



Istanbul Technical University

Faculty of Computer and Informatics

BLG336E – Analysis of Algorithms II, Spring 2021

Homework 2

Finding Minimum Spanning Tree and the Shortest Path on a Graph

Handed out: 06 April 2021

Due: 20 April 2021, 23.59

Res. Asst.: Rumeysa Aslıhan Ertürk, Neşe Güneş

Notes:

- Please submit your homework only through Ninova. Late submissions will not be accepted.
- Please upload two separate source files, one for each question.
- Please do not forget to write your name and student ID on the top of each document you upload.
- You should write your code in C++ language and try to follow an object-oriented methodology with well-chosen variables, methods, and class names and comments where necessary.
- Your code should compile on Linux using g++. You can test your code through ITU's Linux Server (you can access it through SSH).
- Because your codes will be processed with an automated tool (Calico), make sure that your output format matches the given sample output.
- To test your program yourself with the given test cases, please check out the tutorial for Calico provided to you on Ninova.
- You may discuss the problem addressed in the homework at an abstract level with your classmates, but you should not share or copy code from your classmates or any web sources. You should submit your individual homework. In case of detection of an inappropriate exchange of information, disciplinary actions will be taken.
- If you have any questions, please contact Teaching Assistants Rumeysa A. Ertürk via erturkr15@itu.edu.tr or Neşe Güneş via nese.gunes@itu.edu.tr.

“...the treasure of the Turkish motherland, the wealth of the Turkish history, the Turkish nation’s apple of the eye, Istanbul is the city that has a special place in the hearts of all citizens”

Mustafa Kemal Atatürk

Question 1

The emperor of Myzantine has lost his sleep lately due to the intelligence his informants brought. According to this information, his nemesis, the emperor of Mottoman Empire, is planning an attack to the capital, Monstantiople. He starts preparations by gathering proper ammunition and reinforcing the city walls. However, he knows that he is helpless if Mottomans surround the Great Palace when he is inside. Moreover, his family and important people of the empire may also be trapped in other parts of the city at the time of a blockade by the Mottomans. He figures out that if he connects the vital parts of the city with underground tunnels, he may have a chance to run and hide or meet with important people to discuss possible scenarios at the moment of the unwanted event. He calls his engineers and orders them to construct underground tunnels by connecting important parts of the city. He writes down the rules of construction that the engineers must follow.

As the chief engineer of the emperor, you must create the construction plan where you show the steps of the construction you will follow while satisfying the conditions of the emperor which are listed below:

1. The construction cost must be minimal.
2. The construction must start from the Great Palace.
3. The Great palace must be directly connected to at least one church
- 4. The first construction must be between a church and the Great Palace (no matter whether it yields an optimal tunnel structure or not).**
5. The Hippodrome must have a direct connection to the Great Palace.
6. The Hippodrome should not be directly connected to any basilicas.
7. There should not be any direct connections between the houses of two important people.

You will be given a text file (city_plan.txt) which contains the city plan in terms of the cost of constructing a tunnel between two places (place1,place2,distance). You must write a code in C++ that determines the plan of construction. It must print out the order of the tunnels that will be constructed. The abbreviations and their meanings used in the city plan file are shown in Table 1. Figure 1 depicts a sample output.

Please make sure that your output has the exact format with the given sample output. Because your codes will be check using an automated tool, the format of the output is extremely important. Please do not add any additional lines, characters other than the required ones.

Abbreviation	Meaning
GP	Great Palace
Hipp	Hippodrome
Bas1	Basilica 1
Ch1	Church 1
Hp1	Home of an important person 1

Table 1. The abbreviations used in the city plan file and their meanings.

```
Hipp Ch1 1
GP Ch2 2
Bas2 Hp3 3
Ch2 Bas3 4
GP Bas2 6
Hipp Hp1 7
GP Hp4 8
Hipp Hp2 10
GP Hipp 12
Ch2 Bas1 15
68
```

Figure 1. Sample output for question 1. **Please pay attention to the output format** and follow the exact pattern. Each line shows the edges of the resulting MST. **The order of the nodes in one line is the same as the given text file** (e.g. use “GP Ch2 2” instead of “Ch2 GP 2”. Because it is the order given in source text file). **The outputted list should be sorted in ascending order of the edge weights.** The last line should give the total weight of the MST.

“Either I will conquer Istanbul or Istanbul will conquer me.”

Mehmet the Conqueror

Question 2

Meanwhile, the emperor of the Mottoman Empire doesn't sleep either due to the detailed plans on his mind. He shares the dream of his ancestors: conquering the great Monstantiople. He has completed all necessary preparations but he has one more to solve. The army must be secretly moved from Mankara to Monstantiople. However, the emperor must be very careful about this movement because the empire has many enemies which are located on the way and spies of enemies have been wandering around to gain some tips about the plans of the emperor. He figures that it is extremely important to carefully determine the best path to Monstantiople. Hence, he calls his best employees responsible from logistics and orders to determine the optimal path satisfying the conditions he provides them.

As the chief engineer of the emperor, you must determine the optimal path from Mankara to Monstantiople which satisfies the conditions of the emperor which are listed below:

1. The path must be as short as possible.
2. The path must contain safe spots and/or resting spots.
3. The path must not cross a spot which is occupied by enemies.
4. The path must include at least one resting spot for the army to rest.
5. The path must not cross a spot which is directly connected to an enemy occupied place with a distance smaller than 5 units of distance (because a spy may carry the information of the Mottomans being there to the enemies).

You will be given a text file (path_info.txt) which contains the information about the spots on the way along with the distances between them (spot1,spot2,distance). You must write a program in C++ that determines the optimal path from Mankara to Monstantiople. It must print out the spots that the army should follow in order. The abbreviations and their meanings used in the path information file are shown in Table 2. Figure 2 depicts a sample output.

Please make sure that your output has the exact format with the given sample output. Because your codes will be check using an automated tool, the format of the output is extremely important. Please do not add any additional lines, characters other than the required ones.

Abbreviation	Meaning
S1	Safe Spot 1
E1	Enemy Spot 1
R1	Resting Place 1
Ma	Mankara
Mo	Monstantiople

Table 2. The abbreviations used in the path file and their meanings.

```
Ma S1 R1 R2 Mo 19
```

Figure 2. Sample output for question 2. **Please pay attention to the output format** and follow the exact pattern. Your program should give one line output indicating the shortest path that satisfies the given conditions. Starting from the source node, you should print the visited nodes in order by putting a space character in between two nodes. In the end, print the destination node and the cost of the path.