Threads in Java

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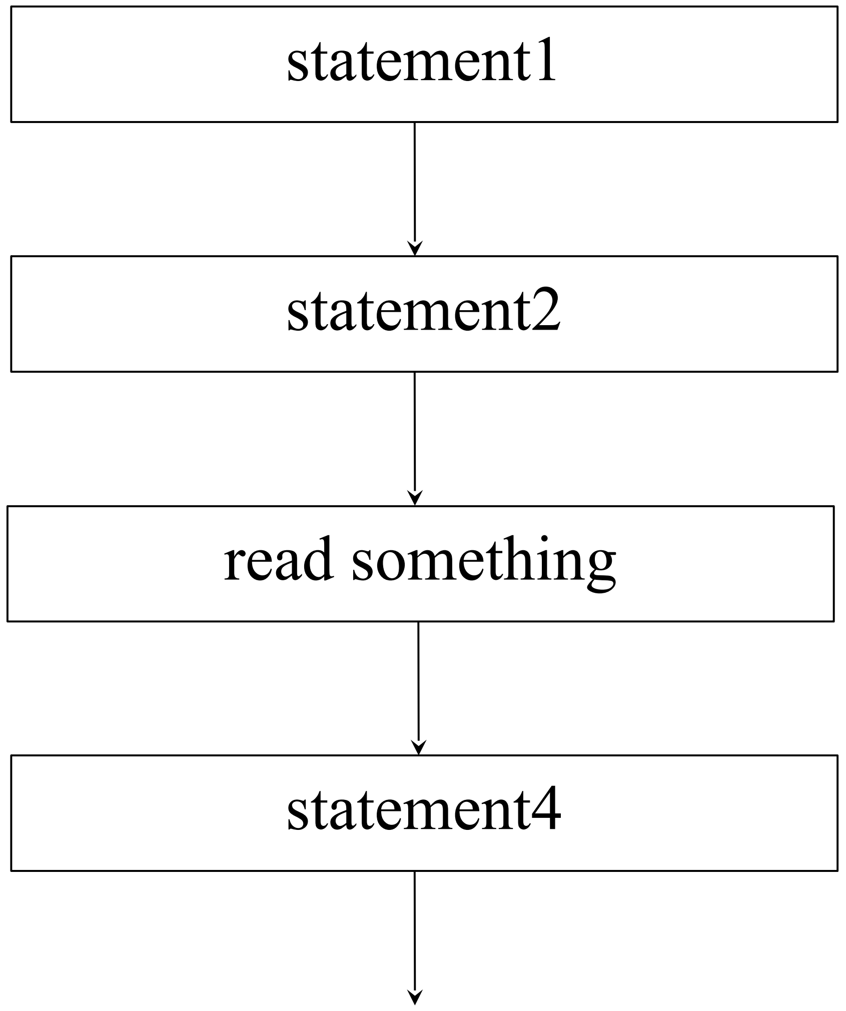
A Thread is a single flow of control

