

Department of Computer Science and Engineering

Indian Institute of Technology, Kharagpur

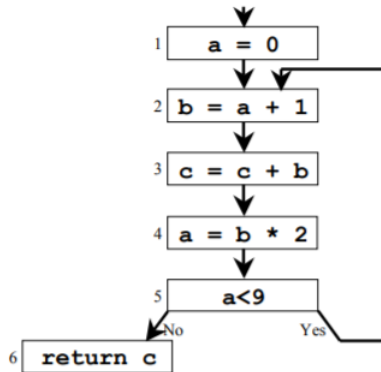
Compiler Theory: CS31003
3rd year CSE, 5th Semester

Theory Quiz 3

Marks: 25

Date: November 12, 2020

1. Consider the following CFG



Identify the correct statement(s)

[2]

- a) variable **b** is live in edges $1 \rightarrow 2$
- b) variable **b** is dead in edges $2 \rightarrow 3 \rightarrow 4$
- c) variable **a** is live in edges $4 \rightarrow 5 \rightarrow 2$
- d) variable **c** is dead in edges $5 \rightarrow 6$

Answer: c)

2. Consider the following three address code

```
Matrix:                                L7:  $\beta = \gamma$ 
    t1 = 0                                goto L5
    i = t1                                L8: t10 = 4 *  $\beta$ 
L1: t2 =  $\alpha - 1$                         t11 = a + t10
    if i < t2 goto L3                    t = *t11
    goto L9                            t12 = 4 *  $\beta$ 
L2: i = i + 1                          t13 = a + t12
    goto L1                            t14 = 4 * i
L3:  $\beta = i$                             t15 = a + t14
    t3 = i + 1                        *t13 = *t15
     $\gamma = t3$                         t16 = 4 * i
L4: if  $\gamma < \alpha$  goto L6            t17 = a + t16
    goto L8                            *t17 = t
L5:  $\gamma = \gamma + 1$                     goto L2
    goto L4                            L9: ret
L6: t4 = 4 *  $\gamma$ 
    t5 = a + t4
    t6 = 4 *  $\beta$ 
    t7 = a + t6
    t8 = *t5
    t9 = *t7
    if t8 < t9 goto L7
    goto L5
```

Identify the correct statement(s)

[2]

- a) Strength reduction can be done for 4 quads
- b) No local optimisation is possible
- c) There is a jump-over-jump which can be removed
- d) There are five temporary registers which are redundant and can be eliminated

Answer: c)

3. Consider the following three address code

```
Multiply:                                L6: t4 =  $\beta$  << 4
       $\alpha$  = 0                               t5 = a + t4
L1: t1 = n - 3                             t6 = m << 3
      if  $\alpha$  < t1 goto L3                 t7 = a + t6
      goto L8                             t8 = *t5
L2:  $\alpha$  =  $\alpha$  + 2                       t9 = *t7
      goto L1                             if t8 >= t9 goto L5
L3: m =  $\alpha$                              m =  $\beta$ 
       $\beta$  =  $\alpha$  + 1                       goto L5
L4: if  $\beta$  < n goto L6                   L7: t10 = m << 3
      goto L7                             t19 = a + t10
L5: j = j + 1                             t = *t19
      goto L4                             t12 = m << 2
                                          t13 = a + t12
                                          t14 =  $\alpha$  << 3
                                          t15 = a + t14
                                          *t13 = *t15
                                          t16 =  $\alpha$  << 3
                                          t18 = a + t16
                                          *t18 = t
                                          goto L2
                                          L8: ret
```

Based on the analysis of leaders, identify the number of basic blocks in the corresponding CFG for this three address code [2]

- a) 8
- b) 10
- c) 11
- d) 12

Answer: d)

4. Consider that LCSE is attempted on following basic block using value numbering

```
// Block B12
0: t14 = 8 * arr
1: t15 = a[t14]
2: t16 = 8 * arr
3: t27 = b[t16]
4: if t15 >= t27 goto B16
   : goto B15
```

Identify the correct statement

[2]

- a) The total number of entries (expressions) in the Hash table is 1
- b) The total number of entries (variables) in the VN table are 7
- c) The total number of unique Indexes in the Name table are 6
- d) The Value Number (VN) table has entries for a[t14]

Answer: a)

