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Concurrency and Multi-Threading in Java

2021 April

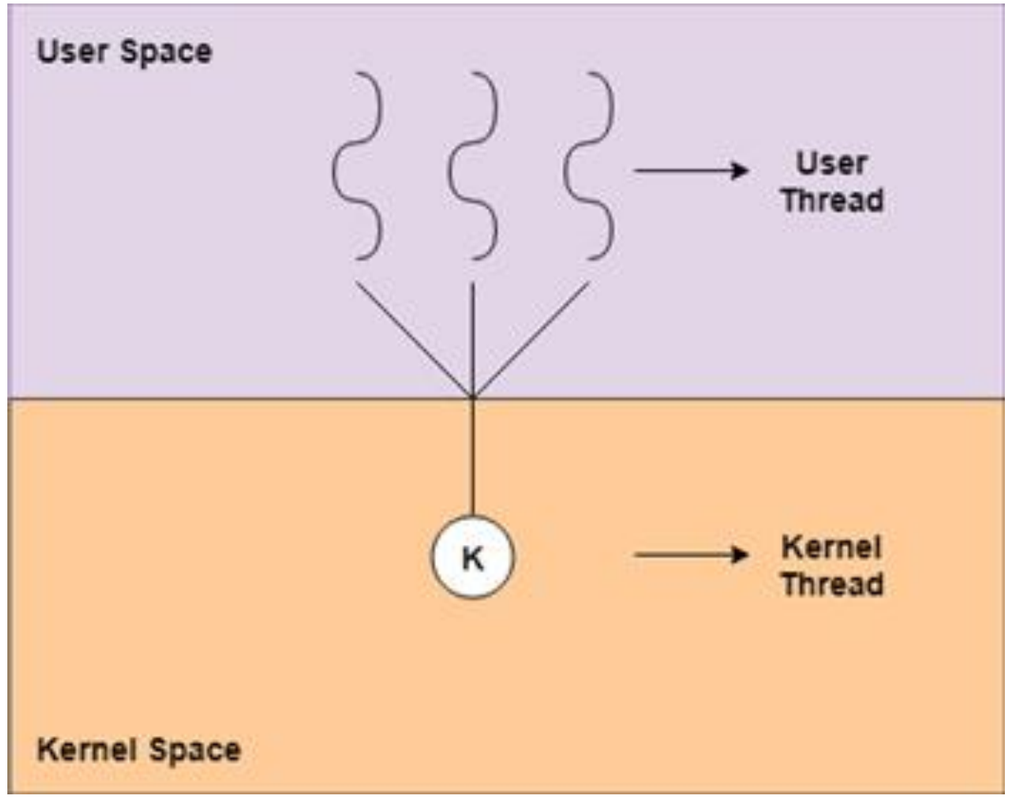
Agenda

- **What is Thread?**
- **Why Multi-Threading?**
- **Status of a Thread**
- **Threading in Java**
  - Methods
  - Implement a thread
  - FutureTask
  - ThreadPoolExecutor
- **synchronized**
- **volatile**

What is Thread?

- Defined at the OS level
- The actual unit of the execution of the OS process
- A set of instructions
- Can be executed “at the same time”
- Has various statuses

What is Thread?



