Understand Java Parallel Streams Internals: Mapping Onto the Common Fork-Join Pool

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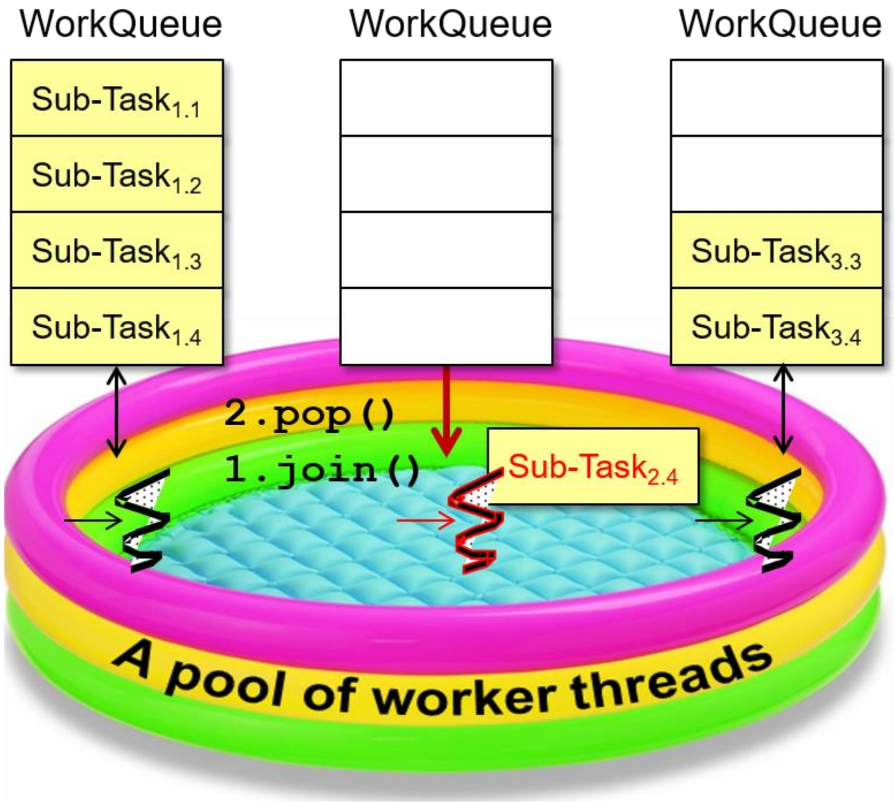
Learning Objectives in this Part of the Lesson

- Understand parallel stream internals, e.g.
  - Know what can change & what can't
  - Partition a data source into "chunks"
  - Process chunks in parallel via the common fork-join pool
    - Recognize how parallel streams are mapped onto the common fork-join pool framework

