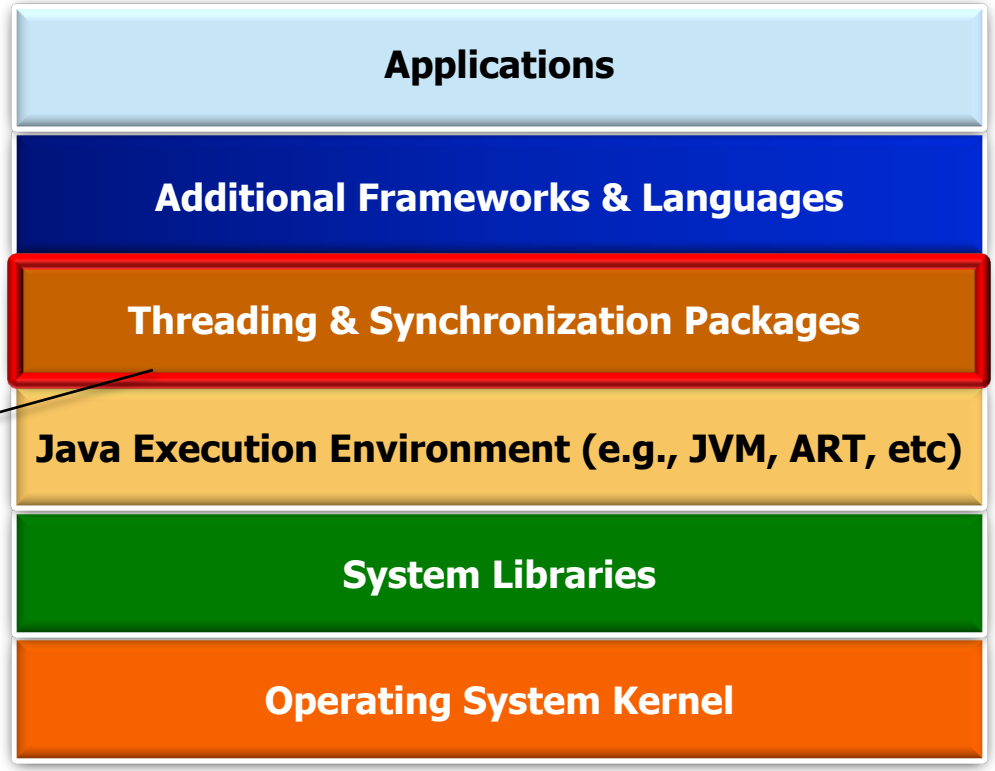


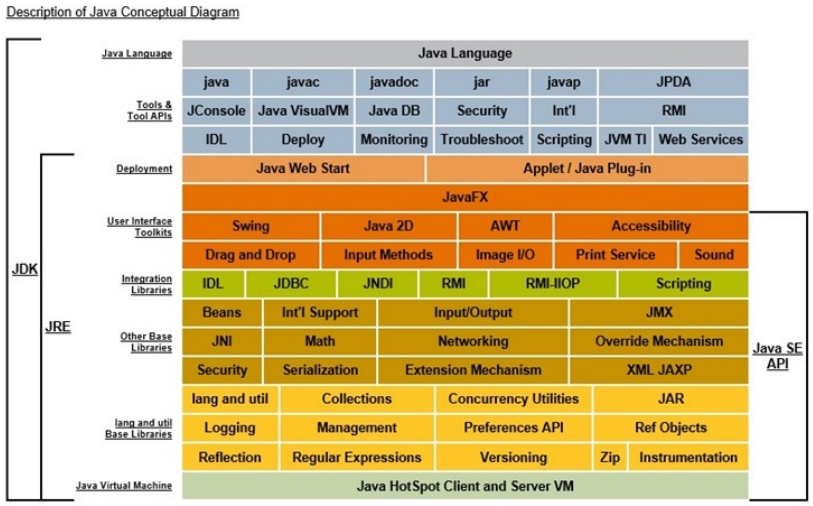
See en.wikipedia.org/wiki/Java_(programming_language)

