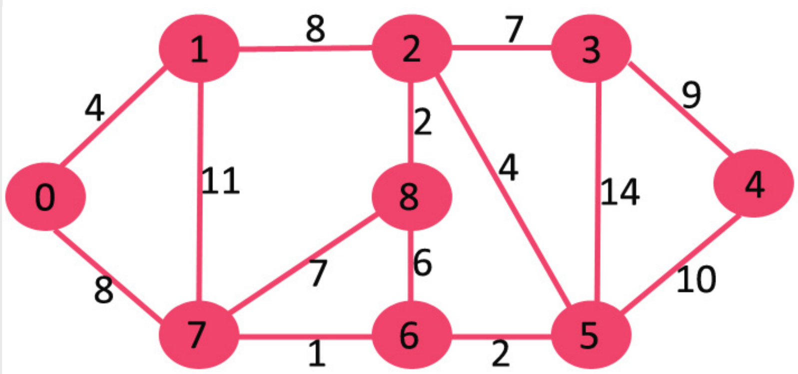
# Greedy Algorithms | Set 7 (Dijkstra's shortest path algorithm)

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

Dijkstra's algorithm is very similar to Prim's algorithm for minimum spanning tree. Like Prim's MST, we generate a *SPT (shortest path tree)* with given source as root. We maintain two sets, one set contains vertices included in shortest path tree, other set includes vertices not yet included in shortest path tree. At every step of the algorithm, we find a vertex which is in the other set (set of not yet included) and has minimum distance from source.

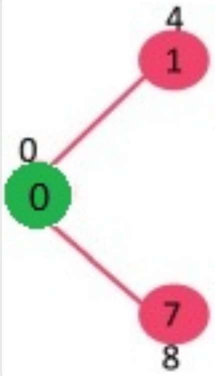
Below are the detailed steps used in Dijkstra's algorithm to find the shortest path from a single source vertex to all other vertices in the given graph.
Algorithm
**1)** Create a set *sptSet* (shortest path tree set) that keeps track of vertices included in shortest path tree, i.e., whose minimum distance from source is calculated and finalized. Initially, this set is empty.
**2)** Assign a distance value to all vertices in the input graph. Initialize all distance values as INFINITE. Assign distance value as 0 for the source vertex so that it is picked first.
**3)** While *sptSet* doesn't include all vertices
….**a)** Pick a vertex u which is not there in *sptSet*and has minimum distance value.
….**b)** Include u to *sptSet*.
….**c)** Update distance value of all adjacent vertices of u. To update the distance values, iterate through all adjacent vertices. For every adjacent vertex v, if sum of distance value of u (from source) and weight of edge u-v, is less than the distance value of v, then update the distance value of v.

Let us understand with the following example:

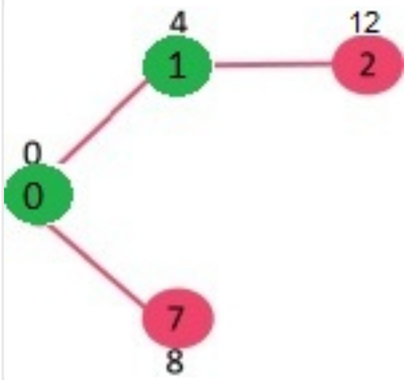



The set *sptSet*is initially empty and distances assigned to vertices are {0, INF, INF, INF, INF, INF, INF, INF} where INF indicates infinite. Now pick the vertex with minimum distance value. The vertex 0 is picked, include it in *sptSet*.

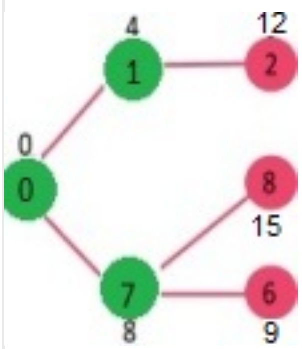
So *sptSet* becomes {0}. After including 0 to *sptSet*, update distance values of its adjacent vertices. Adjacent vertices of 0 are 1 and 7. The distance values of 1 and 7 are updated as 4 and 8. Following subgraph shows vertices and their distance values, only the vertices with finite distance values are shown. The vertices included in SPT are shown in green color.



