The Java Fork-Join Pool Framework (Part 3)

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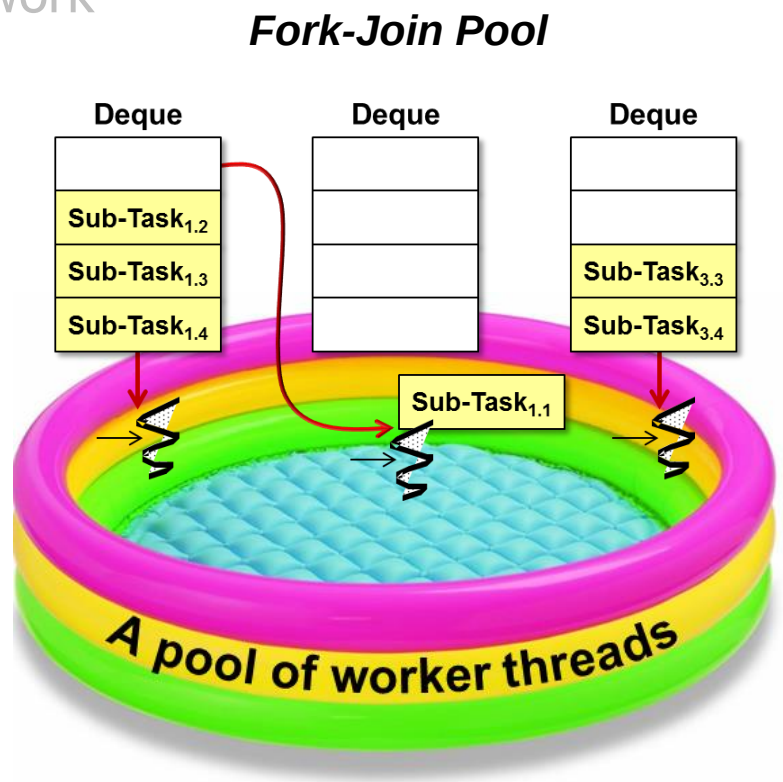
Learning Objectives in this Part of the Lesson

- Understand how the Java fork-join framework processes tasks in parallel
- Recognize the structure & functionality of the fork-join framework
- Know how the fork-join framework is implemented internally



Java Fork-Join Pool Framework Internals

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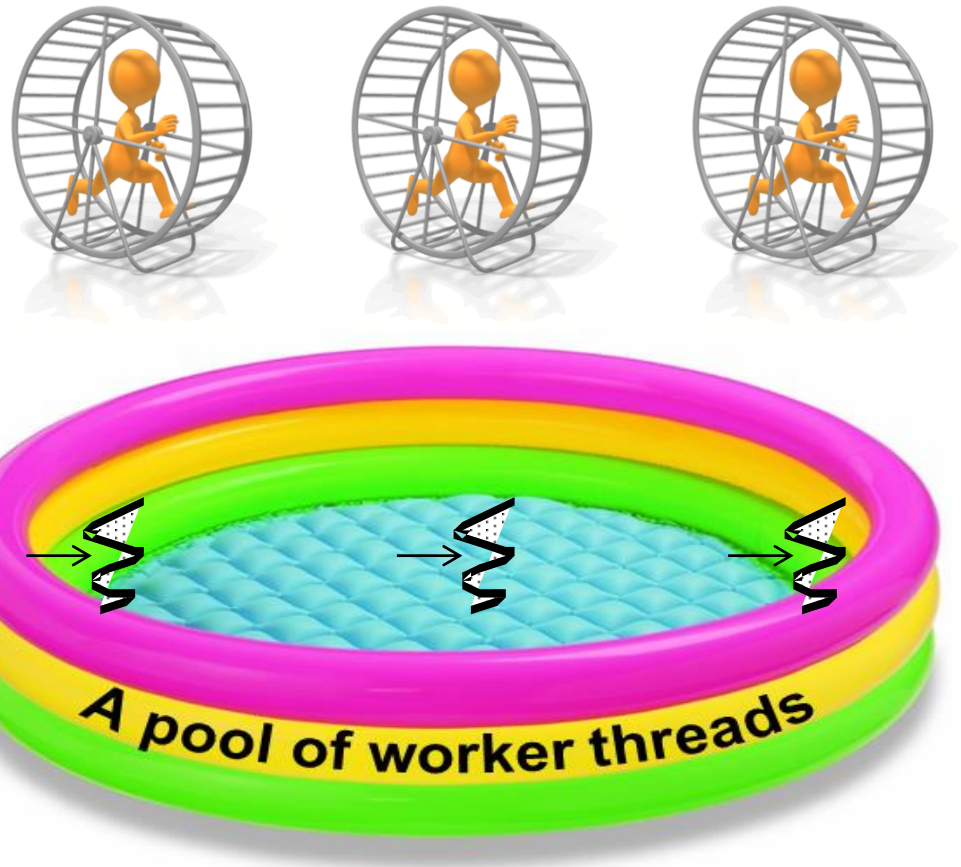
- Each worker thread in a fork-join pool runs a loop that scans for (sub-)tasks to execute



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Blocking a working thread is very costly on modern processors

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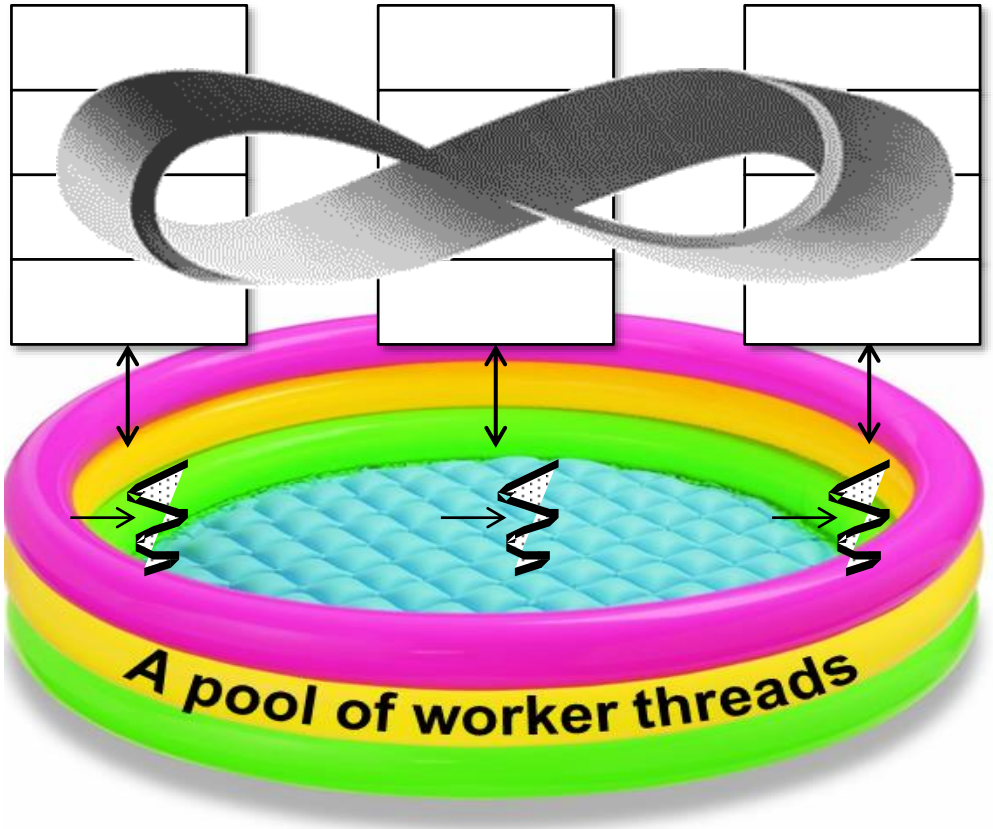
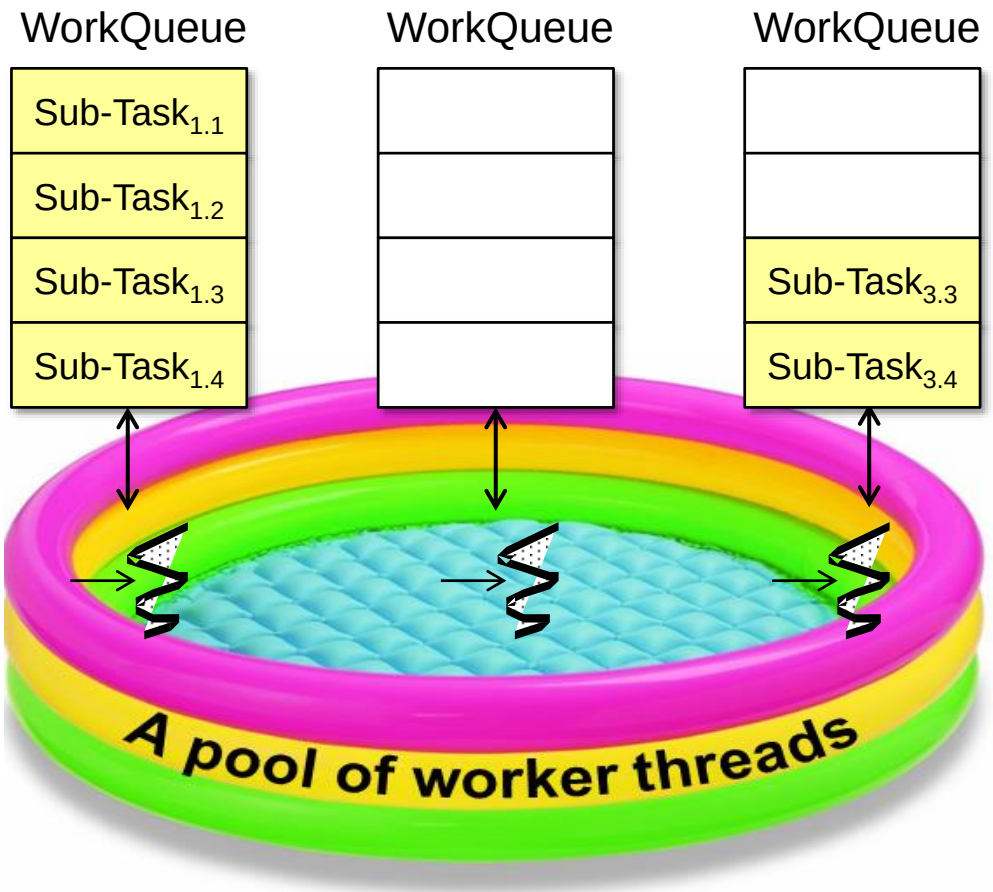
  - The goal is to keep the worker threads as busy as possible!
  - A worker thread only blocks waiting for work if no (sub-) tasks are available to run
  - Each worker thread therefore checks multiple input sources for (sub-)tasks to execute



