Multithreading

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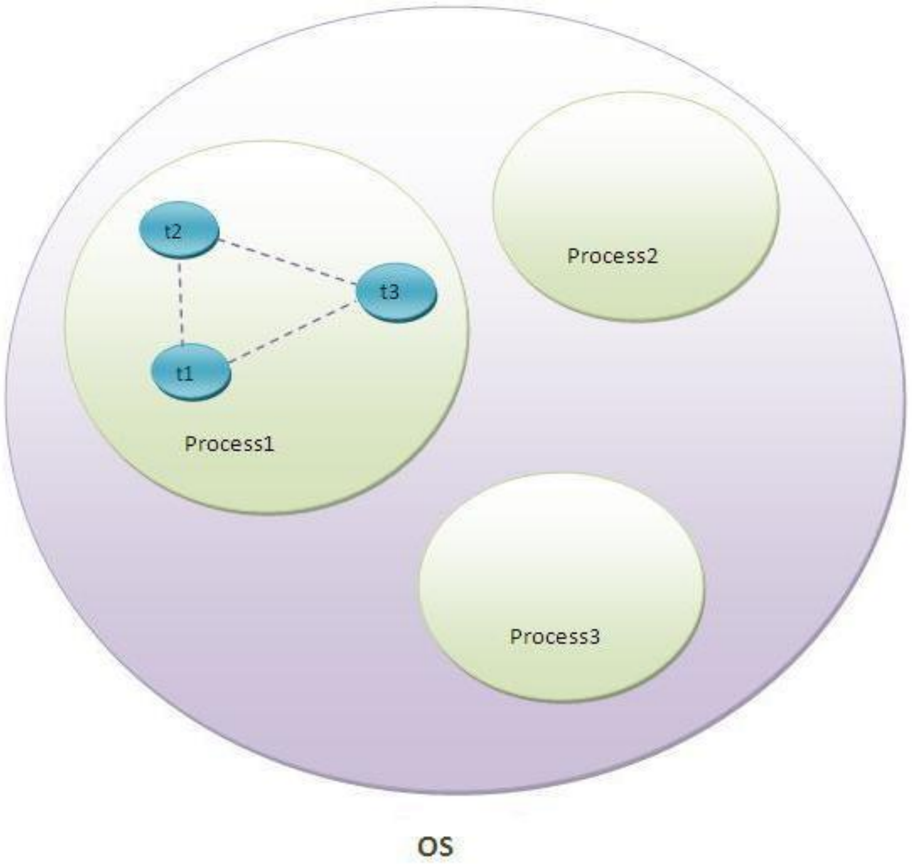
What is Thread?

- A thread is a lightweight sub process having an independent path of execution within a program.
- As threads are independent, if exception occurs in one thread, it doesn't affect other threads.
- All threads shares a common memory area.