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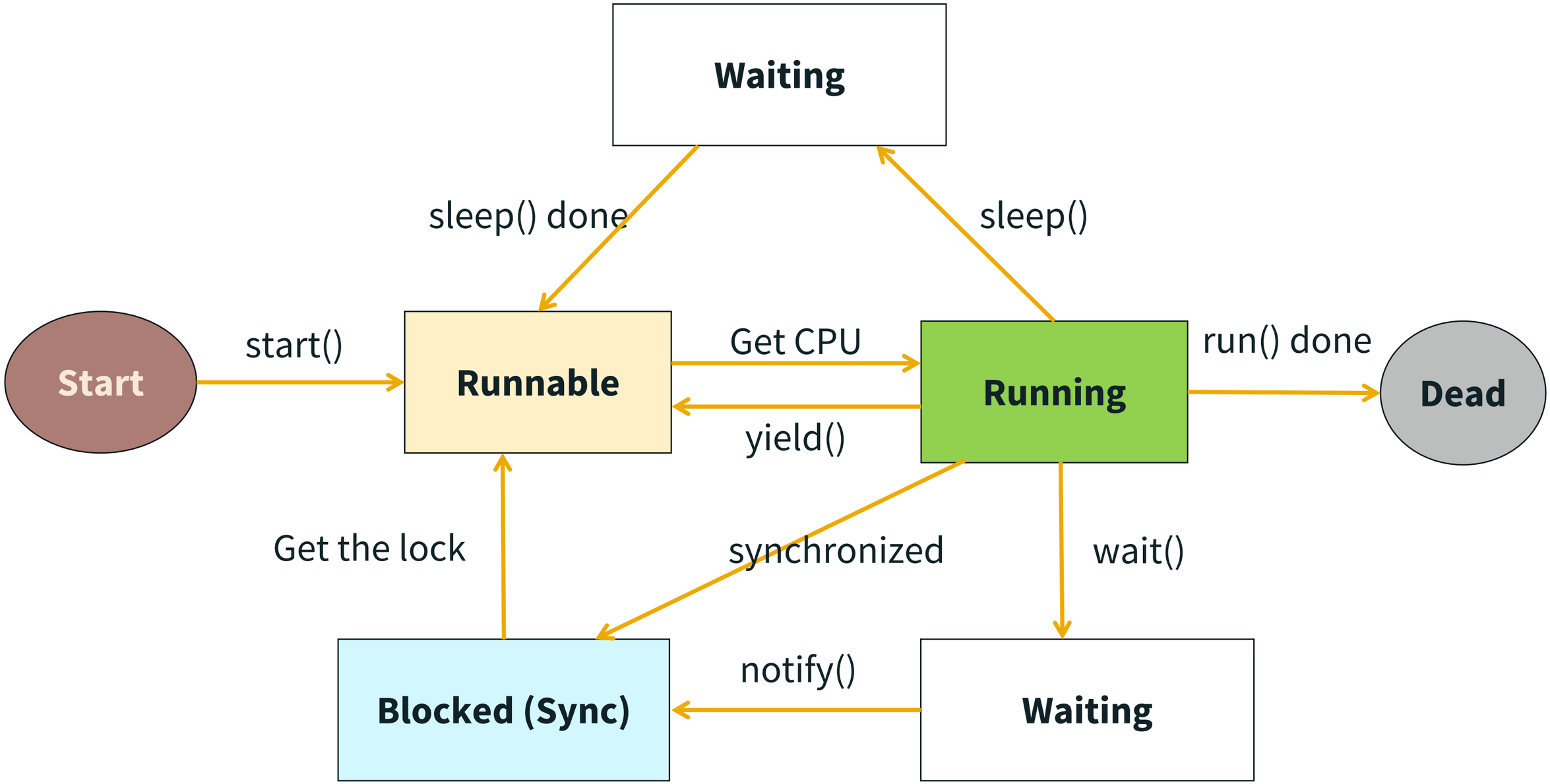
Why Multi-Threading?

Performance!

Status of a Thread

- New
- Runnable
- Running
- Blocked
- Dead

Status of a Thread



Threading in Java

Methods: Thread

- ***Thread.start():*** Move a thread to the runnable queue to race for the CPU time slice.
- ***Thread.yield():*** Releases the CPU time slice to the threads at same priority of the current thread. Does not release the lock.
- ***Thread.sleep(long millis):*** Releases the CPU time slice so that all threads have the opportunity. Supports the time setting. Do not release the lock.
- ***Thread.join():*** Forces the child thread to join the current parent thread. The current thread waits till the child thread completes.

Threading in Java

Methods: Object

- ***Object.wait():*** Releases the CPU time slide. Puts the current thread into the waiting pool. Releases the lock to the object which calls this method.
- ***Object.notify():*** Puts the current thread into the pool to race for the lock against the object calling this method.
- ***Object.notifyAll():*** Puts all the threads wanting the lock against the object calling this method into the pool for racing it.

