$v \in \mathbb{F}_p,\ w \in \text{String},\ \iota \in \text{Clients} \subset \mathbb{N}$

$$\begin{array}{rcll}
\varepsilon & ::= & \texttt{r[}w\texttt{]} \mid \texttt{s[}w\texttt{]} \mid \texttt{m[}w\texttt{]} \mid \texttt{p[}w\texttt{]} \mid & \textit{expressions} \\
 & & v \mid \varepsilon - \varepsilon \mid \varepsilon + \varepsilon \mid \varepsilon * \varepsilon & \\
x & ::= & \texttt{r[}w\texttt{]@}\iota \mid \texttt{s[}w\texttt{]@}\iota \mid \texttt{m[}w\texttt{]@}\iota \mid \texttt{p[}w\texttt{]} \mid \texttt{out@}\iota & \textit{variables} \\
\pi & ::= & \texttt{m[}w\texttt{]@}\iota := \varepsilon\texttt{@}\iota \mid \texttt{p[}w\texttt{]} := e\texttt{@}\iota \mid \texttt{out@}\iota := \varepsilon\texttt{@}\iota \mid \pi;\pi & \textit{protocols}
\end{array}$$

$$\begin{array}{rcl}
\llbracket \sigma, v \rrbracket_\iota & = & v \\
\llbracket \sigma, \varepsilon_1 + \varepsilon_2 \rrbracket_\iota & = & \llbracket \llbracket \sigma, \varepsilon_1 \rrbracket_\iota + \llbracket \sigma, \varepsilon_2 \rrbracket_\iota \rrbracket \\
\llbracket \sigma, \varepsilon_1 - \varepsilon_2 \rrbracket_\iota & = & \llbracket \llbracket \sigma, \varepsilon_1 \rrbracket_\iota - \llbracket \sigma, \varepsilon_2 \rrbracket_\iota \rrbracket \\
\llbracket \sigma, \varepsilon_1 * \varepsilon_2 \rrbracket_\iota & = & \llbracket \llbracket \sigma, \varepsilon_1 \rrbracket_\iota * \llbracket \sigma, \varepsilon_2 \rrbracket_\iota \rrbracket \\
\llbracket \sigma, \texttt{r[}w\texttt{]} \rrbracket_\iota & = & \sigma(\texttt{r[}w\texttt{]@}\iota) \\
\llbracket \sigma, \texttt{s[}w\texttt{]} \rrbracket_\iota & = & \sigma(\texttt{s[}w\texttt{]@}\iota) \\
\llbracket \sigma, \texttt{m[}w\texttt{]} \rrbracket_\iota & = & \sigma(\texttt{m[}w\texttt{]@}\iota) \\
\llbracket \sigma, \texttt{p[}w\texttt{]} \rrbracket_\iota & = & \sigma(\texttt{p[}w\texttt{]})
\end{array}$$

$$(\sigma, x := \varepsilon\texttt{@}\iota) \Rightarrow \sigma\{x \mapsto \llbracket \sigma, \varepsilon \rrbracket_\iota\} \qquad \frac{(\sigma_1, \varepsilon_1) \Rightarrow \sigma_2 \qquad (\sigma_2, \varepsilon_2) \Rightarrow \sigma_3}{(\sigma_1, \varepsilon_1; \varepsilon_2) \Rightarrow \sigma_3}$$

$$\begin{array}{lcll}
(\sigma, x := \varepsilon\texttt{@}\iota) & \Rightarrow_{\mathcal{A}} & \sigma\{x \mapsto \llbracket \sigma, \varepsilon \rrbracket_\iota\} & \iota \in H \\
(\sigma, x := \varepsilon\texttt{@}\iota) & \Rightarrow_{\mathcal{A}} & \sigma\{x \mapsto \llbracket \mathit{rewrite}_{\mathcal{A}}(\sigma_C, \varepsilon) \rrbracket_\iota\} & \iota \in C
\end{array}$$

