CSC 226 SUMMER 2017
ALGORITHMS AND DATA STRUCTURES II
ASSIGNMENT 3 - PROGRAM
UNIVERSITY OF VICTORIA

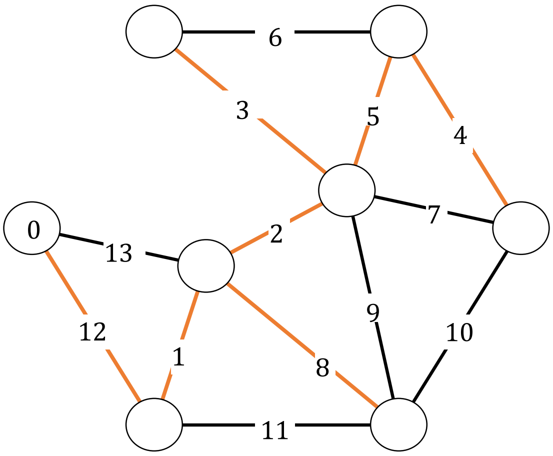
1 Programming Assignment

The assignment is to implement an algorithm to determine if the minimum weight spanning tree of an edge-weighted graph G is the same as the single source spanning tree generated from a specific vertex s in G. A Java template has been provided containing an empty method MSTvsSPT, which takes a single argument consisting of a weighted adjacency matrix for an edge-weighted graph G with distinct edge weights all greater than 0. The expected behavior of the method is as follows:

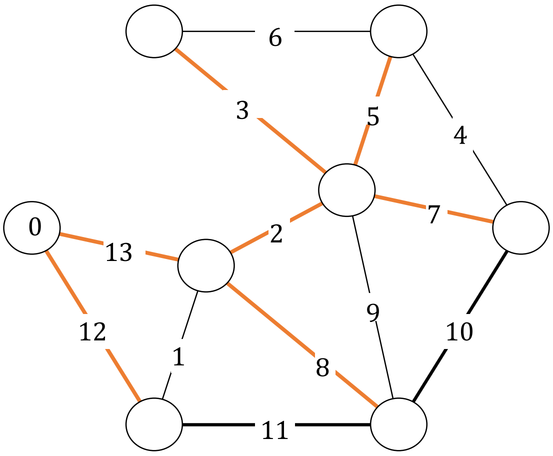
Input: An $n \times n$ array G representing an edge-weighted graph.

Output: A boolean value which is true if the MST equals the SPT and false otherwise.

A correct implementation of the MSTvsSPT function will find the minimum weight spanning tree and the single-source shortest path tree from vertex 0 and compare. If they are the same it returns true, otherwise false. For example, consider the edge-weighted graph below.



The darkened edges of the graph above form the minimum weight spanning tree, whereas the darkened edges below form the single source shortest path tree from vertex 0.



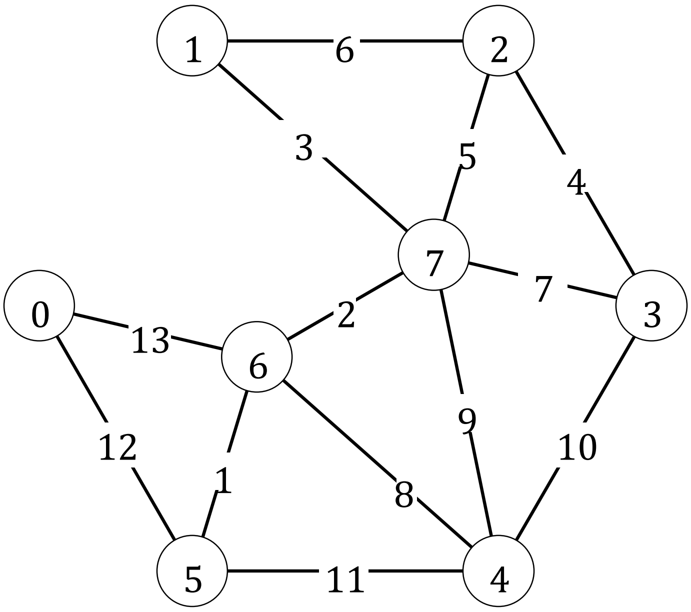
You must use the provided Java template as the basis of your submission, and put your implementation inside the MSTvsSPT method in the template. You may not change the name, return type or parameters of the MSTvsSPT method. You may add additional methods as needed. You may use the UF class, IndexMinPQ class and Edge class from the text book. I have attached the code for these classes to the assignment (I have changed Edge to have int weights). Also, you may use any code from the Prim, Kruskal, Boruvka, Dijkstra and/or Bellman-Ford algorithms from the text in your code. The main method in the template contains code to help you test your implementation by entering test data or reading it from a file. You may modify the main method to help with testing, but only the contents of the MSTvsSPT method (and any methods you have added) will be marked, since the main function will be deleted before marking begins. Do not modify anything in the given files as these will be used in marking as well. Please read through the comments in the template file before starting.

