Overview of Concurrency in Java

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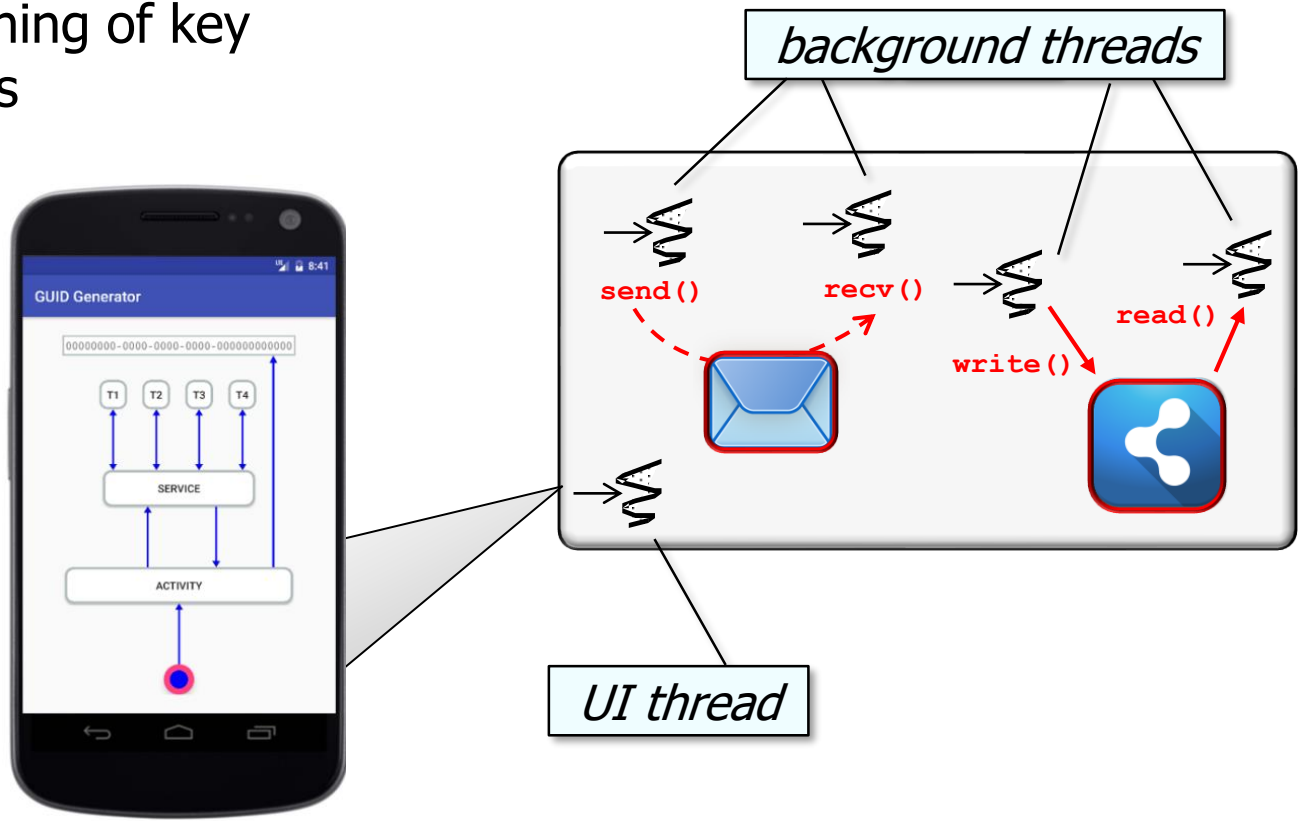
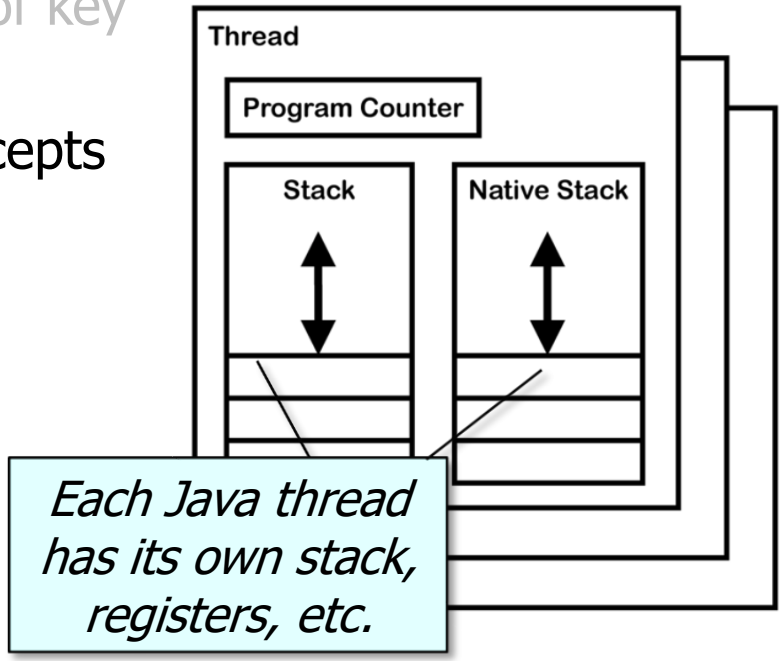
Learning Objectives in this Lesson

