Printing Paths in Dijkstra's Shortest Path Algorithm

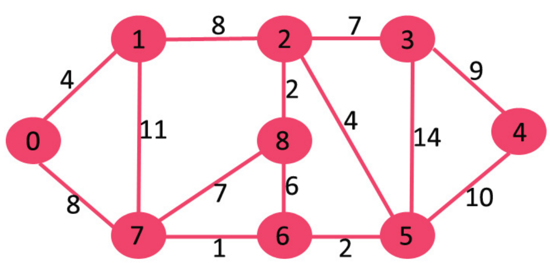
Given a graph and a source vertex in graph, find shortest paths from source to all vertices in the given graph.

We have discussed Dijkstra's Shortest Path algorithm in below posts.

- Dijkstra's shortest path for adjacency matrix representation
- Dijkstra's shortest path for adjacency list representation

The implementations discussed above only find shortest distances, but do not print paths. In this post printing of paths is discussed.

```
For example, consider below graph and source as 0,
```




```
Output should be
Vertex           Distance         Path
0 -> 1          4        0 1
0 -> 2          12        0 1 2
0 -> 3          19        0 1 2 3
0 -> 4          21        0 7 6 5 4
0 -> 5          11        0 7 6 5
0 -> 6          9        0 7 6
0 -> 7          8        0 7
0 -> 8          14        0 1 2 8
```

The idea is to create a separate array parent[]. Value of parent[v] for a vertex v stores parent vertex of v in shortest path tree. Parent of root (or source vertex) is -1. Whenever we find shorter path through a vertex u, we make u as parent of current vertex.

Once we have parent array constructed, we can print path using below recursive function.

```
    if (parent[j]==-1)
        return;

    printPath(parent, parent[j]);

    printf("%d ", j);
}
```

