Multi-threaded programming

An Introduction to concurrency in JAVA

CS2810, January - May 2015

Department of Computer Science and Engineering
Indian Institute of Technology Madras

Evolution of Computers

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Figure: The 1990s

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Figure: Improving Clock Speed

Multi-core processors

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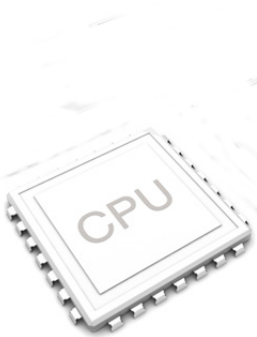


Figure: Single Core at 12 GHz?

Multi-core processors

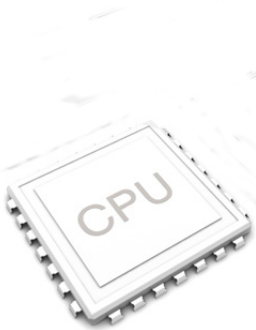


Figure: Single Core at 12 GHz?

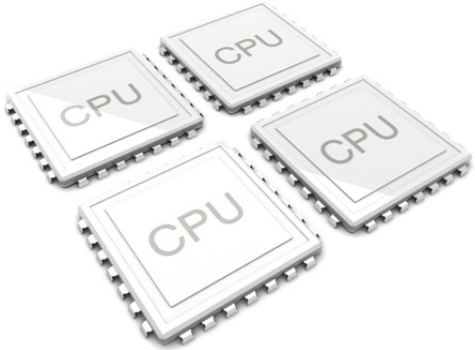


Figure: Multiple Cores: 4 X 3GHz

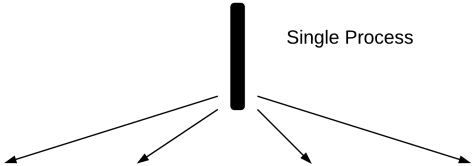
Splitting the process

Single Process

```
for (int i = 25; i < 50; i++)
    A [i] ++;
```

```
for (int i = 75; i < 100; i++)
    A [i] ++;
```

Splitting the process



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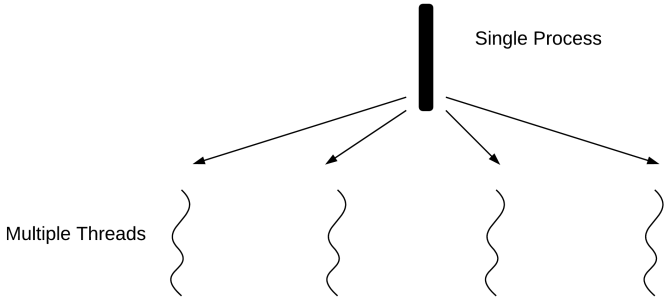

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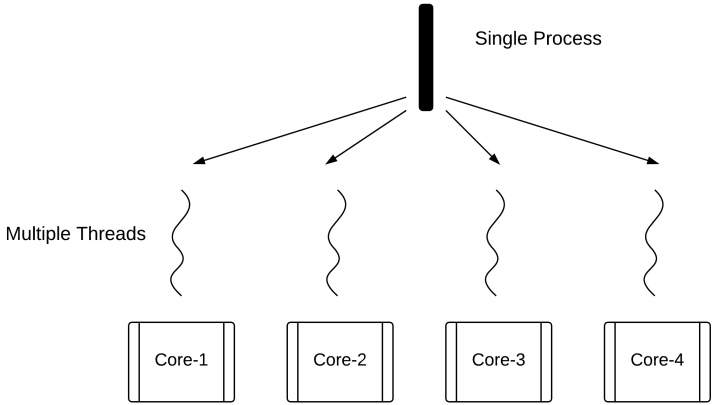

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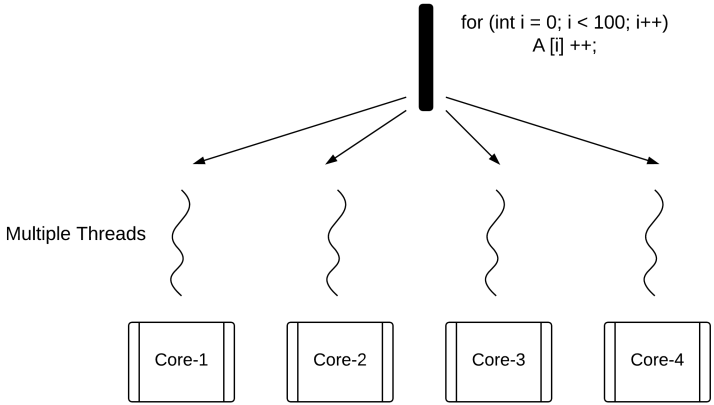

