1 Grammar

$e ::= x \mid new x \Rightarrow \overline{\sigma = e} \mid e.m(e) \mid r$

R is set of resources, M is set of methods

$\epsilon \in Powerset(R \times M)$

$\tau ::= \{\bar{\sigma}\} \mid \{\bar{r}\}$

$\sigma ::= d \ with \ \epsilon$

$r \in R, m \in M$

$d ::= def \ m(x : \tau) : \tau$

2 Effect Rules (Green)

Ep-ValidImpl $\dfrac{\Gamma, x : \tau \vdash e : \tau' \ with \ \epsilon \qquad \sigma = def \ m(x : \tau) : \tau' \ with \ \epsilon}{\Gamma \vdash \sigma = e}$

Ep-Var $\dfrac{}{\Gamma, x : \tau \vdash x : \tau \ with \ \varnothing}$

Ep-Var $\dfrac{}{\Gamma \vdash r : \{r\} \ with \ \varnothing}$

Ep-NewObj $\dfrac{\Gamma, x : \{\bar{\sigma}\} \vdash \overline{\sigma = e} \ OK}{\Gamma \vdash new \ x \ \Rightarrow \ \overline{\{\sigma = e\}} : \{\bar{s}igma\} with \varnothing}$

Ep-MethCallResource $\dfrac{\Gamma \vdash e_1 : \{\bar{r}\} \ with \ \epsilon_1 \qquad \Gamma \vdash e_2 : \tau_2 \ with \ \epsilon_2}{\Gamma \vdash e_1.m(e_2) : \{\bar{r}\} \ with \ \{\bar{r}, m\} \cup \epsilon_1 \cup \epsilon_2}$

Ep-MethCallPure $\dfrac{\begin{array}{c}\Gamma \vdash e_1 : \{\bar{r}\} \ with \ \epsilon_1 \\ \Gamma \vdash e_2 : \tau_2 \ with \ \epsilon_2\end{array} \qquad \sigma \ := \ def \ m_i(y : \tau_2) : \tau \ with \ \epsilon}{\Gamma \vdash e_1.m_i(e_2) : \tau \ with \ \epsilon_1 \ \cup \ \epsilon_2 \ \cup \ \epsilon}$

3 Capture Rules (Orange)

C-NewObj $\dfrac{\Gamma' \subseteq \Gamma \qquad \Gamma', x : \{\bar{d} \ captures \ \varepsilon \vdash d = e\} \ OK}{\Gamma \vdash new \ x \Rightarrow \overline{d = e} : \{x \Rightarrow \bar{d} \ with \ \varepsilon\}}$

$$\text{C-MethCall}\ \frac{\begin{array}{c}\Gamma \vdash e_1 : \{\bar{d}\ captures\ \varepsilon\}\ with\ \varepsilon_1 \\ \Gamma \vdash e_2 : \tau_2\ with\ \varepsilon_2\end{array} \qquad d\ :=\ def\ m_i(y : \tau_2) : \tau}{\Gamma \vdash e_1.m_i(e_2) : \tau\ with\ \varepsilon_1\ \cup\ \varepsilon_2\ \cup\ effects(\tau_2)}$$

Definition of Effects

- $effects(\cdot) = \varnothing$
- $effects(\{\bar{r}\}) = \{(r, m) \mid r \in \bar{r}, m \in M\}$
- $effects(\{\bar{d}\ with\ \varepsilon\}) = \epsilon$
- $effects(\{\bar{\sigma}\}) = \sum_{\sigma \in \bar{\sigma}}\ effects(\sigma)$
- $effects(d\ with\ \epsilon) = \epsilon$