Overview of the Java Executor Framework (Part 1)

Douglas C. Schmidt
d.schmidt@vanderbilt.edu
www.dre.vanderbilt.edu/~schmidt

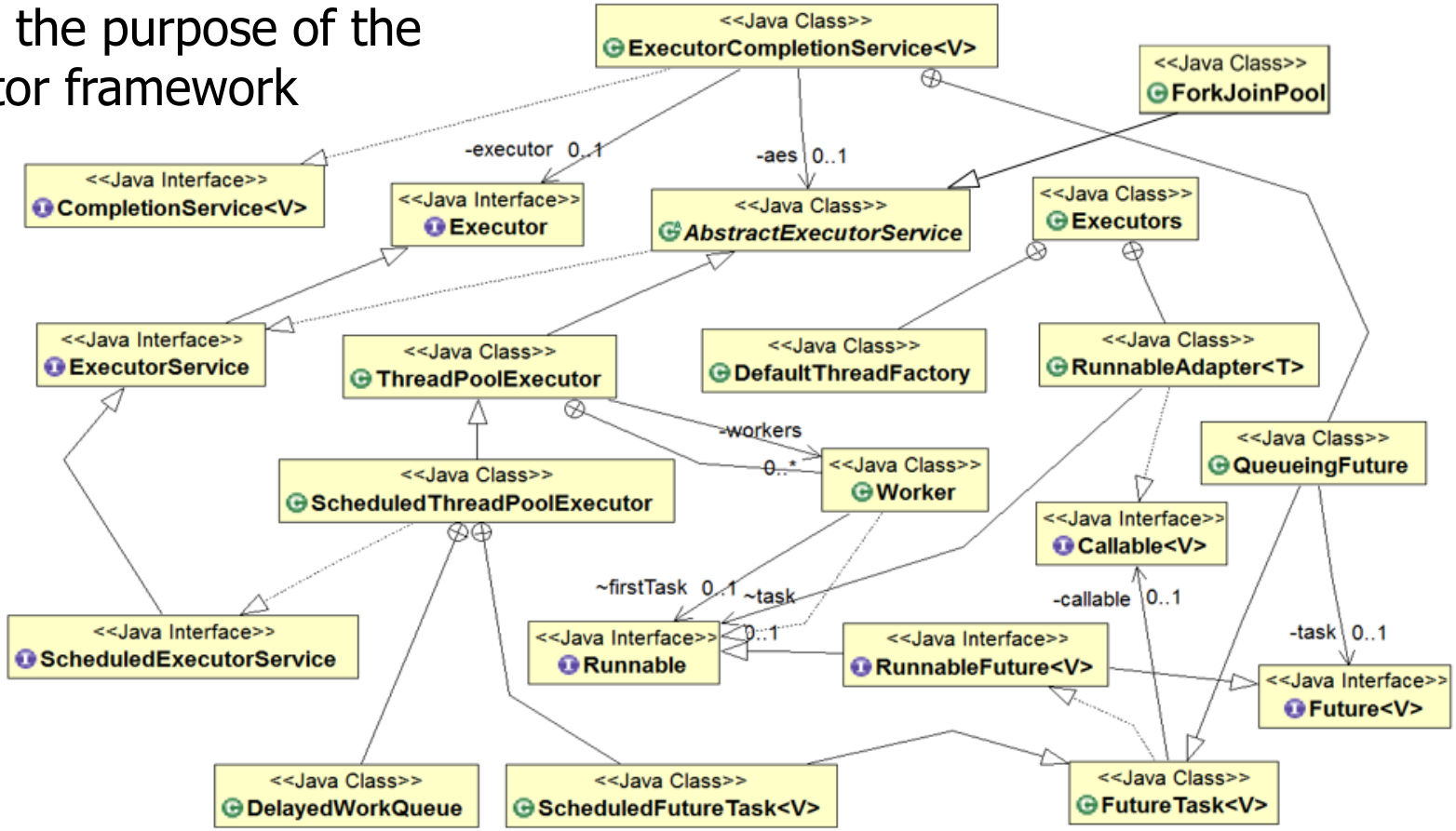
Professor of Computer Science

Institute for Software Integrated Systems

Vanderbilt University
Nashville, Tennessee, USA

Learning Objectives in this Part of the Lesson

- Understand the purpose of the Java executor framework



Decouples thread creation & management from the rest of the app logic

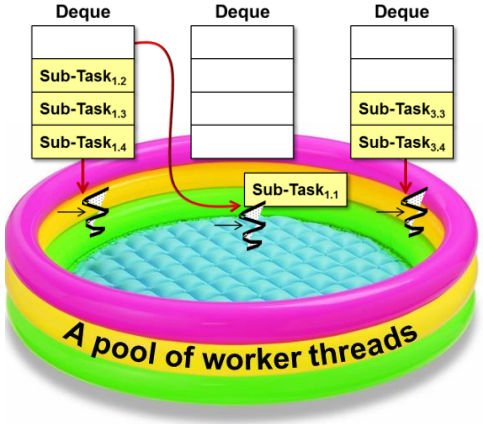
Learning Objectives in this Part of the Lesson