2 Input Format

The testing code in the main function of the template reads a sequence of graphs in a weighted adjacency matrix format and uses the MSTvsSPT function to compare the minimum spanning tree to the single-source shortest path tree. A weighted adjacency matrix A for an edge-weighted graph G on n vertices is an $n \times n$ matrix where entry (i, j) gives the weight of the edge between vertices i and j (or 0 if no edge exists). For example, the matrix

$$A = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 12 & 13 & 0 \\ 0 & 0 & 6 & 0 & 0 & 0 & 0 & 3 \\ 0 & 6 & 0 & 4 & 0 & 0 & 0 & 5 \\ 0 & 0 & 4 & 0 & 10 & 0 & 0 & 7 \\ 0 & 0 & 0 & 10 & 0 & 11 & 8 & 9 \\ 12 & 0 & 0 & 0 & 11 & 0 & 1 & 0 \\ 13 & 0 & 0 & 0 & 8 & 1 & 0 & 2 \\ 0 & 3 & 5 & 7 & 9 & 0 & 2 & 0 \end{bmatrix}$$

corresponds to the edge-weighted graph below. Note that the weighted adjacency matrix for an undirected graph is always symmetric.



The input format used by the testing code in main consists of the number of vertices n followed by the $n \times n$ weighted adjacency matrix. The graph above would be specified as follows:

```
8
 0   0   0   0   0  12  13   0
 0   0   6   0   0   0   0   3
 0   6   0   4   0   0   0   5
 0   0   4   0  10   0   0   7
 0   0   0  10   0  11   8   9
12   0   0   0  11   0   1   0
13   0   0   0   8   1   0   2
 0   3   5   7   9   0   2   0
```

3 Test Datasets

A collection of randomly generated edge-weighted graphs with positive, distinct edge weights has been uploaded to conneX. Your assignment will be tested on graphs similar but not identical to the uploaded graphs. You are encouraged to create your own test inputs to ensure that your implementation functions correctly in all cases.

4 Sample Run

The output of a model solution on the graph above is given in the listing below. Console input is shown in blue.

```
Reading input values from stdin.
Reading graph 1
8
 0   0   0   0   0  12  13   0
 0   0   6   0   0   0   0   3
 0   6   0   4   0   0   0   5
 0   0   4   0  10   0   0   7
 0   0   0  10   0  11   8   9
12   0   0   0  11   0   1   0
13   0   0   0   8   1   0   2
 0   3   5   7   9   0   2   0
Graph 1: Does MST = SPT? false
Processed 1 graph.
Average Time (seconds): 0.00
```

5 Evaluation Criteria

The programming assignment will be marked out of 25, based on a combination of automated testing and human inspection. To receive full marks, the algorithm will determine if the MST equals the SPT from vertex 0, while building both trees simultaneously and including some kind of early false detection technique. That is, to get full marks you cannot simply generate the MST then the SPT and then test if they are the same. You will need to build both simultaneously, while checking as they grow if the answer is sure to be false, insuring a more efficient best-case run time. Of course this test should take constant time.

Score (/50)	**Description**
0 − 5	Submission does not compile or does not conform to the provided template.
5 − 15	The implemented algorithm is inaccurate on the tested inputs.
15 − 20	The implemented algorithm is accurate on all tested inputs but doesn't build the trees simultaneously.
20 − 25	The implemented algorithm is accurate and has a constant time early false detection scheme.

To be properly tested, every submission must compile correctly as submitted, and must be based on the provided template. You may only submit one source file. **If your submission does not compile for any reason (even trivial mistakes like typos), or was not based on the template, it will receive at most 5 out of 25.** The best way to make sure your submission is correct is to download it from conneX after submitting and test it. You are not permitted to revise your submission after the due date, and late submissions will not be accepted, so you should ensure that you have submitted the correct version of your code before the due date. conneX will allow you to change your submission before the due date if you notice a mistake. After submitting your assignment, conneX will automatically send you a confirmation email. If you do not receive such an email, your submission was not received. If you have problems with the submission process, send an email to the instructor **before** the due date.