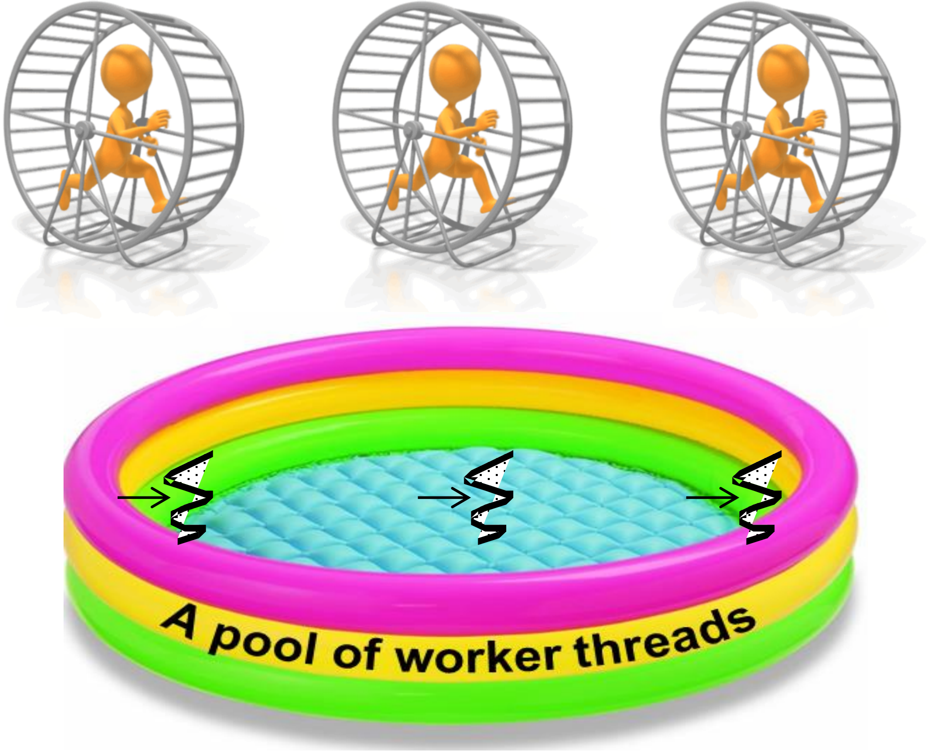


See gee.cs.oswego.edu/dl/papers/fj.pdf

Mapping Parallel Streams Onto the Java Fork-Join Pool

Mapping Parallel Streams Onto the Common Fork-Join Pool

- Each worker thread in the common fork-join pool runs a loop scanning for tasks to run



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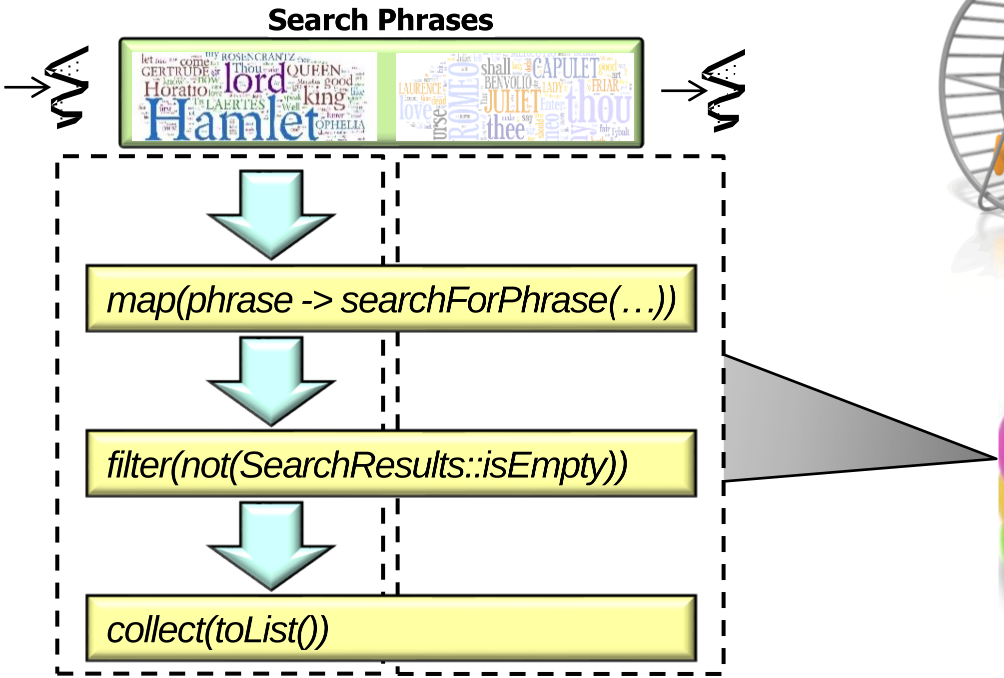

