CS251: Introduction to Language Processing

Tierce-2 Exam (2021-22-W Semester)

Max. Points: 100 **Duration:** 1 hour 30 minutes

March 22, 2022

Instructions

- The question paper consists of 4 pages containing 4 questions.
- Unless specified, assume that precedence and associativity of the operators follow that of C language.
- All the questions are compulsory.

Question-1

Consider the following three address code:

```
1  p=1
2  i=2
3  if n<2 goto (12)
4  s=i*i
5  if s>n goto (13)
6  r=n%i
7  y=n+p
8  if r==0 goto (12)
9  s=n+p
10 i=i+1
11 goto (4)
12 p=0;
13 exit
```

1. Construct the control flow graph for the above three address code.
2. Apply the global common sub-expression elimination optimization and show the transformed control flow graph
3. Apply loop invariant code motion optimization and show the transformed control flow graph

[25 Points]

Question-2

Assume that we have the following target machine model.

Instruction	**Semantics**
Store m, r	Stores the contents of register r to the memory location m
Load r, m	Loads the contents of the memory location m to the register r
OP $r2$, $r2$, $r1$	Performs the binary operation of two register operands $r2$ and $r1$. The result of $r2$ OP $r1$ is stored in $r2$.
OP r, $m2$, $m1$	Performs the binary operation of two memory operands $m2$ and $m1$. The result of $m2$ OP $m1$ is stored in r.
OP r, $m1$, r	Performs the binary operation of memory operand $m1$ and register operand r The result of $m1$ OP r is stored in r.
OP r, r, $m1$	Performs the binary operation of register operand r and memory operand $m1$ The result of r OP $m1$ is stored in r.

Notes:

1. OP can be ADD, SUB, MUL, DIV, etc.
2. You can assume temporary variables available in the memory locations are T0, T1...etc.

Part-(a)

Modify the labeling algorithm that we discussed in the class to calculate the minimum number of registers required to compute an expression tree supporting the above target machine model.

Part-(b)

Use the modified labeled algorithm and compute the minimum number of registers required to compute the following expression.

((a+b)*(c-d*e))+((f*g)/(h+i))

You must draw the expression tree and list the label for each node in the tree. Otherwise, you will not get any points.

Part-(c)

Assume that the target machine has only two registers. Write the final sequence of assembly instructions that are generated for the expression in Part-(b) on the target machine model.

[**30 Points**]

Question-3

Consider the following program, which uses nested functions and is written in **C like** language.

```
void f() {
      int Z=2;
      int X=25;
      void h() {
            int X=50;
            void g() {
                  Z=Z-1;
                  if(Z>0)
                        r();
            }
            X=75;
            g();
      }
      void r() {
            g();
            printf(``%d", X);  % Line L
      }
      h();
}
f();
```

Part-(a)

Show the activation record with the control links for the above snipped of the program under the following scenarios:

1. Static Scoping
2. Dynamic Scoping

Part-(b)

What is the value printed at Line L under the following scenarios? Justify your answer.

1. Static Scoping
2. Dynamic Scoping

[20 Points]

Question-4

Generate the three address codes for the following snippet of the program. Assume that

1. the semantics of for loop follows that of C language
2. array is declared as `int a[10]`, and integer takes 4 bytes
3. boolean operators follow short circuit evaluation

```
for(i=0; i<x+y; i=i+1) {
        z=i*x+y;
        if(i>z) {
                w=z+a[i];
        }
        w=function(z*x,y+z,z+z);
        z=z+w*z;
}
```

[25 Points]