Java Fork-Join Pool Framework Internals

- A worker thread has a "double-ended queue" (aka "deque") that serves as its main input source



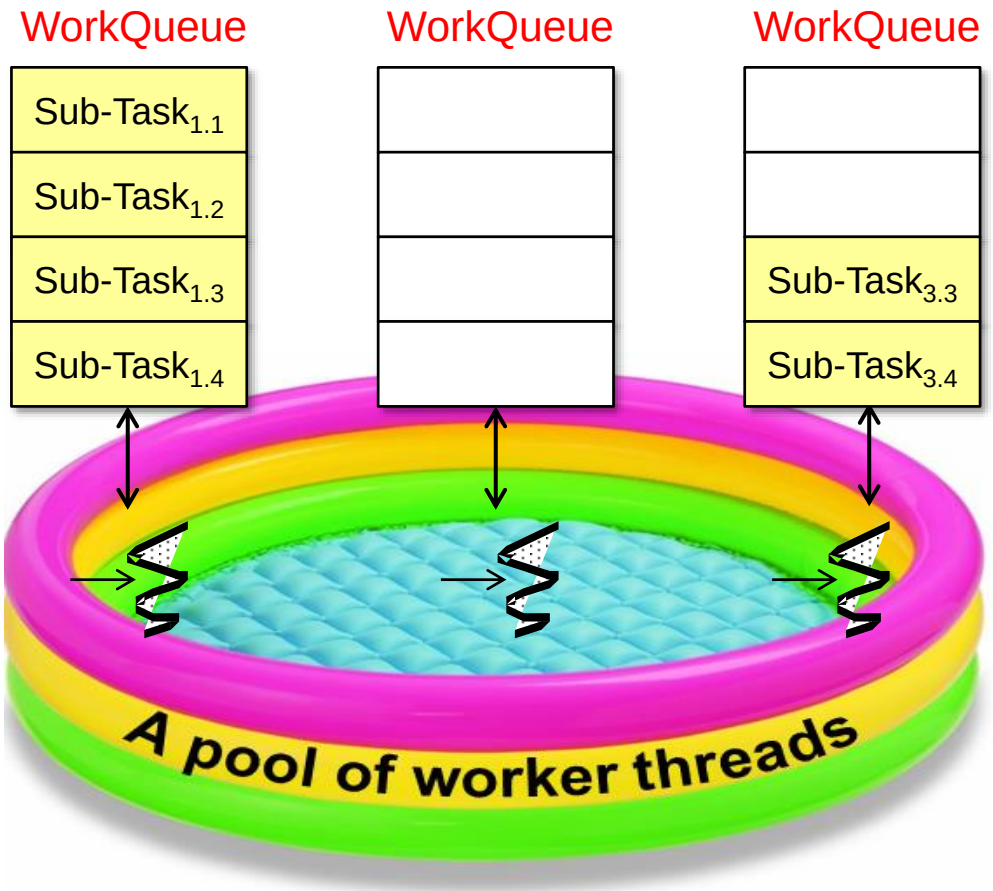
See en.wikipedia.org/wiki/Double-ended_queue

Java Fork-Join Pool Framework Internals

- A worker thread has a "double-ended queue" (aka "deque") that serves as its main input source
  - Implemented by WorkQueue

<<Java Class>>
WorkQueue

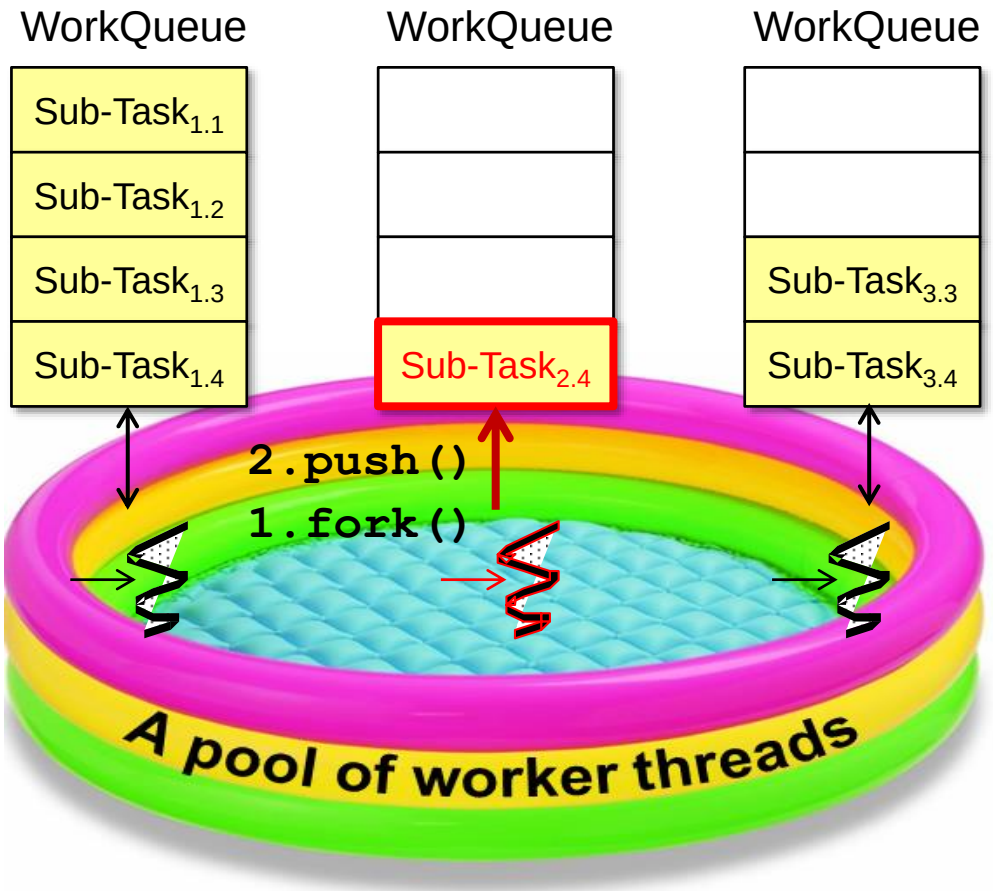
- WorkQueue(ForkJoinPool,ForkJoinWorkerThread,int,int)
- queueSize():int
- isEmpty():boolean
- push(ForkJoinTask<?>):void
- growArray():ForkJoinTask<?>
- pop():ForkJoinTask<?>
- pollAt(int):ForkJoinTask<?>
- poll():ForkJoinTask<?>
- peek():ForkJoinTask<?>
- cancelAll():void
- pollAndExecAll():void
- runTask(ForkJoinTask<?>):void
- tryRemoveAndExec(ForkJoinTask<?>):boolean
- isApparentlyUnblocked():boolean