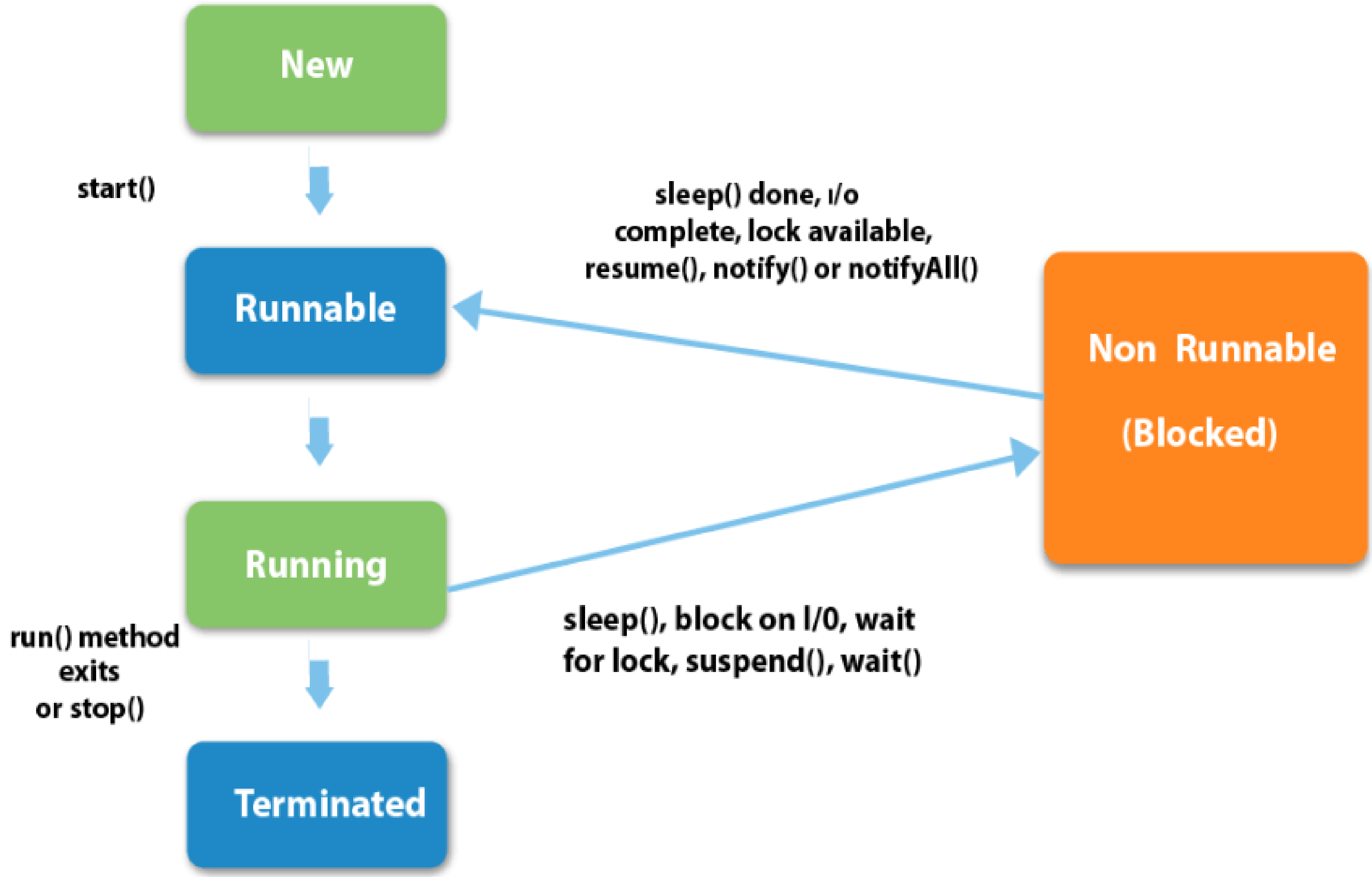
In this figure, thread is executed inside the process. **There can be multiple processes inside the OS and one process can have multiple threads.**

Multitasking

- Multitasking is a process of executing multiple tasks simultaneously. Multitasking is performed to utilize the CPU time efficiently.

- Multitasking can be achieved by two ways:
  1) **Process-based Multitasking (Multiprocessing)**
  2) **Thread-based Multitasking (Multithreading)**

Thread Lifecycle



New

start()

Runnable

sleep() done, I/o
complete, lock available,
resume(), notify() or notifyAll()

Non Runnable

(Blocked)

Running

sleep(), block on I/0, wait
for lock, suspend(), wait()

run() method
exits
or stop()

Terminated

Thread Lifecycle (contd..)

1) New

The thread is in new state if you create an instance of Thread class but before the invocation of start() method.

2) Runnable

The thread is in runnable state after invocation of start() method, but the thread scheduler has not selected it to be the running thread.

3) Running

The thread is in running state if the thread scheduler has selected it.

4) Non-Runnable (Blocked)

This is the state when the thread is still alive, but is currently not eligible to run.

5) Terminated

A thread is in terminated or dead state when its run() method exits.

Creating Threads

- You can 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.

Constructors of Thread class

- Thread()
- Thread(String name)
- Thread(Runnable r)
- Thread(Runnable r,String name)

Methods of Thread class

1. **public void run():**

   is used to perform action for a thread.

