Homework 3 of CS520 Theory of Programming Languages

Submit your solutions to the TAs by putting them in the homework submission box in the third floor of the E3-1 building by 2:00pm on 15 November 2019 (Friday). If you type up your solutions, you can submit them via KLMS.

The numbers in the questions refer to exercise questions in the textbook of the course, i.e. "Theories of Programming Languages" by John C. Reynolds.

Question 1

Solve the part (a) of 5.4 after making the following four modifications. First, the part (a) mentions the type of command meanings $[\![c]\!]$ that we did not cover in lectures. Instead of this type of $[\![-]\!]$, use the following one, which extends the semantics that we studied in lectures:

$$[\![-]\!] \in \big[\langle\text{comm}\rangle \to \Sigma \to \Omega\big].$$

Here

$$\hat{\Sigma} \stackrel{\text{def}}{=} \Sigma \cup (\langle\text{label}\rangle \times \Sigma) \qquad \text{and} \qquad \Omega \simeq \big(\hat{\Sigma} + (\mathbb{Z} \times \Omega) + (\mathbb{Z} \to \Omega)\big)_\perp, \tag{1}$$

and the isomorphism $\simeq$ refers to the existence of two continuous functions

$$\phi : \Omega \to \big(\hat{\Sigma} + (\mathbb{Z} \times \Omega) + (\mathbb{Z} \to \Omega)\big)_\perp \qquad \text{and} \qquad \psi : \big(\hat{\Sigma} + (\mathbb{Z} \times \Omega) + (\mathbb{Z} \to \Omega)\big)_\perp \to \Omega$$

such that

$$\psi \circ \phi = \text{id} \quad \text{and} \quad \phi \circ \psi = \text{id}.$$

Second, extend the semantics in my hand-written notes (the same as the one in Section 5.6), instead of the direct semantics in Section 5.1. Third, you can ignore the variable declaration when extending the semantics. This means that you need to define the semantics of the following language:

$$\begin{aligned}\langle\text{comm}\rangle ::= {} & \langle\text{var}\rangle := \langle\text{intexp}\rangle \mid ?\langle\text{var}\rangle \mid !\langle\text{intexp}\rangle \mid \langle\text{comm}\rangle ; \langle\text{comm}\rangle \\ \mid {} & \textbf{if } \langle\text{boolexp}\rangle \textbf{ then } \langle\text{comm}\rangle \textbf{ else } \langle\text{comm}\rangle \\ \mid {} & \textbf{while } \langle\text{boolexp}\rangle \textbf{ do } \langle\text{comm}\rangle \\ \mid {} & \textbf{fail } \langle\text{label}\rangle \mid \textbf{catch } \langle\text{label}\rangle \textbf{ in } \langle\text{comm}\rangle \textbf{ with } \langle\text{comm}\rangle\end{aligned}$$

Finally, while defining the semantics, especially the one for sequential composition, you may use the extension of a function $f : \Sigma \to \Omega$ to $f_* : \Omega \to \Omega$, which we discussed and is also defined in the textbook.

Question 2

Solve 5.10.

Question 3

Solve the part (c) of 6.2. My solution uses a trick similar to the one in the transition semantics of variable declaration.