# Interleaving

Demonstrated by Ýmir Þórleifsson & Bjartur Þórhallsson

We have a stack machine in that executes this Java bytecode:

|  |
| --- |
| 0: getstatic #2 // push Field x:I 3: iconst\_1 // push constant one onto the stack 4: iadd // Add the two values 5: putstatic #2 // store to Field x:I and pop value |

From the statement

|  |
| --- |
| x=x+1 |

We execute these 4 instructions in two different threads, the problem: how many interleavings do the executions have?

Formula:

p0 = Number of instructions for process first process, p1 = Number of instructions for second process.

(p0 + p1)! / p0! p1!

(4+4)! / 4! 4! = 70

We have 70 interleavings for the two threads executing the same 4-line byte code.

But how many different may x have once the process terminates?

Depending on the order of execution, the x might have the value 1 or 2. If thread 2 executes line 0 before thread one executes line 5, thread two will read the value of x as 0, thus overwriting the field after thread one added the two values and saved it. However, if thread one manages to store the new value before thread two reads it, the value becomes 2.

An example of where x gets the value 2:

t0 = first thread, t1 = second thread, instructions are listed above with the line number.

|  |  |  |  |
| --- | --- | --- | --- |
| **t0** | **t1** | **x** | **Comments** |
| 0 |  | 0 | Pushes x to the stack. |
| 3 |  | 0 | Pushes constant 1 to stack. |
| 4 |  | 0 | Adds the values. |
| 5 |  | 1 | Stores the added values. |
|  | 0 | 1 | Pushes x to the stack. |
|  | 3 | 1 | Pushes constant 1 to stack. |
|  | 4 | 1 | Adds the values. |
|  | 5 | 2 | Stores the added values. |

An example of where x gets the value 1:

|  |  |  |  |
| --- | --- | --- | --- |
| **t0** | **t1** | **x** | **Comments** |
| 0 |  | 0 | Pushes x to the stack. |
|  | 0 | 0 | Pushes x to the stack. |
| 3 |  | 0 | Pushes constant 1 to stack. |
|  | 3 | 0 | Pushes constant 1 to stack. |
| 4 |  | 0 | Adds the values. |
|  | 4 | 0 | Adds the values. |
| 5 |  | 1 | Stores the added values. |
|  | 5 | 1 | Overwrites x with the added values. |