2. **public void start():**

   starts the execution of the thread. JVM calls the run() method on the thread

3. **public void sleep(long milliseconds):**

   Causes the currently executing thread to sleep (temporarily cease execution) for the specified number of milliseconds

4. **public void join():**

   waits for a thread to die

5. **public void join(long miliseconds):**

   waits for a thread to die for the specified milliseconds

Methods of Thread class (contd..)

6. public int getPriority():

returns the priority of the thread

7. public int setPriority(int priority):

changes the priority of the thread.

8. public String getName():

returns the name of the thread.

9. public void setName(String name):

changes the name of the thread.

10. public Thread currentThread():

returns the reference of currently executing thread.

11. public int getId():

returns the id of the thread.

Methods of Thread class (contd..)

12. public Thread.State getState():

returns the state of the thread

13. public boolean isAlive():

tests if the thread is alive

14. public void yield():

causes the currently executing thread object to temporarily pause and allow other threads to execute

15. public void suspend():

is used to suspend the thread(depricated)

16. public void resume():

is used to resume the suspended thread(depricated).

17. public void stop():

is used to stop the thread(depricated).

Methods of Thread class (contd..)

18. public void interrupt():

interrupts the thread.

19. public boolean isInterrupted():

tests if the thread has been interrupted.

20. public static boolean interrupted():

tests if the current thread has been interrupted.

1. Implementing Runnable

- The easiest way to create a thread is to create a class that implements the **Runnable** interface.
- To implement **Runnable**, a class need only implement a single method called **run( )**, which is declared like this:

  public void run( )

- **run( )** can call other methods, use other classes, and declare variables, just like the main thread
- After the new thread is created, it will not start running until you call its **start( )** method, which is declared within **Thread**.
- The **start( )** method is shown here:

  void start( )

If you are not extending the Thread class,your class object would not be treated as a thread object.So you need to explicitly create Thread class object.We are passing the object of your class that implements Runnable so that your class run() method may execute.

Example

```
class Multi3 implements Runnable{
        public void run(){
        System.out.println("thread is running...");
   }

        public static void main(String args[]){
        Multi3 m1=new Multi3();
        Thread t1 =new Thread(m1);
        t1.start();
      }
}
```

Output:

```
thread is running
```

2. 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.

Example

```
class Multi extends Thread
{
        public void run(){
        System.out.println("thread is running...");
       }
        public static void main(String args[])
       {
         Multi t1=new Multi();
          t1.start();
         }
}
```

Thread Scheduler

- **Thread scheduler** in java is the part of the JVM that decides which thread should run.
- There is no guarantee that which runnable thread will be chosen to run by the thread scheduler.
- Only one thread at a time can run in a single process.
- The thread scheduler mainly uses preemptive or time slicing scheduling to schedule the threads.

i. **Preemptive scheduling**

highest priority task executes until it enters the waiting or dead states or a higher priority task comes into existence

ii. **Time slicing**

a task executes for a predefined slice of time and then reenters the pool of ready tasks. The scheduler then determines which task should execute next, based on priority and other factors.

Sleep Method in Thread:

- In some scenarios you would like a thread to stop executing the code for a period of time and then start again.
- ***Sleep method*** in Thread tells the currently executing thread to sleep for specified amount of time in ***MilliSeconds***.
- It can throw InterruptedException . So it should be embedded in the try catch block
- There is no guarantee that the thread will go to **Sleep state** the moment it is executed and no guarantee that the thread will sleep for specified amount of time. The thread scheduler can wake it up any time.
- Once the thread completes or out of its sleep state, it can move to Running or Runnable state.

Example: sleep method

```
class TestSleepMethod1 extends Thread{
 public void run(){
  for(int i=1;i<5;i++){
   try{Thread.sleep(500);}
    catch(InterruptedException e)
          {System.out.println(e);}
   System.out.println(i);
  }
 }
 public static void main(String args[]){
  TestSleepMethod1 t1=new TestSleepMethod1();
  TestSleepMethod1 t2=new TestSleepMethod1();

  t1.start();
  t2.start();
 } }
```

Output:

```
1
1
2
2
3
3
4
4
```

Example: 2

```
class TestCallRun2 extends Thread{
 public void run(){
  for(int i=1;i<5;i++){
    try{Thread.sleep(500);}catch(InterruptedException e){System.out.println
(e);}
    System.out.println(i);
  }
 }
 public static void main(String args[]){
  TestCallRun2 t1=new TestCallRun2();
  TestCallRun2 t2=new TestCallRun2();

  t1.run();
  t2.run();
 }
}
```

Output:

```
1
2
3
4
5
1
2
3
4
5
```

Note: normal object not thread object

join() method

- waits for a thread to die.