- Understand the meaning of key concurrency concepts



Learning Objectives in this Lesson

- Understand the meaning of key concurrency concepts
- Recognize how these concepts are supported in Java



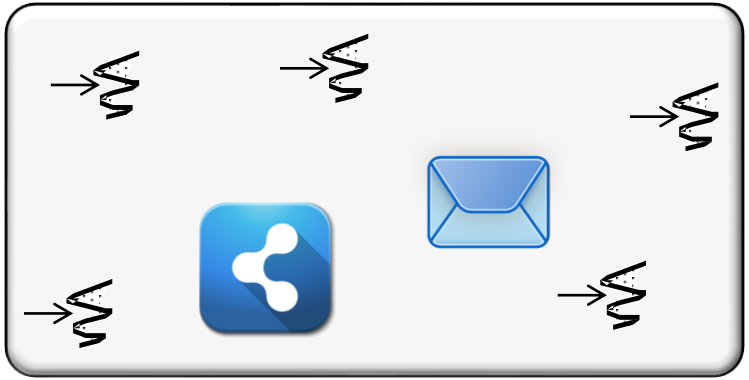
<<Java Class>>
Thread

- yield():void
- currentThread():Thread
- sleep(long):void
- sleep(long,int):void
- Thread()
- Thread(Runnable)
- Thread(String)
- start():void
- run():void
- exit():void
- interrupt():void
- interrupted():boolean
- isInterrupted():boolean
- isAlive():boolean
- setPriority(int):void
- getPriority():int
- join(long):void
- join(long,int):void
- join():void
- setDaemon(boolean):void
- isDaemon():boolean

An Overview of Concurrency

An Overview of Concurrency

- Concurrency is a form of computing where threads can run simultaneously

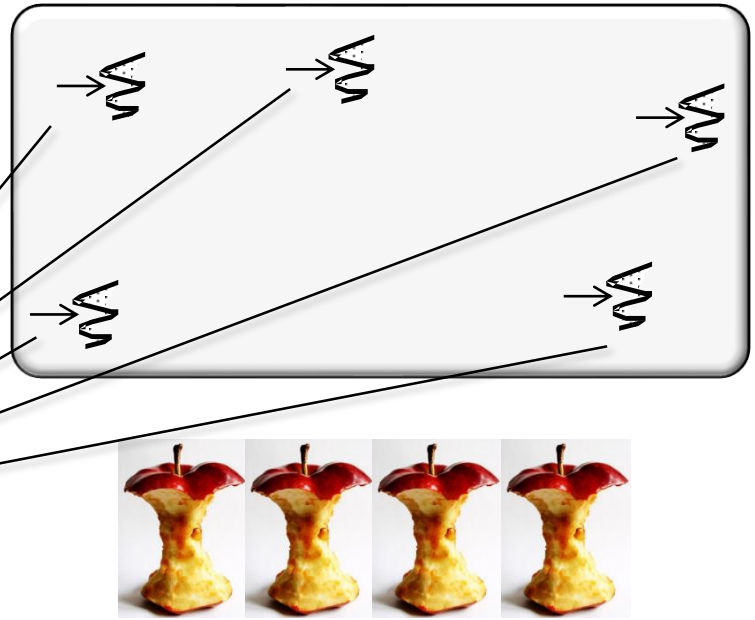


See en.wikipedia.org/wiki/Concurrency_(computer_science)

An Overview of Concurrency

- Concurrency is a form of computing where threads can run simultaneously

```
new Thread(() ->
            someComputations()).
            start();
```