5. Consider the following CFG

<pre>// Block B1 0: n = 5 1: i = 0 : goto B2 // Block B2 0: if i < n goto B4 : goto B7 // Block B3 0: i = i + 1 : goto B2 // Block B4 0: t4 = 4 * i 1: t5 = a[t4] 2: t7 = b[t4] 3: if t5 >= t7 goto B6 : goto B5</pre>	<pre>// Block B5 0: t8 = 4 * i 1: t9 = c + t8 2: t11 = a[t8] 3: t13 = b[t8] 4: t14 = t11 * t13 5: *t9 = t14 : goto B3 // Block B6 0: t15 = 4 * i 1: t16 = c + t15 2: *t16 = 0 : goto B3 // Block B7 0: return</pre>
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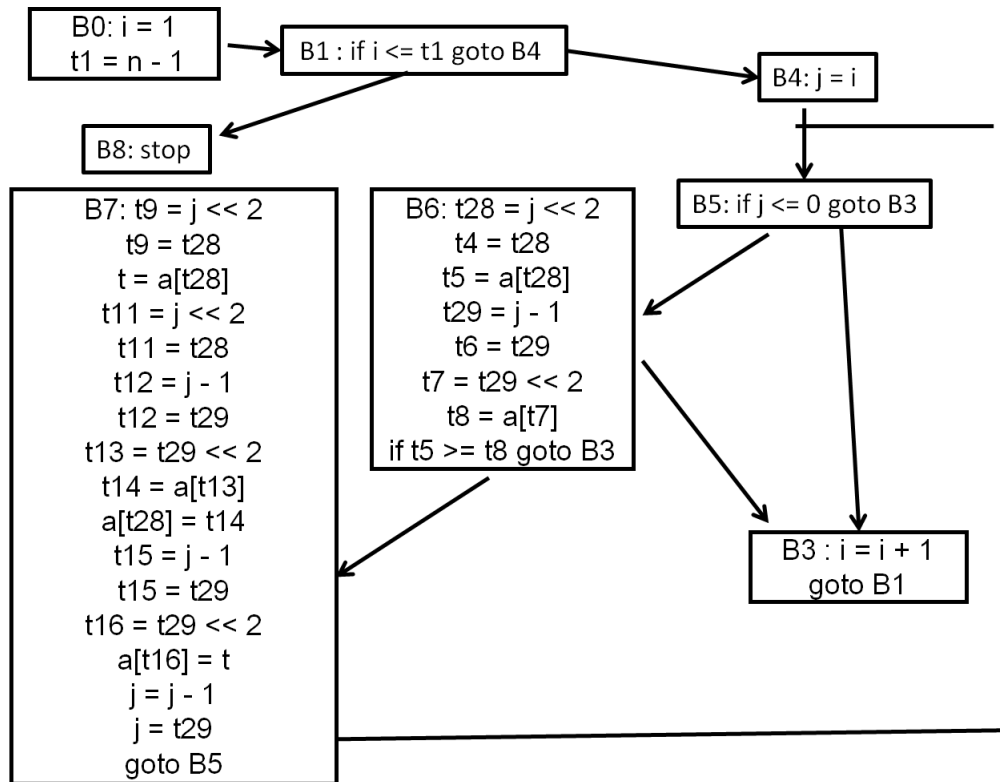
To compute the available expressions we follow a forward computation order of basic blocks (since this is a forward direction DFA) through the CFG. Identify the correct statement(s) based on the iteration order for the process to converge [2]

- a) computation order for the basic blocks B1-B2-B5-B6-B3 will converge in 1 iterations
- b) computation order for the basic blocks B1-B2-B4-B5-B6-B3-B7 will converge in 2 iterations
- c) computation order for the basic blocks B1-B2-B3-B4-B5-B6-B7 will converge in 4 iterations

- d) computation order for the basic blocks – B1-B2-B3-B4-B5-B6-B7 and B1-B2-B4-B5-B6-B3-B7 will converge in 1 iteration

Answer: b)

6. Consider the following CFG



Identify the correct dead codes (quads) from the options below (considering first pass). [2]

a) B7:

t9 = j << 2
t9 = t28

b) B7:

a[t28] = t14

c) B6:

