CS 341, Fall 2019 E. Blais, A. Lubiw

PROGRAMMING ASSIGNMENT 2

DUE: Wednesday, November 20, 5 PM. DO NOT COPY. ACKNOWLEDGE YOUR SOURCES.

Please read `http://www.student.cs.uwaterloo.ca/~cs341` for general instructions and policies.

1. [20 marks] **Shortest simple path.** In this problem, you will implement a program that solves the *Shortest simple path* problem from Question 1 of Assignment 7.

   The input to your program will be a directed graph $G = (V, E)$ with integer weights on the edges and two vertices $s, t \in V$. The graph will be given via adjacency lists. The program must output the minimum weight of a simple path from s to t in G. Recall that a *simple* path is a path that does not repeat vertices, and that the weight of a path is the sum of the weights of the edges in the path.

   More specifically, the input is formatted as follows:

   - Line 1 consists of three positive integers

     $$n \quad s \quad t$$

     separated by whitespace. The integer n indicates that the graph G has vertex set $\{1, 2, \ldots, n\}$. The integers $s, t \in \{1, 2, \ldots, n\}$ are vertices of G.
   - Lines 2 through $n + 1$ each consist of a list of integers

     $$k \quad v_1 \quad w_1 \quad v_2 \quad w_2 \quad \cdots \quad v_k \quad w_k$$

     all separated by whitespace. The first integer k in the list indicates that k pairs (v_j, w_j) follow. The pair v_j, w_j in line $i+1$ indicates that G has an edge of weight w_j going from vertex i to vertex $v_j \in \{1, 2, \ldots, n\}$.

   The output of the program is an integer W denoting the minimum weight of a simple path from s to t in G, if at least one such path exists. If G contains no path from s to t, the algorithm should output `No path`.

   Implement a branch-and-bound algorithm that solves the shortest simple path problem described above. You may write your code in C, C++ or Java.

   See the next page for two example instances of the program and expected output.

Example 1. On input

```
6 1 3
2 2 10 4 -1
1 3 6
1 1 2
3 1 -2 2 8 5 4
2 3 2 4 1
0
```

the correct output is

```
5
```

since the input corresponds to a graph whose shortest simple path from vertices 1 to 3 is $1 \to 4 \to 5 \to 3$ which has total weight $-1 + 4 + 2 = 5$.

Example 2. On input

```
4 1 4
1 2 1
1 3 1
1 1 1
3 1 1 2 1 3 1
```

the valid output is

```
No path
```

since there is no path from vertex 1 to vertex 4 in the graph specified by the input.