TUTORIAL-5

Q1) What is the difference between DFS and BFS. Write applications of both the algorithms.

BFS	DFS
a) It stands for Breadth First Search.	a) It stands for Depth First Search.
b) It uses queue data structure.	b) It uses stakk data structure.
c) It is more suitable for searching vertices which are clear to given source.	c) It is more suitable when there are solutions away from source.
d) BFS considers all neighbours first & therefore not suitable for decision-making trees used in games and puzzles.	d) DFS is more suitable for game or puzzle problems. We make a decision then explore all paths through this decision, and if decision leads to win situation, we stop.
e) The siblings are visited before children.	e) Here, children are visited before siblings.
f) There is no concept of backtracking.	f) It is a recursive algorithm that uses backtracking.
g) It requires more memory.	g) It requires less memory.

Applications:-

- BFS - Bipartite graph and shortest graph, peer to peer networking, crawlers in search engine and GPS navigation system.
- DFS - acyclic graph, topological order, scheduling problems, soduku puzzle.

Q.2) Which data structure are used to implement BFS and DFS. Why?

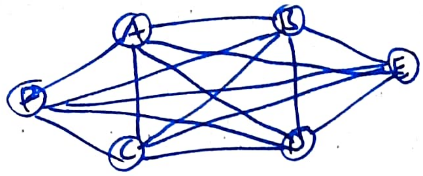
For implementing BFS, we need a queue data structure for finding shortest path between any node. We use queue because things don't have to be processed immediately, but have to be processed in FIFO order like BFS. BFS searches for nodes' level wise, i.e; it searches node wrt their distance from root (source). For this, queue is better to use in BFS.

For implementing DFS, we need a stack data structure as it traverse a graph in depth in depthward motion and uses stack to remember to get the next vertex to start a search, when a dead end occurs in any iteration.

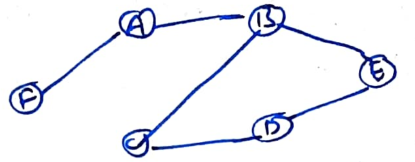
Q.3) What do you mean by sparse and dense graph? Which representation of graph is better for sparse and dense graph?

Dense graph is a graph in which no. of edges is close to maximal no. of edges

Sparse graph is a graph in which no. of edges is very low.



Dense Graph



Sparse graph

- For sparse graph, it is preferred to use Adjacency list.
- For dense graph, it is prefered to use Adjacency Matrix.

Q.4) How can you detect a cycle in a graph using BFS & DFS?

For detecting cycle, in a graph using BFS, we need to use Kahn's algorithm for topological sorting.

The steps involved are:

① Compute in degree (no. of incoming edges) for each of vertex present in graph and initialize count of visited nodes as 0.

② Pick all vertices with in-degree as 0 and add them in queue.

③ Remove a vertex from queue and then,
- increment count of visited nodes by 1.
- Decrease in-degree by 1 for all its neighbouring nodes.
- If in-degree of neighbouring nodes is reduced to zero then add to q

④ Repeat ③ until queue is empty.

⑤ If count of visited nodes is not equal to no. of nodes in graph has cycle, otherwise not.

For detecting cycle in graph using DFS, we need to do the following:
DFS for a connecting graph produces a tree, there is cycle in graph if there is a back edge present in the graph. A back cycle is an edge that is from a node to itself (self-loop) or one of its ancestor in the tree produced by DFS. For a disconnected graph, get DFS forest as output. To detect cycle, check for a cycle in individual trees by checking back edges. To detect a back edge, ~~we~~ keep track of vertices currently in recursion track for DFS traversal. If a vertex is reached that is already in recursion stack, then there is a cycle.

Q.5) What do you mean by disjoint set data structure? Explain 3 operations along with examples which can be performed on disjoint sets?

A disjoint set is a data structure that keeps track of set of elements partitioned into several disjoint subsets. In other words, a disjoint set is a group of sets where no item can be in more than one set.

3 operations:-

1. **Find**:- can be implemented by recursively traversing the parent array until we hit a node who is parent itself.

```
int find (int i)
{
    if(parent[i] == i])
        return i;
    else
        return find(parent[i]);
}
```

2. **Union**:- It takes two elements as input and finds representatives of these sets using the find operation and ~~fillo~~ finally puts either one of the trees under root node of other tree, effectively merging the trees and sets.

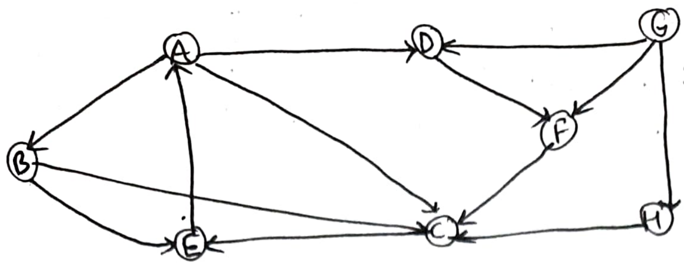
```
void union (int i, int j)
{
    int irep = this.find (i);
    int jrep = this.find (j);
    this.parent [irep] = jrep;
}
```

3. **Union by Rank**:- We need a new array rank[]. Size of array same as parent array. If i is the representative of set, rank[i] is height of tree. We need to minimize height of tree. If we are uniting 2-trees, we call them left and right, then it all depends on rank of left and right.