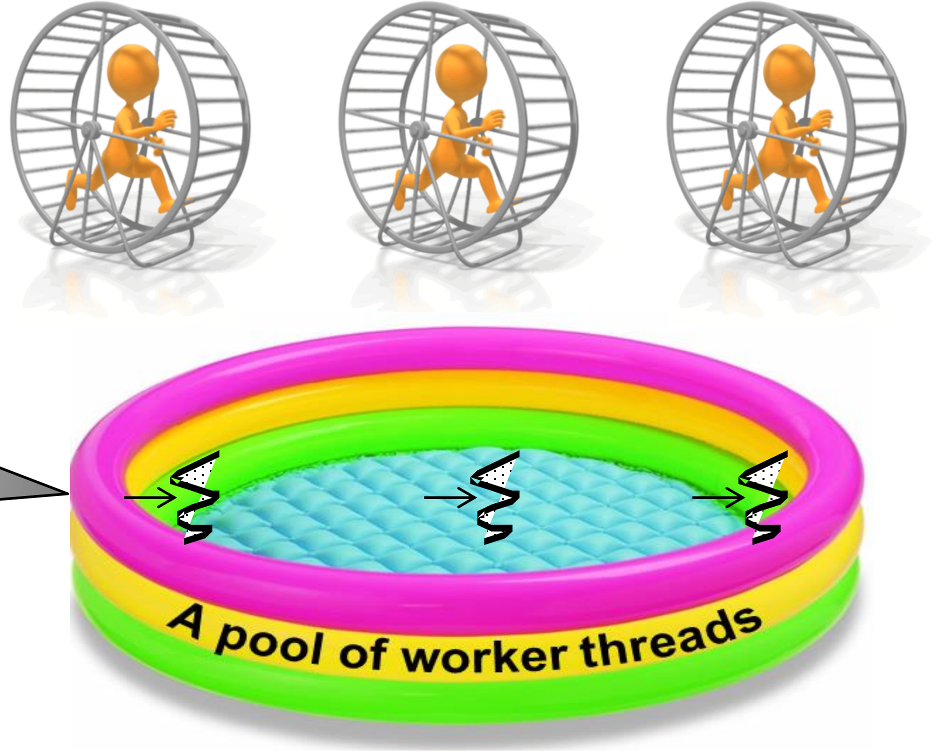

In this lesson, we just care about tasks associated with parallel streams

Mapping Parallel Streams Onto the Common Fork-Join Pool

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  - Goal is to keep worker threads & cores as busy as possible!

