IT300 – Design and Analysis of Algorithms

Lab Assignment – 5

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1. Program 1 – Johnson's Algorithm
    a. Code

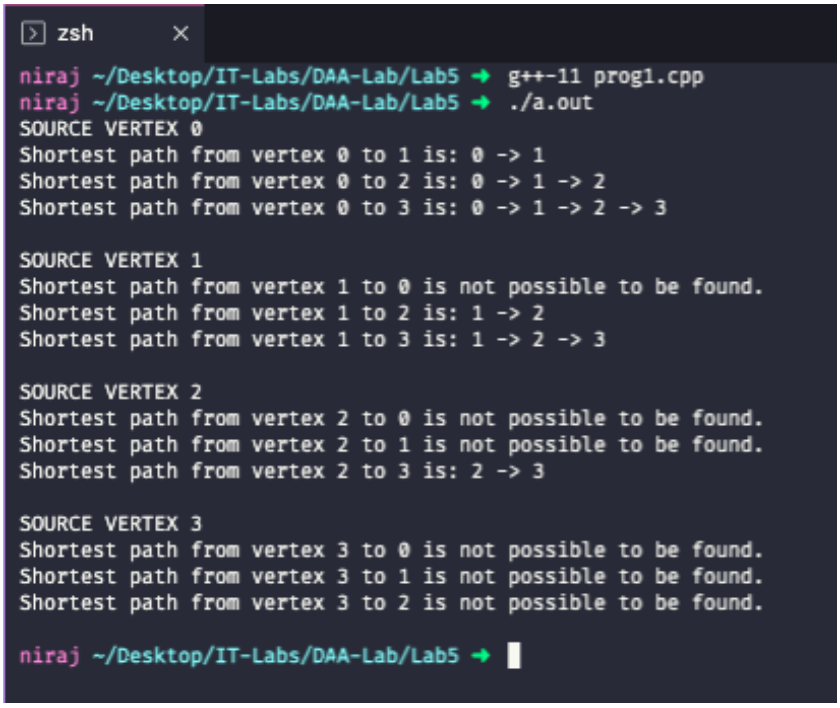
```
#include <iostream>
#include <limits.h>
#include <math.h>
#include <stdio.h>
#include <vector>

using namespace std;

int minDistance(vector<int> dist, vector<bool> vis)
{
  int min = INT_MAX;
  int min_ind;
  for (int i = 0; i < 4; i++)
  {
    if (vis[i] == false && dist[i] <= min)
    {
      min = dist[i];
      min_ind = i;
    }
  }

  return min_ind;
}

void dijkstra(vector<vector<int>> mod_adj_mat, int u, int v)
{
  vector<bool> vis(4, false);
  vector<int> dist(4, INT_MAX);
  vector<int> path(4);
  dist[u] = 0;

  for (int i = 0; i < 3; i++)
  {
    int min_ind = minDistance(dist, vis);
    vis[min_ind] = true;
    for (int j = 0; j < 4; j++)
    {
      if (!vis[j] && mod_adj_mat[min_ind][j] != -1 && dist[min_ind] + mod_adj_mat[min_ind][j] <
dist[j] && dist[min_ind] != INT_MAX)
```

```
      {
        dist[j] = dist[min_ind] + mod_adj_mat[min_ind][j];
        path[j] = min_ind;
      }
    }
  }

  if (dist[v] != INT_MAX)
  {
    int temp_arr[4];
    int x = 0;
    int a = v;
    temp_arr[0] = v;
    x++;

    do
    {
      temp_arr[x] = path[a];
      a = path[a];
      x++;
    } while (a != u);

    cout << "Shortest path from vertex " << u << " to " << v << " is: " << u;
    for (int z = x - 2; z >= 0; z--)
    {
      cout << " -> ";
      cout << temp_arr[z];
    }
    cout << endl;
  }
  else
  {
    cout << "Shortest path from vertex " << u << " to " << v << " is not possible to be found."
<< endl;
  }
}

void dijkstraToAll(vector<vector<int>> mod_adj_mat, int u)
{
  for (int i = 0; i < 4; i++)
