

# Computer Science Comprehensive Exam—Fall 2005

## Programming Languages

**Instructions:** Do *not* put your name on the exam, please answer all the questions directly on the exam itself. You have 90 minutes. Explain answers as fully as possible; if appropriate give examples or define terms. Answer as many questions as you have time for.

1. The programming language Fortran has been in wide-spread use for 50 years. Explain briefly the technical and pragmatic reasons for the success of Fortran.
2. Give a regular expression to describe strings with more than one pair of consecutive  $a$ 's.
3. Consider the definition of a type system by Benjamin Pierce:

A *type system* is a tractable syntactic method for proving the absence of certain program behaviors by classifying phrases according to the kinds of values they compute.

Please tell me in your own words what Pierce meant by each of the following words:

- (a) tractable
  - (b) syntactic
  - (c) behaviors
  - (d) phrases
4. The programming language Java, like all object-oriented languages, has subtype polymorphism. Give an example and explain. Java 1.5 has added universal polymorphism to the language (making it like C++ in this respect), give an example in either Java or C++ of universal polymorphism and explain. Java 1.5 has also added a type of bounded quantification polymorphism. Give an example in Java (or C#) and explain.
  5. What is a nondeterministic control construct? Give an example. Explain their importance.
  6. What is the type of the following ML function? Describe in a few words what the function does.  

```
fun fold f ie nil = ie | f ie (x::xs) = f (x, fold f ie xs)
```
  7. The list data structure is primitive in PROLOG. Nonetheless, explain how the programmer could define the list data structure anyway in PROLOG.
  8. What is a unifying substitution? Give the most general unifying substitution for each of the following pairs of terms ( $x$ ,  $y$ , and  $z$  are variables):

$$\begin{array}{ll} j(x, a, x) & j(x, a, x) \\ j(x, b, x) & j(x, b, y) \\ j(x, y) & j(y, h(a, x)) \\ f(g(a, b), h(x, y)) & f(g(z, b), h(b, b)) \end{array}$$

9. Consider the following PROLOG program where A, B, and C are unary predicate symbols, x, y, and z are variables:

A(y) :- C(y).

B(x) :- A(d).

B(x) :- C(c).

C(a) :- B(b).

C(d).

C(z) :- B(z).

Show the entire search space for the query C(a),B(x)?. Is the search space finite? Please circle the answer: yes / no. How

many solutions are there?