Lund University
Computer Science
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Examination
EDA145
2011–06–01, 14.00–19.00

Examination in Programming language theory

The following texts may be used during the exam:
Nielson, Nielson, Semantics with Applications.
Andersson, Programming language theory, Lecture notes.

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1 Let

$$\begin{aligned} K &= \lambda x.\lambda y.x \\ S &= \lambda x.\lambda y.\lambda z.x\,z\,(y\,z) \\ I &= \lambda x.x \end{aligned}$$

Reduce

$$(S\ (K\ (S\ I))\ K)\ x\ y$$

to normal form.

2 Extend **While** with a `switch` statement

```
switch a of
0: S0
1: S1
...
n: Sn
```

where n is a natural number. If the value of a is a natural number less than or equal to n then the corresponding statement is executed. Specify a natural operational semantics for this statement and describe what will happen according to your semantics if the value of a is outside the range.

3 (Exercise 2.21) Prove that

$$\text{if } \langle S_1, \sigma \rangle \Rightarrow^k \sigma' \text{ then } \langle S_1; S_2, \sigma \rangle \Rightarrow^k \langle S_2, \sigma' \rangle$$

4 Let $f \in D \to D$ be a continuous function on a ccpo $(D, \sqsubseteq)$ and let $d \in D$ satisfy $f\ d \sqsubseteq d$. Show that FIX $f \sqsubseteq d$.

5 Extend **While** with a `break` statement and a block statement

$$S ::= \cdots \mid \texttt{break} \mid \texttt{begin}\ S\ \texttt{end}$$

If the `break` statement is executed inside a block then the execution should continue after the smallest enclosing block.

Define a continuation style semantics for the new statements of the extended language and describe what will happen, according to your definition, if there is no block enclosing the `break` statement.

6 The statement `repeat S until b` is assumed to be equivalent to `S; while ¬b do S`

It has been suggested that the axiomatic semantics `repeat S until b` should be

$$\frac{\{P\}S\{Q\}}{\{P\}\ \texttt{repeat S until b}\ \{Q \wedge b\}}$$

Provide an example with suitable `b`, `S`, P and Q, such that $\{P\}$ `repeat S until b` $\{Q \wedge b\}$ can be proved but not $\{P\}$ `S; while ¬b do S`$\{Q \wedge b\}$.