$$
\begin{array}{llll}
\text{Ctx} & K & ::= & \circ \quad \text{hole} \\
& & & \texttt{(let } K\ x\ M\texttt{)} \quad \text{let context} \\
& & & \texttt{[}K\ M\texttt{]} \quad \text{left app context} \\
& & & \texttt{[}V\ K\texttt{]} \quad \text{right app context} \\
& & & \texttt{(con } qc\ V^*\ K\ M^*\texttt{)} \quad \text{condata context} \\
& & & \texttt{(case } K\ C^*\texttt{)} \quad \text{case context} \\
& & & \texttt{(success } K\texttt{)} \quad \text{success context} \\
& & & \texttt{(bind } K\ x\ M\texttt{)} \quad \text{bind context} \\
& & & \texttt{(builtin } n\ V^*\ K\ M^*\texttt{)} \quad \text{builtin context}
\end{array}
$$

Fig. 1. Grammar of Reduction Contexts

$$
\begin{aligned}
\circ\{N\} &= N \\
\texttt{(let } K\ x\ M\texttt{)}\{N\} &= \texttt{(let } K\{N\}\ x\ M\texttt{)} \\
\texttt{[}K\ M\texttt{]}\{N\} &= \texttt{[}K\{N\}\ M\texttt{]} \\
\texttt{[}M\ K\texttt{]}\{N\} &= \texttt{[}M\ K\{N\}\texttt{]} \\
\texttt{(con } qc\ \vec{V}\ K\ \vec{M}\texttt{)}\{N\} &= \texttt{(con } qc\ \vec{V}\ K\{N\}\ \vec{M}\texttt{)} \\
\texttt{(case } K\ \vec{C}\texttt{)}\{N\} &= \texttt{(case } K\{N\}\ \vec{C}\texttt{)} \\
\texttt{(success } K\texttt{)}\{N\} &= \texttt{(success } K\{N\}\texttt{)} \\
\texttt{(bind } K\ x\ M\texttt{)}\{N\} &= \texttt{(bind } K\{N\}\ x\ M\texttt{)}
\end{aligned}
$$

Fig. 2. Context Insertion

$\boxed{M \ \to_\delta^* \ R}$

Term M reduces in some number of steps to return value R in declaration environment δ

$$\frac{}{V \ \to_\delta^* \ \texttt{(ok } V\texttt{)}}$$

$$\frac{M \ \to_\delta \ \texttt{(ok } M'\texttt{)} \qquad M' \ \to_\delta^* \ R}{M \ \to_\delta^* \ R}$$

$$\frac{M \ \to_\delta \ \texttt{err}}{M \ \to_\delta^* \ \texttt{err}}$$

$\boxed{M \ \to_\delta^n \ R}$

Term M reduces in at most n steps to return value R in declaration environment δ

$$\frac{}{V \ \to_\delta^n \ \texttt{(ok } V\texttt{)}}$$

$$\frac{M \ \to_\delta \ \texttt{(ok } M'\texttt{)}}{M \ \to_\delta^0 \ \texttt{err}}$$

$$\frac{M \ \to_\delta \ \texttt{(ok } M'\texttt{)} \qquad M' \ \to_\delta^n \ R}{M \ \to_\delta^{n+1} \ R}$$

$$\frac{M \ \to_\delta \ \texttt{err}}{M \ \to_\delta^n \ \texttt{err}}$$

$\boxed{M \ \to_\delta \ R}$

Term M reduces in one step to return value R in declaration environment δ

$$\frac{M \ \Rightarrow_\delta \ \texttt{(ok } M'\texttt{)}}{K\{M\} \ \to_\delta \ \texttt{(ok } K\{M'\}\texttt{)}}$$

$$\frac{M \ \Rightarrow_\delta \ \texttt{err}}{K\{M\} \ \to_\delta \ \texttt{err}}$$

Fig. 3. Reduction via Contextual Dynamics

$\boxed{M \ \Rightarrow_\delta \ R}$

Term M locally reduces to return value R in declaration context δ

$$\frac{}{qn \ \Rightarrow_{\delta, qn \mapsto M} \ \texttt{(ok } M\texttt{)}}$$

$$\frac{}{\texttt{[(lam } x\ M\texttt{)}\ V\texttt{]} \ \Rightarrow_\delta \ \texttt{(ok } [V/x]M\texttt{)}}$$

$$\frac{qc, \vec{V} \ \sim \ \vec{C} \ \triangleright \ R}{\texttt{(case (con } qc\ \vec{V}\texttt{)}\ \vec{C}\texttt{)} \ \Rightarrow_\delta \ R}$$

$$\frac{n \text{ on } \vec{V} \text{ reduces to } R}{\texttt{(builtin } n\ \vec{V}\texttt{)} \ \Rightarrow_\delta \ R}$$