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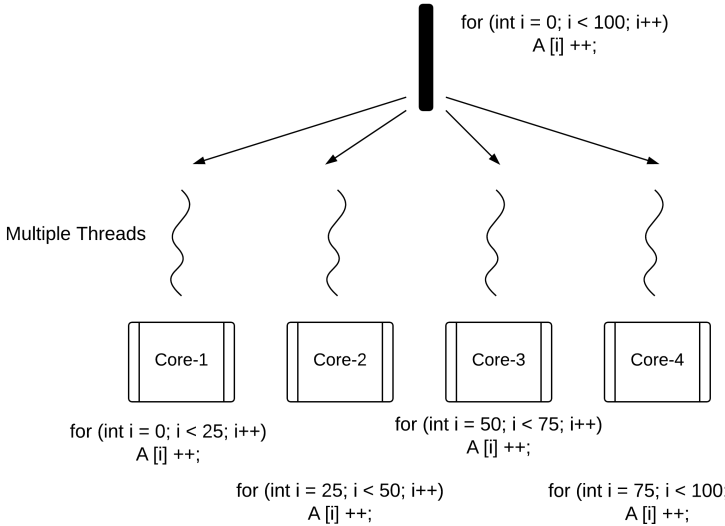

Checkpoint

Motivation 1

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- We want to make best use of the multiple cores in our modern processors.

A Stronger Motivation

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The notion of blocking

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- Eg. VLC Player
- Video is playing <– Thread 1
- Must *still* be able to search playlist <– Thread 2
- This must work even on single-core machines.

Time Slicing

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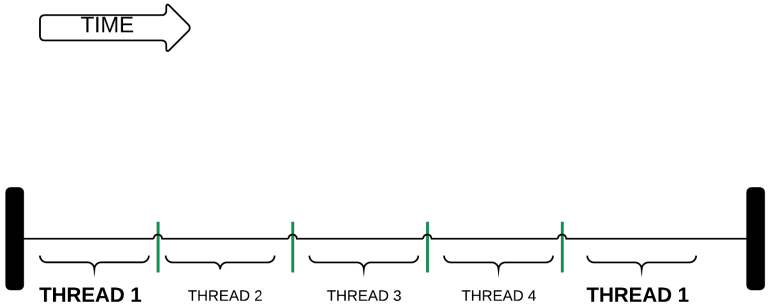
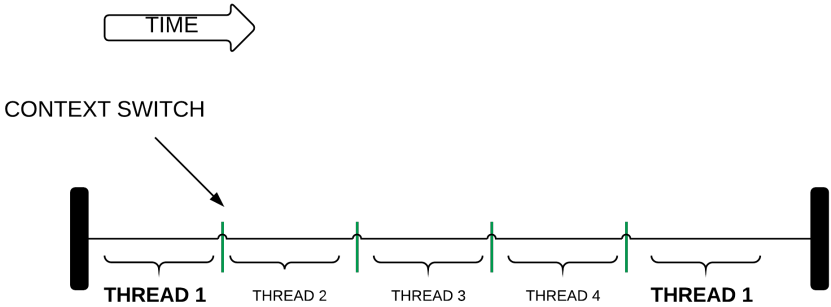


SINGLE CORE
PROCESSOR

Time Slicing



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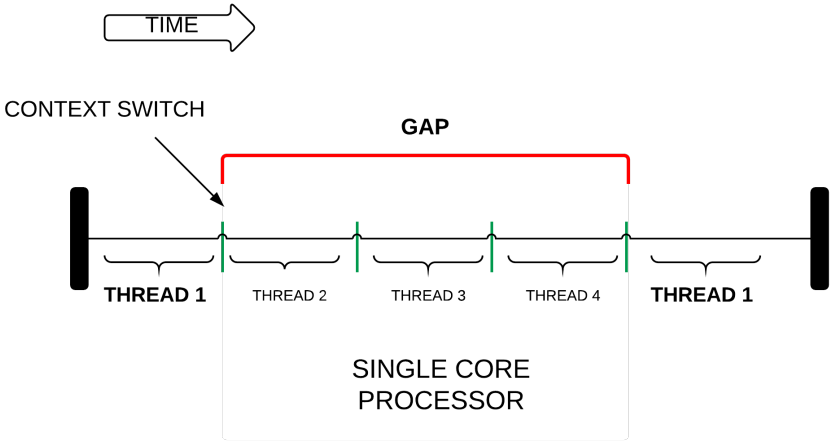

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Motivation 2

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Motivation 1

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Motivation 2

- We need programs to be non-blocking and concurrent.

Defining a Thread

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- A process can consist of multiple threads.
- Threads of the same process share the data segment, but have their own stack, code.

