Java Fork-Join Framework Internals: Work Stealing

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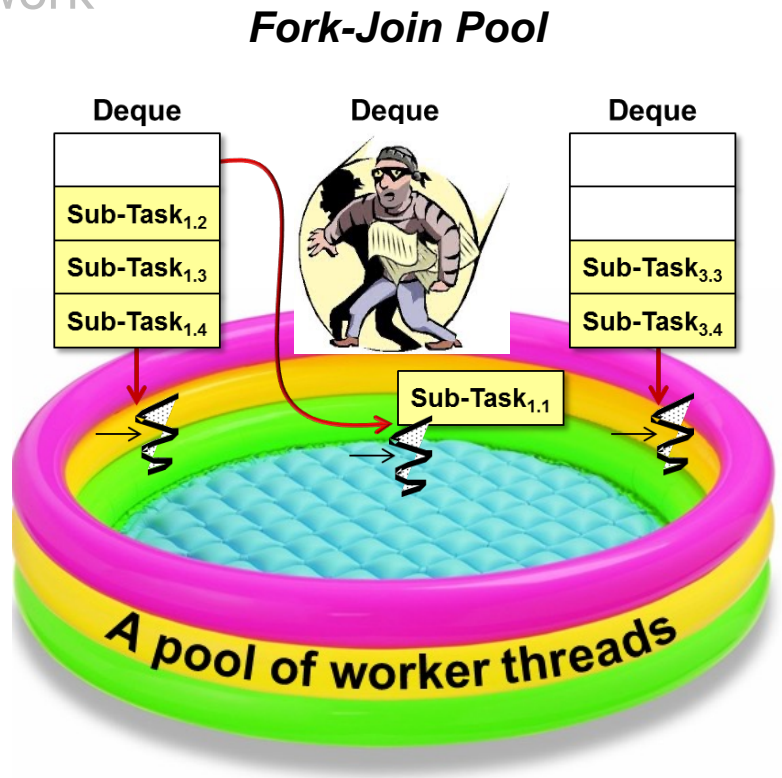
Learning Objectives in this Part of the Lesson

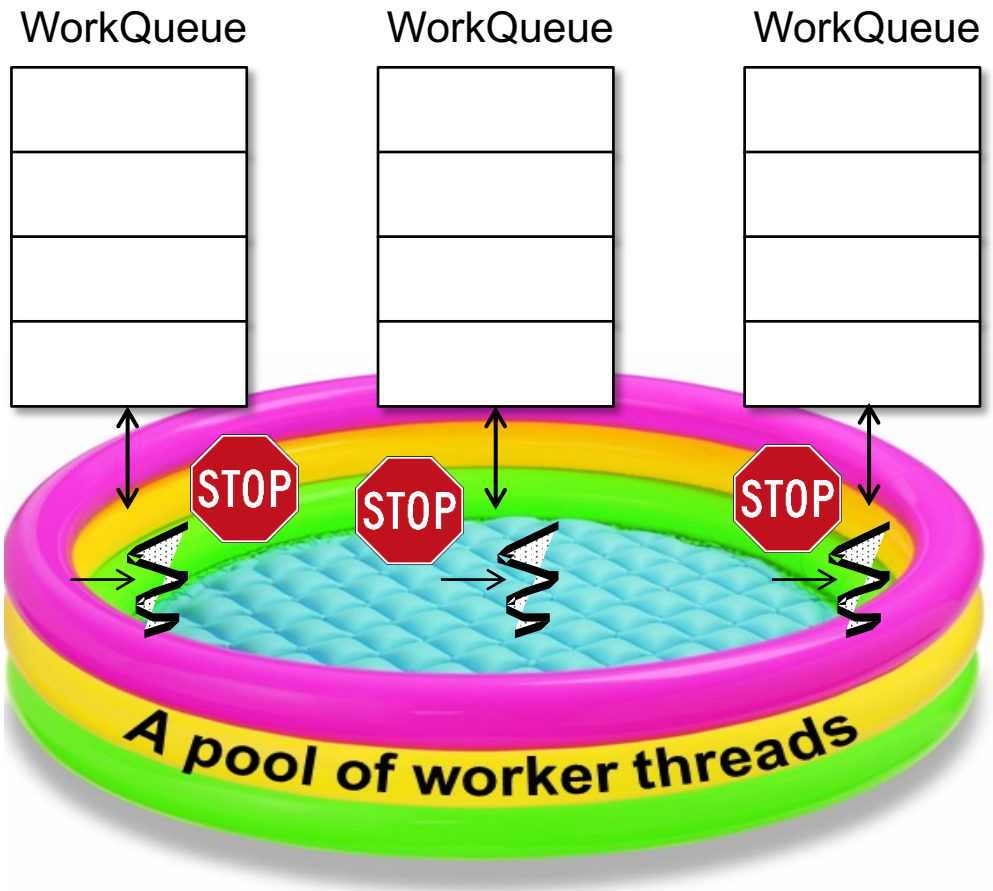
- Understand how the Java fork-join framework implements worker threads
- Understand how the Java fork-join framework implements work stealing



Working Stealing in a Java Fork-Join Pool

Work Stealing in a Java Fork-Join Pool

- Worker threads only block if there are no tasks available to run



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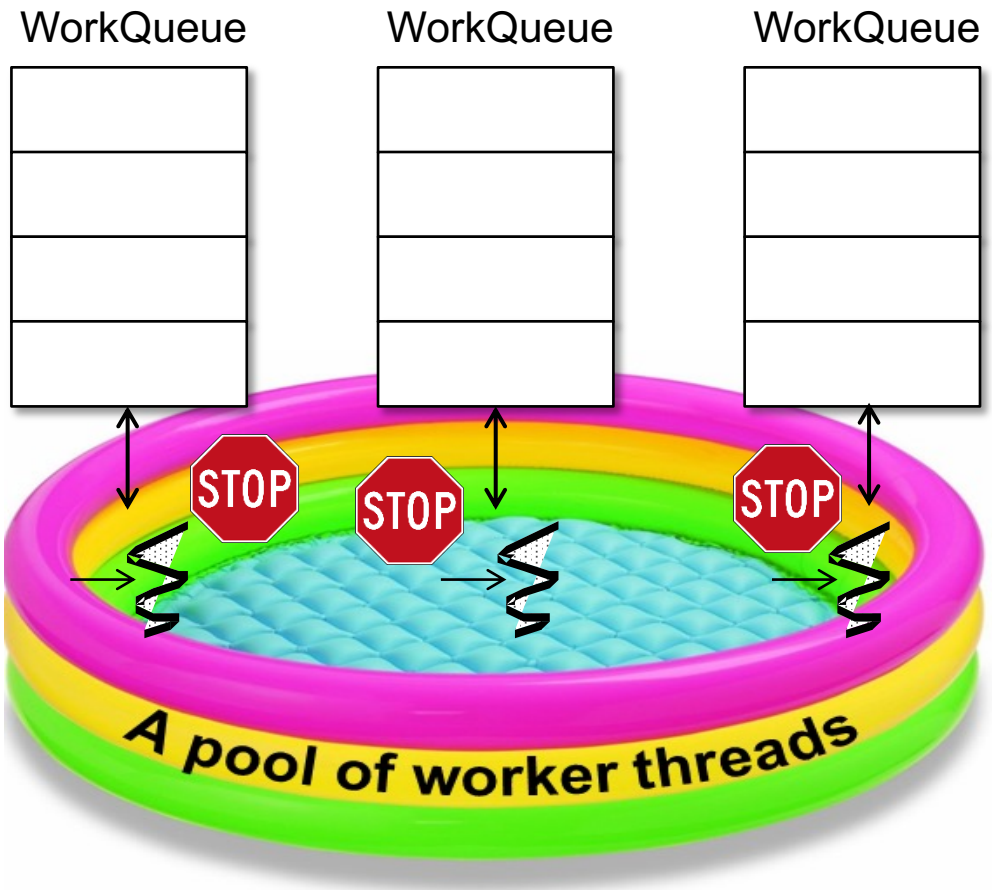
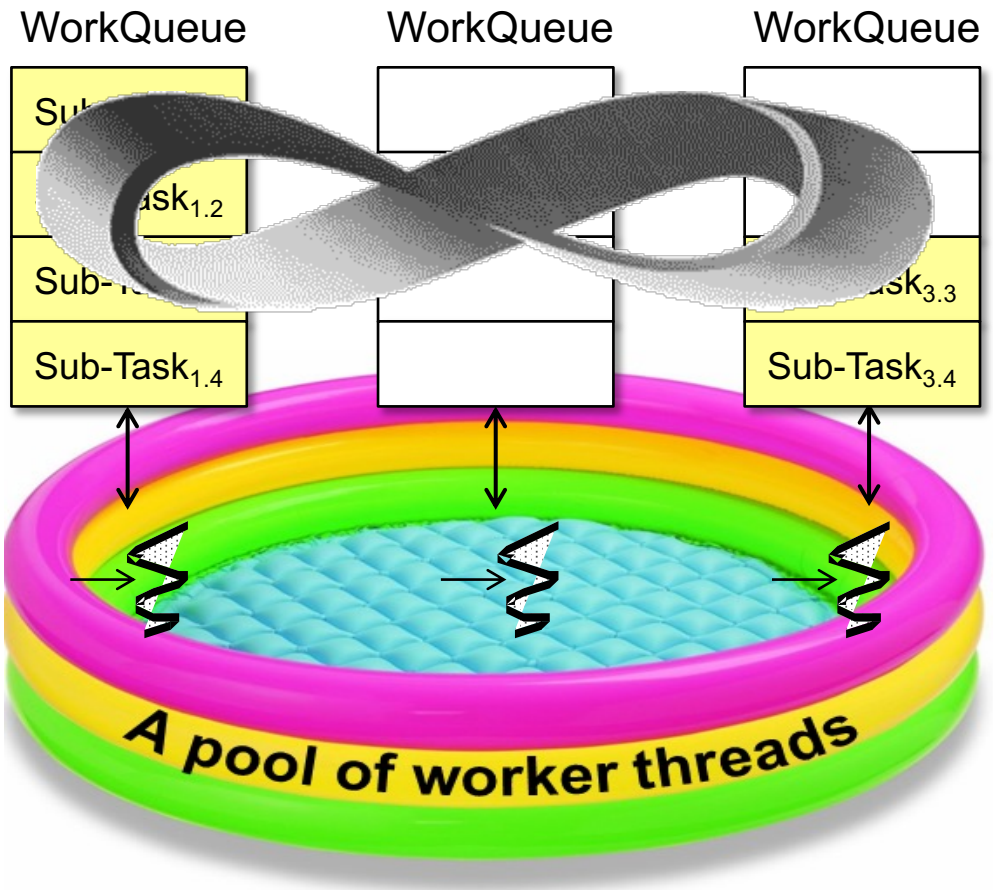
  - Blocking threads & cores is costly on modern processors



