

Graph traversal

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Graph Traversal

- We need also algorithm to traverse a graph like for a tree
- Graph traversal may start at an arbitrary vertex. (Tree traversal generally starts at root vertex)
- Two difficulties in graph traversal, but not in tree traversal:
 - The graph may contain cycles;
 - The graph may not be connected.
- There are two important traversal methods:
 - Breadth-first traversal, based on breadth-first search (BFS).
 - Depth-first traversal, based on depth-first search (DFS).

Breadth-First Traversal

Breadth-first traversal of a graph:

- Is roughly analogous to level-by-level traversal of an ordered tree
- Start the traversal from an arbitrary vertex;
- Visit all of its adjacent vertices;
- Then, visit all unvisited adjacent vertices of those visited vertices in last level;
- Continue this process, until all vertices have been visited.

BFS algorithm

- Implemented with queue;
- Visit an adjacent unvisited vertex to the current vertex, mark it, insert the vertex into the queue, visit next.
- If no more adjacent vertex to visit, remove a vertex from the queue (if possible) and make it the current vertex.
- If the queue is empty and there is no vertex to insert into the queue, then the traversal process finishes.

BFS demo

- [51demo-bfs.ppt](#)

Pseudocode

```
BFS( $G, s$ )  
  for each vertex  $u$  in  $V$  do  
    visited[ $u$ ] = false  
  
  initialize an empty  $Q$   
  Enqueue( $Q, s$ )  
  
  While  $Q$  is not empty do  
     $u$  = Dequeue( $Q$ )  
    if not visited[ $u$ ] then  
      Report( $u$ )  
      visited[ $u$ ] = true  
      for each  $v$  in Adj[ $u$ ] do  
        if not visited[ $v$ ] then  
          Enqueue( $Q, v$ )
```

Quiz 1

- Let implement a graph using the red black tree as in the previous lab.

```
typedef JRB Graph;  
Graph createGraph();  
void addEdge(Graph graph, int v1, int v2);  
int adjacent(Graph graph, int v1, int v2);  
...
```

- Write a function to traverse the graph using BFS algorithm

```
void BFS(Graph graph, int start, int stop, void (*func)(int));
```

- start is the first vertex to visit
- stop is the vertex to be visited at the end, if stop = -1, all the vertices may be visited
- func is a pointer to the function that process on the visited vertices

Example

```
void printVertex(int v) { printf("%4d", v); }
```

```
Graph g = createGraph();  
addEdge(g, 0, 1);  
addEdge(g, 1, 2);  
addEdge(g, 1, 3);  
addEdge(g, 2, 3);  
addEdge(g, 2, 4);  
addEdge(g, 4, 5);  
printf("\nBFS: start from node 1 to 5 : ");  
BFS(g, 1, 4, printVertex);  
printf("\nBFS: start from node 1 to all : ");  
BFS(g, 1, -1, printVertex);
```


Instruction

- Use the double linked list data structure in libfdr to represent a queue as the following
- To create a queue
 - `Dllist queue = new_dllist();`
- To add a visited node
 - `dll_append(queue, new_jval_i(v))`
- To check if the queue is empty
 - `dll_empty(queue)`
- To get a vertex from the queue
 - `node = dll_first(queue)`
 - `v = jval_i(node->val)`
 - `dll_delete_node(node)`

Depth-First Search

- From the given vertex, visit one of its adjacent vertices and leave others;
- Then visit one of the adjacent vertices of the previous vertex;
- Continue the process, visit the graph as deep as possible until:
 - A visited vertex is reached;
 - An end vertex is reached.

Depth-First Traversal

- Start the traversal from an arbitrary vertex;
- Apply depth-first search;
- When the search terminates, backtrack to the previous vertex of the finishing point,
- Repeat depth-first search on other adjacent vertices, then backtrack to one level up.
- Continue the process until all the vertices that are reachable from the starting vertex are visited.
- Repeat above processes until all vertices are visited.

DFS algorithm

- DFS can be implemented with stack, since recursion and programming with stacks are equivalent;
- Visit a vertex v
- Push all adjacent unvisited vertices of v onto a stack
- Pop a vertex off the stack until it is unvisited
- Repeat these steps
- If the stack is empty and there is no vertex to push onto the stack, then the traversal process finishes.

DFS demo

- [demo-dfs-undirected.ppt](#)

Pseudocode

```
DFS (G, s)
  for each vertex u in V do
    visited[u] = false

  initialize an empty stack S
  Put(S, s)

  While S is not empty do
    u = Pop(S)
    if not visited[u] then
      Report(u)
      visited[u] = true
      for each v in Adj[u] do
        if not visited[v] then Put(S, v)
```

Quiz 2

- Continue to write a function to traverse the graph using DFS algorithm

```
void DFS(Graph graph, int start, int stop, void  
    (*func)(int));
```

- start is the first vertex to visit
- stop is the vertex to be visited at the end, if stop = -1, all the vertices may be visited
- func is a pointer to the function that process on the visited vertices

Solution

- graph_traversal.c

Applications

- The paths traversed by BFS or DFS form a tree (called BFS tree or DFS tree).
- BFS tree is also a shortest path tree starting from its root. i.e. Every vertex v has a path to the root s in T and the path is the shortest path of v and s in G .
- DFS is used to check a the path existence between two vertices. It can be used to determine if a graph is connected.

Quiz 3

- Add a new functionality in the metro program in order to find a shortest path between two metro stations.