CS 2210   Compiler Construction

Spring 2020 Final Exam

Due Time: midnight April 26th, 2020

Questions	Points	Scored points
1	15	
2	20	
3	30	
4	35	
Total	**100**	

Note: This is an exam, though in a take-home manner, you are not allowed to discuss, collaborate, share with you classmates. Violation of the exam rules will be recorded and reported.

1. (15 points) Ture or false (1 point each) and simple questions (2 points each).

____ Initial values of global variables are part of the executable image file of a program.
____ Dynamic type checking typically results in faster program execution.
____ A static type system can be designed to reject all bad programs and accept all good programs.
____ Optimizations done on a common low-level IR can be applied to all languages frontends and all machine backends of a compiler.
____ Performing GCSE before applying SSA and after applying SSA can generate different versions of a given program.
____ In SSA representation, a variable is assigned to only once in the IR.
____ Global compiler optimizations optimize the entire program across function boundaries.
____ The loop transformation matrix must be nonsingular.
____ A legal distance vector is a vector that is lexicographically positive.

a. What are the major differences between SDT and SDD?
b. Write three address code of x = (- a) * b + F(–d) / G(e – f). Note that F() ang G() are functions.
c. For the following code sequence, draw the data layout in memory. The initial byte address starts from 0xFA00 and the offset is initialized to 0. Also, assuming that int takes 4 bytes.

```
void foo() {
int A[2][3];
long long B;
int C[3][2][2]
}
```

2. (20 points) For the following rule for a C statement, answer the following questions.

S → **if** (E1 && E2) S1;

a. Write semantic rules for pass 1 of two-pass code generation. Usable functions:
newlabel() – Generates name for new label.
emit(<label>) – Emits label into code.
<code> || <code> – Code concatenation operator. Concatenates the two pieces of code.

Below are the known attributes and the attributes to be updated as part of the rule:
known – E1.code, E2.code, S1.code, S.next
updated – E1.true, E1.false, E2.true, E2.false, S1.next, S.code

b. Write semantic rules for one-pass code generation using backpatching. Usable functions:
backpatch(p, i) – fill holes in list p with statement index i.
merge(p1, p2, …, pN) – returns merged list of p1, p2, …, pN

Below are the known attributes and the attributes to be updated as part of the rule:
known – E1.quad, E1.holes_true, E1.holes_false, E2.quad, E2.holes_true, E2.holes_false, S1.quad, S1.holes_next
updated – S.holes_next

3. (30 points) Given the following code sequence:

```
        R1 = R2 * R3
L1:     R4 = R1/C
        if (R4<W) goto L3
L2:     R5 = R2 * R3
        if (R5<W) goto L4
        R6 = R1/C
        goto L5
L3:     R7 = R2 * R3
        goto L6
L4:     R2 = R3/C
L5:     R9 = R1/C
        if (R9 < W) goto L2
L6:     halt
```

a. (10 points) Draw the control flow graph (CFG) for the code.
b. (20 points) Perform GCSE on the CFG through the steps we discussed in lecture (including constructing the DEF and NKILL set, computing the avail set, and eliminating the CSE)

4. (35 points) Given the following loop nest

```
do i = 1,n
    do j = 1,m
        do k = i+j, l
            A(i,k) = A(i-1,k+1) + B(i,j-1)
        enddo
    enddo
enddo
```

a. Suppose our target is parallelization. Think about all the parallelization strategies we have learned and perform the transformation/restructuring for parallelization.
b. Suppose our target is data locality of ONLY array A with a limited cache size (i.e., C). Think about all loop transformation strategies and perform transformation for data locality.
c. Now, will the transformation in b hurt data locality of array B? If so, can we achieve data locality for both arrays?

Note that, simple answers with just couple of words (e.g., loop permutation) will not get you credits. You need to show step by step of your optimization (e.g., dependence analysis, distance vector, transformation legality, etc). Try as much as you can, partial credits are considered.