Overview of the Java Fork-Join Framework

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Learning Objectives in this Part of the Lesson

- Understand how the Java fork-join framework processes tasks in parallel

See www.baeldung.com/java-fork-join

Overview of the Java Fork-Join Pool Computation Model

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- The fork-join pool provides a high performance, fine-grained task execution framework for Java data parallelism

Class ForkJoinPool

java.lang.Object
    java.util.concurrent.AbstractExecutorService
        java.util.concurrent.ForkJoinPool

All Implemented Interfaces:
`Executor, ExecutorService`

```
public class ForkJoinPool
extends AbstractExecutorService
```

An `ExecutorService` for running `ForkJoinTasks`. A `ForkJoinPool` provides the entry point for submissions from non-`ForkJoinTask` clients, as well as management and monitoring operations.

A `ForkJoinPool` differs from other kinds of `ExecutorService` mainly by virtue of employing *work-stealing*: all threads in the pool attempt to find and execute tasks submitted to the pool and/or created by other active tasks (eventually blocking waiting for work if none exist). This enables efficient processing when most tasks spawn other subtasks (as do most `ForkJoinTasks`), as well as when many small tasks are submitted to the pool from external clients. Especially when setting *asyncMode* to true in constructors, `ForkJoinPools` may also be appropriate for use with event-style tasks that are never joined.

A static `commonPool()` is available and appropriate for most applications. The common pool is used by any ForkJoinTask that is not explicitly submitted to a specified pool. Using the common pool normally reduces resource usage (its threads are slowly reclaimed during periods of non-use, and reinstated upon subsequent use).

For applications that require separate or custom pools, a `ForkJoinPool` may be constructed with a given target parallelism level; by default, equal to the number of available processors. The pool attempts to maintain enough active (or available) threads by dynamically adding, suspending, or resuming internal worker threads, even if some tasks are stalled waiting to join others. However, no such adjustments are guaranteed in the face of blocked I/O or other unmanaged synchronization. The nested `ForkJoinPool.ManagedBlocker` interface enables extension of the kinds of synchronization accommodated.

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

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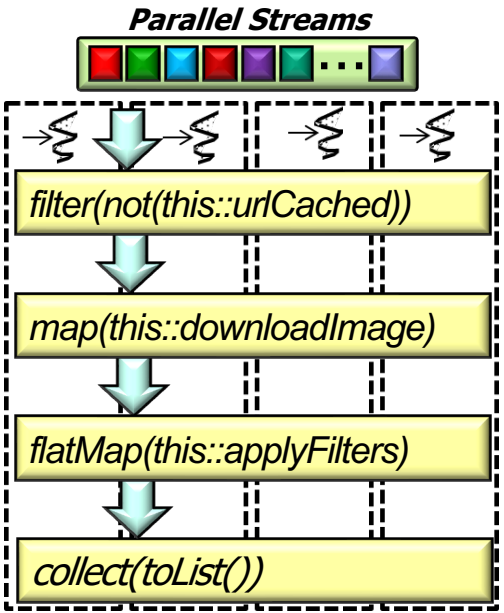
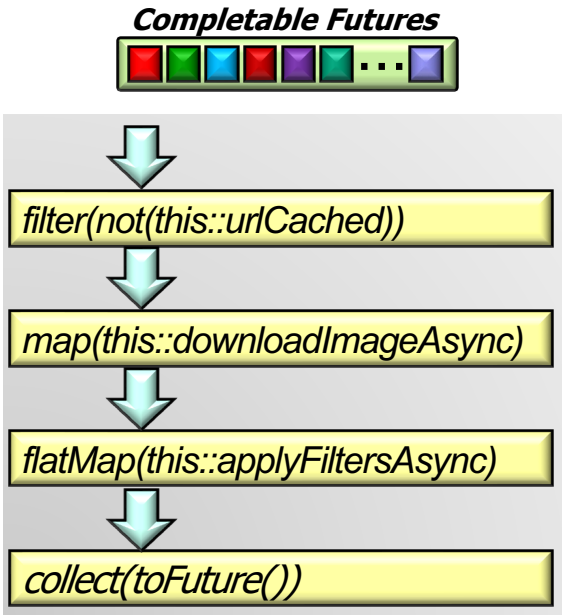
- The fork-join pool provides a high performance, fine-grained task execution framework for Java data parallelism
  - Its parallel computing engine is used by many higher-level frameworks





See www.infoq.com/interviews/doug-lea-fork-join

Overview of the Java Fork-Join Pool Computation Model

- The fork-join pool supports a style of parallel programming optimized to solve problems by "divide & conquer"

```
Solve(problem)
  if (problem is small enough)
    solve problem directly
      (sequential algorithm)
  else
    split problem into independent parts
    fork new sub-tasks to solve each part
    join all sub-tasks
    compose result from sub-results
```

See en.wikipedia.org/wiki/Divide_and_conquer_algorithm

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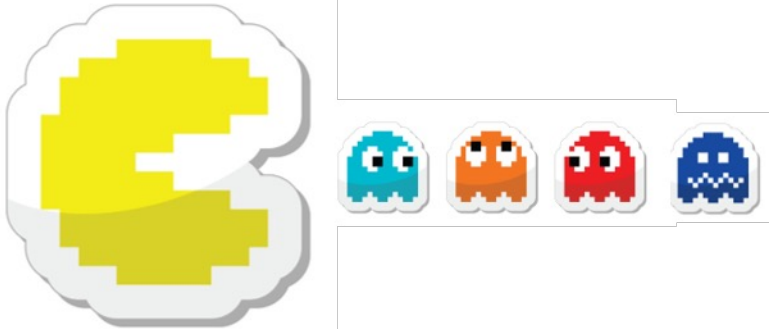

