CSC3100 Data Structures Fall 2022

Programming Assignment II

Due: Dec 11 2022

1 Problem 1: Special Shortest Path

1.1 Statement

City C consists of n nodes, representing different places. There are m edges between these nodes. For the edge $e_i = (u_i, v_i, w_i)$, there is a bidirectional(undirected) trail connecting u_i and v_i with length of w_i.

For a path $P = \{p_i\}$, consisting of edges $p_1, p_2, p_3, \cdots, p_k$, the length of each edge is $l_i = w_{p_i}$. Normally, passing the edge p_i with length l_i will cost l_i units of energy. Specially, if $l_i = K \cdot l_{i-1}$, then passing this edge will only cost $(K-1) \cdot l_{i-1}$ units of energy.

Alice is starting from the node 1. Alice wants to know how many units of energy it will take at least to visit the node x, for any x. If x is unreachable from the start point(node 1), you should output -1 as the result.

1.2 Input Format

The first line consists of three integer numbers n, m, K. The following m lines each consists of three integer numbers u, v, w to describe a bidirectional trail.

1.3 Output Format

You need to output a line consisting of n integers, each representing the minimum units of energy to reach node i from node 1.

1.4 Example

Input 1	Output 1
4 3 0 1 2 2 2 3 4 3 1 5	0 2 5 -1

Input 2	Output 2
3 3 2 1 2 2 2 3 4 3 1 5	0 2 4

1.5 Constraints

Case	Score	Constraints			
$1 \sim 3$	30 pts	$n \leq 10^5$	$m \leq 2 \times 10^5$	K = 0	$1 \leq w_i \leq 10^4$
$4 \sim 5$	20 pts	$n \leq 10^3$	$m \leq 2 \times 10^5$	K = 1	
$6 \sim 7$	20 pts	$n \leq 10^5$	$m \leq 2 \times 10^5$	K = 2	
$8 \sim 10$	30 pts	$n \leq 10^5$	$m \leq 2 \times 10^5$	$K \leq 10^5$	

1.6 Hints

- Hint: You can **modify(or add) some edges to the original graph** to fit this problem into the algorithm you know.

2 Problem 2: Median Search Tree

2.1 Statement

If the sorted array of all the values in the set is $\{a_i\}_{i=1}^{n}$, let $t = \lceil n/2 \rceil$, then the median $2k$ values are $\{a_{t-k+1}, \cdots, a_{t+k}\}$.

Barbara has got a set of values with size of $2k$ initially. Barbara wants to do m operations on it. Each operation belongs to the following 3 types:

- **1 w**: insert a value w.
- **2**: output all the median $2k$ values, i.e. $a_{t-k+p}, \forall 1 \leq p \leq 2k$.
- **3 p**: delete the p-th value among median $2k$ values, i.e. a_{t-k+p}.

We guarantee that all the values will be distinct and the size of the set is always at least $2k$.

2.2 Input Format

The first line consists of two integer numbers m, k. The second line consists of the $2k$ values in the initial set. Then, the following m lines each consists of the command of an operation.

2.3 Output Format

You need to output one line for each query(operation 2). Each line consists of $2k$ positive integers, the median $2k$ values of the set at that time in ascending order.

2.4 Example

Input 1	Output 1
3 1 2 3 1 4 3 1 2	2 4

Input 2	Output 2
5 2 8 4 2 6 2 1 5 2 1 3 2	2 4 6 8 4 5 6 8 3 4 5 6

2.5 Constraints

Case	Score	Constraints			
$1 \sim 3$	30 pts	$n \leq 2 \times 10^3$	$k \leq 25$		$1 \leq w \leq 10^6$
$4 \sim 5$	20 pts	$n \leq 10^5$	$k \leq 25$	no operation 3	
$6 \sim 7$	20 pts	$n \leq 10^5$	k = 1		
$8 \sim 10$	30 pts	$n \leq 10^5$	$k \leq 25$		

2.6 Hints

You can solve this problem with **heaps**.

3 Problem 3: Football Match

3.1 Statement

While the FIFA World Cup is being held in Qatar, BLGG is organizing a football tournament in LGU, too.

