GrumpyIR Static Semantics

April 4, 2021

The GrumpyIR static semantics (i.e., the type system) is given as a five-place relation on a function typing context Δ, a variable typing context Γ, a store typing Σ, an expression e, and a type T, written $\Delta \mid \Gamma \mid \Sigma \vdash e : \mathrm{T}$, pronounced "under Δ, Γ, and Σ, expression e has type T". Formally, the static semantics is taken to be the smallest relation satisfying the following typing rules:

Values and names

$$\textsc{T-n}\quad \frac{}{\Delta \mid \Gamma \mid \Sigma \vdash n : \mathrm{i32}} \qquad \textsc{T-true}\quad \frac{}{\Delta \mid \Gamma \mid \Sigma \vdash \mathrm{true} : \mathrm{bool}} \qquad \textsc{T-false}\quad \frac{}{\Delta \mid \Gamma \mid \Sigma \vdash \mathrm{false} : \mathrm{bool}}$$

$$\textsc{T-tt}\quad \frac{}{\Delta \mid \Gamma \mid \Sigma \vdash \mathrm{tt} : \mathrm{unit}} \qquad \textsc{T-loc}\quad \frac{(l : \mathrm{array}\ \mathrm{T}) \in \Sigma}{\Delta \mid \Gamma \mid \Sigma \vdash l : \mathrm{array}\ \mathrm{T}} \qquad \textsc{T-var}\quad \frac{(x : \mathrm{T}) \in \Gamma}{\Delta \mid \Gamma \mid \Sigma \vdash x : \mathrm{T}}$$

$$\textsc{T-funptr}\quad \frac{(p : \mathrm{fun}\ (\mathrm{T}_1, \mathrm{T}_2, ..., \mathrm{T}_n)\ \mathrm{T}) \in \Delta}{\Delta \mid \Gamma \mid \Sigma \vdash p : \mathrm{fun}\ (\mathrm{T}_1, \mathrm{T}_2, ..., \mathrm{T}_n)\ \mathrm{T}}$$

Unary and binary operators

$$\textsc{T-neg}\quad \frac{\Delta \mid \Gamma \mid \Sigma \vdash e : \mathrm{bool}}{\Delta \mid \Gamma \mid \Sigma \vdash (\mathrm{neg}\ e) : \mathrm{bool}}$$

$$\textsc{T-binop-i32}\quad \frac{\Delta \mid \Gamma \mid \Sigma \vdash e_1 : \mathrm{i32} \qquad \Delta \mid \Gamma \mid \Sigma \vdash e_2 : \mathrm{i32} \qquad b \in \{+, *, -, /\}}{\Delta \mid \Gamma \mid \Sigma \vdash (b\ e_1\ e_2) : \mathrm{i32}}$$

$$\textsc{T-binop-bool}\quad \frac{\Delta \mid \Gamma \mid \Sigma \vdash e_1 : \mathrm{i32} \qquad \Delta \mid \Gamma \mid \Sigma \vdash e_2 : \mathrm{i32} \qquad b \in \{<, ==\}}{\Delta \mid \Gamma \mid \Sigma \vdash (b\ e_1\ e_2) : \mathrm{bool}}$$

Let-expressions and sequencing

$$\textsc{T-let}\quad \frac{\Delta \mid \Gamma \mid \Sigma \vdash e_1 : \mathrm{T}_1 \qquad \Delta \mid \Gamma, (x : \mathrm{T}_1) \mid \Sigma \vdash e_2 : \mathrm{T}_2}{\Delta \mid \Gamma \mid \Sigma \vdash (\mathrm{let}\ x\ e_1\ e_2) : \mathrm{T}_2}$$

$$\textsc{T-seq}\quad \frac{\Delta \mid \Gamma \mid \Sigma \vdash e_1 : \mathrm{T}_1 \qquad \Delta \mid \Gamma \mid \Sigma \vdash e_2 : \mathrm{T}_2}{\Delta \mid \Gamma \mid \Sigma \vdash (\mathrm{seq}\ e_1\ e_2) : \mathrm{T}_2}$$

Arrays

$$\textsc{T-alloc}\quad \frac{\Delta \mid \Gamma \mid \Sigma \vdash e_{size} : \mathrm{i32} \qquad \Delta \mid \Gamma \mid \Sigma \vdash e_{init} : \mathrm{T}}{\Delta \mid \Gamma \mid \Sigma \vdash (\mathrm{alloc}\ e_{size}\ e_{init}) : \mathrm{array}\ \mathrm{T}}$$

$$\textsc{T-set}\quad \frac{\Delta \mid \Gamma \mid \Sigma \vdash e_{arr} : \mathrm{array}\ \mathrm{T} \qquad \Delta \mid \Gamma \mid \Sigma \vdash e_{ix} : \mathrm{i32} \qquad \Delta \mid \Gamma \mid \Sigma \vdash e : \mathrm{T}}{\Delta \mid \Gamma \mid \Sigma \vdash (\mathrm{set}\ e_{arr}\ e_{ix}\ e) : \mathrm{unit}}$$

$$\textsc{T-get}\quad \frac{\Delta \mid \Gamma \mid \Sigma \vdash e_{arr} : \mathrm{array}\ \mathrm{T} \qquad \Delta \mid \Gamma \mid \Sigma \vdash e_{ix} : \mathrm{i32}}{\Delta \mid \Gamma \mid \Sigma \vdash (\mathrm{get}\ e_{arr}\ e_{ix}) : \mathrm{T}}$$

Conditionals and function calls

$$\textsc{T-cond}\quad \frac{\Delta \mid \Gamma \mid \Sigma \vdash e_{cond} : \mathrm{bool} \qquad \Delta \mid \Gamma \mid \Sigma \vdash e_1 : \mathrm{T} \qquad \Delta \mid \Gamma \mid \Sigma \vdash e_2 : \mathrm{T}}{\Delta \mid \Gamma \mid \Sigma \vdash (\mathrm{cond}\ e_{cond}\ e_1\ e_2) : \mathrm{T}}$$

$$\textsc{T-call}\quad \frac{\Delta \mid \Gamma \mid \Sigma \vdash e : \mathrm{fun}\ (\mathrm{T}_1, \mathrm{T}_2, ..., \mathrm{T}_n)\ \mathrm{T} \qquad \Delta \mid \Gamma \mid \Sigma \vdash e_i : \mathrm{T}_i}{\Delta \mid \Gamma \mid \Sigma \vdash (\mathrm{call}\ e\ e_1\ e_2\ ...\ e_n) : \mathrm{T}}$$