The Pervasiveness of Java Synchronizer Classes

- Multiple layers of synchronizers are provided on the Java platform, e.g.
  - The Java language contains some features that synchronize threads
  - Other synchronizers are provided by the Java Class Library

e.g., Java atomics, various locks, conditions, semaphores, & barriers





See en.wikipedia.org/wiki/Java_Class_Library

The Complexities of Synchronizers in Java

The Complexities of Java Synchronizer Classes

- Synchronization complexity arises from coordinating the interactions of entities that run concurrently

The Complexities of Java Synchronizer Classes

- There are two general type of synchronization complexities

See en.wikipedia.org/wiki/No_Silver_Bullet

The Complexities of Java Synchronizer Classes

- There are two general type of synchronization complexities
  - **Inherent complexities**

These fundamental challenges constitute the "rocket science" of the synchronization domain

See www.informit.com/articles/article.aspx?p=726130&seqNum=2

The Complexities of Java Synchronizer Classes

- There are two general type of synchronization complexities
  - **Inherent complexities**
    - *Mutual Exclusion*
      - Ensure concurrent threads don't simultaneously run in a program's critical sections

Race conditions arise when an application depends on the sequence or timing of threads for it to operate properly

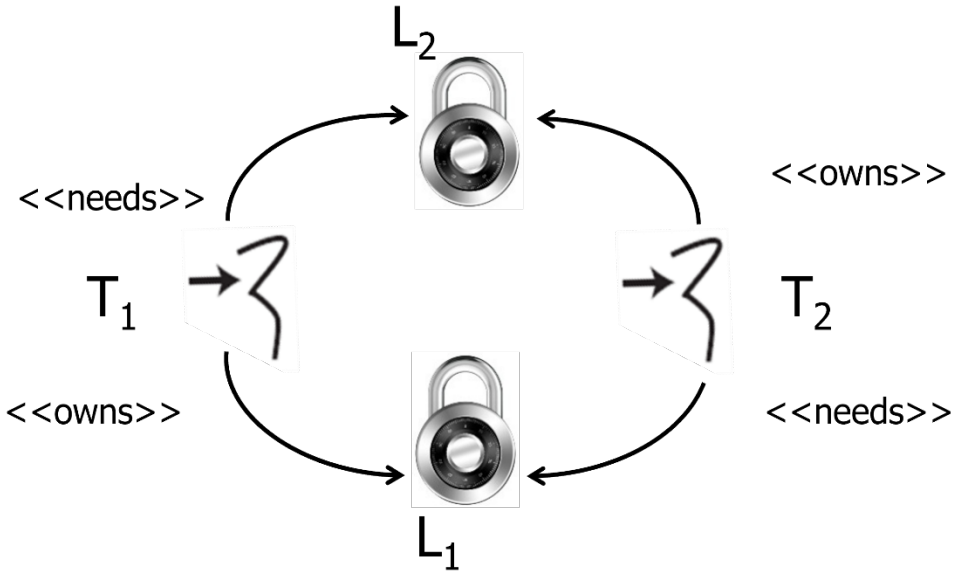
See en.wikipedia.org/wiki/Race_condition

The Complexities of Java Synchronizer Classes

- There are two general type of synchronization complexities
  - **Inherent complexities**
    - *Mutual Exclusion*
    - *Coordination*
      - Manage the order or time in which operations are performed to ensure threads access system resources correctly & efficiently

The Complexities of Java Synchronizer Classes

- There are two general type of synchronization complexities
  - **Inherent complexities**
    - *Mutual Exclusion*
    - *Coordination*
    - *Deadlock*
      - Occurs when 2+ competing actions each wait for the other to finish, & thus none ever do



The Complexities of Java Synchronizer Classes

- There are two general type of synchronization complexities
  - Inherent complexities
  - **Accidental complexities**

These complexities arise from common limitations with techniques, tools, & methods used to synchronize programs

