Dijkstra’s Shortest Path Algorithm using priority_queue of STL

```
1) Initialize distances of all vertices as infinite.


2) Create an empty priority_queue pq.  Every item of pq is a pair (weight,
vertex). Weight (or distance) is used used as first item of pair as first
item is by default used to compare two pairs.

3) Insert source vertex into pq and make its distance as 0.

4) While either pq doesn't become empty
    a) Extract minimum distance vertex from pq.
       Let the extracted vertex be u.
    b) Loop through all adjacent of u and do
       following for every vertex v.

           // If there is a shorter path to v
           // through u.
           If dist[v] > dist[u] + weight(u, v)

               (i) Update distance of v, i.e., do
                     dist[v] = dist[u] + weight(u, v)
               (ii) Insert v into the pq (Even if v is
                    already there)

5) Print distance array dist[] to print all shortest
   paths.
```

Comparing Prim’s and Dijkstra’s Algorithms

In the computation aspect, Prim’s and Dijkstra’s algorithms have three main differences:

1. **Dijkstra’s algorithm finds the shortest path, but Prim’s algorithm finds the MST**
2. Dijkstra’s algorithm can work on both directed and undirected graphs, but Prim’s algorithm only works on undirected graphs
3. Prim’s algorithm can handle negative edge weights, but Dijkstra’s algorithm may fail to accurately compute distances if at least one negative edge weight exists

In practice, Dijkstra’s algorithm is used when we want to save time and fuel traveling from one point to another. Prim’s algorithm, on the other hand, is used when we want to minimize material costs in constructing roads that connect multiple points to each other.

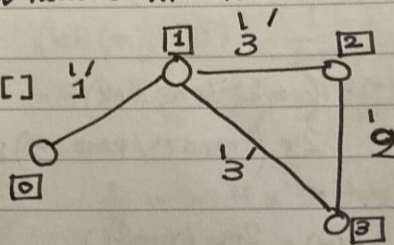
```
// Program to find Dijkstra's shortest path using
// priority_queue in STL
#include<bits/stdc++.h>
using namespace std;
# define INF 0x3f3f3f3f

// iPair ==> Integer Pair
typedef pair<int, int> iPair;

// This class represents a directed graph using
// adjacency list representation
class Graph
{
	int V; // No. of vertices

	// In a weighted graph, we need to store vertex
	// and weight pair for every edge
	list< pair<int, int> > *adj;

public:
	Graph(int V); // Constructor

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

	// prints shortest path from s
	void shortestPath(int s);
};

// Allocates memory for adjacency list
Graph::Graph(int V)
{
	this->V = V;
	adj = new list<iPair> [V];
}

void Graph::addEdge(int u, int v, int w)
{
	adj[u].push_back(make_pair(v, w));
	adj[v].push_back(make_pair(u, w));
}

// Prints shortest paths from src to all other vertices
void Graph::shortestPath(int src)
{
	// Create a priority queue to store vertices that
	// are being preprocessed. This is weird syntax in C++.
	// Refer below link for details of this syntax
	// https://www.geeksforgeeks.org/implement-min-heap-using-stl/
	priority_queue< iPair, vector <iPair> , greater<iPair> > pq;

	// Create a vector for distances and initialize all
	// distances as infinite (INF)
	vector<int> dist(V, INF);

	// Insert source itself in priority queue and initialize
	// its distance as 0.
	pq.push(make_pair(0, src));
	dist[src] = 0;

	/* Looping till priority queue becomes empty (or all
	distances are not finalized) */
	while (!pq.empty())
	{
		// The first vertex in pair is the minimum distance
		// vertex, extract it from priority queue.
		// vertex label is stored in second of pair (it
```

```
            // has to be done this way to keep the vertices
            // sorted distance (distance must be first item
            // in pair)
            int u = pq.top().second;
            pq.pop();

            // 'i' is used to get all adjacent vertices of a vertex
            list< pair<int, int> >::iterator i;
            for (i = adj[u].begin(); i != adj[u].end(); ++i)
            {
                    // Get vertex label and weight of current adjacent
                    // of u.
                    int v = (*i).first;
                    int weight = (*i).second;

                    // If there is shorted path to v through u.
                    if (dist[v] > dist[u] + weight)
                    {
                            // Updating distance of v
                            dist[v] = dist[u] + weight;
                            pq.push(make_pair(dist[v], v));
                    }
            }
    }

    // Print shortest distances stored in dist[]
    printf("Vertex Distance from Source\n");
    for (int i = 0; i < V; ++i)
            printf("%d \t\t %d\n", i, dist[i]);
}

// Driver program to test methods of graph class
int main()
{
    // create the graph given in above fugure
    int V = 9;
    Graph g(V);
    // making above shown graph
    g.addEdge(0, 1, 4);
    g.addEdge(0, 7, 8);
    g.addEdge(1, 2, 8);
    g.addEdge(1, 7, 11);
    g.addEdge(2, 3, 7);
    g.addEdge(2, 8, 2);
    g.addEdge(2, 5, 4);
    g.addEdge(3, 4, 9);
    g.addEdge(3, 5, 14);
    g.addEdge(4, 5, 10);
    g.addEdge(5, 6, 2);
    g.addEdge(6, 7, 1);
    g.addEdge(6, 8, 6);
    g.addEdge(7, 8, 7);

    g.shortestPath(0);
    return 0;
}
```

Commented [L1]: One difference between Prim's & Dijkstra is that in Prim's algorithm the weight of the node is stored but here the distance to the node is store in the priority_queue.

The visited[ ] array is redundant since distance to the node always increases which guarantees every node in the graph is visited once and we don't get into a cycle. [Refer to the image below]

Dijkstra from node '0' will work without visited[]
but in Prim's
without visited[]
the code will
fall in the
cycle.



Dijkstra works without visited[] because distance always increases, which guarantees every node is visited once.

↳ when we pop from PriorityQueue or as we traverse the cycle a 2nd time.