

Depth First Search (DFS)

In this tutorial, you will learn about depth first search algorithm with examples and pseudocode. Also, you will learn to implement DFS in C, Java, Python, and C++.

Depth first Search or Depth first traversal is a recursive algorithm for searching all the vertices of a graph or tree data structure. Traversal means visiting all the nodes of a [graph](#).

Depth First Search Algorithm

A standard DFS implementation puts each vertex of the graph into one of two categories:

1. Visited
2. Not Visited

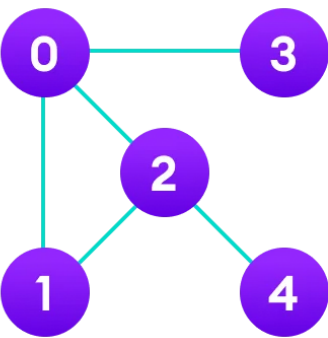
The purpose of the algorithm is to mark each vertex as visited while avoiding cycles.

The DFS algorithm works as follows:

1. Start by putting any one of the graph's vertices on top of a stack.
 2. Take the top item of the stack and add it to the visited list.
 3. Create a list of that vertex's adjacent nodes. Add the ones which aren't in the visited list to the top of the stack.
 4. Keep repeating steps 2 and 3 until the stack is empty.
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Depth First Search Example

Let's see how the Depth First Search algorithm works with an example. We use an undirected graph with 5 vertices.



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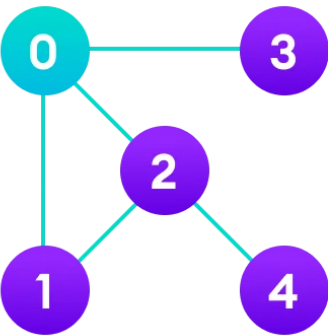
Visited

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Stack

Undirected graph with 5 vertices

We start from vertex 0, the DFS algorithm starts by putting it in the Visited list and putting all its adjacent vertices in the stack.



0				
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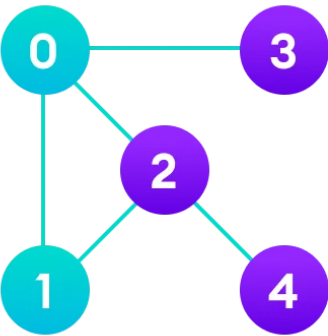
Visited

1	2	3		
---	---	---	--	--

Stack

Visit the element and put it in the visited list

Next, we visit the element at the top of stack i.e. 1 and go to its adjacent nodes. Since 0 has already been visited, we visit 2 instead.



0	1			
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Visited

2	3			
---	---	--	--	--

Stack

Visit the element at the top of stack

Vertex 2 has an unvisited adjacent vertex in 4, so we add that to the top of the stack and visit it.



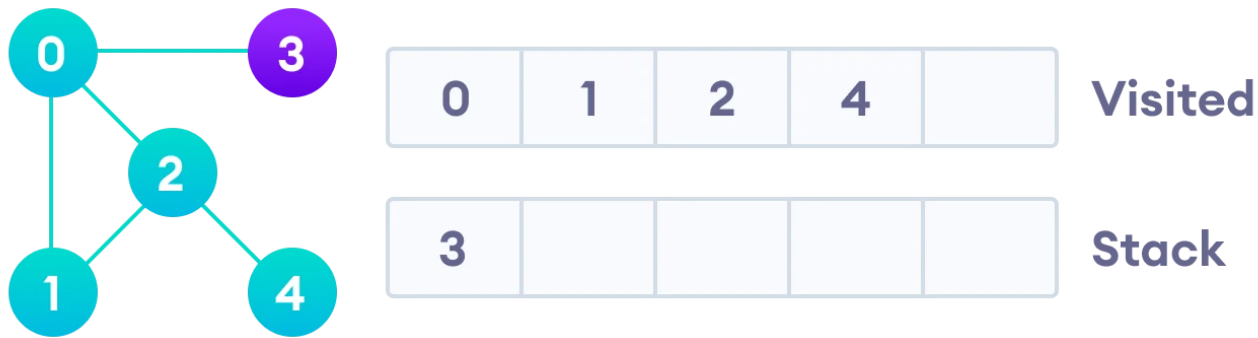
0	1	2		
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Visited

4	3			
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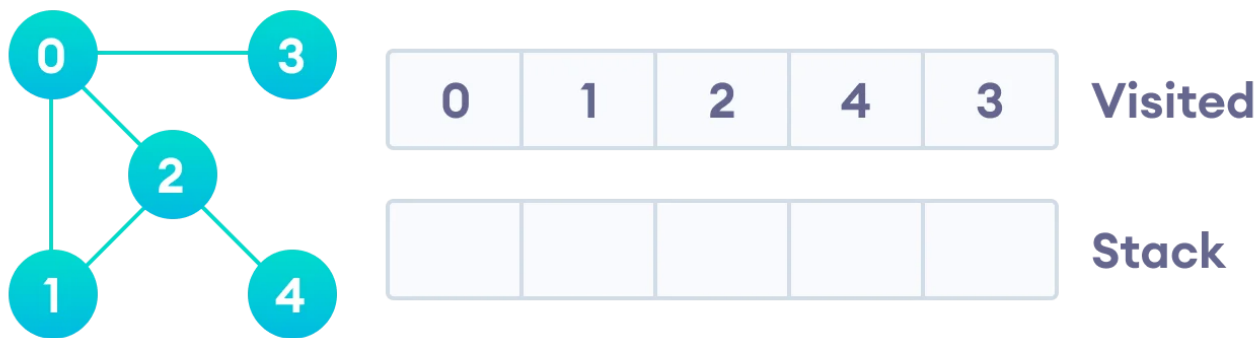
Stack

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DFS Pseudocode (recursive implementation)

The pseudocode for DFS is shown below. In the `init()` function, notice that we run the DFS function on every node. This is because the graph might have two different disconnected parts so to make sure that we cover every vertex, we can also run the DFS algorithm on every node.

```
DFS(G, u)
    u.visited = true
    for each v ∈ G.Adj[u]
        if v.visited == false
            DFS(G,v)

init() {
    For each u ∈ G
        u.visited = false
    For each u ∈ G
        DFS(G, u)
}
```

DFS Implementation in Python, Java and C/C++

The code for the Depth First Search Algorithm with an example is shown below. The code has been simplified so that we can focus on the algorithm rather than other details.

[Python](#)[Java](#)[C](#)[C++](#)

```
// DFS algorithm in C

#include <stdio.h>
#include <stdlib.h>

struct node {
    int vertex;
    struct node* next;
};

struct node* createNode(int v);

struct Graph {
    int numVertices;
    int* visited;

    // We need int** to store a two dimensional array.
    // Similary, we need struct node** to store an array of Linked lists
    struct node** adjLists;
};

// DFS algo
void DFS(struct Graph* graph, int vertex) {
    struct node* adjList = graph->adjLists[vertex];
    struct node* temp = adjList;

    graph->visited[vertex] = 1;
    printf("Visited %d \n", vertex);
```

Complexity of Depth First Search

The time complexity of the DFS algorithm is represented in the form of $O(V + E)$, where V is the number of nodes and E is the number of edges.

The space complexity of the algorithm is $O(V)$.

Application of DFS Algorithm

1. For finding the path
2. To test if the graph is bipartite
3. For finding the strongly connected components of a graph

4. For detecting cycles in a graph