8 Prolog (DE)

(a) Give the result and any variable bindings that occur from making each of the following (independent) queries.

(i) \(32 = A\). \(1\) mark

(ii) \(a(b(6, A)) = a(b(B, 2))\). \(1\) mark

(iii) \(a(b(x, A)) = a(b(5, 4))\). \(1\) mark

(iv) \(A = 3 + 6, A\ is\ 9\). \(1\) mark

(v) \(A\ is\ 3 + 6, A = 9\). \(1\) mark

(b) Given the following clauses,

\[
a(4).
\]
\[
a(x).
\]
\[
b(3,x).
\]
\[
b(1,7).
\]
\[
c(A, B, C) :- a(A), b(B, _), !, a(D).
\]
\[
c(A, _, B) :- b(A, B).
\]

(i) List the solutions reported by Prolog to the query \(c(P, Q, R)\), for each giving any binding of variables that occurs. \(2\) marks

(ii) Explain whether the query in part (b)(i) can bind \(P\) to \(x\). \(1\) mark

(iii) List the solutions to the query \(c(1, 6, R)\), for each giving any binding of variables that occurs. \(1\) mark

(c) We represent a binary tree using a term of the form \([\text{Left, NodeName, Right}]\) or \(\text{null}\). Here is an example perhaps recording a tree of excursions between countries:

\[
[[\text{null, de, null}], \text{uk}, [[\text{null, ua, null}], \text{pt}, \text{null}]]
\]

Write a predicate \(p(+\text{Tree}, +\text{NNames}, -\text{Ps})\) where \(\text{Tree}\) is a tree as above, \(\text{NNames}\) is a list of node names, and \(\text{Ps}\) is to be unified with a list of elements of the form \([N, P]\) where \(N\) is in \(\text{NNames}\) and \(P\) is \(N\)'s parent in \(\text{Tree}\). [For example, supposing \(T\) is bound to the above tree, the query \(p(T, [\text{ua, za}], \text{Ps})\) binds \(\text{Ps}\) to \(\text{[[ua, pt]]}\).] \(5\) marks

(d) Difference lists are a powerful tool for increasing efficiency but they address a very specific problem. Does this issue arise in your implementation of \(p/3\)? In other words, can \(p/3\) be made more efficient using difference lists and why (or why not)? \(2\) marks

(e) Regardless of your answer above, write a predicate \(\text{pdl/3}\) that behaves just like \(p/3\) but uses difference lists in its implementation. \(4\) marks