EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

Fachbereich Informatik

Programmiersprachen und Softwaretechnik

Prof. Dr. Klaus Ostermann

Responsible for the lab
Philipp Schuster
philipp.schuster@uni-tuebingen.de

Programming Languages 2

Homework 5 – WS 18

Tübingen, 22. November 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, November 29, 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: Types

Consider the following programming language:

⟨*term*⟩ ::= '`sqop`' | '`squiggle`' ⟨*term*⟩ | '`squaggle`' ⟨*term*⟩ | '`transmogrify`' ⟨*term*⟩ ⟨*term*⟩

We define the set of types as:

⟨*type*⟩ ::= '`W`'

The typing relation is defined by the following rules. We adopt the convention that $t \in \text{term}$ and $T \in \text{type}$.

$$\textsc{T-Sqop}\ \ \text{sqop} : \text{W} \qquad \textsc{T-Squiggle}\ \ \frac{t : \text{W}}{\text{squiggle}\, t : \text{W}} \qquad \textsc{T-Squaggle}\ \ \frac{t : T}{\text{squaggle}\, t : T}$$

Which of the following terms are well-typed? Prove well-typedness by drawing a derivation tree for those terms that are well-typed. For those terms that are not well-typed it is enough to briefly note that fact.

1. $\mathrm{squiggle}\,\mathrm{sqop}$
2. $\mathrm{squaggle}(\mathrm{squiggle}(\mathrm{squaggle}\,\mathrm{sqop}))$
3. $\mathrm{squaggle}(\mathrm{transmogrify}(\mathrm{squiggle}\,\mathrm{sqop})(\mathrm{squaggle}\,\mathrm{sqop}))$

Task 2: Normal form

Consider the language from Task 1 again. We define the set of values as:

⟨*value*⟩ ::= ‘`sqop`’ | ‘`squiggle`’ ⟨*value*⟩

We define an evaluation relation as:

$$\text{E-SQUIGGLE}\ \frac{t \longrightarrow t'}{\mathrm{squiggle}\,t \longrightarrow \mathrm{squiggle}\,t'} \qquad \text{E-SQUAGGLE}\ \ \mathrm{squaggle}\,t \longrightarrow t$$

For each of the three terms in Task 1, answer the following four questions:

1. Let the term be t. Is there a term t' such that $t \longrightarrow t'$? If so, draw a derivation tree.
2. Is the term in normal form? No proof required.
3. Is the term a value? No proof required.
4. Is the term stuck? No proof required.

Task 3: Progress and Preservation

Prove the following for the language defined in Task 1 and Task 2:

1. **Progress**: For all $t \in \mathrm{term}$ and $T \in \mathrm{type}$ such that $t : T$ holds: either t is a value or there exists a $t' \in \mathrm{term}$ such that $t \longrightarrow t'$.
2. **Preservation**: For all $t, t' \in \mathrm{term}$ and $T \in \mathrm{type}$, if $t : T$ and $t \longrightarrow t'$ then $t' : T$.