



Programming Languages 2

Homework 8 – WS 18

Tübingen, 13. Dezember 2018

In order to be admitted to the exam, you have to successfully submit your homework every week, except for 2 weeks. A successful submission is one where you get at least 1 point.

Handin Please submit this homework until Thursday, December 20, either via email to Philipp Schuster (philipp.schuster@uni-tuebingen.de) before 12:00, or on paper at the beginning of the lab.

Groups You can work in groups of up to 2 people. Please include the names and Matrikelnummern of all group members in your submission.

Points For each of the Tasks you get between 0 and 2 points for a total of 6 points. You get:
1 point, if your submission shows that you tried to solve the task.
2 points, if your submission is mostly correct.

Task 1: Join and Meet

Consider the following set of types:

$\langle type \rangle ::= \text{'Top'} \mid \langle type \rangle \rightarrow \langle type \rangle \mid \{l_i : \langle type \rangle_i\}$

Consider the following rules for the subtyping relation:

$$\begin{array}{c} \text{S-TOP} \\ \vdash S <: \text{Top} \end{array} \qquad \begin{array}{c} \text{S-ARROW} \\ \vdash T_1 <: S_1 \quad \vdash S_2 <: T_2 \\ \hline \vdash S_1 \rightarrow S_2 <: T_1 \rightarrow T_2 \end{array}$$

$$\begin{array}{c} \text{S-RCD} \\ \frac{\{l_i \mid i \in 1..n\} \subseteq \{k_j \mid j \in 1..m\} \quad \text{for each } k_j = l_i, \vdash S_j <: T_i}{\vdash \{k_j : S_j^{j \in 1..m}\} <: \{l_i : T_i^{i \in 1..n}\}} \end{array}$$

For each of the following pairs of types, what is their Join and what is their Meet?

1. $\{a : \text{Top}\}$ and Top
2. $\{a : \text{Top}, b : \text{Top}\} \rightarrow (\{x : \text{Top}\} \rightarrow \{z : \text{Top}\})$ and $\{a : \text{Top}\} \rightarrow (\{y : \text{Top}\} \rightarrow \{z : \text{Top}\})$
3. $(\{a : \text{Top}, b : \text{Top}\} \rightarrow \{x : \text{Top}\}) \rightarrow \{z : \text{Top}\}$ and $(\{a : \text{Top}\} \rightarrow \{y : \text{Top}\}) \rightarrow \{z : \text{Top}\}$

Task 2: Reflexivity of the subtyping relation

Show that for the subtyping relation from Task 1 we have the following property: For all $T \in \text{type}$, we have $T <: T$.

Task 3: Type checker for a language with subtyping

Implement the algorithmic type checker for the language from the lecture in a programming language of your choice. Do not try to write a parser but assume a representation of terms in memory. Examples for a representation of terms and types in Haskell and Java are on the website. Optionally, extend your implementation with support for an if-then-else construct in which case you would have to compute Joins and Meets.