values v	::=	x	variable
	|	$()$	unit
	|	n	integer
	|	$\texttt{Left}\ v \mid \texttt{Right}\ v$	sum constructors
	|	(v_1, v_2)	pair
	|	$\texttt{fun}\ x \mapsto c$	function
	|	$\texttt{handler}\ (\texttt{ret}\ x \mapsto c_r; h)$	handler
computations c	::=	$\texttt{ret}\ v$	returned value
	|	$\texttt{match}\ v\ \texttt{with}\ (x, y) \mapsto c$	product match
	|	$\texttt{match}\ v\ \texttt{with}\ \texttt{Left}\ x \mapsto c_1 \mid \texttt{Right}\ x \mapsto c_2$	sum match
	|	$v_1\ v_2$	application
	|	$op(v; y.c)$	operation call
	|	$\texttt{let rec}\ f\ x : A \to \underline{C} = c_1\ \texttt{in}\ c_2$	recursive function
	|	$\texttt{do}\ x \leftarrow c_1\ \texttt{in}\ c_2$	sequencing
	|	$\texttt{with}\ v\ \texttt{handle}\ c$	handling
operation clauses h	::=	$\emptyset \mid h \cup \{op(x; k) \mapsto c_{op}\}$	

Figure 1: *EEFF* Term Syntax

$$\frac{}{\texttt{match}\ (v_1, v_2)\ \texttt{with}\ (x, y) \mapsto c\ \rightsquigarrow\ c[x \mapsto v_1, y \mapsto v_2]}$$

$$\frac{}{\texttt{match Left}\ v\ \texttt{with Left}\ x \mapsto c_l \mid \texttt{Right}\ x \mapsto c_r\ \rightsquigarrow\ c_l[x \mapsto v]}$$

$$\frac{}{\texttt{match Right}\ v\ \texttt{with Left}\ x \mapsto c_l \mid \texttt{Right}\ x \mapsto c_r\ \rightsquigarrow\ c_r[x \mapsto v]}$$

$$\frac{}{(\texttt{fun}\ x \mapsto c)\ v\ \rightsquigarrow\ c[x \mapsto v]}$$

$$\frac{}{\texttt{let rec}\ f\ x : A \to \underline{C} = c_1\ \texttt{in}\ c_2\ \rightsquigarrow\ c_2[f \mapsto (\texttt{fun}\ x \mapsto \texttt{let rec}\ f\ x : A \to \underline{C} = c_1\ \texttt{in}\ c_1)]}$$

$$\frac{c_1\ \rightsquigarrow\ c_1'}{\texttt{do}\ x \leftarrow c_1\ \texttt{in}\ c_2\ \rightsquigarrow\ \texttt{do}\ x \leftarrow c_1'\ \texttt{in}\ c_2} \qquad \frac{}{\texttt{do}\ x \leftarrow \texttt{ret}\ v\ \texttt{in}\ c\ \rightsquigarrow\ c[x \mapsto v]}$$

$$\frac{}{\texttt{do}\ x \leftarrow op(v;\ y.c_1)\ \texttt{in}\ c_2\ \rightsquigarrow\ op(v;\ y.\texttt{do}\ x \leftarrow c_1\ \texttt{in}\ c_2)}$$

$$\frac{c\ \rightsquigarrow\ c'}{\texttt{with}\ v\ \texttt{handle}\ c\ \rightsquigarrow\ \texttt{with}\ v\ \texttt{handle}\ c'}$$

$$\frac{}{\texttt{with}\ (\texttt{handler}\ (\texttt{ret}\ x \mapsto c_r; h))\ \texttt{handle}\ (\texttt{ret}\ v)\ \rightsquigarrow\ c_r[x \mapsto v]}$$

$$\frac{H = (\texttt{handler}\ (\texttt{ret}\ x \mapsto c_r; h)) \qquad (op(x;\ k) \mapsto c_{op}) \in h}{\texttt{with}\ H\ \texttt{handle}\ (op(v;\ y.c))\ \rightsquigarrow\ c_{op}[x \mapsto v, k \mapsto (\texttt{fun}\ y \mapsto \texttt{with}\ H\ \texttt{handle}\ c)]}$$

Figure 2: *EEFF* Operational Semantics

(value) type A, B	::=	$\texttt{unit}$	unit type
	|	$\texttt{int}$	int type
	|	$\texttt{empty}$	empty type
	|	$A + B$	sum type
	|	$A \times B$	product type
	|	$A \to \underline{C}$	function type
	|	$\underline{C} \Rightarrow \underline{D}$	handler type
computation type $\underline{C}, \underline{D}$	::=	$A ! \Sigma / \mathcal{E}$	
signature Σ	::=	$\emptyset \mid \Sigma \cup \{op : A \to B\}$	
value context Γ	::=	$\varepsilon \mid \Gamma, x : A$	
template context $\mathtt{Z}$	::=	$\varepsilon \mid \mathtt{Z}, z : A \to *$	
template T	::=	$z\ v$	applied variable
	|	$\texttt{match}\ v\ \texttt{with}\ (x, y) \mapsto T$	product match
	|	$\texttt{match}\ v\ \texttt{with}\ \texttt{Left}\ x \mapsto T_1 \mid \texttt{Right}\ x \mapsto T_2$	sum match
	|	$op(v;\ y.T)$	operation call
(effect) theory $\mathcal{E}$	::=	$\emptyset \mid \mathcal{E} \cup \{\Gamma; \mathtt{Z} \vdash T_1 \sim T_2\}$	