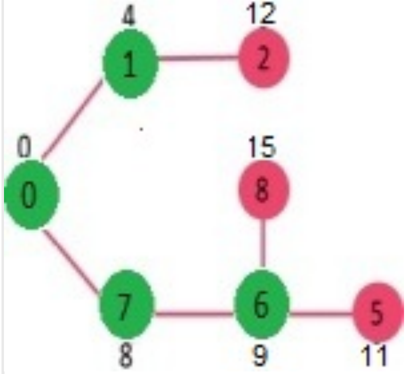

Pick the vertex with minimum distance value and not already included in SPT (not in sptSET). The vertex 1 is picked and added to sptSet. So sptSet now becomes {0, 1}. Update the distance values of adjacent vertices of 1. The distance value of vertex 2 becomes 12.



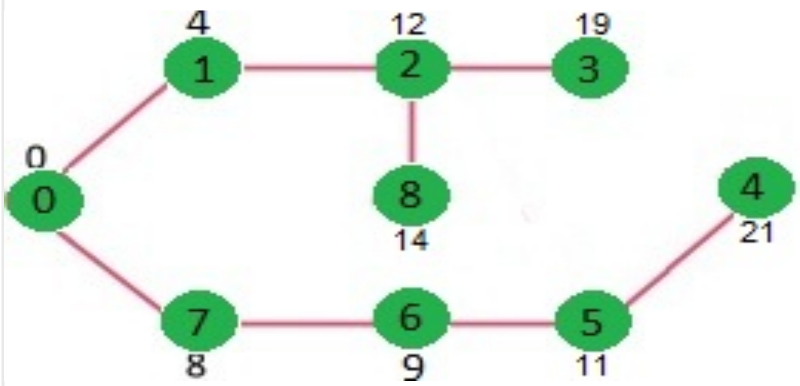

Pick the vertex with minimum distance value and not already included in SPT (not in sptSET). Vertex 7 is picked. So sptSet now becomes {0, 1, 7}. Update the distance values of adjacent vertices of 7. The distance value of vertex 6 and 8 becomes finite (15 and 9 respectively).




Pick the vertex with minimum distance value and not already included in SPT (not in sptSET). Vertex 6 is picked. So sptSet now becomes {0, 1, 7, 6}. Update the distance values of adjacent vertices of 6. The distance value of vertex 5 and 8 are updated.




We repeat the above steps until *sptSet* doesn't include all vertices of given graph. Finally, we get the following Shortest Path Tree (SPT).




***How to implement the above algorithm?***

## We strongly recommend that you click here and practice it, before moving on to the solution.

We use a boolean array sptSet[] to represent the set of vertices included in SPT. If a value sptSet[v] is true, then vertex v is included in SPT, otherwise not. Array dist[] is used to store shortest distance values of all vertices.

---

```
// A 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;
}

// A utility function to print the constructed distance array
int printSolution(int dist[], int n)
{
    printf("Vertex   Distance from Source\n");
    for (int i = 0; i < V; i++)
       printf("%d \t\t %d\n", i, dist[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)
{
     int dist[V];     // The output array.  dist[i] will hold the shortest
                      // distance from src to i

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

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

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

     // Find shortest path for all vertices
     for (int count = 0; count < V-1; count++)
     {
       // Pick the minimum distance 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] != INT_MAX
                                       && dist[u]+graph[u][v] < dist[v])
            dist[v] = dist[u] + graph[u][v];
     }

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

// driver program to test above function
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, 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}
                     };

    dijkstra(graph, 0);

    return 0;
}
```