In other words, it causes the currently running threads to stop executing until the thread it joins with completes its task.

- **Syntax:**

public void join()throws InterruptedException

public void join(long milliseconds)throws InterruptedException

Example:

```
class TestJoinMethod1 extends Thread{
 public void run(){
  for(int i=1;i<=5;i++){
   try{
    Thread.sleep(500);
   }catch(Exception e){System.out.println(e);}
  System.out.println(i);
  }
 }
public static void main(String args[]){
 TestJoinMethod1 t1=new TestJoinMethod1();
 TestJoinMethod1 t2=new TestJoinMethod1();
 TestJoinMethod1 t3=new TestJoinMethod1();
 t1.start();
 try{
  t1.join();
 }catch(Exception e){System.out.println(e);}

 t2.start();
 t3.start();
 }
}
```

Output:

```
1
2
3
4
5
1
1
2
2
3
3
4
4
5
5
```

Using isAlive( ) and join( )

- In the preceding examples to allow main thread to finish last , is accomplished by calling **sleep( )** within **main( )**, with a long enough delay to ensure that all child threads terminate prior to the main thread.
- However, this is hardly a satisfactory solution, and it also raises a larger question: How can one thread know when another thread has ended?
- Fortunately, **Thread** provides a means by which you can answer this question.

Using isAlive( ) and join( )

- Two ways exist to determine whether a thread has finished.
- First, you can call **isAlive( )** on the thread. This method is defined by **Thread**, and its general form is shown here:

final boolean isAlive( )

- The **isAlive( )** method returns **true** if the thread upon which it is called is still running. It returns **false** otherwise.
- While **isAlive( )** is occasionally useful, the method that you will more commonly use to wait for a thread to finish is called **join( )**, shown here:

final void join( ) throws InterruptedException

- This method waits until the thread on which it is called terminates.

Example:

```
public class MyThread extends Thread
{
        public void run()
        {
                System.out.println("r1 ");
                try {
                Thread.sleep(500);
                }
        catch(InterruptedException ie)
        {
                // do something
        }
        System.out.println("r2 ");
        }
        public static void main(String[] args)
        {
                MyThread t1=new MyThread();
                MyThread t2=new MyThread();
                t1.start();
                t2.start();
                System.out.println(t1.isAlive());
                System.out.println(t2.isAlive());
        }
}
```

Output:

```
r1
true
true
r1
r2
r2
```

Synchronization in Java

- Synchronization in java is the capability to control the access of multiple threads to any shared resource.

- Java Synchronization is better option where we want to allow only one thread to access the shared resource.

Why use Synchronization

- The synchronization is mainly used to
- To prevent thread interference.
- To prevent consistency problem.

Concept of Lock in Java

- Synchronization is built around an internal entity known as the lock or monitor.
- Every object has an lock associated with it. By convention, a thread that needs consistent access to an object's fields has to acquire the object's lock before accessing them, and then release the lock when it's done with them.

Thread Synchronization

Mutual Exclusive helps keep threads from interfering with one another while sharing data. This can be done by three ways in java:

- by synchronized method
- by synchronized block
- by static synchronization

Understanding the problem without Synchronization

```
Class Table{
 void printTable(int n){          //method not synchronized
  for(int i=1;i<=5;i++){
    System.out.println(n*i);
    try{
     Thread.sleep(400);
    }catch(Exception e){System.out.println(e);}
  }

 }
}
```

Thread creation

```
class MyThread1 extends Thread{
Table t;
MyThread1(Table t){
this.t=t;
}
public void run(){
t.printTable(5);
}
```

```
class MyThread2 extends Thread{
Table t;
MyThread2(Table t){
this.t=t;
}
public void run(){
t.printTable(100);
}
}
```