  {
    if (i != u)
    {
      dijkstra(mod_adj_mat, u, i);
    }
  }
}

vector<int> bellmanFord(vector<vector<int>> &edge_mat, int adj_mat[][4])
{

  vector<int> dist(5, INT_MAX);
  vector<int> temp;
```

```
  dist[4] = 0;

  for (int i = 0; i < 4; i++)
  {
    temp.push_back(4);
    temp.push_back(i);
    temp.push_back(0);
    edge_mat.push_back(temp);
    temp.clear();
  }
  for (int i = 0; i < 5; i++)
  {
    for (int j = 0; j < edge_mat.size(); j++)
    {
      if ((dist[edge_mat[j][0]] != INT_MAX) && (dist[edge_mat[j][0]] + edge_mat[j][2] <
dist[edge_mat[j][1]]))
      {
        dist[edge_mat[j][1]] = dist[edge_mat[j][0]] + edge_mat[j][2];
      }
    }
  }

  return dist;
}

void johnson(int adj_mat[][4])
{
  vector<vector<int>> edge_mat;
  vector<int> temp(3);
  vector<vector<int>> mod_adj_mat(4, vector<int>(4, 0));
  vector<int> dist;

  for (int i = 0; i < 4; i++)
  {
    for (int j = 0; j < 4; j++)
    {
      if (adj_mat[i][j] != 0)
      {
        temp[0] = i;
        temp[1] = j;
        temp[2] = adj_mat[i][j];
        edge_mat.push_back(temp);
      }
    }
  }

  dist = bellmanFord(edge_mat, adj_mat);

  for (int i = 0; i < 4; i++)
  {
    for (int j = 0; j < 4; j++)
    {
      if (adj_mat[i][j] != 0)
```

```
      {
        mod_adj_mat[i][j] = adj_mat[i][j] + dist[i] - dist[j];
      }
      else
      {
        mod_adj_mat[i][j] = -1;
      }
    }
  }

  for (int i = 0; i < 4; i++)
  {
    cout << "SOURCE VERTEX " << i << endl;
    dijkstraToAll(mod_adj_mat, i);
    cout << endl;
  }
}

int main()
{
  int adj_mat[][4] = {{0, -5, 2, 3},
                      {0, 0, 4, 0},
                      {0, 0, 0, 1},
                      {0, 0, 0, 0}};

  johnson(adj_mat);
  return 0;
}
```