See Doug Lea's talk at www.youtube.com/watch?v=sq0MX3fHkro

Work Stealing in a Java Fork-Join Pool

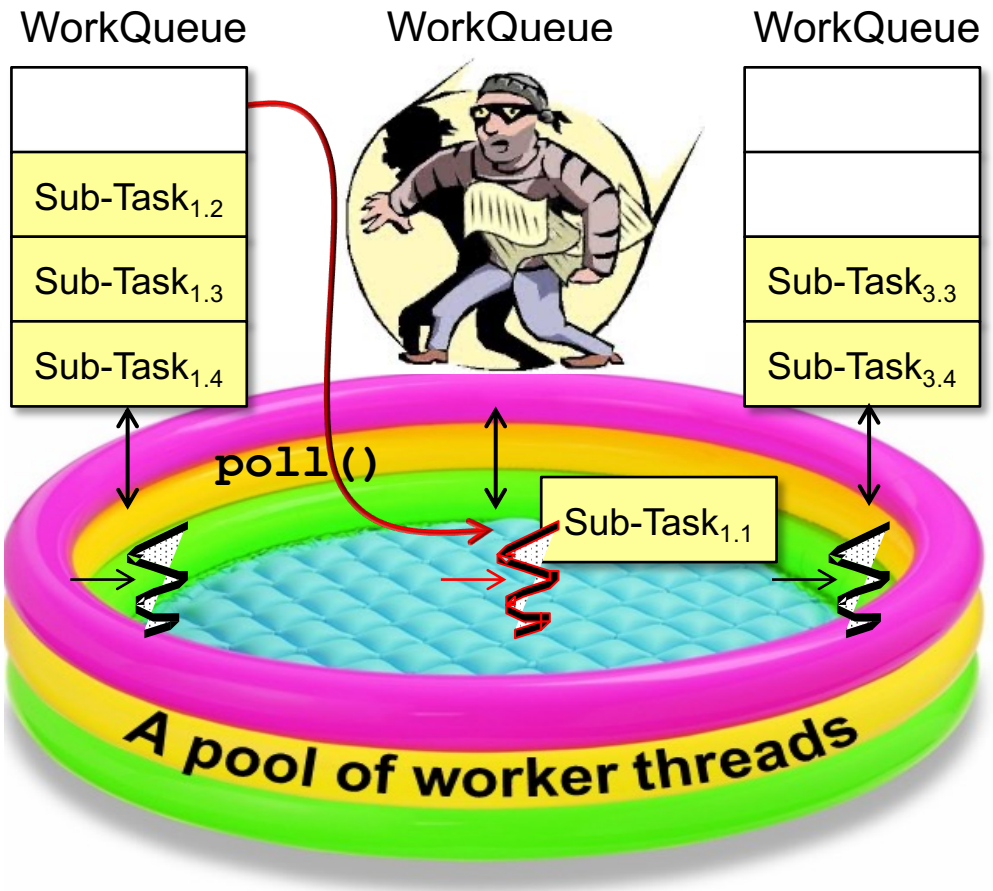
- Worker threads only block if there are no tasks available to run
  - Blocking threads & cores is costly on modern processors
  - A worker thread with an empty deque thus checks other deques in the pool to find tasks to run



See www.dre.vanderbilt.edu/~schmidt/PDF/work-stealing-dequeue.pdf

Work Stealing in a Java Fork-Join Pool

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



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

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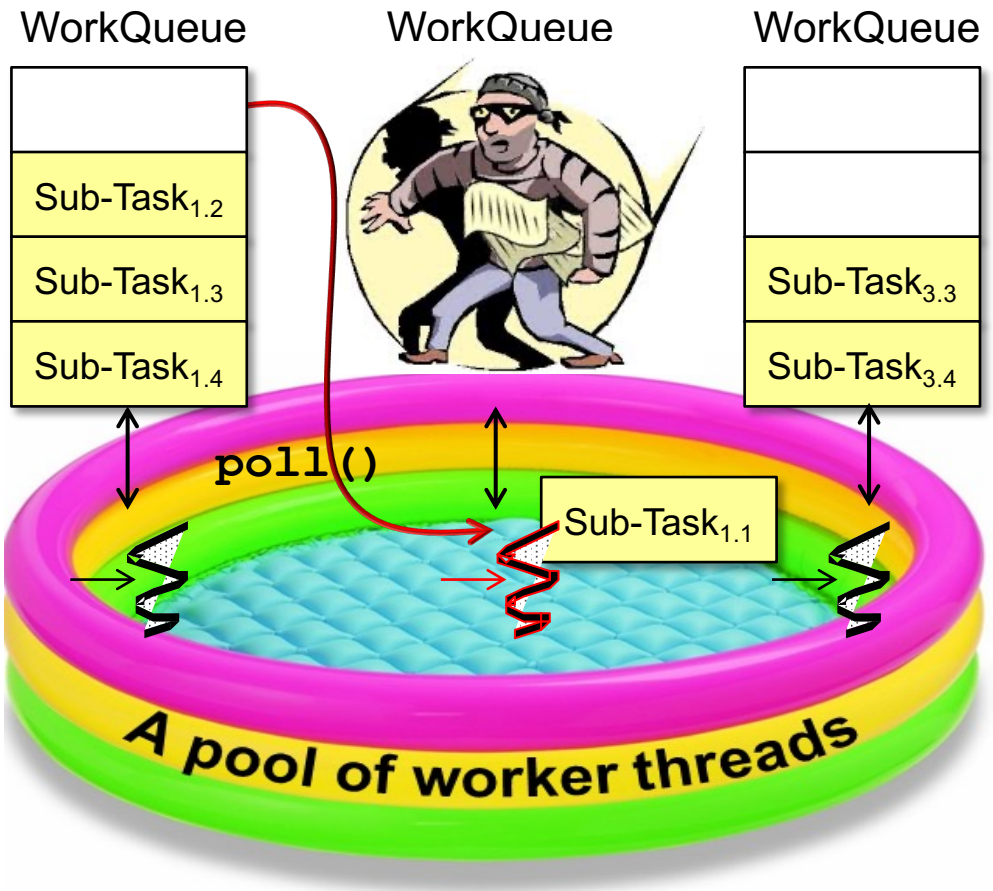

