410255: LP-V. HPC	
Experiment No: 1	**BFS and DFS Using OpenMP**

Aim: Design and implement Parallel Breadth First Search and Depth First Search based on existing algorithms using OpenMP. Use a Tree or an undirected graph for BFS and DFS.

Depth-First Search

Depth-First Search (or DFS) is an algorithm for searching a tree or an undirected graph data structure. Here, the concept is to start from the starting node known as the **root** and traverse as far as possible in the same branch. If we get a node with no successor node, we return and continue with the vertex, which is yet to be visited.

Steps of Depth-First Search

- Consider a node (root) that is not visited previously and mark it visited.
- Visit the first adjacent successor node and mark it visited.
- If all the successors nodes of the considered node are already visited or it doesn't have any more successor node, return to its parent node.

Pseudocode

Let **v** be the vertex where the search starts in Graph **G**.

```
DFS(G,v)

  Stack S := {};

  for each vertex u, set visited[u] := false;
  push S, v;
  while (S is not empty) do
    u := pop S;

    if (not visited[u]) then
      visited[u] := true;
      for each unvisited neighbour w of u
        push S, w;
    end if
```

```
  end while

END DFS()
```

Breadth-First Search

Breadth-First Search (or BFS) is an algorithm for searching a tree or an undirected graph data structure. Here, we start with a node and then visit all the adjacent nodes in the same level and then move to the adjacent successor node in the next level. This is also known as level-by-level search.

Steps of Breadth-First Search

- Start with the root node, mark it visited.
- As the root node has no node in the same level, go to the next level.
- Visit all adjacent nodes and mark them visited.
- Go to the next level and visit all the unvisited adjacent nodes.
- Continue this process until all the nodes are visited.

Pseudocode

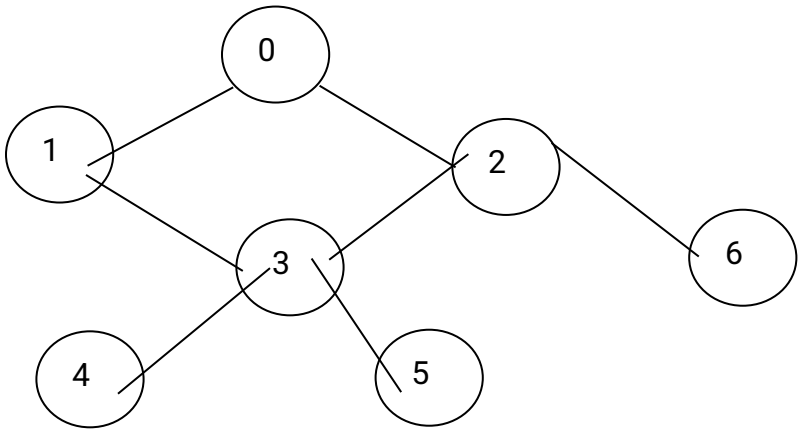
Let **v** be the vertex where the search starts in Graph **G**.

```
BFS(G,v)

  Queue Q := {};

  for each vertex u, set visited[u] := false;
  insert Q, v;
  while (Q is not empty) do
    u := delete Q;

    if (not visited[u]) then
      visited[u] := true;
      for each unvisited neighbor w of u
        insert Q, w;
    end if

  end while

END BFS()
```

Program for Parallel DFS

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

class Graph {
public:
        map<int, bool>visited;
        map<int, list<int>>adj;

        // function to add an edge to graph
        void addEdge(int v, int w);

        // DFS traversal of the vertices reachable from v
        void DFS(int v);
};

void Graph::addEdge(int v, int w)
{
        adj[v].push_back(w); // Add w to v's list.
}

void Graph::DFS(int v)
{
#pragmaomp parallel
        // Mark the current node as visited and print it
        visited[v] = true;
        cout<<v<<" ";
        list<int>::iterator i; // Recur for all the vertices adjacent to this vertex
        for(i=adj[v].begin();i!=adj[v].end();++i)
        {
           if(!visited[*i])
                        DFS(*i);
        }
}

int main()
{
omp_set_num_threads(4);
  int z;
        Graph g;
        g.addEdge(0,1);
        g.addEdge(0,2);
        g.addEdge(1,3);
        g.addEdge(2,3);
```

```
        g.addEdge(3,4);
        g.addEdge(3,5);
       g.addEdge(2,6);
        cout<<"Enter the vertex to start the DFS traversal with: "<<endl;
        cin>>z;
        cout<<"\nDepth First Traversal: \n";
        g.DFS(z);
        cout<<endl;
        return 0;
}
```



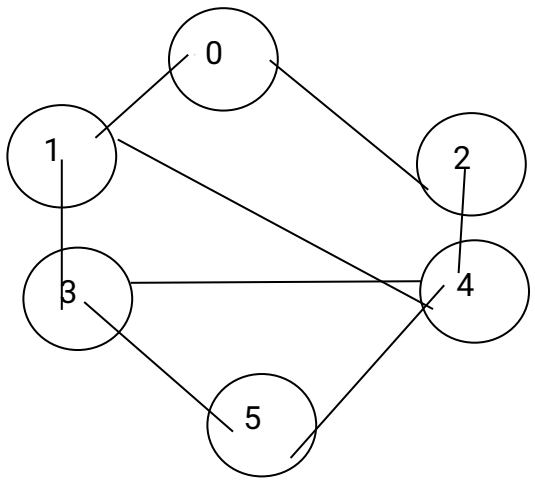
Output –

```
Enter the vertex to start the DFS traversal with:
0

Depth First Traversal:
0 1 3 4 5 2 6
```

Program For Parallel BFS

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

vector<bool> v;
vector<vector<int>> g;

void bfsTraversal(int b)
{

   queue<int> q; //Declare a queue to store all the nodes connected to b
   q.push(b); //Insert b to queue
   v[b]=true;  //mark b as visited

   cout<<"\nThe BFS Traversal is:  ";

   double start=omp_get_wtime();
   while(!q.empty())
   {
      int a = q.front();
      q.pop(); //delete the first element form queue
      #pragma omp parallel
      for(auto j=g[a].begin();j!=g[a].end();j++)
      {
         if (!v[*j])
         {
            v[*j] = true;
            q.push(*j);
         }
      }
      cout<<a<<"  ";
   }
   double end=omp_get_wtime();
   double time=end-start;
   cout<<"\n\nTime taken => "<<time<<endl;
}

void makeEdge(int a, int b)
{
   g[a].push_back(b); //an edge from a to b (directed graph)
}

int main()
```

```
{
   omp_set_num_threads(4);
   int n,e;
   cout<<"Consider first vertex => 0"<<endl;
   cout<<"\nEnter the number of vertices: ";
   cin >> n;
   cout<<"\nEnter the number of edges: ";
   cin>>e;
   v.assign(n, false);
   g.assign(n, vector<int>());
   int a, b, i;
   cout << "\nEnter the edges with source and target vetex: "<<endl;
   for(i=0;i<e;i++)
   {
      cin>>a>>b;
      makeEdge(a, b);
   }
   for (i=0;i<n;i++)
   {
      if (!v[i])   //if the node i is unvisited
      {
         bfsTraversal(i);
      }
   }
   return 0;
}
```



Output –

```
Consider first vertex => 0

Enter the number of vertices: 6

Enter the number of edges: 8

Enter the edges with source and target vetex:
0 1
0 2
1 3
1 4
2 4
3 5
4 5
3 4

The BFS Traversal is:  0  1  2  3  4  5

Time taken => 0.00199986
```