Mapping Parallel Streams Onto the Common Fork-Join Pool

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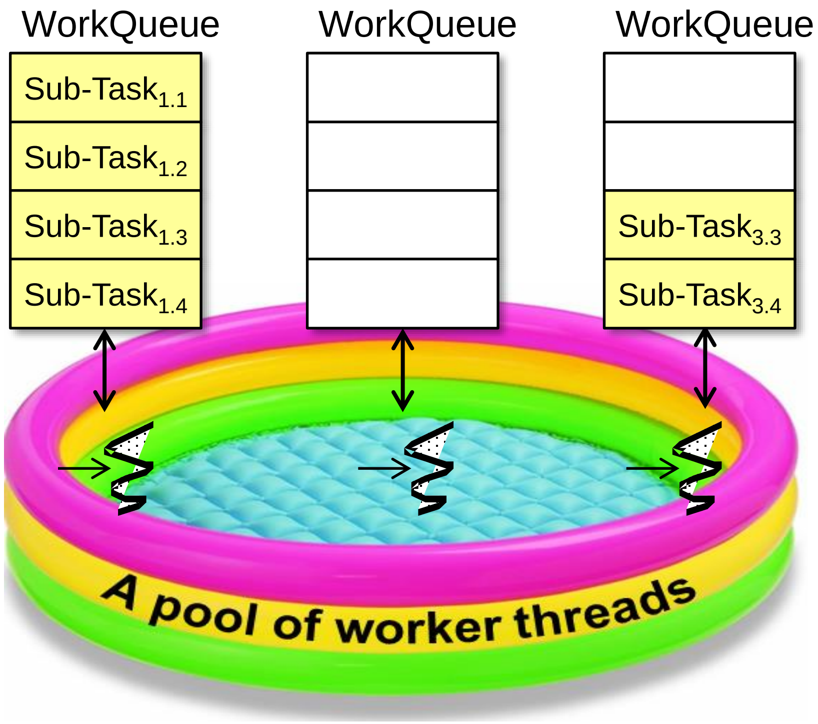
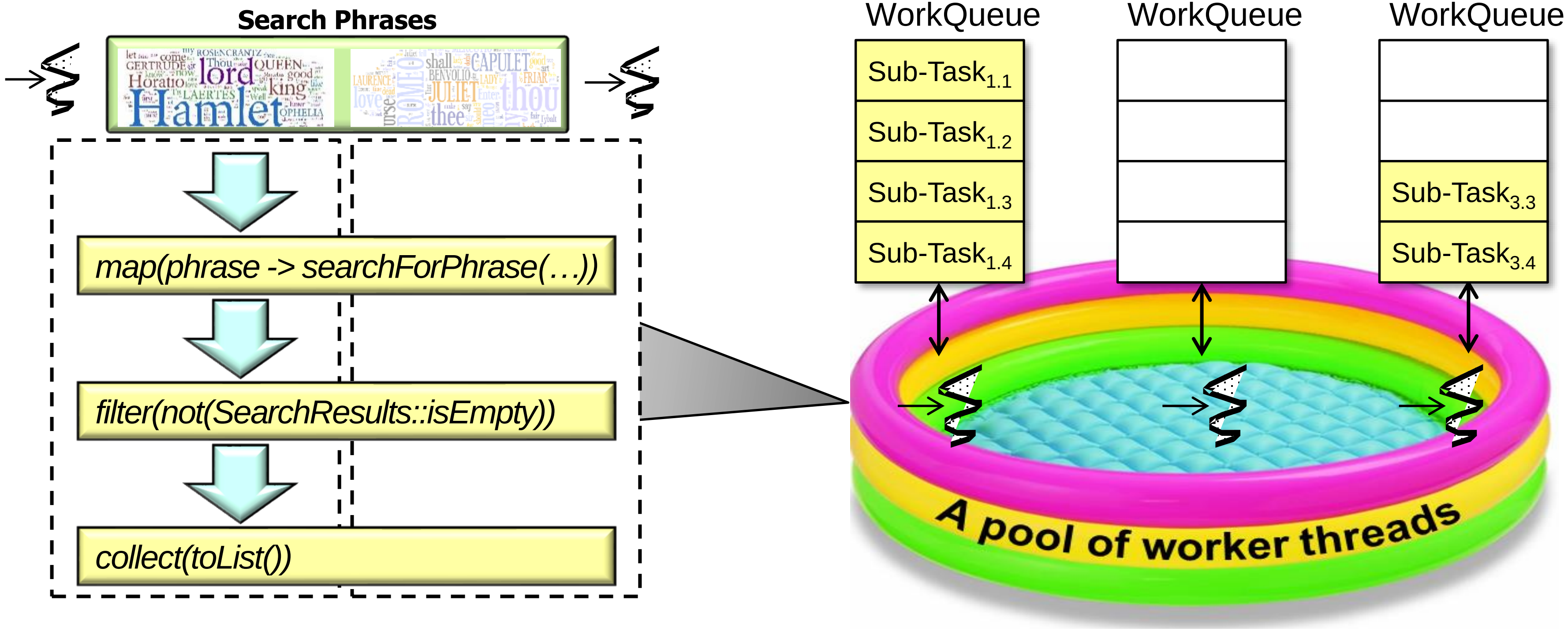
  - Goal is to keep worker threads & cores as busy as possible!
  - A worker thread has a "double-ended queue" (aka "deque") that serves as its main source of tasks



See en.wikipedia.org/wiki/Double-ended_queue

Mapping Parallel Streams Onto the Common Fork-Join Pool

- The parallel streams framework automatically creates fork-join tasks that are run by worker threads in the common fork-join pool



Mapping Parallel Streams Onto the Common Fork-Join Pool

- The AbstractTask super class is used by most fork-join tasks to implement the parallel streams framework

```
abstract class AbstractTask ... {
  public void compute() {
    Spliterator<P_IN> rs = spliterator, ls;
    boolean forkRight = false; ...
    while(... (ls = rs.trySplit()) != null){
      K taskToFork;
      if (forkRight)
      { forkRight = false; ... taskToFork = ...makeChild(rs); }
      else
      { forkRight = true; ... taskToFork = ...makeChild(ls); }
      taskToFork.fork();
    }
  } ...
```

Manages splitting logic, tracking of child tasks, & intermediate results

See openjdk/8-b132/java/util/stream/AbstractTask.java

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Decides whether to split a task further and/or compute it directly