The worker thread deque to steal from is selected randomly to lower contention

Work Stealing in a Java Fork-Join Pool

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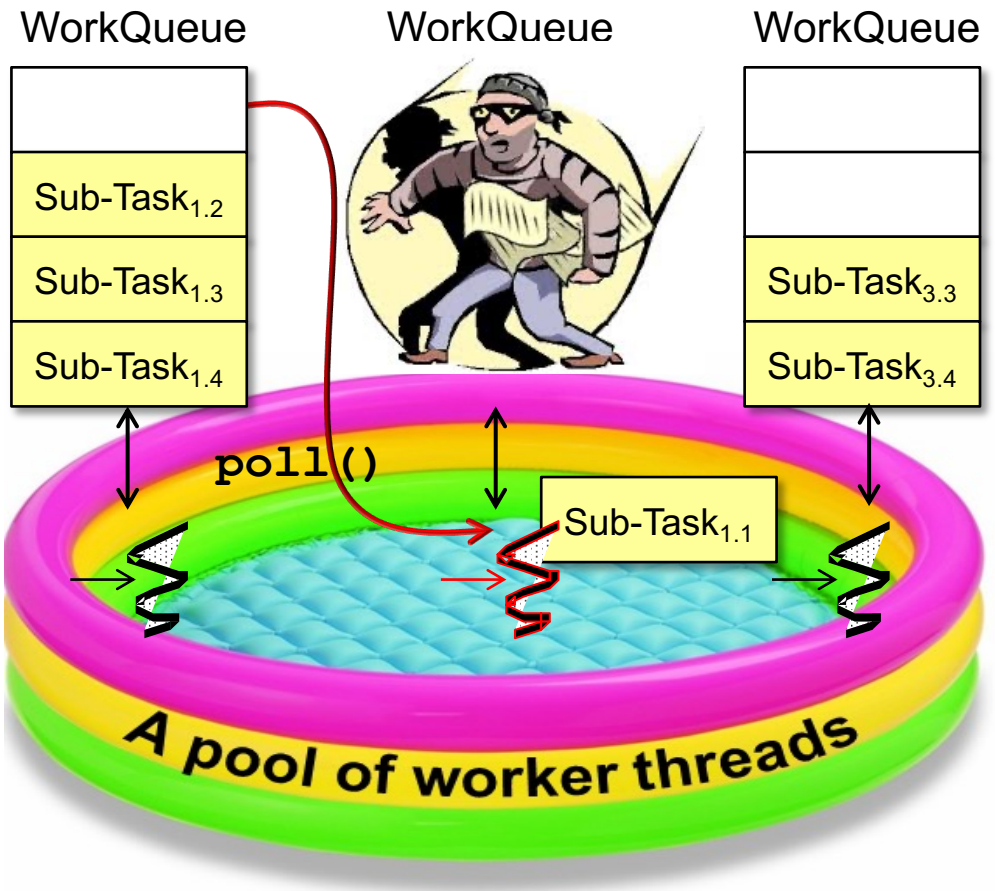
  - Worker threads only steal from other threads in *their* pool
    - i.e., there's no "cross-pool" stealing



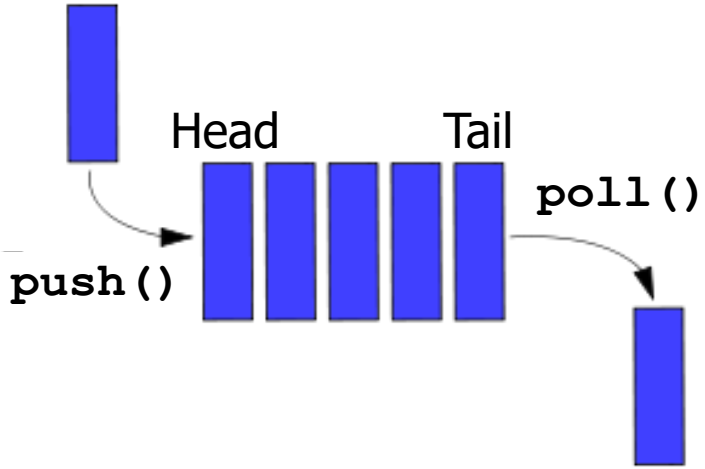
Work Stealing in a Java Fork-Join Pool

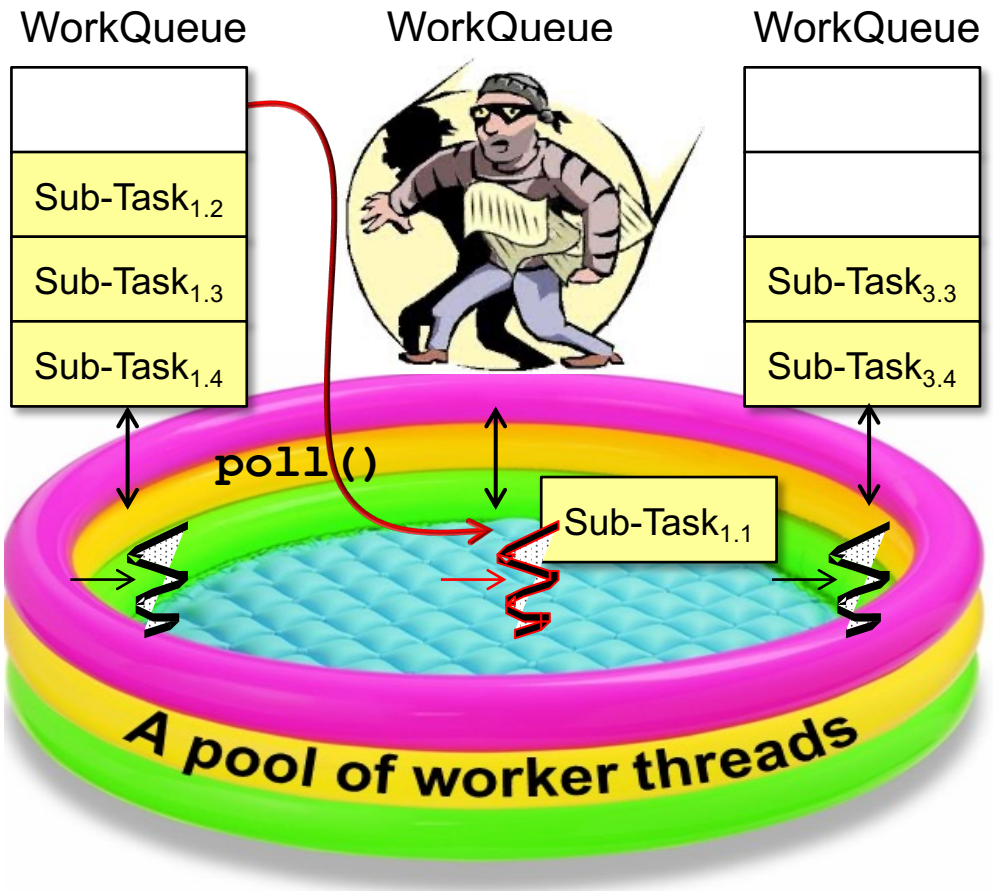
- To maximize core utilization, idle worker threads "steal" work from the tail of busy threads' deques
  - Worker threads only steal from other threads in *their* pool
  - This limitation motivates the use of the common fork-join pool

See upcoming lessons on *"The Common Fork-Join Pool"*

Work Stealing in a Java Fork-Join Pool

- Tasks are stolen in FIFO order





See en.wikipedia.org/wiki/FIFO_(computing_and_electronics)