- Understand the purpose of the Java executor framework
- Know the types of thread pools supported by the framework

Cached (Variable-sized) Thread Pool

Fixed-sized Thread Pool

Work-stealing Thread Pool



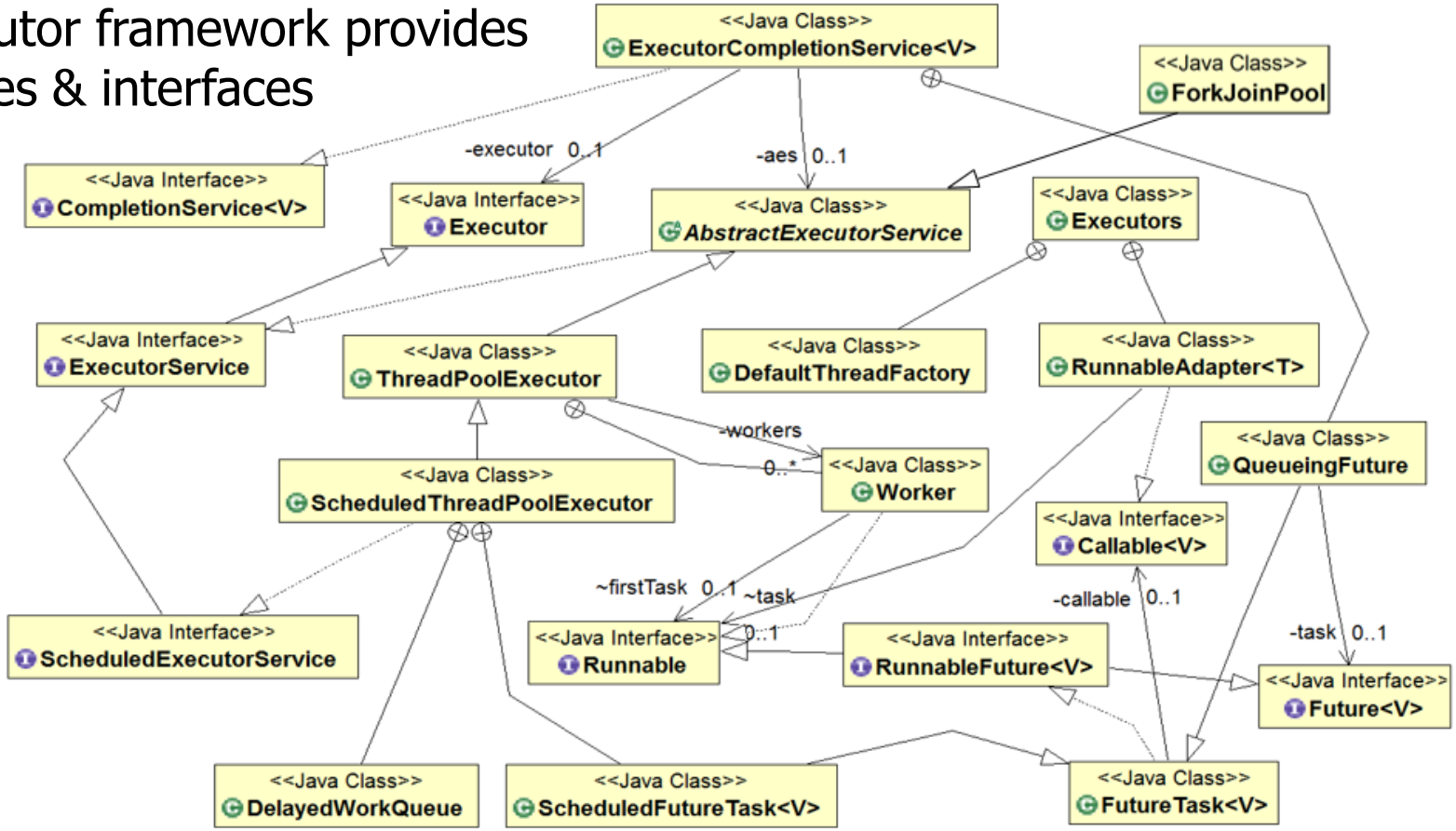
Learning Objectives in this Part of the Lesson