There are n teams in this tournament, numbered from 1 to n. Each team has its popularity, and the popularity of team i is a_i. A match between i and j will gain $a_i \times a_j \ MOD \ M$ attractions.

When a football team loses a match, it will be eliminated from the tournament. At the end, the team left standing will be the champion of this tournament.

BLGG is wondering that what the maximum sum of the attractions of the $(n-1)$ matches.

3.2 Input Format

The first line contains two integers n and M.
The second line contains n integers $a_1, \cdots, a_n$.

3.3 Output Format

Output one integer representing the maximum sum of the attractions of the $(n-1)$ matches.

3.4 Sample Input/Output

Input 1	Output 1
3 114514 1 2 3	9

3.5 Constraints

Case	Score	Constraints		
1	10 pts	$n \leq 10$	$0 \leq a_i, M \leq 2 \times 10^9$	For all $i, j, a_i \times a_j < M$
$2 \sim 5$	40 pts	$n \leq 10$	$0 \leq a_i, M \leq 2 \times 10^9$	
6	10 pts	$n \leq 2000$	$0 \leq a_i, M \leq 2 \times 10^9$	For all $i, j, a_i \times a_j < M$
$7 \sim 10$	40 pts	$n \leq 2000$	$0 \leq a_i, M \leq 2 \times 10^9$	

3.6 Hints

You can try to solve this problem using the graph algorithms we learn in classes.

4 Problem 4: Prefix

4.1 Statement

You are given n strings $s_1, s_2, \cdots, s_n$ and q queries. In i^{th} query, you are given a string t_i, please find out how many strings in $s_1, s_2, \cdots, s_n$ begins with t_i.

4.2 Input Format

The first line is an integer n.
Each of the next n lines contains a string, respectively. The $(i+1)^{th}$ line of input is s_i.
The $(n+2)^{th}$ line of input is an integer q.
Each of the next q lines contains a string, respectively. The $(n+2+i)^{th}$ line of input is t_i.

4.3 Output Format

Output q lines. The i^{th} line contains the answer of i^{th} query.

4.4 Sample Input/Output

Input 1	Output 1
3 wenwen wenbl blgg 3 wen bl csc	2 1 0

4.5 Constraints

All strings only contain lowercase letters.

Case	Score	Constraints	
$1 \sim 4$	40 pts	$n, q \leq 10^3$	$\sum_{i=1}^{n} \lvert s_i \rvert, \sum_{i=1}^{q} \lvert t_i \rvert \leq 10^3$
$5 \sim 10$	60 pts	$n, q \leq 10^6$	$\sum_{i=1}^{n} \lvert s_i \rvert, \sum_{i=1}^{q} \lvert t_i \rvert \leq 10^6$

4.6 Hints

You can try to store $s_1, s_2, \cdots, s_n$ in a tree.
Since the input might be very large, fast input method such as BufferedReader in Java is required.

A. Requirements

Code (90%)

The distribution of programming grade is 20%, 20%, 25%, 25% for the four problems respectively.

You can write your code in Java, Python, C, or C++. The *time limit* may vary among different languages, depending on the performance of the language. Your code must be a complete runnable program instead of only a function. We guarantee test data strictly compliance with the requirements in the description, and you do not need to deal with cases where the input data is invalid.

We provide a example problem to better illustrate the information above.

Report (10%)

You also need to write a report to explain the following:

- What are the possible solutions for the problem?
- How do you solve this problem?
- Why is your solution better than others?

Please note that the maximum number of pages allowed for your report is **5 pages**.

Remember that the report is to illustrate your thinking process. Keep in mind that your report is supposed to show your ideas and thinking process. We expect clear and precise textual descriptions in your report, and we do not recommend that you over-format your report.

B. Example Problem: A + B Problem

Description

Given 2 integers A and B, compute and print A + B

Input

Two integers in one line: A, and B

Output

One integer: A + B

Sample Input I	Sample Output I
1 2	3

Problem Scale & Subtasks

For 100% of the test cases, $0 \leq A, B \leq 10^6$