

25-1/

orig:

← free

$$\frac{\Gamma [X \mapsto T_D] \vdash M : T_R}{\Gamma \vdash \lambda X. M : T_D \rightarrow T_R}$$

new

$\lambda X. M$

into

$\lambda X : T. M$

↳ fix of type annotation.

"int x = 5"
Java

"x = 5"
Python

"y = 'foo'"

"List<posn<int>> l = new List<posn<int>> One(new Posn<int>(5, 6));"

(++11 "auto x = 5" "auto *l = new List<posn<int>> ..."

fun (x) { ... x + 5 ... }
↳ Ah ha! x is an int!

f = fun (x) { ... }

f(5) → Ah! x is an int!

Type Inference - ML, Haskell, Scala, Typed Racket

Constraint Generation

- look at program
- determine how values are used
- generate a system of equations

ThePyType = num
+ str
+ array

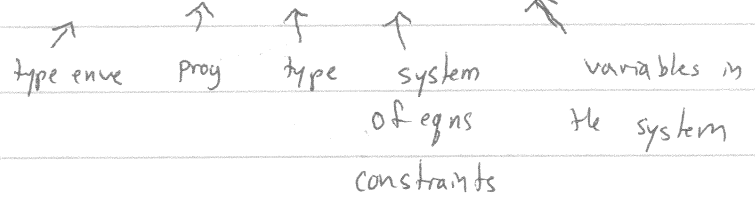
Uni-typed

Constraint Solving

- solves the system
- returns annotations

25-2 / $\Gamma \vdash M : T$ (old type checker)

$\Gamma \vdash M : T ; C ; X$ (new type inference)



$C = \text{set of } T=T$
 $X = \text{set of } A$

$B(b) = T$ B is the constant type lookup

$\Gamma \vdash b : T ; \emptyset ; \emptyset$

$\Gamma \vdash M : T_M ; C_M ; X_M$ A is fresh

$\Gamma \vdash N : T_N ; C_N ; X_N$

$X \mapsto T \in \Gamma$

$\Gamma \vdash X : T ; \emptyset ; \emptyset$

$\Gamma \vdash (M N) : A ; C_M \cup C_N \cup \{T_M = T_N \rightarrow A\}$
 $; X_M \cup X_N \cup \{A\}$

$\Gamma [X \mapsto A] \vdash M : T_M ; C_M ; X_M$

$\Gamma \vdash \lambda X : M : (A \rightarrow T_M) ; C_M ; X_M \cup \{A\}$

$\Gamma \vdash M : T_M ; C_M ; X_M$

$\Gamma \vdash N : T_N ; C_N ; X_N$

$\Gamma \vdash (+ M N) : \text{num} ; C_M \cup C_N \cup \{T_M = \text{Num}, T_N = \text{Num}\}$
 $; X_M \cup X_N$

$\lambda x. (\lambda f.$

$(^2 (^3 f x) + ^5 x)))$

type: $X \rightarrow F \rightarrow \text{Num}$

constraints: $F = X \rightarrow A_2$

$A_2 = \text{Num}$

$X = \text{Num}$

vars: F, X, A_2

$\Gamma_1 \vdash 4 : X ; \emptyset ; \emptyset$

$\Gamma_1 \vdash 3 : F ; \emptyset ; \emptyset$

$\Gamma_1 \vdash 2 : A_2 ; \emptyset \cup \emptyset \cup \{F = X \rightarrow A_2\} ; \{A_2\}$ $\Gamma_1 \vdash 5 : X ; \emptyset ; \emptyset$

$\Gamma_1 = \emptyset [x \rightarrow X] [f \rightarrow F] \vdash 6 : \text{num} ; \{F = X \rightarrow A_2, A_2 = \text{Num}, X = \text{Num}\} ; \{A_2\}$

$\emptyset [x \rightarrow X] \vdash 1 : (F \rightarrow \text{Num}) ; " ; \{A_2, F\}$

$\emptyset \vdash 0 : (X \rightarrow (F \rightarrow \text{Num})) ; " ; \{A_2, F, X\}$

