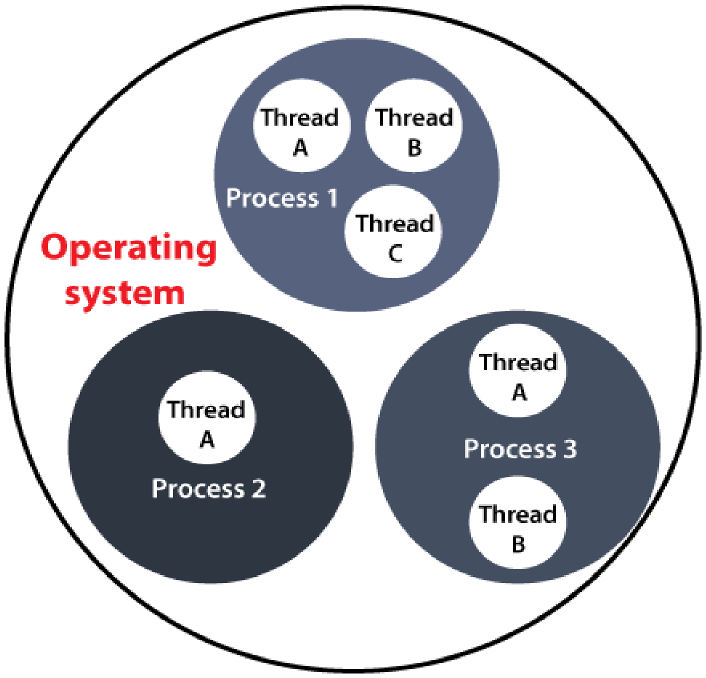
Multithreading in Java

Thread

Thread is a very light-weighted process, or we can say the smallest part of the process that allows a program to operate more efficiently by running multiple tasks simultaneously.

In order to perform complicated tasks in the background, we used the Thread concept in Java. All the tasks are executed without affecting the main program. In a program or process, all the threads have their own separate path for execution, so each thread of a process is independent.

Another benefit of using thread is that if a thread gets an exception or an error at the time of its execution, it doesn't affect the execution of the other threads. All the threads share a common memory and have their own stack, local variables and program counter. When multiple threads are executed in parallel at the same time, this process is known as Multithreading.



There are two distinct types of multitasking: process-based and thread-based.

A process is, in essence, a program that is executing. Thus, process-based multitasking is the feature that allows your computer to run two or more programs concurrently. For example, process-based multitasking enables you to run the Java compiler at the same time that you are using a text editor or visiting a web site. In process-based multitasking, a program is the smallest unit of code that can be dispatched by the scheduler.

In a thread-based multitasking environment, the thread is the smallest unit of dispatchable code. This means that a single program can perform two or more tasks simultaneously. For instance, a text editor can format text at the same time that it is printing, as long as these two actions are being performed by two separate threads. Thus, process-based multitasking deals with the "big picture," and thread-based multitasking handles the details.

Multitasking threads require less overhead than multitasking processes. Processes are heavyweight tasks that require their own separate address spaces. Interprocess communication is expensive and limited. Context switching from one process to another is also costly. Threads, on the other hand, are lighter weight. They share the same address space and cooperatively share the same heavyweight process. Interthread communication is inexpensive, and context switching from one thread to the next is lower in cost. While Java programs make use of process-based multitasking environments, process-based multitasking is not under Java's control. However, multithreaded multitasking is.

Multithreading enables you to write efficient programs that make maximum use of the processing power available in the system. One important way multithreading achieves this is by keeping idle time to a minimum.

The Main Thread

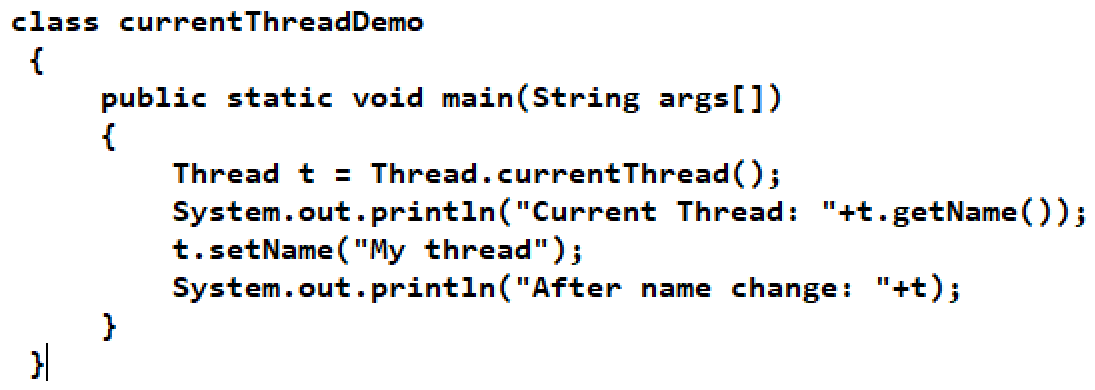
When a Java program starts up, one thread begins running immediately. This is usually called the main thread of your program, because it is the one that is executed when your program begins. The main thread is important for two reasons:

- It is the thread from which other "child" threads will be spawned.
- Often, it must be the last thread to finish execution because it performs various shutdown actions.