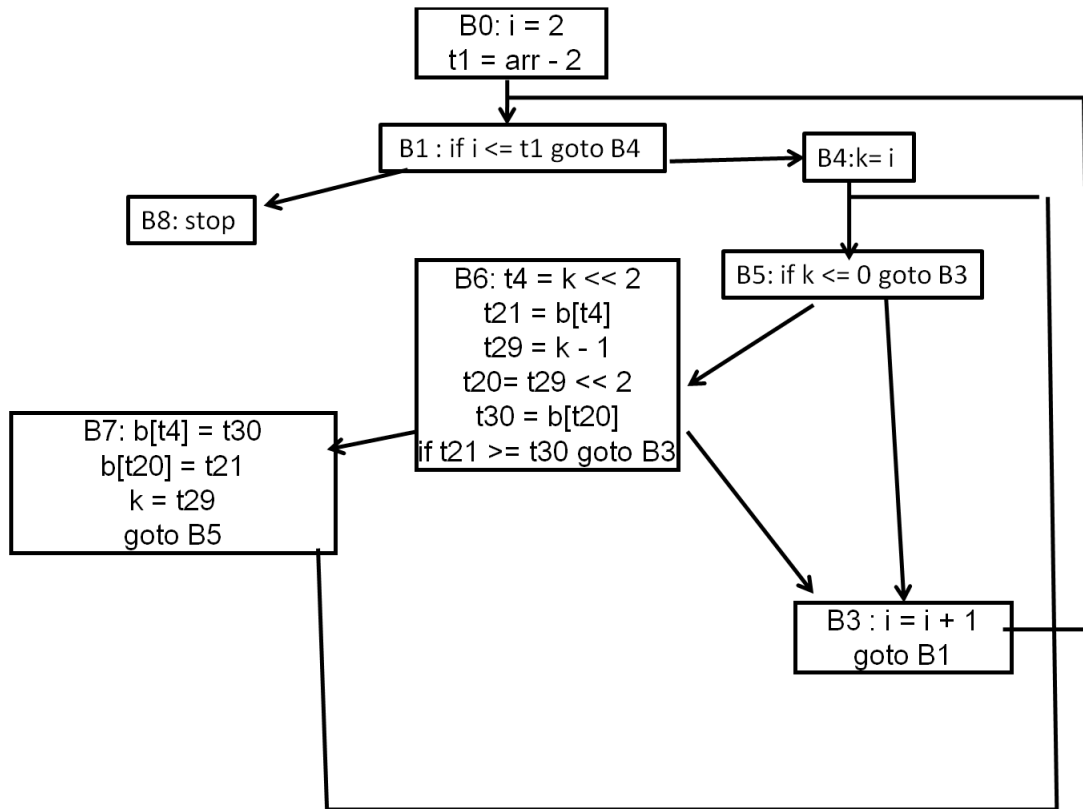
t7 = t29 << 2
t8 = a[t7]

d) B7:

t15 = j - 1
t15 = t29

Answer: a), d)

7. Consider the following CFG



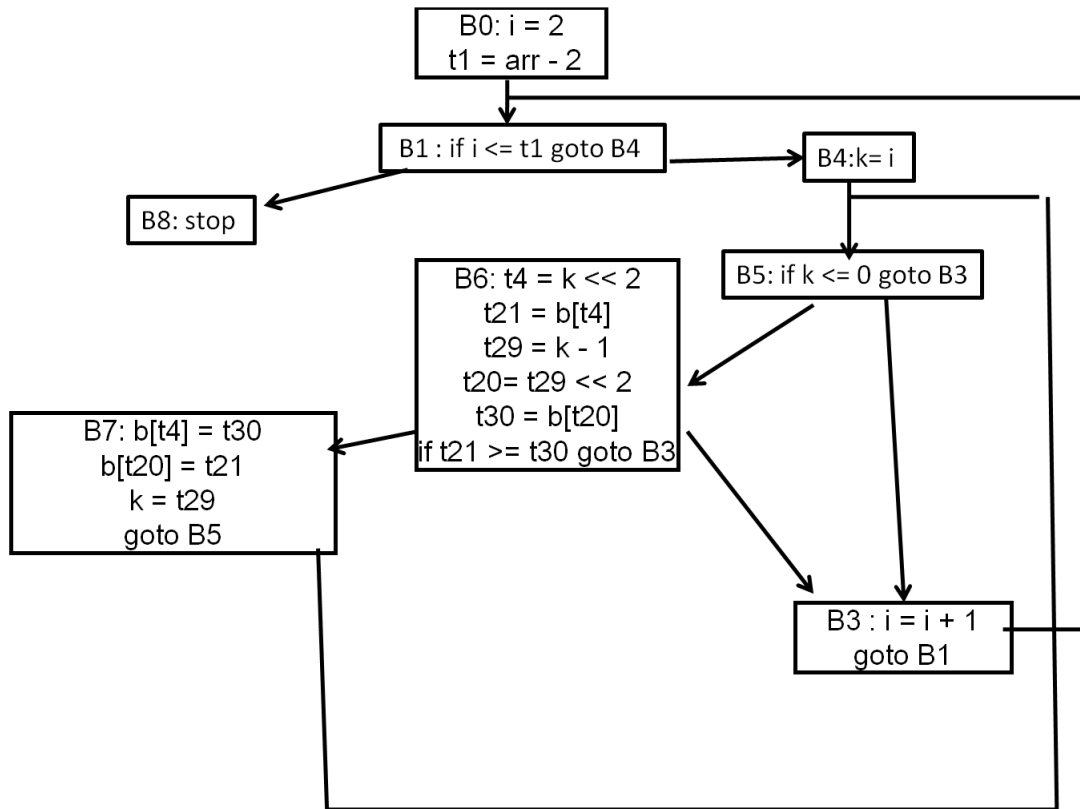
How many variables are live at the entry point of Block B7

[2]

- a) 6
- b) 8
- c) 9
- d) 7

Answer: c)

