

CIS 500 — Software Foundations

Homework Assignment 7

Extensions of simple types

Due: Monday, October 30, 2006, by noon

Submit your solutions as `hw7`, for example using the command:

```
~cis500/bin/cis500submit hw7 hw7.pdf
```

- 1 Exercise** For each new extension to the simply-typed lambda calculus (λ_{\rightarrow}) with error (see Figure 14-1), we must add new rules to propagate the error. For example, in the language $\lambda_{\rightarrow} + \text{error} + \text{booleans}$, we need the rule:

$$\text{if error then } t_2 \text{ else } t_3 \longrightarrow \text{error}$$

What new rules do we need for $\lambda_{\rightarrow} + \text{error} + \text{unit} + \text{references}$, i.e., the language of Figure 13-1 extended with `error`?

- 2 Exercise** Suppose we extend the language $\lambda_{\rightarrow} + \text{unit} + \text{references}$ (Figure 13-1) with the following new syntax, typing rules, and evaluation rules:

$$\begin{array}{l} \mathbf{t} ::= \dots \quad \text{terms:} \\ \quad \text{free } \mathbf{t} \quad \text{deallocation} \\ \\ \frac{\Gamma \mid \Sigma \vdash \mathbf{t} : \text{Ref } T}{\Gamma \mid \Sigma \vdash \text{free } \mathbf{t} : \text{Unit}} \text{T-FREE} \\ \\ \frac{1 \in \text{dom}(\mu)}{\text{free } 1 \mid \mu \longrightarrow \text{unit} \mid (\mu \setminus \{1\})} \text{E-FREEREF} \quad \frac{\mathbf{t} \mid \mu \longrightarrow \mathbf{t}' \mid \mu'}{\text{free } \mathbf{t} \mid \mu \longrightarrow \text{free } \mathbf{t}' \mid \mu'} \text{E-FREE} \end{array}$$

where we use the notation $\mu \setminus \{1\}$ to indicate the store μ without any binding for the location 1. Some questions about this language:

1. Does progress (Theorem 13.5.7) hold for this language? If so, give the new case(s) in the proofs. If not, give a counterexample.
2. Does preservation (Theorem 13.5.3) hold for this language? If so, give the new case(s) in the proofs. If not, give a counterexample.
3. Based on your answers to the previous two questions, can you give a program \mathbf{t} in this language with $\emptyset \mid \emptyset \vdash \mathbf{t} : T$ and $\mathbf{t} \mid \emptyset \longrightarrow^* \mathbf{t}' \mid \mu' \not\rightarrow$ such that \mathbf{t}' is not a value? If not, why not? If so, give such a program.

- 3 Exercise** Exercise 13.3.1 from TAPL. (Again, this exercise has a solution in the back of the book. To get full value out of the assignment, don't peek until after you have written out a complete solution of your own.)

4 Debriefing

1. Approximately how many hours (per person, on average) did you spend on this assignment?
2. Would you rate it as easy, moderate, or difficult?
3. How deeply do you feel you understand the material it covers (0%–100%)?
4. Any other comments?