b. Screenshots

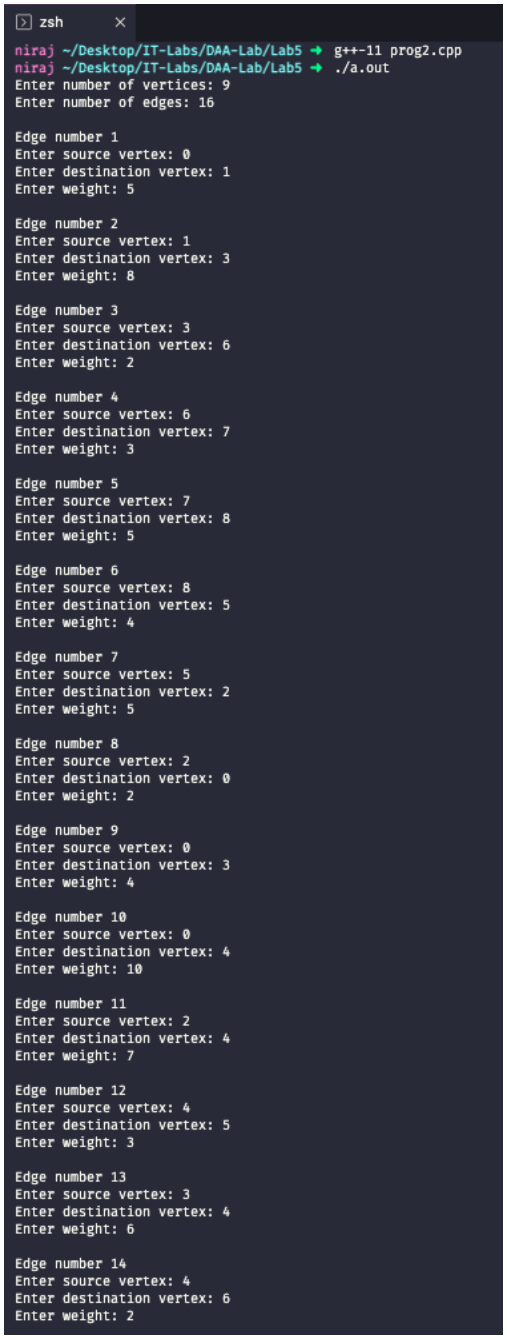


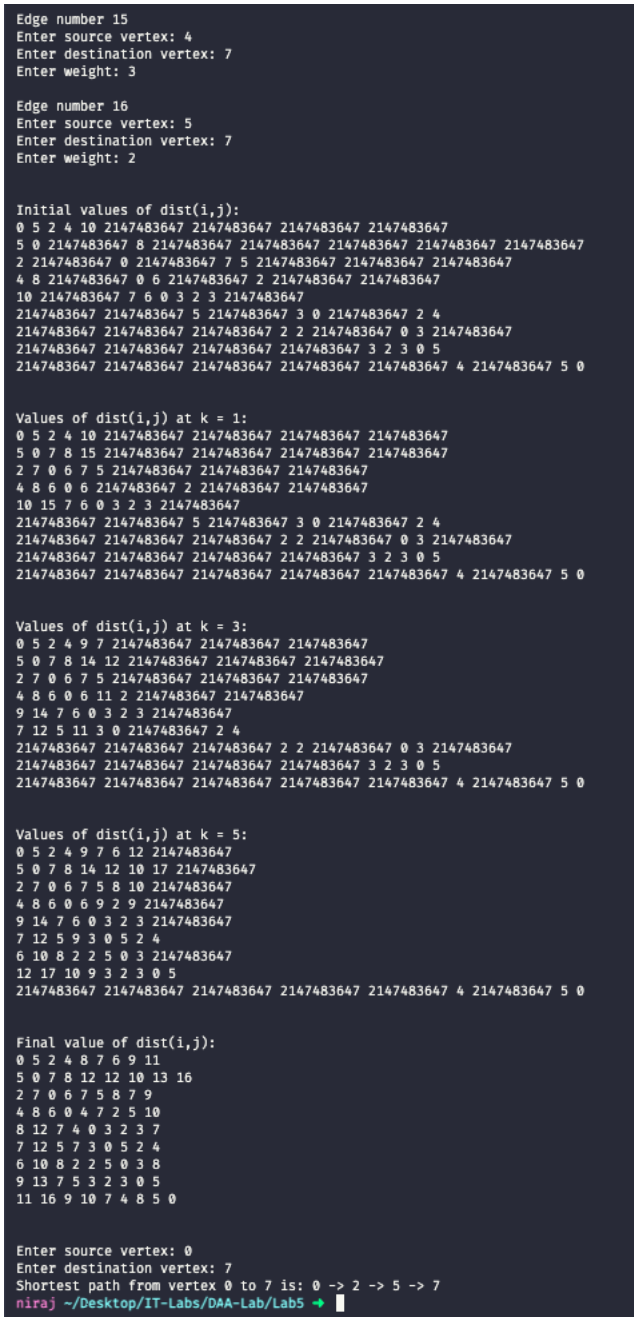
2. Program 2 – Floyd-Warshall Algorithm
    a. Code and Screenshots

```
#include <iostream>
#include <limits.h>
#include <math.h>
#include <stdio.h>
#include <vector>

using namespace std;

void floydWarshall(int no_V, vector<vector<int>> &dist, vector<vector<int>> &next)
{
  for (int k = 0; k < no_V; k++)
  {
    if (k == 1 || k == 3 || k == 5)
    {
      cout << "\n\nValues of dist(i,j) at k = " << k << ": " << endl;
      for (int m = 0; m < no_V; m++)
      {
        for (int n = 0; n < no_V; n++)
        {
          cout << dist[m][n] << " ";
        }
        cout << endl;
      }
    }

    for (int i = 0; i < no_V; i++)
    {
      for (int j = 0; j < no_V; j++)
      {
        if (dist[i][k] == INT_MAX || dist[k][j] == INT_MAX)
        {
          continue;
        }

        if (dist[i][j] > dist[i][k] + dist[k][j])
        {
          dist[i][j] = dist[i][k] + dist[k][j];
          next[i][j] = next[i][k];
        }
      }
    }
  }
}

vector<int> constrPath(int u, int v, vector<vector<int>> next)
{
  vector<int> result;

  if (next[u][v] == -1)
```

```
  {
    return {};
  }
  result.push_back(u);

  while (u != v)
  {
    u = next[u][v];
    result.push_back(u);
  }

  return result;
}

int main()
{
  int no_V, no_E, source, dest, wt, n;
  vector<int> path;

  cout << "Enter number of vertices: ";
  cin >> no_V;
  cout << "Enter number of edges: ";
  cin >> no_E;

  vector<vector<int>> adj_mat(no_V, vector<int>(no_V, INT_MAX));
  vector<vector<int>> dist(no_V, vector<int>(no_V));
  vector<vector<int>> next(no_V, vector<int>(no_V));

  for (int i = 1; i <= no_E; i++)
  {
    cout << "\nEdge number " << i;
    cout << "\nEnter source vertex: ";
