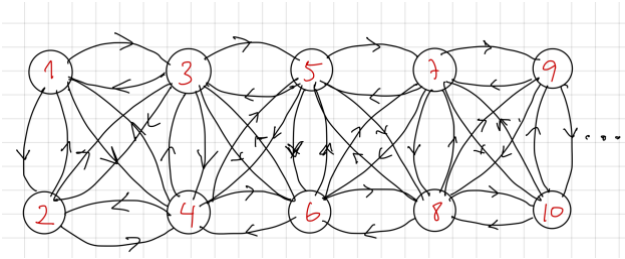
# MEF University
# Department of Computer Engineering
COMP 303 Analysis of Algorithm
Project 2
Analysis of Graph Algorithms

## Part1: Shortest Path

In this part of the project, you are to develop a program in Python3 which finds the shortest path between given source (S) and destination (D) nodes of a Graph by using Dijkstra's shortest path algorithm. In the graph, nodes correspond to cities and weights on the edges correspond to the time to travel between two cities. Given N cities, the graph consists of 2 x N/2 nodes as shown below:




As seen from this graph, there exist an edge from node i to node j if | i - j | <= 3, and i and j are not equal. The number of cities, N, the source (S) and destination (D) cities are input the program.

1. (10 points) First describe the Dijkstra's shortest path algorithm. Determine the running time of the algorithm by summing up the running time of each line in the algorithm. Show the steps of the algorithm for N=10, S=1, D=6, when the distance between two cities, $w_{ij}$ = i + j if | i - j | <= 3, and i and j are not the same. All other weights are infinity.

2. (20 points) Implement the algorithm in Python3 by utilizing a min-heap structure. The program reads N (< 20), S, and D from the user. The weights of edges between nodes i and j are determined by the equation below:

   $w_{ij}$ = i + j, if | i - j | <= 3, and i and j are not equal.

   In the code, insert comment to the right of every line of the code to explain its purpose and repetition times.

**The program will output the shortest path together with the cost of this path**.

3. (20 points) Add counters to every block of repetition in the code to measure the number of repetitions. At the end of the program give the total number of repetitions. Set all costs of repetitions ($c_i$) to 1. Run the program for N = 10, 50, 100, 200, 500, 1000 and 2000 with S=1, and D=N. Draw and compare the actual (measured) running time, which is total number of repetitions, and the theoretical running time as a graph. Interpret the results.

## Part 2: Minimum Spanning Tree (MST)

4. (10 points) First describe the Kruskal's MST algorithm. Determine the running time of the algorithm by summing up the running time of each line in the algorithm. Show the steps of the algorithm for N=10, when the distance between two cities, $w_{ij} = i + j$ if $| i - j | <= 3$, and i and j are not the same. All other weights are infinity.

5. (20 points) Implement the Kruskal's MST algorithm in Python3. The program reads N (< 20) and returns the edges of the MST and its total weight. The weights of edges between nodes i and j are determined by the equation below:

$$w_{ij} = i + j, \quad \text{if } | i - j | <= 3, \text{ and i and j are not equal.}$$

In the code, insert comment to the right of every line of the code to explain its purpose and repetition times.

**The program will output the edges of MST together with the total cost of the tree**.

6. (20 points) Add counters to every block of repetition in the code to measure the number of repetitions. At the end of the program give the total number of repetitions. Set all costs of repetitions ($c_i$) to 1. Run the program for N = 10, 50, 100, 200, 500, 1000 and 2000. Draw and compare the actual (measured) running time, which is total number of repetitions, and the theoretical running time as a graph. Interpret the results.

Your report should exhibit all your work including your codes, results, and interpretations.