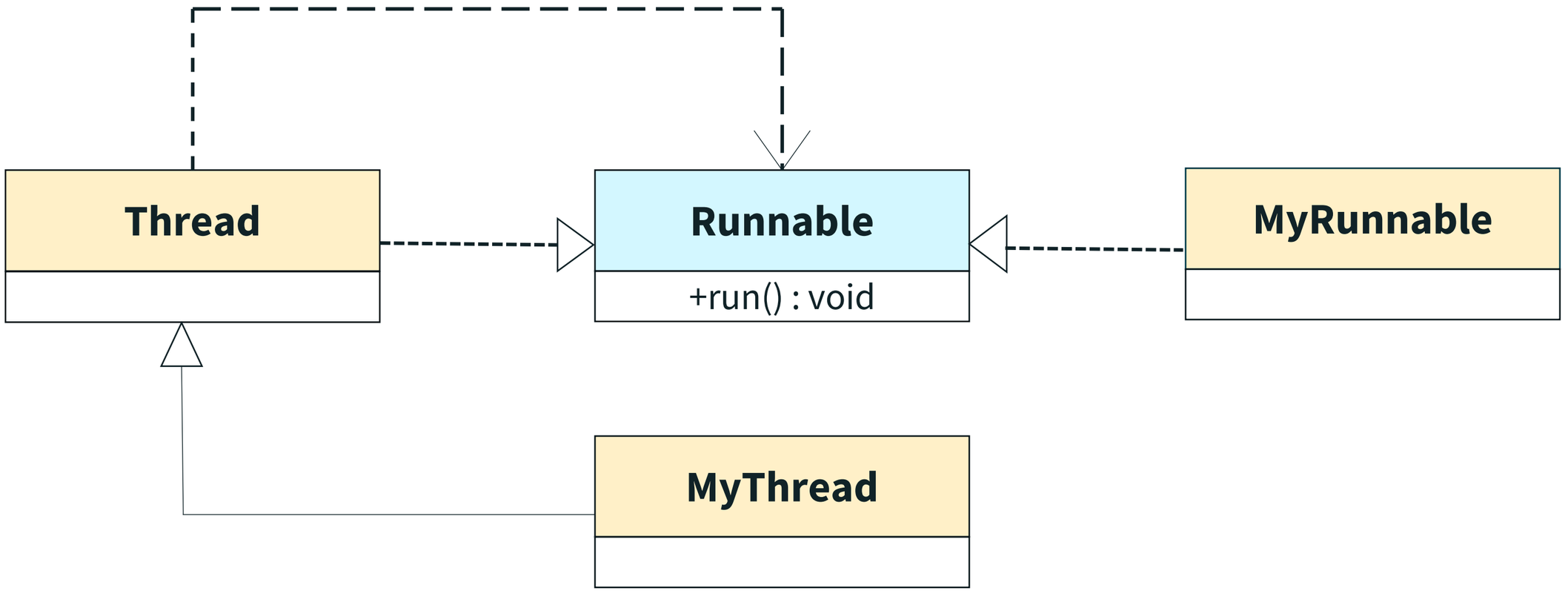
Threading in Java

Implement a Thread

- Extend *Thread* class
- Implement *Runnable* interface
- Callable<V> & Future

Threading in Java

Thread V.S. Runnable



Threading in Java

Thread V.S. Runnable

- *Thread* implements *Runnable*
- *Thread* mainly describes the threading functionalities
- *Runnable* is abstracted specifically focusing on the description of the resource
- *Runnable* implementation can be reused by different threads