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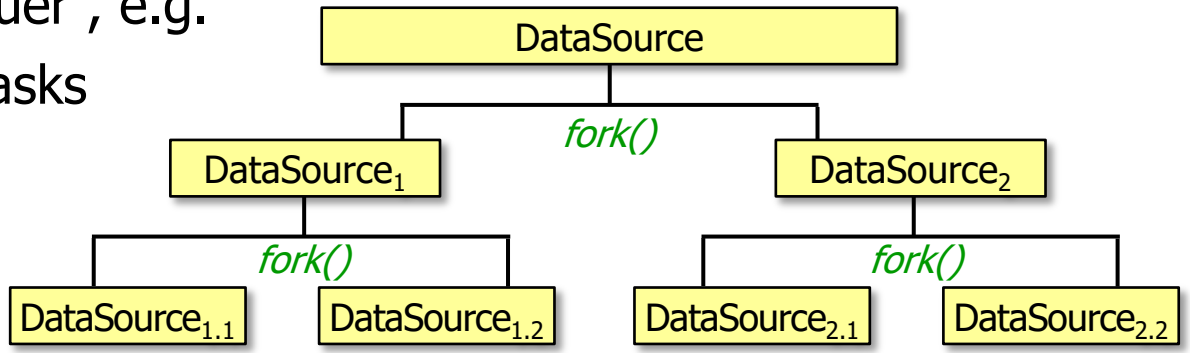
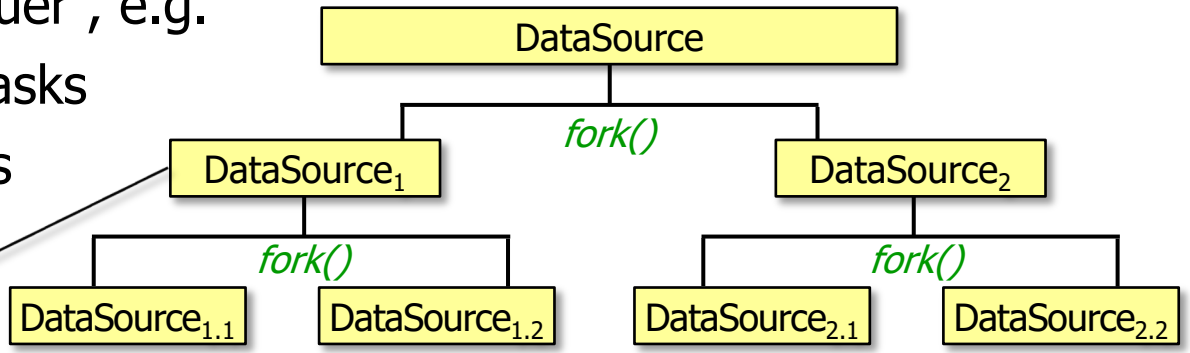


See en.wikipedia.org/wiki/Fork-join_model

Overview of the Java Fork-Join Pool Computation Model

- The fork-join pool supports a style of parallel programming optimized to solve problems by "divide & conquer", e.g.
  - Splitting a task into sub-tasks
    - A task creates sub-tasks by fork()'ing



Ideally these sub-tasks split evenly & efficiently

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/ForkJoinTask.html#fork

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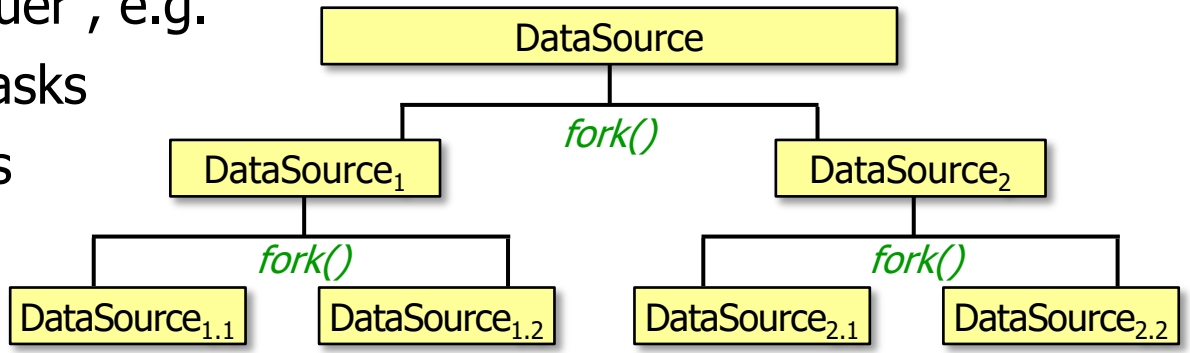

A (sub-)task only splits itself into (more) sub-tasks if the work is sufficiently large at that level

