CS 333 - Homework #1

Due To

3 April 2024 Wednesday, by 11.59 pm.

Homework 1

There are 2 independent tasks in this homework.

Task1 (50 Points)

This task is intended to provide you experience in building/manipulating adjacency list representations of graphs, and to reinforce your understanding of BFS and DFS by adapting them to solve a novel problem. This programming assignment is to be completed individually in either Java or Python (your choice) and submitted to LMS.

Zip file "KidneyDonation" is attached with some starter code (in Python and Java both) and test cases. Modify the DonorCycle.java or donor_cycle.py file (you don't need to do both!) to solve the problem described in the writeup below.

Here is a summary of the test cases provided:

- example.txt is the example file in the writeup. The answer should be True.
- slides.txt is the directed graph from the slides with the right-most node as the query. The answer should be False.
- straightline.txt is just a line of vertices. The answer should be False.
- biggerloop.txt is 10 vertices in a circle. The answer should be True.
- almostcycle.txt is 10 vertices in a cycle, but with one edge in the opposite direction from the rest. The answer should be False.
- complete.txt is 10 vertices that are each connected to all the other vertices. The answer should be True.
- lollypop0.txt is a graph with vertices in a lollypop shape, meaning there is a straight line of nodes connected to nodes in a loop. The query node is at the start of the stick of the lollypop, so the answer should be False.
- lollypop5.txt is the same lollypop graph as above, but now the query node is in the candy portion of the lollypop. The answer should be True.

To give input to your program, you should just run the program. At first nothing will appear to happen, but then if you copy-paste the contents of a file into the console (the place that things print to in your IDE) and hit enter the code should run. The starter code parses the input for you and invokes a function using those parameters. To provide output, simply print to the console. Make sure you do not have any print statements besides just your answer. There will be additional tests run when you submit that you will not have direct access to, so make sure you do some debugging on your own, too

Description

Kidneys are organs in the human body whose function is critical for maintaining life. Put simply, the kidneys primarily serve to regulate the salinity, water content, and ph of one's blood, and also remove toxins of various kinds from the body. If someone has no working kidneys then they must either receive frequent kidney dialysis (which cycles blood through a machine to perform the function of a kidney), or else receive a new kidney from an organ donor. Humans are generally born with two kidneys, and one functioning kidney is sufficient for survival, so it is possible (though not risk-free) for a living person to donate a kidney to a patient in need. To protect from disease, the human immune system has evolved to recognize and attack cells from other individuals. As such, before donation, we must check whether a donor and recipient are compatible. Donor-patient compatibility is determined by weighing many factors, but one important factor is HLA match compatibility.

HLA Matching

Human Leukocyte Antigens (HLAs) are proteins that attach to the membranes of cells to help the immune system identify which cells are "self" cells and which are "invader" cells. Each person has a collection of different HLAs, and the more HLAs that are shared between the donor and the recipient the safer the transplant will be. The similarity is measured by a "HLA match score", and we will consider a patient and donor to be compatible in the case that their match score is at least 60. Because of all the factors at play for donor-recipient compatibility, it may be the case that a recipient does not know any compatible donors. To help that patient find a donor, donation networks have been set up. The idea is that if Recipient A needs a kidney, but their friend Donor A is not compatible, then perhaps Donor A could give a kidney to compatible Recipient B in exchange for Donor B giving a kidney to Recipient A. So in short, if Recipient A has no known donors, they can try to identify a "kidney trade" with another recipient using one of their donors. These trades could also be larger "kidney donation cycles", where Donor A gives to Recipient B, Donor B gives to recipient C, and Donor C gives to recipient A. For the sake of this assignment, our cycles can be of any length, but they must be cycles (the idea being that Donor A is only willing to donate a kidney if the result is Recipient A receiving one).

Problem Statement

For this assignment you will implement an algorithm to identify whether a given recipient can receive a kidney through a donation cycle.

Kidney Donation Cycle Definition

A sequence of recipients $(r_0, r_1, r_2, \ldots, r_{n-1})$ is a kidney donation cycle of length n provided:

- all of $r_1, \ldots, r_{n-1}$ are kidney recipients,
- for each choice of $0 \leq i < n - 1$ there exists a donor associated with r_i is compatible with r_{i+1},
- and a donor associated with r_{n-1} is compatible with r_0.

Input

Your input will be string (which you can think of as the contents of a file) which contains the following information:

- One row giving the number of recipients (call this n). Each recipient will be identified by a number between 0 and $n - 1$ (inclusive)
- One row giving the number of donors (call this m). Each donor will be identified by a number between 0 and $m - 1$ (inclusive)
- One row containing m comma-separated integers between 0 and $n - 1$ indicating the recipient that each donor is associated with.
- A table giving the HLA match points for every Donor-Recipient pair, represented as a sequence of m rows each with n comma-separated integers.
- One row giving a "query recipient".
- Overall, the input will have $m + 4$ lines.

