Algorithms

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Topics: Depth First Search

Depth First Search

TUTORIAL PROBLEMS VISUALIZER BETA

Depth First Search (DFS)

The DFS algorithm is a recursive algorithm that uses the idea of backtracking. It involves exhaustive searches of all the nodes by going ahead, if possible, else by backtracking.

Here, the word backtrack means that when you are moving forward and there are no more nodes along the current path, you move backwards on the same path to find nodes to traverse. All the nodes will be visited on the current path till all the unvisited nodes have been traversed after which the next path will be selected.

This recursive nature of DFS can be implemented using stacks. The basic idea is as follows:
Pick a starting node and push all its adjacent nodes into a stack.
Pop a node from stack to select the next node to visit and push all its adjacent nodes into a stack.
Repeat this process until the stack is empty. However, ensure that the nodes that are visited are marked. This will prevent you from visiting the same node more than once. If you do not mark the nodes that are visited and you visit the same node more than once, you may end up in an infinite loop.

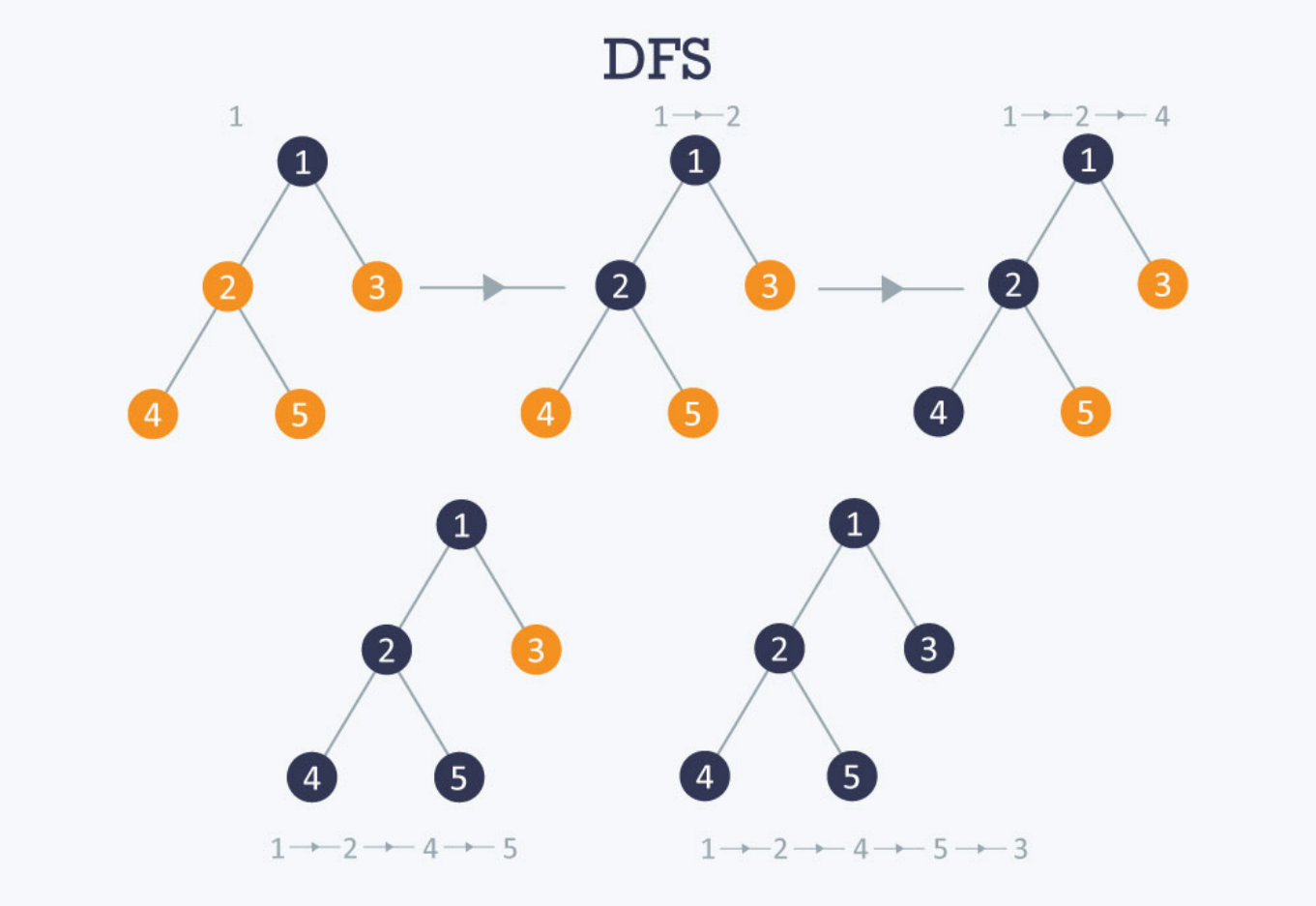
Pseudocode

```
    DFS-iterative (G, s):                                  //Where G is graph
and s is source vertex
      let S be stack
      S.push( s )            //Inserting s in stack
      mark s as visited.
      while ( S is not empty):
```

```
        //Pop a vertex from stack to visit next
        v  =  S.top( )
       S.pop( )
       //Push all the neighbours of v in stack that are not visited
      for all neighbours w of v in Graph G:
          if w is not visited :
                    S.push( w )
                   mark w as visited


DFS-recursive(G, s):
     mark s as visited
     for all neighbours w of s in Graph G:
          if w is not visited:
               DFS-recursive(G, w)
```