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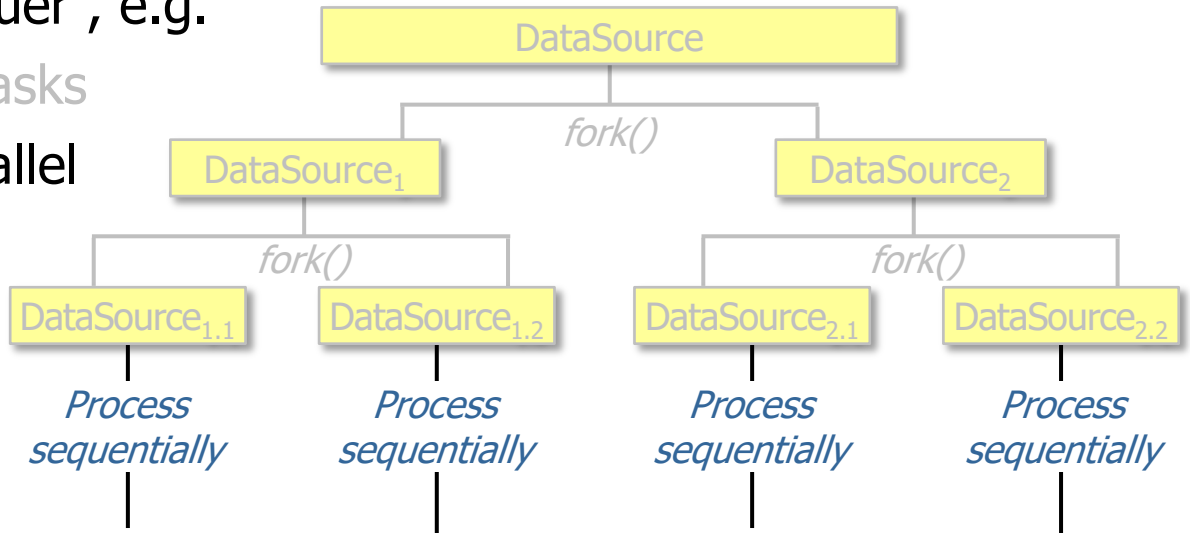
  - Splitting a task into sub-tasks
  - Applying sub-tasks in parallel



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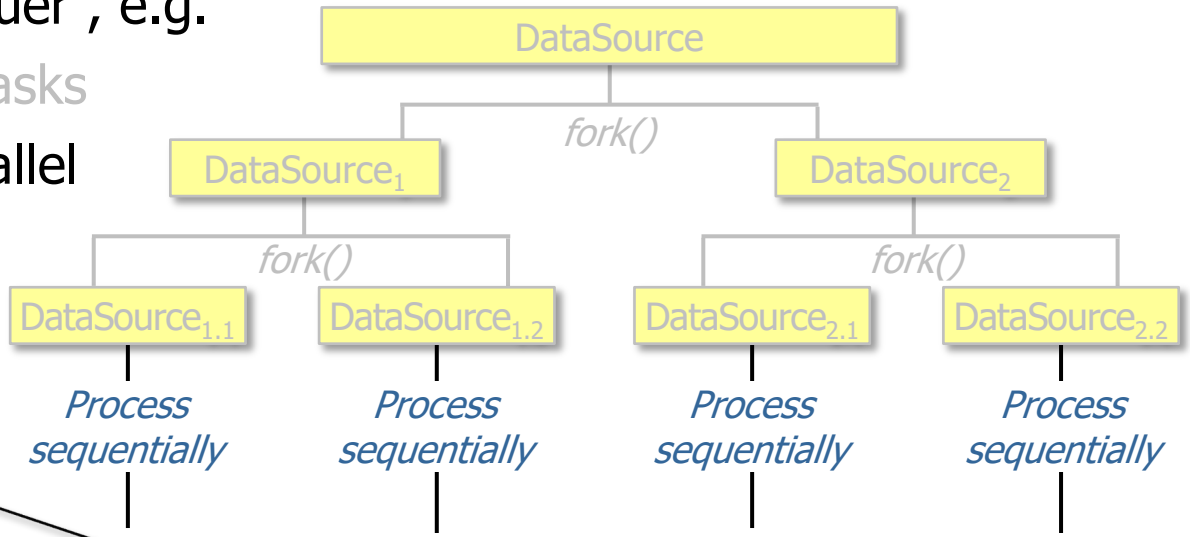
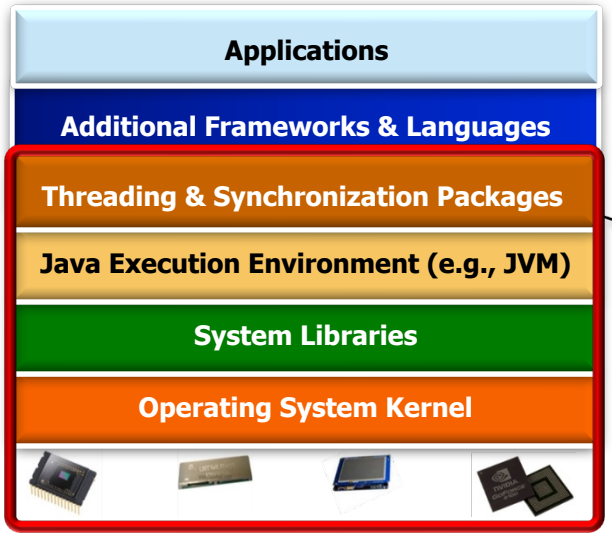
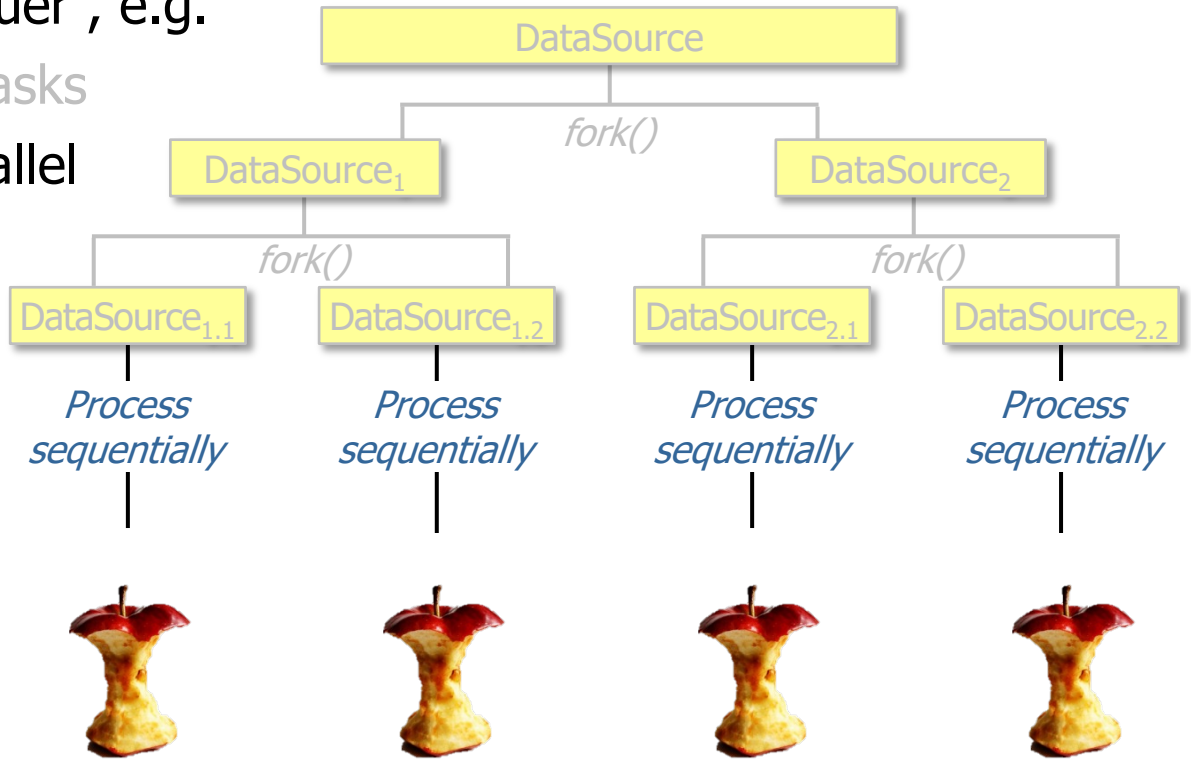




