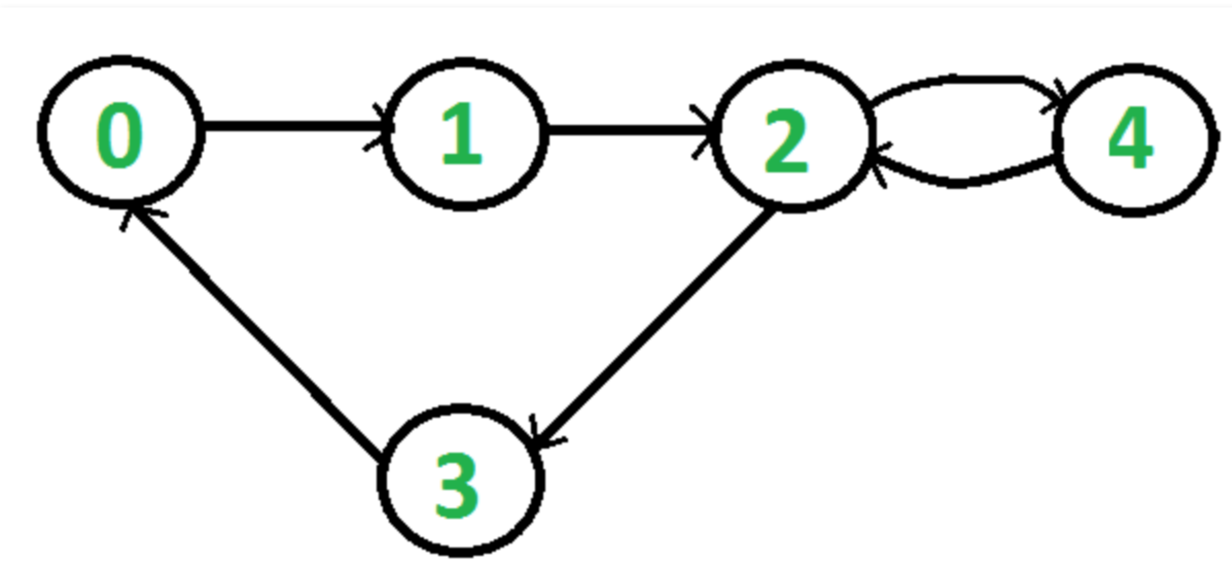
Detect Cycle in a Directed Graph using BFS

Difficulty Level : Medium • Last Updated : 02 Jul, 2021

Given a directed graph, check whether the graph contains a cycle or not. Your function should return true if the given graph contains at least one cycle, else return false. For example, the following graph contains two cycles 0->1->2->3->0 and 2->4->2, so your function must return true.



Recommended: Please solve it on "***PRACTICE***" first, before moving on to the solution.

We have discussed a DFS based solution to detect cycle in a directed graph. In this post, BFS based solution is discussed.
 e idea is to simply use Kahn's algorithm for Topological Sorting

Steps involved in detecting cycle in a directed graph using BFS.

Step-1: Compute in-degree (number of incoming edges) for each of the vertex present in the graph and initialize the count of visited nodes as 0.

Step-2: Pick all the vertices with in-degree as 0 and add them into a queue (Enqueue operation)

Step-3: Remove a vertex from the queue (Dequeue operation) and then.

1. Increment count of visited nodes by 1.
2. Decrease in-degree by 1 for all its neighboring nodes.
3. If in-degree of a neighboring nodes is reduced to zero, then add it to the queue.

Step 4: Repeat Step 3 until the queue is empty.

Step 5: If count of visited nodes is **not** equal to the number of nodes in the graph has cycle, otherwise not.

How to find in-degree of each node?

There are 2 ways to calculate in-degree of every vertex:

Take an in-degree array which will keep track of

1) Traverse the array of edges and simply increase the counter of the destination node by 1.


```
    indegree[dest]++
```

Time Complexity: O(V+E)

2) Traverse the list for every node and then increment the in-degree of all the nodes connected to it by 1.

```
for each node in Nodes
    If (list[node].size()!=0) then
    for each dest in list
        indegree[dest]++;
```

Time Complexity: The outer for loop will be executed V number of times and the inner for loop will be executed E number of times, Thus overall time complexity is O(V+E).