Work Stealing in a Java Fork-Join Pool

- Tasks are stolen in FIFO order
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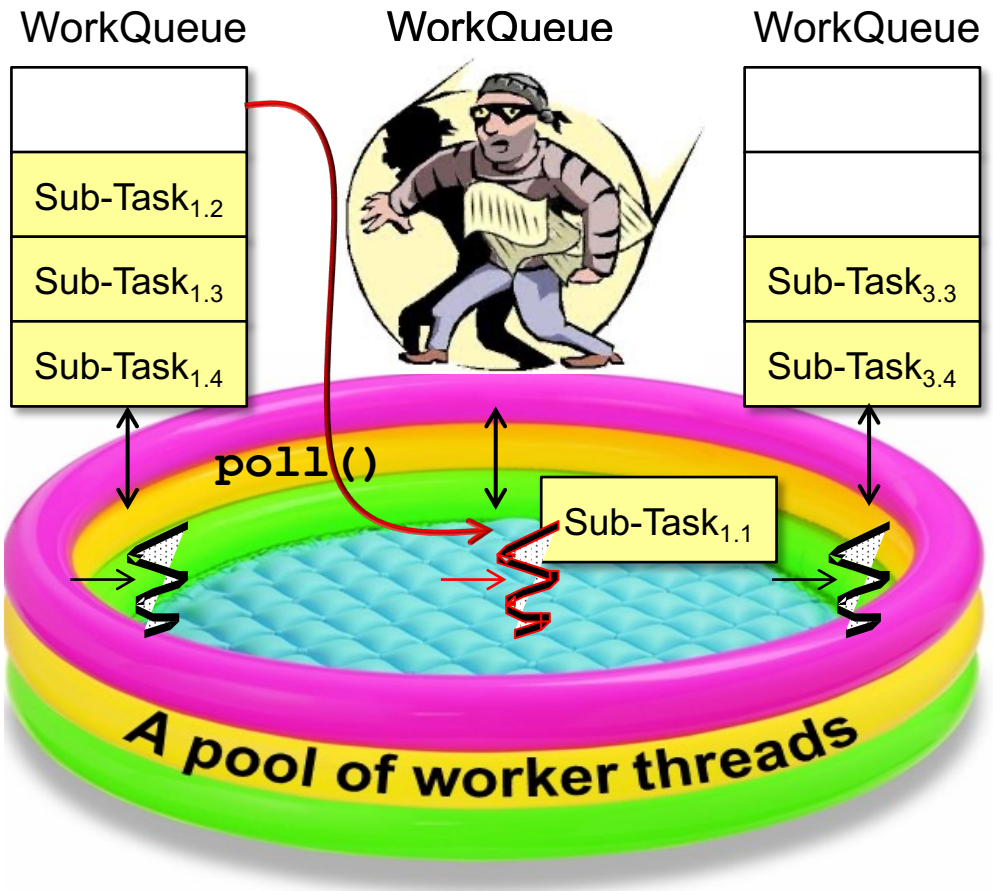
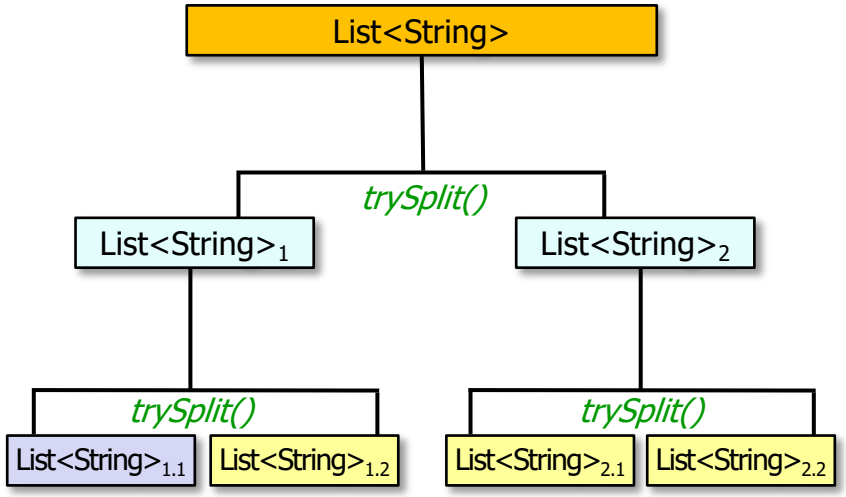
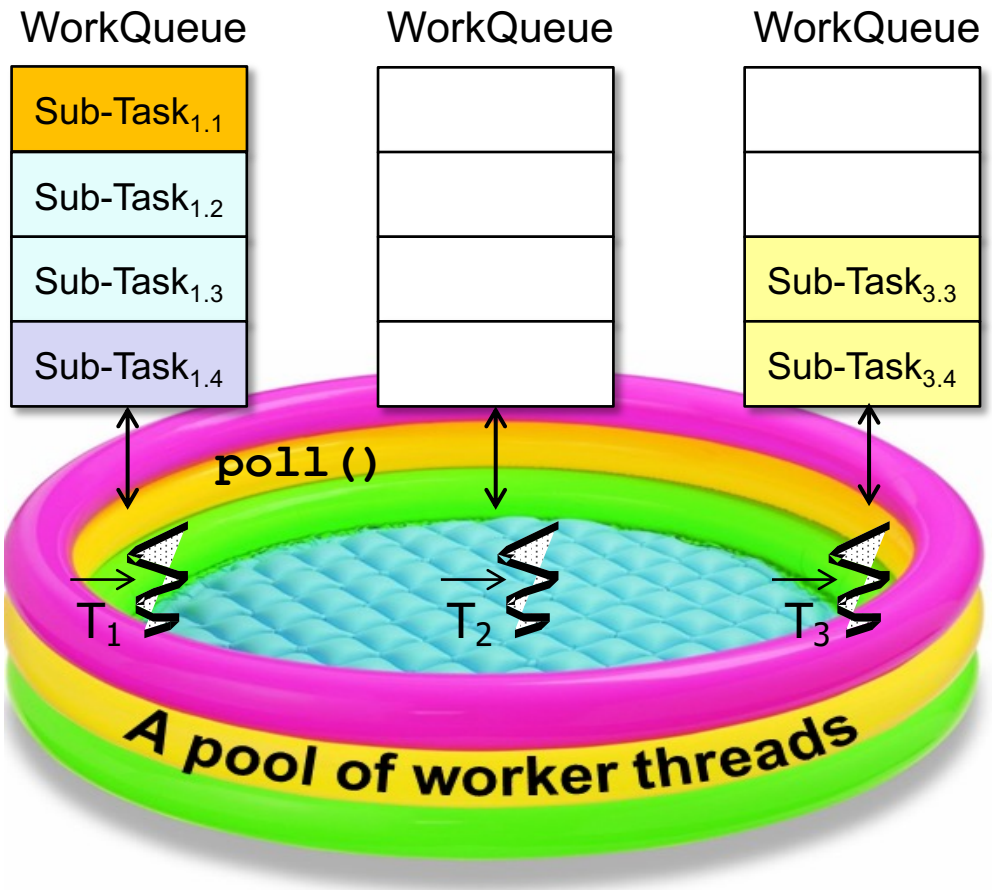


See www.ibm.com/support/knowledgecenter/en/SS3KLZ/com.ibm.java.diagnostics.healthcenter.doc/topics/resolving.html

Work Stealing in a Java Fork-Join Pool

- Tasks are stolen in FIFO order
  - Minimizes contention w/worker thread owning the deque
  - An older stolen task may provide a larger unit of work





This behavior arises from "divide & conquer" nature of fork-join tasks that split evenly

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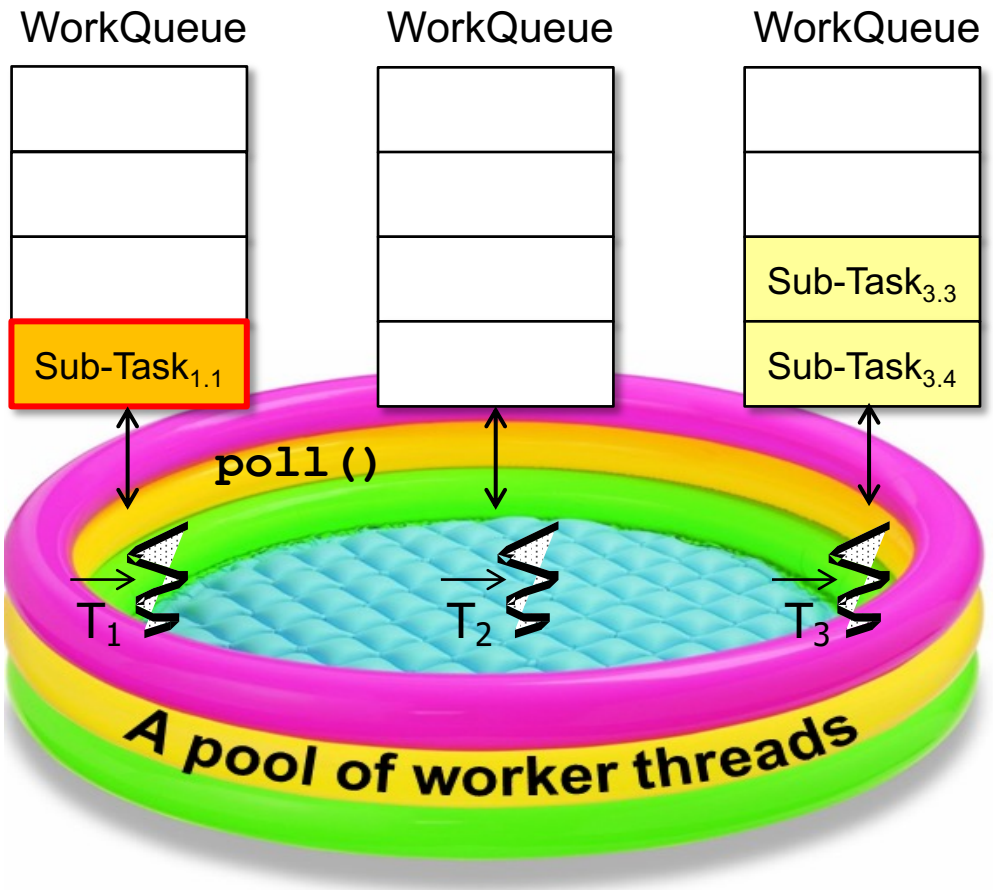
List<String>



Larger chunks are pushed onto the deque before smaller chunks

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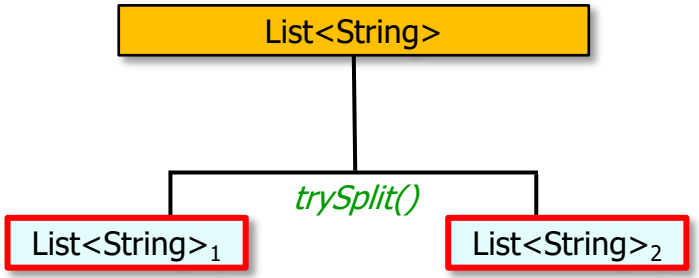