Implemented by fork-join framework, Java execution environment, OS, & hardware

Overview of the Java Fork-Join Pool Computation Model

- The fork-join pool supports a style of parallel programming optimized to solve problems by "divide & conquer", e.g.
  - Splitting a task into sub-tasks
  - Applying sub-tasks in parallel
    - Sub-tasks run in parallel on different cores



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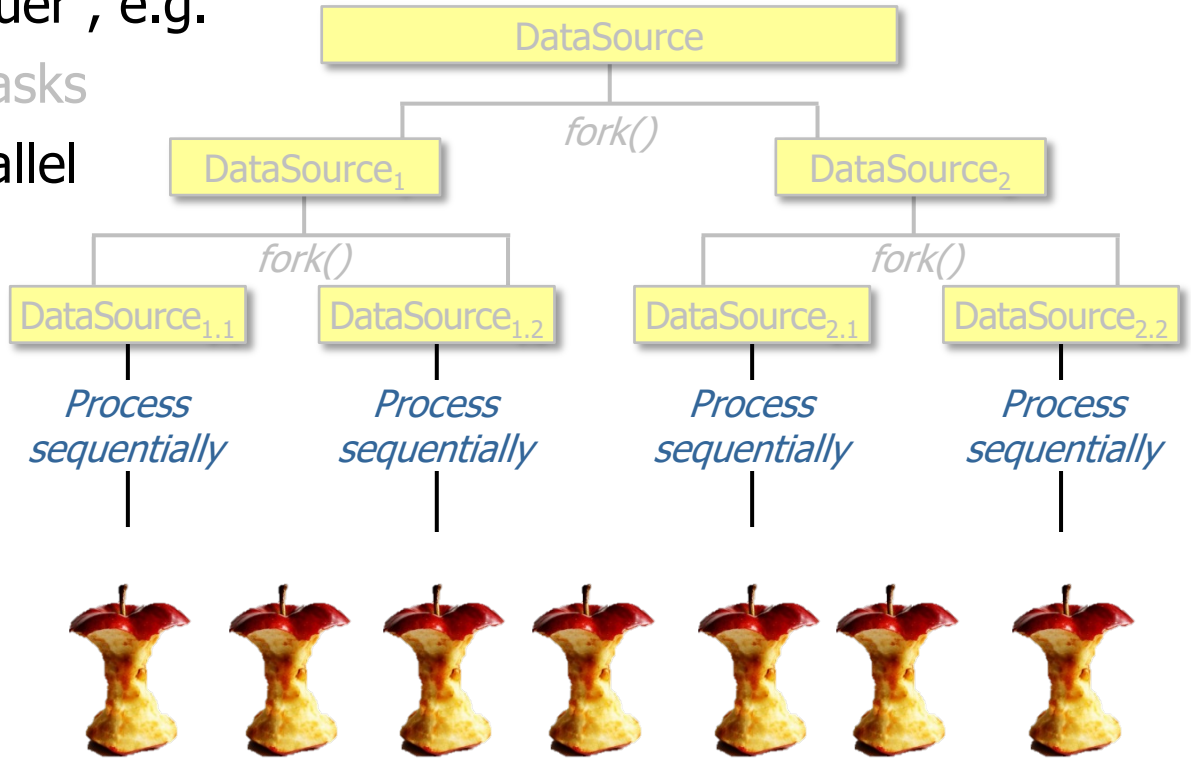