See java8/util/concurrent/ForkJoinPool.java

Java Fork-Join Pool Framework Internals

- If a task run by a worker thread calls fork() the new task is pushed on the head of the worker's deque



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

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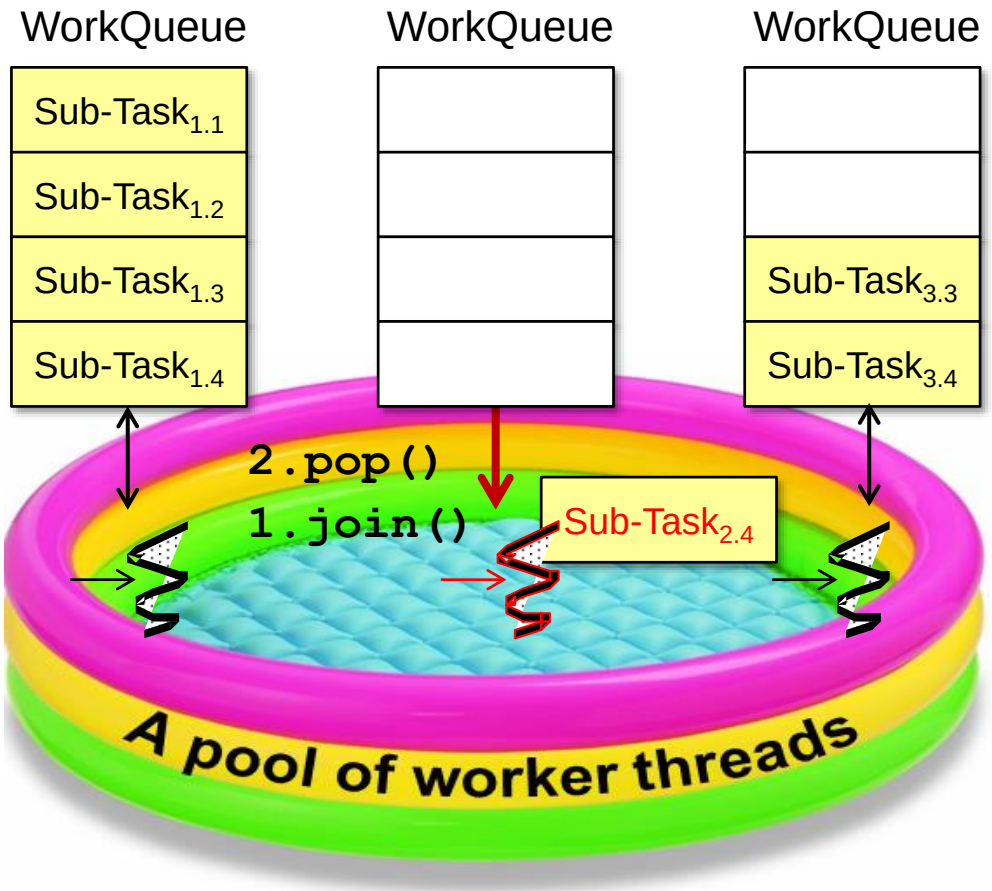
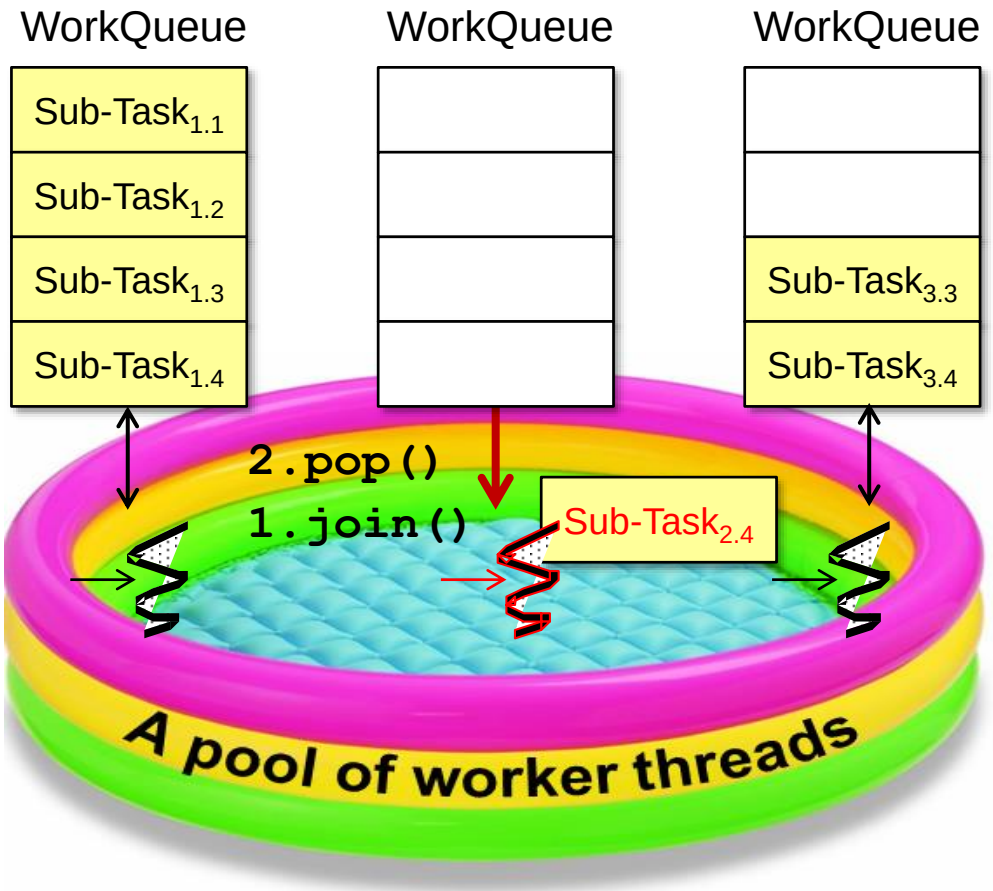
- If a task run by a worker thread calls fork() the new task is pushed on the head of the worker's deque
  - A worker thread processes its deque in LIFO order