Below is the complete implementation

C/C++

```
// C program for Dijkstra's single
// source shortest path algorithm.
// The program is for adjacency matrix
// representation of the graph.
#include <stdio.h>
#include <limits.h>

// Number of vertices
// in the graph
#define V 9

// A utility function to find the
// vertex with minimum distance
// value, from the set of vertices
// not yet included in shortest
// path tree
int minDistance(int dist[],
                bool sptSet[])
{

    // Initialize min value
    int min = INT_MAX, min_index;

    for (int v = 0; v < V; v++)
        if (sptSet[v] == false &&
                   dist[v] <= min)
            min = dist[v], min_index = v;

    return min_index;
}

// Function to print shortest
// path from source to j
// using parent array
void printPath(int parent[], int j)
{

    // Base Case : If j is source
    if (parent[j] == - 1)
```

```
        printf("%d ", j);
    }

    // A utility function to print
    // the constructed distance
    // array
    int printSolution(int dist[], int n,
                          int parent[])
    {
        int src = 0;
        printf("Vertex\t Distance\tPath");
        for (int i = 1; i < V; i++)
        {
            printf("\n%d -> %d \t\t %d\t\t%d ",
                          src, i, dist[i], src);
            printPath(parent, i);
        }
    }

    // Funtion that implements Dijkstra's
    // single source shortest path
    // algorithm for a graph represented
    // using adjacency matrix representation
    void dijkstra(int graph[V][V], int src)
    {

        // The output array. dist[i]
        // will hold the shortest
        // distance from src to i
        int dist[V];

        // sptSet[i] will true if vertex
        // i is included / in shortest
        // path tree or shortest distance
        // from src to i is finalized
        bool sptSet[V];

        // Parent array to store
        // shortest path tree
        int parent[V];

        // Initialize all distances as
        // INFINITE and stpSet[] as false
        for (int i = 0; i < V; i++)
        {
            parent[0] = -1;
            dist[i] = INT_MAX;
            sptSet[i] = false;
        }

        // Distance of source vertex
        // from itself is always 0
        dist[src] = 0;

        // Find shortest path
```

```
        // vertex from the set of
        // vertices not yet processed.
        // u is always equal to src
        // in first iteration.
        int u = minDistance(dist, sptSet);

        // Mark the picked vertex
        // as processed
        sptSet[u] = true;

        // Update dist value of the
        // adjacent vertices of the
        // picked vertex.
        for (int v = 0; v < V; v++)

            // Update dist[v] only if is
            // not in sptSet, there is
            // an edge from u to v, and
            // total weight of path from
            // src to v through u is smaller
            // than current value of
            // dist[v]
            if (!sptSet[v] && graph[u][v] &&
                dist[u] + graph[u][v] < dist[v])
            {
                parent[v] = u;
                dist[v] = dist[u] + graph[u][v];
            }
    }

    // print the constructed
    // distance array
    printSolution(dist, V, parent);
}

// Driver Code
int main()
{
    //  Let us create the example
    // graph discussed above
    int graph[V][V] = {{0, 4, 0, 0, 0, 0, 0, 8, 0},
                       {4, 0, 8, 0, 0, 0, 0, 11, 0},
                        {0, 8, 0, 7, 0, 4, 0, 0, 2},
                        {0, 0, 7, 0, 9, 14, 0, 0, 0},
                        {0, 0, 0, 9, 0, 10, 0, 0, 0},
                        {0, 0, 4, 0, 10, 0, 2, 0, 0},
                        {0, 0, 0, 14, 0, 2, 0, 1, 6},
                        {8, 11, 0, 0, 0, 0, 1, 0, 7},
                        {0, 0, 2, 0, 0, 0, 6, 7, 0}
                    };

    dijkstra(graph, 0);
    return 0;
}
```

```
// A Java program for Dijkstra's
// single source shortest path
// algorithm. The program is for
// adjacency matrix representation
// of the graph.

class DijkstrasAlgorithm {

    private static final int NO_PARENT = -1;

    // Function that implements Dijkstra's
    // single source shortest path
    // algorithm for a graph represented
    // using adjacency matrix
    // representation
    private static void dijkstra(int[][] adjacencyMatrix,
                                        int startVertex)
    {
        int nVertices = adjacencyMatrix[0].length;

        // shortestDistances[i] will hold the
        // shortest distance from src to i
        int[] shortestDistances = new int[nVertices];

        // added[i] will true if vertex i is
        // included / in shortest path tree
        // or shortest distance from src to
        // i is finalized
        boolean[] added = new boolean[nVertices];

        // Initialize all distances as
        // INFINITE and added[] as false
        for (int vertexIndex = 0; vertexIndex < nVertices;
                                            vertexIndex++)
        {
            shortestDistances[vertexIndex] = Integer.MAX_VALUE;
            added[vertexIndex] = false;
        }

        // Distance of source vertex from
        // itself is always 0
        shortestDistances[startVertex] = 0;

        // Parent array to store shortest
        // path tree
        int[] parents = new int[nVertices];

        // The starting vertex does not
        // have a parent
        parents[startVertex] = NO_PARENT;

        // Find shortest path for all
        // vertices
        for (int i = 1; i < nVertices; i++)
        {
```

```
            // always equal to startNode in
            // first iteration.
            int nearestVertex = -1;
            int shortestDistance = Integer.MAX_VALUE;
            for (int vertexIndex = 0;
                     vertexIndex < nVertices;
                     vertexIndex++)
            {
                if (!added[vertexIndex] &&
                    shortestDistances[vertexIndex] <
                    shortestDistance)
                {
                    nearestVertex = vertexIndex;
                    shortestDistance = shortestDistances[vertexIndex];
                }
            }

            // Mark the picked vertex as
            // processed
            added[nearestVertex] = true;

            // Update dist value of the
            // adjacent vertices of the
            // picked vertex.
            for (int vertexIndex = 0;
                     vertexIndex < nVertices;
                     vertexIndex++)
            {
                int edgeDistance = adjacencyMatrix[nearestVertex][vertexIndex];

                if (edgeDistance > 0
                    && ((shortestDistance + edgeDistance) <
                        shortestDistances[vertexIndex]))
                {
                    parents[vertexIndex] = nearestVertex;
                    shortestDistances[vertexIndex] = shortestDistance +
                                                       edgeDistance;
                }
            }
        }

        printSolution(startVertex, shortestDistances, parents);
    }

    // A utility function to print
    // the constructed distances
    // array and shortest paths
    private static void printSolution(int startVertex,
                                      int[] distances,
                                      int[] parents)
    {
        int nVertices = distances.length;
        System.out.print("Vertex\t Distance\tPath");

        for (int vertexIndex = 0;
```

```
            {
                System.out.print("\n" + startVertex + " -> ");
                System.out.print(vertexIndex + " \t\t ");
                System.out.print(distances[vertexIndex] + "\t\t");
                printPath(vertexIndex, parents);
            }
        }
    }

    // Function to print shortest path
    // from source to currentVertex
    // using parents array
    private static void printPath(int currentVertex,
                                  int[] parents)
    {

        // Base case : Source node has
        // been processed
        if (currentVertex == NO_PARENT)
        {
            return;
        }
        printPath(parents[currentVertex], parents);
        System.out.print(currentVertex + " ");
    }

        // Driver Code
    public static void main(String[] args)
    {
        int[][] adjacencyMatrix = { { 0, 4, 0, 0, 0, 0, 0, 8, 0 },
                                    { 4, 0, 8, 0, 0, 0, 0, 11, 0 },
                                    { 0, 8, 0, 7, 0, 4, 0, 0, 2 },
                                    { 0, 0, 7, 0, 9, 14, 0, 0, 0 },
                                    { 0, 0, 0, 9, 0, 10, 0, 0, 0 },
                                    { 0, 0, 4, 0, 10, 0, 2, 0, 0 },
                                    { 0, 0, 0, 14, 0, 2, 0, 1, 6 },
                                    { 8, 11, 0, 0, 0, 0, 1, 0, 7 },
                                    { 0, 0, 2, 0, 0, 0, 6, 7, 0 } };
        dijkstra(adjacencyMatrix, 0);
    }
}

// This code is contributed by Harikrishnan Rajan
```