- If rank of left is less than right then it's best to move left under right and vice-versa.
- If ranks are equal, rank of result will always be one greater than rank of trees.

```
void union (int i, int j)
{ int irep = this.Find(i);
  int jrep = this.Find(j);
  if (irep == jrep) return;
  irank = Rank[irep];
  jrank = Rank[jrep];
  if ( irank < jrank) this.parent[irep] = jrep;
  else if (jrank < irank) this.parent[jrep] = irep;
  else   this.parent [irep] = jrep;
         Rank[jrep]++;
}
```

Q.6) Run BFS and DFS on graph shown below.



BFS

Child	G	H	D	F	C	E	A	B
Parent		G	G	G	H		~~C~~E	A

Path → G → H → C → E → A → B

DFS

~~G~~
D
H
~~F~~
~~C~~
~~E~~
~~A~~
~~B~~

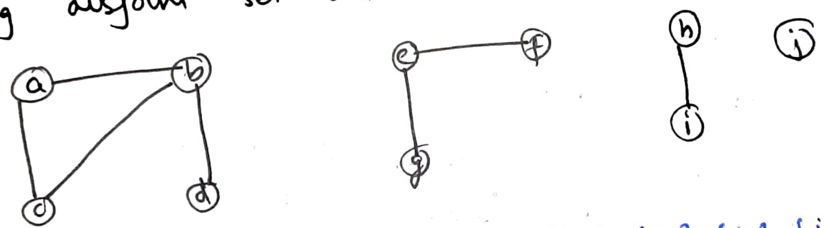
Visited Nodes

G
F
C
E
A
B

Stack

Path → G → F → C → E → A → B

Q.7) Find out no. of connected components and vertices in each component using disjoint set data structure.



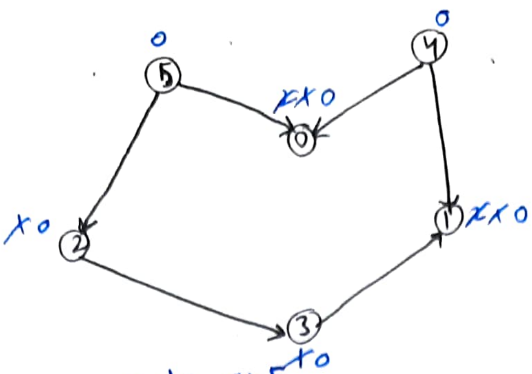
V = {a} {b} {c} {d} {e} {f} {g} {h} {i} {j}

E = {a, b}, {a, c}, {b, c}, {b, d}, {e, f}, {e, g}, {h, i}, {j}

(a, b) {a, b}, {c} {d} {e} {f} {g} {h} {i} {j}
(a, c) {a, b, c} {d} {e} {f} {g} {h} {i} {j}
(b, c) {a, b, c} {d} {e} {f} {g} {h} {i} {j}
(b, d) {a, b, c, d} {e} {f} {g} {h} {i} {j}
(e, f) {a, b, c, d} {e, f} {g} {h} {i} {j}
(e, g) {a, b, c, d} {e, f, g} {h} {i} {j}
(h, i) {a, b, c, d} {e, f, g} {h, i} {j}

No. of connected components = 3

Q.8) Apply topological sort and DFS on graph having vertices from 0 to 5.



We take source code as 5.

Applying Topological Sort

DFS(5)
↓
DFS(0)

DFS(2)
↓
DFS(3)
↓
DFS(1)

DFS(4)
↓
Not possible

q: 5|4; Pop 5 and decrement indegree of it by 1.

q: 4|2; Pop 4 and decrement indegree and push 0

q: 2|0; Pop 2 and decrement indegree and push 3

q: 0|3; Pop 0, Pop 3, push 1

q: 1; Pop 1

5 4 2 0 3 1 Ans

4
5
2
3
1
0

stack $4 \rightarrow 5 \rightarrow 2 \rightarrow 3 \rightarrow 1 \rightarrow 0$

Q.9) Heap data structure can be used to implement priority queue. Name few graph algorithm where you need to use priority queue and why?

Yes, heap data structure can be used to implement priority queue. It will take O(log N) time to insert and delete each element in priority queue. Based on heap structure, priority queue has two types max-priority queue based on max heap and min priority queue based on min-heap. Heaps provide better performance comp to array and linked list.

The graphs like Dijkstra's shortest path algorithm, Prim's Minimum spanning tree use priority queue.

- Dijkstra's Algorithm:- When graph is stored in form of adjacency list or matrix, priority queue is used to extract minimum efficiently when implementing the algorithm.
- Prim's Algorithm:- It is used to store keys of nodes and extract minimum key node at every step.

Q.10) Differentiate between Min-heap and Max-heap.

Min - Heap	Max - Heap
• In min-heap, key present at root node, must be less than or equal to among keys present at all of its children.	• In max-heap, the key present at root node must be greater than or equal to among keys present at all of its children.
• The minimum key element is present at the root.	• The maximum key almost is present at the root.
• It uses ascending priority.	• It uses descending priority.
• The smallest element has priority while construction of min-heap.	• The largest element has priority, while construction of max-heap.
• The smallest element is the first to be popped from the heap.	• The largest element is the first to be popped from the heap.