Course "Formal Methods"
Lab Test Project

Roberto Sebastiani
DISI, Università di Trento, Italy

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Name (please print):

Surname (please print):

1   Recursive functions

1. Write an SMV model that represents the following pseudocode:

Algorithm 1 FACTORIAL(n)

1: **if** $n < 0$ **then**
2:     **return** 0
3: **end if**
4: **if** $n == 0$ **then**
5:     **return** 1
6: **end if**
7: **return** $n * factorial(n - 1)$

Model the return value, stored on the stack by each recursive call, using an unbounded array: *array integer of integer*. Let `arr` be such array and assume we want to compute the factorial of 3, then the following should hold at the end of the computation `READ(arr, 0) = 1`, `READ(arr, 1) = 1`, `READ(arr, 2) = 2` and `READ(arr, 3) = 6`.

See the nuXmv user manual for the semantics and operations allowed on this type. Remember that an unconstrained *FROZENVAR* of type *integer* can be used to represent any value in $\mathbb{Z}$.

Verify that the definition is correct for the factorial of the numbers from 0 to 5 included. Write a property that holds iff $READ(arr, n) = n * READ(arr, n - 1)$ with $READ(arr, 0) = 1$ for every $n \in \mathbb{N}$.

2. Write a similar SMV model, but for the fibonacci sequence. Verify that the definition is

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Algorithm 2 FIBONACCI(n)

1: **if** $n \leq 0$ **then**
2:     **return** 0
3: **end if**
4: **if** $n == 1$ **then**
5:     **return** 1
6: **end if**
7: **return** $fibonacci(n - 1) + fibonacci(n - 2)$

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correct for the numbers from 0 to 7 included. Write a property that holds iff $READ(arr, n) = READ(arr, n - 1) + READ(arr, n - 2)$ with $READ(arr, 0) = 0$ and $READ(arr, 1) = 1$ for every $n \in \mathbb{N}$.