Featherweight C++

Syntax:

$$\mathtt{S} ::= \mathtt{public} \mid \mathtt{private} \mid \mathtt{protected}$$

$$\mathtt{T} ::= \mathtt{int} \mid \mathtt{bool} \mid \mathtt{C} \mid \mathtt{T}*$$

$$\mathtt{L} ::= \mathtt{class\ C : S\ C}\{\overline{\mathtt{T}}\ \overline{\mathtt{f}};\ \mathtt{K}\ \overline{\mathtt{M}}\}$$

$$\mathtt{K} ::= \mathtt{C}(\overline{\mathtt{C}}\ \overline{\mathtt{f}})\{\mathtt{C}() : \mathtt{D}(\overline{\mathtt{f}});\ \mathtt{this} \to \overline{\mathtt{f}} = \overline{\mathtt{f}};\}$$

$$\mathtt{M} ::= \mathtt{C\ m}(\overline{\mathtt{C}}\ \overline{\mathtt{x}})\{\ \mathtt{return\ e};\ \}$$

$$\mathtt{e} ::= \mathtt{x} \mid \mathtt{e.f} \mid \mathtt{e.m}(\overline{\mathtt{e}}) \mid \mathtt{new\ C}(\overline{\mathtt{e}}) \mid (\mathtt{C})\mathtt{e} \mid\ *\mathtt{e} \mid \mathtt{\&e} \mid \mathtt{e;e} \mid \mathtt{a}$$

$$\mathtt{a} ::= \mathtt{T\ x} := \mathtt{e}$$

Subtyping:

$$\mathtt{C} <: \mathtt{C}$$

$$\frac{\mathtt{C} <: \mathtt{D} \qquad \mathtt{D} <: \mathtt{E}}{\mathtt{C} <: \mathtt{E}}$$

$$\frac{\mathtt{class\ C:S\ D}\{\ldots\}}{\mathtt{C} <: \mathtt{D}}$$

Field lookup:

$$\mathtt{fields}(\mathtt{C}) = \bullet$$

$$\frac{\mathtt{class\ C:S\ D}\{\overline{\mathtt{C}}\ \overline{\mathtt{f}};\ \mathtt{K}\ \overline{\mathtt{M}}\} \qquad \mathtt{fields}(\mathtt{D}) = \overline{\mathtt{D}}\ \overline{\mathtt{g}}}{\mathtt{fields}(\mathtt{c}) = \overline{\mathtt{D}}\ \overline{\mathtt{g}}, \overline{\mathtt{C}}\ \overline{\mathtt{f}}}$$

Method type lookup:

$$\frac{\texttt{class C:S D}\{\bar{\texttt{C}}\ \bar{\texttt{f}};\ \texttt{K}\ \bar{\texttt{M}}\} \qquad \texttt{B m}(\bar{\texttt{B}}\ \bar{\texttt{x}})\{\ \texttt{return e;}\ \} \in \bar{\texttt{M}}}{\texttt{mtype}(\texttt{m},\ \texttt{C}) = \bar{\texttt{B}} \to \texttt{B}}$$

$$\frac{\texttt{class C:S D}\{\bar{\texttt{C}}\ \bar{\texttt{f}};\ \texttt{K}\ \bar{\texttt{M}}\} \qquad \texttt{m} \notin \bar{\texttt{M}}}{\texttt{mtype}(\texttt{m},\ \texttt{C}) = \texttt{mtype}(\texttt{m},\ \texttt{D})}$$

Method body lookup:

$$\frac{\texttt{class C:S D}\{\bar{\texttt{C}}\ \bar{\texttt{f}};\ \texttt{K}\ \bar{\texttt{M}}\} \qquad \texttt{B m}(\bar{\texttt{B}}\ \bar{\texttt{x}})\{\ \texttt{return e;}\ \} \in \bar{\texttt{M}}}{\texttt{mbody}(\texttt{m},\ \texttt{C}) = \bar{\texttt{x}}.\texttt{e}}$$

$$\frac{\texttt{class C:S D}\{\bar{\texttt{C}}\ \bar{\texttt{f}};\ \texttt{K}\ \bar{\texttt{M}}\} \qquad \texttt{m} \notin \bar{\texttt{M}}}{\texttt{mbody}(\texttt{m},\ \texttt{C}) = \texttt{mbody}(\texttt{m},\ \texttt{D})}$$

Expression typing:

$$\Gamma \vdash \texttt{x} : \Gamma(\texttt{x})$$

$$\frac{\Gamma \vdash \texttt{e}_0 : \texttt{C}_0 \qquad \texttt{fields}(\texttt{C}_0) = \bar{\texttt{C}}\ \bar{\texttt{f}}}{\Gamma \vdash \texttt{e}_0.\texttt{f}_\texttt{i} : \texttt{C}_\texttt{i}}$$

$$\frac{\Gamma \vdash \texttt{e}_0 : \texttt{C}_0 \qquad \texttt{mtype}(\texttt{m},\ \texttt{C}_0) = \bar{\texttt{D}} \to \texttt{C} \qquad \Gamma \vdash \bar{\texttt{e}} : \bar{\texttt{C}} \qquad \bar{\texttt{C}} <: \bar{\texttt{D}}}{\Gamma \vdash \texttt{e}_0.\texttt{m}(\bar{\texttt{e}}) : \texttt{C}}$$