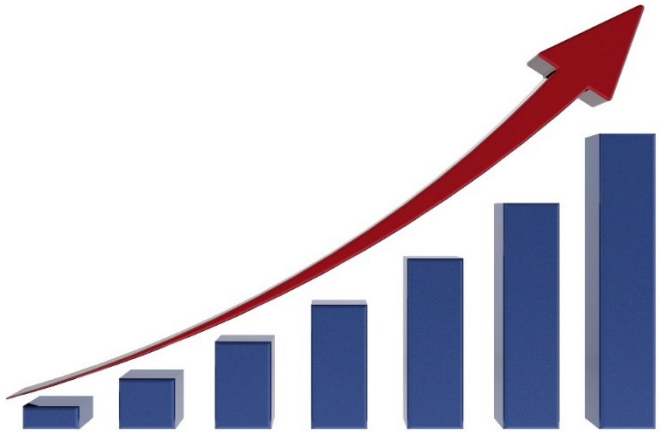

Performance typically increases as the # of cores increases

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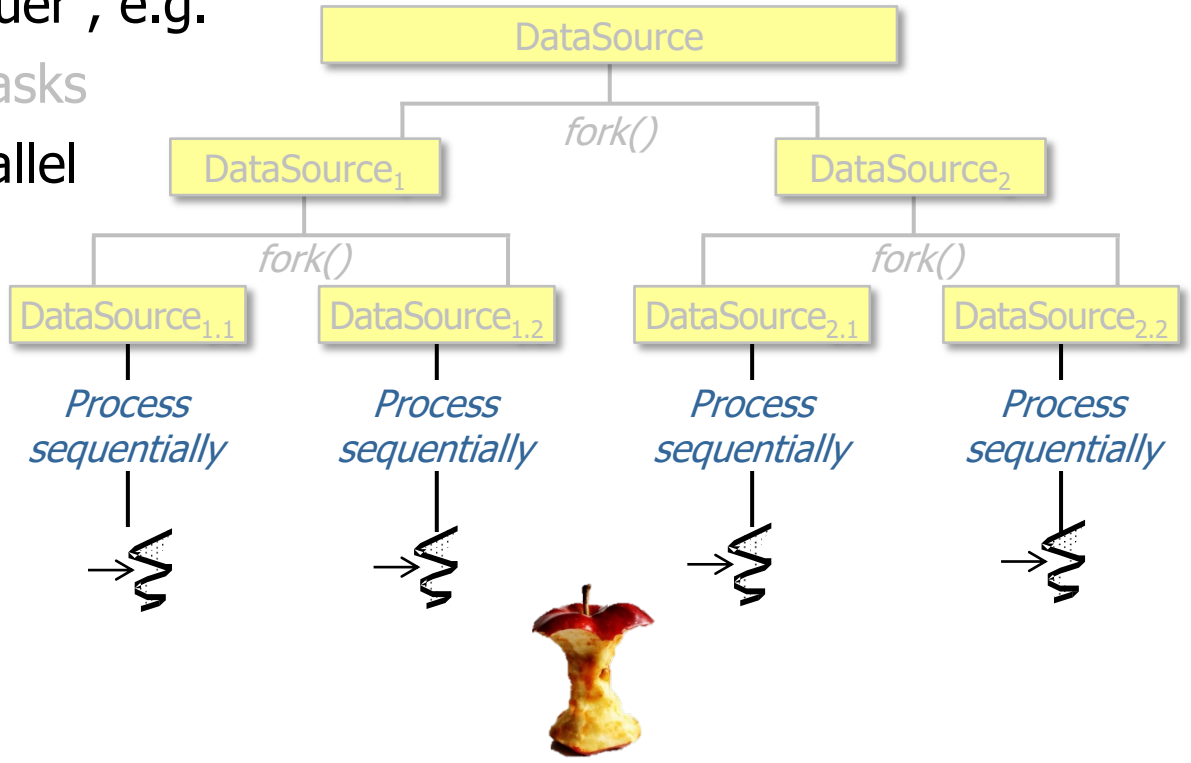
  - Splitting a task into sub-tasks
  - Applying sub-tasks in parallel
    - Sub-tasks run in parallel on different cores
    - Sub-tasks can also run concurrently in different threads on a single core



This configuration may not enhance performance unless sub-tasks are I/O bound

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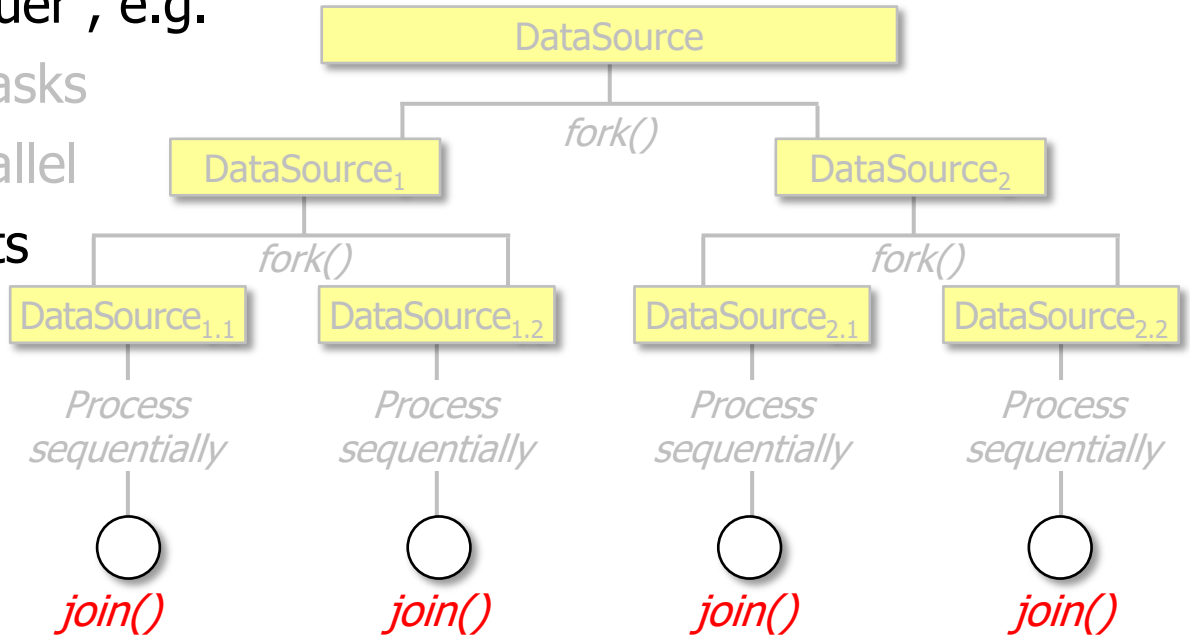
  - Applying sub-tasks in parallel
  - Combining sub-task results



