The Java Fork-Join Pool Framework: Work Stealing

Douglas C. Schmidt

d.schmidt@vanderbilt.edu

www.dre.vanderbilt.edu/~schmidt

Professor of Computer Science

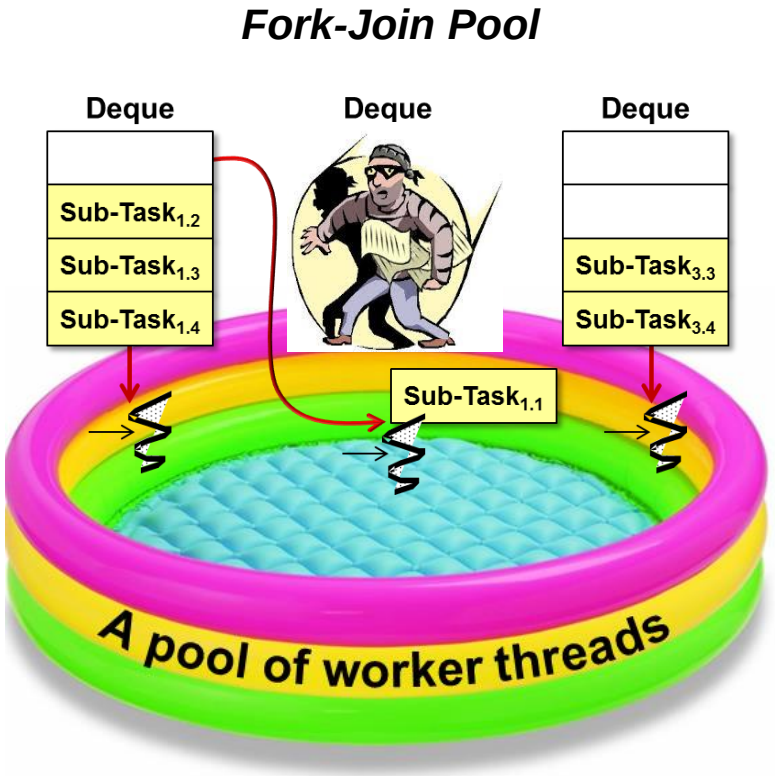
Institute for Software Integrated Systems

Vanderbilt University

Nashville, Tennessee, USA

Learning Objectives in this Part of the Lesson

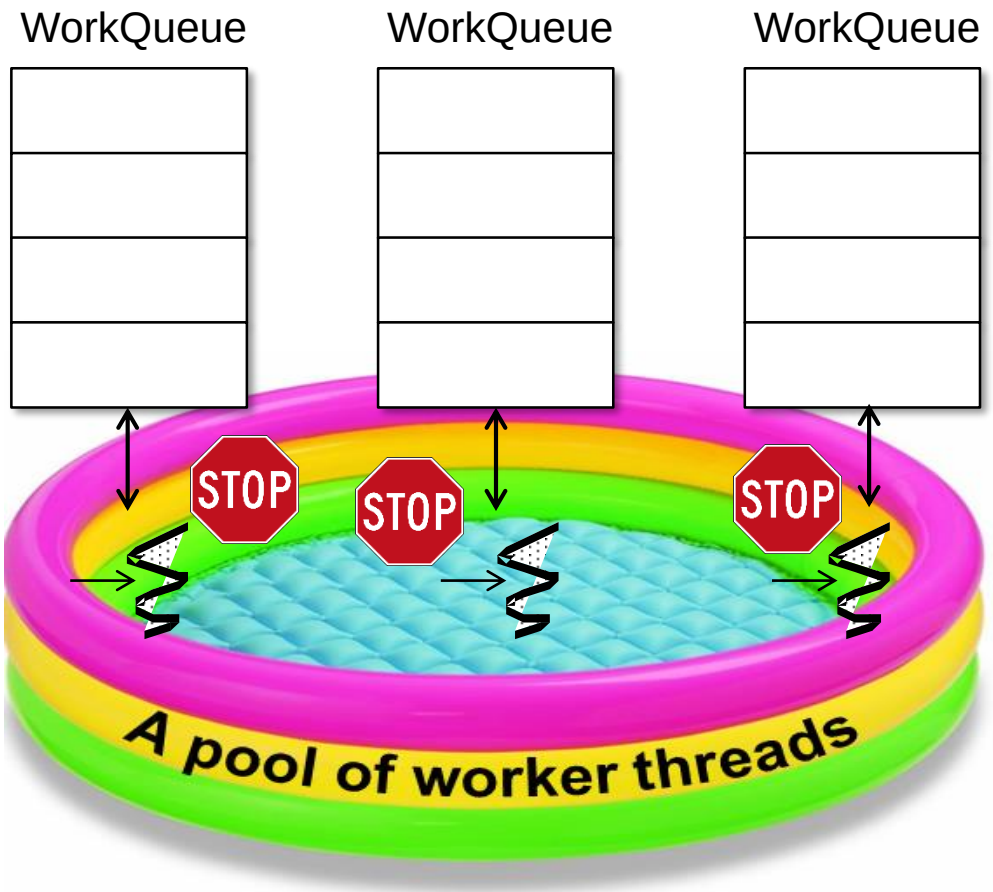
- Know how the fork-join framework implements worker threads
- Recognize how the fork-join framework implements work stealing



