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Practical No. 7

Aim: Develop a program that finds and prints all the nodes reachable from a specified starting node in a directed graph using Breadth-First Search (BFS).

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AIM: Develop a program that finds and prints all the nodes reachable from a specified starting node in a directed graph using Breadth-First Search (BFS).

OBJECTIVE/EXPECTED LEARNING OUTCOME:

The objectives and expected learning outcome of this practical are:

- To understand and implement the Breadth First Search method of graph traversal.

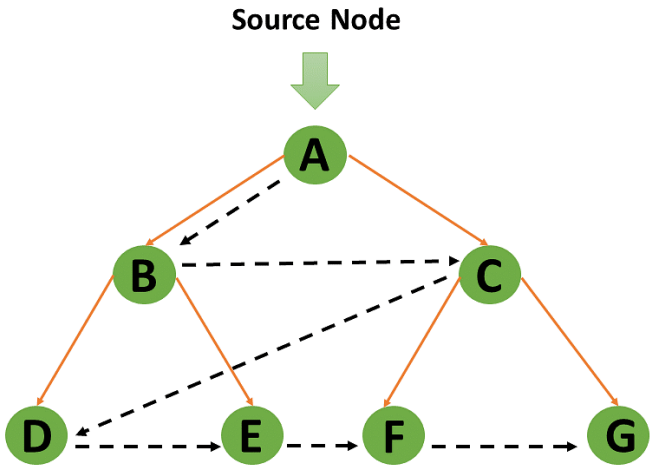
THEORY:

Breadth First Search (BFS) is a fundamental **graph traversal algorithm.** Graph traversal means visiting every vertex and edge exactly once in a well-defined order. While using certain graph algorithms, you must ensure that each vertex of the graph is visited exactly once.

It begins with a node, then first traverses all its adjacent. Once all adjacent are visited, then their adjacent are traversed level by level. BFS itself can be used to detect cycle in a directed and undirected graph, find shortest path in an unweighted graph and many more problems. Breadth-First Search uses a queue data structure technique to store the vertices.

Algorithm:

```
BFS (G, s)              //Where G is the graph and s is the source node
      let Q be queue.
      Q.enqueue( s )   //Inserting s in queue
      mark s as visited.
      while ( Q is not empty)
            v  =  Q.dequeue( )
            for all neighbours w of v in Graph G
               if w is not visited
                        Q.enqueue( w )
                        mark w as visited.
```



Applications of BFS Algorithm:

1. For GPS navigation
2. Path finding algorithms
3. In Ford-Fulkerson algorithm to find maximum flow in a network
4. Cycle detection in an undirected graph
5. In minimum spanning tree

CODE:

```
#include <stdio.h>
#include <stdlib.h>
#define MAX 100
typedef struct {
    int items[MAX];
    int front;
    int rear;
} Queue;
typedef struct {
    int adj[MAX][MAX];
    int numVertices;
```