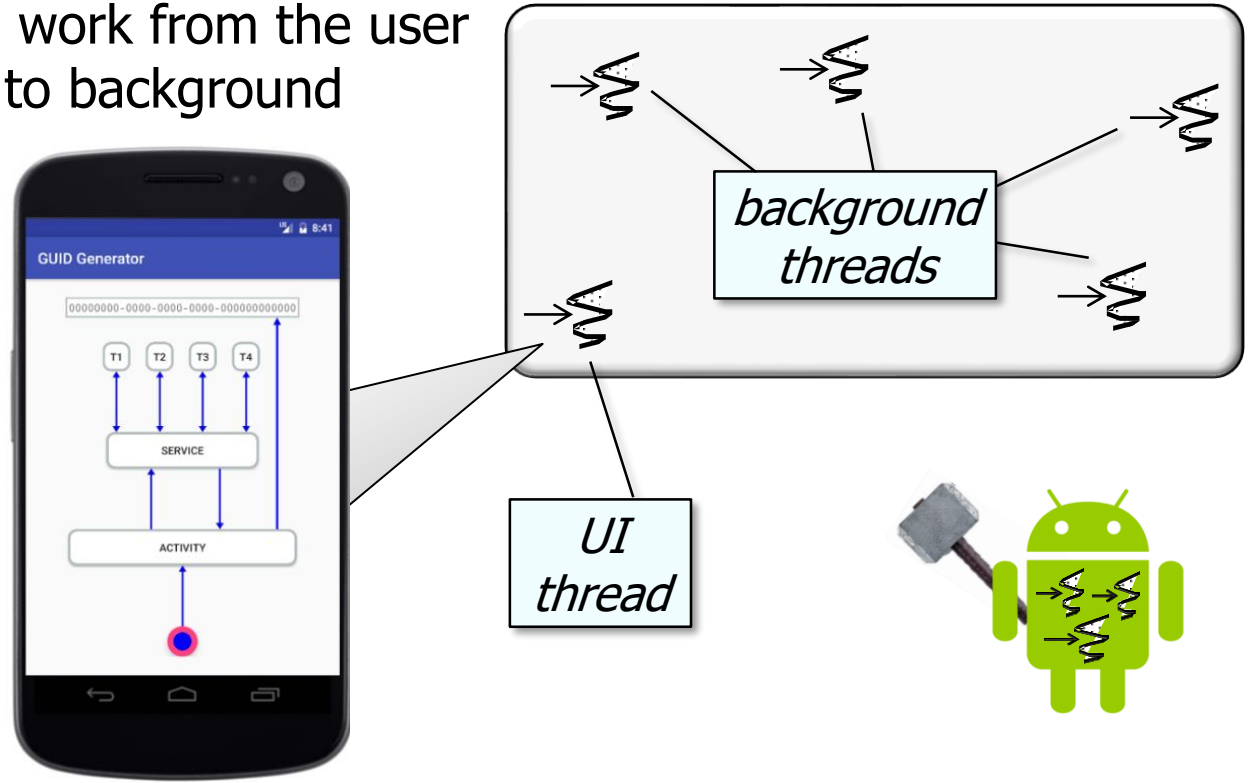


A thread is a unit of execution for instruction streams that can run concurrently on processor cores

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

An Overview of Concurrency

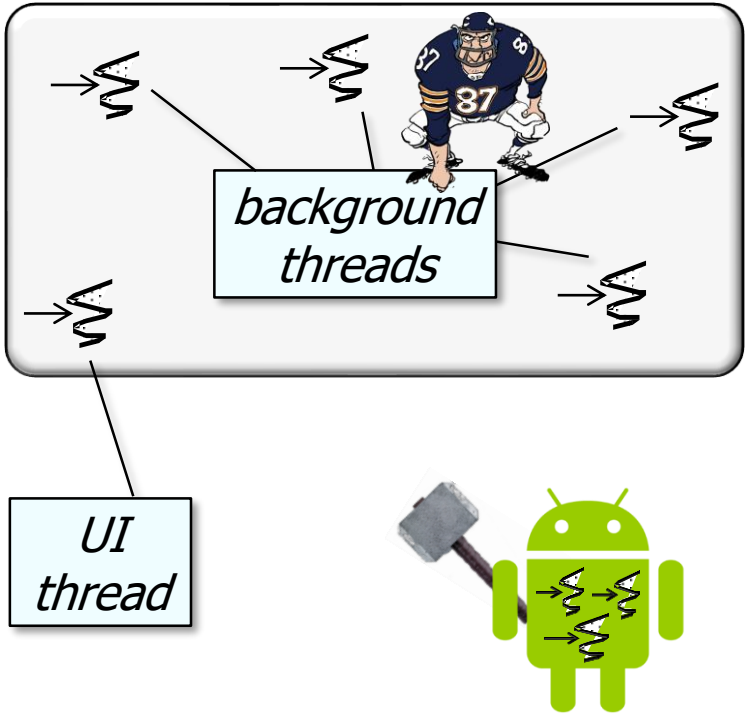
- Concurrency is a form of computing where threads can run simultaneously
  - Often used to offload work from the user interface (UI) thread to background thread(s)



See developer.android.com/topic/performance/threads.html

An Overview of Concurrency

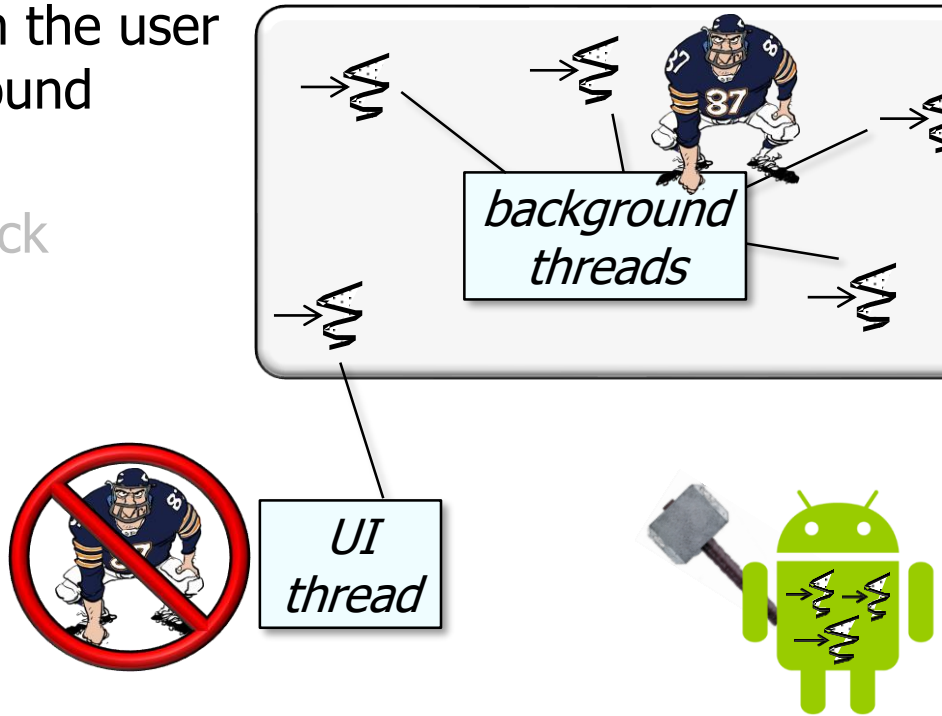
- Concurrency is a form of computing where threads can run simultaneously
  - Often used to offload work from the user interface (UI) thread to background thread(s), e.g.
    - Background thread(s) can block