Working Stealing in a Java Fork-Join Pool

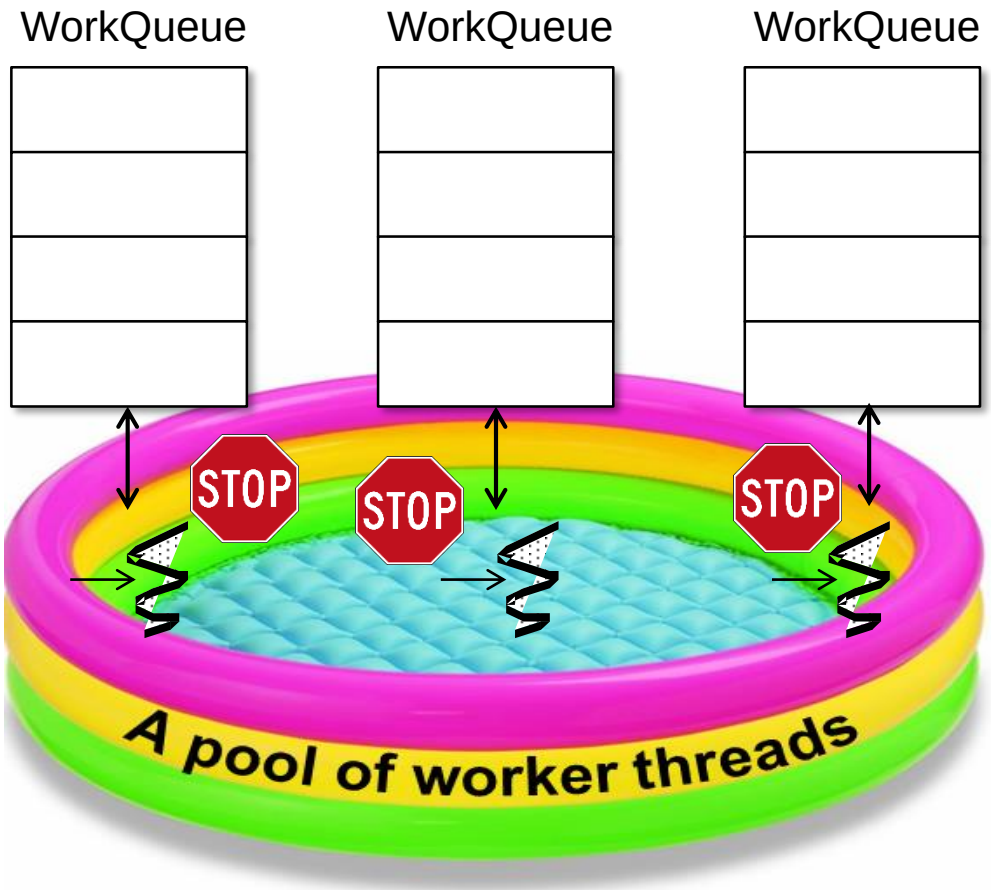
Work Stealing in a Java Fork-Join Pool

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



Work Stealing in a Java Fork-Join Pool

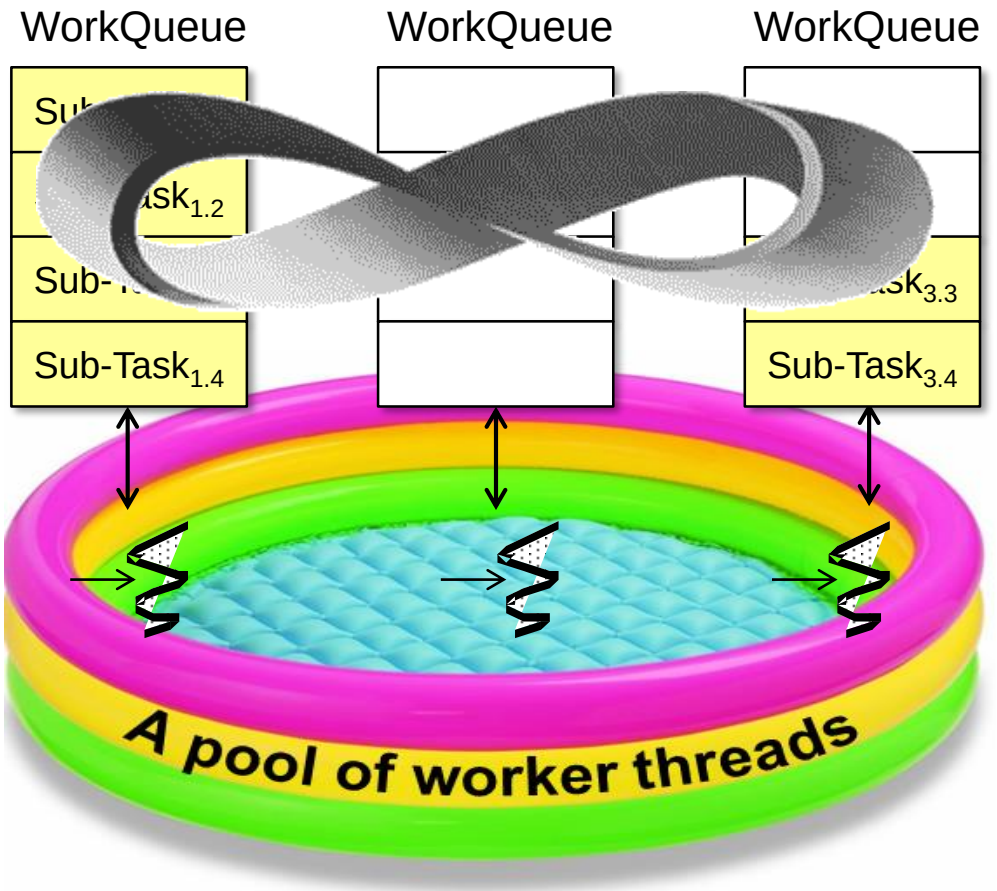
- Worker threads only block if there are no tasks available to run
  - Blocking threads & cores is costly on modern processors



