Background on Concurrency & Parallelism in Java (Part 1)

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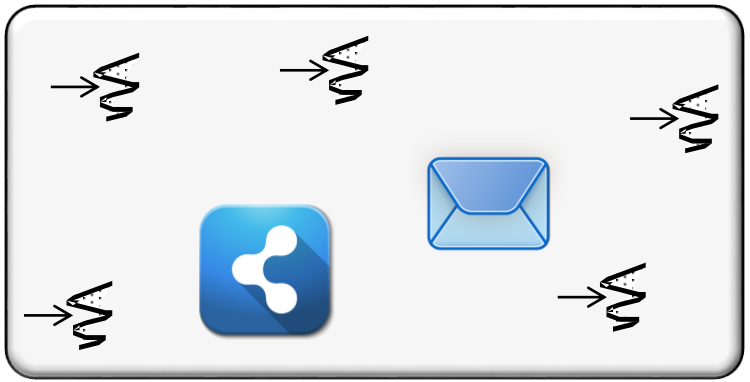
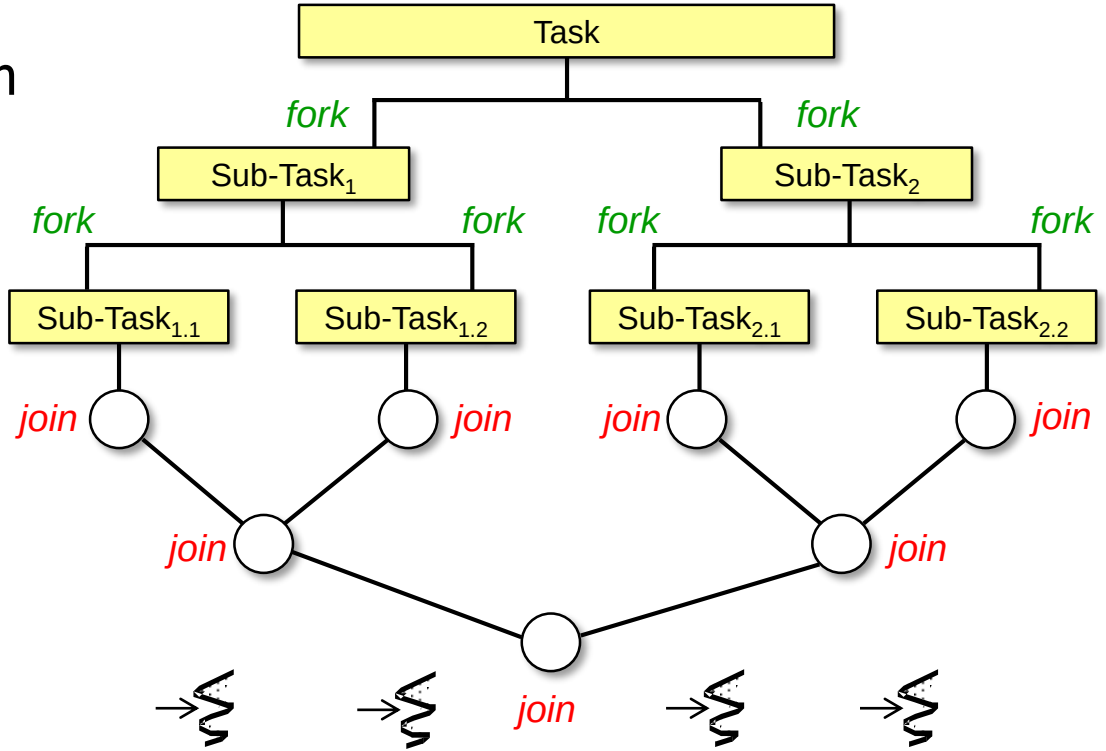
Learning Objectives in this Part of the Lesson

- Understand the meaning of the terms concurrency & parallelism





An Overview of Concurrency

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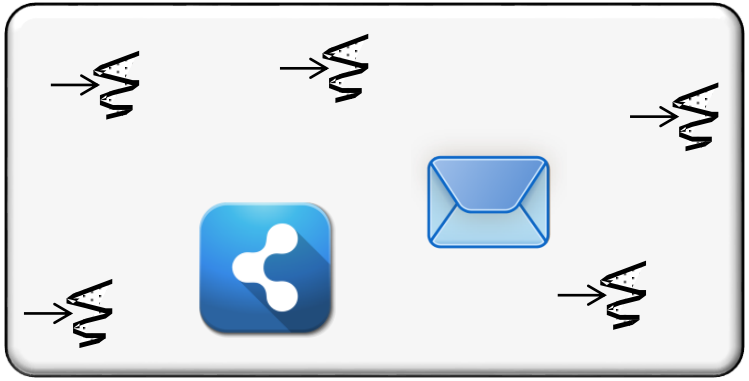
- Concurrency is a form of computing where threads can run simultaneously



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

An Overview of Concurrency

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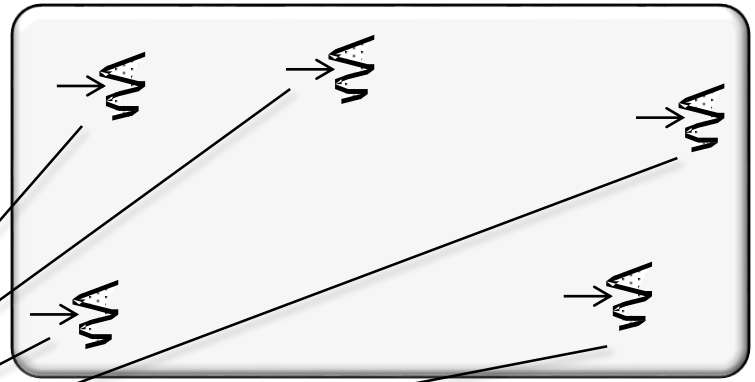
```
new Thread(() ->
            someComputations());
```