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```

Keep partitioning input source until trySplit() returns null

See docs.oracle.com/javase/8/docs/api/java/util/Spliterator.html#trySplit

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```

Alternate which child is forked to avoid biased spliterators

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```

Fork a new sub-task & continue processing the other in the loop

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

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  public void compute() {
    Spliterator<P_IN> rs = spliterator, ls;
    boolean forkRight = false; ...
    while(... (ls = rs.trySplit()) != null){
      ...
    }
    task.setLocalResult(task.doLeaf());
  } ...
```
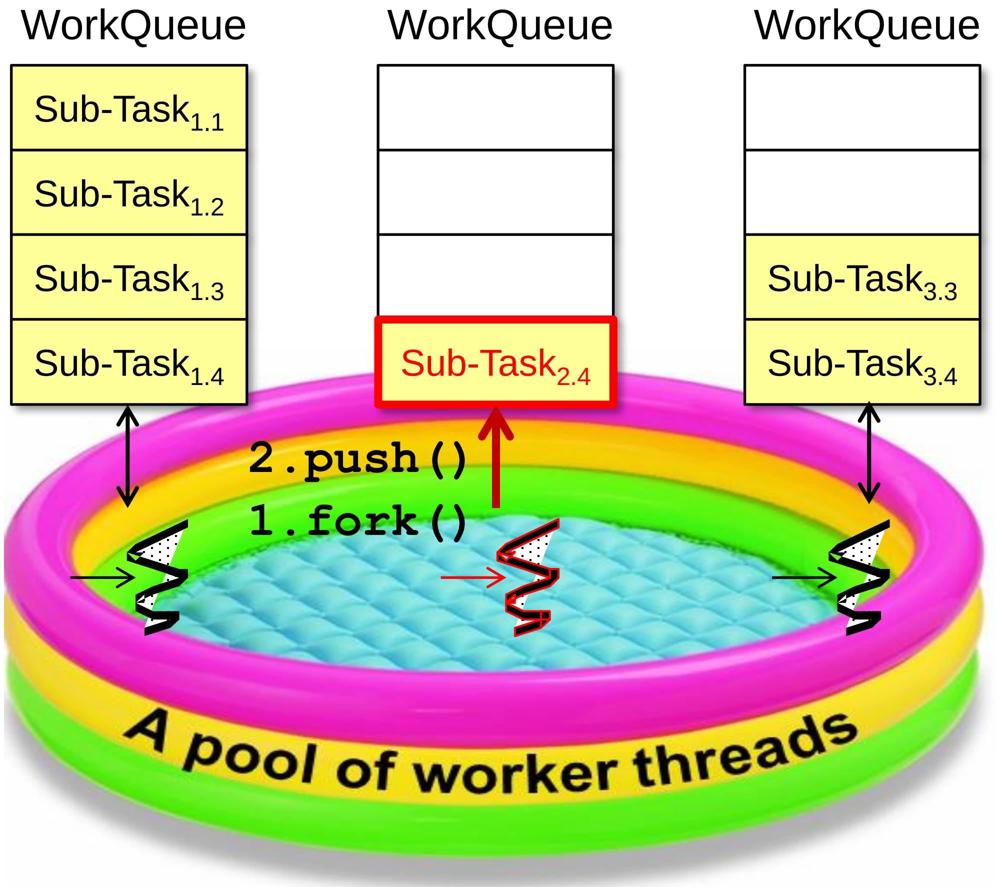

After trySplit() returns null this method typically calls forEachRemaining(), which then processes all elements sequentially by calling tryAdvance()

See docs.oracle.com/javase/8/docs/api/java/util/Spliterator.html#forEachRemaining

Mapping Parallel Streams Onto the Common Fork-Join Pool

- After the AbstractTask.compute() method calls fork() on a task this task is pushed onto the head of its worker thread's deque