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

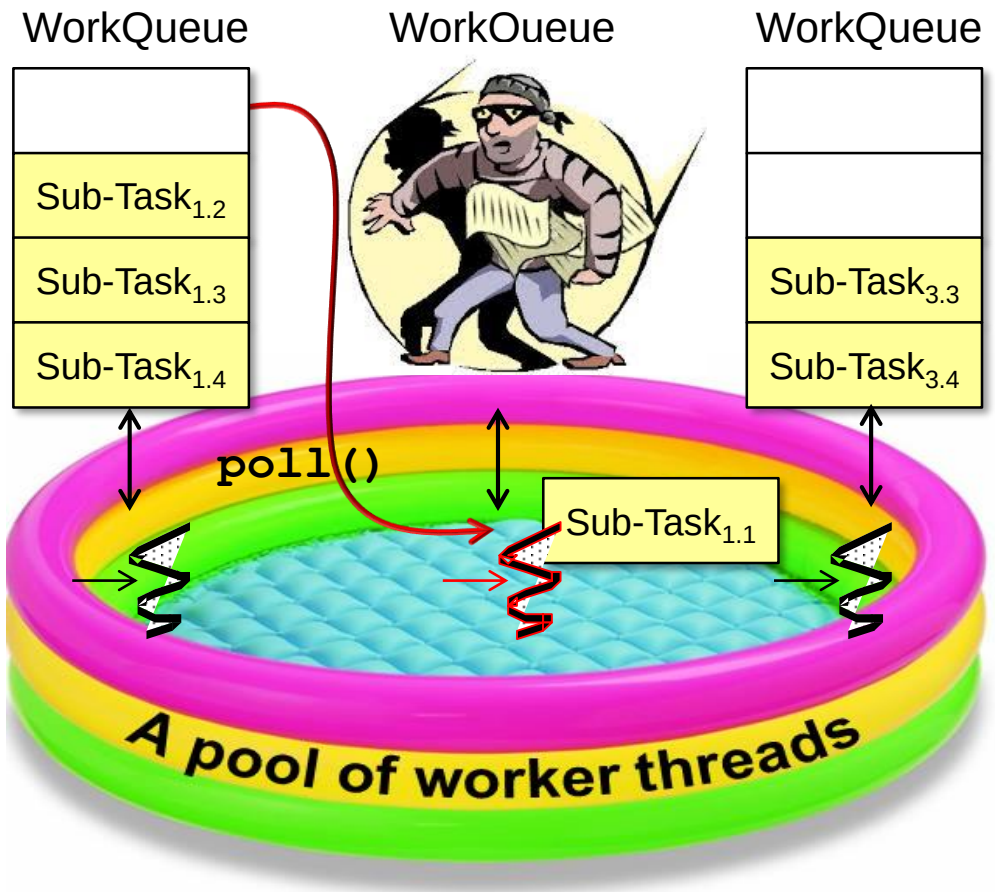
Work Stealing in a Java Fork-Join Pool

- Worker threads only block if there are no tasks available to run
  - Blocking threads & cores is costly on modern processors
  - Each worker thread therefore checks other deques in the pool to find other tasks to run



Work Stealing in a Java Fork-Join Pool

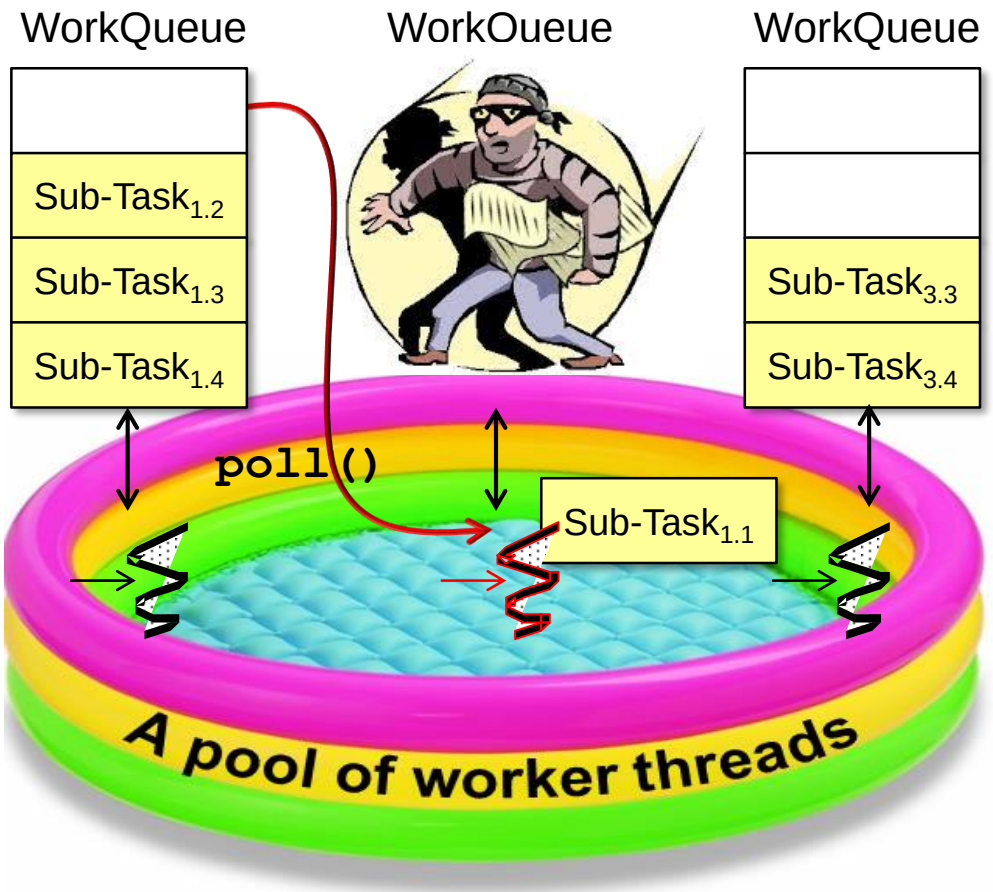
- To maximize core utilization, idle worker threads "steal" work from the tail of busy threads' deques