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

Java Fork-Join Pool Framework Internals

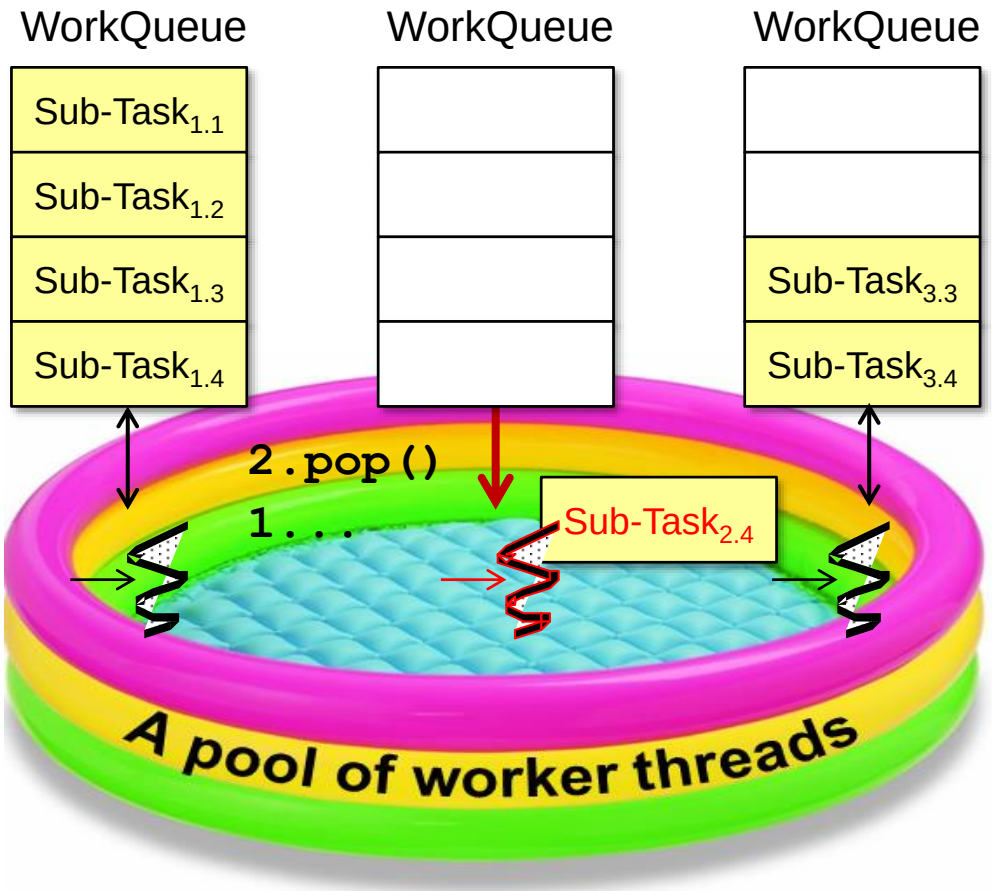
- If a task run by a worker thread calls fork() the new task is pushed on the head of the worker's deque
  - A worker thread processes its deque in LIFO order, i.e.
    - It pops (sub-)tasks from the head of its deque & runs them to completion



See en.wikipedia.org/wiki/Run_to_completion_scheduling

Java Fork-Join Pool Framework Internals

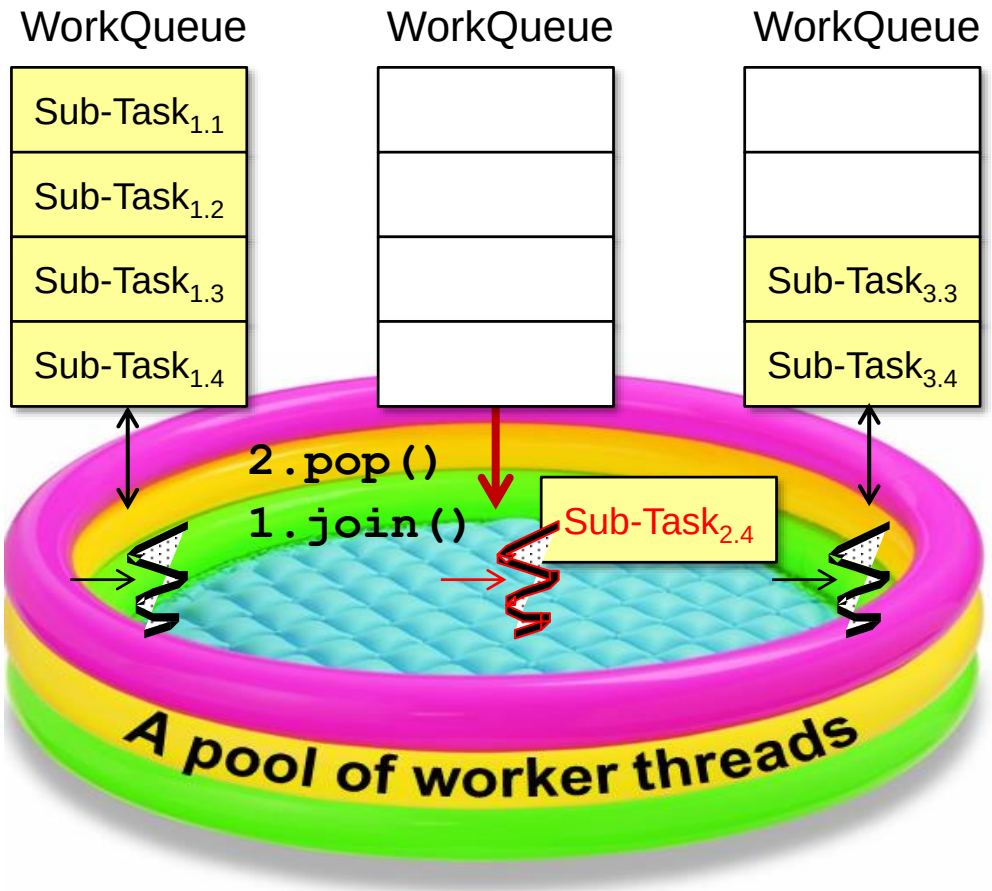
- If a task run by a worker thread calls fork() the new task is pushed on the head of the worker's deque
  - A worker thread processes its deque in LIFO order
  - LIFO order improves locality of reference & cache performance



See en.wikipedia.org/wiki/Locality_of_reference

Java Fork-Join Pool Framework Internals

- If a task run by a worker thread calls join() it pitches in" to pop & execute (sub-)tasks