See developer.android.com/training/multiple-threads/communicate-ui.html

An Overview of Concurrency

- Concurrency is a form of computing where threads can run simultaneously
  - Often used to offload work from the user interface (UI) thread to background thread(s), e.g.
    - Background thread(s) can block
    - The UI thread does not block



See developer.android.com/training/multiple-threads/communicate-ui.html

An Overview of Concurrency in Java

An Overview of Concurrency in Java

- A Java thread is an object

Class Thread

java.lang.Object
    java.lang.Thread

All Implemented Interfaces:

Runnable

Direct Known Subclasses:

ForkJoinWorkerThread

```
public class Thread
extends Object
implements Runnable
```

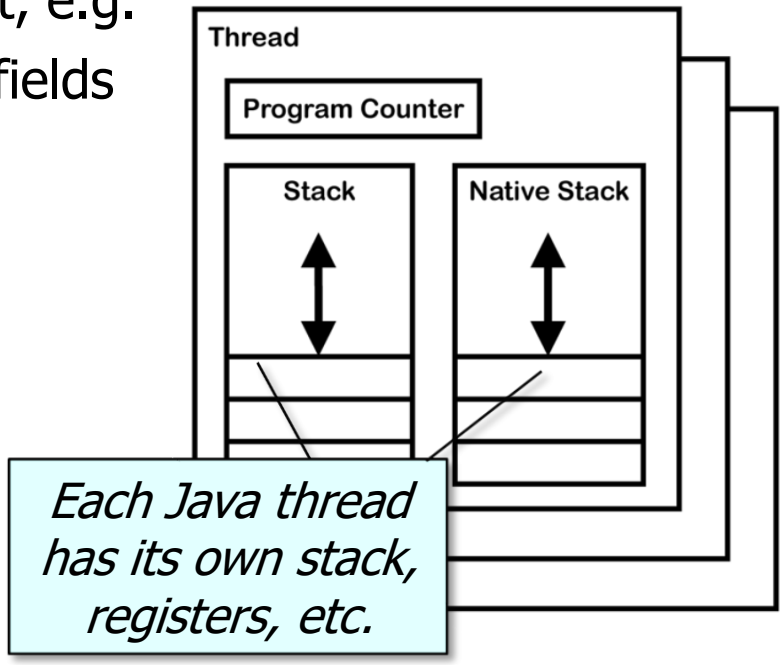
A *thread* is a thread of execution in a program. The Java Virtual Machine allows an application to have multiple threads of execution running concurrently.

Every thread has a priority. Threads with higher priority are executed in preference to threads with lower priority. Each thread may or may not also be marked as a daemon. When code running in some thread creates a new `Thread` object, the new thread has its priority initially set equal to the priority of the creating thread, and is a daemon thread if and only if the creating thread is a daemon.

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

An Overview of Concurrency in Java

- A Java thread is an object, e.g.
  - It contains methods & fields



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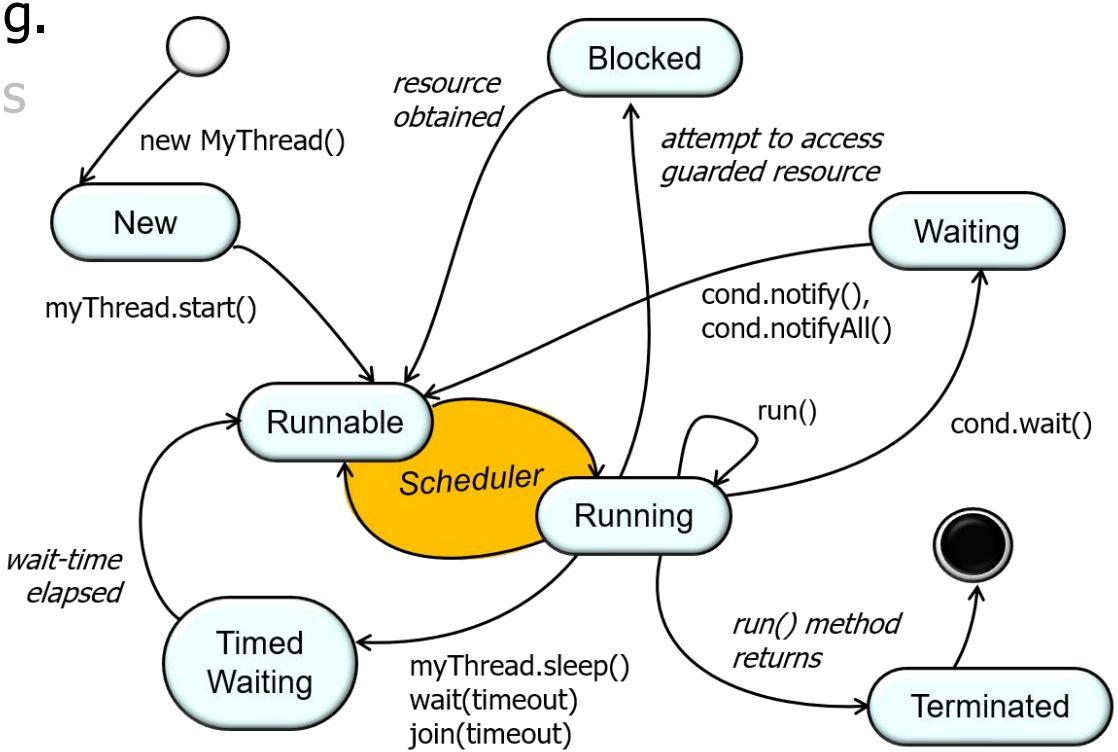
See blog.jamesdbloom.com/JVMInternals.html