Figure 3: *EEFF* Type Syntax

$$\frac{\Gamma \vdash v \Leftarrow A}{\Gamma \vdash (v : A) \Rightarrow A} \qquad \frac{\Gamma \vdash v \Rightarrow A' \qquad A = A'}{\Gamma \vdash v \Leftarrow A} \qquad \frac{(x : A) \in \Gamma}{\Gamma \vdash x \Rightarrow A}$$

$$\frac{}{\Gamma \vdash () \Rightarrow \texttt{unit}} \qquad \frac{}{\Gamma \vdash n \Rightarrow \texttt{int}} \qquad \frac{\Gamma \vdash v \Leftarrow A}{\Gamma \vdash \texttt{Left}\ v \Leftarrow A + B}$$

$$\frac{\Gamma \vdash v \Leftarrow B}{\Gamma \vdash \texttt{Right}\ v \Leftarrow A + B} \qquad \frac{\Gamma \vdash v_1 \Leftarrow A \qquad \Gamma \vdash v_2 \Leftarrow B}{\Gamma \vdash (v_1, v_2) \Leftarrow A \times B}$$

$$\frac{\Gamma \vdash v_1 \Rightarrow A \qquad \Gamma \vdash v_2 \Rightarrow B}{\Gamma \vdash (v_1, v_2) \Rightarrow A \times B} \qquad \frac{\Gamma, x : A \vdash c \Leftarrow \underline{C}}{\Gamma \vdash \texttt{fun}\ x \mapsto c \Leftarrow A \to \underline{C}}$$

$$\frac{\Gamma, x : A \vdash c_r \Leftarrow \underline{D} \qquad \Gamma \vdash h : \Sigma \Rightarrow \underline{D}\ \text{respects}\ \mathcal{E}}{\Gamma \vdash \texttt{handler}\ (\texttt{ret}\ x \mapsto c_r; h) \Leftarrow A!\Sigma/\mathcal{E} \Rightarrow \underline{D}} \qquad \frac{}{\Gamma \vdash \emptyset \Leftarrow \emptyset \Rightarrow \underline{D}}$$

$$\frac{\Gamma \vdash h \Leftarrow \Sigma \Rightarrow \underline{D} \qquad \Gamma, x : A_{op}, k : B_{op} \to \underline{D} \vdash c_{op} \Leftarrow \underline{D} \qquad op \notin \Sigma}{\Gamma \vdash h \cup \{op(x;\ k) \mapsto c_{op}\} \Leftarrow (\Sigma \cup \{op : A_{op} \to B_{op}\}) \Rightarrow \underline{D}}$$

$$\frac{\Gamma \vdash c \Leftarrow \underline{C}}{\Gamma \vdash (c : \underline{C}) \Rightarrow \underline{C}} \qquad \frac{\Gamma \vdash c \Rightarrow \underline{C}' \qquad \underline{C} = \underline{C}' \qquad \text{effect subtyping?}}{\Gamma \vdash c \Leftarrow \underline{C}}$$

$$\frac{\Gamma \vdash v \Rightarrow A + B \qquad \Gamma, x : A \vdash c_l \Leftarrow \underline{C} \qquad \Gamma, x : B \vdash c_r \Leftarrow \underline{C}}{\Gamma \vdash \texttt{match}\ v\ \texttt{with}\ \texttt{Left}\ x \mapsto c_l \mid \texttt{Right}\ x \mapsto c_r \Leftarrow \underline{C}}$$

$$\frac{\Gamma \vdash v \Rightarrow A \times B \qquad \Gamma, x : A, y : B \vdash c \Rightarrow \underline{C}}{\Gamma \vdash \texttt{match}\ v\ \texttt{with}\ (x, y) \mapsto c \Rightarrow \underline{C}} \qquad \frac{\Gamma \vdash v_1 \Rightarrow A \to \underline{C} \qquad \Gamma \vdash v_2 \Leftarrow A}{\Gamma \vdash v_1\ v_2 \Rightarrow \underline{C}}$$

$$\frac{\Gamma, f : A \to \underline{C}, x : A \vdash c_1 \Leftarrow \underline{C} \qquad \Gamma, f : A \to \underline{C} \vdash c_2 \Rightarrow \underline{D}}{\Gamma \vdash \texttt{let rec}\ f\ x : A \to \underline{C} = c_1\ \texttt{in}\ c_2 \Rightarrow \underline{D}} \qquad \frac{\Gamma \vdash v \Rightarrow A}{\Gamma \vdash \texttt{ret}\ v \Rightarrow A!\emptyset/\emptyset}$$

$$\frac{(op : A_{op} \to B_{op}) \in \Sigma \qquad \Gamma \vdash v \Leftarrow A_{op} \qquad \Gamma, y : B_{op} \vdash c \Leftarrow A!\Sigma/\mathcal{E}}{\Gamma \vdash op(v;\ y.c) \Leftarrow A!\Sigma/\mathcal{E}}$$

$$\frac{\Gamma \vdash c_1 \Rightarrow A!\Sigma/\mathcal{E} \qquad \Gamma, x : A \vdash c_2 \Leftarrow B!\Sigma/\mathcal{E} \qquad \text{effect subtyping?}}{\Gamma \vdash \texttt{do}\ x \leftarrow c_1\ \texttt{in}\ c_2 \Leftarrow B!\Sigma/\mathcal{E}}$$

$$\frac{\Gamma \vdash v \Rightarrow \underline{C} \Rightarrow \underline{D} \qquad \Gamma \vdash c \Leftarrow \underline{C}}{\Gamma \vdash \texttt{with}\ v\ \texttt{handle}\ c \Rightarrow \underline{D}}$$

Figure 4: *EEFF* Type System