- Understand the purpose of the Java executor framework
- Know the types of thread pools supported by the framework
- Recognize a human known use of thread pools

Overview of the Java Executor Framework

Overview of The Java Executor Framework

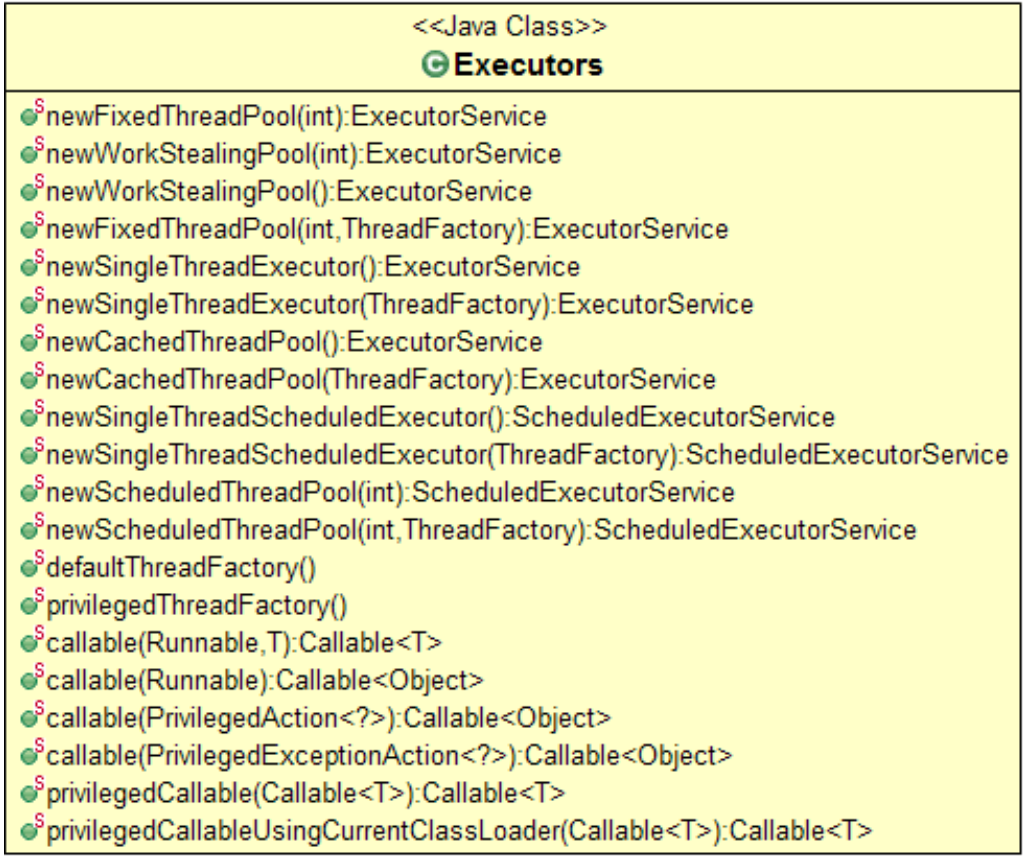
- Java's executor framework provides many classes & interfaces