An Overview of Concurrency in Java

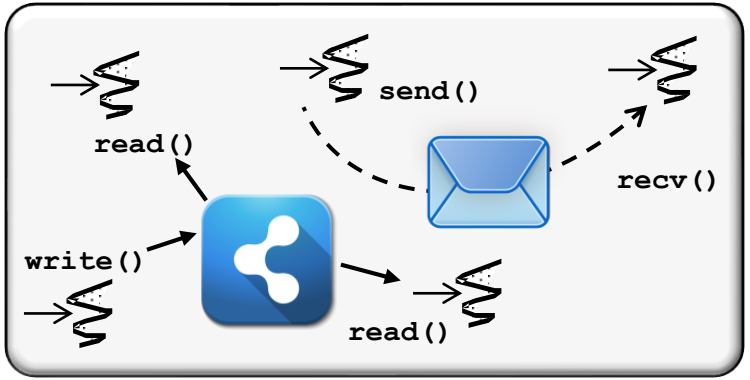
- A Java thread is an object, e.g.
  - It contains methods & fields
  - It can also be in one of various "states"



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

An Overview of Concurrency in Java

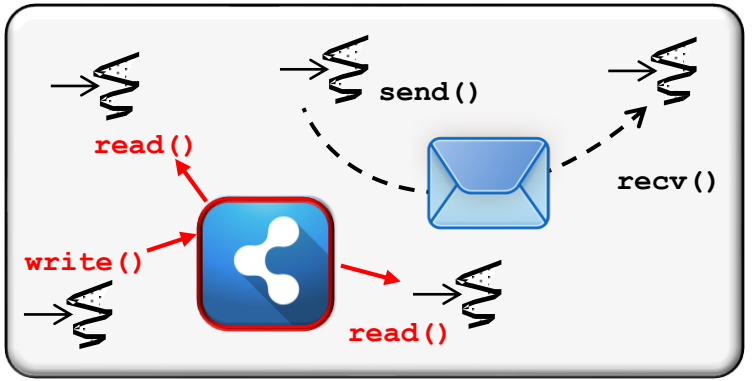
- Concurrent Java threads interact via shared objects and/or message passing

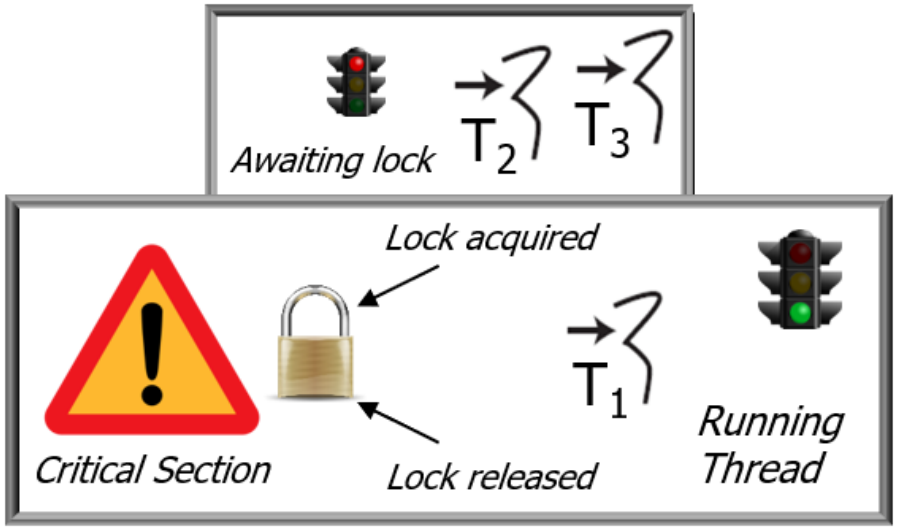


See docs.oracle.com/javase/8/docs/api/?java/util/concurrent/package-summary.html

An Overview of Concurrency in Java

- Concurrent Java threads interact via shared objects and/or message passing
  - **Shared objects**
    - Synchronize concurrent operations on objects to ensure certain properties

