August 7, 2022 ▪ Graph

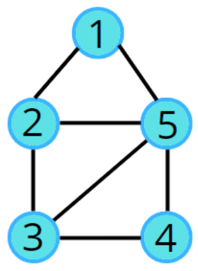
Breadth First Search (BFS): Level Order Traversal

Problem Statement: Given an undirected graph, return a vector of all nodes by traversing the graph using breadth-first search (BFS).

Pre-req: Graph Representation, Queue STL

Examples:

```
Example 1:
Input:
```



```
Output: 1 2 5 3 4
```

```
Example 2:
Input:
```

Search

Search

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L2...

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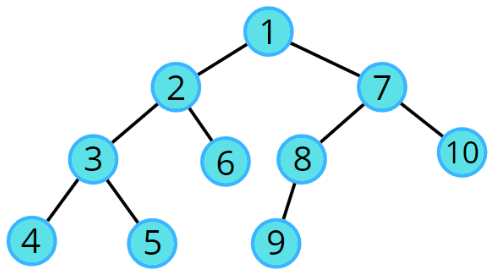

```
Output: 1 2 7 3 6 8 10 4 5 9
```

Solution

***Disclaimer**: Don't jump directly to the solution, try it out yourself first.*

Approach:

Initial Configuration:

- Queue data structure: follows FIFO, and will always contain the starting.
- Visited array: an array initialized to 0

1. In BFS, we start with a "starting" node, mark it as visited, and push it into the queue data structure.
2. In every iteration, we pop out the node 'v' and put it in the solution vector, as we are traversing this node.
3. All the unvisited adjacent nodes from 'v' are visited next and are pushed into the queue. The list of adjacent neighbors of the node can be accessed from the adjacency list.
4. Repeat steps 2 and 3 until the queue becomes empty, and this way you can easily traverse all the nodes in the graph.

In this way, all the nodes are traversed in a breadthwise manner.

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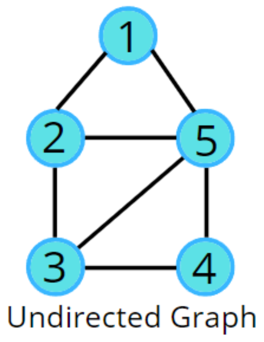
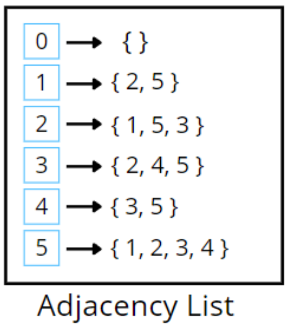
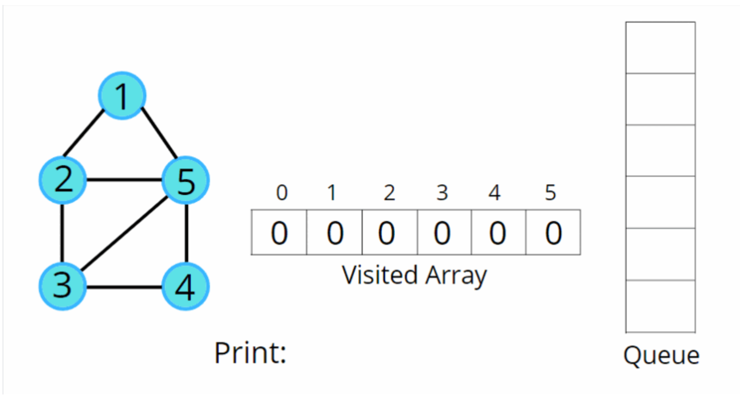




0	{ }
1	{ 2, 5 }
2	{ 1, 5, 3 }
3	{ 2, 4, 5 }
4	{ 3, 5 }
5	{ 1, 2, 3, 4 }



Code:

C++ Code

```
#include <bits/stdc++.h>
using namespace std;

class Solution {
  public:
    // Function to return Breadth First Trave
    vector<int> bfsOfGraph(int V, vector<int>
        int vis[V] = {0};
        vis[0] = 1;
        queue<int> q;
        // push the initial starting node
        q.push(0);
        vector<int> bfs;
        // iterate till the queue is empty
        while(!q.empty()) {
           // get the topmost element in the
            int node = q.front();
            q.pop();
            bfs.push_back(node);
            // traverse for all its neighbour
            for(auto it : adj[node]) {
                // if the neighbour has previ
            }
        }
        return bfs;
    }
};

void addEdge(vector <int> adj[], int u, int v
    adj[u].push_back(v);
    adj[v].push_back(u);
}

void printAns(vector <int> &ans) {
    for (int i = 0; i < ans.size(); i++) {
        cout << ans[i] << " ";
    }
}

int main()
{
    vector <int> adj[6];

    addEdge(adj, 0, 1);
    addEdge(adj, 1, 2);
    addEdge(adj, 1, 3);
    addEdge(adj, 0, 4);

    Solution obj;
    vector <int> ans = obj.bfsOfGraph(5, adj)
    printAns(ans);

    return 0;
}
```

Output: 0 1 4 2 3

Time Complexity: O(N) + O(2E), Where N = Nodes, 2E is for total degrees as we traverse all adjacent nodes.

Space Complexity: O(3N) ~ O(N), Space for queue data structure visited array and an adjacency list

Java Code

```
import java.util.*;
class Solution {
        Queue < Integer > q = new LinkedList

        q.add(0);
        vis[0] = true;

        while (!q.isEmpty()) {
            Integer node = q.poll();
            bfs.add(node);

            // Get all adjacent vertices of t
            // If a adjacent has not been vis
            // visited and enqueue it
            for (Integer it: adj.get(node)) {
                if (vis[it] == false) {
                    vis[it] = true;
                    q.add(it);
                }
            }
        }

        return bfs;
    }

    public static void main(String args[]) {

        ArrayList < ArrayList < Integer >> ad
        for (int i = 0; i < 5; i++) {
            adj.add(new ArrayList < > ());
        }
        adj.get(0).add(1);
        adj.get(1).add(0);
        adj.get(0).add(4);
        adj.get(4).add(0);
        adj.get(1).add(2);
        adj.get(2).add(1);
        adj.get(1).add(3);
        adj.get(3).add(1);

        Solution sl = new Solution();
        ArrayList < Integer > ans = sl.bfsOfG
        int n = ans.size();
        for(int i = 0;i<n;i++) {
            System.out.print(ans.get(i)+" ");
        }
    }
}
```

Space Complexity: O(3N) ~ O(N), Space for queue data structure visited array and an adjacency list

> Special thanks to **Vanshika Singh Gour** for contributing to this article on takeUforward. If you also wish to share your knowledge with the takeUforward fam, please check out this article. If you want to suggest any improvement/correction in this article please mail us at write4tuf@gmail.com

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