$$\frac{\Gamma \vdash \texttt{e}_0 : \texttt{T}*}{\Gamma \vdash *\texttt{e}_0 : \texttt{T}}$$

$$\frac{\Gamma \vdash \texttt{e}_0 : \texttt{C}_0* \qquad \texttt{fields}(\texttt{C}_0) = \bar{\texttt{C}}\ \bar{\texttt{f}}}{\Gamma \vdash \texttt{e}_0 \to \texttt{f}_\texttt{i} : \texttt{C}_\texttt{i}}$$

$$\frac{\Gamma \vdash \texttt{e}_0 : \texttt{C}_0* \qquad \texttt{mtype}(\texttt{m},\ \texttt{C}_0) = \bar{\texttt{T}} \to \texttt{T} \qquad \Gamma \vdash \bar{\texttt{e}} : \bar{\texttt{T}}}{\Gamma \vdash \texttt{e}_0 \to \texttt{m}(\bar{\texttt{e}}) : \texttt{T}}$$

$$\frac{\Gamma \vdash \texttt{e}_0 : \texttt{T}}{\Gamma \vdash \&\texttt{e}_0 : \texttt{T}*}$$

$$\frac{\Gamma \vdash \texttt{e}_0 : \texttt{T}_0 \qquad \texttt{e}_1 : \texttt{T}}{\Gamma \vdash \texttt{e}_0;\texttt{e}_1 : \texttt{T}}$$

$$\frac{\Gamma \vdash \texttt{e}_0 : \texttt{T}}{\Gamma \vdash \texttt{x} := \texttt{e}_0 : \texttt{T}}$$

Method typing:

Class typing:

$$\frac{\texttt{K::=C(}\bar{\texttt{C}}\bar{\texttt{f}}\texttt{)\{C():D(}\bar{\texttt{f}}\texttt{); this->}\bar{\texttt{f}}\texttt{=}\bar{\texttt{f}}\texttt{;\}} \quad \texttt{fields(D)=}\bar{\texttt{D}}\ \bar{\texttt{g}} \quad \bar{\texttt{M}}\ \texttt{OK IN C}}{\texttt{class C:S D\{}\bar{\texttt{C}}\ \bar{\texttt{f}}\texttt{; K }\bar{\texttt{M}}\texttt{\} OK}}$$

Memory:

$$\texttt{st} = \texttt{Mem} \rightarrow \texttt{Value}$$

$$\texttt{env} = \texttt{Var} \rightarrow \texttt{Mem}$$

$$\frac{\texttt{x} \in \texttt{env} \quad \texttt{Mem}_\texttt{x}\texttt{=env(x)}}{\texttt{<x:=v,env,st>} \rightarrow \texttt{<v,env["x"} \mapsto \texttt{Mem}_\texttt{x}\texttt{],st[env("x")} \mapsto \texttt{v]>}}$$

$$\frac{\texttt{x} \notin \texttt{env} \quad \texttt{Mem}_\texttt{x}\texttt{=len(st)+1}}{\texttt{<x:=v,env,st>} \rightarrow \texttt{<v,env["x"} \mapsto \texttt{Mem}_\texttt{x}\texttt{],st[env("x")} \mapsto \texttt{v]>}}$$

$$\frac{\texttt{p : T*} \quad \texttt{Mem}_\texttt{x}\texttt{=env("p")} \quad \texttt{Mem}_\texttt{v}\texttt{=env("v")}}{\texttt{<p:=\&v,env,st>} \rightarrow \texttt{<\&v,env,st[Mem}_\texttt{x} \mapsto \texttt{Mem}_\texttt{v}\texttt{]>}}$$

$$\frac{\texttt{p : T*} \quad \texttt{Mem}_\texttt{x}\texttt{=env("p")}}{\texttt{<*p:=v,env,st>} \rightarrow \texttt{<v,env,st[Mem}_\texttt{x} \mapsto \texttt{v]>}}$$

$$\texttt{p : T*} \quad \texttt{Mem}_\texttt{x}\ \texttt{is unused} \in \texttt{st} \quad \texttt{Mem}_\texttt{x} = \texttt{len(st)} + \texttt{1}$$

$$\frac{\texttt{For each field f}_\texttt{i} \in \texttt{T, Mem}_{\texttt{x}_\texttt{i}} = \texttt{len(st)+i}}{\texttt{<p:=new T(}\bar{\texttt{e}}\texttt{),env,st>} \rightarrow \texttt{<T(}\bar{\texttt{v}}\texttt{),env["p"} \mapsto \texttt{Mem}_\texttt{x}\texttt{],st[Mem}_\texttt{x} \mapsto \texttt{T(}\bar{\texttt{v}}\texttt{), Mem}_{\texttt{x}_0} \mapsto \texttt{f}_0\texttt{,...,Mem}_{\texttt{x}_\texttt{i}} \mapsto \texttt{f}_\texttt{i}\texttt{]>}}$$

$$\frac{\texttt{x:T}}{\texttt{<\&x,env,st>} \rightarrow \texttt{<env("x"),env,st>}}$$

$$\frac{\texttt{st(env("x"))=v}}{\texttt{<x,env,st>} \rightarrow \texttt{<v,env,st>}}$$

$$\frac{\texttt{Mem}_\texttt{x}\texttt{=env(p)} \quad \texttt{st(Mem}_\texttt{x}\texttt{)=v}}{\texttt{<*p,env,st>} \rightarrow \texttt{<v,env,st>}}$$