

Computer Science & Engineering Department
I. I. T. Kharagpur

Principles of Programming Languages: CS40032

Elective

Assignment – 6: Extended type calculus, $\lambda_{rr}^{\rightarrow}$

Marks: 30

Assign Date: 19th March, 2020

Submit Date: 26th March, 2019

Note: Please refer to the slides on pre-expressions and type-checking rules for any clarifications of the syntax.

1. The given extended typed λ -calculus expressions have undefined types. Find the inconsistencies and try to fix them by modifying the type environment and/or the pre-expressions (In case multiple answers are possible, write any one). [2*5 = 10]

(a) Given $\mathcal{E}_0 = \{y : Int\}$:

$y := 4$

(b) Given the constants $2 : Int, 3 : Int, 4 : Int, func : Int \rightarrow Bool \rightarrow Int$

$\lambda(argv : Bool \times Int \times (Int \rightarrow Bool \rightarrow Int)). (argv) < 3, 4, func >$

(c) Given the constants $true : Bool$ and $4 : Int$

$\lambda(b : Bool). (if\ b\ then\ \{true\}\ else\ \{4\})$

(d) Given $\mathcal{E}_0 = \{r : \{|I_1 : Int, I_2 : Float, I_3 : Double|\}$

$\lambda(f : Double \rightarrow Int, g : Int \rightarrow Double).(f(g(r.I_2)))$

(e) Given $\mathcal{E}_0 = \{M : Double + Bool + Int\}$

case M of

$x : Double\ then\ (x) \ ||$

$y : Bool\ then\ (y) \ ||$

$z : Int\ then\ (z)$

2. Derive the type of each of the following expression. Show the derivation in each term. [2+4+4 = 10]

(a) Given $\mathcal{E}_0 = \{x : Ref\ Bool, y : Bool\}$ and the constants $succ : Int \rightarrow Int, true : Bool, 4 : Int$:

$succ\ 4; x := true$

(b) Given $\mathcal{E}_0 = \{M : Int + Bool\}$ and the constants $succ : Int \rightarrow Int, 4 : Int, 6 : Int$:

case M of

$x : Int\ then\ (succ\ x) \ ||$

$b : Bool\ then\ (if\ b\ then\ 4\ else\ 6)$

(c) Given the constants $\{1 : Int, 99.9 : Float, myOp : Float \rightarrow Float\}$

$\lambda(f : Float \rightarrow Float).\lambda(x : Float).(f\ x)\ (proj_2(< 1, myOp, 99.9 >))$

3. Derive the type of each of the following expression and evaluate them.
Any assumptions are welcome. [5 + 5 = 10]

- (a) Given the constants $pred : Int \rightarrow Int$ is a function that computes the predecessor, $true : Bool$, $false : Bool$, $1 : Int$, $4 : Int$, $3 : Int$:

$$\{pred\ 4, \text{ if true then false else false}\}.I_1$$

- (b) Given $isGreaterThanOr$ and $isZero$ are type constants with the type $Float \rightarrow Int \rightarrow Bool$ and $Int \rightarrow Bool$ respectively. The type of y and 3 is Int :

$$\lambda(y : Int).(\text{if false then } (\lambda(f : Bool \rightarrow Bool). (f (isZero\ y)))$$

$$\text{else } (\lambda(g : Bool \rightarrow Bool). (g (3.8\ isGreaterThanOr\ y))))\ 6$$