The overall time complexity of the algorithm is O(V+E)

C++

```cpp
// A C++ program to check if there is a cycle in
// directed graph using BFS.
#include <bits/stdc++.h>
using namespace std;

// Class to represent a graph
class Graph {
    int V; // No. of vertices'

    // Pointer to an array containing adjacency lisr
    list<int>* adj;

public:
    Graph(int V); // Constructor

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

    // Returns true if there is a cycle in the graph
    // else false.
    bool isCycle();
};

Graph::Graph(int V)
{
    this->V = V;
    adj = new list<int>[V];
}

void Graph::addEdge(int u, int v)
```

```
{
    adj[u].push_back(v);
}

// This function returns true if there is a cycle
// in directed graph, else returns false.
bool Graph::isCycle()
{
    // Create a vector to store indegrees of all
    // vertices. Initialize all indegrees as 0.
    vector<int> in_degree(V, 0);

    // Traverse adjacency lists to fill indegrees of
    // vertices. This step takes O(V+E) time
    for (int u = 0; u < V; u++) {
        for (auto v : adj[u])
            in_degree[v]++;
    }

    // Create an queue and enqueue all vertices with
    // indegree 0
    queue<int> q;
    for (int i = 0; i < V; i++)
        if (in_degree[i] == 0)
            q.push(i);

    // Initialize count of visited vertices
    int cnt = 0;

    // Create a vector to store result (A topological
    // ordering of the vertices)
    vector<int> top_order;

    // One by one dequeue vertices from queue and enqueue
    // adjacents if indegree of adjacent becomes 0
    while (!q.empty()) {

        // Extract front of queue (or perform dequeue)
        // and add it to topological order
        int u = q.front();
        q.pop();
        top_order.push_back(u);

        // Iterate through all its neighbouring nodes
        // of dequeued node u and decrease their in-degree
        // by 1
        list<int>::iterator itr;
        for (itr = adj[u].begin(); itr != adj[u].end(); itr++)

            // If in-degree becomes zero, add it to queue
            if (--in_degree[*itr] == 0)
                q.push(*itr);
```

```
            cnt++;
        }

        // Check if there was a cycle
        if (cnt != V)
            return true;
        else
            return false;
    }

    // Driver program to test above functions
    int main()
    {
        // Create a graph given in the above diagram
        Graph g(6);
        g.addEdge(0, 1);
        g.addEdge(1, 2);
        g.addEdge(2, 0);
        g.addEdge(3, 4);
        g.addEdge(4, 5);

        if (g.isCycle())
            cout << "Yes";
        else
            cout << "No";

        return 0;
    }
```

Java

```
    // Java program to check if there is a cycle in
    // directed graph using BFS.
    import java.io.*;
    import java.util.*;

    class GFG
    {

        // Class to represent a graph
        static class Graph
        {
            int V; // No. of vertices'

            // Pointer to an array containing adjacency list
            Vector<Integer>[] adj;

            @SuppressWarnings("unchecked")
            Graph(int V)
```

```
    {
        // Constructor
        this.V = V;
        this.adj = new Vector[V];
        for (int i = 0; i < V; i++)
            adj[i] = new Vector<>();
    }

    // function to add an edge to graph
    void addEdge(int u, int v)
    {
        adj[u].add(v);
    }

    // Returns true if there is a cycle in the graph
    // else false.

    // This function returns true if there is a cycle
    // in directed graph, else returns false.
    boolean isCycle()
    {

        // Create a vector to store indegrees of all
        // vertices. Initialize all indegrees as 0.
        int[] in_degree = new int[this.V];
        Arrays.fill(in_degree, 0);

        // Traverse adjacency lists to fill indegrees of
        // vertices. This step takes O(V+E) time
        for (int u = 0; u < V; u++)
        {
            for (int v : adj[u])
                in_degree[v]++;
        }

        // Create an queue and enqueue all vertices with
        // indegree 0
        Queue<Integer> q = new LinkedList<Integer>();
        for (int i = 0; i < V; i++)
            if (in_degree[i] == 0)
                q.add(i);

        // Initialize count of visited vertices
        int cnt = 0;

        // Create a vector to store result (A topological
        // ordering of the vertices)
        Vector<Integer> top_order = new Vector<>();

        // One by one dequeue vertices from queue and enqueue
        // adjacents if indegree of adjacent becomes 0
        while (!q.isEmpty())
```

```
            {

                // Extract front of queue (or perform dequeue)
                // and add it to topological order
                int u = q.poll();
                top_order.add(u);

                // Iterate through all its neighbouring nodes
                // of dequeued node u and decrease their in-degree
                // by 1
                for (int itr : adj[u])
                    if (--in_degree[itr] == 0)
                        q.add(itr);
                cnt++;
            }

            // Check if there was a cycle
            if (cnt != this.V)
                return true;
            else
                return false;
        }
    }

    // Driver Code
    public static void main(String[] args)
    {

        // Create a graph given in the above diagram
        Graph g = new Graph(6);
        g.addEdge(0, 1);
        g.addEdge(1, 2);
        g.addEdge(2, 0);
        g.addEdge(3, 4);
        g.addEdge(4, 5);

        if (g.isCycle())
            System.out.println("Yes");
        else
            System.out.println("No");
    }
}

// This code is contributed by
// sanjeev2552
```

