

Quick Look

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Old rules

$$\frac{\Gamma, x : A \vdash e \Leftarrow H \Rightarrow B}{\Gamma \vdash \lambda x. e \Leftarrow A \rightarrow H \Rightarrow A \rightarrow B} \text{ABS}$$

$$\frac{\Gamma \vdash f \Leftarrow ? \rightarrow H \Rightarrow A \rightarrow B \quad \Gamma \vdash a \Leftarrow A \Rightarrow A}{\Gamma \vdash f a \Leftarrow H \Rightarrow B} \text{APP}$$

$$\frac{\Gamma \vdash a \Leftarrow ? \Rightarrow A \quad \Gamma \vdash f \Leftarrow A \rightarrow H \Rightarrow A \rightarrow B}{\Gamma \vdash f a \Leftarrow H \Rightarrow B} \text{ALTAPP}$$

Easy for the original rule APP , but hard for the alternative $ALTAPP$:
 $f\ e_1, f\ e_1\ e_2$, etc.

Easy for the alternative rule $ALTAPP$, but hard for the original one
 APP : $(\lambda x. e)\ y, (\lambda x. e)\ y\ z$

Hard for both: $\text{case } (\lambda a. e_1)\ (\lambda b. e_2)\ x$

Quick Look at the argument

$$\frac{(x : A) \in \Gamma}{\Gamma \vdash x \Rightarrow A} \text{QL-ARG-VAR}$$

$$\frac{}{\Gamma \vdash (e : H) \Rightarrow H} \text{QL-ARG-ANNOT}$$

$$\frac{}{\Gamma \vdash \text{unit} \Rightarrow 1} \text{QL-ARG-UNIT}$$

$$\frac{e \neq x \quad e \neq (e' : H') \quad e \neq \text{unit}}{\Gamma \vdash e \Rightarrow ?} \text{QL-ARG-FAIL}$$

The new rule

$$\frac{\Gamma \vdash a \Rightarrow H_A \quad \Gamma \vdash f \Leftarrow H_A \rightarrow H_B \Rightarrow A \rightarrow B \quad \Gamma \vdash a \Leftarrow A \Rightarrow A}{\Gamma \vdash f a \Leftarrow H_B \Rightarrow B} \text{APP-QL-AI}$$

Quick Look at the function

$$\frac{\begin{array}{l} \Gamma \vdash f \Rightarrow H_A \rightarrow H'_B \quad \Gamma \vdash a \Leftarrow H_A \Rightarrow A \\ \Gamma \vdash f \Leftarrow A \rightarrow H_B \sqcup H'_B \Rightarrow A \rightarrow B \end{array}}{\Gamma \vdash f \ a \Leftarrow H_B \Rightarrow B} \text{QL-FUN}$$

Quick Look

$$\frac{(x : A) \in \Gamma \quad H \sqsubseteq A}{\Gamma \vdash x \leftarrow H \rightarrow A} \text{QL-VAR}$$

$$\frac{}{\Gamma \vdash (e : H_1) \leftarrow H_2 \rightarrow H_1 \sqcup H_2} \text{QL-ANNOT}$$

$$\frac{e \neq x \quad e \neq (e' : H')}{\Gamma \vdash e \leftarrow H \rightarrow H} \text{QL-FAIL}$$

New rules

$$\frac{\Gamma \vdash f \Leftarrow ? \rightarrow H \Rightarrow H_A \rightarrow H_B \quad \begin{array}{l} \Gamma \vdash a \Leftarrow H_A \Rightarrow A \\ \Gamma \vdash f \Leftarrow A \rightarrow H_B \Rightarrow A \rightarrow B \end{array}}{\Gamma \vdash f \ a \Leftarrow H \Rightarrow B} \text{QL-APP}$$

$$\frac{\Gamma \vdash e_2 \Leftarrow ? \Rightarrow H_2 \quad \Gamma \vdash e_1 \Leftarrow H \Rightarrow f ; \bar{e} ; H'}{\Gamma \vdash e_1 \ e_2 \Leftarrow H \Rightarrow f ; \bar{e} ; H'} \text{QLD-APP}$$

$$\frac{(x : A) \in \Gamma \quad H \sqsubseteq A}{x \vdash H \Leftarrow A \Rightarrow ; ;} \text{QLD-VAR}$$

$$\frac{}{\Gamma \vdash (e : H_1) \Leftarrow H_2 \Rightarrow H_1 \sqcup H_2} \text{QL-ANNOT}$$

$$\frac{e \neq x \quad e \neq (e' : H')}{\Gamma \vdash e \Leftarrow H \Rightarrow H} \text{QL-FAIL}$$

$$\frac{\Gamma \vdash e_1 \ e_2 \Leftarrow H \Rightarrow f ; \bar{e} ; H'}{\Gamma \vdash e_1 \ e_2 \Leftarrow H \Rightarrow B}$$