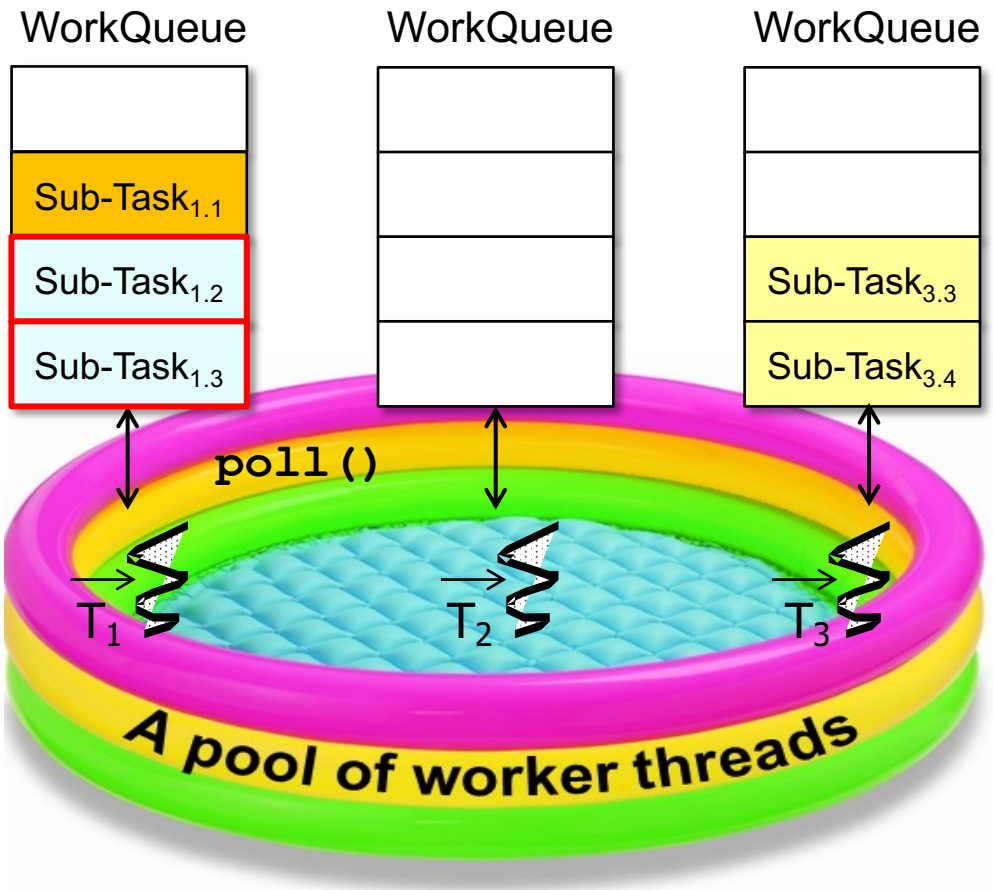

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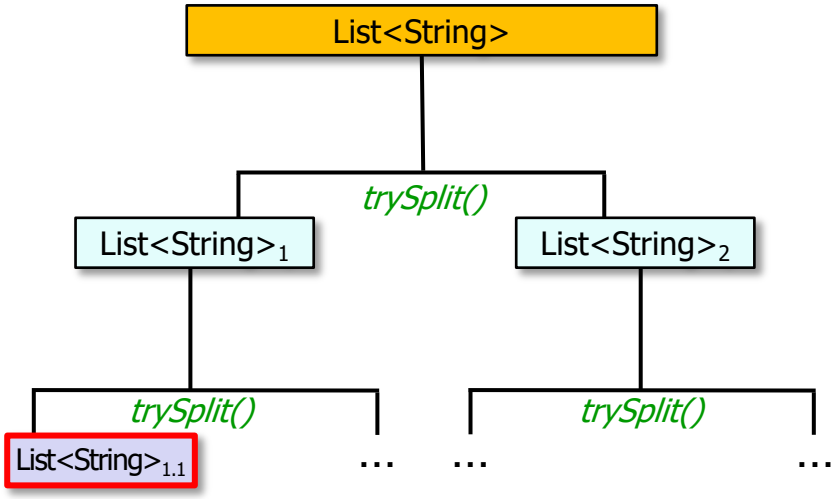

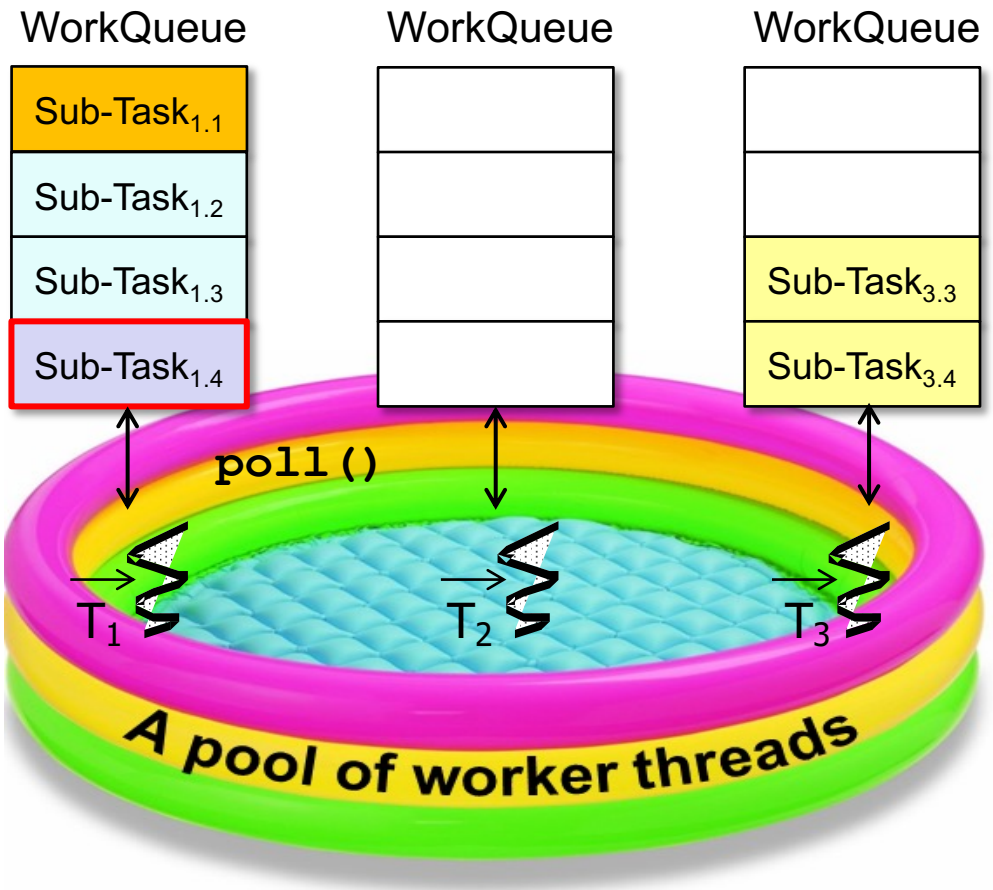

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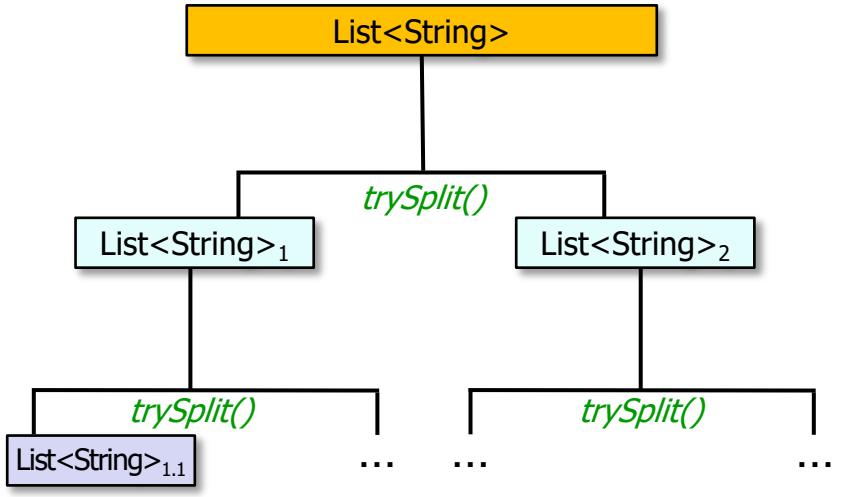