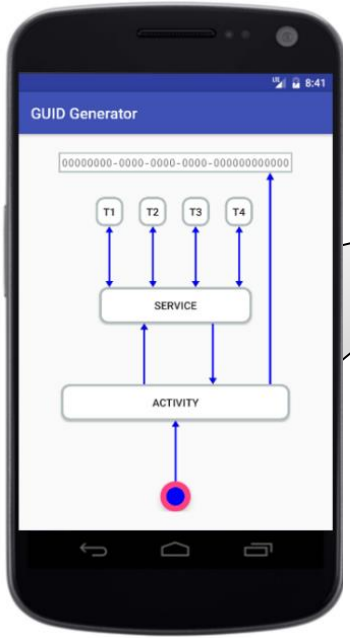


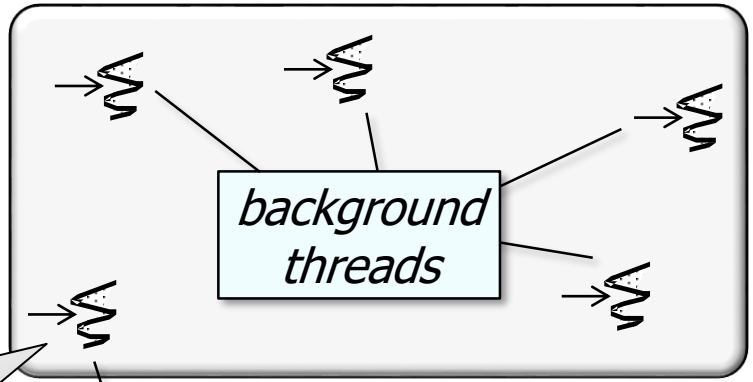
A Java threads are units of execution for instruction streams that can run concurrently on processor cores

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)



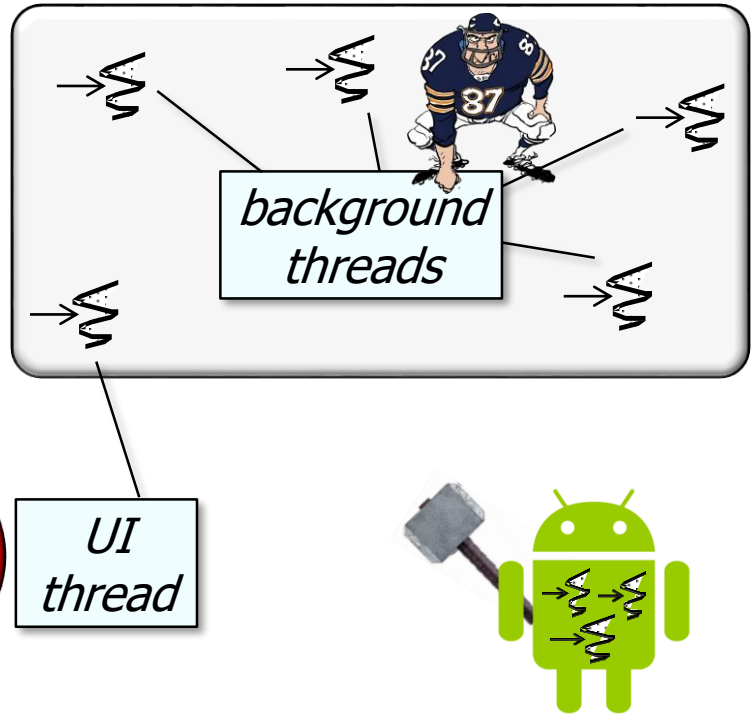


UI thread

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

An Overview of Concurrency

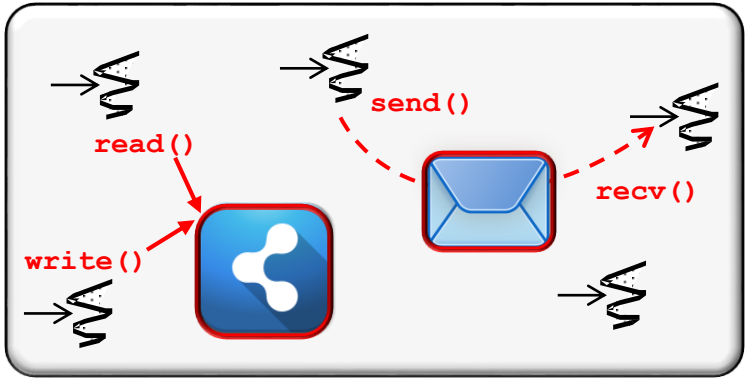
- Concurrency is a form of computing where threads can run simultaneously
  - Often used to offload work from the user interface (UI) thread to background thread(s), e.g.
    - Background thread(s) can block
    - The UI thread does not block



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

An Overview of Concurrency

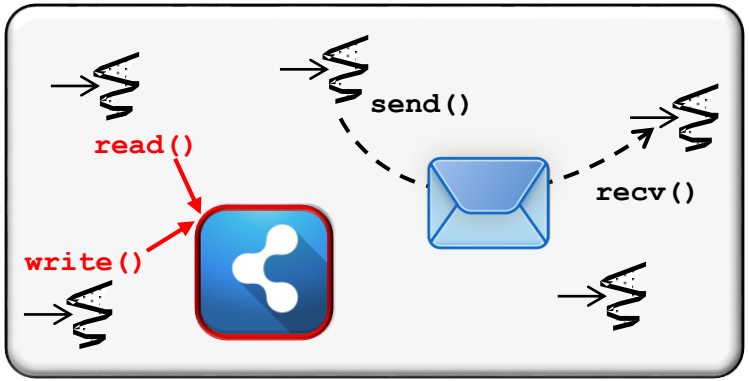
- Concurrent Java threads interact via shared objects and/or message passing