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

Work Stealing in a Java Fork-Join Pool

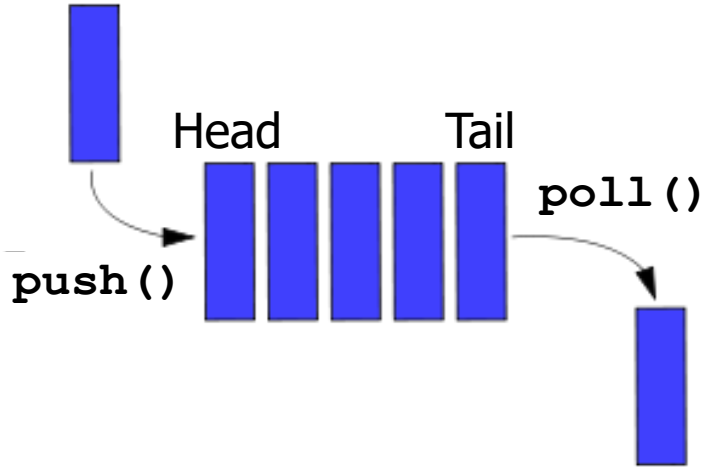
- To maximize core utilization, idle worker threads "steal" work from the tail of busy threads' deques

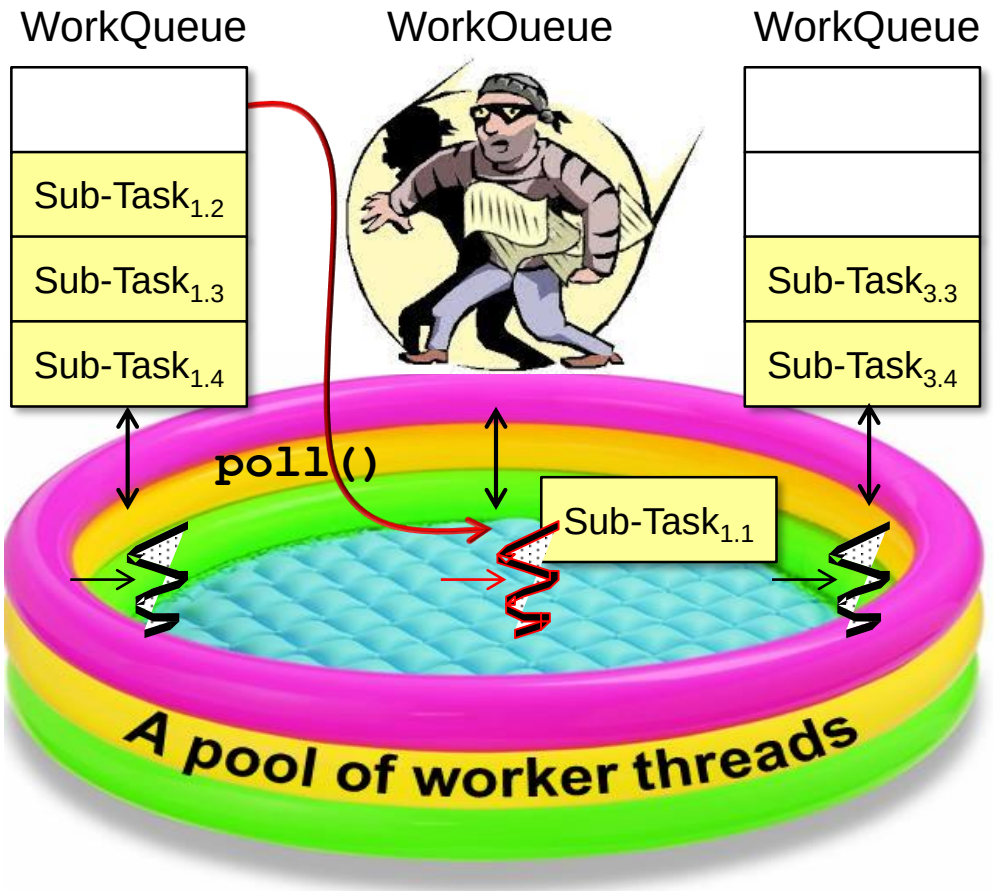


The worker thread deque to steal from is selected randomly to lower contention

Work Stealing in a Java Fork-Join Pool

- Tasks are stolen in FIFO order