Python

```
# Python program for Dijkstra's
# single source shortest
# path algorithm. The program
# is for adjacency matrix
```

```
#Class to represent a graph
class Graph:

    # A utility function to find the
    # vertex with minimum dist value, from
    # the set of vertices still in queue
    def minDistance(self,dist,queue):
        # Initialize min value and min_index as -1
        minimum = float("Inf")
        min_index = -1

        # from the dist array,pick one which
        # has min value and is till in queue
        for i in range(len(dist)):
            if dist[i] < minimum and i in queue:
                minimum = dist[i]
                min_index = i
        return min_index


    # Function to print shortest path
    # from source to j
    # using parent array
    def printPath(self, parent, j):

        #Base Case : If j is source
        if parent[j] == -1 :
            print j,
            return
        self.printPath(parent , parent[j])
        print j,


    # A utility function to print
    # the constructed distance
    # array
    def printSolution(self, dist, parent):
        src = 0
        print("Vertex \t\tDistance from Source\tPath")
        for i in range(1, len(dist)):
            print("\n%d --> %d \t\t%d \t\t\t\t\t" % (src, i, dist[i])),
            self.printPath(parent,i)


    '''Function that implements Dijkstra's single source shortest path
    algorithm for a graph represented using adjacency matrix
    representation'''
    def dijkstra(self, graph, src):

        row = len(graph)
        col = len(graph[0])

        # The output array. dist[i] will hold
        # the shortest distance from src to i
        # Initialize all distances as INFINITE
```

```
        parent = [-1] * row

        # Distance of source vertex
        # from itself is always 0
        dist[src] = 0

        # Add all vertices in queue
        queue = []
        for i in range(row):
            queue.append(i)

        #Find shortest path for all vertices
        while queue:

            # Pick the minimum dist vertex
            # from the set of vertices
            # still in queue
            u = self.minDistance(dist,queue)

            # remove min element
            queue.remove(u)

            # Update dist value and parent
            # index of the adjacent vertices of
            # the picked vertex. Consider only
            # those vertices which are still in
            # queue
            for i in range(col):
                '''Update dist[i] only if it is in queue, there is
                an edge from u to i, and total weight of path from
                src to i through u is smaller than current value of
                dist[i]'''
                if graph[u][i] and i in queue:
                    if dist[u] + graph[u][i] < dist[i]:
                        dist[i] = dist[u] + graph[u][i]
                        parent[i] = u


        # print the constructed distance array
        self.printSolution(dist,parent)

g= Graph()

graph = [[0, 4, 0, 0, 0, 0, 0, 8, 0],
        [4, 0, 8, 0, 0, 0, 0, 11, 0],
        [0, 8, 0, 7, 0, 4, 0, 0, 2],
        [0, 0, 7, 0, 9, 14, 0, 0, 0],
        [0, 0, 0, 9, 0, 10, 0, 0, 0],
        [0, 0, 4, 14, 10, 0, 2, 0, 0],
        [0, 0, 0, 0, 0, 2, 0, 1, 6],
        [8, 11, 0, 0, 0, 0, 1, 0, 7],
        [0, 0, 2, 0, 0, 0, 6, 7, 0]
        ]

# Print the solution
```