Output: 5 100 10 200 15 300 20 400 25 500

Cont…

```
class TestSynchronization1{
        public static void main(String args[]){
        Table obj = new Table();//only one object
        MyThread1 t1=new MyThread1(obj);
        MyThread2 t2=new MyThread2(obj);
        t1.start();
        t2.start();
        }
}
```

```
Output:
 5
100
10
200
15
300
20
400
25
500
```

Java synchronized method

- If you declare any method as synchronized, it is known as synchronized method.
- Synchronized method is used to lock an object for any shared resource.
- When a thread invokes a synchronized method, it automatically acquires the lock for that object and releases it when the thread completes its task.

Synchronized Method

```
//example of java
class Table{
 synchronized void printTable(int n){//synchronized method

   for(int i=1;i<=5;i++){
     System.out.println(n*i);
     try{
      Thread.sleep(400);
     }catch(Exception e){System.out.println(e);}
   }
   }
}
```

```
Output:
 5
 10
15
20
25
100
200
300
400
 500
```

Synchronized block in java

- Synchronized block can be used to perform synchronization on any specific resource of the method.
- Suppose you have 50 lines of code in your method, but you want to synchronize only 5 lines, you can use synchronized block.
- If you put all the codes of the method in the synchronized block, it will work same as the synchronized method.

Points to remember for Synchronized block

- Synchronized block is used to lock an object for any shared resource.
- Scope of synchronized block is smaller than the method.

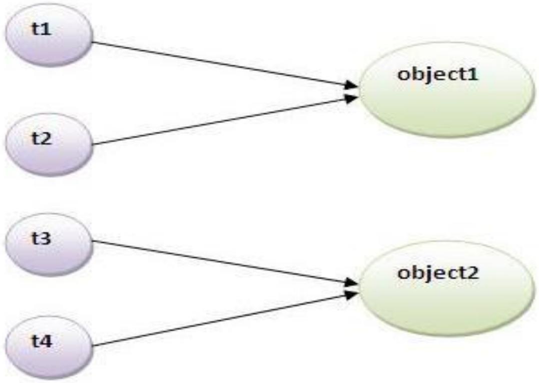
Synchronized Block

```
class Table{
  void printTable(int n){
  synchronized(this){//synchronized block
    for(int i=1;i<=5;i++){
     System.out.println(n*i);
     try{
      Thread.sleep(400);
     }catch(Exception e){System.out.println(e);}
    }
  }
 }//end of the method
}
```

```
Output:
 5
 10
15
20
25
100
200
300
400
 500
```

Static synchronization

- If you make any static method as synchronized, the lock will be on the class not on object.



- In case of synchronized method and synchronized block there cannot be interference between t1 and t2 or t3 and t4 because t1 and t2 both refers to a common object that have a single lock.

Cont...

```
Class Table{
 synchronized static void printTable(int n){
       //method not synchronized
  for(int i=1;i<=5;i++){
   System.out.println(n*i);
   try{
    Thread.sleep(400);
   }catch(Exception e){System.out.println(e);}
  }

 }
}
```

Thread creation

```
class MyThread1 extends Thread
{
public void run(){
Table.printTable(1);
}
}
```

```
class MyThread2 extends Thread
{
public void run(){
Table.printTable(5);
}
}
```

```
class MyThread4 extends Thread
{
public void run(){
Table.printTable(10);
}
}
```

```
class MyThread4 extends Thread
{
public void run(){
Table.printTable(15);
}
}
```

Output: 5 100 10 200 15 300 20 400 25 500

Cont...

```
public class TestSynchronization4{
public static void main(String t[]){
MyThread1 t1=new MyThread1();
MyThread2 t2=new MyThread2();
MyThread3 t3=new MyThread3();
MyThread4 t4=new MyThread4();
t1.start();
t2.start();
t3.start();
t4.start();
}
}
```

```
Output:    Output:
1          10
2          20
3          30
4          40
5          50

5          15
10         30
15         45
20         60
25         75
```