The following image shows how DFS works.



Time complexity $O(V + E)$, when implemented using an adjacency list.

Applications

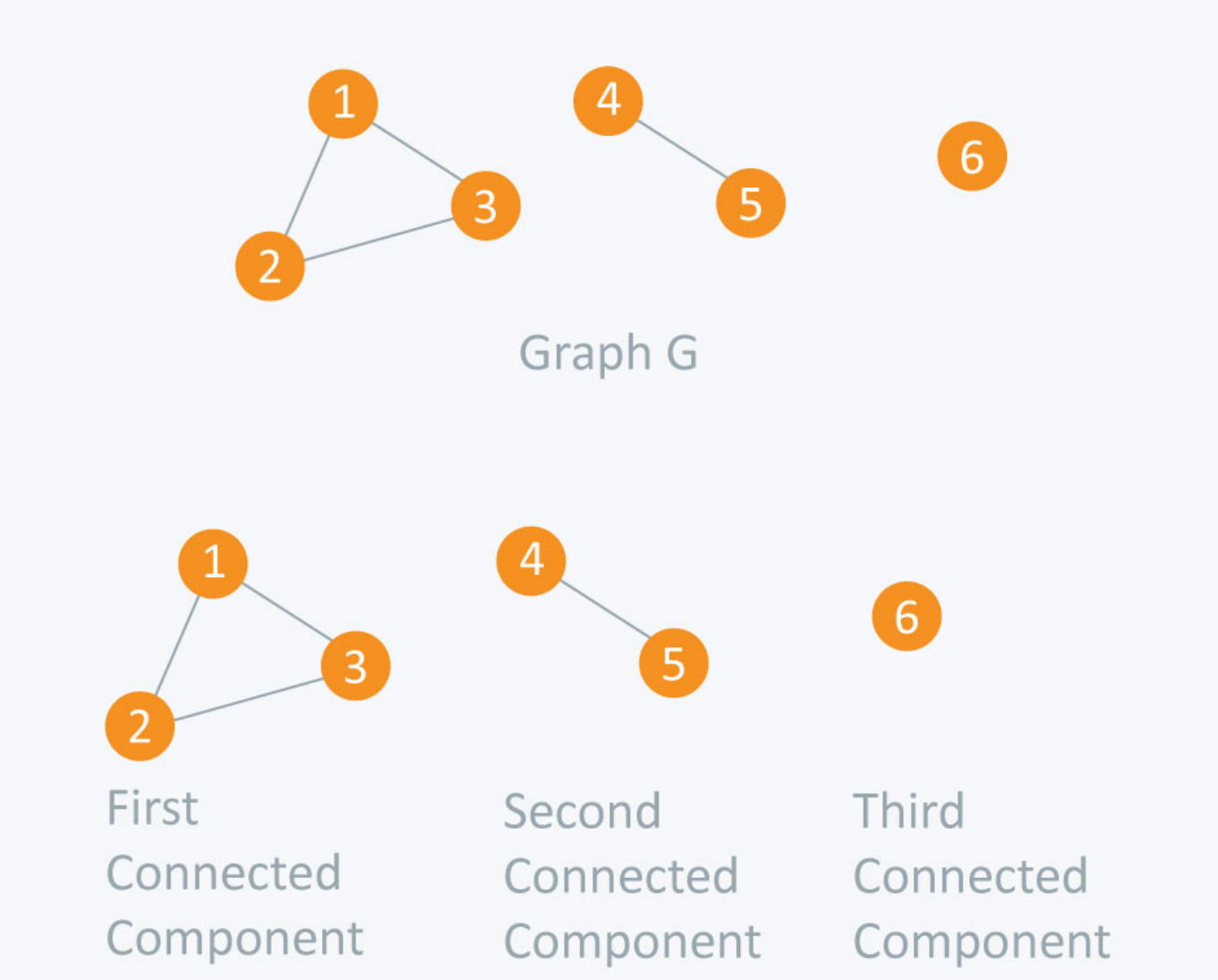
How to find connected components using DFS?