$$\begin{array}{rcll}
(\sigma, \texttt{assert(}\varepsilon_1 = \varepsilon_2\texttt{)@}\iota) & \Rightarrow_{\mathcal{A}} & \sigma & \text{if } \llbracket \sigma, \varepsilon_1 \rrbracket_\iota = \llbracket \sigma, \varepsilon_2 \rrbracket_\iota \text{ or } \iota \in C \\
(\sigma, \texttt{assert(}\phi(\varepsilon)\texttt{)@}\iota) & \Rightarrow_{\mathcal{A}} & \bot & \text{if } \neg\phi(\sigma, \llbracket \sigma, \varepsilon \rrbracket_\iota)
\end{array}$$

$$(\sigma, x := \varepsilon\texttt{@}\iota) \Rightarrow \sigma\{x \mapsto \llbracket \sigma, \varepsilon \rrbracket_\iota\} \qquad \frac{(\sigma_1, \varepsilon_1) \Rightarrow \bot}{(\sigma_1, \varepsilon_1; \varepsilon_2) \Rightarrow \bot}$$

$\ell \in \text{Field},\ y \in \text{EVar},\ f \in \text{FName}$

$$\begin{array}{rcl}
e & ::= & v \mid \texttt{r[}e\texttt{]} \mid \texttt{s[}e\texttt{]} \mid \texttt{m[}e\texttt{]} \mid \texttt{p[}e\texttt{]} \mid e \ \mathit{binop}\ e \mid \texttt{let}\ y = e\ \texttt{in}\ e \mid \\
 & & f(e, \ldots, e) \mid \{\ell = e; \ldots; \ell = e\} \mid e.\ell \\
\mathbf{c} & ::= & \texttt{m[}e\texttt{]@}e := e\texttt{@}e \mid \texttt{p[}e\texttt{]} := e\texttt{@}e \mid \texttt{out@}e := e\texttt{@}e \mid \texttt{assert(}e = e\texttt{)@}e \mid \\
 & & f(e, \ldots, e) \mid \mathbf{c}; \mathbf{c} \mid \texttt{pre(}E\texttt{)} \mid \texttt{post(}E\texttt{)} \\
\mathit{binop} & ::= & + \mid - \mid * \mid \texttt{++} \\
v & ::= & w \mid \iota \mid \varepsilon \mid \{\ell = v; \ldots; \ell = v\} \\
\mathit{fn} & ::= & f(y, \ldots, y)\{e\} \mid f(y, \ldots, y)\{\mathbf{c}\} \\
\phi & ::= & \texttt{r[}e\texttt{]@}e \mid \texttt{s[}e\texttt{]@}e \mid \texttt{m[}e\texttt{]@}e \mid \texttt{p[}e\texttt{]} \mid \texttt{out@}e \mid \phi + \phi \mid \phi - \phi \mid \phi * \phi \\
E & ::= & \phi = \phi \mid E \land E
\end{array}$$

$$\frac{e[v/y] \Rightarrow v'}{\mathtt{let}\ y = v\ \mathtt{in}\ e \Rightarrow v'}$$

$$\frac{C(f) = y_1, \ldots, y_n,\ e \qquad e_1 \Rightarrow v_1 \cdots e_n \Rightarrow v_n \qquad e[v_1/y_1] \cdots [v_n/y_n] \Rightarrow v}{f(e_1, \ldots, e_n) \Rightarrow v}$$

$$\frac{e_1 \Rightarrow v_1 \cdots e_n \Rightarrow v_n}{\{\ell_1 = e_1; \ldots; \ell_n = e_n\} \Rightarrow \{\ell_1 = v_1; \ldots; \ell_n = v_n\}} \qquad \frac{e \Rightarrow \{\ldots; \ell = v; \ldots\}}{e.\ell \Rightarrow v} \qquad \frac{e_1 \Rightarrow w_1 \qquad e_2 \Rightarrow w_2}{e_1{+}{+}e_2 \Rightarrow w_1 w_2}$$

$$\frac{e_1 \Rightarrow \varepsilon_1 \qquad e_2 \Rightarrow \varepsilon_2}{(\pi, (E_1, E_2), \mathsf{on}, \mathtt{assert}(e_1 = e_2)@\iota) \Rightarrow (\pi, (E_1, E_2 \wedge \lfloor \varepsilon_1 @ \iota \rfloor = \lfloor \varepsilon_2 @ \iota \rfloor, \mathsf{on})}$$