

Homework 4

Date Out: Tuesday, November 28

Due Date: Tuesday, December 5 (start of class)

1 Control-Flow Graphs, Basic Blocks

1. What are the constraints of a basic block?
2. What data structure can be used to represent a basic block given its constraints? Why?
3. Given the following code, identify the basic blocks and draw the control flow graph:

```
1   B := C
2   I := 0
3   T := 4 * I
4   U := A[T]
5   V := U * U
6   W := 4 * I
7   A[W] := V
8   if V > D goto 13
9   I := I + 1
10  if I < B goto 3
11  X := C + D
12  E := X
13  Y := C + B
14  F := Y
```

2 Optimization

1. Perform common sub-expression elimination, copy propagation, dead-code elimination, algebraic transformations, and constant folding on the following code to the following code:

```
b := 4 - 2
t1 := b / 2
t2 := a * t1
t3 := t2 * b
t4 := t3 + c
t5 := t2 * b
t6 := t5 + c
d := t4 * t6
```

3 Constant Propagation

1. Convert the following RAM program into a control-flow graph. Then at each program point, specify the constant value of x (whether it is $\top$, $\perp$ or a constant c .)

```
z = 3
x = 1
while (x < 0)
{
    if (x == 1)
        y = 7
    else
        y = z + 4
    x = 3
}
```

4 Liveness Analysis

1. Which variables are live at the specified locations in the following intermediate code? Assume that only variable **e** is live following line 12.

(a) before line 7

(b) after line 10

```
1  b := 6
2  if c > 1 goto LabelC
3 Label A:
4  a := a - 1
5  if c > 3 goto LabelC
6 Label B:
7  e := 2
8  if d < 2 goto LabelA
9 Label C:
10 a := 5
11 if d > 10 goto LabelB
12 e := a + c
```