Compiling from F_i^+ to JavaScript

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Syntax of F_i^+

Types	$A, B, C ::= \top \mid \bot \mid \mathbb{B} \mid X \mid A \to B \mid \forall X{*}A.\ B \mid \{\ell : A\} \mid A \,\&\, B$
Type indices	$\tau ::= \mathbb{B} \mid \overrightarrow{\tau} \mid \tau^{\forall} \mid \{\ell : \tau\} \mid \tau_1 \,\&\, \tau_2$
Expressions	$e ::= \{\} \mid b \mid x \mid \mathbf{fix}\, e \mid \lambda x{:}A.\ e{:}B \mid e_1\ e_2 \mid \Lambda X{*}A.\ e{:}B \mid e\ A \mid \{\ell = e\} \mid e.\ell$ $\mid e_1 \,,,\, e_2 \mid e : A$
Values	$v ::= \{\} \mid b \mid \lambda x{:}A.\ e{:}B \mid \Lambda X{*}A.\ e{:}B \mid \{\ell = v\} \mid v_1 \,,,\, v_2$

$\boxed{|A| = \tau}$ *(Type translation)*

$$|\mathbb{B}| = \mathbb{B} \qquad |X| = X \qquad |\forall X{*}A.\ B| = |B|^{\forall} \qquad |A \to B| = \overrightarrow{|B|} \qquad |\{\ell : A\}| = \{\ell : |A|\} \qquad |A \,\&\, B| = |A| \,\&\, |B|$$

$\boxed{\rceil A \lceil}$ *(Top-like types)*

$$\textsc{TL-Top}\ \frac{}{\rceil \top \lceil} \qquad \textsc{TL-And}\ \frac{\rceil A \lceil \qquad \rceil B \lceil}{\rceil A \,\&\, B \lceil} \qquad \textsc{TL-Arrow}\ \frac{\rceil B \lceil}{\rceil A \to B \lceil} \qquad \textsc{TL-All}\ \frac{\rceil B \lceil}{\rceil \forall X{*}A.\ B \lceil} \qquad \textsc{TL-Rcd}\ \frac{\rceil A \lceil}{\rceil \{\ell : A\} \lceil}$$

$\boxed{A^\circ}$ *(Ordinary types)*

$$\textsc{O-Top}\ \frac{}{\top^\circ} \qquad \textsc{O-Bot}\ \frac{}{\bot^\circ} \qquad \textsc{O-Base}\ \frac{}{\mathbb{B}^\circ} \qquad \textsc{O-Var}\ \frac{}{X^\circ} \qquad \textsc{O-Arrow}\ \frac{B^\circ}{(A \to B)^\circ} \qquad \textsc{O-All}\ \frac{B^\circ}{(\forall X{*}A.\ B)^\circ} \qquad \textsc{O-Rcd}\ \frac{A^\circ}{\{\ell : A\}^\circ}$$

$\boxed{\Gamma \vdash e \Leftrightarrow A \rightsquigarrow z \textbf{ in } J}$ *(Type-directed compilation)*

J-Top
$$\frac{}{\Gamma \vdash \{\} \Rightarrow \top \rightsquigarrow z \textbf{ in } \varnothing}$$

J-TopAbs
$$\frac{\rceil B \lceil}{\Gamma \vdash \lambda x{:}A.\ e{:}B \Rightarrow A \to B \rightsquigarrow z \textbf{ in } \varnothing}$$

J-TopTAbs
$$\frac{\rceil B \lceil}{\Gamma \vdash \Lambda X{*}A.\ e{:}B \Rightarrow \forall X{*}A.\ B \rightsquigarrow z \textbf{ in } \varnothing}$$

J-TopRcd
$$\frac{\Gamma \vdash e \Rightarrow A \qquad \rceil A \lceil}{\Gamma \vdash \{\ell = e\} \Rightarrow \{\ell : A\} \rightsquigarrow z \textbf{ in } \varnothing}$$

J-Base
$$\frac{\tau = |\mathbb{B}|}{\Gamma \vdash b \Rightarrow \mathbb{B} \rightsquigarrow z \textbf{ in } S_1}$$

