Homework 7: Object Calculus

Due: Tuessday, December 8, 2003.

This homework should be done individually. Its purpose is to have you learn about the untyped first-order object calculus, which is the basis for our formal study of aspect-oriented programs.

For this homework, read chapter 6 and the first two pages of chapter 7 in Abadi and Cardelli's book *A Theory of Objects* (Springer-Verlag, 1996). This was passed out in class. (If you wish, you may omit section 6.6.)

Don't hesitate to contact the staff if you are not clear about what to do.

1. (5 points) According to the conventions of the object calculus, are the following two objects the same? (That is, are they in the $\equiv$ relation?)

$$[arg = \varsigma(x)x.arg,\ val = \varsigma(y)y.succ]$$
$$[val = \varsigma(z)z.succ,\ arg = \varsigma(n)n.arg]$$

2. (5 points) According to the conventions of the object calculus, are the following two objects the same? (That is, are they in the $\equiv$ relation?)

$$[arg = \varsigma(x)x.arg,\ val = \varsigma(y)y.succ]$$
$$[foo = \varsigma(x)x.foo,\ v = \varsigma(y)y.succ]$$

3. (2 points) Consider the term $(calculator.enter.arg \Leftarrow \varsigma(x)5.0).val.equals$. According to the conventions of the object calculus, which of the following is the correct way this should be parsed?

   (a) $(((calculator.enter).arg \Leftarrow \varsigma(x)5.0).val).equals$

   (b) $(calculator.(enter.(arg \Leftarrow \varsigma(x)5.0.(val.equals))))$

4. (15 points) Using the operational semantics on p. 64, give a formal derivation of the following (from p. 72), using Abadi and Cardelli's proof format (see pp. 79-80).

$$(o.arg \Leftarrow \varsigma(z)3).val$$
$$\text{where } o \stackrel{\text{def}}{=} [arg = \varsigma(x)x.arg,\ val = \varsigma(x)x.arg]$$

   (Hint, define abbreviations for the objects that appear along the way, instead of writing them into the body of the derivation.)

5. (3 points) What term in the λ-calculus is the object o defined in problem 4 a desugaring of? That is, what lambda term desugars to o in problem 4.

6. (2 points) Given that o is defined as in problem 4, what term in the λ-calculus is the term $(o.arg \Leftarrow \varsigma(z)3).val$ a desugaring of?

7. (3 points) Consider the object *calculator* defined as follows:

$$\begin{aligned} calculator \stackrel{\text{def}}{=}\ & [arg = \varsigma(s)0.0, \\ & acc = \varsigma(s)0.0, \\ & enter = \varsigma(s)[arg = \varsigma(x)x.arg,\ val = \varsigma(x)s.arg \Leftarrow \varsigma(z)x.arg], \\ & equals = \varsigma(s)s.arg] \end{aligned}$$

   Aside from leaving out the *add* and *sub* methods, is this equivalent to (i.e., a correct desugaring of) the object *calculator* that is shown at the top of p. 72 of the Abadi and Cardelli book? (That is, does it properly follow the desugaring rules?) If not, give a correct desugaring of this object.

8. (30 points; extra credit) Using the operational semantics on p. 64, and a corrected definition of the *calculator* object given in problem 7, give a formal derivation of the following (from p. 72), using Abadi and Cardelli's proof format (see pp. 79-80).

$$(calculator.enter.arg \Leftarrow \varsigma(x)5.0).val.equals$$

In your derivation, consider 5.0 to be an object (not a selection). (Hint, define abbreviations for the objects that appear along the way, instead of writing them into the body of the derivation.)