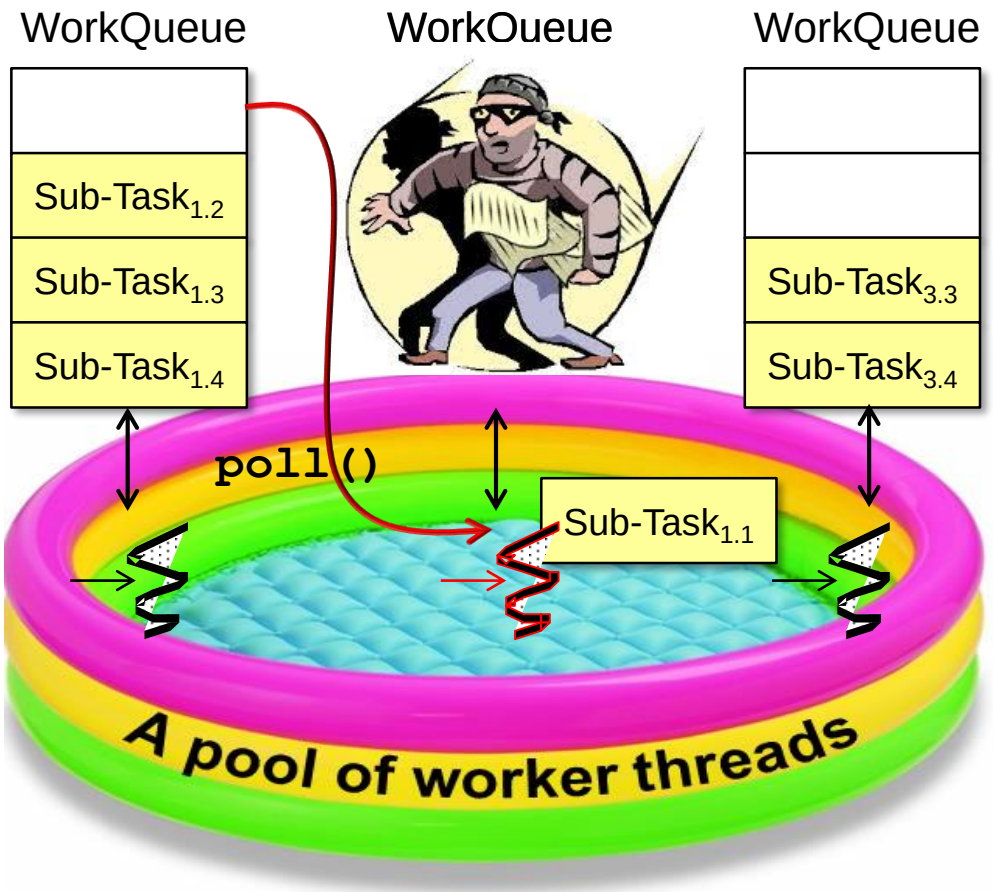




See en.wikipedia.org/wiki/FIFO_(computing_and_electronics)

Work Stealing in a Java Fork-Join Pool

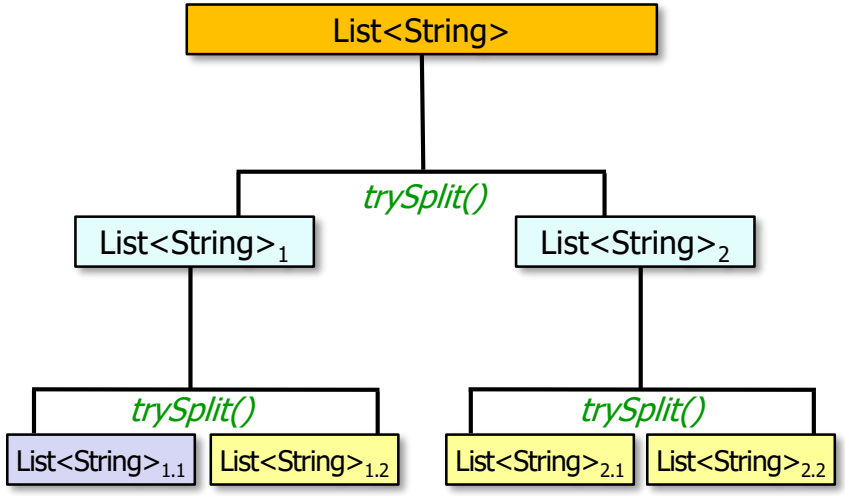
- Tasks are stolen in FIFO order
  - Minimizes contention w/worker thread owning the deque

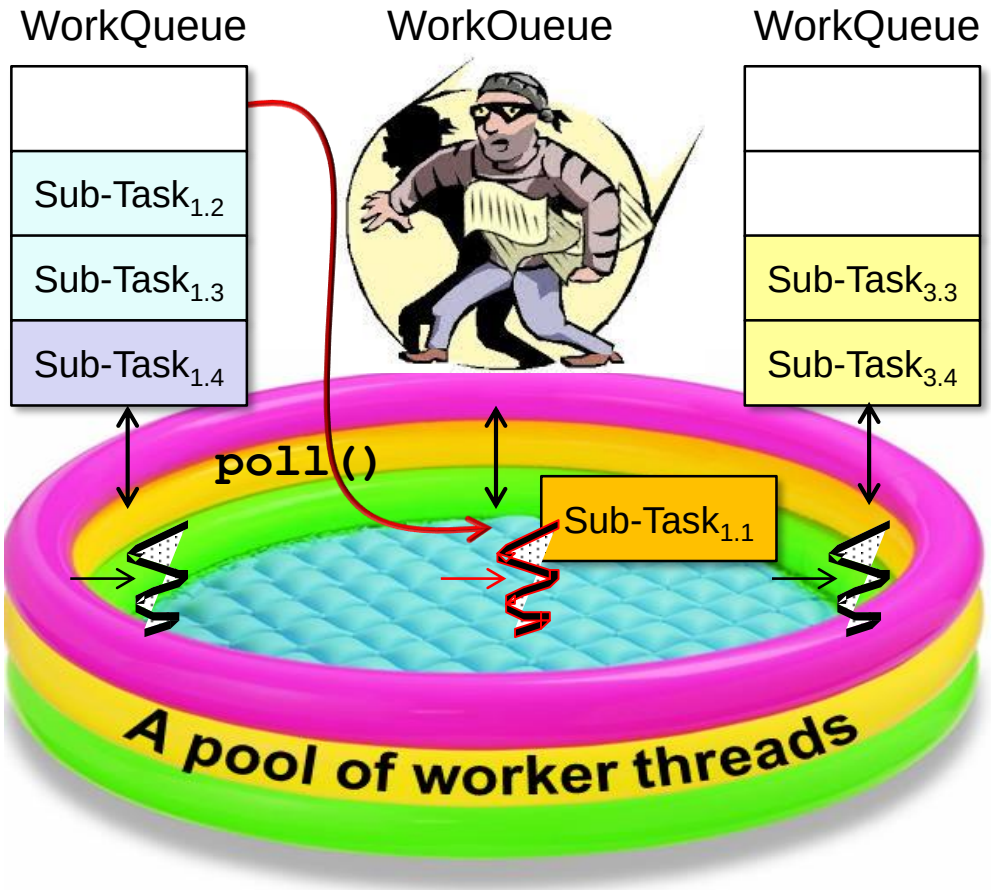


See www.ibm.com/support/knowledgecenter/en/SS3KLZ/com.ibm.java.diagnostics.healthcenter.doc/topics/resolving.html