J-Var
$$\frac{x : A \in \Gamma}{\Gamma \vdash x \Rightarrow A \rightsquigarrow z \textbf{ in } S_2}$$

J-Fix
$$\frac{\tau = |\overrightarrow{A}| \qquad \Gamma \vdash e \Rightarrow A \to A \rightsquigarrow y \textbf{ in } J}{\Gamma \vdash \textbf{fix}\, e \Rightarrow A \rightsquigarrow z \textbf{ in } S_3}$$

J-Abs
$$\frac{\tau = |\overrightarrow{B}| \qquad \Gamma, x : A \vdash e \Leftarrow B \rightsquigarrow y \textbf{ in } J}{\Gamma \vdash \lambda x{:}A.\ e{:}B \Rightarrow A \to B \rightsquigarrow z \textbf{ in } S_4}$$

J-App
$$\frac{\Gamma \vdash e_1 \Rightarrow A \rightsquigarrow x \textbf{ in } J_1 \qquad A \rhd B \to C \qquad \Gamma \vdash e_2 \Leftarrow B \rightsquigarrow y \textbf{ in } J_2 \qquad A \rhd x \bullet y \hookrightarrow z \textbf{ with } J_3}{\Gamma \vdash e_1\ e_2 \Rightarrow C \rightsquigarrow z \textbf{ in } S_5}$$

J-TAbs
$$\frac{\tau = |B|^{\forall} \qquad \Gamma, X * A \vdash e \Leftarrow B \rightsquigarrow y \textbf{ in } J}{\Gamma \vdash \Lambda X{*}A.\ e{:}B \Rightarrow \forall X{*}A.\ B \rightsquigarrow z \textbf{ in } S_6}$$

J-TApp
$$\frac{\Gamma \vdash e \Rightarrow B \rightsquigarrow y \textbf{ in } J_1 \qquad B \rhd \forall X{*}C_1.\ C_2 \qquad \Gamma \vdash A * C_1 \qquad B \rhd y \bullet A \hookrightarrow z \textbf{ with } J_2}{\Gamma \vdash e\ A \Rightarrow C_2[X \mapsto A] \rightsquigarrow z \textbf{ in } S_7}$$

J-Rcd
$$\frac{\tau = \{\ell : |A|\} \qquad \Gamma \vdash e \Rightarrow A \rightsquigarrow y \textbf{ in } J}{\Gamma \vdash \{\ell = e\} \Rightarrow \{\ell : A\} \rightsquigarrow z \textbf{ in } S_8}$$

J-Proj
$$\frac{\Gamma \vdash e \Rightarrow A \rightsquigarrow y \textbf{ in } J_1 \qquad A \rhd \{\ell : B\} \qquad A \rhd y \bullet \ell \hookrightarrow z \textbf{ with } J_2}{\Gamma \vdash e.\ell \Rightarrow B \rightsquigarrow z \textbf{ in } S_9}$$

J-Merge
$$\frac{\Gamma \vdash e_1 \Rightarrow A \rightsquigarrow z \textbf{ in } J_1 \qquad \Gamma \vdash e_2 \Rightarrow B \rightsquigarrow z \textbf{ in } J_2 \qquad \Gamma \vdash A * B}{\Gamma \vdash e_1 \,,,\, e_2 \Rightarrow A \,\&\, B \rightsquigarrow z \textbf{ in } S_{10}}$$

J-Anno
$$\frac{\Gamma \vdash e \Leftarrow A \rightsquigarrow z \textbf{ in } J}{\Gamma \vdash e : A \Rightarrow A \rightsquigarrow z \textbf{ in } J}$$

J-Sub
$$\frac{\Gamma \vdash e \Rightarrow A \rightsquigarrow x \textbf{ in } J_1 \qquad A <: B \rightsquigarrow x \mapsto y \textbf{ with } J_2}{\Gamma \vdash e \Leftarrow B \rightsquigarrow y \textbf{ in } S_{11}}$$

```
/* S1 */
z[t] = b;

/* S2 */
Object.assign(z, x);
```

```
/* S3 */
Object.assign(z,
  new function() {
    var y = {};
    J;
    y[t](this, this);
  }
);

/* S4 */
z[t] = (x, y) => { J };

/* S5 */
var x = {};
```

```
J1;
var y = {};
J2;
J3;

/* S6 */
z[t] = X => {
  var y = {};
  J;
  return y;
};

/* S7 */
```

```
var y = {};
J1;
J2;

/* S8 */
z[t] = () => {
  var y = {};
  J;
  return y;
};

/* S9 */
var y = {};
```

```
J1;
J2;

/* S10 */
J1;
J2;

/* S11 */
var x = {};
J1;
J2;
```

