Universität Koblenz-Landau

FB 4 Informatik

Prof. Dr. Viorica Sofronie-Stokkermans 30.1.2014

Collection of exercises: Part 2

Exercise 1. Use the Nelson-Oppen procedure for checking the satisfiability of the following formulae:

1. $1 \leq c \wedge c \leq 3 \wedge f(c) \not\approx f(1) \wedge f(c) \not\approx f(3) \wedge f(1) \not\approx f(2)$
   in the combination $LI(\mathbb{Z}) \cup UIF_{\{f\}}$.
2. $f(c) \approx c + d \wedge c \leq d + e \wedge c + e \leq d \wedge d = 1 \wedge f(c) \not\approx f(2)$
   in the combination $LI(\mathbb{Z}) \cup UIF_{\{f\}}$.
3. $c + d \approx e \wedge f(e) \approx e \wedge f(c + d) \not\approx e$
   in the combination $LI(\mathbb{Q}) \cup UIF_{\{f\}}$.

Exercise 2. Let $\mathcal{T} = LI(\mathbb{Q})$, and let $Q := x \geq 1, R := x \leq y, P := x+x \leq 2$. Use a DPLL($\mathcal{T}$) method to check the satisfiability w.r.t. $\mathcal{T}$ of the following set of clauses:

$$
\begin{array}{ll}
(C_1) & \neg R \vee P \\
(C_2) & \neg Q \vee \neg P \\
(C_4) & R \vee P
\end{array}
$$

Exercise 3. In what follows we consider the theory of arrays defined in the lecture. We assume that the theory of indices $\mathcal{T}_i$ is $LI(\mathbb{Z})$, and the theory of elements $\mathcal{T}_e$ is $LI(\mathbb{Q})$.

Which of the formulae below are in the array property fragment and which are not? Justify your answer. (The universally quantified variables i, j are of sort index; the indices $k, l_i, u_i, i = 1, 2$ which are not universally quantified are considered to be constants of sort index)

(1) $\forall i \ (a[a[i]] > a[i])$

(2) $\forall i \ (i > a[i])$

(3) $\forall i \ (a[i] > b[i])$

(4) $\forall i \ (i \leq a[k] \rightarrow a[i] = a[k])$

(5) $\forall i, j \ (l_1 < i < u_1 < l_2 < j < u_2 \rightarrow a[i] \leq a[j])$

(6) $\forall i, j \ (l_1 < i < j < u_2 \rightarrow a[i] \leq a[j])$

(7) $\forall i, j \ (l_1 < i \leq j < u_2 \rightarrow a[i] \leq a[j])$

Exercise 4. Consider the array property formula:

$F : write(a, l, v_1)[k] = b[k] \wedge b[k] = v_2 \wedge a[k] = v_1 \wedge v_1 \neq v_2 \wedge \forall i (i \leq l-1 \rightarrow a[i] = b[i]) \wedge \forall i (i \geq l+1 \rightarrow a[i] = b[i])$

(1) Apply Steps 1–6 described in the lecture to F. Let F_6 be the formula obtained after Step 6.

(2) Check the satisfiability of F_6 using one of the versions of the $DPLL(\mathcal{T})$ procedure presented in the class. For theory reasoning in combinations of theories use the Nelson-Oppen procedure.