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# Why is the complexity of DFS O(V+E)?

I have tried understanding this from various online sources and spent sufficient time trying to wrap my head around this, but still can't understand why the complexity of DFS comes out to O(V+E).

If anyone could explain this with an example in some detail, it would be great!

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**Jian Sun**
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## 3 Answers

**Mukul Bhutani**, Once a BITSian, always a BITSian!
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Ok, so lets say we have a graph G(V,E).
pseudo code for dfs would go like this:
we have a "isVisited" array(or any data structure to mark if a vertex has been visited or not).

(Note: i am using the stack implementation for easier understanding)

```
1.Stack stack; // i have named my stack as "stack"
2.isVisited(root) = true;
3.stack.push(root);
4.while(stack is not empty)
5.{
6.    currentNode = stack.top();
7.     stack.pop();
8.     print(currNode); //or whatever operation you want to do!
9.    for all each v in adj[currNode]
10     if(!isVisited[v])
11     {
12        stack.push(v);
13       isVisited[v] = true;
14     }
15 }
```

Now for the analyses part....
Lets break the work done... lets exclude the lines 9-14 for now... Do we agree the work done in while loop excluding lines 9-14 is constant?
Once we have established this fact lets see how many times this loop executes. Simple enough to see that each vertex it added to stack once and hence it executes V times. Thus total work done O(V).

Now lets take line 9-14 part separately.
How many times have the lines 9-14 executed? For each while loop they have been executed same number of times as the elements in the respective vertex's adjacency list. And if you add up all the adjacency lists of all the vertices how many executions you get? O(E).

combining these two separate works done the total work comes out to be O(V)

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+ O(E) = O(V+E)
This is called aggregate analysis. For details refer stackoverflow or the good old Introduction to algorithms by cormen et al.

PS: for understanding purposes I might have been slightly off the mark here or there... but you would be able get the basic idea i guess.

Written 14 Jul, 2014 • View Upvotes

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**Satish Patel**, Algoricursive
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There are two procedures involved in Depth First Search, one `DFS(G)` and supporting routine `DFS-VISIT(G,u)`as per the standard Algorithm. There is need understand that `E` which is edges in the graph are represented as linked list.
What we do in Depth First Search is first we paint all the nodes white which runs in `O(V)` self explanatory. And the `DFS-VISIT(G,u)` procedure is called if and only if the concerning node that is u is white. and since `DFS` procedure calls the `DFS-VISIT(G,u)` and if the node is white then it is self-recursioned which visits linked list representation of the edge i.e. `O(E)`.
Concluding the running time to `O(V+E)`.

References: Introduction to Algorithms (book)

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**Himanshu Bhardwaj**, B.E. (Hons) Computer Science, BITS Pilani
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**Time Complexity of DFS is notO( V+E).**
Actually it depends on the data structure you are using to represent your graph.
For example if you represent your graph using adjecency matrix in that case it will we O(V^2) .i.e independent from E. or if you represent your graph using edge list then it will be O(VE) (why?? Find out and tell me :p)



...n only it ... be O(V+E).
Now I think the question why it this case it will be O(V+E).

Suppose you have an adjacency list where neighbour of every node are stored in form of link list (or may be vector.)

In DFS, you will explore each node and its neighbours exactly **once.**

time complexity to explore node i is O(1) while of exploring its neighbours is O(degree(i)).

so total time complexity over all nodes will be
O(Σ(1+degree(i))) 1<=i<=V
As Σdegree(i) = 2*E = O(E) (Why??)
So O( Σ(1+degree(i)) ) = O(V+E) :)

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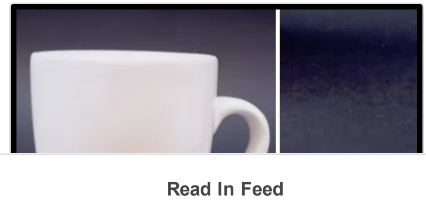

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