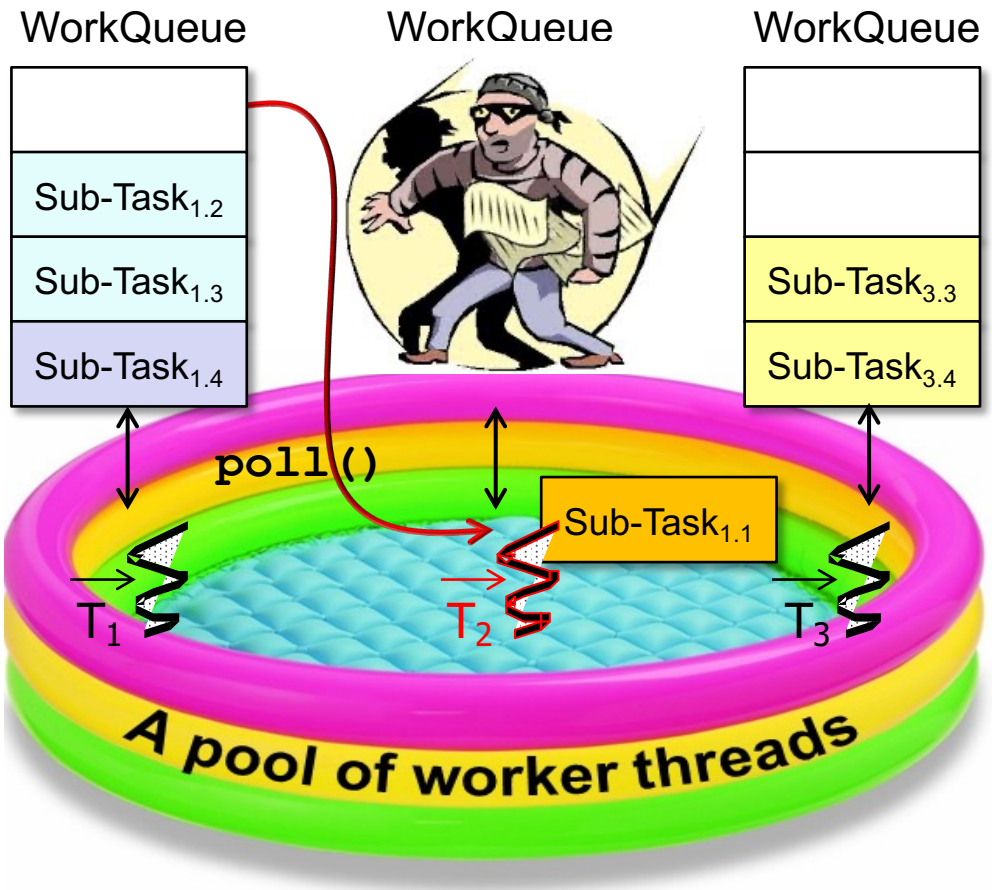

Thread T_2 steals a larger (sub-)task from the end of the deque

Work Stealing in a Java Fork-Join Pool

- Tasks are stolen in FIFO order
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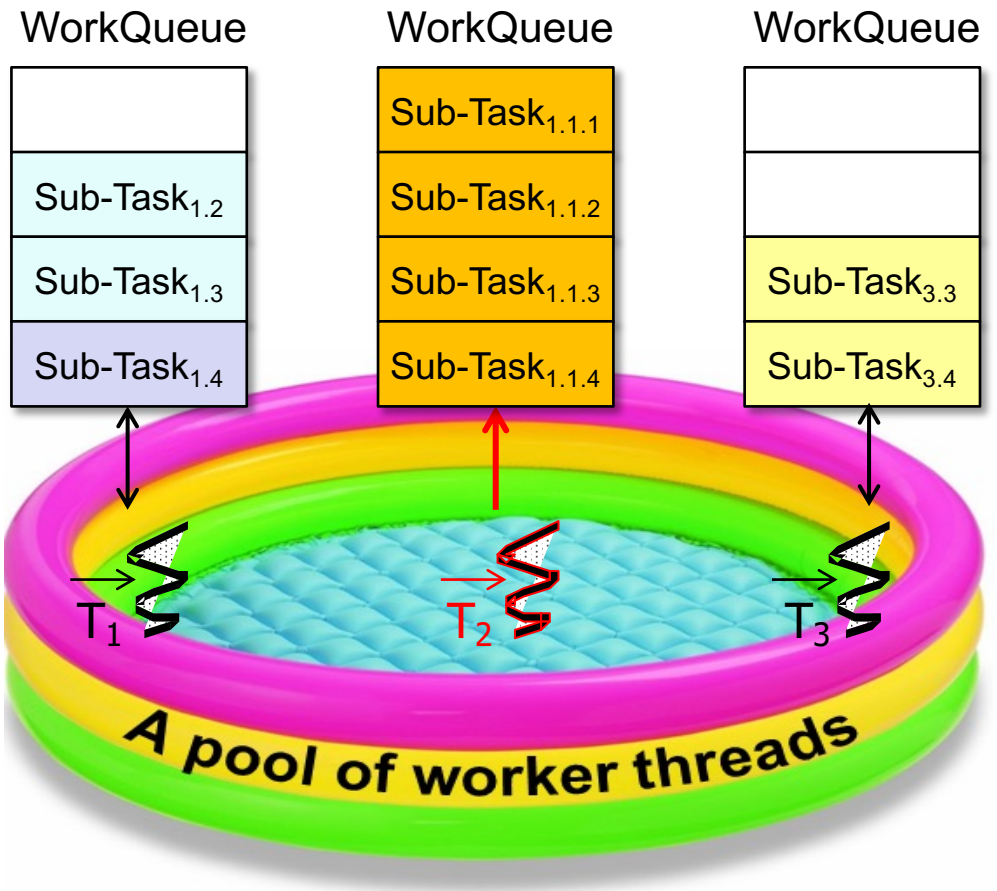
  - An older stolen task may provide a larger unit of work
    - Enables further recursive decompositions by the stealing thread



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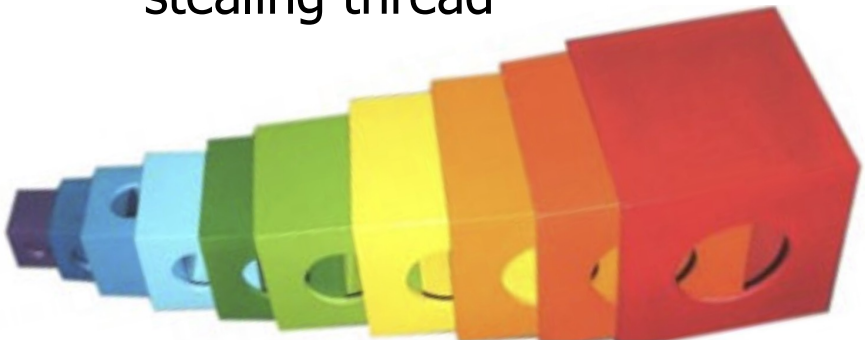
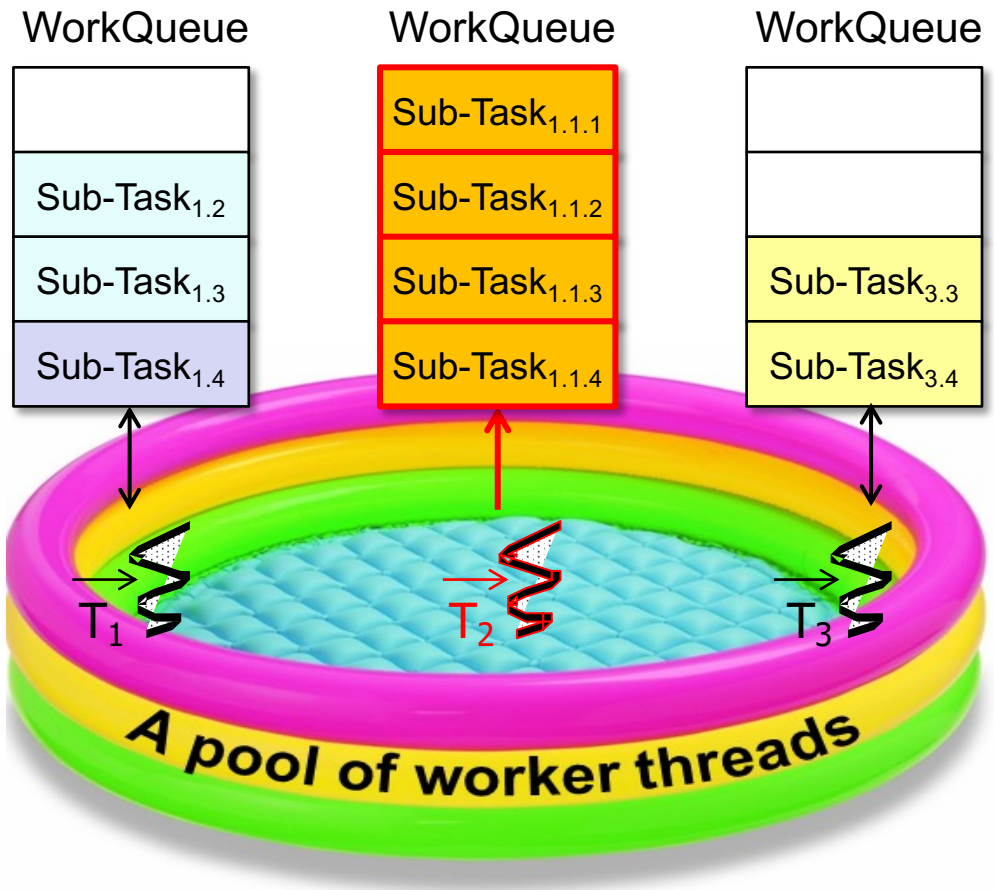
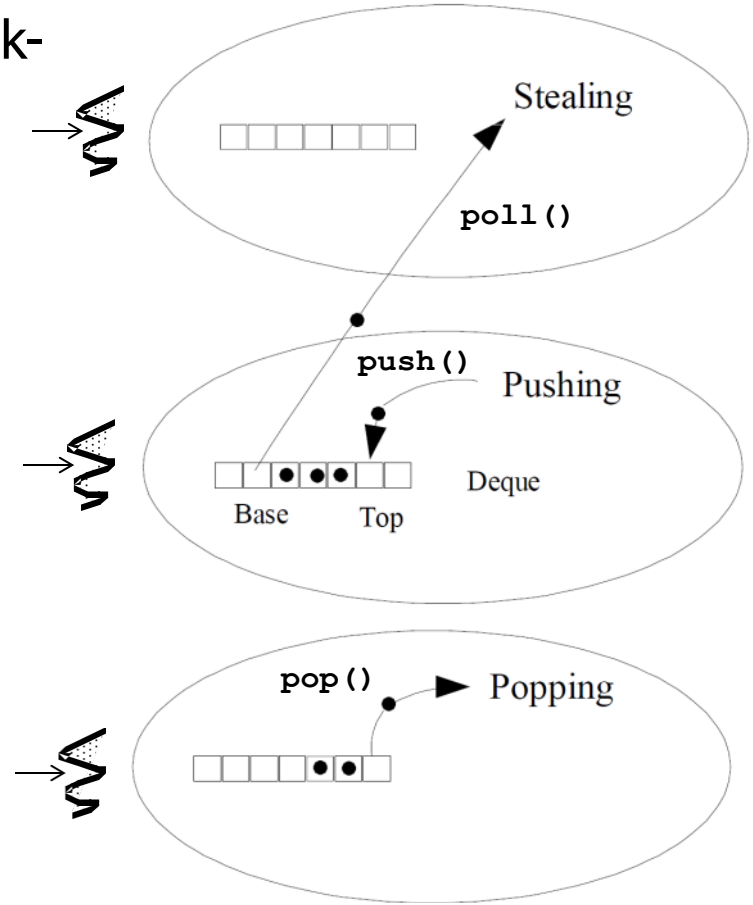