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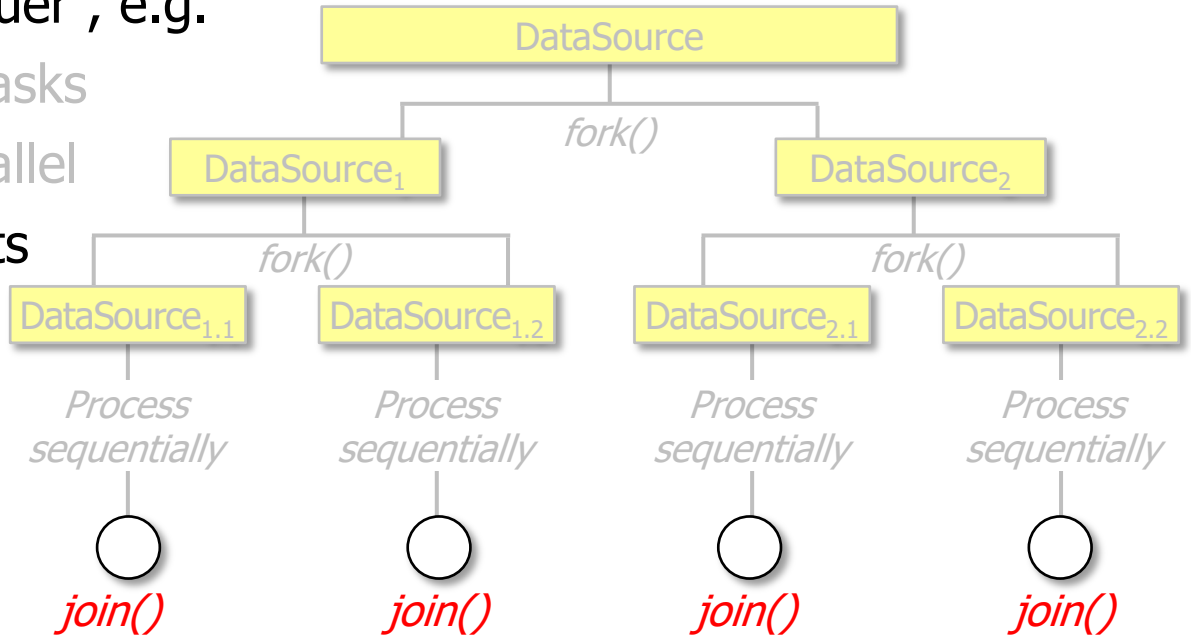
    - join() "waits" for a sub-task to finish



See docs.oracle.com/javase/8/docs/api/java/util/concurrent/ForkJoinTask.html#join

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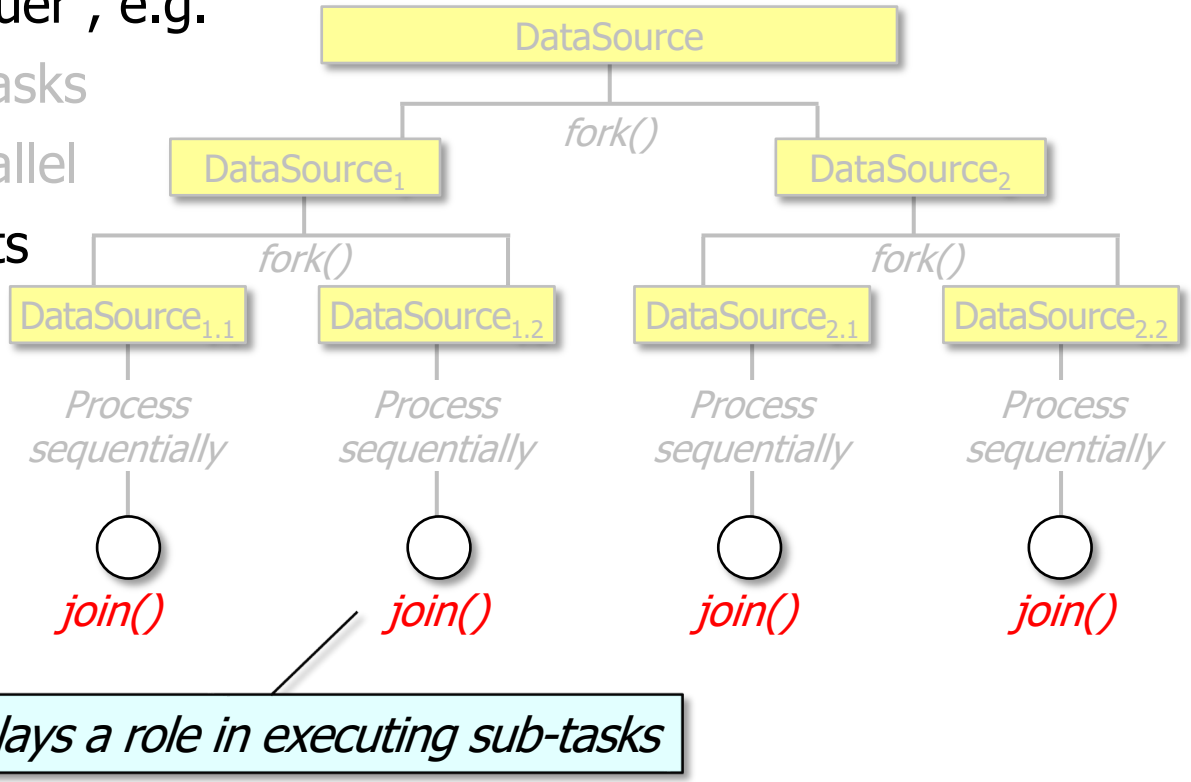

