Harvard School of Engineering and Applied Sciences — CS 152: Programming Languages

Logic Programming; Dynamic Types
Section and Practice Problems

Section 12

1 Logic Programming

To try playing around with Prolog, go to `http://www.swi-prolog.org/`. You will be able to use Prolog online at `https://swish.swi-prolog.org/`.

To try playing around with Datalog, you can go to either `http://abcdatalog.seas.harvard.edu/` to download a Java-based Datalog implementation, or you can go to `https://datalog.db.in.tum.de/` to use Datalog online.

Although you can use the tools above to get the answers to the section problems below very easily, work out the answers by hand (to make sure you understand the semantics of Prolog and Datalog), and then you can check your answers by using the tools to execute the programs.

(a) Consider the following Prolog program (where $[]$ is a constant representing the empty list, $[t]$ is shorthand for $\mathsf{cons}(t, [])$ and $[t_1, t_2|t_3]$ is shorthand for $\mathsf{cons}(t_1, \mathsf{cons}(t_2, t_3))$.

$$\begin{array}{l} \mathsf{foo}([], []). \\ \mathsf{foo}([X], [X]). \\ \mathsf{foo}([X, Y|S], [Y, X|T]) \text{ :- } \mathsf{foo}(S, T). \end{array}$$

For each of the following queries, compute the substitutions that Prolog will generate, if any. (Note that there is a difference between an empty substitution, and no substitution.) If the query evaluation will not terminate, explain why.

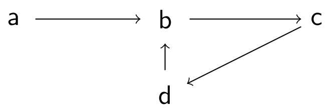
- $\mathsf{foo}([\mathsf{a}, \mathsf{b}], X)$.
- $\mathsf{foo}([\mathsf{a}, \mathsf{b}, \mathsf{c}], X)$.
- $\mathsf{foo}([\mathsf{a}, \mathsf{b}], [\mathsf{a}, \mathsf{b}])$
- $\mathsf{foo}(X, [\mathsf{a}])$
- $\mathsf{foo}(X, Y)$.

(b) Consider the following Datalog program.

$$\begin{array}{l} \mathsf{bar}(\mathsf{a}, \mathsf{b}, \mathsf{c}). \\ \mathsf{bar}(X, Y, Z) \text{ :- } \mathsf{bar}(Y, X, Z). \\ \mathsf{bar}(X, Y, Z) \text{ :- } \mathsf{bar}(Z, Y, X), \mathsf{quux}(X, Z). \\ \mathsf{quux}(\mathsf{b}, \mathsf{c}). \\ \mathsf{quux}(\mathsf{c}, \mathsf{d}). \\ \mathsf{quux}(X, Y) \text{ :- } \mathsf{quux}(Y, X). \\ \mathsf{quux}(X, Z) \text{ :- } \mathsf{quux}(X, Y), \mathsf{quux}(Y, Z). \end{array}$$

Find all solutions to the query $\mathsf{bar}(X, Y, Z)$.

(c) Suppose that we represent a directed graph using the predicates $\mathsf{edge}(X, Y)$ to indicate that there is an edge from node X to node Y. For example, the following graph is represented by the following facts:



```
node(a).
node(b).
node(c).
node(d).
edge(a, b).
edge(b, c).
edge(c, d).
edge(d, b).
```

(i) Write a Datalog program that computes reachable(X, Y), where reachable(X, Y) holds if there is a path (of zero or more edges) from X to Y.

(ii) Write a Datalog program that computes sameSCC(X, Y), where sameSCC(X, Y) holds if nodes X and node Y are in the same strongly connected component. (Hint: use the predicate reachable.)