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

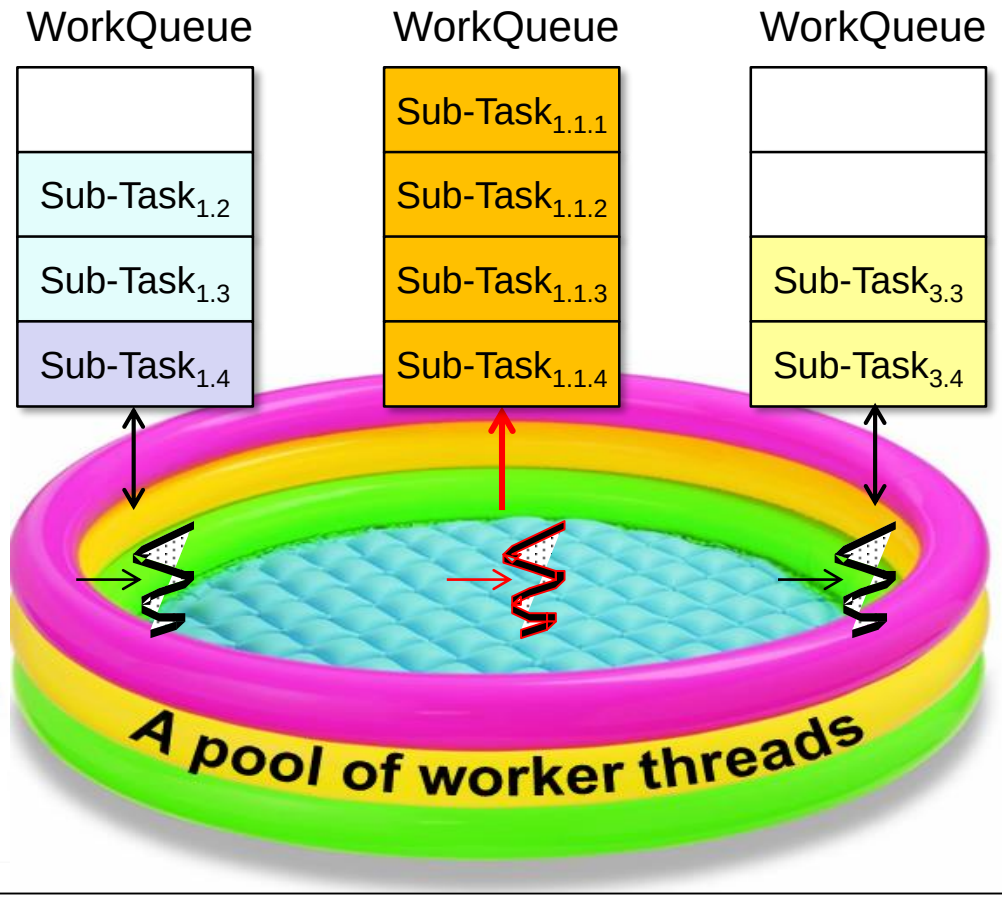




This behavior arises from "divide & conquer" nature of fork-join tasks that split evenly

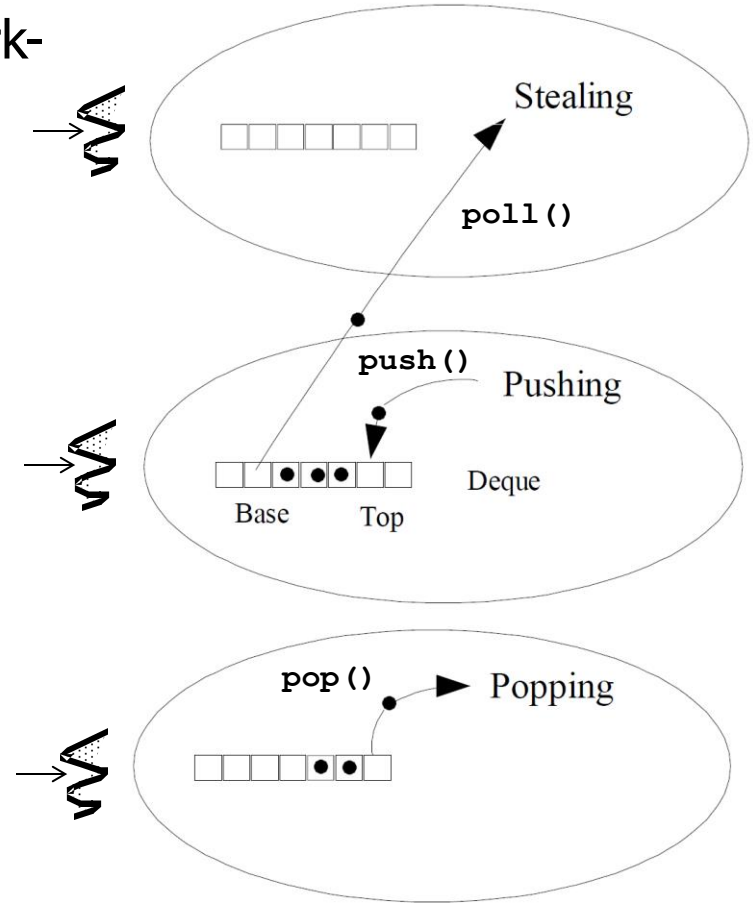
Work Stealing in a Java Fork-Join Pool

- 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
    - Enables further recursive decompositions by the stealing thread



