HOMEWORK 1

1 Definition of languages

1. Give the prefix and postfix notations of \( a \ast (b + c) \ast d \).

2. Postfix notation: Exercise 2.8 page 49

3. Exercise 2.14 a. page 51

4. Exercise 2.7 for expressions c and d of exercise 2.6

5. What are the terminals and the nonterminals of the following BNF grammar?

\[
\begin{align*}
\langle \text{goal} \rangle &::= \langle \text{letter} \rangle \mid \langle \text{letter} \rangle \langle \text{next} \rangle \\
\langle \text{next} \rangle &::= , \langle \text{letter} \rangle \\
\langle \text{letter} \rangle &::= \text{A}
\end{align*}
\]

Describe the language described by the previous BNF grammar.

6. Write a BNF grammar that describes the structure of US telephone numbers, which can either be \((xxx)xxxx - xxxx\) or \(xxxx - xxxx\), where \(x\) is a digit from 0 to 9.

7. Write a BNF grammar for identifiers that consist of an arbitrarily long string of letters and digits, the first one of which must be a letter.

2 Recursion, functional language programming and SML

1. Describe in 5 lines one of the industrial application of functional language programming (use the web and books).

2. Write a recursive function to compute \(2^n\) for \(n \geq 0\) (Write an algorithm or the JAVA code).

3. Write the Fibonacci function in JAVA and compute \(Fibonacci(10)\), \(Fibonacci(40)\), \(Fibonacci(80)\), \(Fibonacci(800)\) ???

4. Consider the function \(f\) such that:

\[
f(n) = \begin{cases} 
  x - 1 & \text{if } x > 0 \\
  f(f(n + 2)) & \text{otherwise}
\end{cases}
\]

Compute \(f(0)\) and \(f(10)\).
5. What are the results and the types of the following expressions:

\[
\begin{aligned}
\text{hd}([6,1,2]); \\
\text{tl} [7,2,3]; \\
\text{hd} [1]; \\
\text{tl} [6]; \\
\text{explode} ("abcd"); \\
"f" :: ["a", "c", "i", "l", "e"]]; \\
["m", "e", "t"] @ ["a", "n", "l", "n", "a", "g", "a", "g", "e"]; \\
\end{aligned}
\]

6. What are the type of the following expressions:

\[
\begin{aligned}
((1,2),3); \\
(1,(2,3)); \\
(1,2,3); \\
(1.2,(["2",[4,5]])); \\
[[3,4],[],[5]]; \\
[(9,3,5),(1,2,1),(9,4,2]); \\
(["b","a"],[nil,[1,2,3]]);
\end{aligned}
\]

7. Give examples of expressions of the following types:

\[
\begin{aligned}
\text{int} & \text{ list list list} \\
\text{int} & \star \text{ string list} \\
(\text{int} & \star \text{ string}) & \text{ list} \\
(\text{string list} & \star (\text{int} & \star \text{ real} & \star \text{ string})) & \star \text{ int} \\
(((\text{int} & \star \text{ int}) & \star (\text{string list} & \star \text{ real})) & \star (\text{real} & \star \text{ string}))
\end{aligned}
\]

Note: In the types parentheses are sometimes used for clarifying the problem.

8. Write a function \textbf{max4} that computes the maximum of 4 integers. What is the type of this function?

9. Define a function \textbf{circumference} and a function \textbf{area} that compute the circumference and the area of a circle with respect to its radius. You will use \(\pi =3.14159\). What are the types of your functions?

10. Write a function \textbf{Move} that given a list \([a_1, a_2, \ldots, a_n]\), returns \([a_2, \ldots, a_n, a_1]\). What is the type of your function?