COMS W4115
Programming Languages and Translators
Homework Assignment 3

Prof. Stephen A. Edwards
Columbia University

Due November 26th, 2008
at 1:10 PM (beginning of class)

Submit solution on paper (no email). Please write your name clearly on the paper.

Do this assignment alone. You may consult the instructor and the TAs, but not other students.

1. For the following C array,

   ```
   int a[3][2];
   ```

   assume you are working with a 32-bit little-endian processor with the usual alignment rules (e.g., a Pentium) and

   (a) Show how its elements are laid out in memory.

   (b) Write the address expression for accessing `a[i][j]`.

   (c) Verify parts a) and b) by writing a small C program that contains and accesses such an array and looking at the assembly language output with the C compiler's -S flag (e.g., `gcc -O -S array.c`. Turn in a copy of your C program and an annotated version of the assembly listing. Make sure the assembly listing is no more than 40 lines.

2. In an assembly-language-like notation (e.g., use MIPS or a pseudocode of your own choosing), write what an optimizing compiler would produce for the following two `switch` statements.

   ```
   switch (a) {
   case 1:  x = 7; break;
   case 2:  x = 1; break;
   case 3:  x = 8; y = 42; break;
   case 4:  y = 17; break;
   case 5:  z = 18; break;
   default: z = 3; break;
   }
   ```

   ```
   switch (b) {
   case 1:    a = 3; break;
   case 10:   a = 9; break;
   case 100:  b = 14; c = 12; break;
   case 1000: c = 23; break;
   default:   c = 20; break;
   }
   ```

3. For a 32-bit little-endian processor with the usual alignment rules, show the memory layout and size in bytes of the following three C variables.

   ```
   union {
     int a;
     struct {
        char b; /* 8-bit */
        int c; /* 32-bit */
     } s;
   } u1;
   ```

   ```
   struct {
     char a;
     short c;
     char b;
     int d;
   } s1;
   ```

   ```
   struct {
     char a;
     short b;
     int c;
     char d;
   } s2;
   ```

4. Consider the following C-like program.

   ```
   int w = 5;
   int x = 6;

   int incw() { return ++w; }
   int incx() { return ++x; }

   void foo(y, z){
     printf("%d\n", y + y);
     x = 1;
     printf("%d\n", z);
   }

   int main() {
     foo(incw(), incx()); return 0;
   }
   ```

   What does it print if the language uses

   (a) Applicative-order evaluation?

   (b) Normal-order evaluation?