Work Stealing in a Java Fork-Join Pool

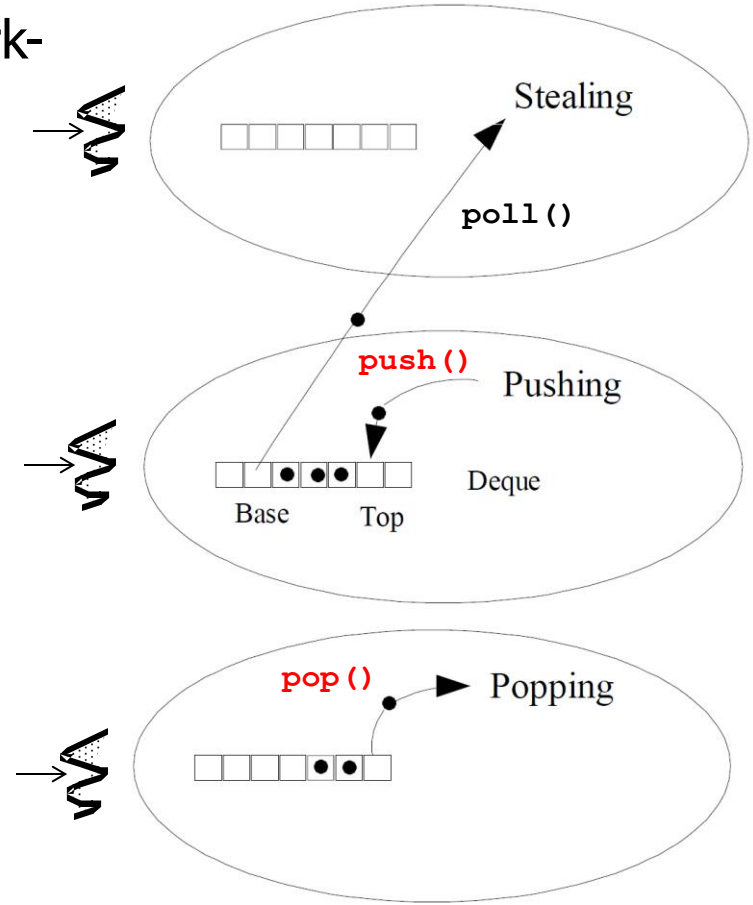
- The WorkQueue deque that implements work-stealing minimizes locking contention



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

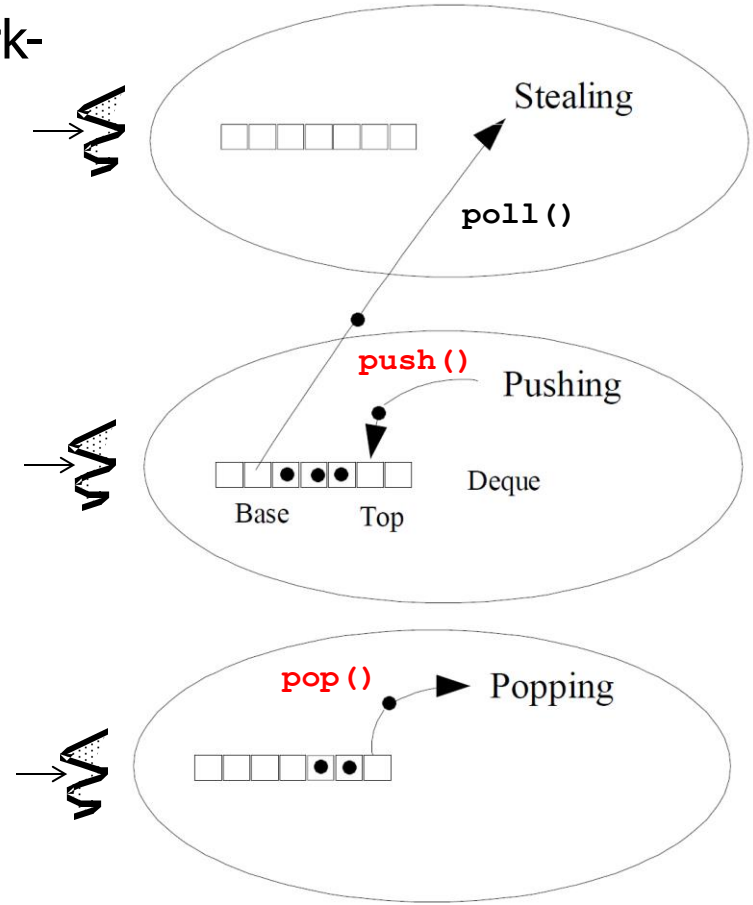
Work Stealing in a Java Fork-Join Pool

- The WorkQueue deque that implements work-stealing minimizes locking contention
  - push() & pop() are only called by the owning worker thread



Work Stealing in a Java Fork-Join Pool

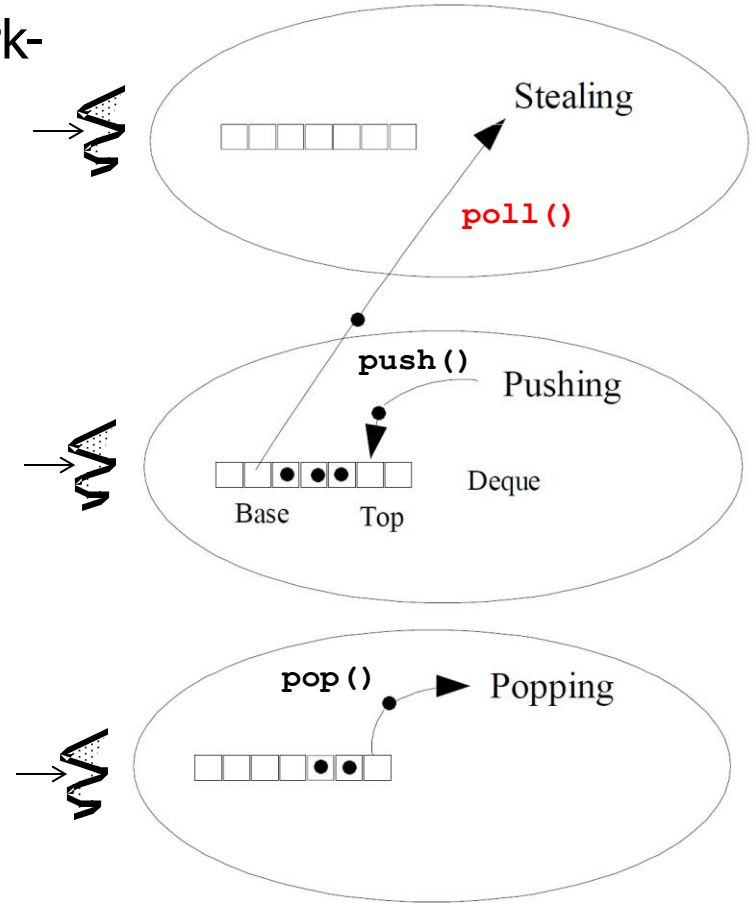
- The WorkQueue deque that implements work-stealing minimizes locking contention
  - push() & pop() are only called by the owning worker thread
    - These methods use wait-free "compare-and-swap" (CAS) operations