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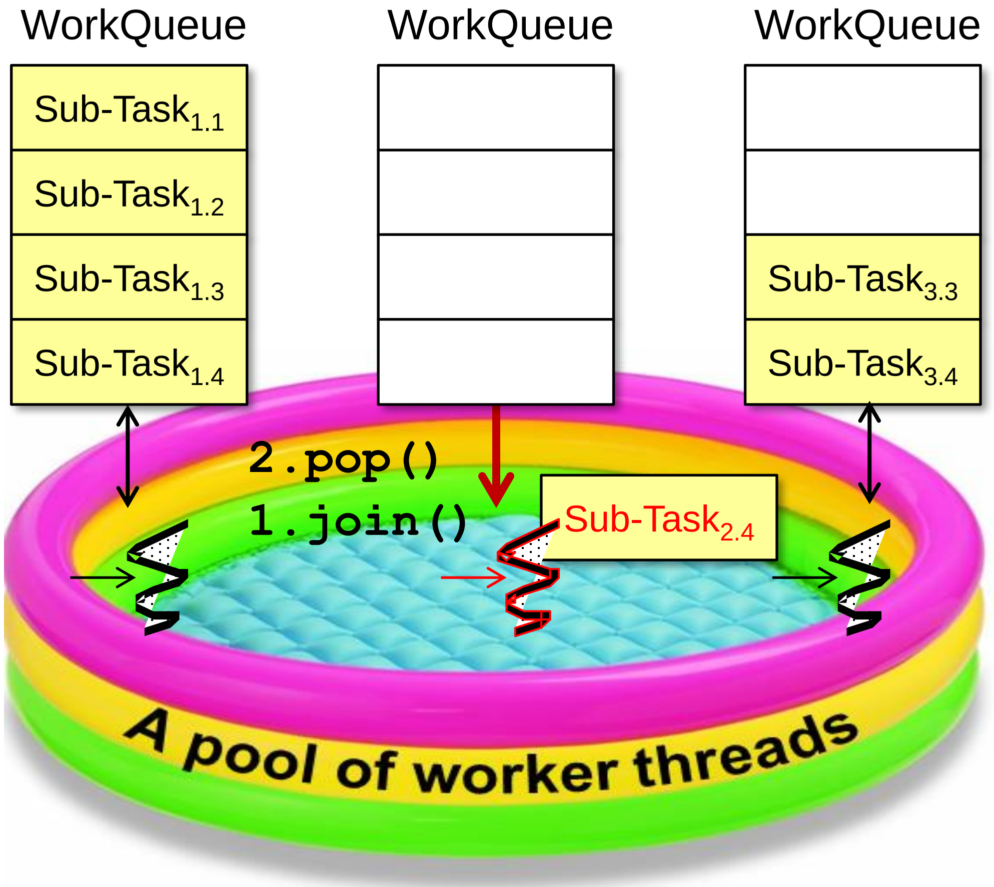
Mapping Parallel Streams Onto the Common Fork-Join Pool

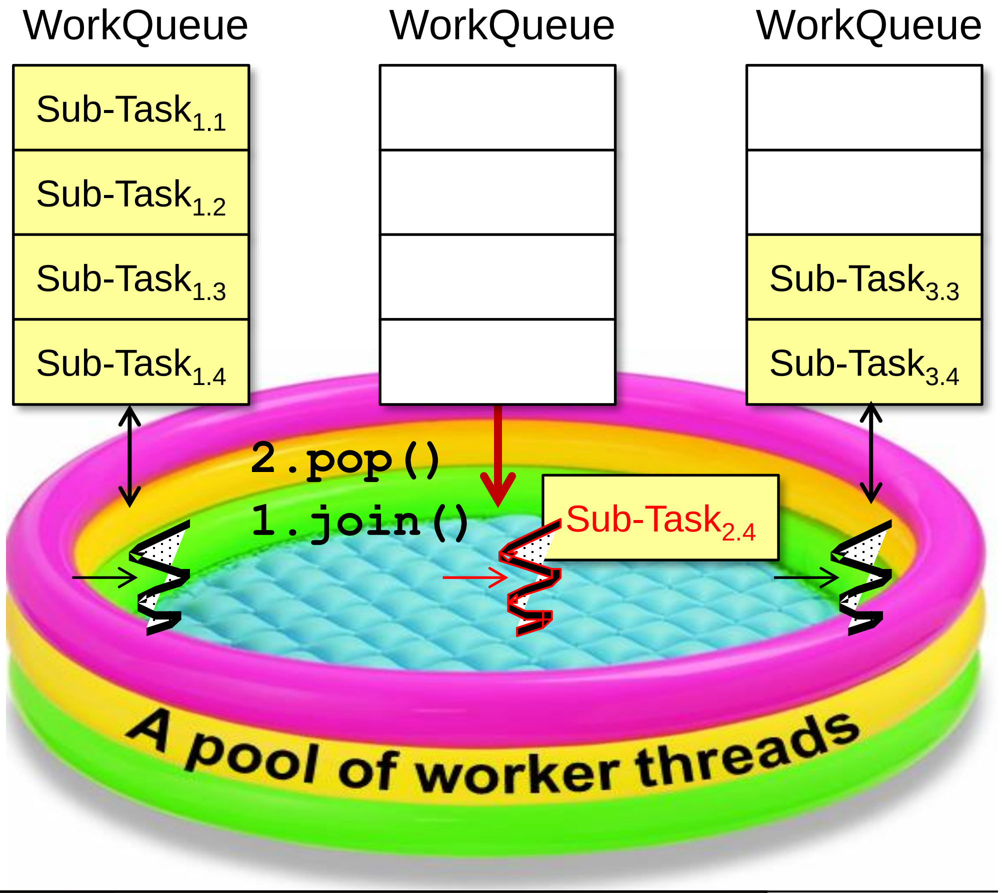
- Each worker thread processes its deque in LIFO order



See en.wikipedia.org/wiki/Stack_(abstract_data_type)

Mapping Parallel Streams Onto the Common Fork-Join Pool

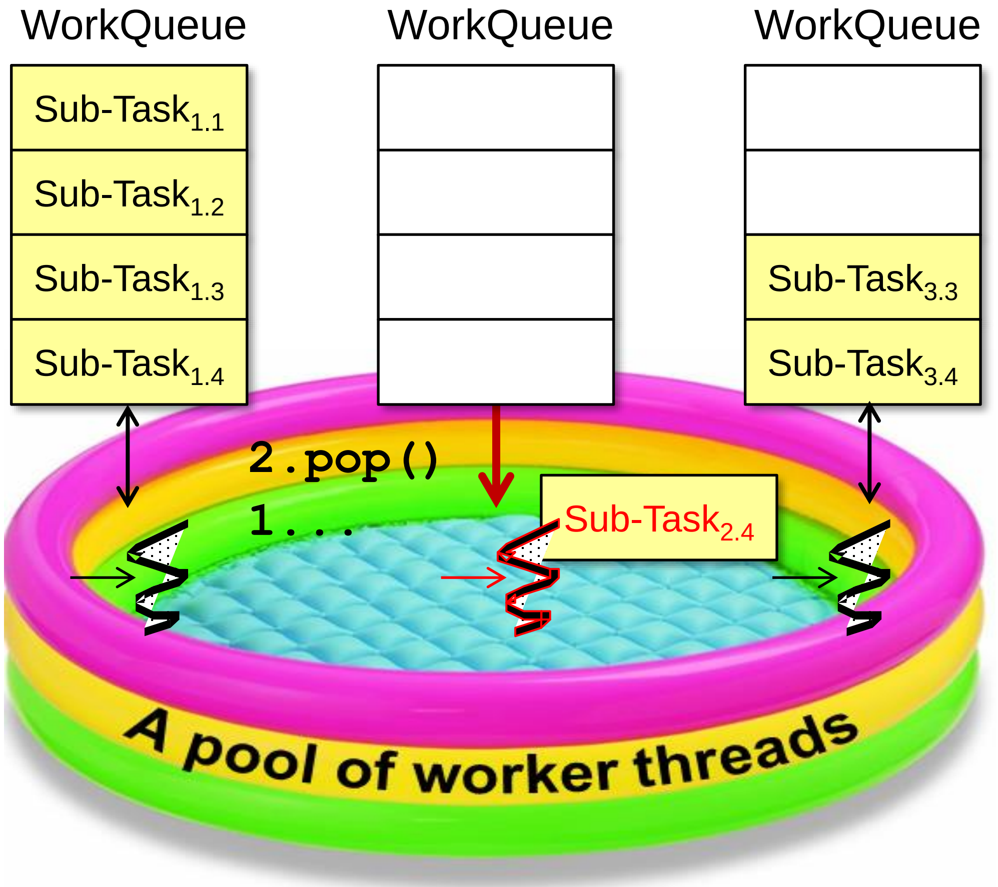
- Each worker thread processes its deque in LIFO order
  - A task pop'd from the head of a deque is run to completion



See en.wikipedia.org/wiki/Run_to_completion_scheduling

Mapping Parallel Streams Onto the Common Fork-Join Pool

