Algorithms and Data Structures 2021: First Practical Assignment

October 12, 2021

1 Instructions

The practical assignment consists of two parts, a program and a report.

The program must be written in Java, C++, C or Python 3. You can only use libraries that come with a minimal installation of the language. You must write all code yourself, copying code from fellow students or the internet is considered plagiarism.[1].

The report must contain an explanation of your algorithm, an analysis of it's correctness and an analysis of it's runtime complexity. The report must have **at least 2 and at most 10** pages. Write your names on the first page of the report.

The deadline for the first practical assignment is **Wednesday November 17, 15:30**. You should submit your code and report via Brightspace. You are allowed to work on the assignment in pairs. Then you must be enrolled in the same practical group on Brightspace. Only one team member has to submit the assignment.

2 Grading

Grades will be determined as follows. You may earn up to 100 points for your solution:

- 20 points for the explanation of your algorithm.
- 10 points for the correctness analysis.
- 10 points for the complexity analysis.
- 50 points for the test results. See the subsection on test results for more (important) information.
- 10 points for the quality of the code.

The grade is the total number of points divided by 10. If you have questions, do not hesitate to contact Jelmer Firet, `jelmer.firet@ru.nl`.

[1] We will check this using MOSS. Note that MOSS results can be viewed without logging in. Therefore we will not require you to put your name or student number in your code.

3 Bridging the Grand Canyon

The Grand Canyon is one of the natural wonders of the world and receives close to 5 millon visitors per year. Visitors may either see the Grand Canyon from the South Rim or from the North Rim. Although the South Rim and North Rim are only 10 miles apart as the raven flies, they are separated by more than 215 miles of road. It is possible to hike from one rim to the other through the canyon, but this is a really strenuous hike that takes 12-15 hours.

Figure 1: The Grand Canyon.

An eccentric American billionaire, who recently adopted the name Z-Æ-M, hired you as a consultant. Z-Æ-M wants to construct a spectacular bridge that will allow tourists to cross the Grand Canyon more easily. Think of the canyon as an infinitely long straight line with width W. To be more specific, the canyon is a set of the all points with $0 < y < W$ in xy-plane. Z-Æ-M's idea is to build N huge pillars at specific places scattered across the canyon. The location of the k-th pillar is (X_k, Y_k). On top of these pillars, Z-Æ-M wants to place huge disks. Both pillars and disks will be made from kryptonite, an extremely strong and fully transparent new material. There are M different types of disks. The i-th type of disks has radius R_i, and its price is C_i per disk. Z-Æ-M can buy as many disks as needed. For each disk, its center must be at the location (X_k, Y_k) of the k-th pillar, for some k. Tourists can walk from one disk to another if they overlap or touch each other.[2] Disks may extend past the South Rim ($y = 0$) and the North Rim ($y = W$), or rest on other pillars. Tourists can only move on the rims and the disks. What is the minimum cost of all the disks needed to make it possible to walk from the South Rim to the North Rim?

[2]One of your instructors has nightmares in which he has to cross the canyon using Z-Æ-M's bridge.

3.1 Input

The first line has 3 space-separated integers N, M and W. The next N lines contain 2 space-separated integers X_k and Y_k. The final M lines contain 2 space-separated integers R_i and C_i. You may assume the following constraints on the input parameters:

$$\begin{aligned} 2 \leq &\ W &&\leq 10^9 \\ 0 \leq &\ X_k &&\leq 10^9 \\ 1 \leq &\ Y_k &&< W \\ 1 \leq &\ R_i &&\leq 10^9 \\ 1 \leq &\ C_i &&\leq 10^6 \end{aligned}$$

The testcases are divided into three groups:
small: $1 \leq N, M \leq 50$,
large: $1 \leq N, M \leq 400$,
line: $1 \leq N, M \leq 2000$ and $X_k = 0$ for every pillar.

3.2 Output

Print the minimum cost to make it possible to move from $y = 0$ to $y = W$. If this is not possible, print "impossible" (without quotes).

3.3 Examples

Sample input 1:

```
11 3 13
1 9
4 2
4 6
8 7
11 4
15 4
15 10
19 4
19 5
19 10
26 1
2 1
3 100
4 10000
```

Sample output 1:

```
206
```

Sample input 2:

```
4 4 100
0 10
0 30
0 55
0 80
5 4
10 4
15 6
20 10
```

Sample output 2:

```
24
```

The solution of sample input 1 is illustrated in the diagram below:

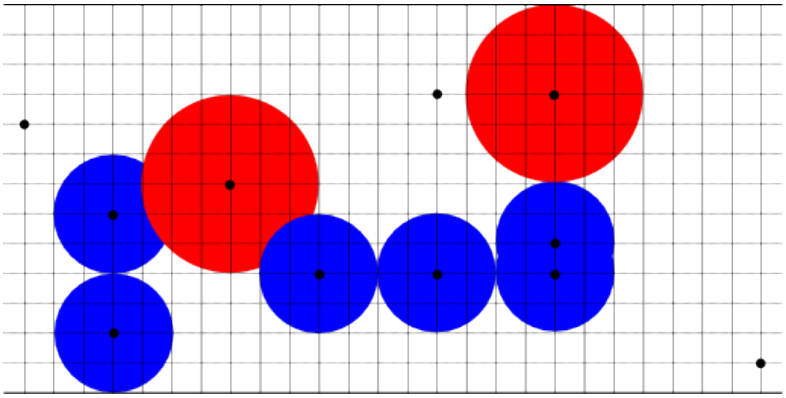

Figure 2: Solution for sample input 1.

3.4 Testing your code

You can test your program using DOMJudge (`https://domjudge.science.ru.nl`). Near the start of the semester you should have received credentials from Jelmer via mail. You should ensure your program works in DOMJudge, as we will use it to judge your solution. During the last days before the deadline the test server generally receives more submissions, therefore taking much longer to judge your submission. This is one of the reasons we advice to start early.

You can also test your code locally. We will provide a set of examples on Brightspace. To use these redirect the `.in` file to the standard input of your program and compare the output with the `.out` file.

```
./program <1.in >1.out
diff -bq 1.out 1.ans
```

3.5 Test results

We will be running several tests and you will get points for every correct answer within the time limit. If your code does not compile or does not read and write via `stdin` and `stdout`, you will get zero points on the test cases. So please test your code on the test server! If you pass all test cases on the test server, you can rest assured you will get a good number of points for the test results, but this does not guarantee the maximum number of points for the test results.[3]

If you encounter any issues, ask for help early!

[3] However, you can assume this if your solution works for all valid inputs and finishes well within the time limit.