See upcoming lesson on "*The Java Fork-Join Pool: Key Methods in ForkJoinTask*"

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  - Combining sub-task results
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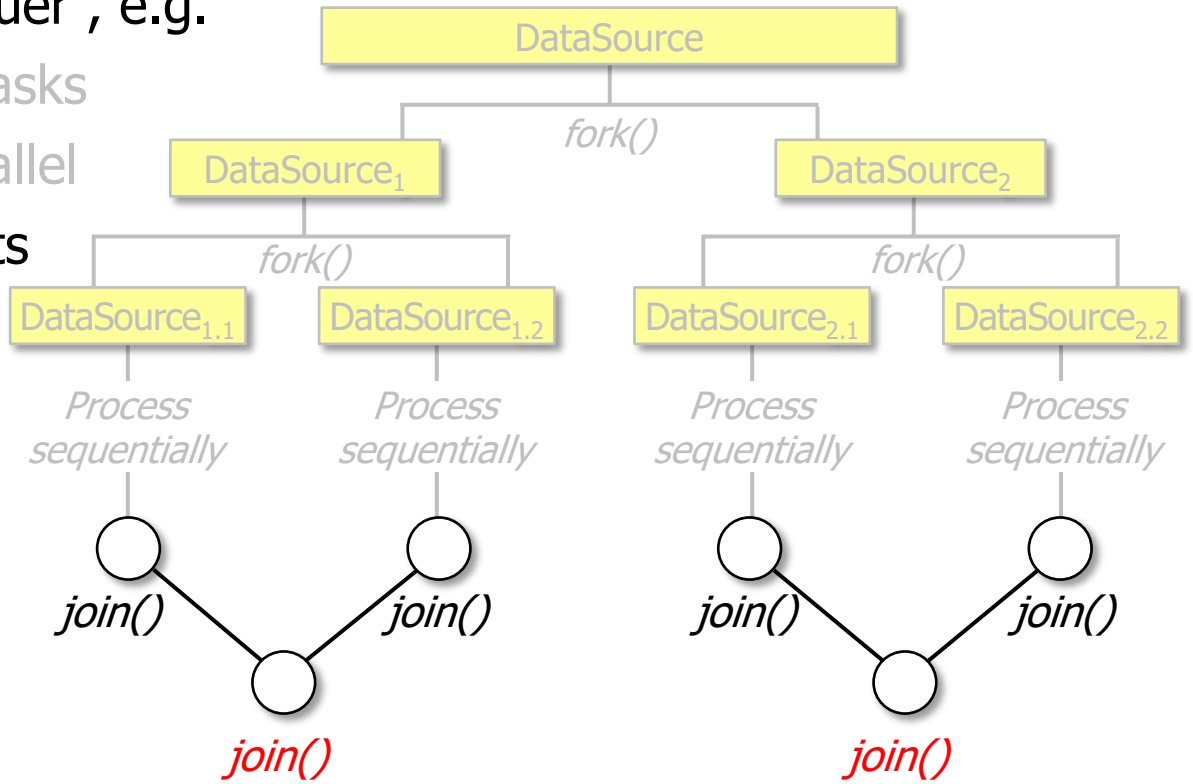
      - & merges the results