Decouples thread creation & management from the rest of the app logic

Overview of The Java Executor Framework

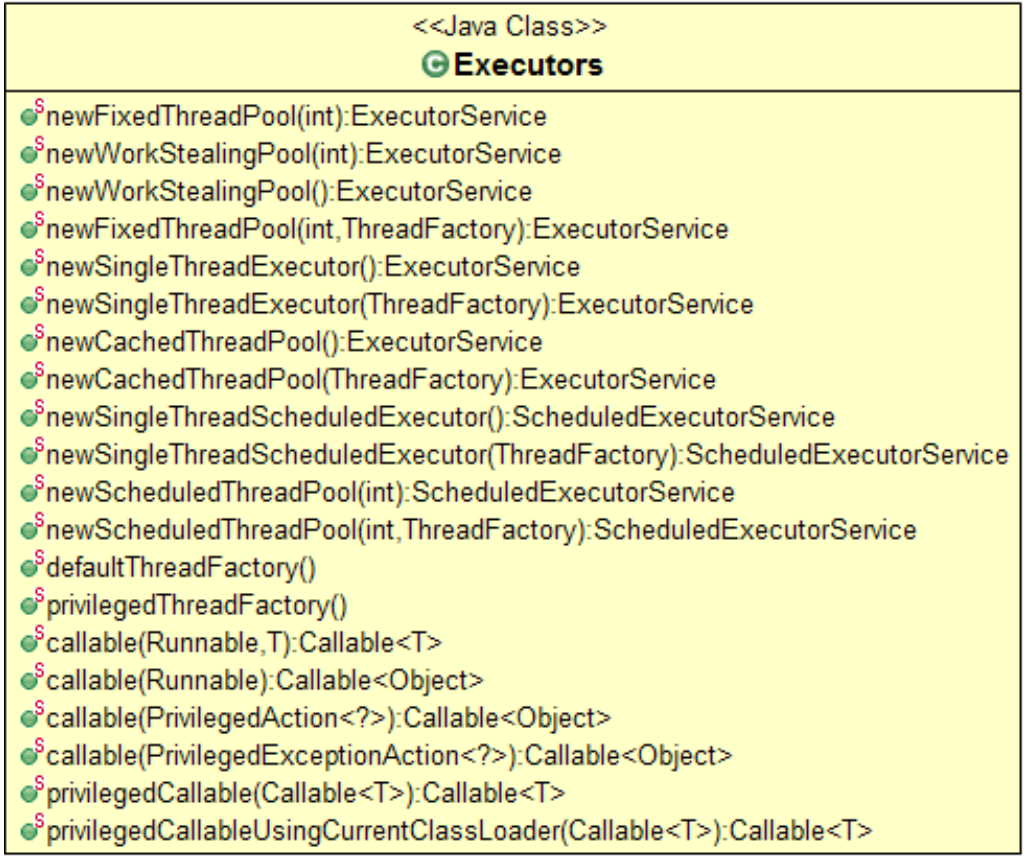
- The Executors utility class provides access to key mechanisms in the Java executor framework



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

Overview of The Java Executor Framework

- The Executors utility class provides access to key mechanisms in the Java executor framework
  - A utility class is a final class having only static methods, no state, & a private constructor



See www.quora.com/What-is-the-best-way-to-write-utility-classes-in-Java/answer/Jon-Harley

Overview of The Java Executor Framework

- The Executors utility class provides access to key mechanisms in the Java executor framework
  - A utility class is a final class having only static methods, no state, & a private constructor
  - Its factory methods create various types of thread pools

<<Java Class>>
Executors

- newFixedThreadPool(int):ExecutorService
- newWorkStealingPool(int):ExecutorService
- newWorkStealingPool():ExecutorService
- newFixedThreadPool(int,ThreadFactory):ExecutorService
- newSingleThreadExecutor():ExecutorService
- newSingleThreadExecutor(ThreadFactory):ExecutorService
- newCachedThreadPool():ExecutorService
- newCachedThreadPool(ThreadFactory):ExecutorService
- newSingleThreadScheduledExecutor():ScheduledExecutorService
- newSingleThreadScheduledExecutor(ThreadFactory):ScheduledExecutorService
- newScheduledThreadPool(int):ScheduledExecutorService
- newScheduledThreadPool(int,ThreadFactory):ScheduledExecutorService
- defaultThreadFactory()
- privilegedThreadFactory()
- callable(Runnable,T):Callable<T>
- callable(Runnable):Callable<Object>
- callable(PrivilegedAction<?>):Callable<Object>
- callable(PrivilegedExceptionAction<?>):Callable<Object>
- privilegedCallable(Callable<T>):Callable<T>
- privilegedCallableUsingCurrentClassLoader(Callable<T>):Callable<T>

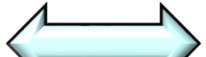
See en.wikipedia.org/wiki/Thread_pool_pattern

Overview of Thread Pools

Overview of Thread Pools

- Concurrent programs must often handle a large # of clients

e.g., consider a web server that must handle thousands of client requests simultaneously



Overview of Thread Pools

- However, spawning a thread per client doesn't scale

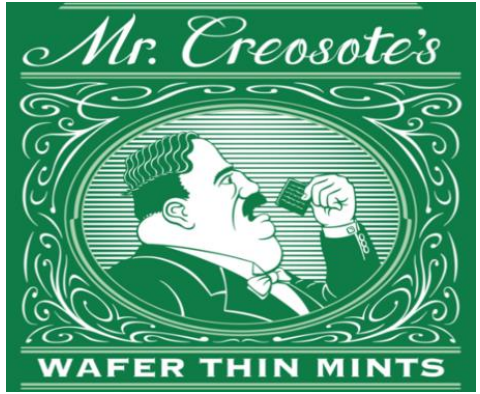
Overview of Thread Pools

- However, spawning a thread per client doesn't scale
  - Dynamically spawning a thread per client incurs excessive processing overhead

```
void handleClientRequest(Request request) {
  new Thread(makeRequestRunnable(request));
  ...
```

