COSE212: Programming Languages

Lecture 9-2 — Manual Type Annotation

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Language: LETREC with Type Annotation

$$
\begin{aligned}
E \quad \rightarrow \quad & n \\
\mid \quad & x \\
\mid \quad & E + E \\
\mid \quad & E - E \\
\mid \quad & \texttt{iszero } E \\
\mid \quad & \texttt{if } E \texttt{ then } E \texttt{ else } E \\
\mid \quad & \texttt{let } x = E \texttt{ in } E \\
\mid \quad & \texttt{proc } (x : t)\ E \\
\mid \quad & \texttt{letrec } t_1\ f(x : t_2) = E \texttt{ in } E \\
\mid \quad & E\ E
\end{aligned}
$$

Examples

- `proc (x:int) (x+1)`

- ```
  letrec int double (x: int) =
      if iszero x then 0 else (double (x-1)) +2
  in double 2
  ```

- `proc (f: (bool -> int)) proc (n: int) (f (iszero n))`

Typing Rules

$$\overline{\Gamma \vdash n : \text{int}} \qquad \overline{\Gamma \vdash x : \Gamma(x)}$$

$$\frac{\Gamma \vdash E_1 : \text{int} \qquad \Gamma \vdash E_2 : \text{int}}{\Gamma \vdash E_1 + E_2 : \text{int}} \qquad \frac{\Gamma \vdash E_1 : \text{int} \qquad \Gamma \vdash E_2 : \text{int}}{\Gamma \vdash E_1 - E_2 : \text{int}}$$

$$\frac{\Gamma \vdash E : \text{int}}{\Gamma \vdash \text{iszero } E : \text{bool}} \qquad \frac{\Gamma \vdash E_1 : \text{bool} \qquad \Gamma \vdash E_2 : t \qquad \Gamma \vdash E_3 : t}{\text{if } E_1 \text{ then } E_2 \text{ else } E_3 : t}$$

$$\frac{\Gamma \vdash E_1 : t_1 \qquad [x \mapsto t_1]\Gamma \vdash E_2 : t_2}{\Gamma \vdash \text{let } x = E_1 \text{ in } E_2 : t_2} \qquad \frac{\Gamma \vdash E_1 : t_1 \rightarrow t_2 \qquad \Gamma \vdash E_2 : t_1}{\Gamma \vdash E_1 \ E_2 : t_2}$$

$$\frac{[x \mapsto t_1]\Gamma \vdash E : t_2}{\Gamma \vdash \text{proc } (x : t_1) \ E : t_1 \rightarrow t_2} \qquad \frac{\begin{array}{c}[x \mapsto t_2, f \mapsto (t_2 \rightarrow t_1)]\Gamma \vdash E_1 : t_1 \\ [f \mapsto (t_2 \rightarrow t_1)]\Gamma \vdash E_2 : t\end{array}}{\Gamma \vdash \text{letrec } t_1 \ f(x : t_2) = E_1 \text{ in } E_2 : t}$$

Type Check Algorithm