ULC

Syntax.

$$
\begin{aligned}
t &::= n \mid \lambda x.\, t \mid x \mid t\ t \mid t\ op\ t \\
v &::= n \mid \lambda x.\, t \\
\Omega &::= t \mid \mathit{fail}
\end{aligned}
$$

Structural operational semantics, small step, call by value.

$$\Omega \to \Omega$$

$$\frac{}{\lambda x.\, t \to t[v/x]}\ (\text{Beta}) \qquad \frac{}{n\ op\ n' \to n[\![op]\!]n'}\ (\text{Op}) \qquad \frac{t_1 \to t_1'}{t_1\ t_2 \to t_1' t_2}\ (\text{App1})$$

$$\frac{t_2 \to t_2'}{(\lambda x.\, t)\ t_2 \to (\lambda x.\, t)\ t_2'}\ (\text{App2}) \qquad \frac{t_1 \to t_1'}{t_1\ op\ t_2 \to t_1'\ op\ t_2}\ (\text{Op1})$$

$$\frac{t_2 \to t_2'}{n\ op\ t_2 \to n\ op\ t_2'}\ (\text{Op2})$$

Fail reductions.

$$\frac{}{(\lambda x.\, t)\ op\ t \to \mathit{fail}}\ (\text{Op-fail-l}) \qquad \frac{}{n\ op(\lambda x.\, t) \to \mathit{fail}}\ (\text{Op-fail-r}) \qquad \frac{}{n\ t \to \mathit{fail}}\ (\text{App-fail-fun})$$

$$\frac{t_2 \to \mathit{fail}}{(\lambda x.\, t)\ t_2 \to \mathit{fail}}\ (\text{App-fail-arg}) \qquad \frac{t_1 \to \mathit{fail}}{t_1\ t_2 \to \mathit{fail}}\ (\text{App-fail-1}) \qquad \frac{t_1 \to \mathit{fail}}{t_1\ op\ t_2 \to \mathit{fail}}\ (\text{Op-fail-1})$$

$$\frac{t_2 \to \mathit{fail}}{n\ op\ t_2 \to \mathit{fail}}\ (\text{Op-fail-2})$$