See wiki.c2.com/?AccidentalComplexity

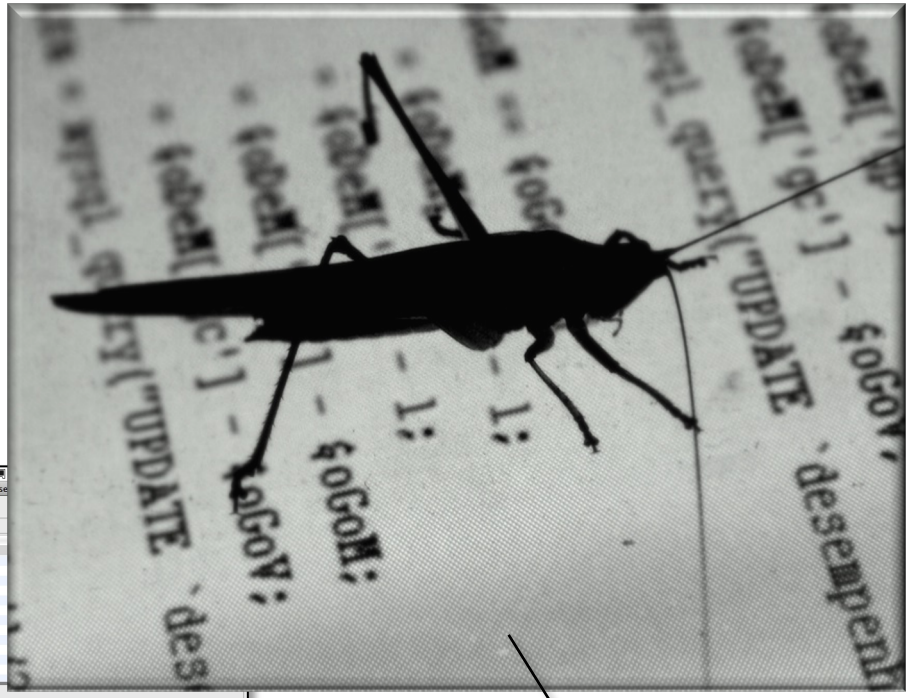
The Complexities of Java Synchronizer Classes

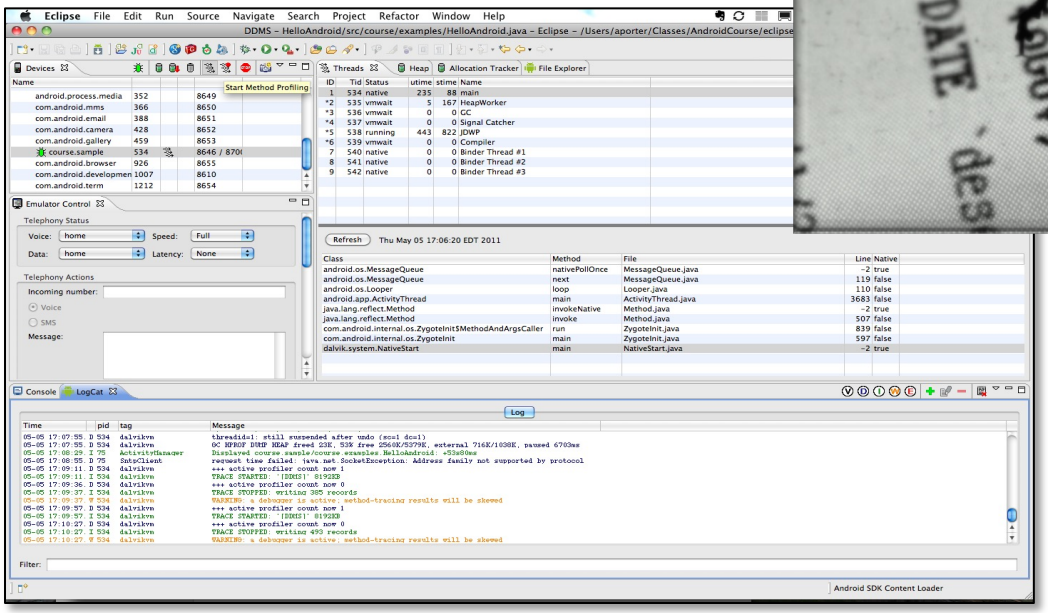
- There are two general type of synchronization complexities
  - **Inherent complexities**
  - **Accidental complexities**
    - Tool limitations make it hard to debug concurrent programs

See en.wikipedia.org/wiki/Trepanning for more on traditional "debugging" techniques!