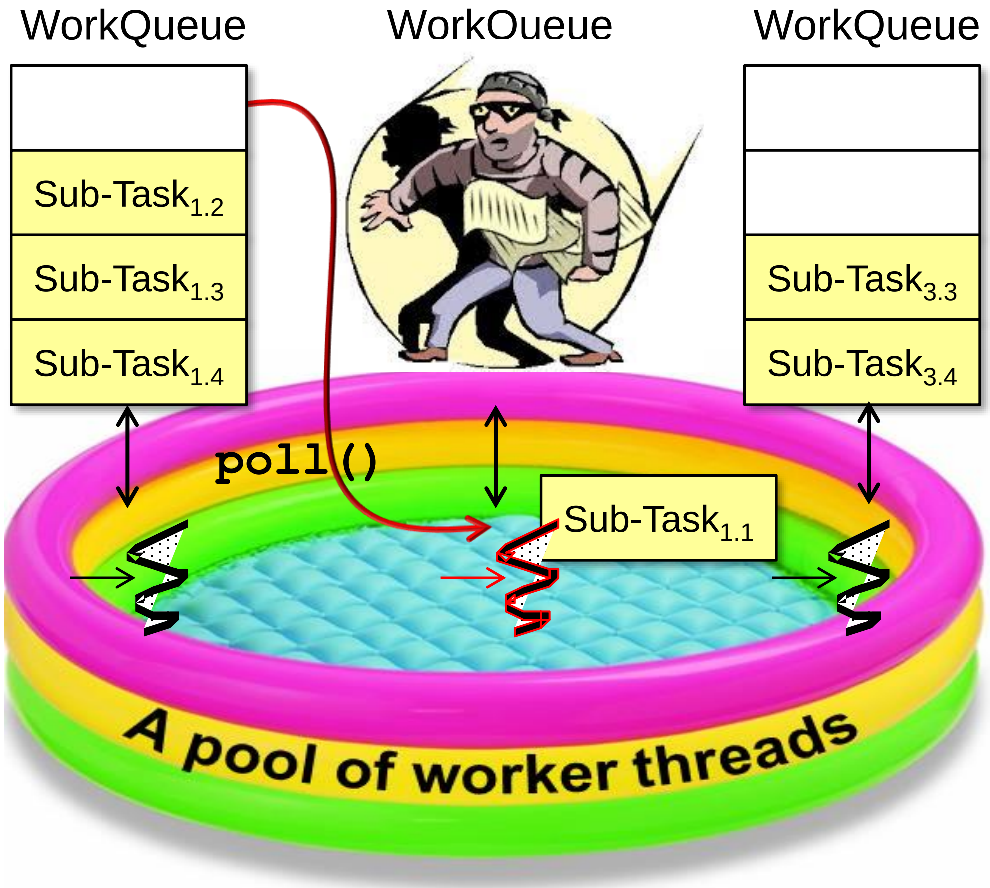
- Each worker thread processes its deque in LIFO order
  - A task pop'd from the head of a deque is run to completion
  - LIFO order improves locality of reference & cache performance



See en.wikipedia.org/wiki/Locality_of_reference

Mapping Parallel Streams Onto the Common Fork-Join Pool

- To maximize core utilization, idle worker threads "steal" work from the tail of busy threads' deques



See upcoming lessons on "*The Java Fork-Join Framework*"

End of Understand Java Parallel Stream Internals: Mapping Onto the Common Fork-Join Pool