Although the main thread is created automatically when your program is started, it can be controlled through a Thread object. To do so, you must obtain a reference to it by calling the method currentThread( ), which is a public static member of Thread. Its general form is shown here:

static Thread currentThread( )

This method returns a reference to the thread in which it is called. Once you have a reference to the main thread, you can control it just like any other thread.

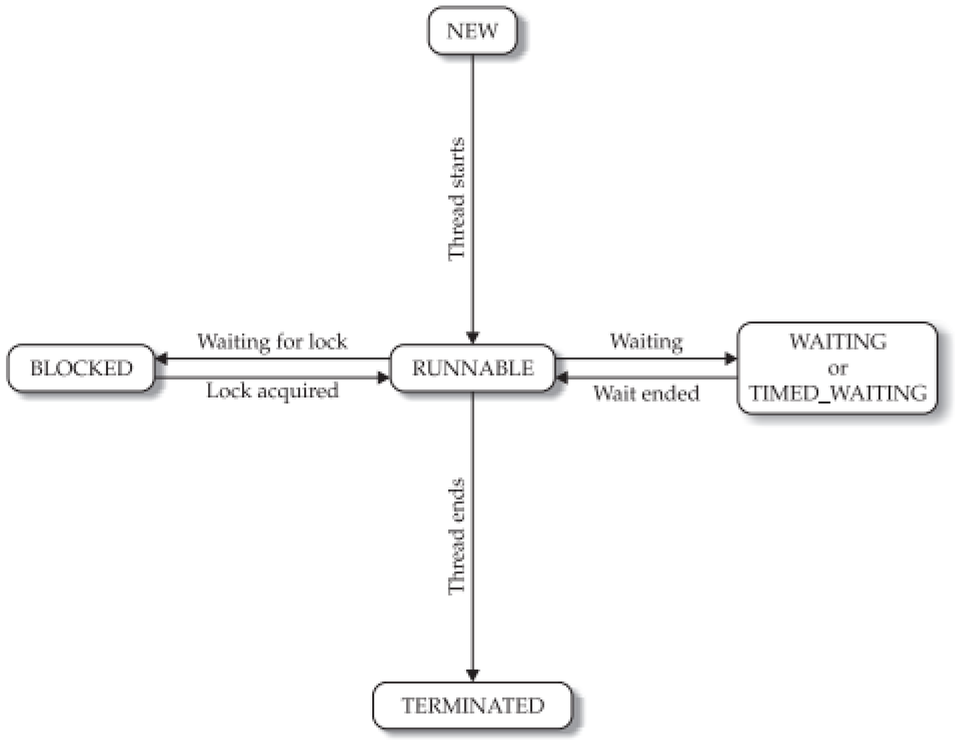


```
class currentThreadDemo
 {
     public static void main(String args[])
     {
         Thread t = Thread.currentThread();
         System.out.println("Current Thread: "+t.getName());
         t.setName("My thread");
         System.out.println("After name change: "+t);
     }
 }
```

Output:

```
Current thread: main
After name change: Thread[My thread, 5, main]
```

Life Cycle of a Thread / States of a Thread



Value	State
BLOCKED	A thread that has suspended execution because it is waiting to acquire a lock.
NEW	A thread that has not begun execution.
RUNNABLE	A thread that either is currently executing or will execute when it gains access to the CPU.
TERMINATED	A thread that has completed execution.
TIMED_WAITING	A thread that has suspended execution for a specified period of time, such as when it has called **sleep( )**. This state is also entered when a timeout version of **wait( )** or **join( )** is called.
WAITING	A thread that has suspended execution because it is waiting for some action to occur. For example, it is waiting because of a call to a non-timeout version of **wait( )** or **join( )**.

Creating a Thread

In the most general sense, you create a thread by instantiating an object of type Thread.

Java defines two ways in which this can be accomplished:

- You can implement the Runnable interface.
- You can extend the Thread class, itself.