    cin >> source;
    cout << "Enter destination vertex: ";
    cin >> dest;
    cout << "Enter weight: ";
    cin >> wt;
    adj_mat[source][dest] = wt;
    adj_mat[dest][source] = wt;
  }

  for (int i = 0; i < no_V; i++)
  {
    for (int j = 0; j < no_V; j++)
    {
      if (i == j)
        adj_mat[i][j] = 0;
    }
  }

  cout << "\n\nInitial values of dist(i,j): " << endl;
  for (int i = 0; i < no_V; i++)
  {
```

```
    for (int j = 0; j < no_V; j++)
    {
      dist[i][j] = adj_mat[i][j];
      cout << dist[i][j] << " ";
      if (adj_mat[i][j] == INT_MAX)
      {
        next[i][j] = -1;
      }
      else
      {
        next[i][j] = j;
      }
    }
    cout << endl;
  }

  floydWarshall(no_V, dist, next);

  cout << "\n\nFinal value of dist(i,j): " << endl;
  for (int m = 0; m < no_V; m++)
  {
    for (int n = 0; n < no_V; n++)
    {
      cout << dist[m][n] << " ";
    }
    cout << endl;
  }

  cout << "\n\nEnter source vertex: ";
  cin >> source;
  cout << "Enter destination vertex: ";
  cin >> dest;
  path = constrPath(source, dest, next);
  cout << "Shortest path from vertex " << source << " to " << dest << " is: " << path[0];
  for (int i = 1; i < path.size(); i++)
  {
    cout << " -> " << path[i];
  }
  cout << endl;

  return 0;
}
```





b. How can the output of the Floyd-Warshall algorithm be used to detect the presence of a negative□weight cycle? Explain your answer.

Ans. The output of Floyd-Warshall algorithm can be used to check if a negative-weight cycle is present or not. All we have to do is check the diagonal entries of dist(i,j) matrix. If the value of the diagonal entries is negative, then there exists a negative weight cycle. This means that there is a path from the vertex to itself, hence it has negative weight.