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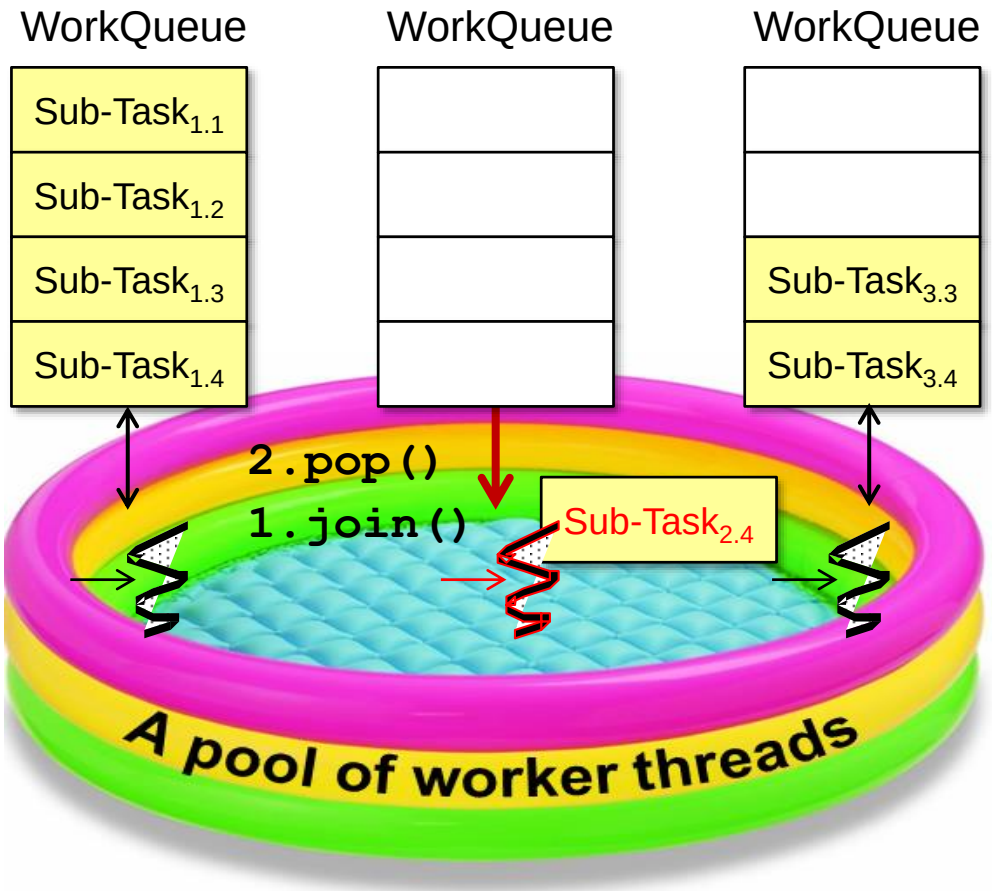
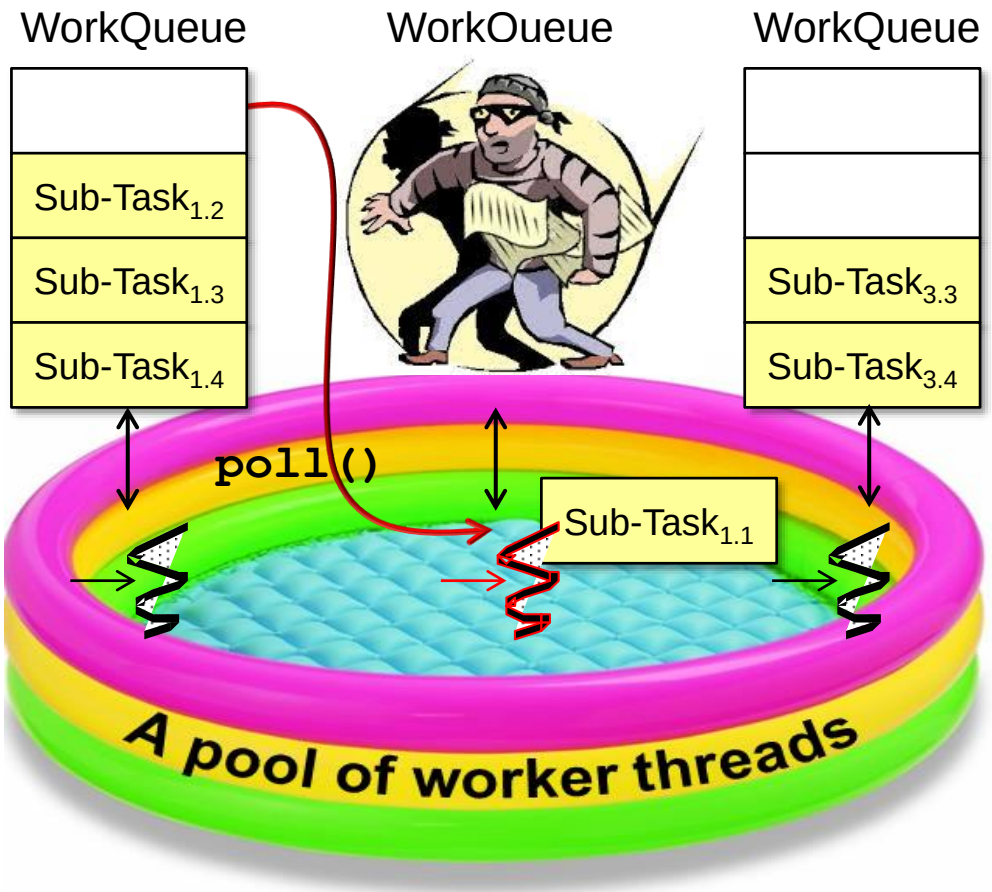
"Collaborative Jiffy Lube" model of processing!



See en.wikipedia.org/wiki/Jiffy_Lube

Java Fork-Join Pool Framework Internals

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



jiffy lube®

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

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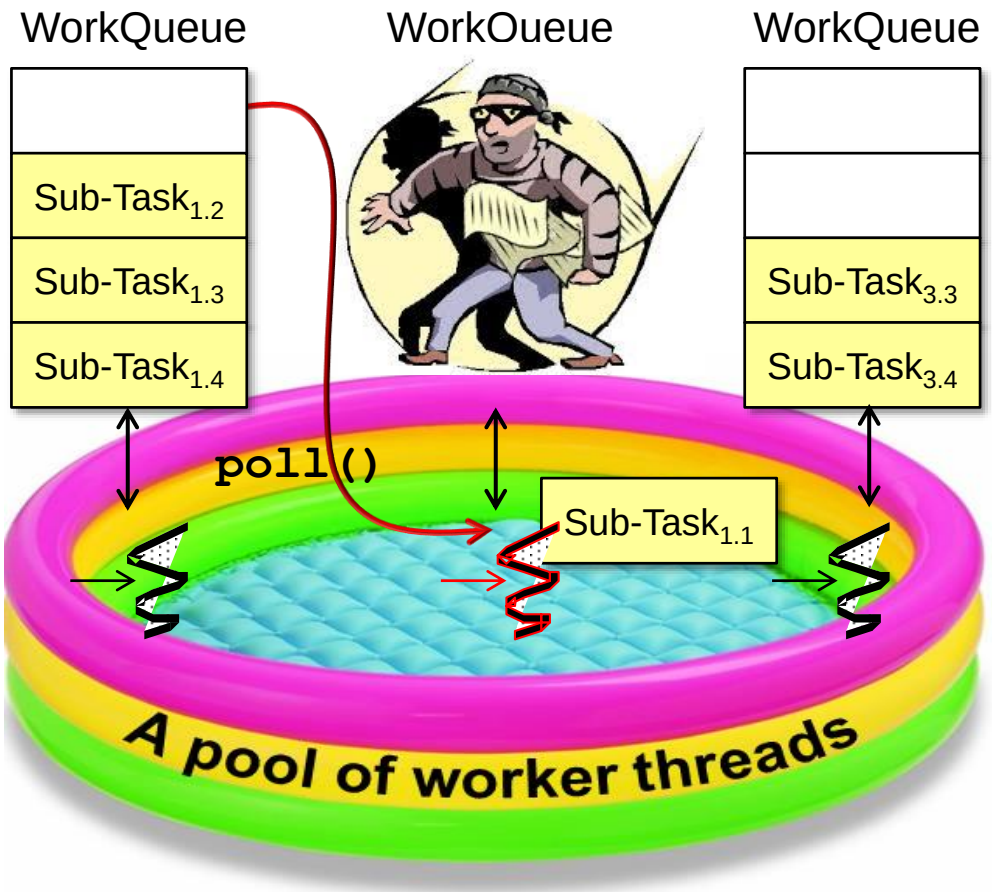
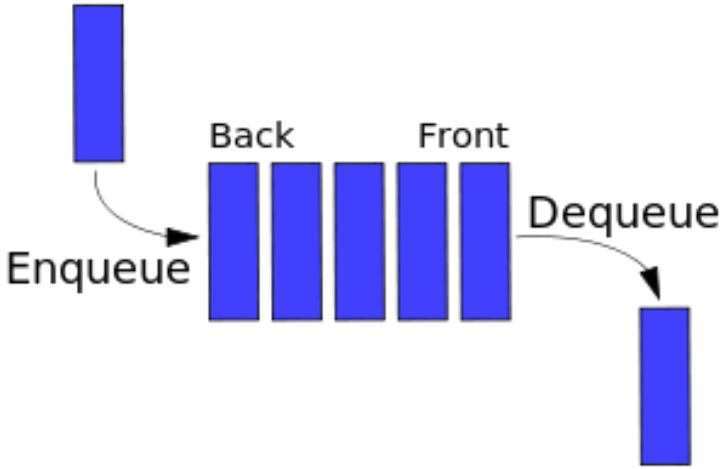
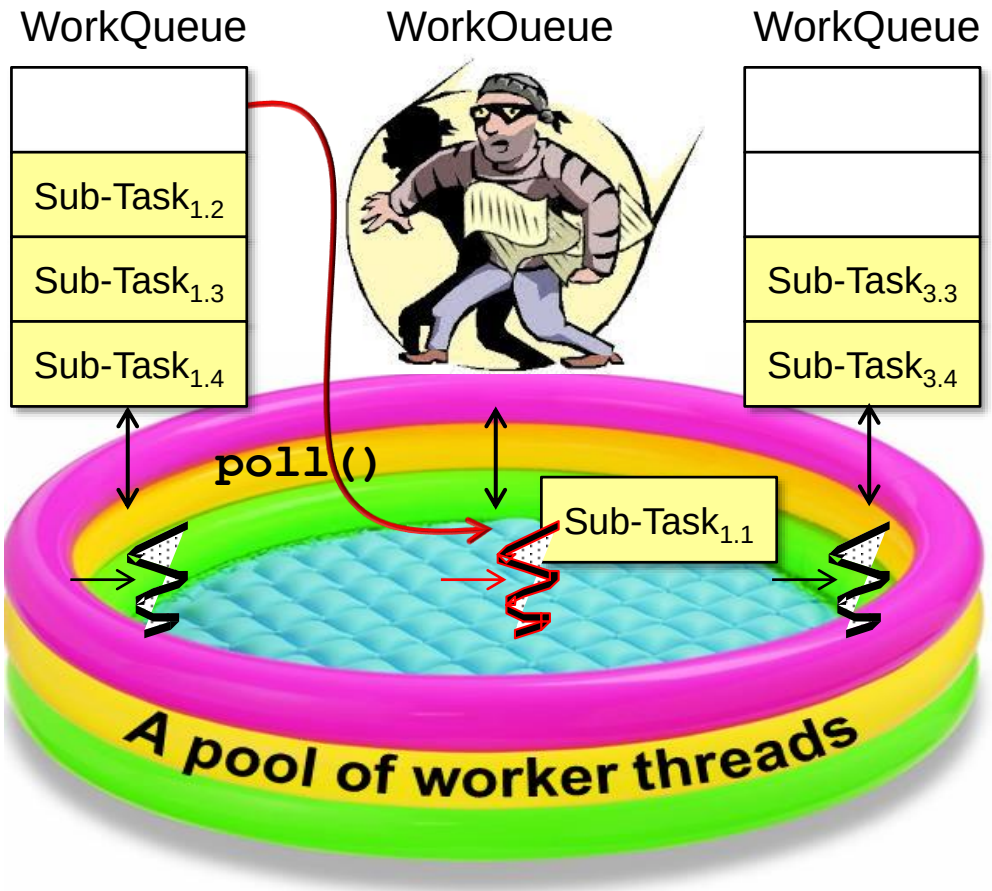