Fig. 4. Local Reduction

$\boxed{qc, \vec{V} \ \sim \ \vec{C} \ \triangleright \ R}$

Constructor qc with arguments $\vec{V}$ matches clauses $\vec{C}$ to produce result R

$$\frac{}{qc, \vec{V} \ \sim \ \epsilon \ \triangleright \ \texttt{err}}$$

$$\frac{qc \ = \ qc'}{qc, \vec{V} \ \sim \ \texttt{(cl}\ qc' \ \texttt{(}\tilde{x}\texttt{)} \ M\texttt{)}, \vec{C} \ \triangleright \ \texttt{(ok}\ [\vec{V}/\vec{x}]M\texttt{)}}$$

$$\frac{qc \ \neq \ qc' \qquad qc, \vec{V} \ \sim \ \vec{C} \ \triangleright \ R}{qc, \vec{V} \ \sim \ \texttt{(cl}\ qc' \ \texttt{(}\tilde{x}\texttt{)} \ M\texttt{)}, \vec{C} \ \triangleright \ R}$$

Fig. 5. Case Matching

Instr	I	::=	`(success` V`)`	success
			`(failure)`	failure
			`(txhash)`	transaction hash
			`(blocknum)`	block number
			`(blocktime)`	block time
			`(bind` M x M`)`	computation bind

Fig. 6. Grammar of Instructions and Return Instructions

$\boxed{M \ \rightsquigarrow^*_{E,\delta} \ R}$

Term M executes in some number of steps to return value R in declaration environment δ and blockchain environment E

$$\frac{M \ \rightarrow^*_{\delta} \ \texttt{err}}{M \ \rightsquigarrow^*_{E,\delta} \ \texttt{err}}$$

$$\frac{M \ \rightarrow^*_{\delta} \ \texttt{(ok}\ V\texttt{)} \qquad V \ \neq \ I}{M \ \rightsquigarrow^*_{E,\delta} \ \texttt{err}}$$

$$\frac{M \ \rightarrow^*_{\delta} \ \texttt{(ok}\ V\texttt{)} \qquad V \ = \ \texttt{(success}\ V'\texttt{)}}{M \ \rightsquigarrow^*_{E,\delta} \ \texttt{(ok}\ V'\texttt{)}}$$

$$\frac{M \ \rightarrow^*_{\delta} \ \texttt{(ok}\ V\texttt{)} \qquad V \ = \ \texttt{(failure)}}{M \ \rightsquigarrow^*_{E,\delta} \ \texttt{err}}$$

$$\frac{M \ \rightarrow^*_{\delta} \ \texttt{(ok}\ V\texttt{)} \qquad V \ = \ \texttt{(txhash)}}{M \ \rightsquigarrow^*_{E,\delta} \ \texttt{(ok}\ E_{txhash}\texttt{)}}$$

$$\frac{M \ \rightarrow^*_{\delta} \ \texttt{(ok}\ V\texttt{)} \qquad V \ = \ \texttt{(blocknum)}}{M \ \rightsquigarrow^*_{E,\delta} \ \texttt{(ok}\ E_{blocknum}\texttt{)}}$$

$$\frac{M \ \rightarrow^*_{\delta} \ \texttt{(ok}\ V\texttt{)} \qquad V \ = \ \texttt{(blocktime)}}{M \ \rightsquigarrow^*_{E,\delta} \ \texttt{(ok}\ E_{blocktime}\texttt{)}}$$

$$\frac{\begin{array}{c} M \ \rightarrow^*_{\delta} \ \texttt{(ok}\ V\texttt{)} \\ V \ = \ \texttt{(bind}\ V_0 \ x \ M'_1\texttt{)} \\ V_0 \ \rightsquigarrow^*_{E,\delta} \ \texttt{err} \end{array}}{M \ \rightsquigarrow^*_{E,\delta} \ \texttt{err}}$$

$$\frac{\begin{array}{c} M \ \rightarrow^*_{\delta} \ \texttt{(ok}\ V\texttt{)} \\ V \ = \ \texttt{(bind}\ V_0 \ x \ M'_1\texttt{)} \\ V_0 \ \rightsquigarrow^*_{E,\delta} \ \texttt{(ok}\ V'\texttt{)} \\ [V'/x]M'_1 \ \rightsquigarrow^*_{E,\delta} \ R \end{array}}{M \ \rightsquigarrow^*_{E,\delta} \ R}$$

Fig. 7. Execution