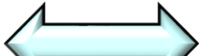
Overview of Thread Pools

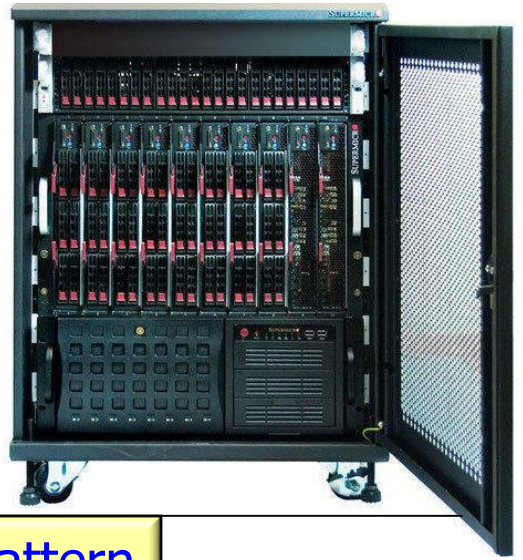
- However, spawning a thread per client doesn't scale
  - Dynamically spawning a thread per client incurs excessive processing overhead
  - An excessive amount of memory is also needed to store all the threads



Overview of Thread Pools

- A pool of threads is often a better way to scale concurrent app performance





See en.wikipedia.org/wiki/Thread_pool_pattern

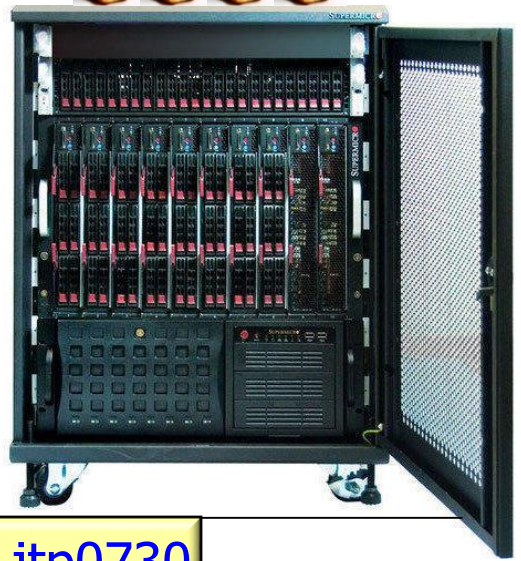
Overview of Thread Pools

- A pool of threads is often a better way to scale concurrent app performance
  - Amortizes memory/processing overhead associated with spawning threads

See cs.stackexchange.com/a/25899

Overview of Thread Pools

- A pool of threads is often a better way to scale concurrent app performance
  - Amortizes memory/processing overhead associated with spawning threads
  - Pool size determined by factors like # of cores, I/O-bound vs. compute-bound tasks, etc.



See www.ibm.com/developerworks/library/j-jtp0730

Overview of Thread Pools

- Java's executor framework supports several types of thread pools

Overview of Thread Pools

- Java's executor framework supports several types of thread pools
  - *Fixed-size pool*
    - Reuses a fixed # of threads to amortize creation overhead

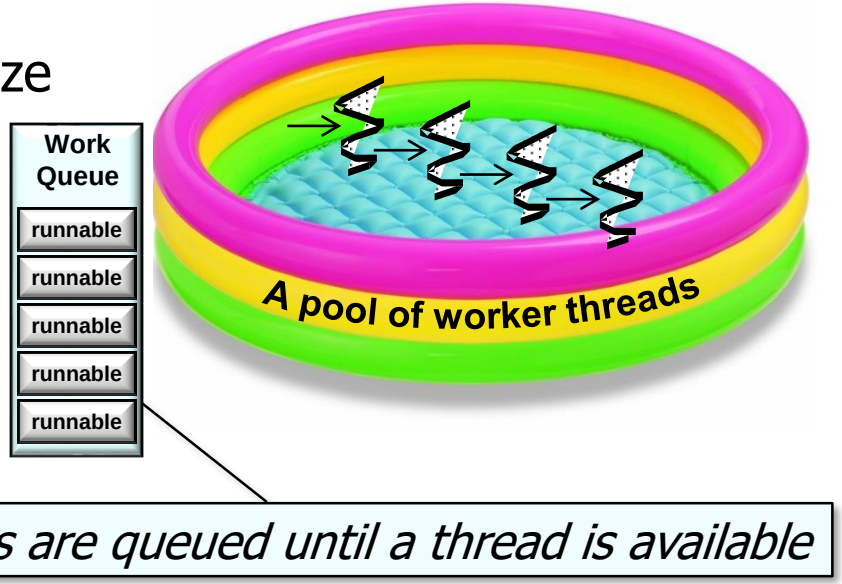

```
mExecutor = Executors
     .newFixedThreadPool
        (sMAX_THREADS);
...

void handleClientRequest(Request request) {
  mExecutor.execute(makeRequestRunnable(request));
```