The worker thread deque to steal from is selected randomly to lower contention

Java Fork-Join Pool Framework Internals

- Tasks are stolen in FIFO order





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

Java Fork-Join Pool Framework Internals

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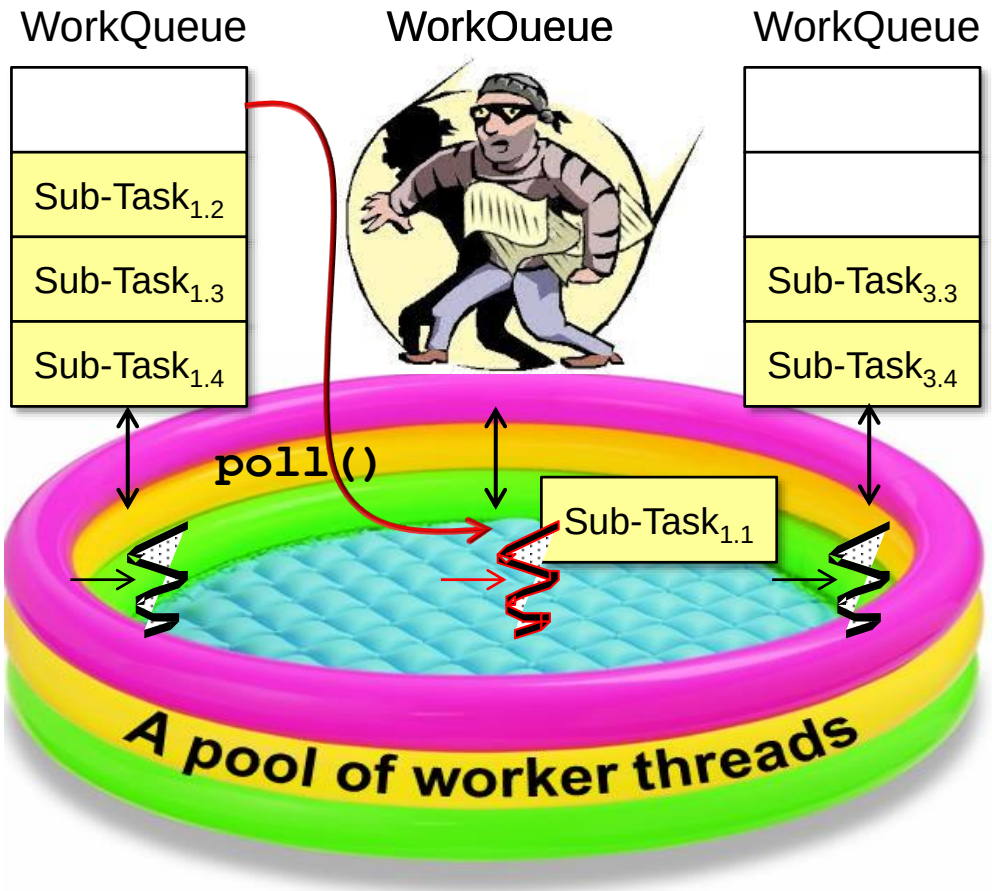
  - Minimizes contention with thread owning the deque



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

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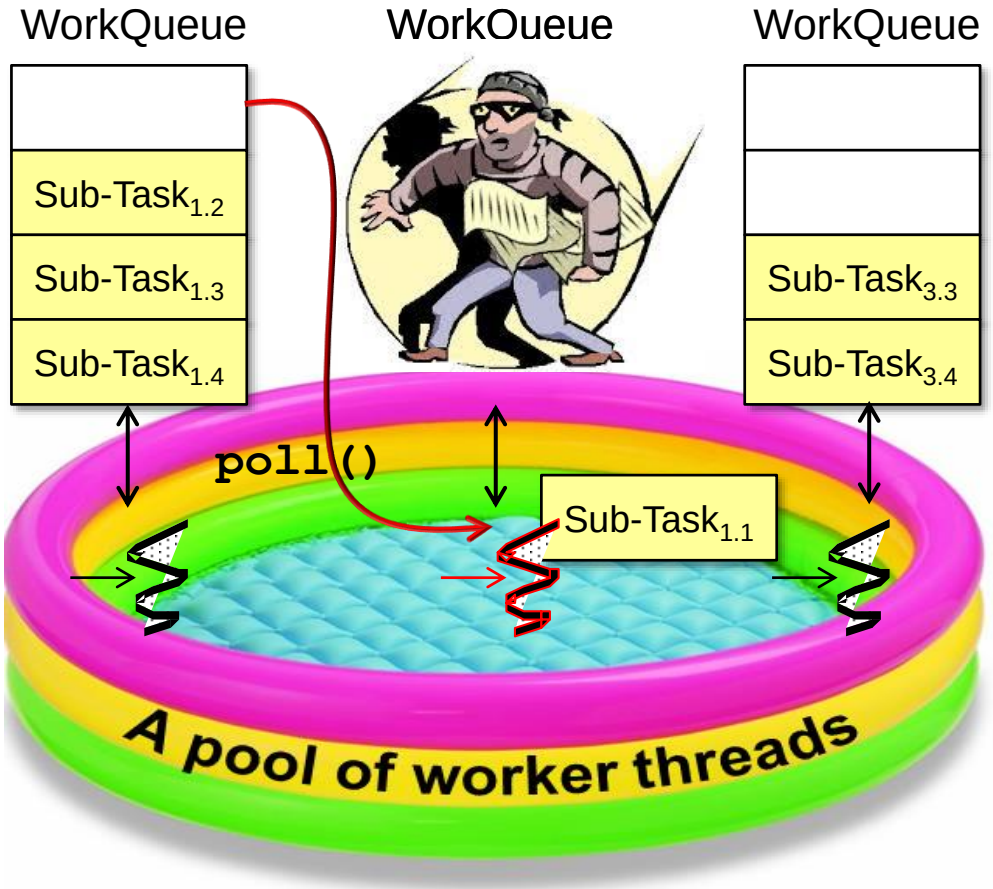