Implementing Runnable

The Runnable interface describes a class whose instances can be run as a thread. The interface itself is very simple, describing only one method (run) that is called automatically by Java when the thread is started.

void run()

Called when the thread is started. Place the code that you want the thread to execute inside this method.

To use the Runnable interface to create and start a thread, you have to do the following:

1. Create a class that implements Runnable .

2. Provide a run method in the Runnable class.

3. Create an instance of the Thread class and pass your Runnable object to its constructor as a parameter.

A Thread object is created that can run your Runnable class.

4. Call the Thread object's start method.

The run method of your Runnable object is called and executes in a separate thread.

Here's an example of a class that implements Runnable:

```
public class RunnableClass implements Runnable1

{

public void run()

{

// code to execute when thread is run goes here

}

}
```

Here's an example that instantiates a RunnableClass object, and then creates a Thread object to run the RunnableClass object:

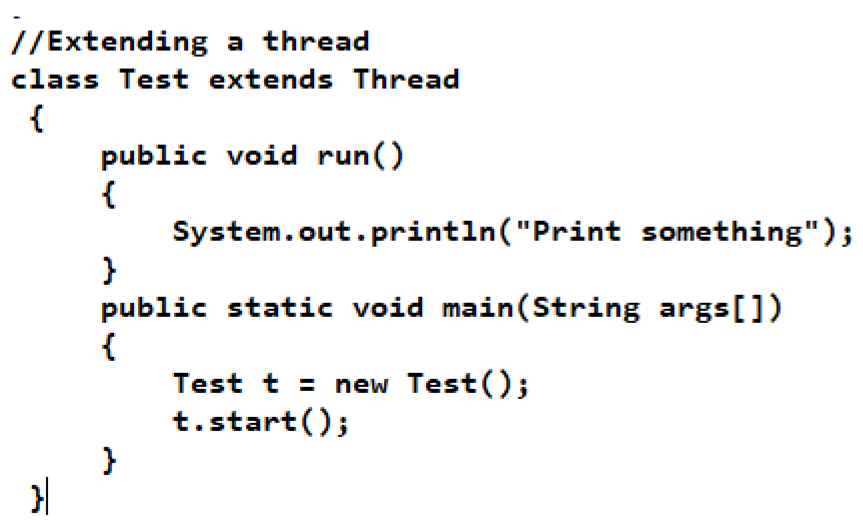
```
RunnableClass rc = new RunnableClass();

Thread t = new Thread(rc);

t.start();
```

Extending Thread

The second way to create a thread is to create a new class that extends Thread, and then to create an instance of that class. The extending class must override the run( ) method, which is the entry point for the new thread. It must also call start( ) to begin execution of the new thread.



```
//Extending a thread
class Test extends Thread
 {
     public void run()
     {
         System.out.println("Print something");
     }
     public static void main(String args[])
     {
         Test t = new Test();
         t.start();
     }
 }
```

Creating Multiple threads

```
class MultithreadingDemo implements Runnable {
  public void run()
  {
    try {
      // Displaying the thread that is running
      System.out.println("Thread " + Thread.currentThread().getId()
        + " is running");
    }
    catch (Exception e) {
      // Throwing an exception
      System.out.println("Exception is caught");
    }
  }
}


// Main Class
class Multithread {
    public static void main(String[] args)
    {
        int n = 8; // Number of threads
        for (int i = 0; i < n; i++) {
            Thread object = new Thread(new MultithreadingDemo());
            object.start();
        }
    }
}
```

Thread Priorities

Java assigns to each thread a priority that determines how that thread should be treated with respect to the others. Thread priorities are integers that specify the relative priority of one thread to another. As an absolute value, a priority is meaningless; a higher-priority thread doesn't run any faster than a lower-priority thread if it is the only thread running. Instead, a thread's priority is used to decide when to switch from one running thread to the next. This is called a context switch. The rules that determine when a context switch takes place are simple:

- A thread can voluntarily relinquish control. This is done by explicitly yielding, sleeping, or blocking on pending I/O. In this scenario, all other threads are examined, and the highest-priority thread that is ready to run is given the CPU.

- A thread can be preempted by a higher-priority thread. In this case, a lower-priority thread that does not yield the processor is simply preempted—no matter what it is doing—by a higher-priority thread. Basically, as soon as a higher-priority thread wants to run, it does. This is called preemptive multitasking.