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/Executors.html#newFixedThreadPool

Overview of Thread Pools

- Java's executor framework supports several types of thread pools
  - *Fixed-size pool*
    - Reuses a fixed # of threads to amortize creation overhead




```
mExecutor = Executors
     .newFixedThreadPool
        (sMAX_THREADS);
...

void handleClientRequest(Request request) {
  mExecutor.execute(makeRequestRunnable(request));
```

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/Executors.html#newFixedThreadPool

Overview of Thread Pools

- Java's executor framework supports several types of thread pools
  - *Fixed-size pool*
    - Reuses a fixed # of threads to amortize creation overhead
    - Compute-bound tasks on an N-core CPU run best with a pool of ~N threads

See www.ibm.com/developerworks/library/j-jtp0730

Overview of Thread Pools

- Java's executor framework supports several types of thread pools
  - *Fixed-size pool*
    - Reuses a fixed # of threads to amortize creation overhead
    - Compute-bound tasks on an N-core CPU run best with a pool of ~N threads
    - I/O-bound tasks on an N-core CPU run best with N*(1+WT/ST) threads
      - WT = wait time & ST = service time

The goal is to keep the cores fully utilized

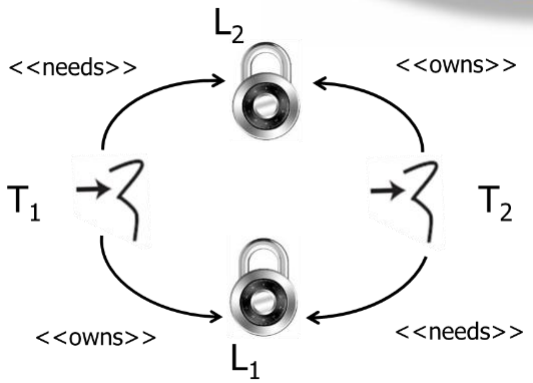
Overview of Thread Pools

- Java's executor framework supports several types of thread pools
  - *Fixed-size pool*
    - Reuses a fixed # of threads to amortize creation overhead
    - Compute-bound tasks on an N-core CPU run best with a pool of ~N threads
    - I/O-bound tasks on an N-core CPU run best with N*(1+WT/ST) threads
      - WT = wait time & ST = service time
      - You can estimate the ratio for a typical request using profiling

See www.baeldung.com/java-profilers

Overview of Thread Pools

- Java's executor framework supports several types of thread pools
  - *Fixed-size pool*
    - Reuses a fixed # of threads to amortize creation overhead
    - Compute-bound tasks on an N-core CPU run best with a pool of ~N threads
    - I/O-bound tasks on an N-core CPU run best with N*(1+WT/ST) threads
    - Deadlock can be a problem with fixed-size thread pools that use bounded queues



See en.wikipedia.org/wiki/Deadlock

Overview of Thread Pools

- Java's executor framework supports several types of thread pools
  - *Fixed-size pool*
  - *Cached*
    - Create new threads on-demand in response to client workload


```
mExecutor = Executors
     .newCachedThreadPool();
...
```

```
void handleClientRequest(Request request) {
  mExecutor.execute(makeRequestRunnable(request));
```

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/Executors.html#newCachedThreadPool

Overview of Thread Pools

- Java's executor framework supports several types of thread pools
  - *Fixed-size pool*
  - *Cached*
    - Create new threads on-demand in response to client workload

Threads are terminated if not used for a certain time

```
mExecutor = Executors
     .newCachedThreadPool();
...
```

