COMP3610/6361 Principles of Programming Languages

Assignment 1

ver 1.0

Submission Guidelines

- Due time: ~~Aug 10, 2023, 11am (Canberra Time)~~ **Aug 13, 2023, 11:59pm (Canberra Time)**
- Submit a pdf via Wattle.
- Scans of hand-written text are fine, as long as they are readable and neat.
- Please read and sign the declaration on the last page and attach a copy to your submission.
- **No late submission, deadline is strict**

Exercise 1 (Syntax) (30 Marks)

Type checking can be done with help of a type system, or with a refined syntax – to a certain degree.

Question 1 Refine the syntax given on Slide 33 of Lecture 1 (IMP – Syntax), such that it can distinguish boolean expressions, integer expressions and program expressions.

Question 2 Explain in a few sentences your design decisions: you can, for example, explain which expressions are excluded and which are not (and why this makes sense). To get you started, you may ask yourself whether the expression

$$\textbf{while } 5 \geq (\textbf{if } \ !l \geq 3 \textbf{ then } 3 \textbf{ else } 6) \textbf{ do } l := !l + 1$$

should be allowed. Parentheses are only given to help the reader.

Exercise 2 (Semantics) (25 Marks)

We extend the syntax of our simple while language to be the following:

Booleans	$b \in \mathbb{B} = \{\texttt{true}, \texttt{false}\}$
Integers (Values)	$n \in \mathbb{Z} = \{\ldots, -1, 0, 1, \ldots\}$
Locations	$l \in \mathbb{L} = \{l, l_0, l_1, l_2, \ldots\}$
Operations	$op ::= + \mid \geq \mid \wedge$

Expressions

$$\begin{aligned} E ::= {} & n \mid b \mid E \ op \ E \mid \\ & l := E \mid !l \mid \\ & \textbf{if } E \textbf{ then } E \textbf{ else } E \mid \\ & \textbf{skip} \mid E \ ; E \mid \\ & \textbf{while } E \textbf{ do } E \mid \end{aligned}$$

Question 3 The operator $\wedge$ denotes Boolean conjunction. Extend the sos-rules (operational semantics) to define the 'standard' behaviour of $\wedge$.

Question 4 Extend the syntax and the semantics with a (nondeterministic) choice operator $\sqcup$. The idea is that $E_1 \sqcup E_2$ can freely choose between E_1 and E_2 as long as E_i $(1 \leq i \leq 2)$ is not stuck.

Exercise 3 (Types) (10 Marks)

Give a derivation tree to prove that

$$\{\} \vdash \textbf{if } 3 \geq 7 \textbf{ then } 3+5 \textbf{ else } 4 : \text{int}$$

is well typed.

Exercise 4 (A Well-typed Program) (35 Marks)

Question 5 Write a program P in the simple imperative language of the lecture that computes the factorial of the integer initially stored in location l_1. Make sure that you only use the syntax given on Slide 33 of the first lecture.

Question 6 Prove that your program P is well typed. That means, give a type derivation for

$$l_1 : \text{intref} \vdash P : \text{unit}$$

Academic Integrity

I declare that this work upholds the principles of academic integrity, as defined in the University Academic Misconduct Rule; is entirely my own work, with only the exceptions listed; is produced for the purposes of this assessment task and has not been submitted for assessment in any other context, except where authorised in writing by the course convener; gives appropriate acknowledgement of the ideas, scholarship and intellectual property of others insofar as these have been used; in no part involves copying, cheating, collusion, fabrication, plagiarism or recycling.

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Date Signature