# SimFL

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## Syntax

$$T \in \textsc{TypeCon} \qquad C \in \textsc{DataCon}$$

$$
\begin{aligned}
e \in \textsc{Expr} ::= {} & x \\
\mid {} & n \\
\mid {} & C \\
\mid {} & [\,] \\
\mid {} & [\, e\, \overline{\langle , \; e \rangle}\,] \\
\mid {} & e \bullet e \\
\mid {} & (\bullet) \\
\mid {} & \mathsf{fun}\ x\ \texttt{->}\ e \\
\mid {} & e\ e \\
\mid {} & \mathsf{let}\ x = e\ \mathsf{in}\ e \\
\mid {} & \mathsf{let\ rec}\ f\ x = e\ \overline{\langle \mathsf{and\ rec}\ f\ x = e \rangle}\ \mathsf{in}\ e \\
\mid {} & \mathsf{case}\ e\ \mathsf{of}\ \texttt{\{}\ p\ \texttt{->}\ e\ \overline{\langle \texttt{;}\ p\ \texttt{->}\ e \rangle}\ \texttt{\}} \\
\mid {} & \mathsf{if}\ e\ \mathsf{then}\ e\ \mathsf{else}\ e
\end{aligned}
$$

$$
\begin{aligned}
\bullet \in \textsc{BinOp} ::= {} & s\overline{s} \\
v \in \textsc{Value} ::= {} & C\ \overline{v} \\
\mid {} & (\textbf{closure}\ x \to e, \rho)
\end{aligned}
$$

## Natural Semantics

$$\frac{}{\rho \vdash n \Rightarrow n}\ \textsc{Num} \qquad \frac{}{\rho \vdash C \Rightarrow C}\ \textsc{Con} \qquad \frac{(x, v) \in \rho}{\rho \vdash x \Rightarrow v}\ \textsc{Var}$$

$$\frac{}{\rho \vdash \mathsf{fun}\ x\ \texttt{->}\ e \Rightarrow (\textbf{closure}\ x \to e, \rho)}\ \textsc{Fun}$$

$$\frac{\rho \vdash e_1 \Rightarrow (\textbf{closure}\ x \to e_3, \sigma) \qquad \rho \vdash e_2 \Rightarrow v_2 \qquad \sigma[x \mapsto v_2] \vdash e_3 \Rightarrow v_3}{\rho \vdash e_1\ e_2 \Rightarrow v_3}\ \textsc{App}$$

$$\frac{\rho \vdash e_1 \Rightarrow C\ \hat{v} \qquad \rho \vdash e_2 \Rightarrow v}{\rho \vdash e_1\, e_2 \Rightarrow C\ \hat{v}, v}\ \textsc{AppCons}$$

$$\frac{\rho \vdash e_1 \Rightarrow v_1 \qquad \rho[x \mapsto v_1] \vdash e_2 \Rightarrow v_2}{\rho \vdash \mathsf{let}\ x = e_1\ \mathsf{in}\ e_2 \Rightarrow v_2}\ \textsc{Let}$$

$$\frac{\rho[f \mapsto (\textbf{closure}\ x \to \mathsf{let\ rec}\ f\ x = e_1\ \mathsf{in}\ e_2, \rho)] \vdash e_2 \Rightarrow v}{\rho \vdash \mathsf{let\ rec}\ f\ x = e_1\ \mathsf{in}\ e_2 \Rightarrow v}\ \textsc{LetRec}$$

$$\frac{\rho \vdash e \Rightarrow v \qquad v \rhd p_i : \sigma_i \qquad \rho, \sigma_i \vdash e_i \Rightarrow v_i \qquad i \leq n}{\rho \vdash \mathsf{case}\ e\ \mathsf{of}\ \{\overline{\langle p_n\ \texttt{->}\ e_n \rangle}\} \Rightarrow v_2}\ \textsc{Case}$$

$$\frac{\rho \vdash e_1 \Rightarrow v_1 \qquad \rho \vdash e_2 \Rightarrow v_2 \qquad \mathsf{builtin}\ \bullet}{\rho \vdash e_1 \bullet e_2 \Rightarrow v_1 [\![\bullet]\!] v_2}\ \textsc{BuiltInOp}$$

$$\frac{\rho \vdash \mathsf{fun\ a\ \texttt{->}\ (fun\ b\ \texttt{->}\ a\ \bullet\ b)} \Rightarrow v \qquad \mathsf{builtin}\ \bullet}{\rho \vdash \texttt{(}\,\bullet\,\texttt{)} \Rightarrow v}\ \textsc{BuiltInFun}$$

$$\frac{}{v \rhd \_ : \varnothing}\ \textsc{MatchAny} \qquad \frac{}{v \rhd x : \{x \mapsto v\}}\ \textsc{MatchVar}$$

$$\frac{\forall i \leq n,\ \ v_i \rhd p_i : \sigma_i \qquad \bigcap_{j=1}^{n} \mathsf{free}(p_j) = \varnothing \qquad \sigma = \bigcup_{j=1}^{n} \sigma_j}{C\ \hat{v} \rhd C\ \hat{p} : \sigma}\ \textsc{MatchCons}$$