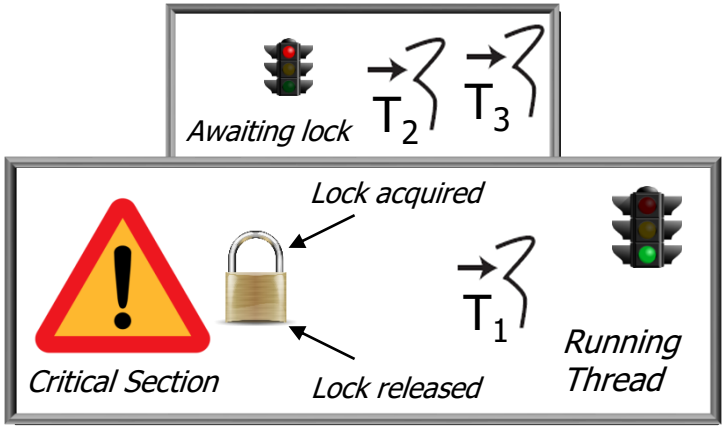


See docs.oracle.com/javase/8/docs/api/?java/util/concurrent/package-summary.html

An Overview of Concurrency

- Concurrent Java threads interact via shared objects and/or message passing
  - **Shared objects**
    - Synchronize concurrent operations on objects so object state remains coherent after each operation

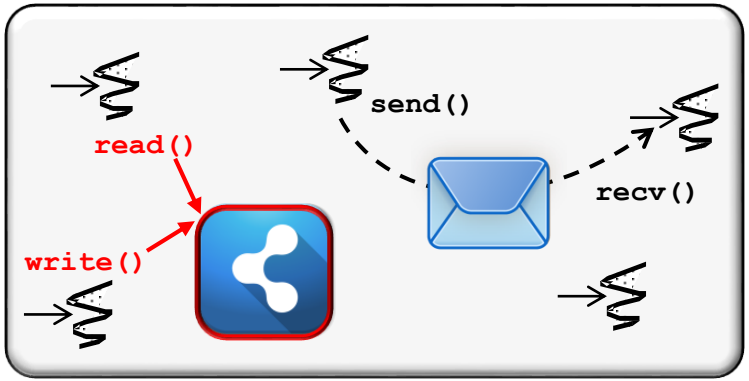




See tutorials.jenkov.com/java-concurrency/thread-safety.html

An Overview of Concurrency

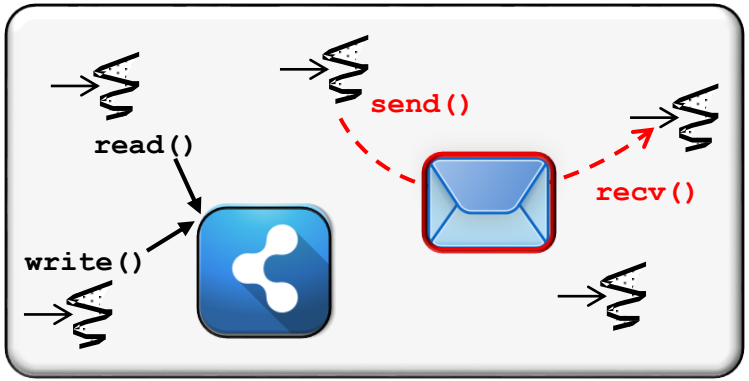
- Concurrent Java threads interact via shared objects and/or message passing
  - **Shared objects**
    - Synchronize concurrent operations on objects so object state remains coherent after each operation
    - Examples of Java synchronizers:
      - Synchronized statements/methods
      - Reentrant locks & intrinsic locks
      - Atomic operations
      - Semaphores & condition objects
      - "Compare-and-swap" (CAS) operations in sun.misc.unsafe

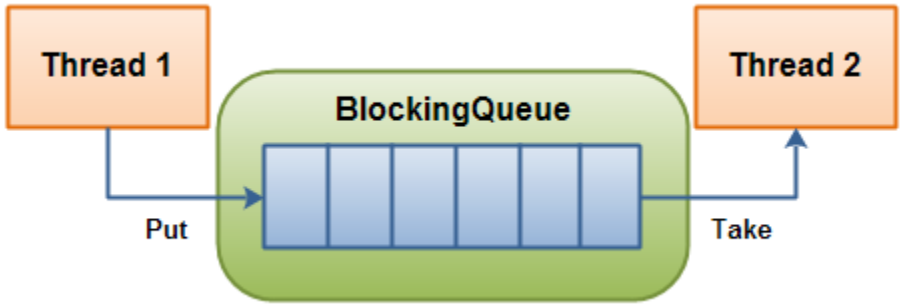


See dzone.com/articles/the-java-synchronizers

An Overview of Concurrency

- 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

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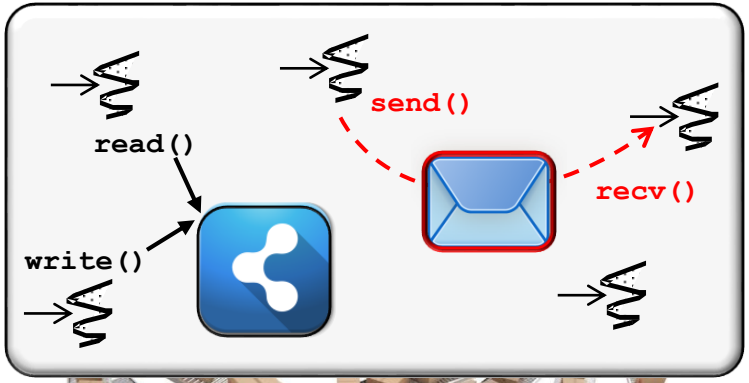
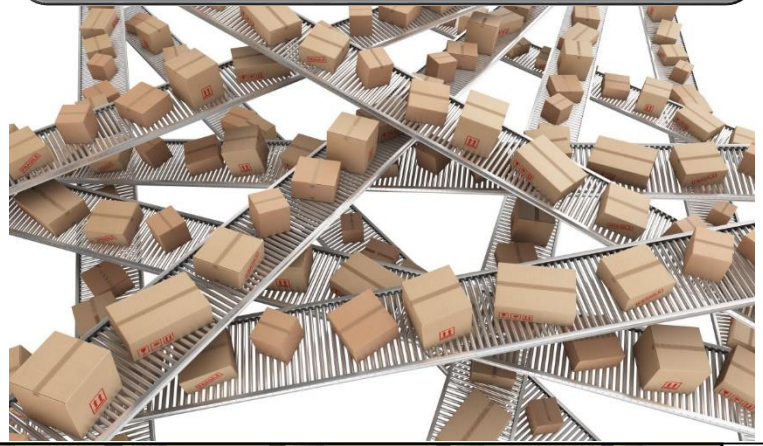
  - **Shared objects**
  - **Message passing**
    - Send message(s) from producer thread(s) to consumer thread(s) via a thread-safe queue
    - Examples of Java thread-safe queues
      - Array & linked blocking queues
      - Priority blocking queue
      - Synchronous queue
      - Concurrent linked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