Java Fork-Join Pool Framework Internals

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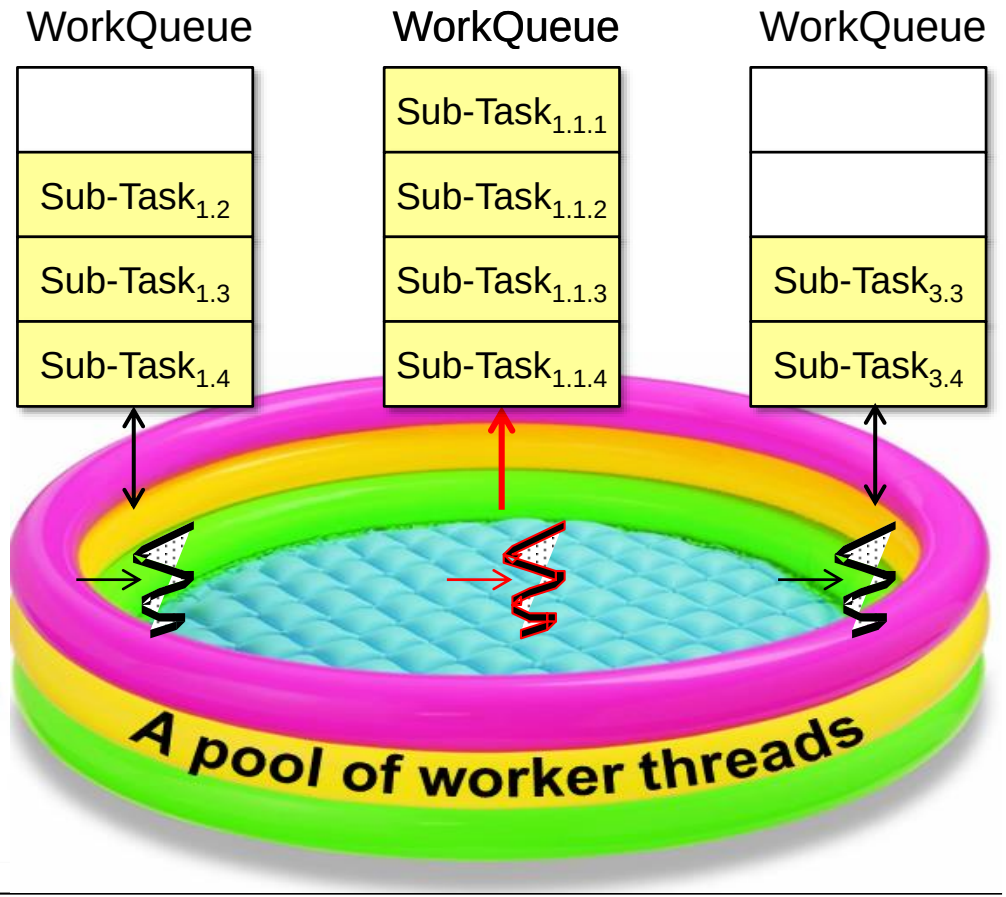
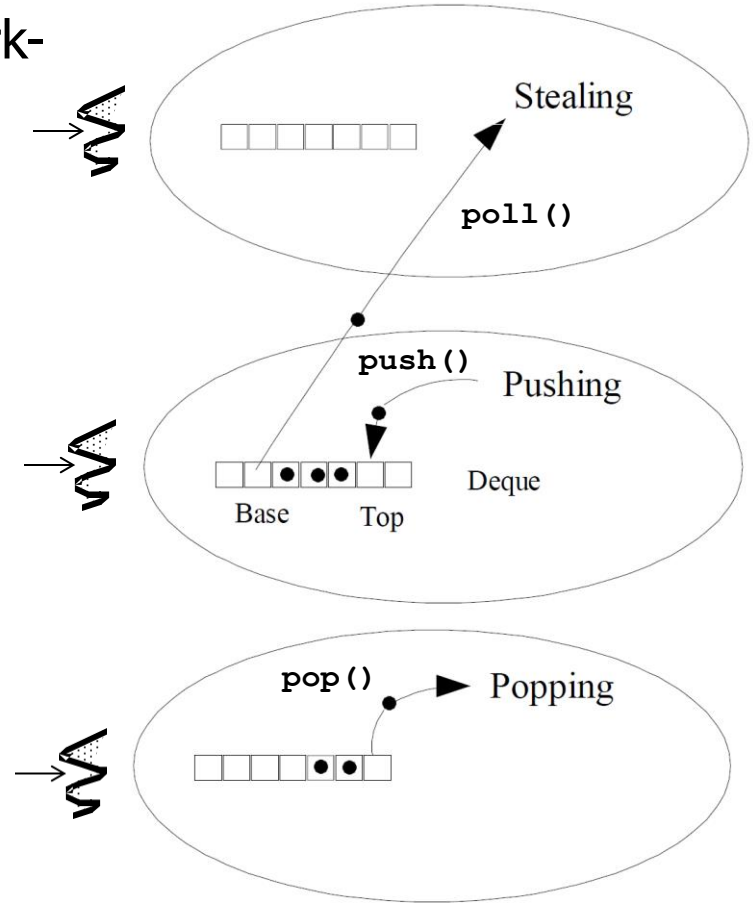
  - Minimizes contention with thread owning the deque
  - An older stolen task may provide a larger unit of work
    - Enables further recursive decompositions by the stealing thread



Java Fork-Join Pool Framework Internals

- 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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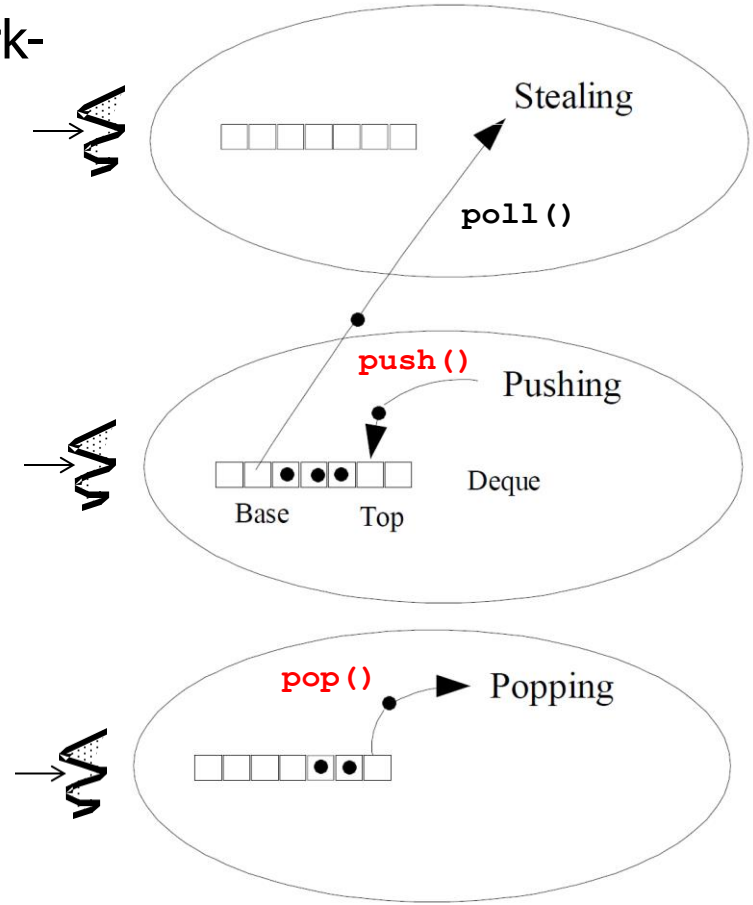
  - push() & pop() are only called by the owning worker thread