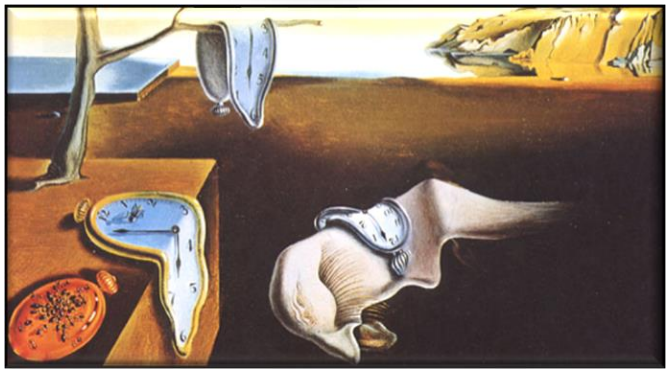
```
void handleClientRequest(Request request) {
  mExecutor.execute(makeRequestRunnable(request));
```

Overview of Thread Pools

- Java's executor framework supports several types of thread pools
  - *Fixed-size pool*
  - *Cached*
    - Create new threads on-demand in response to client workload
    - There's no need to estimate the size of the thread pool

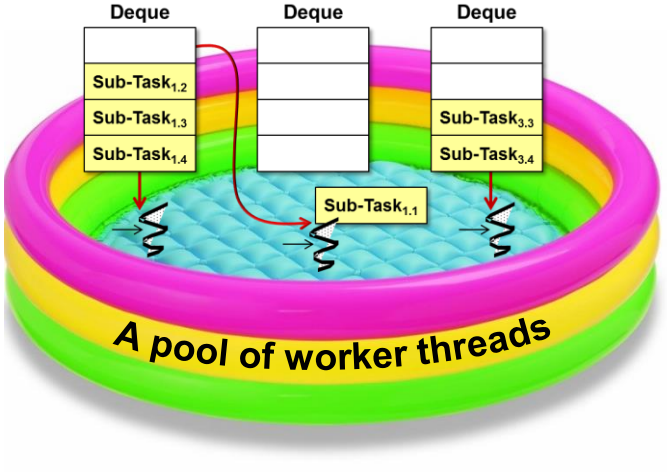
Overview of Thread Pools

- Java's executor framework supports several types of thread pools
  - *Fixed-size pool*
  - *Cached*
    - Create new threads on-demand in response to client workload
    - There's no need to estimate the size of the thread pool
    - However, performance may suffer due to overhead of creating new threads



Overview of Thread Pools

- Java's executor framework supports several types of thread pools
  - *Fixed-size pool*
  - *Cached*
  - *Fork/join pool*
    - Supports "work-stealing" queues that maximize core utilization



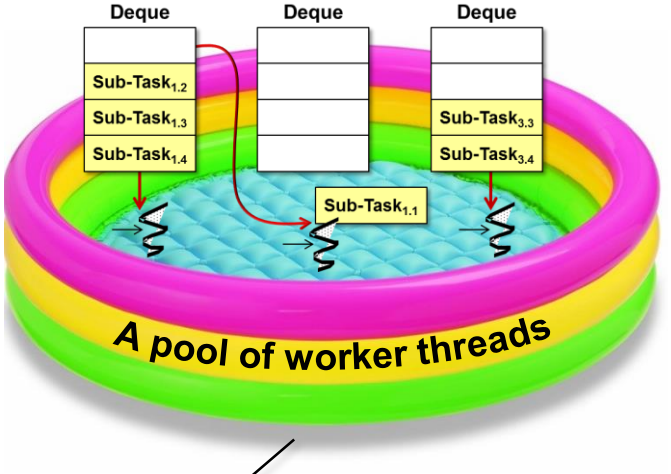

```
mExecutor = Executors
     .newWorkStealingPool();
...

void handleClientRequest(Request request) {
  mExecutor.execute(makeRequestRunnable(request)); ...
```

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/Executors.html#newWorkStealingPool

Overview of Thread Pools

- Java's executor framework supports several types of thread pools
  - *Fixed-size pool*
  - *Cached*
  - *Fork/join pool*
    - Supports "work-stealing" queues that maximize core utilization



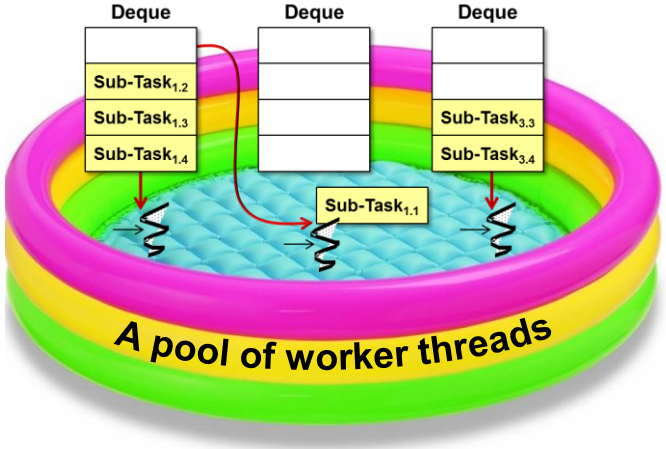

```
mExecutor = Executors
     .newWorkStealingPool();
...
```