See the example

Threading in Java

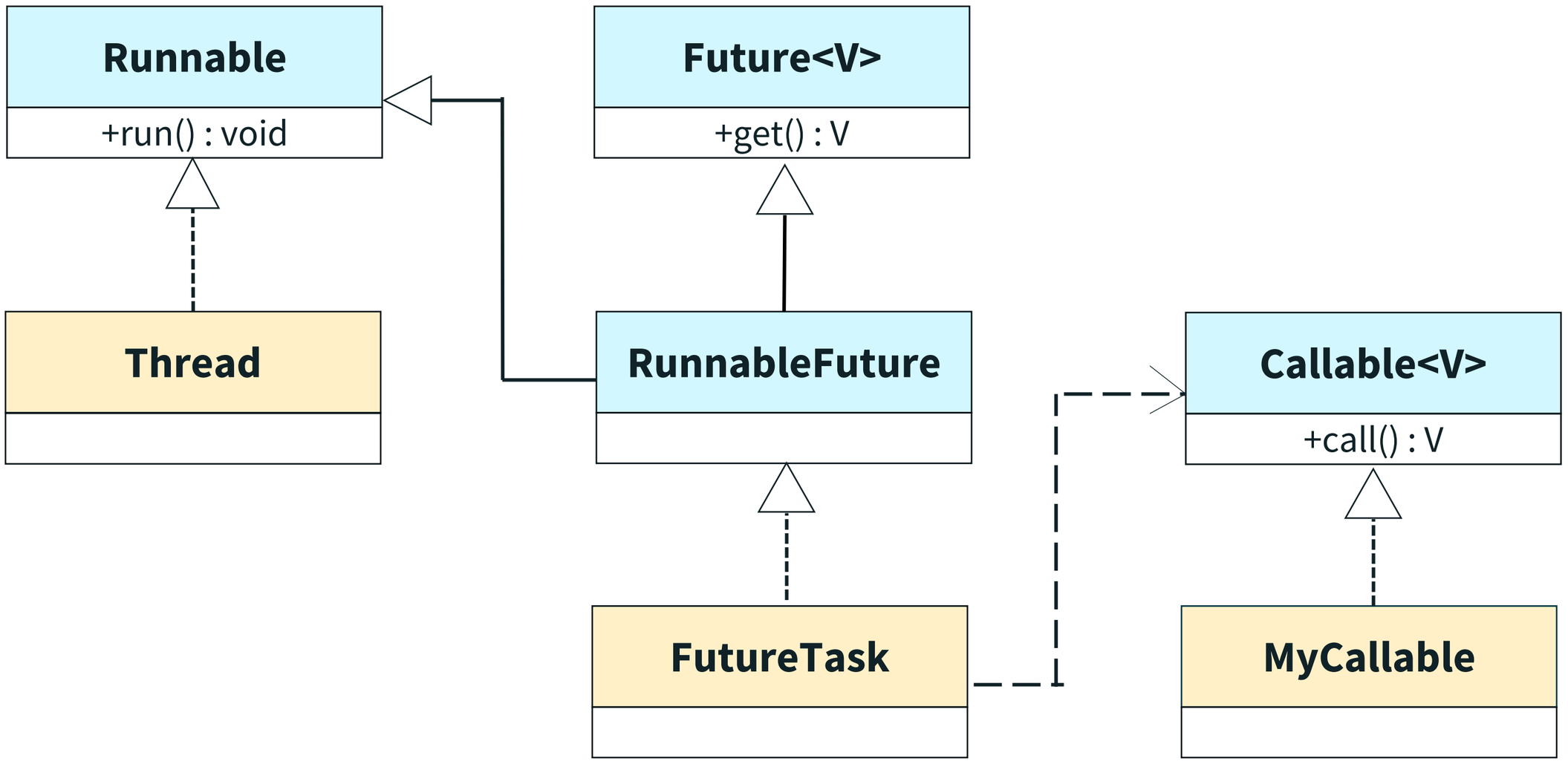
Runnable V.S. Callable

- They are both interfaces
- The *call()* method of *Callable throws exception*
- The *call()* method of *Callable* could return a result(works with FutureTask)

See the example

Threading in Java

Runnable V.S. Callable



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Threading in Java

FutureTask

- ***V get():*** Waits if necessary for the computation to complete, and then retrieves its result.
- ***boolean cancel(boolean mayInterruptIfRunning) :*** Attempts to cancel execution of this task.
- ***boolean isDone():*** Returns true if this task completed.
- ***boolean isCancelled():*** Returns true if this task was cancelled before it completed normally.

For more details:

https://docs.oracle.com/javase/8/docs/api/java/util/concurrent/FutureTask.html

Threading in Java

ThreadPoolExecutor

- Thread pools address two different problems: they usually provide improved performance when executing large numbers of asynchronous tasks, due to reduced per-task invocation overhead, and they provide a means of bounding and managing the resources, including threads, consumed when executing a collection of tasks.
- Each *ThreadPoolExecutor* also maintains some basic statistics, such as the number of completed tasks.

Threading in Java

ThreadPoolExecutor

- Implements *Executor* and *ExecutorService* (default implementation)
- Extends *AbstractExecutorService*
- 4 constructors:

ThreadPoolExecutor
ThreadPoolExecutor(int, int, long, TimeUnit, BlockingQueue<Runnable>)
ThreadPoolExecutor(int, int, long, TimeUnit, BlockingQueue<Runnable>, ThreadFactory)
ThreadPoolExecutor(int, int, long, TimeUnit, BlockingQueue<Runnable>, RejectedExecutionHandler)
ThreadPoolExecutor(int, int, long, TimeUnit, BlockingQueue<Runnable>, ThreadFactory, RejectedExecutionHandler)

For more details:

https://docs.oracle.com/javase/8/docs/api/java/util/concurrent/ThreadPoolExecutor.html

