Control-Flow Analysis Exercises

1

Problem1

For the source code program below:

1. Determine the corresponding control flow graph.
2. Determine the dominators of each node in the CFG
3. Determine the immediate dominator tree
4. Identify the set of nodes in each natural loop. Are there any nested loops? Why or why not.

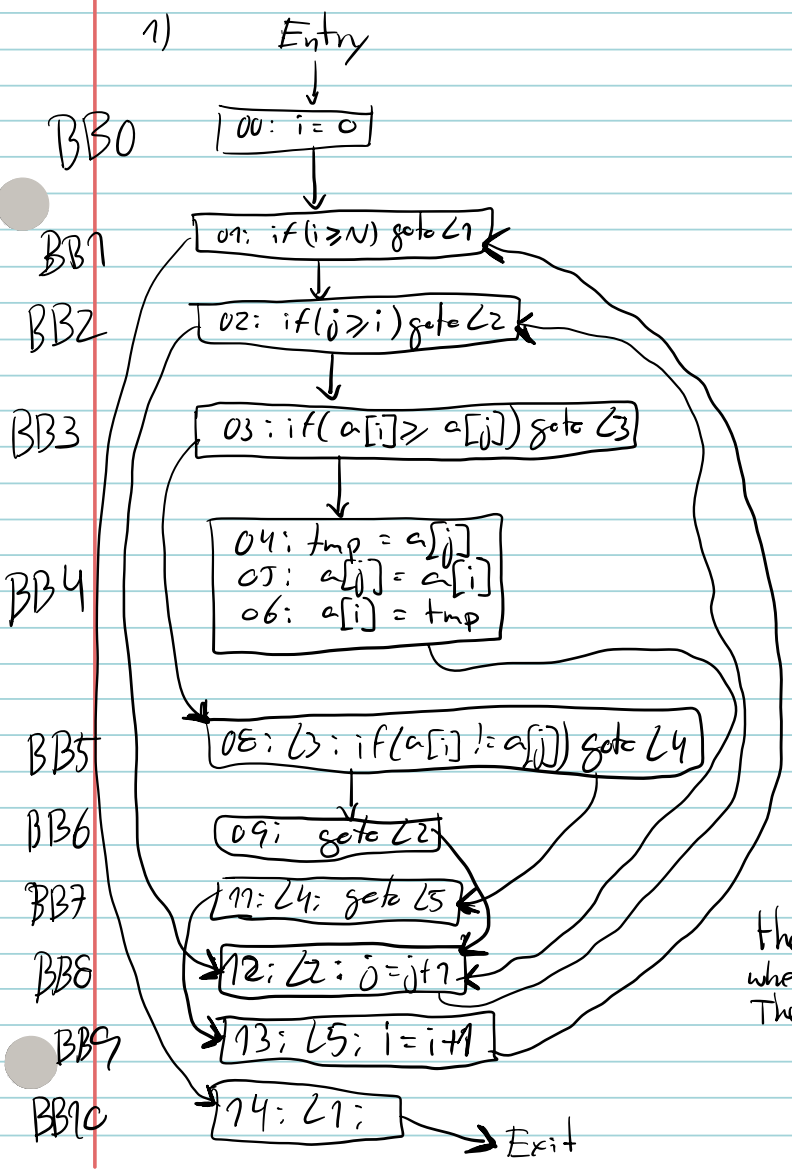
```
00:   i = 0;
01:   while (i < N) do
02:     for(i=0; j < i; j++)
03:        if(a[i] < a[j]) then
04:           tmp = a[j];
05:           a[j] = a[i]
06:           a[i] = tmp;
07:        else
08:           if(a[i] == a[j]) then
09:             continue;
10:           else
11:             break;
12:      end for
13:      i = i + 1;
14:   end while
```

Note: Assume there are *entry* and *exit* nodes corresponding to the entry point and exit points of the code segment, which would correspond to the prologue and epilogue sections of the procedure's generated code.

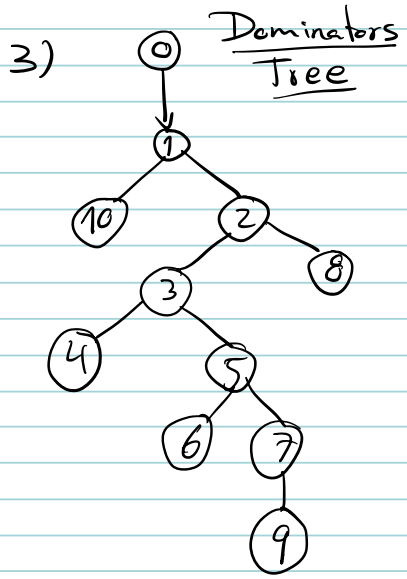
2) Dominators

0: {0}
1: {0, 1}
2: {0, 1, 2}
3: {0, 1, 2, 3}
4: {0, 1, 2, 3, 4}
5: {0, 1, 2, 3, 5}
6: {0, 1, 2, 3, 5, 6}
7: {0, 1, 2, 3, 5, 7}
8: {0, 1, 2, 8}
9: {0, 1, 2, 3, 5, 7, 9}
10: {0, 1, 10}

1)



3)



4) Natural Loops

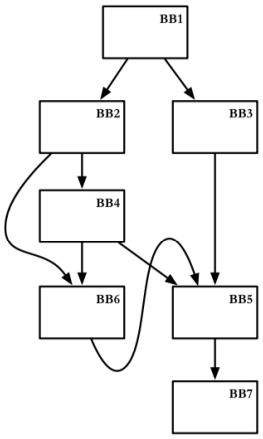
- 9 → 1 Nodes {1, 2, 3, 4, 5, 6, 7, 8, 9}
- 8 → 2 Nodes {2, 3, 4, 5, 6, 8}

There are 2 nested loops because the natural loops have different headers, and when this happens they can be disjoint or nested. They aren't disjoint, so they must be nested.

(2)

Problem 2

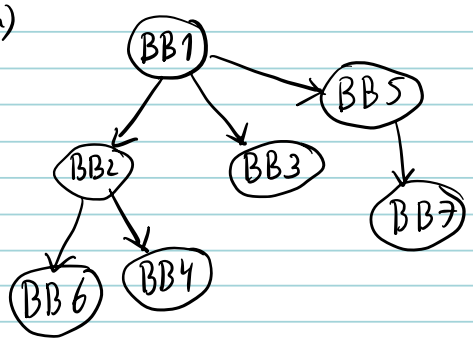
Consider the Control-Flow Graph (CFG) shown below.



For this CFG determine the following:

a. The dominator tree.
b. The back edges, if any, and the corresponding natural loops and associated loop bodies.

a)



b) There are no edges in the Control-Flow Graph, so there are no natural loops and associated loop bodies.