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

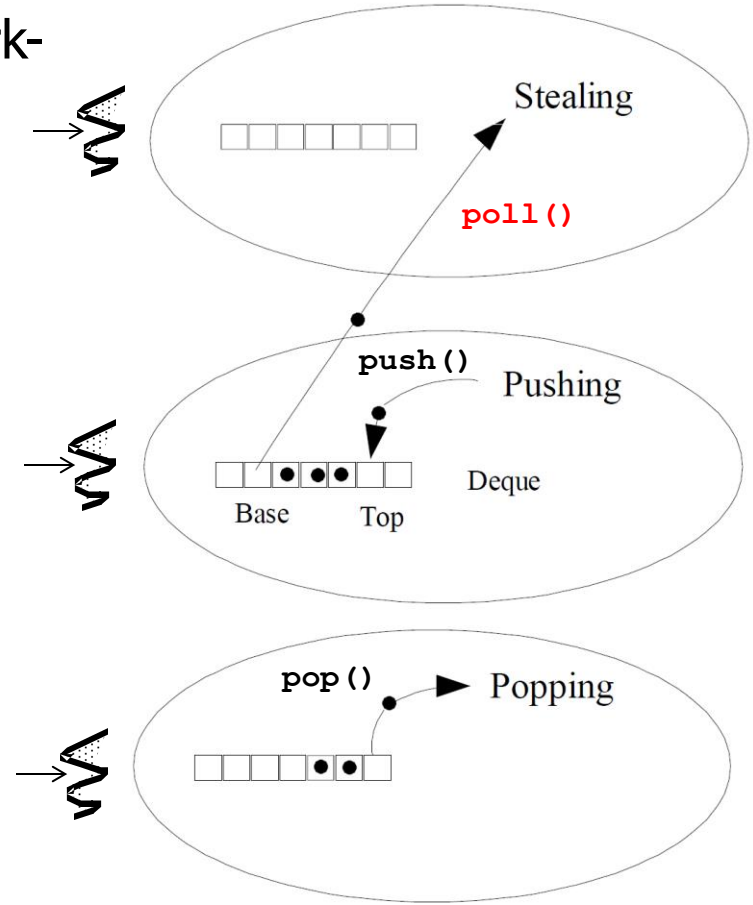
Work Stealing in a Java Fork-Join Pool

- The WorkQueue deque that implements work-stealing minimizes locking contention
  - push() & pop() are only called by the owning worker thread
  - poll() may be called from another worker thread to "steal" a (sub-)task



Work Stealing in a Java Fork-Join Pool

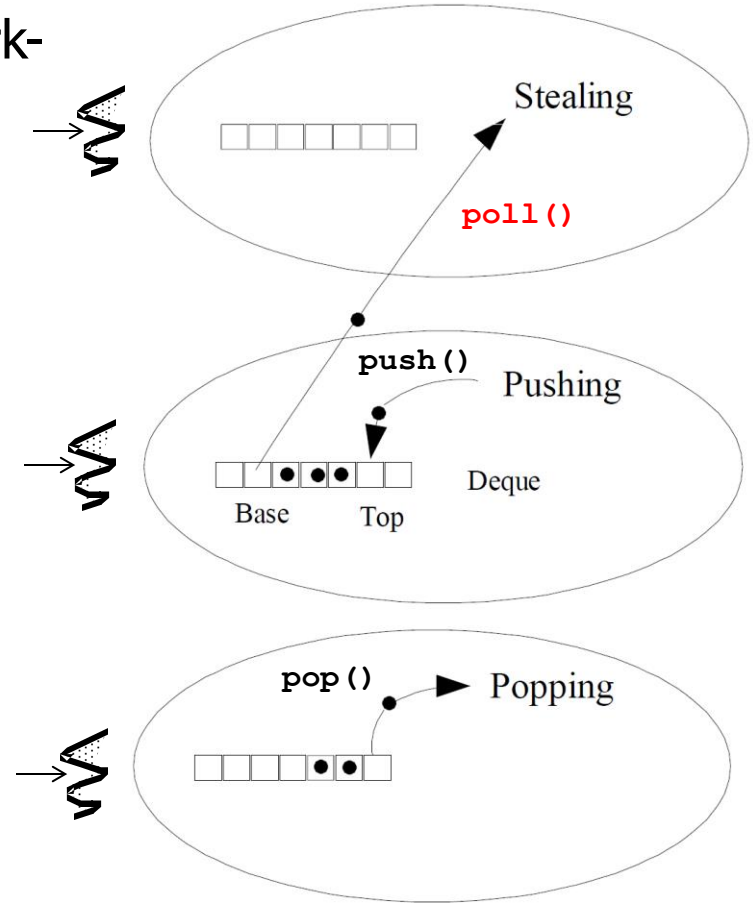
- The WorkQueue deque that implements work-stealing minimizes locking contention
  - push() & pop() are only called by the owning worker thread
  - poll() may be called from another worker thread to "steal" a (sub-)task
    - May not always be wait-free



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

Work Stealing in a Java Fork-Join Pool

- The WorkQueue deque that implements work-stealing minimizes locking contention
  - push() & pop() are only called by the owning worker thread
  - poll() may be called from another worker thread to "steal" a (sub-)task
    - May not always be wait-free
      - See "Implementation Overview" comments in the ForkJoinPool source code for details..



See java8/util/concurrent/ForkJoinPool.java

End of the Java Fork-Join Pool: Work Stealing