$\boxed{A \ \triangleright \ x \bullet \mathit{arg} \ \hookrightarrow \ z \ \textbf{with} \ J}$ *(Distributive application)*

A-Top
$$\frac{\rceil A \lceil}{A \ \triangleright \ x \bullet \mathit{arg} \ \hookrightarrow \ z \ \textbf{with} \ \varnothing}$$

A-Arrow
$$\frac{\tau = |\overrightarrow{B}|}{A \to B \ \triangleright \ x \bullet y \ \hookrightarrow \ z \ \textbf{with} \ S_{12}}$$

A-All
$$\frac{\tau_1 = |B|^{\forall} \qquad \tau_2 = |C|}{\forall X * A.\ B \ \triangleright \ x \bullet C \ \hookrightarrow \ z \ \textbf{with} \ S_{13}}$$

A-Rcd
$$\frac{\tau = \{\ell : |A|\}}{\{\ell : A\} \ \triangleright \ x \bullet \ell \ \hookrightarrow \ z \ \textbf{with} \ S_{14}}$$

A-And
$$\frac{A \ \triangleright \ x \bullet \mathit{arg} \ \hookrightarrow \ z \ \textbf{with} \ J_1 \quad B \ \triangleright \ x \bullet \mathit{arg} \ \hookrightarrow \ z \ \textbf{with} \ J_2}{A \,\&\, B \ \triangleright \ x \bullet \mathit{arg} \ \hookrightarrow \ z \ \textbf{with} \ S_{15}}$$

```
/* S12 */
x[t](y, z);
```

```
/* S13 */
Object.assign(z, x[t1](t2));

/* S14 */
Object.assign(z, x[t]());
```

```
/* S15 */
J1;
J2;
```

$A <: B \rightsquigarrow x \mapsto y \textbf{ with } J$ *(Coercive subtyping)*

S-Top
$$\frac{B^\circ \qquad \rceil B \lceil}{A <: B \rightsquigarrow x \mapsto y \textbf{ with } \varnothing}$$

S-Base
$$\frac{\tau = |\mathbb{B}|}{\mathbb{B} <: \mathbb{B} \rightsquigarrow x \mapsto y \textbf{ with } S_{16}}$$

S-Arrow
$$\frac{\begin{array}{c}\tau_1 = \overrightarrow{|A_2|} \\ \tau_2 = \overrightarrow{|B_2|} \qquad B_2^\circ \qquad B_1 <: A_1 \\ A_2 <: B_2 \rightsquigarrow x_2 \mapsto y_2 \textbf{ with } J_2\end{array}}{A_1 \to A_2 <: B_1 \to B_2 \rightsquigarrow x \mapsto y \textbf{ with } S_{17}}$$

S-All
$$\frac{\begin{array}{c}\tau_1 = |A_2|^\forall \qquad \tau_2 = |B_2|^\forall \\ B_2^\circ \qquad B_1 <: A_1 \\ A_2 <: B_2 \rightsquigarrow x_2 \mapsto y_2 \textbf{ with } J_2\end{array}}{\forall X * A_1.\ A_2 <: \forall X * B_1.\ B_2 \rightsquigarrow x \mapsto y \textbf{ with } S_{18}}$$

S-Rcd
$$\frac{\begin{array}{c}\tau_1 = \{\ell : |A|\} \\ \tau_2 = \{\ell : |B|\} \qquad B^\circ \\ A <: B \rightsquigarrow x_0 \mapsto y_0 \textbf{ with } J\end{array}}{\{\ell : A\} <: \{\ell : B\} \rightsquigarrow x \mapsto y \textbf{ with } S_{19}}$$