The Complexities of Java Synchronizer Classes

- There are two general type of synchronization complexities
  - Inherent complexities
  - **Accidental complexities**
    - Tool limitations make it hard to debug concurrent programs
      - The behavior in the debugger doesn't reflect actual behavior



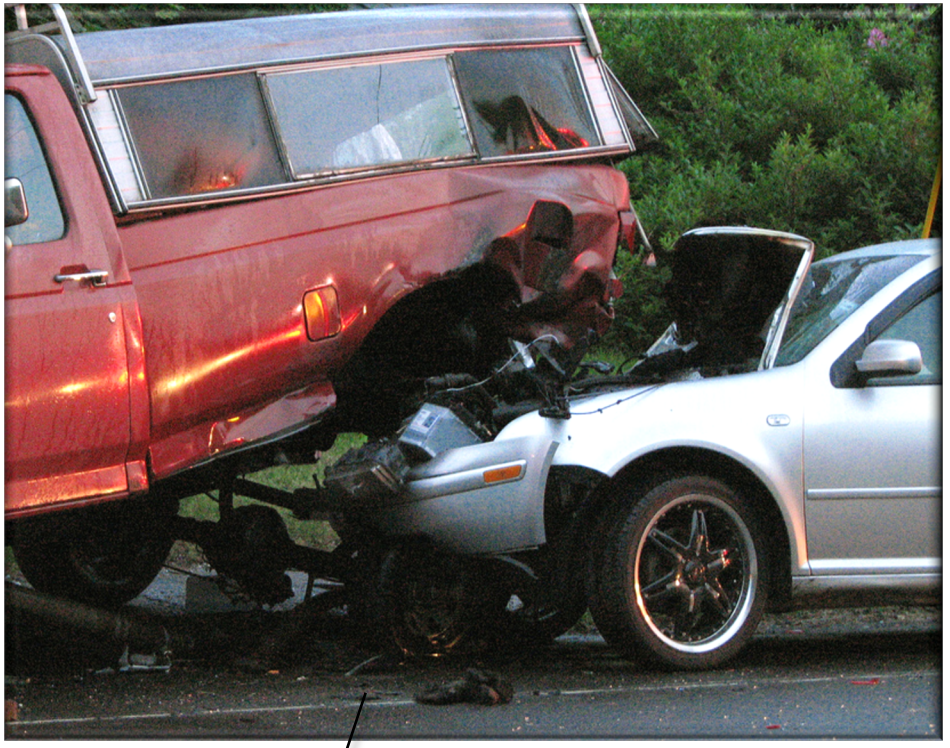


The very act of observing a program can alter its state

See en.wikipedia.org/wiki/Heisenbug

The Complexities of Java Synchronizer Classes

- There are two general type of synchronization complexities
  - **Inherent complexities**
  - **Accidental complexities**
    - Tool limitations make it hard to debug concurrent programs
      - The behavior in the debugger doesn't reflect actual behavior
      - Lack of tool support to identify & rectify *race conditions*

