CS5214 Design of Optimizing Compilers

Professor Weng-Fai Wong

Assignment Two

February 27, 2016

Abstract

This is the answer presented by Pan An. My student number is A0134556A. After tryin all the cool tools in Python, GNUPlot, and some books and papers, I finally figured out that this assignment is not about programming. Alright so I'm just gonna present some results that are partially calculated with my hand. Some of the math greatly damaged my brain(kidding). Also I wanted to put a lot of references but it seems that time is not enough for that. The folder contains some of the rough calculation results performed by Python and some other tools.

1 The LengauerTarjan algorithm

For the first question I simply assumn that in this diagram it does not have very terrible effect by counting the **start** and **stop** nodes into the algorithm.

1.1 Depth First Search

I simply used **networkx** in Python to do some of the graph operation for me. The depth first search tree is stored in a picture in **img folder**.

After performing DFS on the tree, the DFT numbering is listed below in the form of (n_{DFT}, Node). Node with number 0 and 100 are the start and stop node.

```
(1, 0)
(2, 1)
(3, 2)
(4, 8)
(5, 31)
(6, 4)
(7, 5)
(8, 6)
(9, 7)
(10, 9)
(11, 10)
(12, 11)
(13, 12)
```

```
(14, 13)
(15, 14)
(16, 15)
(17, 16)
(18, 33)
(19, 18)
(20, 34)
(21, 21)
(22, 100)
(23, 3)
(24, 17)
(25, 19)
```

Noticing that there could be multiple answers to DFS tree numbering, I am using this one as the answer for the next couple questions.

1.2 Dominators

Most of the time semi-dominators of nodes in a graph is the immediate dominator. To make it possible for people to compare, here is the result for the immediate dominators of te graph(node: immediate dominator):

```
0: 0,
1: 0,
2: 1,
3: 31,
4: 3,
5: 4,
6: 4,
7: 3,
8: 1,
9: 8,
10: 9,
11: 10,
12: 10,
13: 12,
14: 13,
15: 14,
16: 15,
17: 33,
18: 16,
19: 34,
21: 18,
31: 1,
33: 16,
34: 18,
100: 21
```

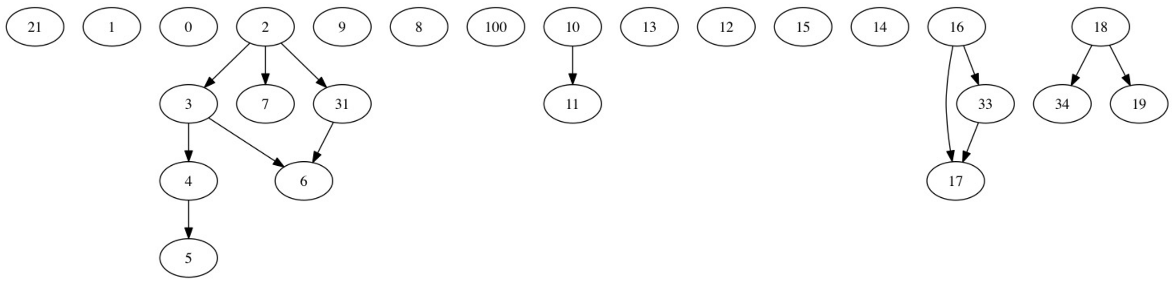
And the semi-dominators I have computed is listed(node: semi-dominator):

$$(0:0),(1:0),(3:31),(4:3),(5:4),(6:4),(7:3),(8,2)$$

$$(9,8),(10,9),(11,10),(12,10),(13,12),(14,13),(15,14)$$

$$(16,15),(17,33),(18,16),(19,34),(21,18),(31,1),(33,16),(100,21)$$

1.3 Control Dependency



1.4 Strongly Connected Componants

A directed graph is called strongly connected if there is a path in each direction between each pair of vertices of the graph.

Strongly connected graphs are(all edges amongs these nodes included):

- Nodes with self loop: 9, 13, 15, 19
- Graph composed with node 16 and 33
- Graph composed with node 3, 4, 6, 7
- Graph composed with node 3, 4, 6, 7, 5
- Graph composed with node 9, 10, 11

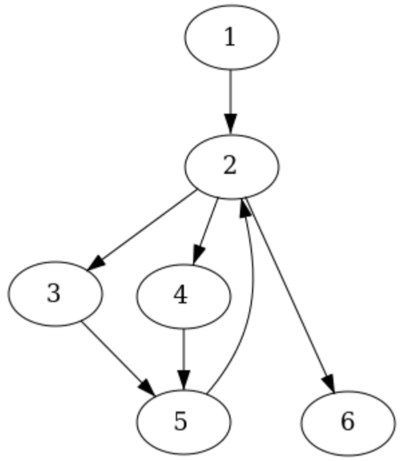
1.5 Question 7

Dominant frontier: 2, 16 and 18.

Block 33 should be inserted with the function.

2 Dataflow analysis

The algorithm can be considered finding the node which post-dominates all node with the $USE(n) > 0$. Also the node should be the 'first one'.



Consider the following graph:

The algorithm is described below, it will return one single node that satisfies the need:

- Initiate set S_u, N_p as two empty sets;
- DFS the graph, at the same time calculate $USE(n)$ for each node, and put all nodes with $USE(n) > 0$ in to S_u;
- Traverse the graph and calculate the the set of nodes each node post dominates(Lengauer and Tarjans Algorithm). Post dominating set of node i is noted as Dom_i. If $S_u \subseteq Dom_i$, put node i into N_p;
- For node i in N_p after the traversal, if $N_p \cap Dom_i$ is empty, return the node and terminate the process.
- Return the stop node(or none value found).

We assumn that in the graph node **2 and 4** are with a postive $USE(n)$ value(variable is used). The algorithm will first traverse the graph and find the variable usage, and after this process:

$$S_u = \{2, 4\}$$

After this the algorithm does another traversal. finding the nodes that post dominates both 2 and 4. After this traversal:

$$N_p = \{6\}$$

And since this 6 is the only reason that post dominates both 2 and 4, the algorithm returns node 6.

But when CFG is very large. The program will enumerate N_p again to find the first node that satisfies all the condition.