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

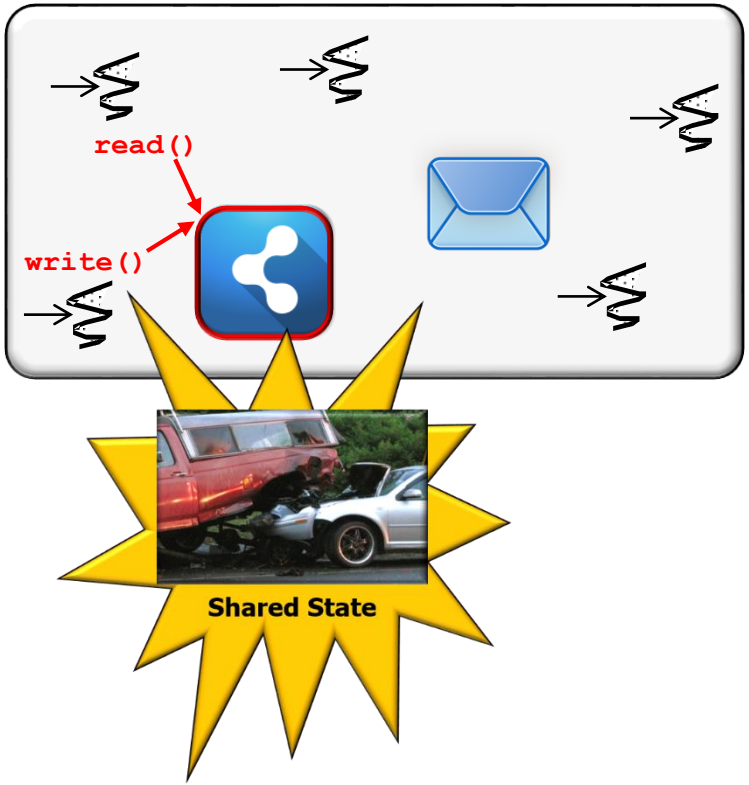
An Overview of Concurrency

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

See en.wikipedia.org/wiki/Thread_safety

An Overview of Concurrency

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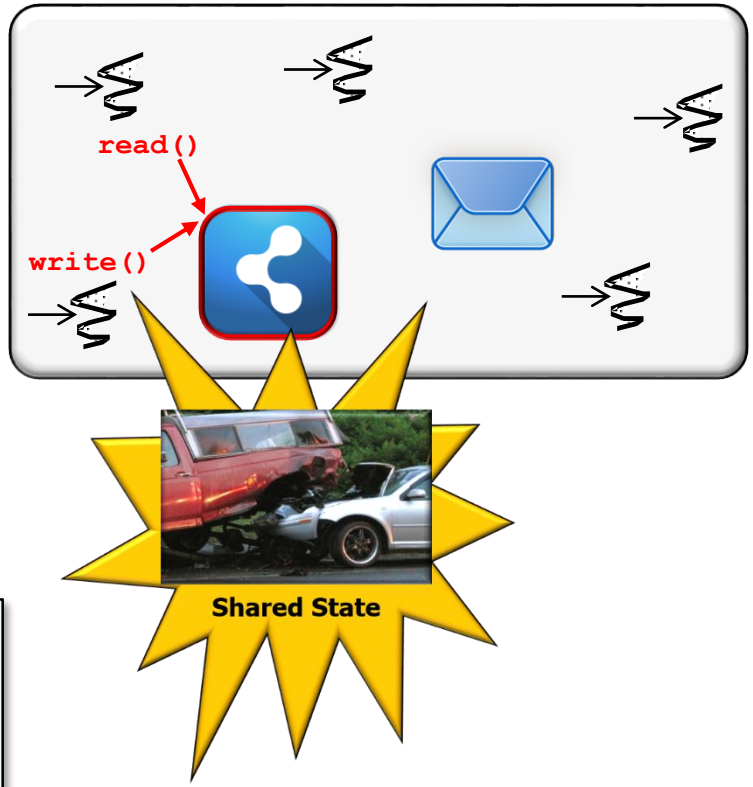

This test program induces race conditions due to lack of synchronization between producer & consumer threads accessing a bounded queue