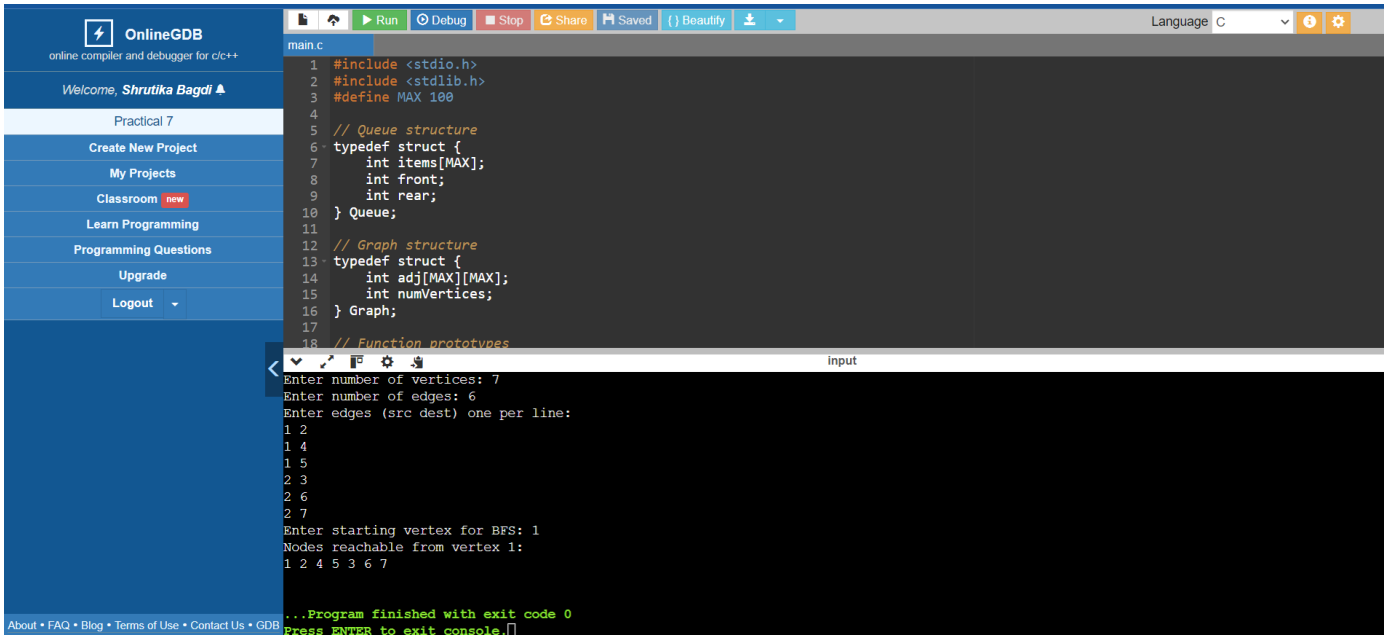
```
} Graph;
void initializeGraph(Graph* g, int vertices);
void addEdge(Graph* g, int src, int dest);
void bfs(Graph* g, int start);
void enqueue(Queue* q, int value);
int dequeue(Queue* q);
int isEmpty(Queue* q);
void initializeQueue(Queue* q);
int main() {
    Graph g;
    int vertices, edges, src, dest;
    printf("Enter number of vertices: ");
    scanf("%d", &vertices);
    printf("Enter number of edges: ");
    scanf("%d", &edges);
    initializeGraph(&g, vertices);
    printf("Enter edges (src dest) one per line:\n");
    for (int i = 0; i < edges; i++) {
        scanf("%d %d", &src, &dest);
        addEdge(&g, src - 1, dest - 1);
    }
    int start;
    printf("Enter starting vertex for BFS: ");
    scanf("%d", &start);
    printf("Nodes reachable from vertex %d:\n", start);
    bfs(&g, start - 1); // Adjust for 1-based to 0-based indexing
    return 0;
}
void initializeGraph(Graph* g, int vertices) {
    g->numVertices = vertices;
    for (int i = 0; i < vertices; i++)
```

```
        for (int j = 0; j < vertices; j++)
            g->adj[i][j] = 0; // Initialize adjacency matrix
}
void addEdge(Graph* g, int src, int dest) {
    g->adj[src][dest] = 1; // Add edge from src to dest
    g->adj[dest][src] = 1; // If undirected graph
}
void bfs(Graph* g, int start) {
    Queue q;
    int visited[MAX] = {0}; // Visited array
    initializeQueue(&q);
    enqueue(&q, start);
    visited[start] = 1;

    while (!isEmpty(&q)) {
        int u = dequeue(&q);
        printf("%d ", u + 1); // Adjust output for 1-based indexing
        for (int v = 0; v < g->numVertices; v++) {
            if (g->adj[u][v] && !visited[v]) {
                enqueue(&q, v);
                visited[v] = 1; // Mark as visited
            }
        }
    }
    printf("\n");
}
void initializeQueue(Queue* q) {
    q->front = -1;
    q->rear = -1;
}
void enqueue(Queue* q, int value) {
```

```
    if (q->rear == MAX - 1) {
        printf("Queue is full\n");
        return;
    }
    if (q->front == -1) {
        q->front = 0;
    }
    q->rear++;
    q->items[q->rear] = value;
}
int dequeue(Queue* q) {
    if (isEmpty(q)) {
        printf("Queue is empty\n");
        return -1;
    }
    int item = q->items[q->front];
    q->front++;
    if (q->front > q->rear) {
        q->front = q->rear = -1; // Reset the queue
    }
    return item;
}
int isEmpty(Queue* q) {
    return q->front == -1;
}
```

INPUT & OUTPUT WITH DIFFERENT TEST CASES:



CONCLUSION:

DISCUSSION AND VIVA VOCE:

- Explain the Breadth First Search algorithm.
- Discuss the complexity of Breadth First Search algorithm.
- Explain the applications of Breadth First Search algorithm.

REFERENCES:

- *https://www.geeksforgeeks.org/breadth-first-search-or-bfs-for-a-graph/*
- *https://www.javatpoint.com/breadth-first-search-algorithm*
- *https://www.hackerearth.com/practice/algorithms/graphs/breadth-first-search/tutorial/*
- *https://www.simplilearn.com/tutorials/data-structure-tutorial/bfs-algorithm*
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- *https://www.programiz.com/dsa/graph-bfs*