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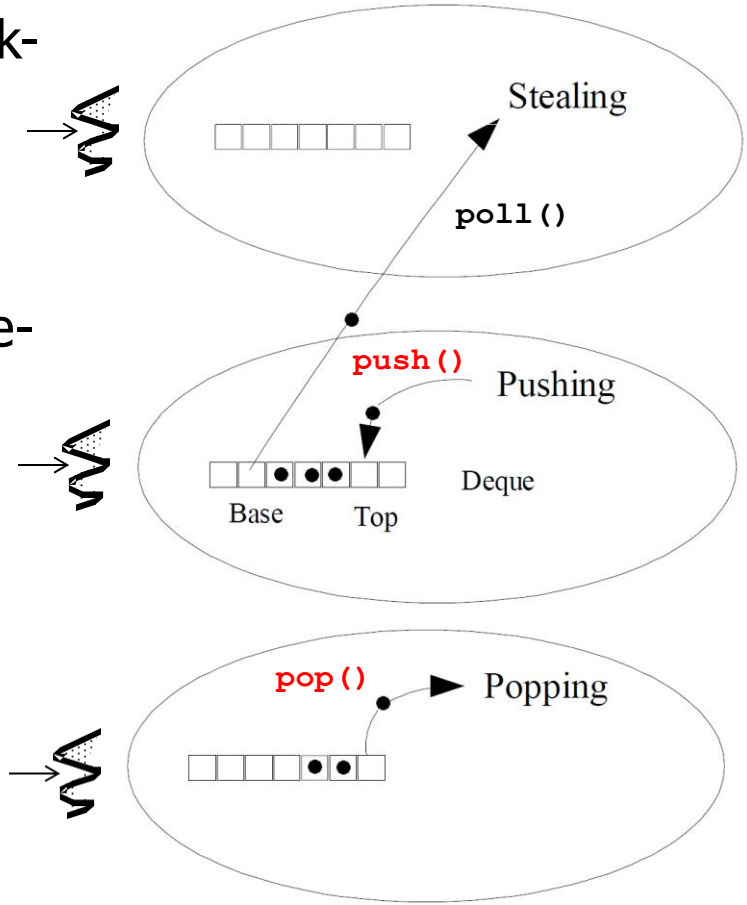
    - These operations use wait-free "compare-and-swap" (CAS) operations



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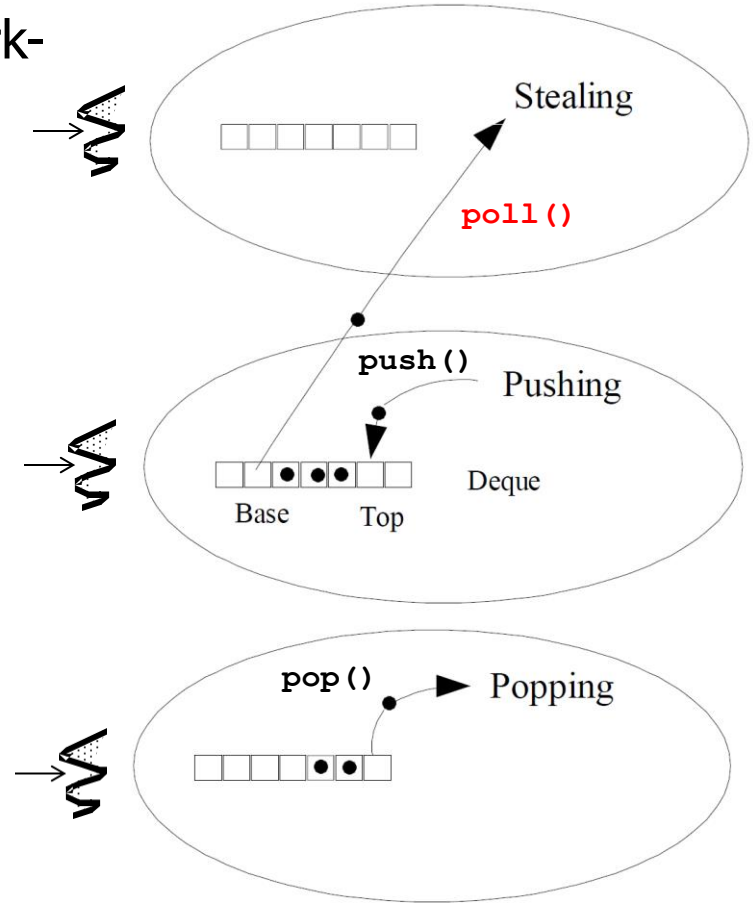

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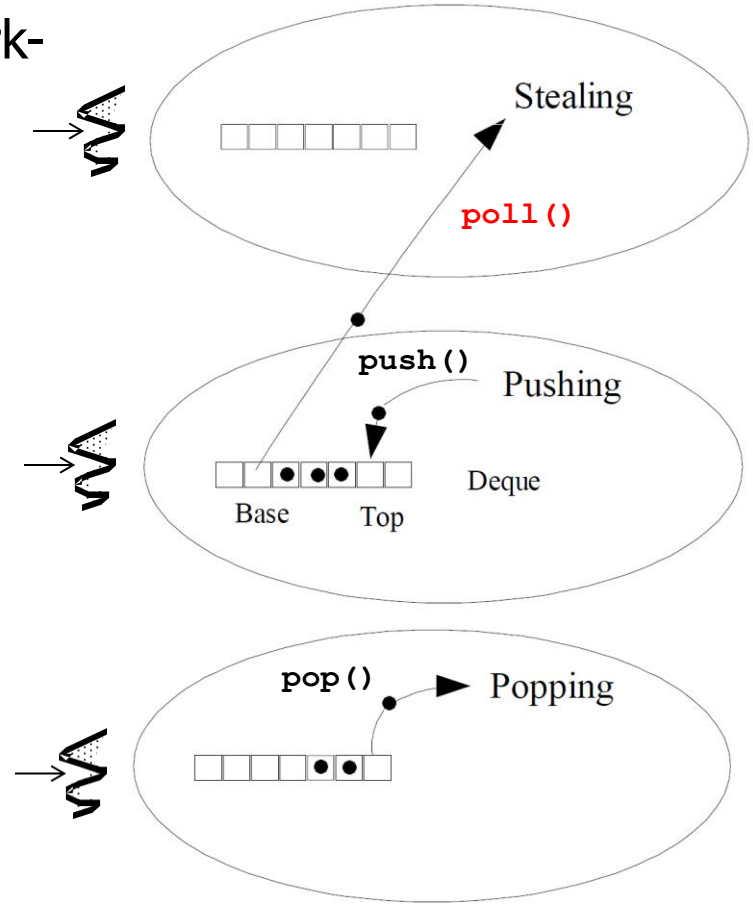

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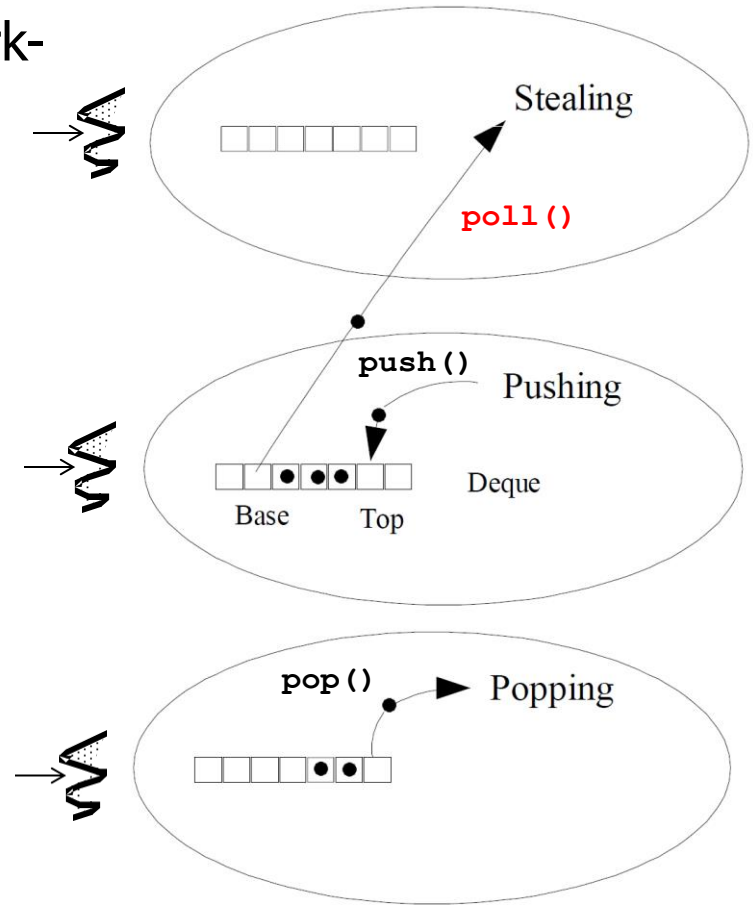
      - See "Implementation Overview" comments in the ForkJoinPool source code for details..



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End of the Java Fork-Join Pool Framework (Part 3)