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

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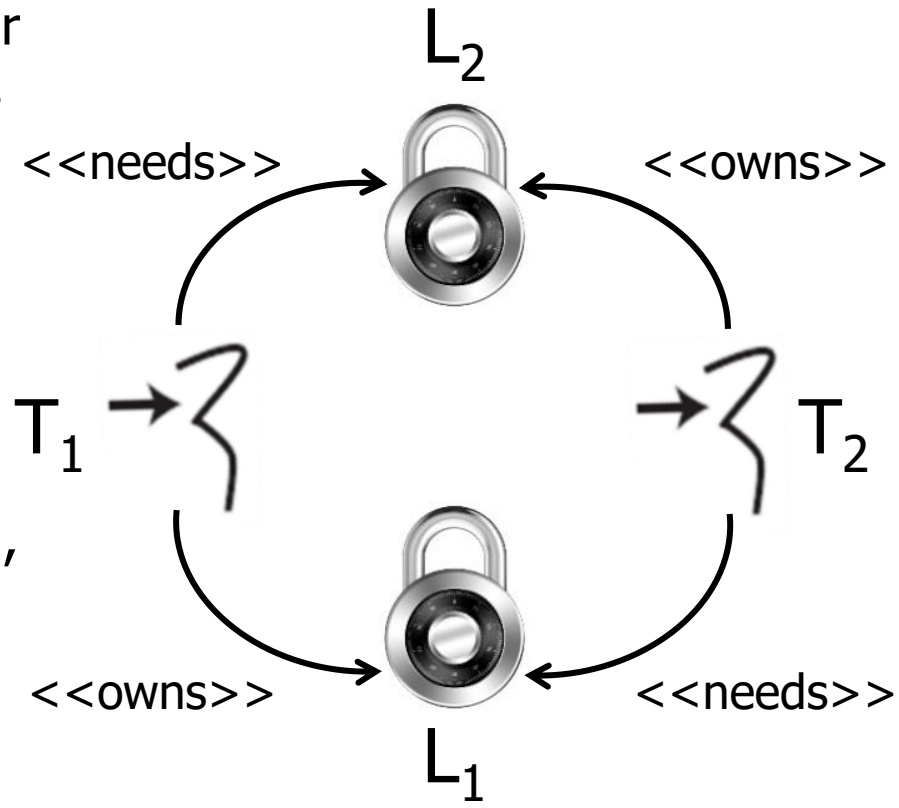
- Key goals of using shared objects and/or message passing are to share resources safely/efficiently & avoid hazards, e.g.
  - Race conditions
  - Memory inconsistencies
    - These errors occur when different threads have inconsistent views of what should be the same data

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

An Overview of Concurrency

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

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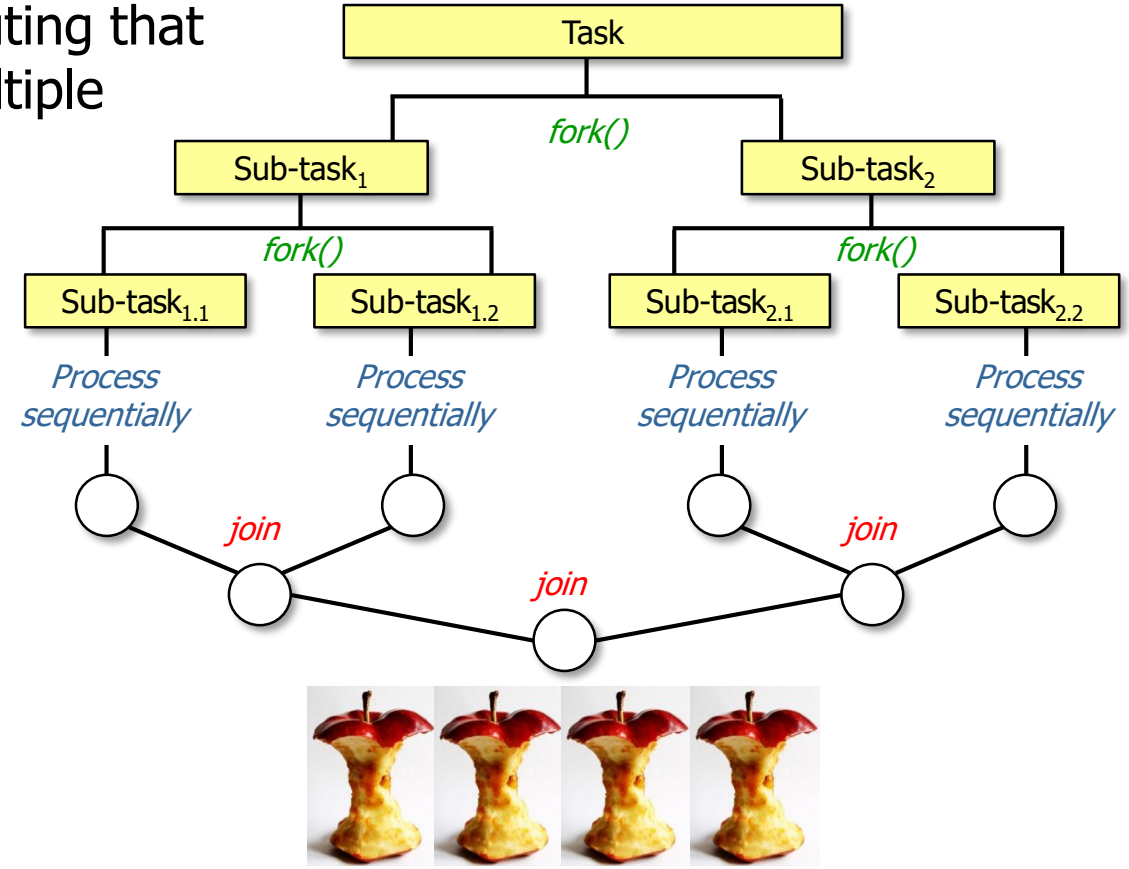
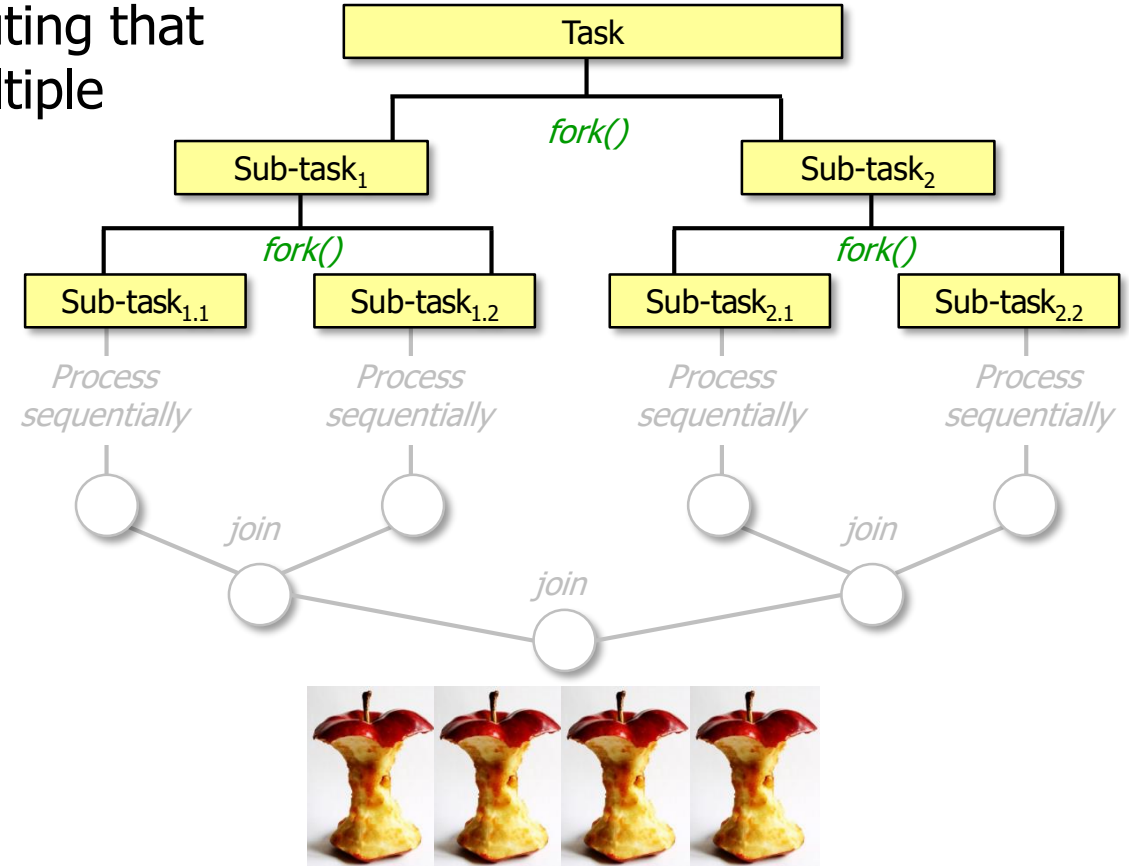