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- Language specific.
- JAVA -`java.util.concurrent` package
- To create a thread:
  - Implement the Runnable interface
  - Override the run() function
  - Create a Thread object out of this class
  - Start the Thread.

Using Threads

Using Threads

```
class MyRunnable implements Runnable
{
    @Override
    public void run ()
    {
        // Code that the thread should execute

    }
}
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class MyRunnable implements Runnable
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    // Thread's internal variables
    private int param;

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    public MyRunnable (int param)
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```

```
public static void main (String [] args)
{
    // Initiating Runnable
    MyRunnable mRunnable = new MyRunnable (10);

    // Constructing the Thread
    Thread t = new Thread (mRunnable);

    // Starting the thread
    t.start ();
}
```

Issues

```
public class Counter
{
    private int c = 0;

    public void increment () {
        c ++;
    }
    public void decrement () {
        c --;
    }
    public int value () {
        return c;
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  - `MOV AX, [memC]`
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  - `MOV [memC], AX`

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  - `MOV AX, [memC]`
  - `DEC AX`
  - `MOV [memC], AX`

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- Decrementing c is also three steps
  - `MOV AX, [memC]`
  - `DEC AX`
  - `MOV [memC], AX`
- Suppose Thread 1 calls `increment()` and Thread 2 calls `decrement ()`

Issue

Issue

THREAD 1 Calls increment ()	THREAD 2 Calls decrement ()
MOV AX, [memC]	
INC AX	
CONTEXT SWITCH	
	MOV AX, [memC]
	DEC AX
	MOV [memC], AX
CONTEXT SWITCH	
MOV [memC], AX	

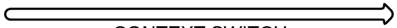
Issue

THREAD 1
Calls increment ()

THREAD 2
Calls decrement ()

MOV AX, [memC]

INC AX



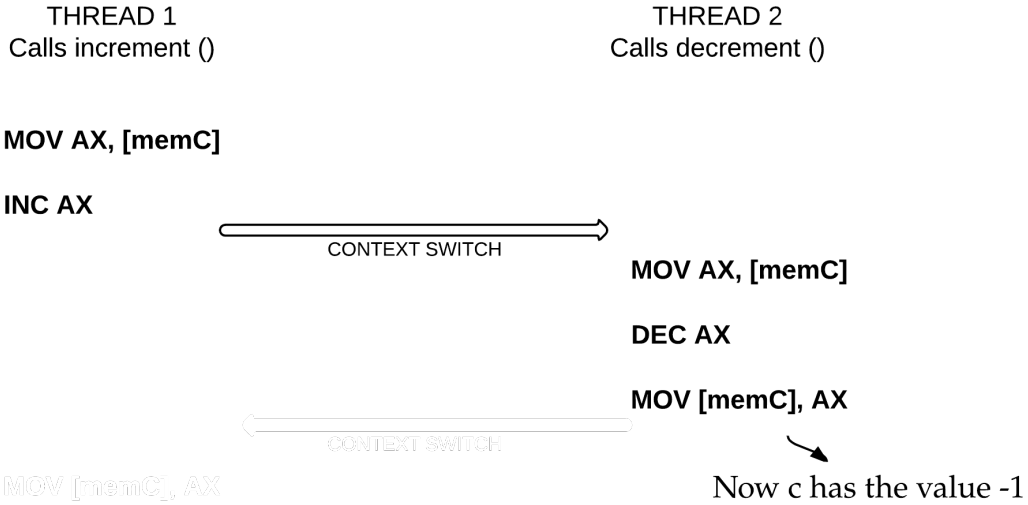
MOV AX, [memC]

DEC AX

MOV [memC], AX

MOV [memC], AX

Issue


THREAD 1
Calls increment ()
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Calls decrement ()
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MOV [memC], AX
Now c has the value -1

Issue

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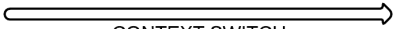

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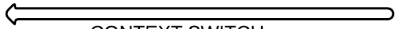
MOV [memC], AX



MOV [memC], AX

Now c has the value 1. But we expected 0

Using Locks

```
public class Counter
{
    private int c = 0;

    private Object lock = new Object ();

    public void increment () {
        synchronized (lock) {
            c ++;
        }
    }
    public void decrement () {
        synchronized (lock) {
            c --;
        }
    }
    public int value () {
        return c;
    }
}
```

Deadlock

```
public class Counter
{
    private int c = 0;

    private Object lock1 = new Object ();
    private Object lock2 = new Object ();

    public void increment () {
        synchronized (lock1) {
            synchronized (lock2) {
                c ++;
            }
        }
    }
    public void decrement () {
        synchronized (lock2) {
            synchronized (lock1) {
                c --;
            }
        }
    }
    public int value () {
        return c;
    }
}
```

Multiplayer games - Dead Reckoning

Reading

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