S-AndL
$$\frac{C^\circ \qquad A <: C \rightsquigarrow x \mapsto y \textbf{ with } J}{A \,\&\, B <: C \rightsquigarrow x \mapsto y \textbf{ with } J}$$

S-AndR
$$\frac{C^\circ \qquad B <: C \rightsquigarrow x \mapsto y \textbf{ with } J}{A \,\&\, B <: C \rightsquigarrow x \mapsto y \textbf{ with } J}$$

S-Split
$$\frac{\begin{array}{c}B_1 \lhd B \rhd B_2 \\ A <: B_1 \rightsquigarrow x \mapsto y_1 \textbf{ with } J_1 \\ A <: B_2 \rightsquigarrow x \mapsto y_2 \textbf{ with } J_2 \\ y_1 : B_1 \ \rhd\ z : B \ \lhd\ y_2 : B_2 \textbf{ with } J_3\end{array}}{A <: B \rightsquigarrow x \mapsto z \textbf{ with } S_{20}}$$

```
/* S16 */
y[t] = x[t];

/* S17 */
y[t2] = p => {
  var x2 = x[t1](p);
  var y2 = {};
  J2;
  return y2;
};
```

```
/* S18 */
y[t2] = X => {
  var x2 = x[t1](X);
  var y2 = {};
  J2;
  return y2;
};

/* S19 */
y[t2] = () => {
  var x0 = x[t1]();
  var y0 = {};
  J;
  return y0;
}

/* S20 */
var y1 = {};
J1;
var y2 = {};
J2;
J3;
```

$\boxed{x : A \ \triangleright \ z : C \ \triangleleft \ y : B \ \textbf{with} \ J}$ *(Coercive merging)*

M-And
$$\frac{\tau_1 = |A| \qquad \tau_2 = |B|}{x : A \ \triangleright \ z : A \,\&\, B \ \triangleleft \ y : B \ \textbf{with} \ S_{21}}$$

M-Arrow
$$\frac{\begin{array}{c}\tau = |\overrightarrow{B}| \\ \tau_1 = |\overrightarrow{B_1}| \qquad \tau_2 = |\overrightarrow{B_2}| \\ y_1 : B_1 \ \triangleright \ y : B \ \triangleleft \ y_2 : B_2 \ \textbf{with} \ J\end{array}}{x_1 : A \to B_1 \ \triangleright \ z : A \to B \ \triangleleft \ x_2 : A \to B_2 \ \textbf{with} \ S_{22}}$$

M-All
$$\frac{\begin{array}{c}\tau = |B|^{\forall} \\ \tau_1 = |B_1|^{\forall} \qquad \tau_2 = |B_2|^{\forall} \\ y_1 : B_1 \ \triangleright \ y : B \ \triangleleft \ y_2 : B_2 \ \textbf{with} \ J\end{array}}{x_1 : \forall X * A.\ B_1 \ \triangleright \ z : \forall X * A.\ B \ \triangleleft \ x_2 : \forall X * A.\ B_2 \ \textbf{with} \ S_{23}}$$

M-Rcd
$$\frac{\begin{array}{c}\tau = \{\ell : |A|\} \\ \tau_1 = \{\ell : |A_1|\} \\ \tau_2 = \{\ell : |A_2|\} \\ y_1 : A_1 \ \triangleright \ y : A \ \triangleleft \ y_2 : A_2 \ \textbf{with} \ J\end{array}}{x_1 : \{\ell : A_1\} \ \triangleright \ z : \{\ell : A\} \ \triangleleft \ x_2 : \{\ell : A_2\} \ \textbf{with} \ S_{24}}$$

```
/* S21 */
Object.assign(z, x, y);
```

```
/* S22 */
z[t] = p => {
  var y1 = x1[t1](p);
  var y2 = x2[t2](p);
  var y = {};
  J;
  return y;
};
```

```
/* S23 */
z[t] = X => {
  var y1 = x1[t1](X);
  var y2 = x2[t2](X);
  var y = {};
  J;
  return y;
};
```

```
/* S24 */
var y1 = x1[t1]();
var y2 = x2[t2]();
var y = {};
J;
z[t] = y;
```