See en.wikipedia.org/wiki/Parallel_computing

An Overview of Parallelism

- Parallelism is a form of computing that performs several steps on multiple processor cores, i.e.
  - Split – partition a task into sub-tasks



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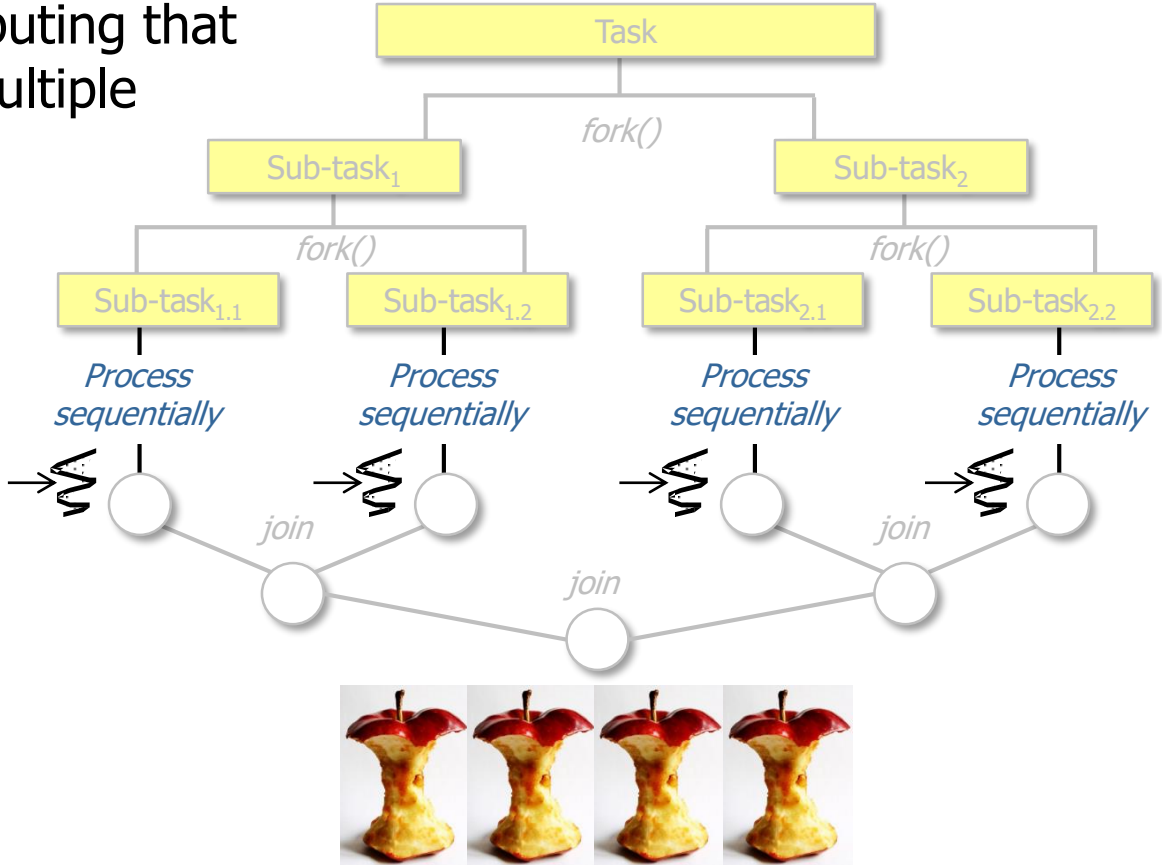