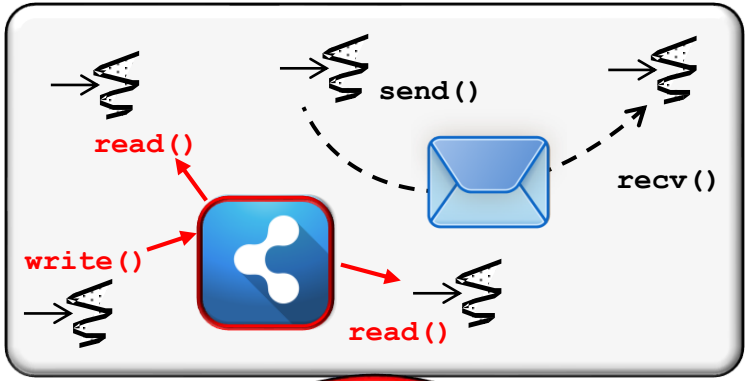




See en.wikipedia.org/wiki/Synchronization_(computer_science)

An Overview of Concurrency in Java

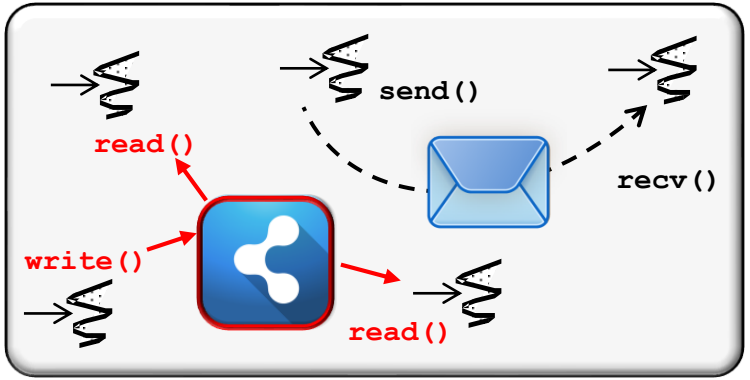
- Concurrent Java threads interact via shared objects and/or message passing
  - **Shared objects**
    - Synchronize concurrent operations on objects to ensure certain properties, e.g.
      - *Mutual exclusion*
        - Interactions between threads won't corrupt shared mutable data



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

An Overview of Concurrency in Java

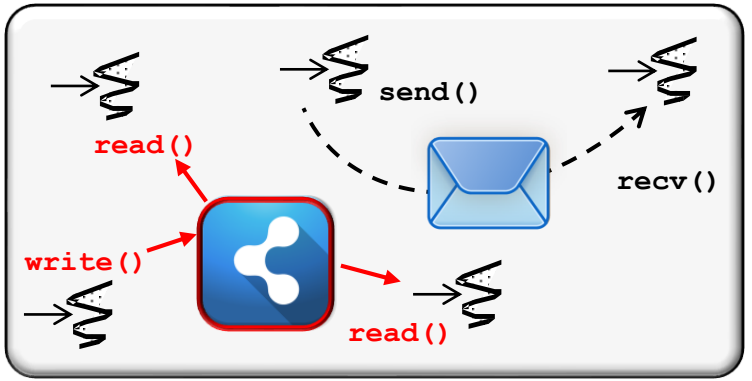
- Concurrent Java threads interact via shared objects and/or message passing
  - **Shared objects**
    - Synchronize concurrent operations on objects to ensure certain properties, e.g.
      - *Mutual exclusion*
      - *Coordination*
        - Operations occur in the right order, at the right time, & under the right conditions



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

An Overview of Concurrency in Java

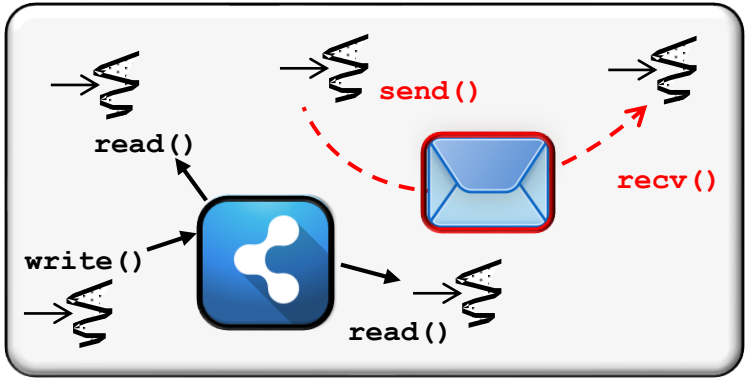
- Concurrent Java threads interact via shared objects and/or message passing
  - **Shared objects**
    - Synchronize concurrent operations on objects to ensure certain properties
    - Examples of Java synchronizers:
      - Synchronized statements/methods
      - Reentrant locks & intrinsic locks
      - Atomic operations
      - Semaphores
      - Condition objects
      - "Compare-and-swap" (CAS) operations in sun.misc.unsafe

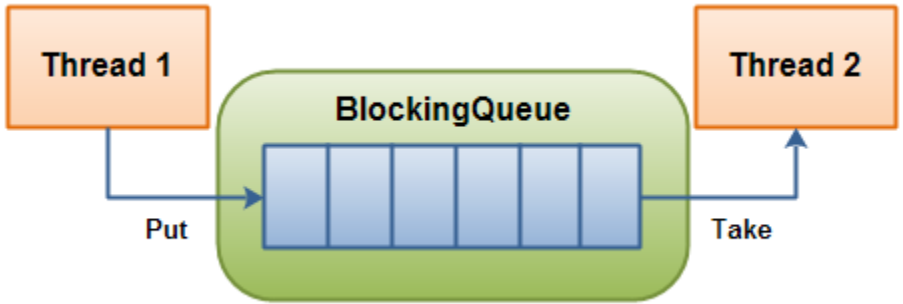


See dzone.com/articles/the-java-synchronizers

An Overview of Concurrency in Java

- Concurrent Java threads interact via shared objects and/or message passing
  - Shared objects
  - **Message passing**
    - Send message(s) from producer thread(s) to consumer thread(s) via a thread-safe queue