Run on IDE

## Java

```java
// A Java program for Dijkstra's single source shortest path algorithm.
// The program is for adjacency matrix representation of the graph
import java.util.*;
import java.lang.*;
import java.io.*;

class ShortestPath
{
    // A utility function to find the vertex with minimum distance value,
    // from the set of vertices not yet included in shortest path tree
    static final int V=9;
    int minDistance(int dist[], Boolean sptSet[])
    {
        // Initialize min value
        int min = Integer.MAX_VALUE, min_index=-1;

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

        return min_index;
    }

    // A utility function to print the constructed distance array
    void printSolution(int dist[], int n)
    {
        System.out.println("Vertex   Distance from Source");
        for (int i = 0; i < V; i++)
            System.out.println(i+" \t\t "+dist[i]);
    }

    // Funtion that implements Dijkstra's single source shortest path
    // algorithm for a graph represented using adjacency matrix
    // representation
    void dijkstra(int graph[][], int src)
    {
        int dist[] = new int[V]; // The output array. dist[i] will hold
                                 // the shortest distance from src to i

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

        // Initialize all distances as INFINITE and stpSet[] as false
        for (int i = 0; i < V; i++)
        {
            dist[i] = Integer.MAX_VALUE;
```

```java
            sptSet[i] = false;
        }

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

        // Find shortest path for all vertices
        for (int count = 0; count < V-1; count++)
        {
            // Pick the minimum distance 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]!=0 &&
                        dist[u] != Integer.MAX_VALUE &&
                        dist[u]+graph[u][v] < dist[v])
                    dist[v] = dist[u] + graph[u][v];
        }

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

    // Driver method
    public static void main (String[] args)
    {
        /* Let us create the example graph discussed above */
       int graph[][] = new int[][]{{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}
                                 };
        ShortestPath t = new ShortestPath();
        t.dijkstra(graph, 0);
    }
}
//This code is contributed by Aakash Hasija
```

Run on IDE

Output:

```
Vertex   Distance from Source
0                0
```

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

**Notes:**

**1)** The code calculates shortest distance, but doesn't calculate the path information. We can create a parent array, update the parent array when distance is updated (like prim's implementation) and use it show the shortest path from source to different vertices.

**2)** The code is for undirected graph, same dijkstra function can be used for directed graphs also.

**3)** The code finds shortest distances from source to all vertices. If we are interested only in shortest distance from source to a single target, we can break the for loop when the picked minimum distance vertex is equal to target (Step 3.a of algorithm).