To set a thread's priority, use the setPriority( ) method, which is a member of Thread. This is its general form:

final void setPriority(int level)

Here, level specifies the new priority setting for the calling thread. The value of level must be within the range MIN_PRIORITY and MAX_PRIORITY. Currently, these values are 1 and 10, respectively. To return a thread to default priority, specify NORM_PRIORITY, which is currently 5. These priorities are defined as static final variables within Thread.You can obtain the current priority setting by calling the getPriority( ) method of Thread, shown here:

final int getPriority( )

Synchronization

When two or more threads need access to a shared resource, they need some way to ensure that the resource will be used by only one thread at a time. The process by which this is achieved is called synchronization.

Key to synchronization is the concept of the monitor. A monitor is an object that is used as a mutually exclusive lock. Only one thread can own a monitor at a given time. When a thread acquires a lock, it is said to have entered the monitor. All other threads attempting to enter the locked monitor will be suspended until the first thread exits the monitor. These other threads are said to be waiting for the monitor. A thread that owns a monitor can reenter the same monitor if it so desires.

For example, if you want two threads to communicate and share a complicated data structure, such as a linked list, you need some way to ensure that they don't conflict with each other. That is, you must prevent one thread from writing data while another thread is in the middle of reading it. For this purpose, Java implements an elegant twist on an age-old model of interprocess synchronization: the monitor. The monitor is a control mechanism first defined by C.A.R. Hoare. You can think of a monitor as a very small box that can hold only one thread. Once a thread enters a monitor, all other threads must wait until that thread exits the monitor. In this way, a monitor can be used to protect a shared asset from being manipulated by more than one thread at a time.In Java, there is no class "Monitor"; instead, each object has its own implicit monitor that is automatically entered when one of the object's synchronized methods is called. Once a thread is inside a synchronized method, no other thread can call any other synchronized method on the same object.

Self Study Inter-thread communication or Co-operation is all about allowing synchronized threads to communicate with each other.

Cooperation (Inter-thread communication) is a mechanism in which a thread is paused running in its critical section and another thread is allowed to enter (or lock) in the same critical section to be executed.It is implemented by following methods of Object class:

1. wait()

2. notify()

3. notifyAll()

wait( ) tells the calling thread to give up the monitor and go to sleep until some

other thread enters the same monitor and calls notify( ) or notifyAll( ).

notify( ) wakes up a thread that called wait( ) on the same object.

notifyAll( ) wakes up all the threads that called wait( ) on the same object. One of the threads will be granted access.

These methods are declared within Object, as shown here:

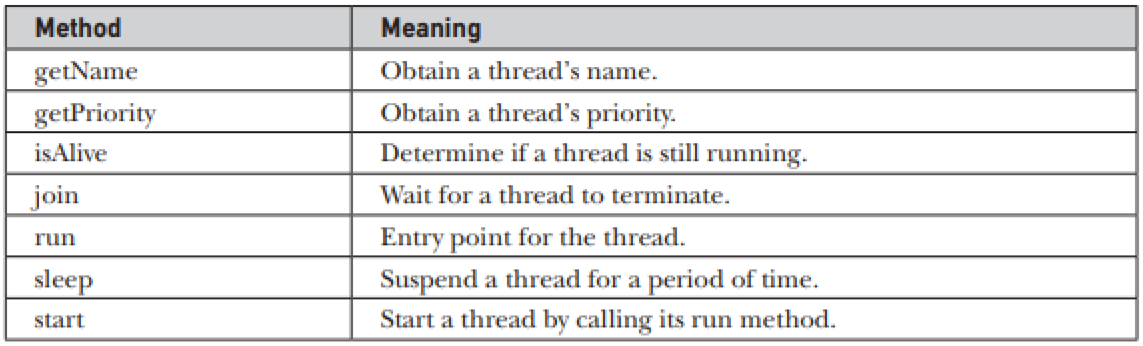
final void wait( ) throws InterruptedException

final void notify( )

final void notify All()

The Thread Class and the Runnable Interface

Java's multithreading system is built upon the Thread class, its methods, and its companion interface, Runnable. Thread encapsulates a thread of execution. Since you can't directly refer to the ethereal state of a running thread, you will deal with it through its proxy, the Thread instance that spawned it. To create a new thread, your program will either extend Thread or implement the Runnable interface.



Method	Meaning
getName	Obtain a thread's name.
getPriority	Obtain a thread's priority.
isAlive	Determine if a thread is still running.
join	Wait for a thread to terminate.
run	Entry point for the thread.
sleep	Suspend a thread for a period of time.
start	Start a thread by calling its run method.

The suspend() method of thread class puts the thread from running to waiting state. This method is used if you want to stop the thread execution and start it again when a certain event occurs. This method allows a thread to temporarily cease execution. The suspended thread can be resumed using the resume() method.

Syntax: **public final void** suspend()

sleep(time): This is a method used to sleep the thread for some milliseconds time.