The pool size defaults to all available cores as its target parallelism level

```
void handleClientRequest(Request request) {
  mExecutor.execute(makeRequestRunnable(request)); ...
```

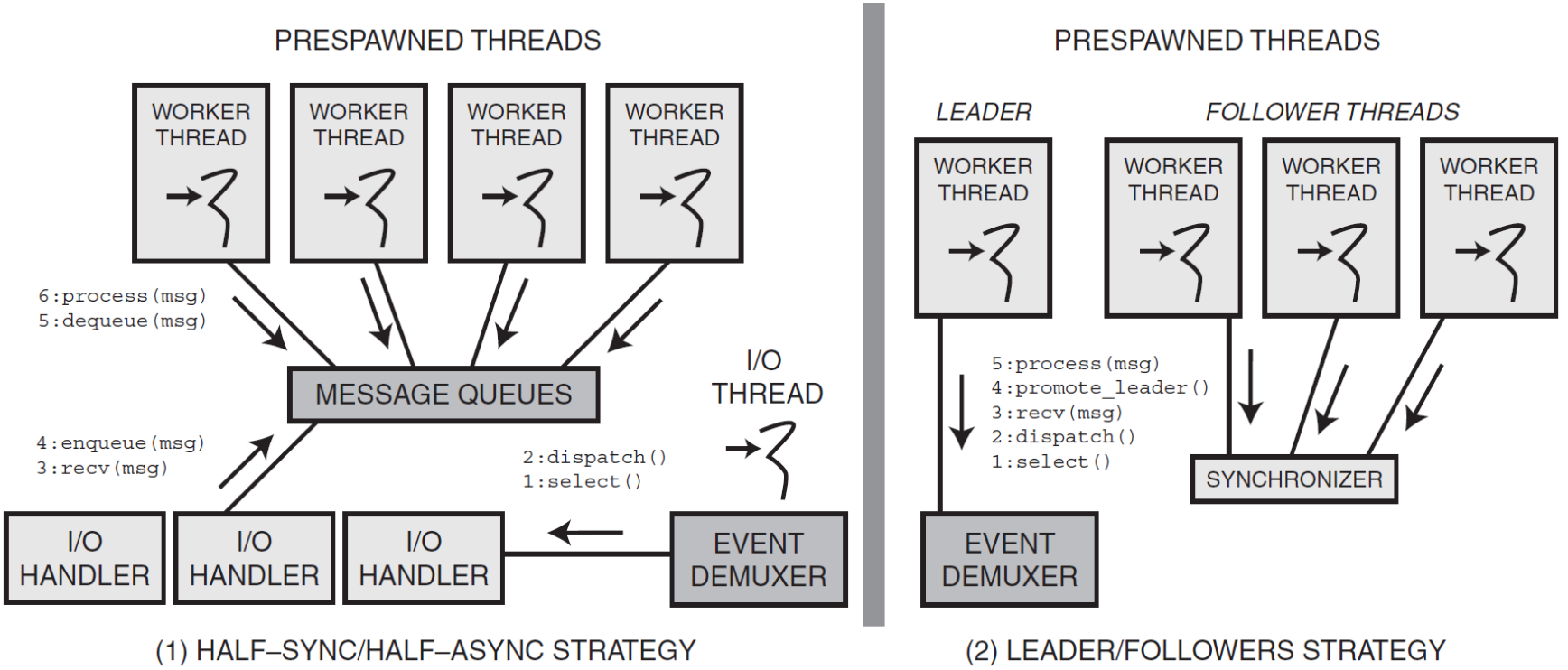
Overview of Thread Pools

- Java's executor framework supports several types of thread pools
  - *Fixed-size pool*
  - *Cached*
  - *Fork/join pool*
    - Supports "work-stealing" queues that maximize core utilization
    - Strike a balance between a fixed- & variable # of threads in the pool



Overview of Thread Pools

- There are also other ways to implement thread pools



See www.dre.vanderbilt.edu/~schmidt/PDF/lf.pdf & www.dre.vanderbilt.edu/~schmidt/PDF/HS-HA.pdf

Human Known Uses of Thread Pools

Human Known Uses of Thread Pools

- A "call center" is a human known use of a thread pool

See en.wikipedia.org/wiki/Call_centre

End of Overview of the Java Executor Framework (Part 1)