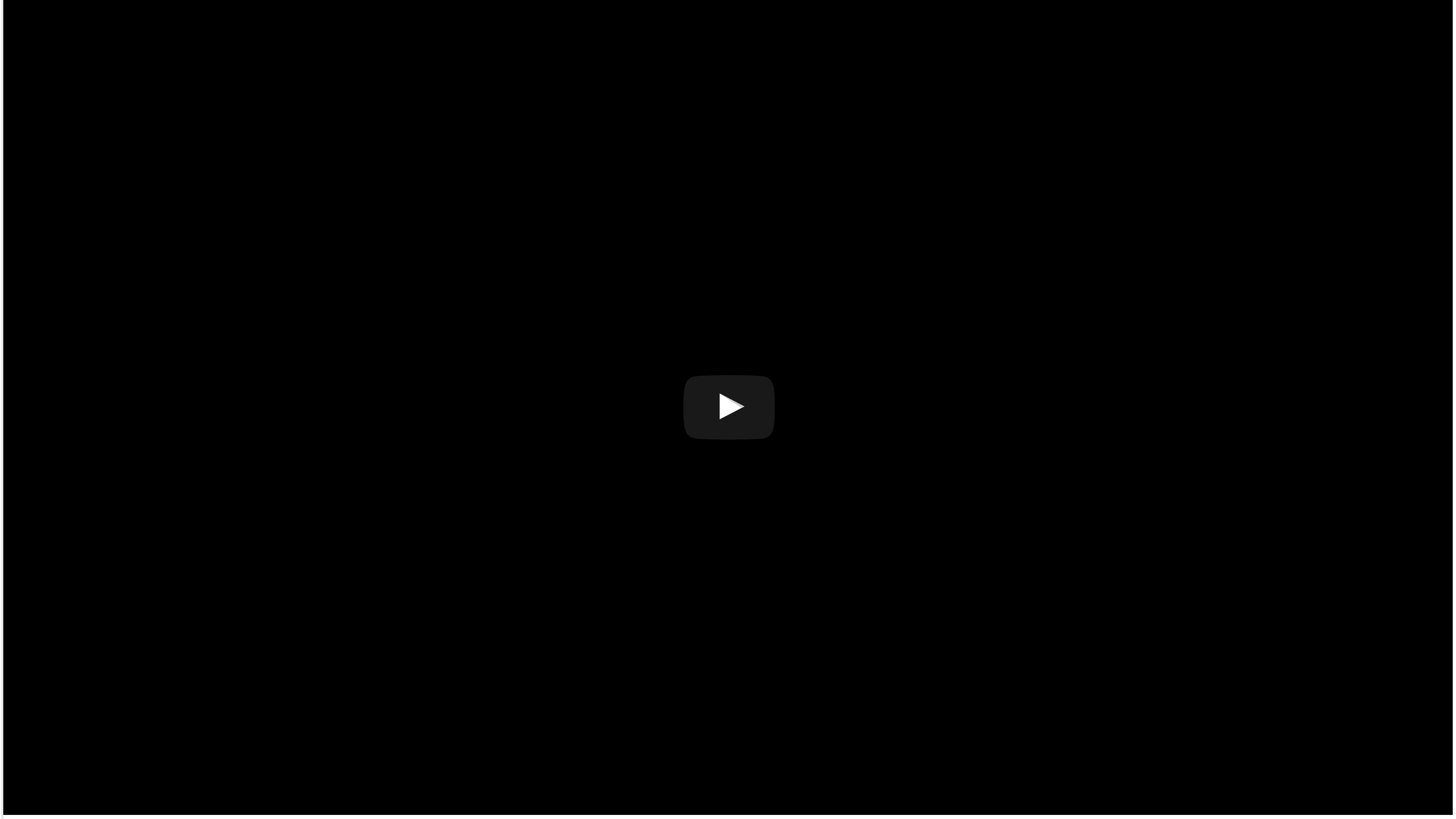
**4)** Time Complexity of the implementation is O(V^2). If the input graph is represented using adjacency list, it can be reduced to O(E log V) with the help of binary heap. Please see
Dijkstra's Algorithm for Adjacency List Representation for more details.

**5)** Dijkstra's algorithm doesn't work for graphs with negative weight edges. For graphs with negative weight edges, Bellman–Ford algorithm can be used, we will soon be discussing it as a separate post.

Dijkstra's Algorithm for Adjacency List Representation

Printing Paths in Dijkstra's Shortest Path Algorithm

Dijkstra's shortest path algorithm using set in STL



Please write comments if you find anything incorrect, or you want to share more information about the topic discussed above.



## GATE CS Corner    Company Wise Coding Practice

Graph Greedy Dijkstra shortest path

### Recommended Posts:

Greedy Algorithms | Set 8 (Dijkstra's Algorithm for Adjacency List Representation)
Greedy Algorithms | Set 5 (Prim's Minimum Spanning Tree (MST))
Dynamic Programming | Set 16 (Floyd Warshall Algorithm)
Dynamic Programming | Set 23 (Bellman–Ford Algorithm)
Dijkstra's shortest path algorithm using set in STL

(Login to Rate and Mark)

2.9 Average Difficulty : **2.9/5.0**
Based on **80** vote(s)

Add to TODO List
Mark as DONE

Writing code in comment? Please use ide.geeksforgeeks.org, generate link and share the link here.

Load Comments

Share this post!