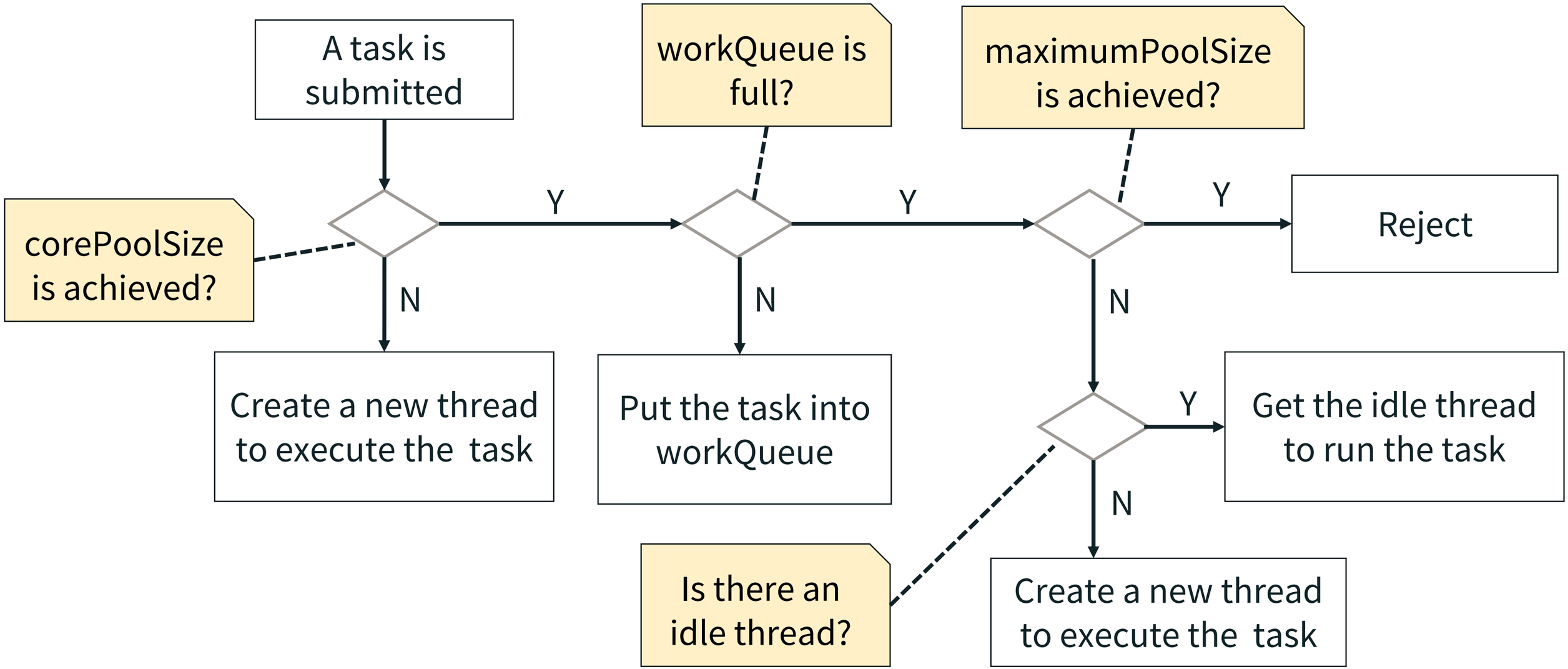
Threading in Java

ThreadPoolExecutor

1	corePoolSize	int
2	maximumPoolSize	int
3	keepAliveTime	long
4	unit	TimeUnit
5	workQueue	BlockingQueue<Runnable>
6	threadFactory	ThreadFactory
7	handler	RejectedExecutionHandler

Threading in Java

ThreadPoolExecutor



Threading in Java

ThreadPoolExecutor

3 strategies for queuing:

- **Direct handoffs**

  - hands off tasks to threads without holding
  - default choice for a work queue is a SynchronousQueue

- **Unbounded queues**

  - Never out-of-bound.
  - i.e. LinkedBlockingQueue

- **Bounded queues**

  - prevent resource exhaustion when used with finite maximumPoolSizes
  - i.e. ArrayBlockingQueue

Threading in Java

ThreadPoolExecutor

4 Default thread pool provided by ***Executor***:

- **FixedThreadPool**

  - core size = max size, keepAliveTime = 0

  - LinkedBlockingQueue

- **SingleThreadExecutor**

  - Wrappered by FinalizableDelegatedExecutorService

  - core size = max size = 1

  - LinkedBlockingQueue

Threading in Java

ThreadPoolExecutor

4 Default thread pool provided by ***Executor***:

- **CachedThreadPool**

  - corePoolSize = 0, maximumPoolSize = Integer.MAX_VALUE, keepAliveTime = 60

  - SynchronousQueue

- **ScheduledThreadPool**

  - Tasks are schedulable

  - core size is customizable, max size = Integer.MAX_VALUE

  - DelayedWorkQueue, unbounded

Threading in Java

synchronized

- Allows only one thread to entry, blocks the others
- Executable only when a thread gains the lock
- Can specify a block of codes, a method or a class

See the example

Threading in Java

volatile

- To specify a variable
- According to JMM, the threads usually copy the shared variables from the main memory to the work memory being used by the executors. But a volatile variable keeps being written back into the main memory so that no dirty read happens when reading it by any threads.

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