Compiler Design June 13, 2017

Final Exam
(Total: 100 points)

1. [**6**] What are the six phases in the structure of a compiler?
(Hint: There are four phases in the front-end and two phases in the back-end.)

2. [**8**] Eliminate left recursion of the following translation scheme:

$$\begin{array}{ll} A \to A_1 Y & \{A.a = g(A_1.a, Y.y)\} \\ A \to X & \{A.a = f(X.x)\} \end{array}$$

3. Below is a grammar for expressions involving operator + and integer or floating-point operands. Floating-point numbers are distinguished by having a decimal point.

$$E \to E + T \ \mid\ T$$
$$T \to \textbf{num}.\textbf{num} \ \mid\ \textbf{num}$$

   (1) [**8**] Give a SDD with an attribute *type* to determine the type of each term T and expression E.

   (2) [**8**] Give a SDD with attributes *lexval* (supplied by the lexical analyzer) and *val* to translate expressions into postfix notation. Use the unary operator **intToFloat** to turn an integer into an equivalent float and the symbol '||' for concatenation.

4. [**10**] Multidimensional arrays can be stored in row-major order (last subscript varies fastest), as in C++, or in column-major order (first subscript varies fastest), as in Fortran. **Develop the access function for three-dimensional row-major arrays**.

   HINT: Let the subscript ranges of the three dimensions be named `min(1)`, `min(2)`, `min(3)`, `max(1)`, `max(2)`, and `max(3)`, where `min(1)`, `min(2)`, and `min(3)` are lower bounds for dimension one, dimension two, and dimension three, respectively, and `max(1)`, `max(2)`, and `max(3)` are upper bounds for dimension one, dimension two, and dimension three, respectively. Assume the element size is `size`.)

5. For each of the following types of variables, state the place in memory where a compiler allocates the space for such a variable.

   (1) [**3**] A non-static variable local to a procedure

   (2) [**3**] A global variable

   (3) [**3**] A dynamically allocated global variable

   (4) [**3**] A formal parameter

   (5) [**3**] A compiler-generated temporary variable

6. [**15**] Name five components of a typical activation record (or frame) and explain their functions.

7. Considering the following code fragment:

```
1: a = read();
2: b = a*a;
3: c = read();
4: d = b+c;
5: if (d > a) {
6:   e = d+1;
7: } else {
8:   e = a+1;
9:   print(a);
10: }
11: print(e);
```

   (1) [**10**] Draw the control-flow graph for the code.

   (2) [**10**] What is the fewest number of registers that is needed for this program, without spilling? Justify your answer by showing the interference graph and a coloring of the inference graph.

   (3) [**10**] Compute the reaching definitions at the entry and exist of each basic block. Use the label which precedes a statement to indicate a definition.