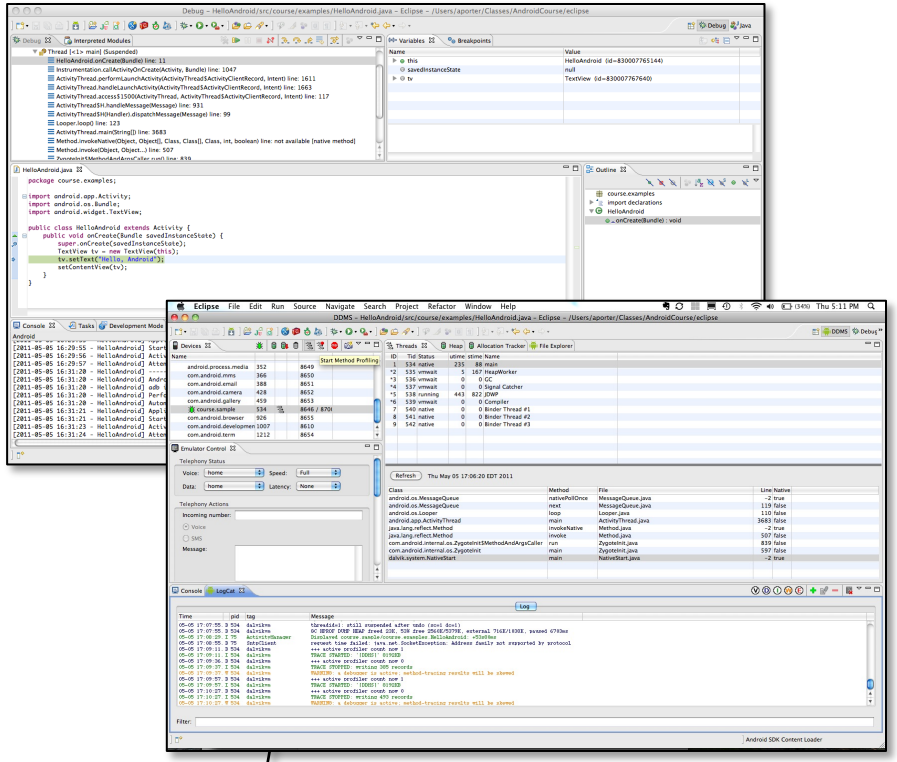


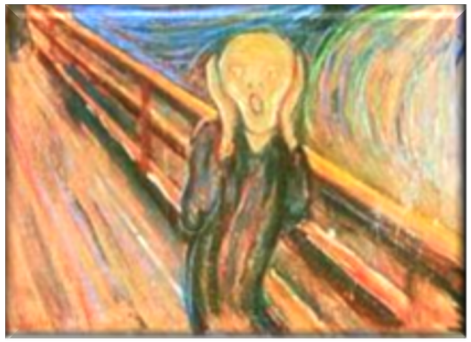
Occur when multiple threads "crash" into unprotected data structures & corrupt them

See en.wikipedia.org/wiki/Race_condition

The Complexities of Java Synchronizer Classes

- There are two general type of synchronization complexities
  - **Inherent complexities**
  - **Accidental complexities**
    - Tool limitations make it hard to debug concurrent programs
      - The behavior in the debugger doesn't reflect actual behavior
      - Lack of tool support to identify & rectify *race conditions*
        - Conventional Java debuggers don't detect race conditions

