

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.