8. Consider the following CFG



Spill 4 variables – `arr`, `t1`, `i`, `k` into memory and do the Live Variable analysis. Using graph colouring for Register Interference Graph, feasible allocation can be achieved using how many (minimum) registers. [2]

- a) 4
- b) 5
- c) 9
- d) 7

Answer: b)

9. Consider the following basic block

```

B10:    t18 = m + 2
        t20 = a + t18
        t11 = t20
        br = *t11
        t13 = t20
        t19 = k >> 4
        t21 = a + t19
        t15 = t21
        *t13 = *t15
        t17 = t21

```

```

    *t17 = br
    goto B3

```

How many copy propagation instances are present in the basic block. [1]

- a) 3
- b) 2
- c) 4
- d) None

Answer: c)

10. State whether the target code based on x86 architecture for the following expression is correct.

```
b = z[i]
```

Consider `int` as the data type for all. [1]

```

mov edx, DWORD PTR _i$[ebp]
mov eax, DWORD PTR _b$[ebp]
mov DWORD PTR _z$[ebp+edx*4], eax

```

- a) True
- b) False

Answer: False

11. Consider the following productions and semantic rules

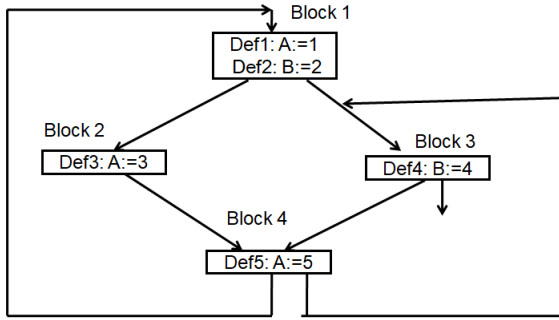
Productions	Semantic Rules
$T \rightarrow FT'$	$T'.x = F.val$
$T' \rightarrow *T_1T'$	$T.val = T'.y$
$T' \rightarrow \in$	$T_1'.x = T'.x * F.val$
$F \rightarrow id$	$T'.y = T_1'.y$
	$T'.y = T'.x$
	$F.val = id.lexval$

Identify the correct statement(s) [1]

- a) x is an inherited attribute
- b) Both x and y are inherited attributes
- c) y is a synthesized attribute
- d) Both x and y are synthesized attributes

Answer: a), c)

12. Consider the following CFG



Identify the correct statement based on DFA data flow equations

[1]

- a) Kill (Block 1) = {Def1, Def3, Def4}
- b) Kill (Block 2) = {Def1, Def2}
- c) Gen (Block 2) = {Def2 }
- d) Kill (Block 1) = {Def3, Def4, Def5}

Answer: d)

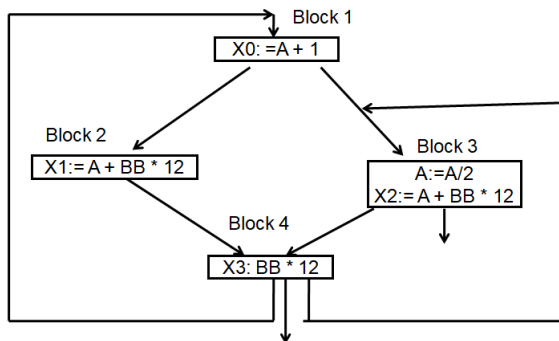
13. Identify the correct statement

[1]

- a) Any statement which is the target of a conditional or unconditional goto cannot be a leader of a basic block
- b) Dead Code Elimination is a type of peephole optimization
- c) Consider B1, B2 as basic blocks. There is a directed edge $B1 \rightarrow B2$, if B2 can immediately follow B1 in some execution sequence:
B2 immediately follows B1 in the order of the program, and B1 does not end in an unconditional jump
- d) The control flow among basic Blocks are represented as trees

Answer: c)

14. Consider the following CFG



Identify the incorrect statement(s) based on the set of available expressions in each block after 2 iterations

[2]

- a) $\text{out}(\text{Block2}) = \{A+1, A/2\}$
- b) $\text{out}(\text{Block2}) = \{A+1, BB * 12, A + BB * 12\}$
- c) $\text{in}(\text{Block4}) = \{BB * 12, A + BB * 12\}$
- d) $\text{out}(\text{Block4}) = \{BB * 12, A + BB * 12\}$

Answer: a)

15. Consider the following three address code snippet

```

    i = 1
    t1 = n - 1
L0: if i <= t1 goto L2
    goto L6
L1: i = i + 1
    goto L0
L2: j = i
L3: if j <= 0 goto L1
    t4 = j << 2

```

.....

Identify the correct statement(s)

[2]

- a) L0: if i <= t1 goto L2 is a leader
- b) t1 = n - 1 is a leader
- c) There are 4 leaders in this code snippet
- d) goto L6 is not a leader

Answer: a)