Python3

```
# A Python3 program to check if there is a cycle in
# directed graph using BFS.
```

```
import math
import sys
from collections import defaultdict

# Class to represent a graph
class Graph:
    def __init__(self,vertices):
        self.graph=defaultdict(list)
        self.V=vertices # No. of vertices'

    # function to add an edge to graph
    def addEdge(self,u,v):
        self.graph[u].append(v)

# This function returns true if there is a cycle
# in directed graph, else returns false.
def isCycleExist(n,graph):

    # Create a vector to store indegrees of all
    # vertices. Initialize all indegrees as 0.
    in_degree=[0]*n

    # Traverse adjacency lists to fill indegrees of
    # vertices. This step takes O(V+E) time
    for i in range(n):
        for j in graph[i]:
            in_degree[j]+=1

    # Create an queue and enqueue all vertices with
    # indegree 0
    queue=[]
    for i in range(len(in_degree)):
        if in_degree[i]==0:
            queue.append(i)

    # Initialize count of visited vertices
    cnt=0

    # One by one dequeue vertices from queue and enqueue
    # adjacents if indegree of adjacent becomes 0
    while(queue):

        # Extract front of queue (or perform dequeue)
        # and add it to topological order
        nu=queue.pop(0)

        # Iterate through all its neighbouring nodes
        # of dequeued node u and decrease their in-degree
        # by 1
        for v in graph[nu]:
            in_degree[v]-=1
```

```
            # If in-degree becomes zero, add it to queue
            if in_degree[v]==0:
                queue.append(v)
        cnt+=1

    # Check if there was a cycle
    if cnt==n:
        return False
    else:
        return True


# Driver program to test above functions
if __name__=='__main__':

    # Create a graph given in the above diagram
    g=Graph(6)
    g.addEdge(0,1)
    g.addEdge(1,2)
    g.addEdge(2,0)
    g.addEdge(3,4)
    g.addEdge(4,5)

    if isCycleExist(g.V,g.graph):
        print("Yes")
    else:
        print("No")

# This Code is Contributed by Vikash Kumar 37
```

