Multithreading

Running > 1 pieces of code concurrently, each piece of code is called a **thread**

Term	Definition
Single-threaded program	Executed sequentially
Multithreaded program	Many tasks of a program running concurrently
Thread	Flow of execution, from start to end of a task

Multitasking vs Multithreading

Slide 7 Lecture

Java Thread Model

A thread in Java exists in several states

- **New** : A newly instantiated Thread object
- **Running** : Name implies
- **Suspended** : Same as pausing, can be resumed
- **Blocked** : Can happen when waiting for resource
- **Terminated** : Halts completely, no resume

Advatanges of Java Multithreading

- Threads are independent
- Saves time
- Exception in a thread doesn't affect another

How to create a thread

2 ways to do it

- Implementing the `Runnable` interface
- Extending the `Thread` class

Creating a task and a thread

In a nutshell

Tasks are objects of a class (`Task` class) that **implements** the `Runnable` interface

The method `run()` needs to be overridden from the interface

Soooo a `Task` **must be executed** in a `Thread` (using the constructor)

then by invoking the `.start()` method

Code

In CustomTask.java

```
public class myTask implements Runnable {
  public TaskClass() {
    // Constructor
  }

  // From the Runnable
  public void run() {
    // The task code
  }
}
```

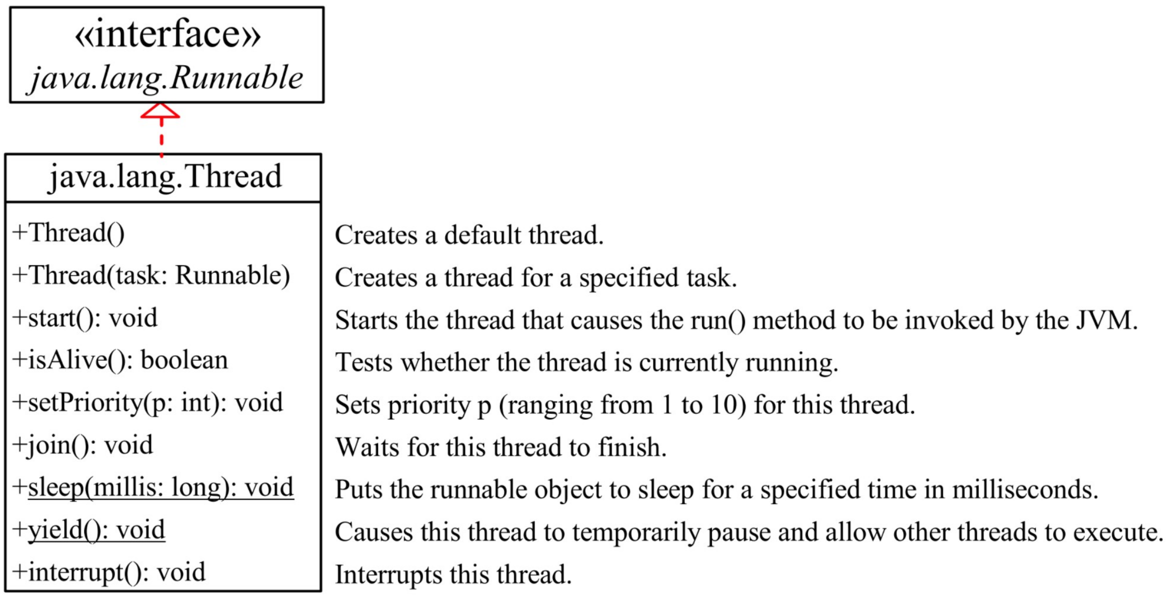
In ThreadApp.java

```
public class ThreadApp {
  public static void main (String[] args) {
    myTask taskForThread1 = new myTask();

    Thread thread1 = new Thread(taskForThread1);

    thread1.start(); // Executes the run() method
  }
}
```