A graph is said to be disconnected if it is not connected, i.e. if two nodes exist in the graph such that there is no edge in between those nodes. In an undirected graph, a connected component is a set of vertices in a graph that are linked to each other by paths.

Consider the example given in the diagram. Graph G is a disconnected graph and has the following 3 connected components.

- First connected component is 1 -> 2 -> 3 as they are linked to each other
- Second connected component 4 -> 5
- Third connected component is vertex 6

In DFS, if we start from a start node it will mark all the nodes connected to the start node as visited. Therefore, if we choose any node in a connected component and run DFS on that node it will mark the whole connected component as visited.



Input File

6
4
1 2
2 3

1 3
4 5

Code

```
#include <iostream>
#include <vector>
 using namespace std;

 vector <int> adj[10];
 bool visited[10];

 void dfs(int s) {
      visited[s] = true;
      for(int i = 0;i < adj[s].size();++i)    {
       if(visited[adj[s][i]] == false)
            dfs(adj[s][i]);
      }
 }

 void initialize() {
      for(int i = 0;i < 10;++i)
       visited[i] = false;
 }

 int main() {
      int nodes, edges, x, y, connectedComponents = 0;
      cin >> nodes;                          //Number of nodes
      cin >> edges;                          //Number of edges
      for(int i = 0;i < edges;++i) {
       cin >> x >> y;
  //Undirected Graph
       adj[x].push_back(y);                    //Edge from vertex x to vertex y
       adj[y].push_back(x);                    //Edge from vertex y to vertex x
      }

      initialize();                            //Initialize all nodes as not
visited

      for(int i = 1;i <= nodes;++i) {
       if(visited[i] == false)     {
            dfs(i);
            connectedComponents++;
       }
      }
```

```
        cout << "Number of connected components: " << connectedComponents << endl;
        return 0;
    }
```

Output

Number of connected components: 3

Time complexity $O(V + E)$, when implemented using the adjacency list.

Contributed by: Prateek Garg

TEST YOUR UNDERSTANDING

Unreachable Nodes

You have been given a graph consisting of N nodes and M edges. The nodes in this graph are enumerated from 1 to N . The graph can consist of self-loops as well as multiple edges. This graph consists of a special node called the head node. You need to consider this and the entry point of this graph. You need to find and print the number of nodes that are unreachable from this head node.

Input Format

The first line consists of a 2 integers N and M denoting the number of nodes and edges in this graph. The next M lines consist of 2 integers a and b denoting an undirected edge between node a and b. The next line consists of a single integer x denoting the index of the head node.

Output Format:

You need to print a single integer denoting the number of nodes that are unreachable from the given head node.

Constraints

$1 \leq N \leq 10^5$

$1 \leq M \leq 10^5$

$1 \leq x \leq N$

SAMPLE INPUT

```
10 10
8 1
8 3
7 4
7 5
2 6
10 7
2 8
10 9
2 10
5 10
2
```

SAMPLE OUTPUT

```
0
```

Enter your code or Upload your code as file. Save C (gcc 5.4.0)

```
/*
// Sample code to perform I/O:

scanf("%s", name);                // Reading input from STDIN
printf("Hi, %s.\n", name);        // Writing output to STDOUT

// Warning: Printing unwanted or ill-formatted data to output will cause the test
*/

// Write your code here

```

11:1

Provide custom input

Press Ctrl-space for autocomplete suggestions.