C#

```
// C# program to check if there is a cycle in
// directed graph using BFS.
using System;
using System.Collections.Generic;

class GFG{

// Class to represent a graph
public class Graph
{

    // No. of vertices'
    public int V;

    // Pointer to an array containing
    // adjacency list
    public List<int>[] adj;
```

```
    public Graph(int V)
    {

        // Constructor
        this.V = V;
        this.adj = new List<int>[V];
        for (int i = 0; i < V; i++)
        adj[i] = new List<int>();
    }

    // Function to add an edge to graph
    public void addEdge(int u, int v)
    {
        adj[u].Add(v);
    }

    // Returns true if there is a cycle in the
    // graph else false.

    // This function returns true if there is
    // a cycle in directed graph, else returns
    // false.
    public bool isCycle()
    {

        // Create a vector to store indegrees of all
        // vertices. Initialize all indegrees as 0.
        int[] in_degree = new int[this.V];

        // Traverse adjacency lists to fill indegrees
        // of vertices. This step takes O(V+E) time
        for(int u = 0; u < V; u++)
        {
            foreach(int v in adj[u])
                in_degree[v]++;
        }

        // Create an queue and enqueue all
        // vertices with indegree 0
        Queue<int> q = new Queue<int>();
        for(int i = 0; i < V; i++)
            if (in_degree[i] == 0)
                q.Enqueue(i);

        // Initialize count of visited vertices
        int cnt = 0;

        // Create a vector to store result
        // (A topological ordering of the
        // vertices)
        List<int> top_order = new List<int>();
```

```
            // One by one dequeue vertices from
            // queue and enqueue adjacents if
            // indegree of adjacent becomes 0
            while (q.Count != 0)
            {

                // Extract front of queue (or perform
                // dequeue) and add it to topological
                // order
                int u = q.Peek();
                q.Dequeue();
                top_order.Add(u);

                // Iterate through all its neighbouring
                // nodes of dequeued node u and decrease
                // their in-degree by 1
                foreach(int itr in adj[u])
                    if (--in_degree[itr] == 0)
                        q.Enqueue(itr);

                cnt++;
            }

            // Check if there was a cycle
            if (cnt != this.V)
                return true;
            else
                return false;
        }
    }

    // Driver Code
    public static void Main(String[] args)
    {

        // Create a graph given in the above diagram
        Graph g = new Graph(6);
        g.addEdge(0, 1);
        g.addEdge(1, 2);
        g.addEdge(2, 0);
        g.addEdge(3, 4);
        g.addEdge(4, 5);

        if (g.isCycle())
            Console.WriteLine("Yes");
        else
            Console.WriteLine("No");
    }


    // This code is contributed by Princi Si
```

Javascript

```
<script>

// JavaScript program to check if there is a cycle in
// directed graph using BFS.

// Class to represent a graph
// No. of vertices'
var V = 0;

// Pointer to an array containing
// adjacency list
var adj ;

function initialize(v)
{

    // Constructor
    V = v;
    adj = Array.from(Array(V), ()=>Array(V));
}

// Function to add an edge to graph
function addEdge(u, v)
{
    adj[u].push(v);
}

// Returns true if there is a cycle in the
// graph else false.

// This function returns true if there is
// a cycle in directed graph, else returns
// false.
function isCycle()
{

    // Create a vector to store indegrees of all
    // vertices. Initialize all indegrees as 0.
    var in_degree = Array(V).fill(0);

    // Traverse adjacency lists to fill indegrees
    // of vertices. This step takes O(V+E) time
    for(var u = 0; u < V; u++)
    {
        for(var v of adj[u])
            in_degree[v]++;
    }
```

```
    // Create an queue and enqueue all
    // vertices with indegree 0
    var q = [];
    for(var i = 0; i < V; i++)
        if (in_degree[i] == 0)
            q.push(i);

    // Initialize count of visited vertices
    var cnt = 0;

    // Create a vector to store result
    // (A topological ordering of the
    // vertices)
    var top_order = [];

    // One by one dequeue vertices from
    // queue and enqueue adjacents if
    // indegree of adjacent becomes 0
    while (q.length != 0)
    {

        // Extract front of queue (or perform
        // dequeue) and add it to topological
        // order
        var u = q[0];
        q.shift();
        top_order.push(u);

        // Iterate through all its neighbouring
        // nodes of dequeued node u and decrease
        // their in-degree by 1
        for(var itr of adj[u])
            if (--in_degree[itr] == 0)
                q.push(itr);

        cnt++;
    }

    // Check if there was a cycle
    if (cnt != V)
        return true;
    else
        return false;
}

// Create a graph given in the above diagram
initialize(6)
addEdge(0, 1);
addEdge(1, 2);
addEdge(2, 0);
addEdge(3, 4);
addEdge(4, 5);
```

```
if (isCycle())
    document.write("Yes");
else
    document.write("No");


</script>
```

Output:

```
Yes
```

Time Complexity : O(V+E)

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