The Thread Class



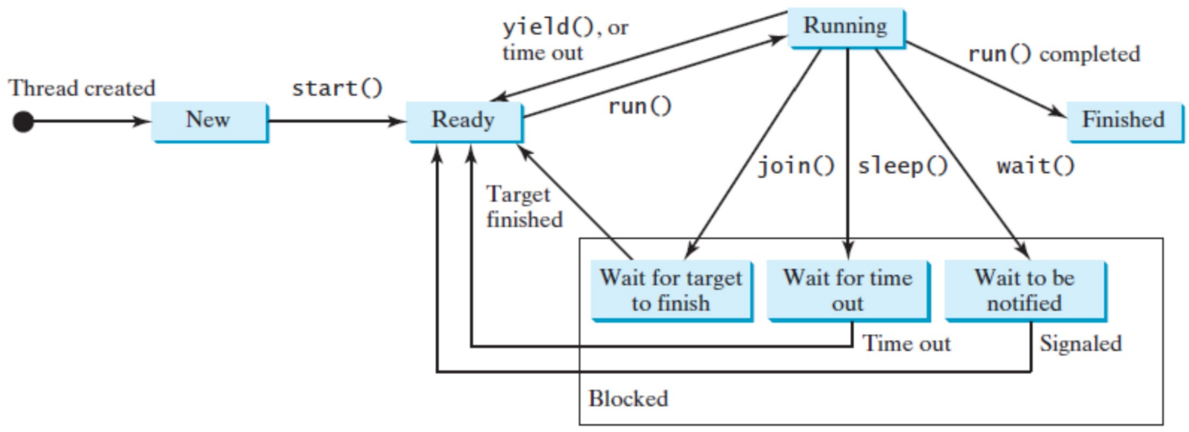
+Thread()	Creates a default thread.
+Thread(task: Runnable)	Creates a thread for a specified task.
+start(): void	Starts the thread that causes the run() method to be invoked by the JVM.
+isAlive(): boolean	Tests whether the thread is currently running.
+setPriority(p: int): void	Sets priority p (ranging from 1 to 10) for this thread.
+join(): void	Waits for this thread to finish.
+sleep(millis: long): void	Puts the runnable object to sleep for a specified time in milliseconds.
+yield(): void	Causes this thread to temporarily pause and allow other threads to execute.
+interrupt(): void	Interrupts this thread.

Notable Methods

Name	Type	Description
`sleep(long millis)`	static	Sleeps the current thread; lets other threads to execute; raises `InterruptedException` (checked)
`yield()`	static	temporarily release time for other threads
`setPriority(int arg0)`	instance	From 1 to 10 (Low to High), higher priority is executed first when queued using `.start()`
`join()`	instance	Forces one thread to wait for another thread to die before it can execute
`isAlive()`	instance	True if `Ready/Blocked/Running`, False if `new/terminated`
`interrupt()`	instance	**Rarely invoked**, if it is `Ready/Running`, set interrupted to true; if blocked, it is awakened and enters `Ready` state, an `InterruptedException` is thrown

| `isInterrupt()` |instance| Check if a thread is stopping what it is originally doing and doing something else instead

Lifecycle of Thread



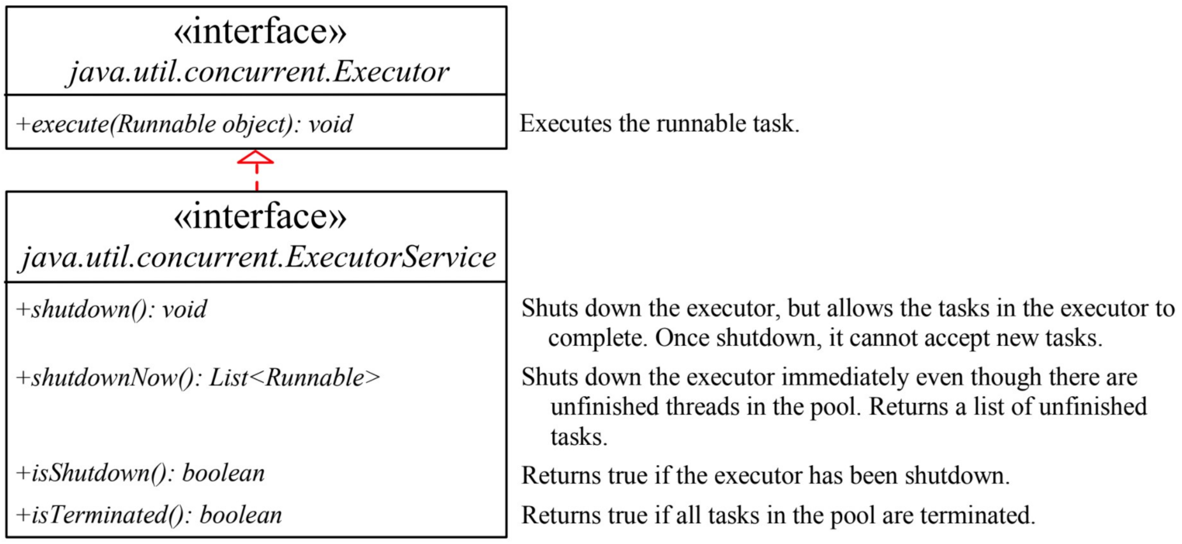
Depreciated Methods

`stop()` - kills the thread, assign `null` instead
`suspend()` - puts the the thread to wait until `.resume()` is called