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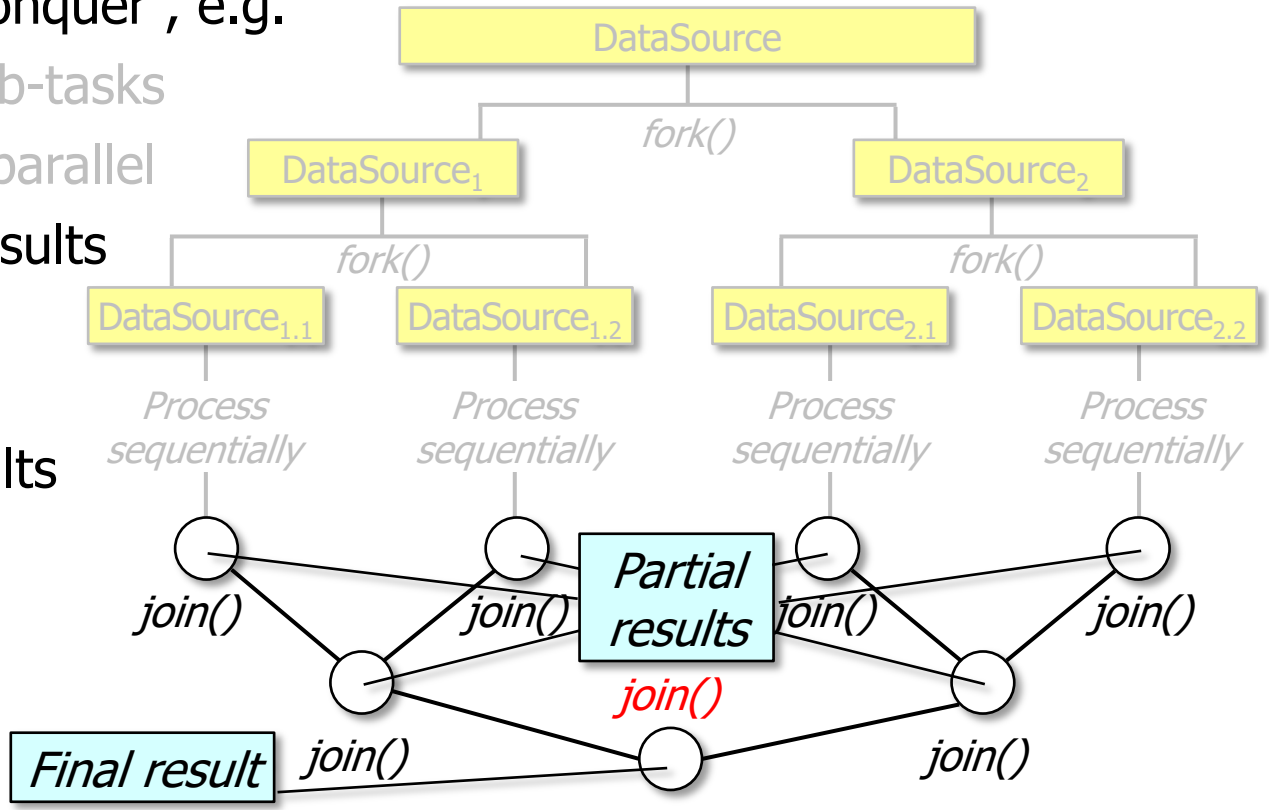

Partial (sub-)results are merged into a final result

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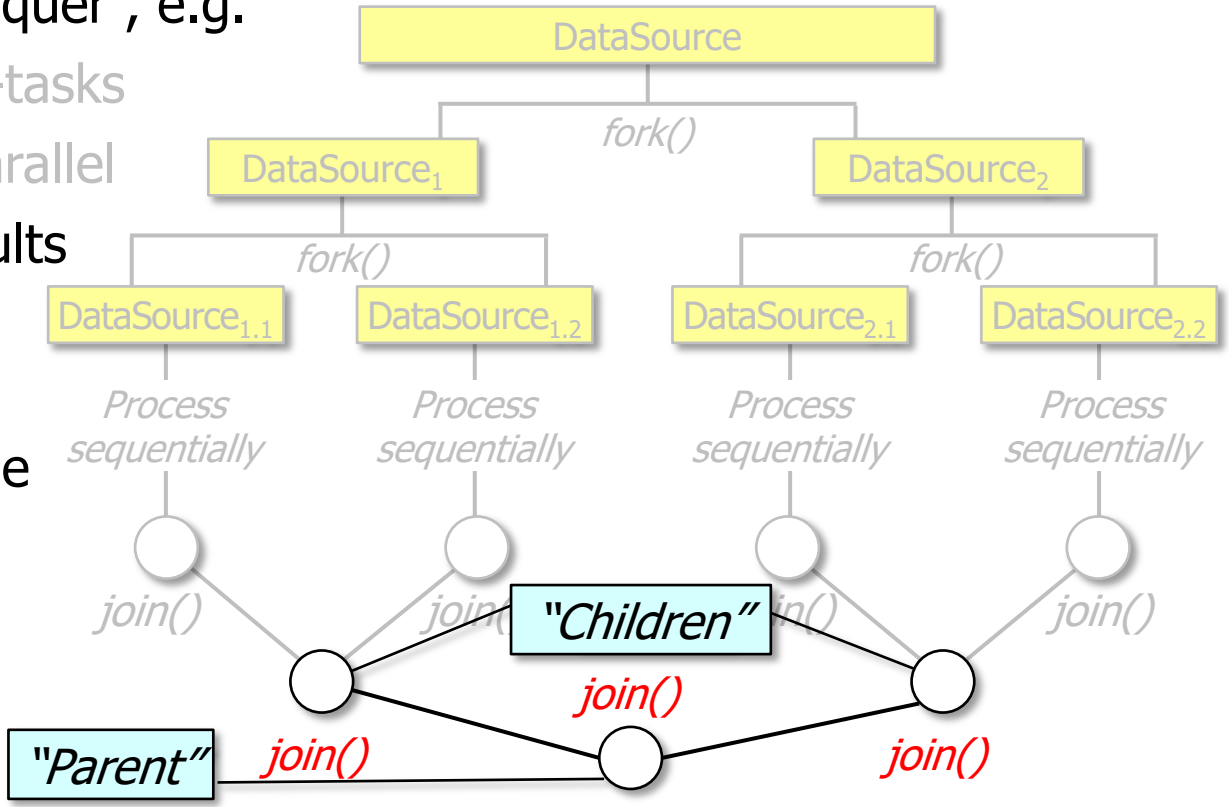
  - Combining sub-task results
    - join() "waits" for a sub-task to finish
    - join() occurs in a single thread at each level



As a result, there's typically no need for synchronizers during the joining phase

End of Overview of the Java Fork-Join Framework