Project 1

The theme of this project is to implement the basic network design model that is presented in the lecture note entitled “An Application to Network Design”, and experiment with it.

Specific Tasks:

1. Create software that is capable of doing the following:

   • As input, it receives the number of nodes \(N\), the traffic demand values \(b_{ij}\) between pairs of nodes, and the unit cost values for the potential links \(a_{ij}\).
   
   • As output, the program generates a network topology, with capacities assigned to the links, according to the studied model, using the shortest path based fast solution method (see at the end of the cited lecture note). The program also computes the total cost of the designed network, according to the model.

Important notes:

   • Any programming language and operating system can be used, it is your choice.
   
   • For the shortest path algorithm you may download and utilize any existing software module from the Internet. If you use this opportunity, then include in your documentation a precise reference that tells where the module comes from, so that we can check it out.

2. Clearly explain how your program works. It is helpful to use flowcharts for visualizing the explanation.

3. Run your program on randomly generated examples, as explained below.

   • Let the number of nodes be \(N = 25\) in each example.
For each example, generate the $a_{ij}, b_{ij}$ values as independent random integers, in the range $[0, \ldots, M]$, where $M$ is a parameter that will change in each experiment.

- Run your program with the values $M = 1, 2, 4, 8, 16$, so there are altogether 5 experiments.

- For each experiment show the resulting network topology graphically. For simplicity, let it be represented by an undirected graph, in which there is an edge between nodes $i$ and $j$, whenever the network design model assigns nonzero capacity between these nodes, at least in one direction.

4. Show in a diagram how the total cost of the network depends on the parameter $M$.

5. For each experiment, compute the density of the resulting undirected graph. This density is defined as the ratio of the actual number of edges vs. the maximum possible number of edges. That is, if in an experiment the actual number of edges is $m$, then the corresponding density value is

\[ D = \frac{m}{N(N - 1)/2}. \]

Show graphically in a diagram how $D$ depends on the parameter $M$ that specifies the size of the range from which the random numbers are chosen.

**Note:** If there is anything that is not specified in this project description, that means it is left to your choice.

**Questions?** See the note above.

**Submission guidelines**

Describe everything, including algorithms, program, sources, results and figures neatly and clearly in a study. Include everything in a single document.
that can be read as a report. It should have a professional appearance, scanned handwriting is not acceptable!

Submit the document through eLearning. (Do not send it via e-mail!) Do not include executable code, but include the source code that you wrote, in an appendix to the study. Your submission will be read as a report, but usually we do not run the program. On the other hand, if either there are signs of cheating, or if you want to dispute the received score, then you will be asked to demonstrate your program on a computer, show and explain its details.

*Notes:*

- The work should be individual and original. Any form of cheating is a serious violation of University policies and can lead to serious consequences.

- It may be helpful to think about the whole project presentation that your task is not only to solve a technical problem, but you also have to “sell” the results. Try to look at your work from the viewpoint of a potential customer, to whom you want to sell such a software product. How convincing would your presentation look for a customer? Try to imagine: would you buy the product if somebody else offered it and you were the customer?