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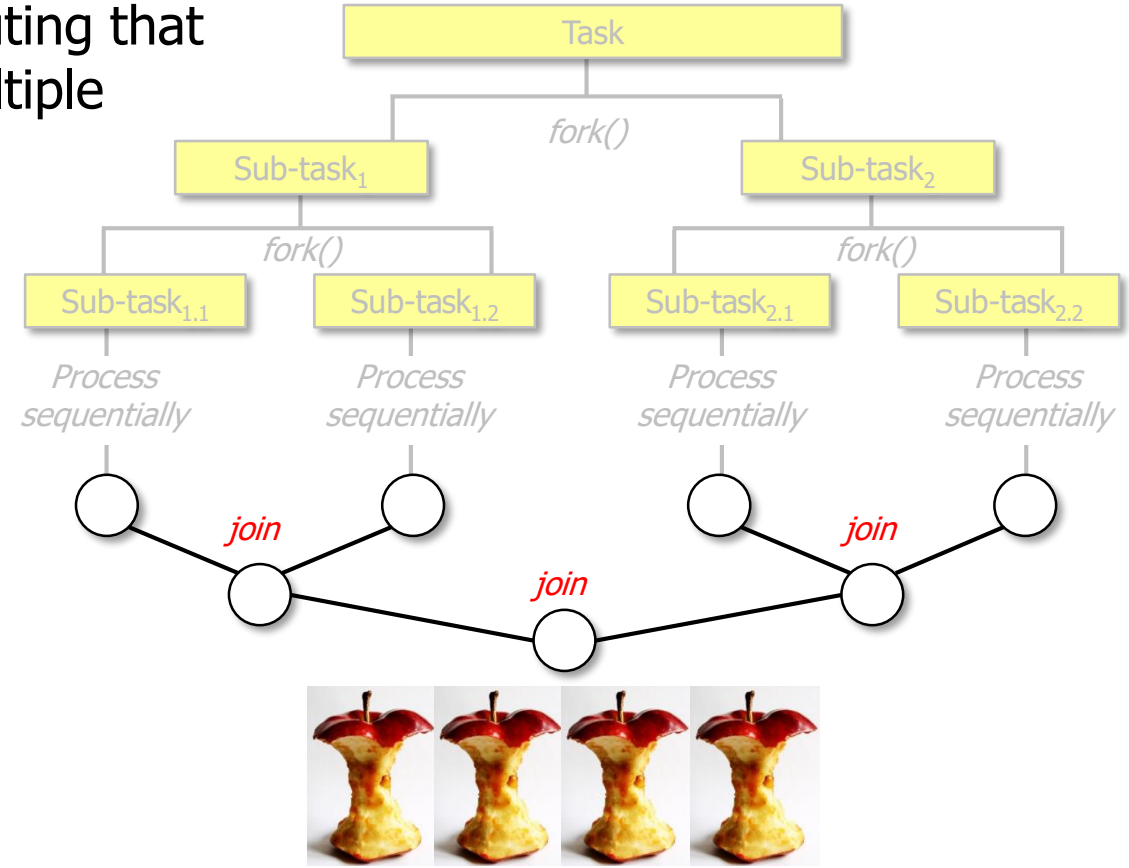
- Parallelism is a form of computing that performs several steps on multiple processor cores, i.e.
  - Split – partition a task into sub-tasks
  - Apply – Run independent sub-tasks in parallel
  - Combine – Merge the sub-results from sub-tasks into one final result



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  - Parallelism thus focuses on optimizing performance
    - e.g., throughput, scalability, & latency

See www.ibm.com/developerworks/library/j-java-streams-4-brian-goetz

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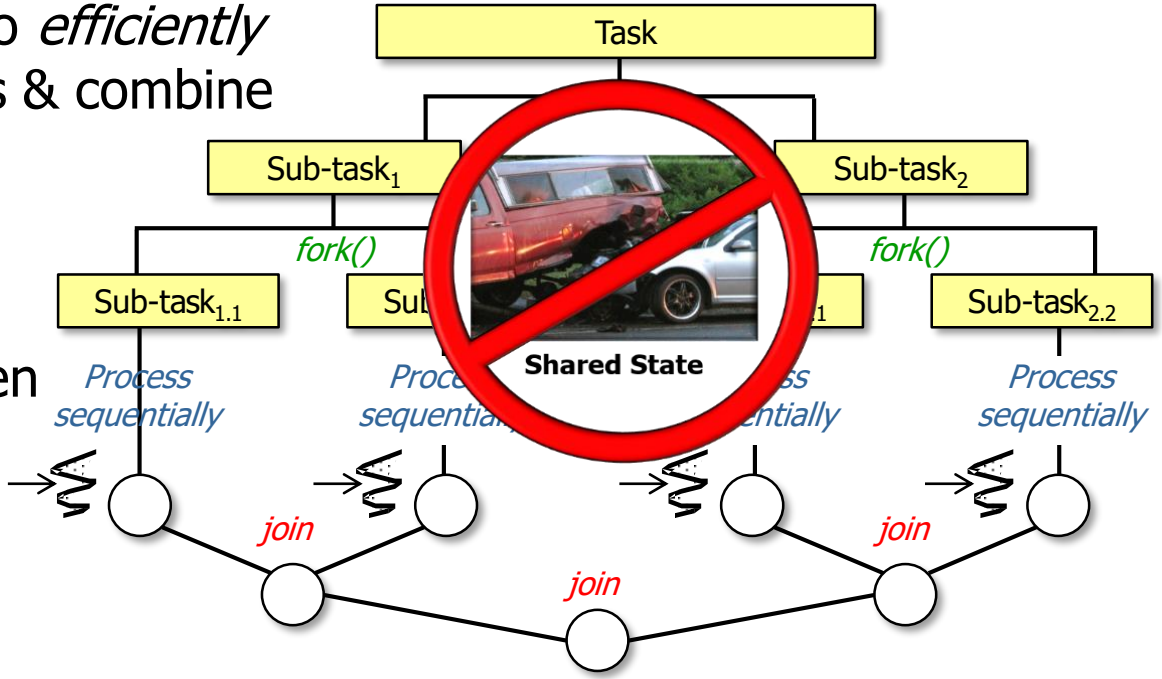

See henrikeichenhardt.blogspot.com/2013/06/why-shared-mutable-state-is-root-of-all.html

