Homework 4
COSE212, Fall 2016

Hakjoo Oh

Due: 11/18, 24:00

Problem 1 Write an interpreter for the following language:

Syntax

$$
\begin{array}{rcl}
P & \to & E \\
E & \to & n \\
 & | & x \\
 & | & E + E \\
 & | & E - E \\
 & | & E * E \\
 & | & E / E \\
 & | & \texttt{iszero}\ E \\
 & | & \texttt{read} \\
 & | & \texttt{if}\ E\ \texttt{then}\ E\ \texttt{else}\ E \\
 & | & \texttt{let}\ x = E\ \texttt{in}\ E \\
 & | & \texttt{letrec}\ f(x) = E\ \texttt{in}\ E \\
 & | & \texttt{proc}\ x\ E \\
 & | & E\ E \\
 & | & E\ \langle x \rangle \\
 & | & \texttt{set}\ x = E \\
 & | & E; E \\
 & | & \texttt{begin}\ E\ \texttt{end}
\end{array}
$$

Semantics

$$
\begin{array}{rcl}
\mathit{Val} & = & \mathbb{Z} + \mathit{Bool} + \mathit{Procedure} + \mathit{RecProcedure} \\
\mathit{Procedure} & = & \mathit{Var} \times E \times \mathit{Env} \\
\mathit{RecProcedure} & = & \mathit{Var} \times \mathit{Var} \times E \times \mathit{Env} \\
\rho \in \mathit{Env} & = & \mathit{Var} \to \mathit{Loc} \\
\sigma \in \mathit{Mem} & = & \mathit{Loc} \to \mathit{Val}
\end{array}
$$

$$\frac{}{\rho, \sigma \vdash n \Rightarrow n, \sigma}$$

$$\frac{}{\rho, \sigma \vdash x \Rightarrow \sigma(\rho(x)), \sigma}$$

$$\frac{\rho, \sigma_0 \vdash E_1 \Rightarrow n_1, \sigma_1 \qquad \rho, \sigma_1 \vdash E_2 \Rightarrow n_2, \sigma_2}{\rho, \sigma_0 \vdash E_1 + E_2 \Rightarrow n_1 + n_2, \sigma_2}$$

$$\frac{\rho, \sigma_0 \vdash E_1 \Rightarrow n_1, \sigma_1 \qquad \rho, \sigma_1 \vdash E_2 \Rightarrow n_2, \sigma_2}{\rho, \sigma_0 \vdash E_1 - E_2 \Rightarrow n_1 - n_2, \sigma_2}$$

$$\frac{\rho, \sigma_0 \vdash E_1 \Rightarrow n_1, \sigma_1 \qquad \rho, \sigma_1 \vdash E_2 \Rightarrow n_2, \sigma_2}{\rho, \sigma_0 \vdash E_1 * E_2 \Rightarrow n_1 * n_2, \sigma_2}$$

$$\frac{\rho, \sigma_0 \vdash E_1 \Rightarrow n_1, \sigma_1 \qquad \rho, \sigma_1 \vdash E_2 \Rightarrow n_2, \sigma_2}{\rho, \sigma_0 \vdash E_1 / E_2 \Rightarrow n_1 / n_2, \sigma_2}$$

$$\frac{\rho, \sigma_0 \vdash E \Rightarrow 0, \sigma_1}{\rho, \sigma_0 \vdash \texttt{iszero}\ E \Rightarrow \mathit{true}, \sigma_1}$$

$$\frac{\rho, \sigma_0 \vdash E \Rightarrow n, \sigma_1}{\rho, \sigma_0 \vdash \texttt{iszero}\ E \Rightarrow \mathit{false}, \sigma_1}\ n \neq 0$$

$$\frac{\rho, \sigma_0 \vdash E_1 \Rightarrow \mathit{true}, \sigma_1 \qquad \rho, \sigma_1 \vdash E_2 \Rightarrow v, \sigma_2}{\rho, \sigma_0 \vdash \texttt{if}\ E_1\ \texttt{then}\ E_2\ \texttt{else}\ E_3 \Rightarrow v, \sigma_2}$$

$$\frac{\rho, \sigma_0 \vdash E_1 \Rightarrow \mathit{false}, \sigma_1 \qquad \rho, \sigma_1 \vdash E_3 \Rightarrow v, \sigma_2}{\rho, \sigma_0 \vdash \texttt{if}\ E_1\ \texttt{then}\ E_2\ \texttt{else}\ E_3 \Rightarrow v, \sigma_2}$$

$$\frac{\rho, \sigma_0 \vdash E_1 \Rightarrow v_1, \sigma_1 \qquad [x \mapsto l]\rho, [l \mapsto v_1]\sigma_1 \vdash E_2 \Rightarrow v, \sigma_2}{\rho, \sigma_0 \vdash \texttt{let}\ x = E_1\ \texttt{in}\ E_2 \Rightarrow v, \sigma_2}\ l \notin \mathrm{Dom}(\sigma_1)$$

$$\frac{\boxed{\text{Complete the definition.}}}{\rho, \sigma_0 \vdash \texttt{letrec}\ f(x) = E_1\ \texttt{in}\ E_2 \Rightarrow}$$

$$\frac{}{\rho, \sigma \vdash \texttt{proc}\ x\ E \Rightarrow (x, E, \rho), \sigma}$$

$$\frac{\begin{array}{c}\rho, \sigma_0 \vdash E_1 \Rightarrow (x, E, \rho'), \sigma_1 \qquad \rho, \sigma_1 \vdash E_2 \Rightarrow v, \sigma_2 \\ [x \mapsto l]\rho', [l \mapsto v]\sigma_2 \vdash E \Rightarrow v', \sigma_3\end{array}}{\rho, \sigma_0 \vdash E_1\ E_2 \Rightarrow v', \sigma_3}\ l \notin \mathrm{Dom}(\sigma_2)$$

$$\frac{\rho, \sigma_0 \vdash E_1 \Rightarrow (f, x, E, \rho'), \sigma_1 \quad \boxed{\text{Complete the definition.}}}{\rho, \sigma_0 \vdash E_1\ E_2 \Rightarrow}$$

$$\frac{\rho, \sigma_0 \vdash E_1 \vdash (x, E, \rho'), \sigma_1 \qquad [x \mapsto \rho(y)]\rho', \sigma_1 \vdash E \Rightarrow v', \sigma_2}{\rho, \sigma_0 \vdash E_1\ \langle y \rangle \Rightarrow v', \sigma_2}$$

$$\frac{\rho, \sigma_0 \vdash E_1 \vdash (f, x, E, \rho'), \sigma_1 \qquad \boxed{\text{Complete the definition.}}}{\rho, \sigma_0 \vdash E_1 \ \langle y \rangle \Rightarrow}$$

$$\frac{\rho, \sigma_0 \vdash E \Rightarrow v, \sigma_1}{\rho, \sigma_0 \vdash \texttt{set}\ x = E \Rightarrow v, [\rho(x) \mapsto v]\sigma_1}$$

$$\frac{\rho, \sigma_0 \vdash E_1 \Rightarrow v_1, \sigma_1 \qquad \rho, \sigma_1 \vdash E_2 \Rightarrow v_2, \sigma_2}{\rho, \sigma_0 \vdash E_1; E_2 \Rightarrow v_2, \sigma_2}$$

$$\frac{\rho, \sigma_0 \vdash E \Rightarrow v, \sigma_1}{\rho, \sigma_0 \vdash \texttt{begin}\ E\ \texttt{end} \Rightarrow v, \sigma_1}$$

Complete the holes in the semantic definitions and implement an interpreter for the defined language.