Thread Pools

`Executor` interface for executing tasks in a thread pool
`ExecutorService` interface for managing and controlling tasks

It is to limit the number of threads running concurrently



«interface»
java.util.concurrent.Executor

+execute(Runnable object): void

Executes the runnable task.

«interface»
java.util.concurrent.ExecutorService

+shutdown(): void

Shuts down the executor, but allows the tasks in the executor to complete. Once shutdown, it cannot accept new tasks.

+shutdownNow(): List<Runnable>

Shuts down the executor immediately even though there are unfinished threads in the pool. Returns a list of unfinished tasks.

+isShutdown(): boolean

Returns true if the executor has been shutdown.

+isTerminated(): boolean

Returns true if all tasks in the pool are terminated.

Using the ExecutorService

`ExecutorService executor = Executors.newFixedThreadPool(3);`

3 threads will be limited to run at the same time

Multithreading Problems

Race Condition : accessing a common resource in a way that causes conflict; class must be **thread-safe** to prevent this problem.

To prevent Race Condition

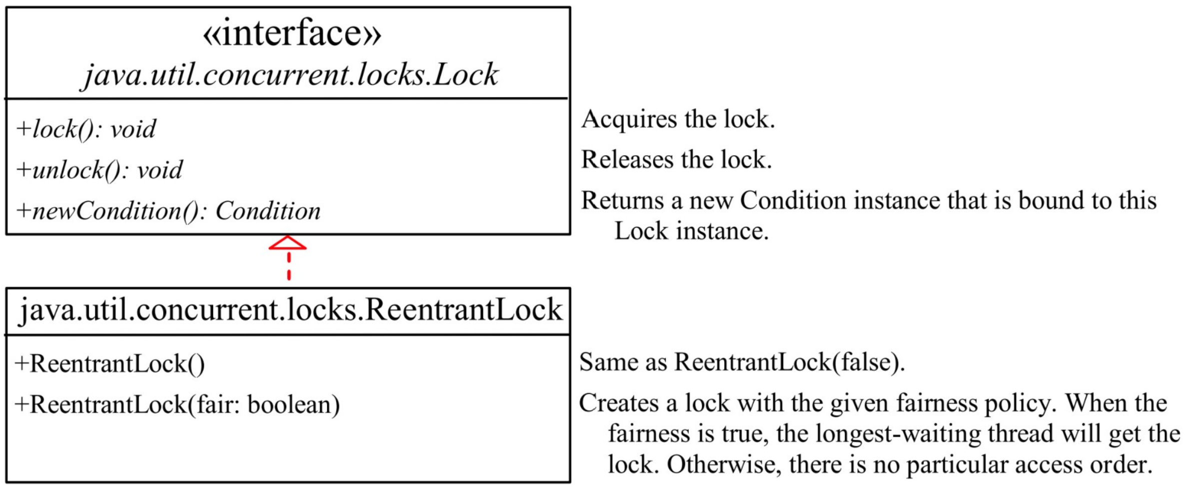
Use the `synchronized` keyword to access a method to allow only 1 thread at a time, such part of code is called the **Critical Region**

OR

```
public void deposit(double amount) {
    synchronized(this) {
        //code here
    }
}
```

More specialized critical region

Use the `ReentrantLock` class (implements `Lock`) for resource sharing


«interface»
java.util.concurrent.locks.Lock
+lock(): void
+unlock(): void
+newCondition(): Condition
Acquires the lock.
Releases the lock.
Returns a new Condition instance that is bound to this Lock instance.
java.util.concurrent.locks.ReentrantLock
+ReentrantLock()
+ReentrantLock(fair: boolean)
Same as ReentrantLock(false).
Creates a lock with the given fairness policy. When the fairness is true, the longest-waiting thread will get the lock. Otherwise, there is no particular access order.

```
private Lock lock = new ReentrantLock();

public void deposit(int amount) {
    lock.lock();
    // Critical Region Code
    lock.unlock();
}
```