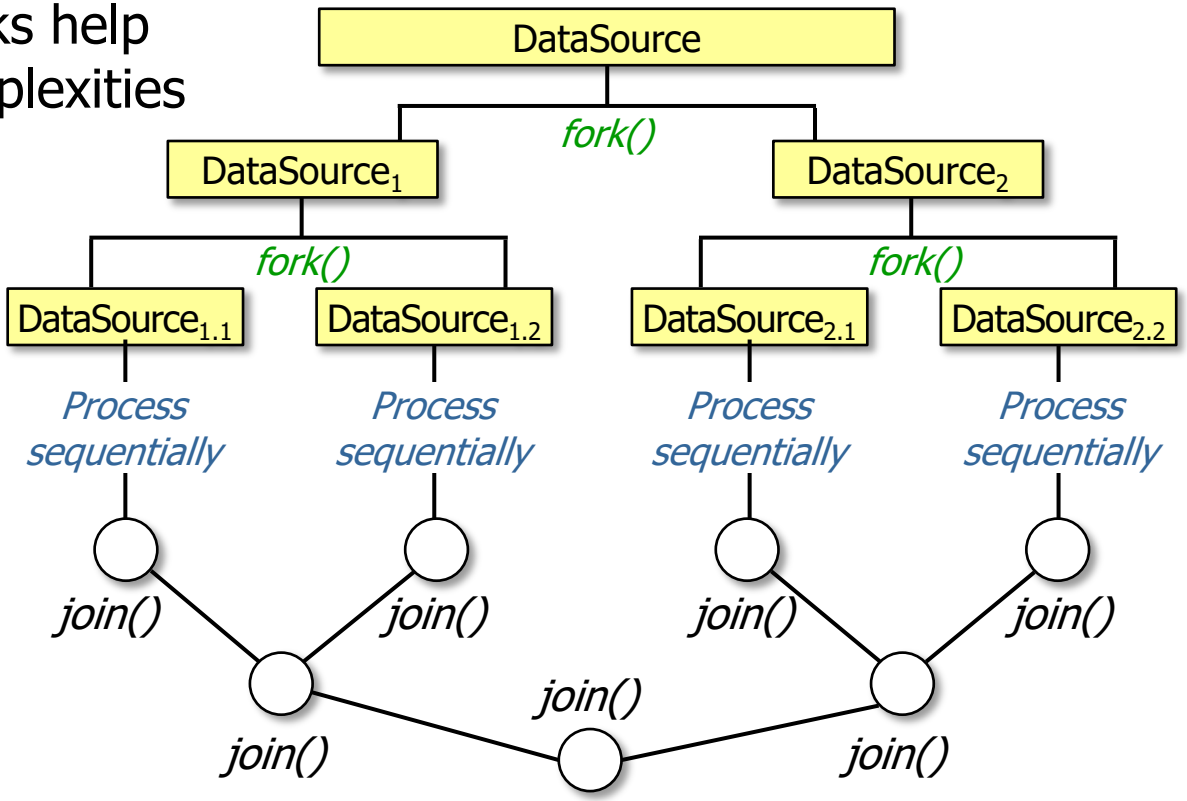




Problems often don't surface until runtime

The Complexities of Java Synchronizer Classes

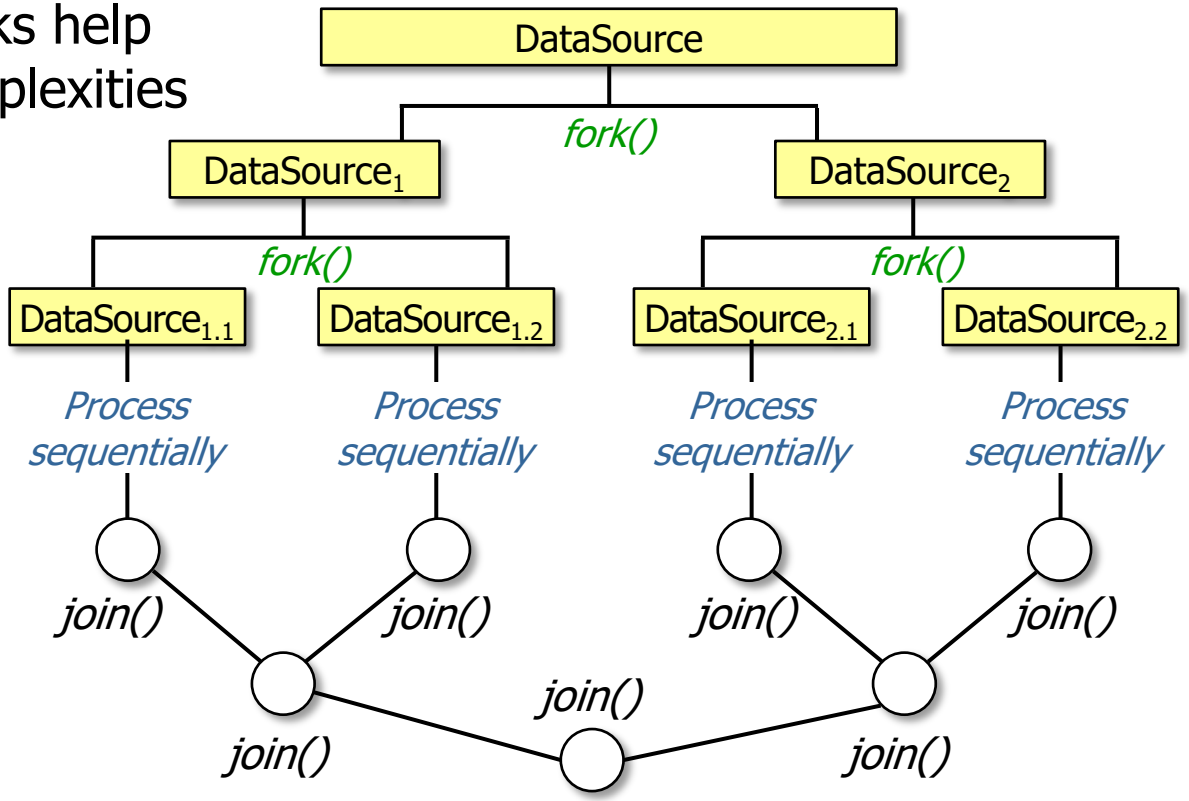
- Java's parallelism frameworks help reduce synchronization complexities via "divide & conquer"



See en.wikipedia.org/wiki/Divide-and-conquer_algorithm

The Complexities of Java Synchronizer Classes

- Java's parallelism frameworks help reduce synchronization complexities via "divide & conquer"
  - These frameworks largely eliminate the need for synchronization when writing concurrent apps



End of the Pervasiveness & Complexity of Java Synchronizers