Again, larger chunks are pushed onto the deque before smaller chunks

Work Stealing in a Java Fork-Join Pool

- The WorkQueue deque that implements work-stealing minimizes locking contention



See www.dre.vanderbilt.edu/~schmidt/PDF/work-stealing-deque.pdf

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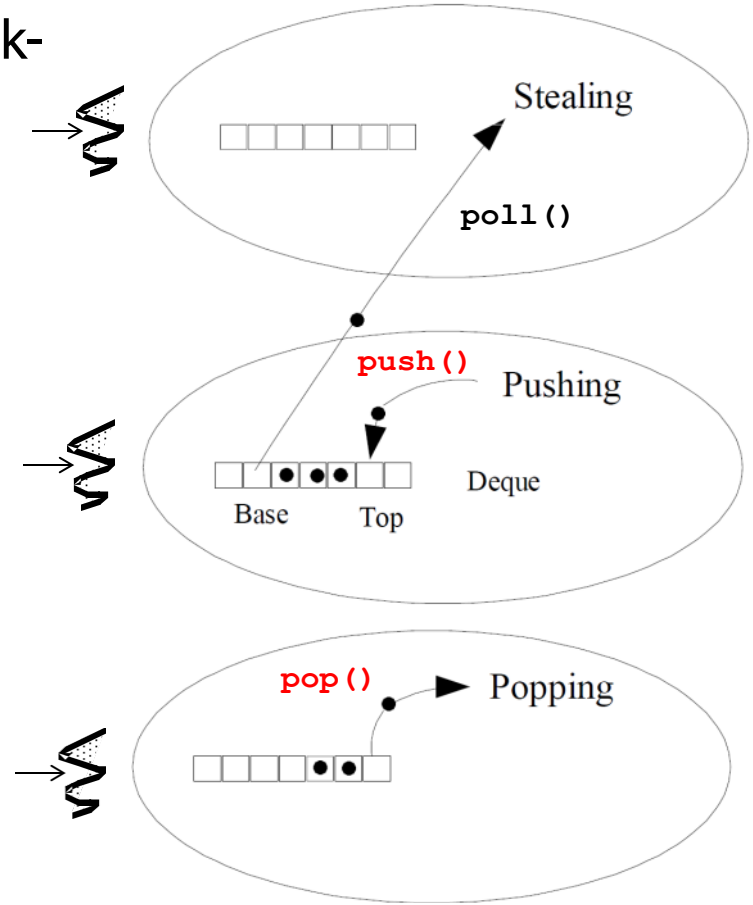

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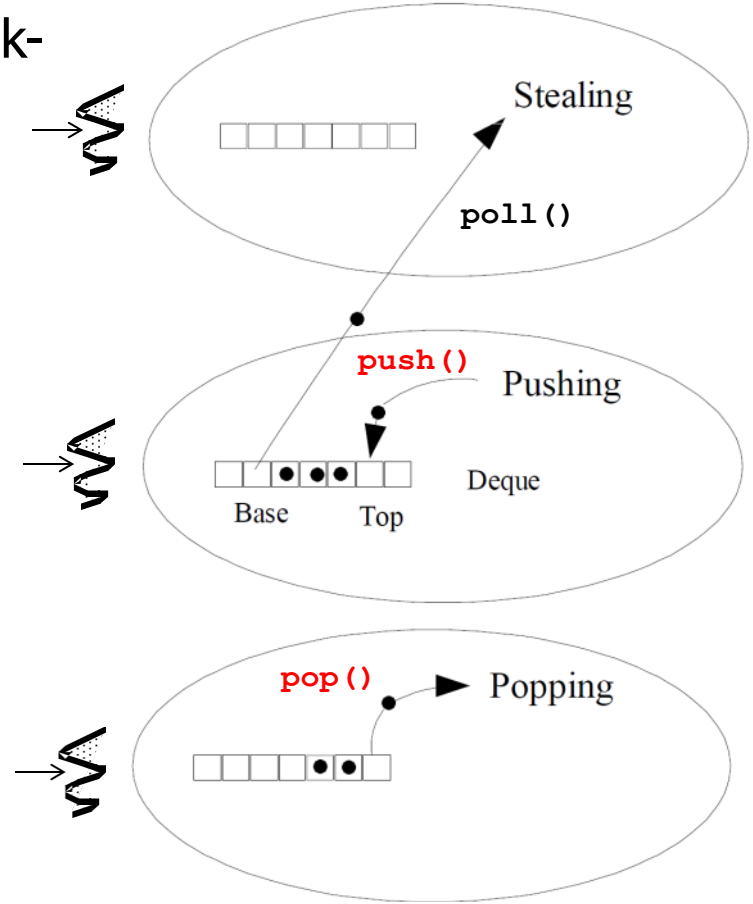

See en.wikipedia.org/wiki/Compare-and-swap

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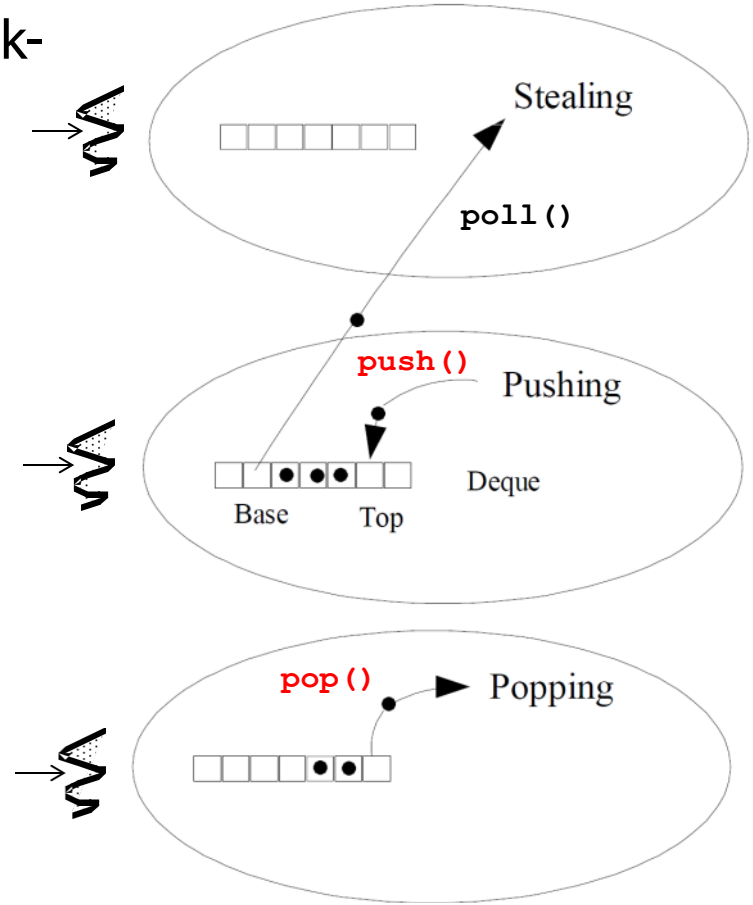
      - An operation is "wait-free" if every thread completes its operation in a bounded # of steps, irrespective of the # of contending threads



See www.justsoftwaresolutions.co.uk/threading/non_blocking_lock_free_and_wait_free.html