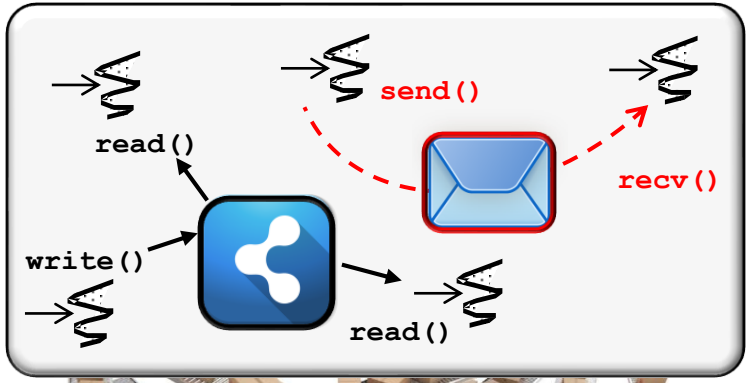


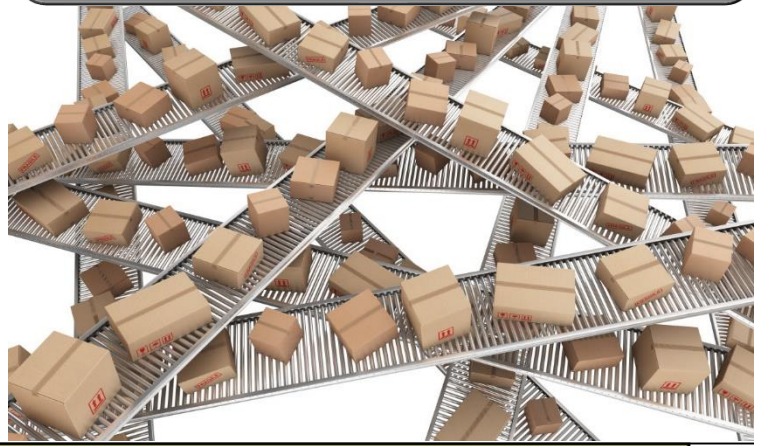


See en.wikipedia.org/wiki/Message_passing

An Overview of Concurrency in Java

- Concurrent Java threads interact via shared objects and/or message passing
  - **Shared objects**
  - **Message passing**
    - Send message(s) from producer thread(s) to consumer thread(s) via a thread-safe queue
    - Examples of Java thread-safe queues
      - Array & linked blocking queues
      - Priority blocking queue
      - Synchronous queue
      - Concurrent linked queue





See docs.oracle.com/javase/tutorial/collections/implementations/queue.html

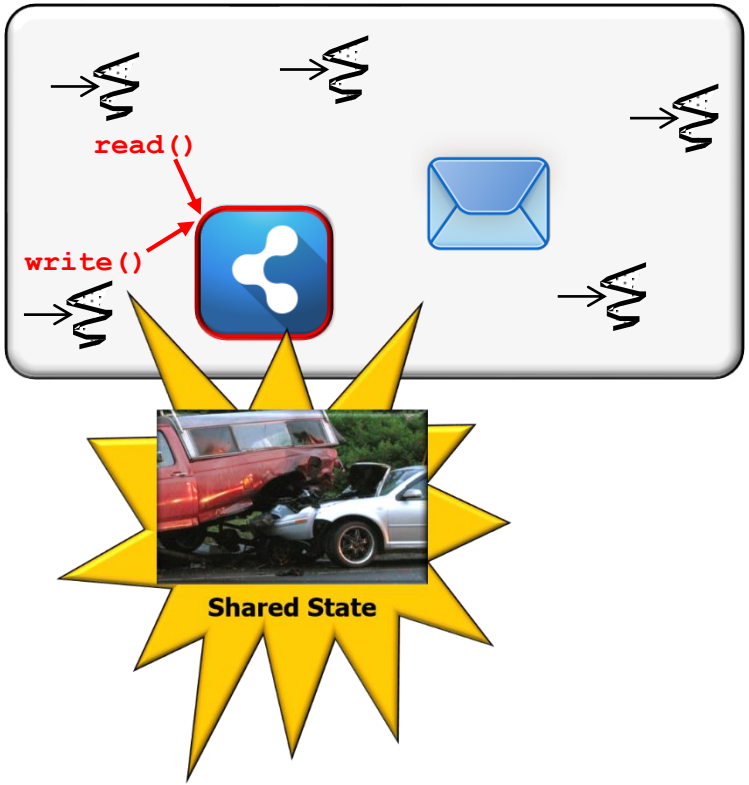
An Overview of Concurrency in Java

- Key goals of using Java shared objects and/or message passing are to share resources safely & avoid hazards

See en.wikipedia.org/wiki/Thread_safety

An Overview of Concurrency in Java

- Key goals of using Java shared objects and/or message passing are to share resources safely & avoid hazards, e.g.
  - Race conditions
    - Race conditions occur when a program depends upon the sequence or timing of threads for it to operate properly



