Homework 3

CS 540
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1 Prove or disprove the following conjectures:

a) **Conjecture**. Let (n, d) be an edge. (n, d) is a back edge if and only if d is an ancestor of n in the dominator tree.

b) **Conjecture**. Every loop contains vertices d and n such that (n, d) is a back edge.

c) **Conjecture**. Every natural loop is the natural loop of at most one back edge.

2 Consider the flow graph of problem 2 in homework 2.

a) Algorithmically construct the set of dominators $D(n)$ of each node n. Show $D(n)$ after each iteration of the while-loop. Process nodes in the for-loops by increasing node number.

b) Which edges are back edges?

c) Construct the dominator tree.

d) Construct the natural loop of each back edge. Show the partially constructed loop and stack after each iteration of the while-loop. Process nodes in the for-loop by increasing node number.

3 Consider the following Pascal fragment:

```
for i := 1 to 5 do
  for j := 1 to i do
    begin
      a := h + 2;
      b := a + i;
      c := b + j
    end
```

a) Translate the fragment into a three-address program.

b) Explain formally and intuitively why no loop-invariant definitions are moved by code motion.

4 Consider the following flow graph:

Apply the code motion algorithm successively to the inner loop and the outer loop. Mark all loop-invariant definitions and show the resulting flow graph after each application.