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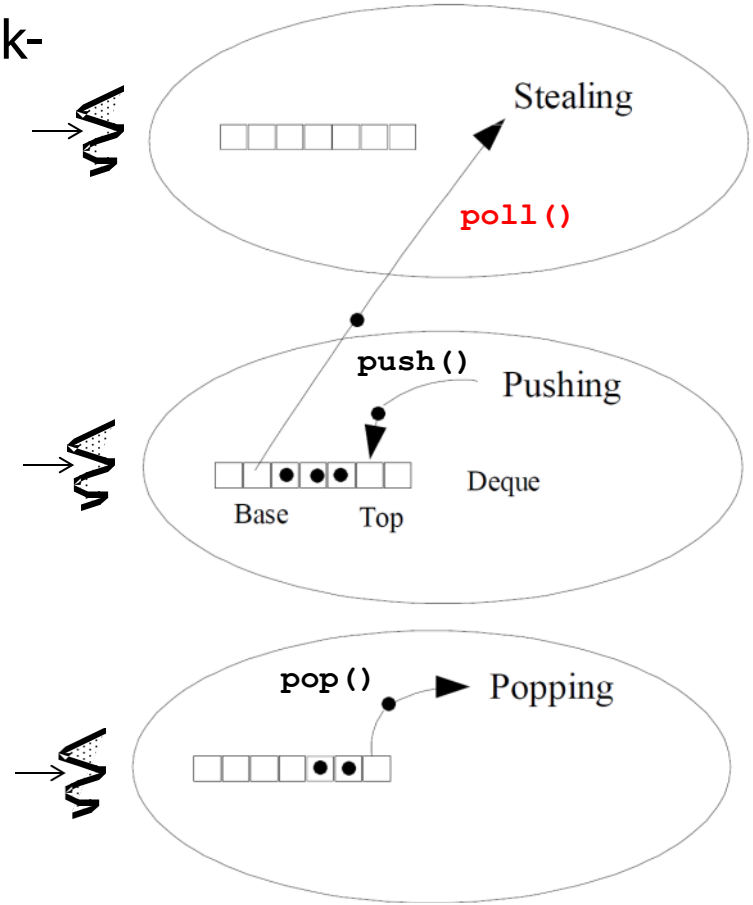

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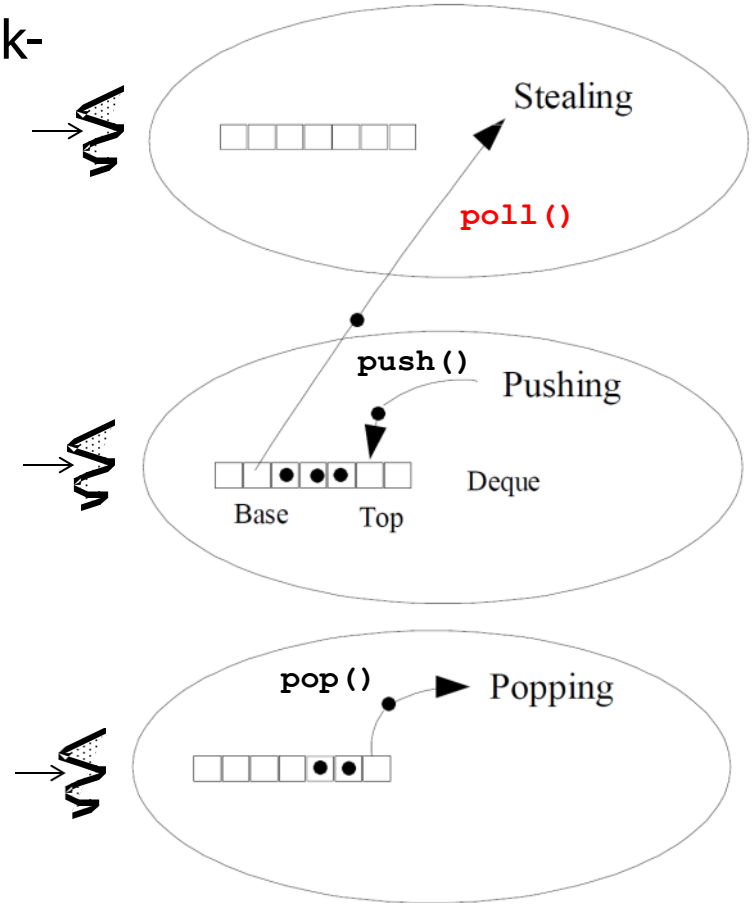

See gee.cs.oswego.edu/dl/papers/fj.pdf

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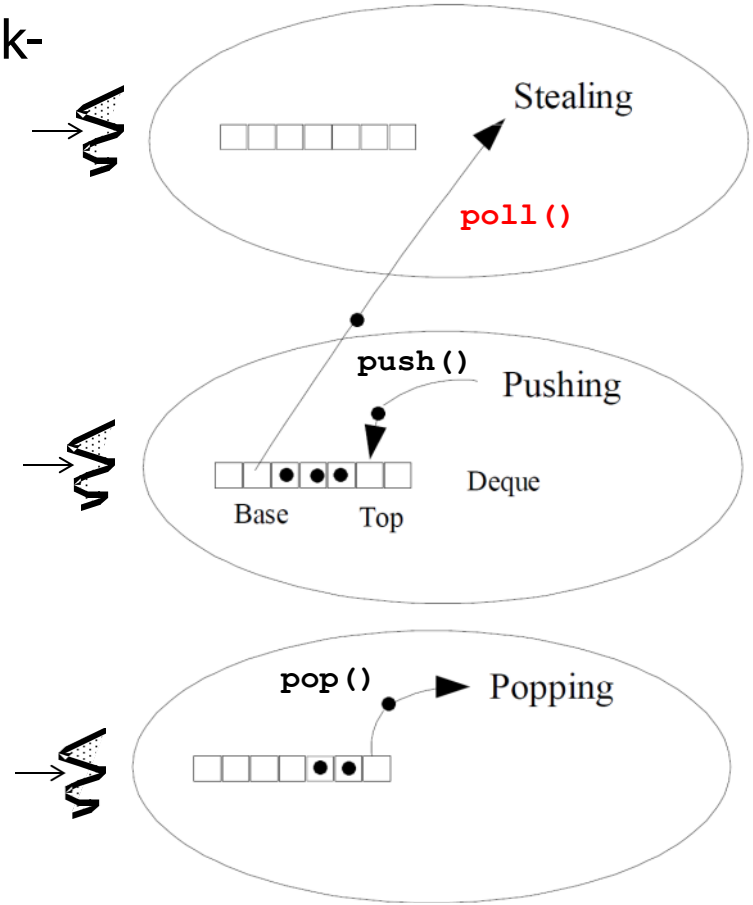

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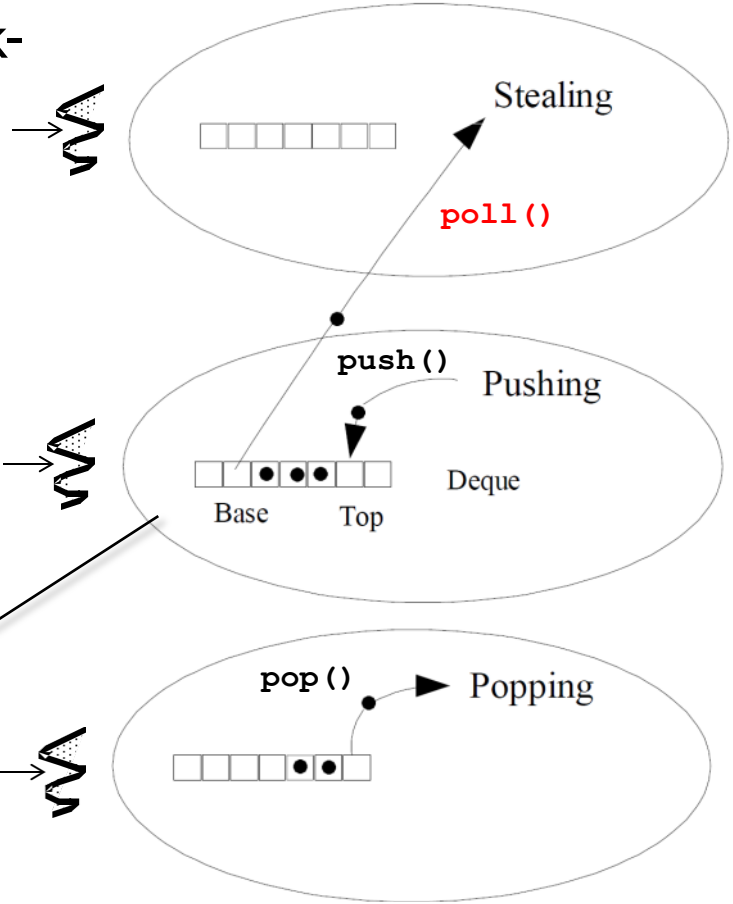

See "Implementation Overview" comments in the ForkJoinPool source code for details..

See java8/util/concurrent/ForkJoinPool.java

End of Java Fork-Join Framework Internals: Work Stealing