

12 Optimising Compilers (tmj32)

- (a) Describe inference-based program analysis on expressions  $e$ . Explain how it can be used to judge effect systems. [3 marks]

- (b) Give inference rules and a set of effects for an effect system for the following language:

$$e ::= x \mid \lambda x.e \mid e_1 e_2 \mid \text{if } e_1 \text{ then } e_2 \text{ else } e_3 \mid \mathcal{O}(\xi).e \mid \mathcal{W}(\xi e_1).e_2 \mid \mathcal{C}(\xi).e$$

where  $\mathcal{O}(\xi).e$  opens file  $\xi$  and results in the value of  $e$ ,  $\mathcal{W}(\xi e_1).e_2$  evaluates  $e_1$  and writes its (integer) value to file  $\xi$  before resulting in the value of  $e_2$ , and  $\mathcal{C}(\xi).e$  closes file  $\xi$  before resulting in the value of  $e$ . The language types are integers and functions. [4 marks]

- (c) Give and explain the safety condition for this system. [3 marks]

- (d) Show how the rules from Part (b) assign a type and effect(s) to the following expression.

$$\mathcal{O}(\xi).\text{if } x \text{ then } \lambda x.\mathcal{W}(\xi x).\mathcal{C}(\xi).x \text{ else } \lambda x.\mathcal{C}(\xi).x$$

[5 marks]

- (e) Justify that the effect system will allow us to identify all expressions with incorrect use of files or, using an example, describe why it won't and show how to alter the effect system so that it will allow us to. [5 marks]