

## 2 Typing Rules

### Literals

$$\text{true} : \text{Bool} \quad (\text{T-TRUE})$$

$$\text{false} : \text{Bool} \quad (\text{T-FALSE})$$

### Variables

$$\frac{\Gamma(x) = T}{\Gamma \vdash x : T} \quad (\text{T-VAR})$$

### Patterns

$$\overline{\Gamma \vdash n : T} \quad (\text{T-LITERALPATTERN})$$

$$\overline{\Gamma \vdash x : T \Rightarrow \{x : T\}} \quad (\text{T-VARIABLEPATTERN})$$

$$\overline{\Gamma \vdash \_ : T} \quad (\text{T-DISCARDPATTERN})$$

$$\frac{\Gamma \vdash p_1 : T_1 \Rightarrow \Gamma_1 \dots \Gamma \vdash p_n : T_n \Rightarrow \Gamma_n}{\Gamma \vdash (p_1, \dots, p_n) : T_1 \times \dots \times T_n \Rightarrow \Gamma_1 \cup \dots \cup \Gamma_n} \quad (\text{T-TUPLEPATTERN})$$

$$\frac{\Gamma \vdash p_1 : T_1 \Rightarrow \Gamma_1 \dots \Gamma \vdash p_n : T_n \Rightarrow \Gamma_n}{\Gamma \vdash C(p_1, \dots, p_n) : T \Rightarrow \Gamma_1 \cup \dots \cup \Gamma_n} \quad (\text{T-VARIANTPATTERN})$$

$$\frac{\Gamma \vdash p_1 : T_1 \Rightarrow \Gamma_1 \dots \Gamma \vdash p_n : T_n \Rightarrow \Gamma_n}{\Gamma \vdash T\{f_1 = p_1, \dots, f_n = p_n\} : T \Rightarrow \Gamma_1 \cup \dots \cup \Gamma_n} \quad (\text{T-DESTRUCTPATTERN})$$

### Subtyping

$$S <: S \quad (\text{S-REFL})$$

$$\frac{S <: U \quad U <: T}{S <: T} \quad (\text{S-TRANS})$$

### Subsumption

$$\frac{\Gamma \vdash e : S \quad S <: T}{\Gamma \vdash e : T} \quad (\text{T-SUB})$$

## Function

$$\frac{\Gamma, x : T_{arg}, ret_f : T_{ret} \vdash S : \text{Void}}{\Gamma \vdash \text{fn}(x : T_{arg}) \rightarrow T_{ret} \text{ do } S \text{ end} : \text{Void}} \quad (\text{T-FN})$$

$$\frac{\Gamma, x : T_{arg}, ret_f : T_{ret} \vdash S : \text{Void}}{\Gamma, f : T_{arg} \rightarrow T_{ret} ; \Delta, f : \text{const} \vdash \text{fn } f(x : T_{arg}) \rightarrow T_{ret} \text{ do } S \text{ end} : \text{Void}} \quad (\text{T-FNDEF})$$

$$\frac{\Gamma \vdash e : S_{ret} \quad ret_f : T_{ret} \in \Gamma \quad S_{ret} <: T_{ret}}{\Gamma \vdash \text{return } e : \text{Void}} \quad (\text{T-RETURN})$$

$$\frac{\Gamma \vdash f : T_{arg} \rightarrow T_{ret} \quad \Gamma \vdash e : S_{arg} \quad S_{arg} <: T_{arg}}{\Gamma \vdash f(e) : T_{ret}} \quad (\text{T-APP})$$

## Variable Definitions

$$\frac{\Gamma \vdash e : T}{\Gamma, x : T ; \Delta, x : \text{var} \vdash \text{let } x = e : \text{Void}} \quad (\text{T-LET})$$

$$\frac{\Gamma \vdash e : T}{\Gamma, x : T ; \Delta, x : \text{const} \vdash \text{const } x = e : \text{Void}} \quad (\text{T-CONST})$$

## Sequence

$$\frac{\Gamma \vdash S_1 : \text{Void} \quad \Gamma \vdash S_2 : \text{Void}}{\Gamma \vdash S_1 ; S_2 : \text{Void}} \quad (\text{T-SEQUENCE})$$

## Assignment

$$\frac{\Gamma(x) = T \quad \Sigma(x) = \text{var} \quad \Gamma \vdash e : S \quad S <: T}{\Gamma \vdash x = e : \text{Void}} \quad (\text{T-ASSIGN})$$

## Scope

$$\frac{\Gamma \vdash S : \text{Void}}{\Gamma \vdash \text{do } S \text{ end} : \text{Void}} \quad (\text{T-SCOPE})$$

## If

$$\frac{\Gamma \vdash e : \text{Bool} \quad \Gamma \vdash S_1 : \text{Void} \quad \Gamma \vdash S_2 : \text{Void}}{\text{if } e \text{ do } S_1 \text{ end else do } S_2 \text{ end} : \text{Void}} \quad (\text{T-IFELSE})$$

$$\frac{\Gamma \vdash e_1 : \text{Bool} \quad \Gamma \vdash e_2 : T_1 \quad \Gamma \vdash e_3 : T_2}{\text{if } e_1 \text{ then } e_2 \text{ else } e_3 : \text{lub}(T_1, T_2)} \quad (\text{T-IFTHEN})$$

## Match

$$\frac{\Gamma \vdash e : T \quad \forall i. \Gamma, x : T \vdash p_i \text{ ok} \quad \Gamma, x : T \vdash g : \text{Bool} \quad \Gamma, x : T \vdash S_i : \text{Void}}{\Gamma \vdash \text{match } e \text{ as } x \text{ case } p_i \text{ if } g \text{ do } S_i \text{ end ... end} : \text{Void}} \quad (\text{T-MATCHSTMT})$$

$$\frac{\Gamma \vdash e : T \quad \forall i. \Gamma, x : T \vdash p_i \text{ ok} \quad \Gamma, x : T \vdash g : \text{Bool} \quad \Gamma, x : T \vdash e_i : T_i}{\Gamma \vdash \text{match } e \text{ as } x \text{ case } p_i \text{ if } g \Rightarrow e_i \dots \text{end} : \text{lub}(T_1, \dots, T_n)} \quad (\text{T-MATCHEXPR})$$

## While

$$\frac{\Gamma \vdash e : \text{Bool} \quad \Gamma, \text{loop} \vdash S : \text{Void}}{\Gamma \vdash \text{while } e \text{ do } S \text{ end} : \text{Void}} \quad (\text{T-WHILE})$$

## Break/Continue

$$\frac{\text{loop} \in \Gamma}{\Gamma \vdash \text{break} : \text{Void}} \quad (\text{T-BREAK})$$

$$\frac{\text{loop} \in \Gamma}{\Gamma \vdash \text{continue} : \text{Void}} \quad (\text{T-CONTINUE})$$

## Throw

$$\frac{\Gamma \vdash e : T}{\Gamma \vdash \text{throw } e : \text{Void}} \quad (\text{T-THROW})$$

## Try

$$\frac{\Gamma \vdash e : T_1 \quad \Gamma \vdash e_{\text{def}} : T_2}{\Gamma \vdash \text{try } e \text{ else } e_{\text{def}} : \text{lub}(T_1, T_2)} \quad (\text{T-TRYELSE})$$

$$\frac{\Gamma \vdash S : \text{Void} \quad \forall i. \Gamma, x_i : T_i \vdash S_i : \text{Void}}{\Gamma \vdash \text{try } S \text{ catch } T_i \text{ as } x_i \text{ do } S_i \text{ end ... end} : \text{Void}} \quad (\text{T-TRYCATCH})$$