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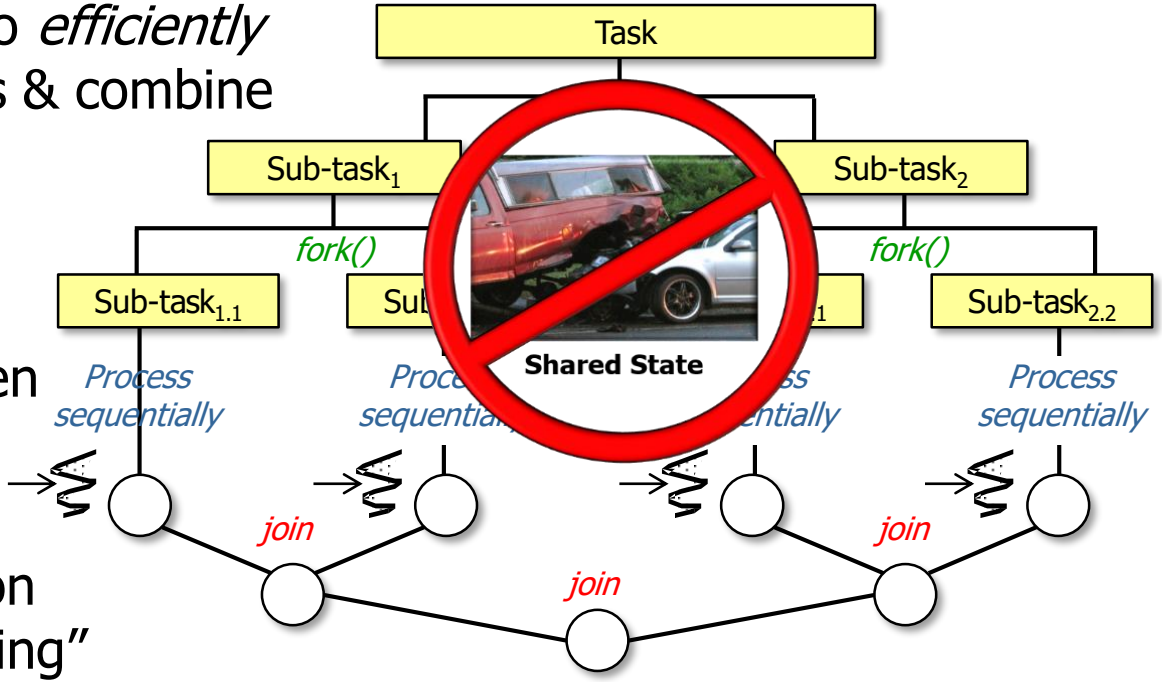
    - Hence Java's emphasis on "fork-join" & "work-stealing"



See en.wikipedia.org/wiki/Fork-join_model & en.wikipedia.org/wiki/Work_stealing

An Overview of Parallelism

- Brian Goetz has an excellent talk about the evolution of Java from concurrent to parallel computing

See www.youtube.com/watch?v=NsDE7E8sIdQ

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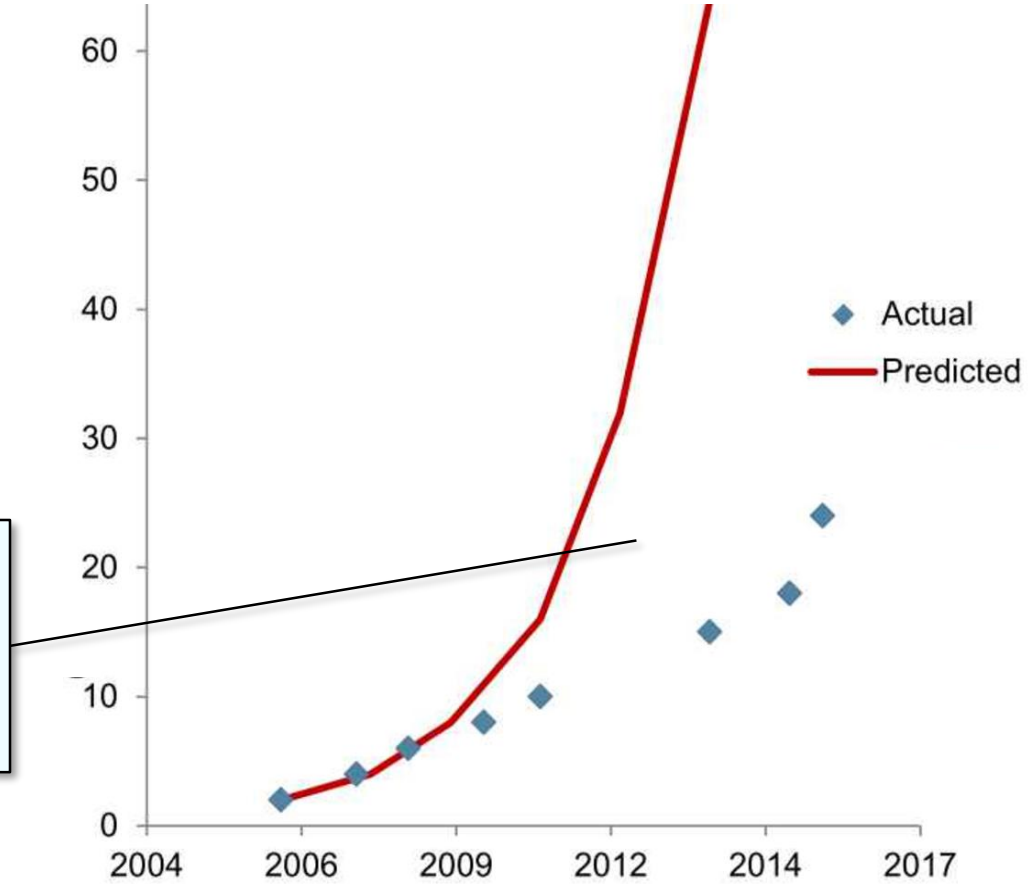

His talk emphasizes that Java 8 combines functional programming with fine-grained data parallelism to leverage many-core processors

See www.infoq.com/presentations/parallel-java-se-8

End of Background on Java Concurrency & Parallelism (Part 1)