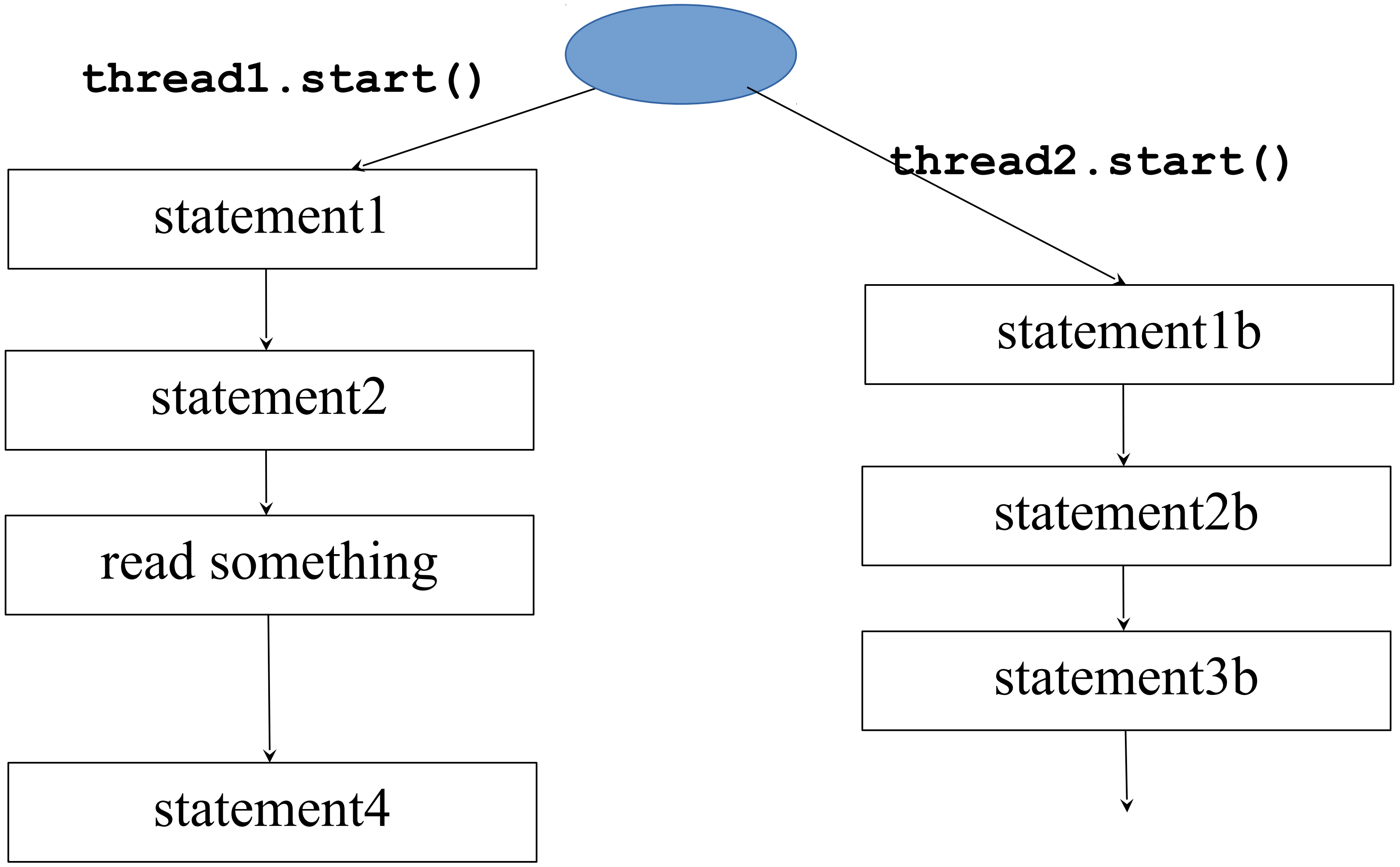


Each statement must finish before next one is executed.

This is the way our console-based programs run.

A Program can create multiple threads

Threads execute independently. They are not synchronized.



Why Use Threads?

- Perform tasks in parallel
  - connection to database
  - I/O operations
  - long-running computations (can be in parallel)
- Prevent user interface from "freezing"

  UI remains responsive while work is being done.

  Android requires responsive UI... or it will kill you!

  `AsyncTask` class for background tasks.

Basic way to create a Thread

Use the Thread class.   There are 2 ways:

1. extend Thread class and override run()

```
public class PrompterThread extends Thread {
   private String message;
   public Prompter(String message) {
        this.message = message;
   }

   /** the work we want to perform */
   public void run() {
        System.out.println( message );
   }
```

Basic way to create a Thread

2. Define class that implements Runnable. Put an instance of this Runnable in a Thread.

```
public class Prompter implements Runnable {
   private String message;
   public Prompter(String message) {
       this.message = message;
   }
   /** the work we want to perform */
   public void run() {
       System.out.println( message );
    }
}
Thread prompterThread = new Thread(
                          new Prompter() );
```

Running a Thread

Call the start( ) method of Thread.

It runs in a separate *thread* and returns control immediately

```
// Method 1. use a subclass of Thread
Thread thread1 = new PrompterThread("Hello");
thread1.start( );


// Method 2. use a Runnable and wrap in a Thread
Runnable prompter = new Prompter("Hello");
Thread thread2 = new Thread( prompter );
thread2.start();
```

Sequence Diagram

Demo

1. Hello and Goodbye threads.

   Say "Hello", "and", "Goodbye" in separate threads, wait 500ms, repeat.

   ... the messages are not always synchronized.

   Note:

   if "main" method quits without waiting for

   threads or killing them, they will keep running,

   even if console window is closed.