See en.wikipedia.org/wiki/Race_condition#Software

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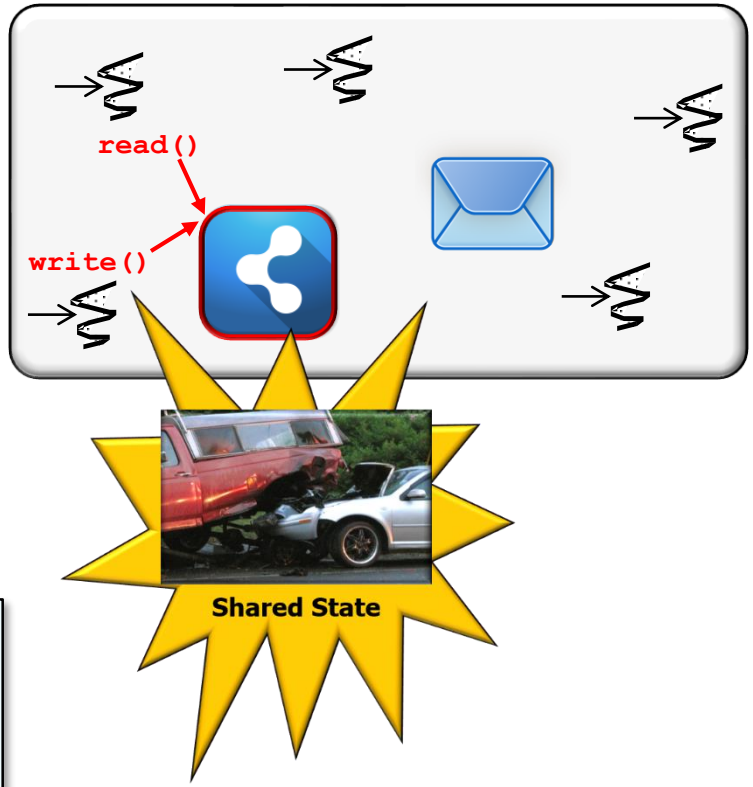


This test program induces race conditions due to lack of synchronization between producer & consumer threads accessing a bounded queue

See github.com/douglascraigschmidt/LiveLessons/tree/master/BuggyQueue

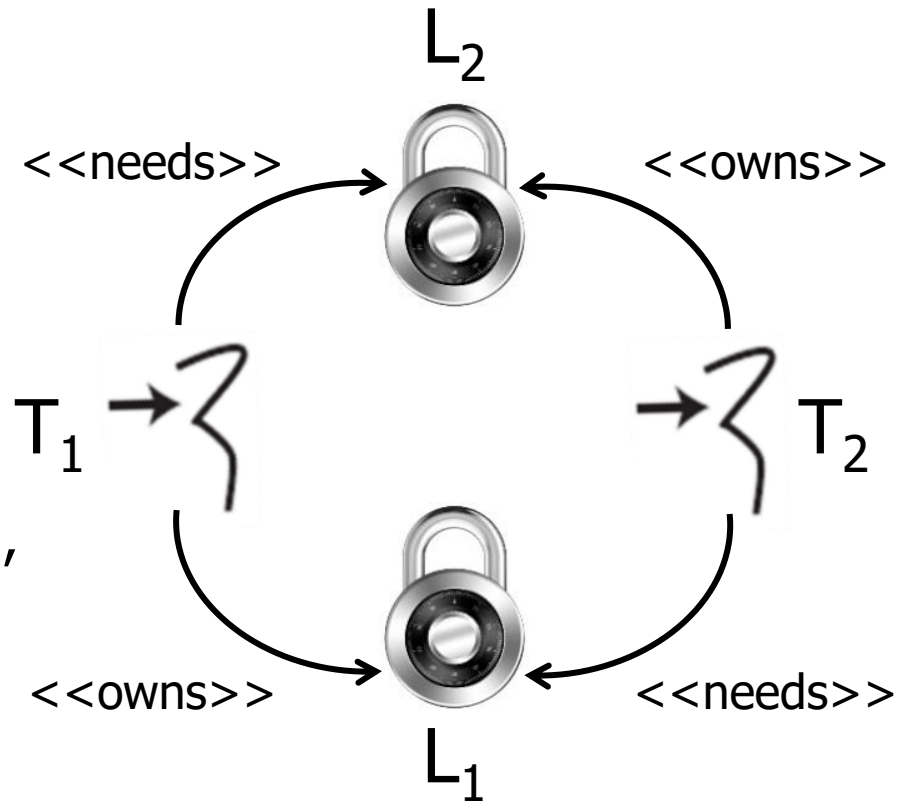
An Overview of Concurrency in Java

- Key goals of using Java shared objects and/or message passing are to share resources safely & avoid hazards, e.g.
  - Race conditions
  - Memory inconsistencies
    - These errors occur when different threads have inconsistent views of what should be the same data

See jeremymanson.blogspot.com/2007/08/atomicity-visibility-and-ordering.html

An Overview of Concurrency in Java

- Key goals of using Java shared objects and/or message passing are to share resources safely & avoid hazards, e.g.
  - Race conditions
  - Memory inconsistencies
  - Deadlocks
    - Occur when 2+ competing threads are waiting for the other(s) to finish, & thus none ever do



See en.wikipedia.org/wiki/Deadlock

End of Overview of Concurrency in Java