C#

```
// C# program for Dijkstra's
// single source shortest path
// algorithm. The program is for
// adjacency matrix representation
// of the graph.
using System;

public class DijkstrasAlgorithm
{

    private static readonly int NO_PARENT = -1;

    // Function that implements Dijkstra's
    // single source shortest path
    // algorithm for a graph represented
    // using adjacency matrix
    // representation
    private static void dijkstra(int[,] adjacencyMatrix,
                                        int startVertex)
    {
        int nVertices = adjacencyMatrix.GetLength(0);

        // shortestDistances[i] will hold the
        // shortest distance from src to i
        int[] shortestDistances = new int[nVertices];

        // added[i] will true if vertex i is
        // included / in shortest path tree
        // or shortest distance from src to
        // i is finalized
        bool[] added = new bool[nVertices];

        // Initialize all distances as
        // INFINITE and added[] as false
        for (int vertexIndex = 0; vertexIndex < nVertices;
                                            vertexIndex++)
        {
            shortestDistances[vertexIndex] = int.MaxValue;
            added[vertexIndex] = false;
        }

        // Distance of source vertex from
        // itself is always 0
        shortestDistances[startVertex] = 0;

        // Parent array to store shortest
        // path tree
        int[] parents = new int[nVertices];

        // The starting vertex does not
```

```
        // vertices
        for (int i = 1; i < nVertices; i++)
        {

            // Pick the minimum distance vertex
            // from the set of vertices not yet
            // processed. nearestVertex is
            // always equal to startNode in
            // first iteration.
            int nearestVertex = -1;
            int shortestDistance = int.MaxValue;
            for (int vertexIndex = 0;
                    vertexIndex < nVertices;
                    vertexIndex++)
            {
                if (!added[vertexIndex] &&
                    shortestDistances[vertexIndex] <
                    shortestDistance)
                {
                    nearestVertex = vertexIndex;
                    shortestDistance = shortestDistances[vertexIndex];
                }
            }

            // Mark the picked vertex as
            // processed
            added[nearestVertex] = true;

            // Update dist value of the
            // adjacent vertices of the
            // picked vertex.
            for (int vertexIndex = 0;
                    vertexIndex < nVertices;
                    vertexIndex++)
            {
                int edgeDistance = adjacencyMatrix[nearestVertex,vertexIndex];

                if (edgeDistance > 0
                    && ((shortestDistance + edgeDistance) <
                        shortestDistances[vertexIndex]))
                {
                    parents[vertexIndex] = nearestVertex;
                    shortestDistances[vertexIndex] = shortestDistance +
                                                    edgeDistance;
                }
            }
        }

        printSolution(startVertex, shortestDistances, parents);
    }

    // A utility function to print
    // the constructed distances
    // array and shortest paths
    private static void printSolution(int startVertex,
```

```
        Console.Write("Vertex\t Distance\tPath");

        for (int vertexIndex = 0;
                vertexIndex < nVertices;
                vertexIndex++)
        {
            if (vertexIndex != startVertex)
            {
                Console.Write("\n" + startVertex + " -> ");
                Console.Write(vertexIndex + " \t\t ");
                Console.Write(distances[vertexIndex] + "\t\t");
                printPath(vertexIndex, parents);
            }
        }
    }

    // Function to print shortest path
    // from source to currentVertex
    // using parents array
    private static void printPath(int currentVertex,
                                    int[] parents)
    {

        // Base case : Source node has
        // been processed
        if (currentVertex == NO_PARENT)
        {
            return;
        }
        printPath(parents[currentVertex], parents);
        Console.Write(currentVertex + " ");
    }

    // Driver Code
    public static void Main(String[] args)
    {
        int[,] adjacencyMatrix = { { 0, 4, 0, 0, 0, 0, 0, 8, 0 },
                                    { 4, 0, 8, 0, 0, 0, 0, 11, 0 },
                                    { 0, 8, 0, 7, 0, 4, 0, 0, 2 },
                                    { 0, 0, 7, 0, 9, 14, 0, 0, 0 },
                                    { 0, 0, 0, 9, 0, 10, 0, 0, 0 },
                                    { 0, 0, 4, 0, 10, 0, 2, 0, 0 },
                                    { 0, 0, 0, 14, 0, 2, 0, 1, 6 },
                                    { 8, 11, 0, 0, 0, 0, 1, 0, 7 },
                                    { 0, 0, 2, 0, 0, 0, 6, 7, 0 } };
        dijkstra(adjacencyMatrix, 0);
    }
}

// This code has been contributed by 29AjayKumar
```

```
0 -> 1          4         0 1
0 -> 2          12         0 1 2
0 -> 3          19         0 1 2 3
0 -> 4          21         0 7 6 5 4
0 -> 5          11         0 7 6 5
0 -> 6          9         0 7 6
0 -> 7          8         0 7
0 -> 8          14         0 1 2 8
```

This article is contributed by **Aditya Goel**. Please write comments if you find anything incorrect, or you want to share more information about the topic discussed above

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