Waiting for threads to finish

- After Thread.start() control returns immediately.
- To wait for another thread to finish, use join.

```
public static void main(String[] args) {
    Thread thread1 =
           new Thread( new Greeter("Hello") );

    thread1.start();
    try {
       thread1.join();
    } catch (InterruptedException ie) {
       // something interrupted the thread
       // while we were waiting
    }
}
```

InterruptedException

A Thread can be interrupted by calling thread.interrupt().

If the thread is busy, waiting, or sleeping then an InterruptedException is thrown in the thread.

```
try {
   Thread.sleep( 2000 ); // time in millisec
} catch (InterruptedException ie) {
   // something invoked interrupt( ) while
   // we were sleeping!
}
```

Checking for Interruptions

If your thread *might* be interrupted, you can check for it using `Thread.interrupted( )`

```
class Downloader implements Runnable {
   public void run( ) {
      // read a big file into buffer
      while((size=in.read(buffer)) > 0) {
         // check for interruption
         if ( Thread.interrupted() ) {
            // close streams and return
            in.close();
            return;
         }
         // otherwise, process the buffer
```

Thread class

Thread

currentThread( ): Thread

interrupt( ): void

interrupted(): boolean

getName( ): String

sleep(millisec: long): void

many more methods

Interrupt Demo

In the "Hello and Goodbye" demo modify main method:

when user presses ENTER, interrupt the greeter threads.

Use:

`thread.interrupt( )` - interrupt thread

Impatient Demo

Write an impatient greeter:

Prompt user his name and print "Hello, *username*."
but don't wait more than 5 seconds for a reply.

Use a separate thread to get the user's name.

`thread.join(timeout)` - wait for thread at most timeout millisecs

`thread.interrupt( )` - interrupt thread

`thread.destroy( )` - doesn't

Demo

1. "main" waits for threads to finish.

2. In Hello / Goodbye, give each thread a name.

```
new Thread( String name )
new Thread( Runnable task, String name )
```

2. In each thread, get its name and print it.
Use Thread.currentThread() and thread.getName().

Thread Managers and Thread Pools

For most uses, you should use one of these:

Timer - run a task at specified time or frequency

ExecutorService

- manage one or more threads (called a *thread pool*).
- reuse threads (efficient memory use).
- can also run *Callable* tasks (return a value in future)
- shutdown or cancel tasks

Demo

1. Rewrite ImpatientGreeter to use ExecutorService:

```
ExecutorService executor =
    Executors.newSingleThreadExecutor( );
executor.submit( runnable );
```

wait for thread:

```
    executor.awaitTermination(5, TimeUnit.SECONDS)
```

kill threads: `executor.shutdownNow( )`

Demo

2. Rewrite Hello / Goodbye to use Timer.

timer.schedule(TimerTask, long delay, long period)

timer.scheduleAtFixedRate(TimerTask, delay, period)

ExecutorService

Defines several kinds of thread pools.

Example:

You want to run some tasks using threads, but use at *most 4 theads at one time* (to avoid task switching).

```
final int MAX_THREADS = 4;
ExecutorService executor =
         Executors.newFixedThreadPool(MAX_THREADS);

// add tasks to queue for execution
executor.execute(runnable1);
executor.execute(runnable2);
 . . .
executor.execute(runnable10);
```

Protected Blocks of Code

When multiple threads access the same object, or same memory, what can go wrong?

What if two threads try to change some memory at the same time?

Thread-safe classes

StringBuffer - thread safe (OK for 2 threads to share)

StringBuilder - not thread sale

AtomicInteger, AtomicLong, etc. - thread safe Integer, Long, etc.

"synchronized" methods

If a method is "synchronized" then one one thread can execute it at a time. Other threads must wait.

```
public synchronized List withdraw(double amount) {
    // only one thread can execute this method
    // at any time. Other threads must wait.
```

Problem: synchronized methods are slooooow.

References

The Java Tutorial:
https://docs.oracle.com/javase/tutorial

Threads & Executors Tutorial (Winterbe blog)
http://winterbe.com/posts/2015/04/07/java8-concurrency-tutorial-thread-executor-examples/

This is a really good blog for Java! Have a look.

Concurrency (general)

https://docs.oracle.com/javase/tutorial/essential/concurrency/index.html