1997 Paper 9 Question 7

Optimising Compilers

Explain what is meant by an *effect system* for a typed language. Distinguish between immediate effects and possible other effects; also give a typical form of sequent $\Gamma \vdash e : \langle whatever \rangle$. [4 marks]

Given the following subset of ML,

$$e ::= x \mid \lambda x.e \mid e\ e' \mid let\ x = e\ in\ e' \mid if\ e\ then\ e'\ else\ e'' \mid ref\ e \mid\ !e \mid e := e',$$

design an effect system for terms e, for which the (immediate) effects of an expression are any subset of $\{C, R, W\}$ representing reference creation, dereferencing and assignment to some reference cell. You may assume that the ML-like types t of the language involve integers, functions and reference types but have no polymorphism. Assume also that assignment returns the value assigned. It suffices to give clauses for x, $\lambda x.e$, $e\ e'$, $if\ e\ then\ e'\ else\ e''$ and $e := e'$. [6 marks]

Explain how your system copes with terms like

$$\lambda x.\lambda y.if\ x\ then\ y := 1\ else\ 0$$

and

$$\lambda x.\lambda y.if\ x\ then\ \lambda z.y := z + 1\ else\ \lambda z.0.$$

(If your system cannot handle these cases then instead explain how one might adjust it to do so.) [4 marks]

Explain how the analysis might be used to determine when the optimisation of $e + e$ to $let\ x = e\ in\ x + x$ is safe. [3 marks]

Similarly, suggest a criterion on the type or effect of f in $let\ f = \lambda x.e\ in\ f(1) + f(2)$ which would enable the two calls to f to be evaluated concurrently. [3 marks]