Output and Running Time

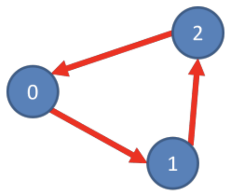
Your code will print just a single Boolean value (True or False in Python, true or false in Java) indicating whether there exists a kidney donation cycle which includes the query recipient.

The worst-case asymptotic running time of your program should belong to $O(nm)$, where n is the number of recipients and m is the number of donors (if it helps you to verify your running time, observe that it must be that $m \geq n$).

Example

This graph would be the result of the following text. We have an edge from recipient 0 to 1 because donor 2 has a match score of 71 with recipient 1, and donor 2 is the friend of recipient 0. There is an edge from recipient 1 to recipient 2 because donor 6 has a match score of 100 with recipient 2, and donor 6 is friends with recipient 1. There is an edge from recipient 2 to recipient 0 because donors 7 and 8 have a match score of 90 with recipient 0.

```
3
9
0,0,0,1,1,1,1,2,2
10,15,20
20,20,9
0,71,20
2,2,2
3,3,3
4,4,4
5,5,100
90,0,0
90,0,0
0
```



Task2 (50 Points)

Motivation

A new board called "Depth Finder" is hitting the shelves. The goal of this game is to find a trench in your opponent's sea floor. Each player's board is a list of n distinct floating point values representing the depth of the sea floor at various locations. You and your opponent alternate turns "pinging" locations on your opponent's sea floor, with the goal of finding a trench (i.e. a local maximum depth). To guarantee that a local minimum exists, the first two and last two depths must be 1, 2, 4, and 3 respectively. The winner is the first to find and declare a trench of their opponent's.

Problem Statement

You will write a divide and conquer algorithm which efficiently finds a local maximum in your opponent's list of depths. Specifically, you will write an algorithm which can find and declare a local maximum value in your opponent's board in no more than $3\lceil \log 2(n) \rceil$ "pings", where a ping is one request for the depth of a particular location. To find a local maximum depth you must have pinged three consecutive locations where the middle location is larger than the other two. To declare a local maximum you must clearly state this found index as your "final answer". For example, if we had the board below of size 10, indices 4 and 6 each contain a local maximum. You would win the game by either pinging locations 3, 4, and 5, then declaring 4 as your final answer, or else by pinging locations 5, 6, and 7 then declaring 6 as your final answer.

1	2	4.5	5.7	7	6.2	9	8.6	4	3
0	1	2	3	4	5	6	7	8	9

The starter code provided consists of three files:

- **GameBoard.java / gameboard.py**: This is implements an object to represent the gameboard. When constructing a gameboard object you simply provide an integer value to constructor (this value must be at least 5). The program then sets up the board, randomly selecting one location to be the local maximum. To ensure you don't peek, the board generates depths when pinged, rather than in advance. There are only 2 methods/attributes that your submission may access in Gameboard:
  - ping(location): This is the ping method. The argument is the index you would like to ping, the output is a float(python)/double(java) representing the depth at that location. If you exceed maximum allotted ping count then the method will print a statement indicating this, and then only return 0.
  - size: This attribute represents the size of the board (i.e. the length of the list of depths) For debugging purposes a toString()(java)/str(python) method is provided for nice printing of the board. You will not submit this file.
- **GamePlayer.java / gameplayer.py**: This is the file you will modify and submit. In here there is the header of just one method: playgame_dc(gb, left, right). You should implement this function to be a divide and conquer algorithm to play the game. gb is the gameboard, left represents the leftmost index at which a local maximum may appear, and right represents the rightmore index at which a local maximum may appear. Your algorithm should return the index of a local maximum in the given gameboard. Your algorithm must also follow the divide and conquer paradigm. In particular, it must include a conquer step consisting of recursive calls on one or more subproblems.
- **PlayGame.java / playgame.py**: This is the file you will run. It takes an integer as input in the console to represent the size of the board, creates a gameboard object using that size, calls the divide and conquer algorithm you will implement using that gameboard with left = 0 and right=size, then gives the valued retured as the "final answer". You should see "trench found!" printed to the console if you correctly found the trench within the allotted pings. Remember, to correctly find the trench you must have also pinged on both sides of it to see that the values are smaller. You will not submit this file.

Input

Your input will be a single integer represening the board size.

Output and Running Time

The function you implement will return a single integer representing the index of a local maximum in the given gameboard. Your algorithm must find the local maximum using no more than $3\lceil \log 2(n) \rceil$ pings.

Submission Rules

You will submit this homework via the LMS system. You should follow the file-naming conventions and guidelines below:

- You should submit your source files as a ZIP archive file (NOT RAR or other formats). The name of the file should be in format **"<USER-ID>_hw<HOMEWORK-NR>.zip"**. For example, if your username is vy1043, then the name of the submitted file should be "vy1043_hw1.zip". Pay attention that all the letters are in lower-case. ZIP archive is supposed to contain just the source files, under two folders corresponding to the two tasks ("KidneyDonation" and "DepthFinder" folders).
- Late submissions and files that do not compile are not accepted.
- You can resubmit your homework (until the deadline) if you need to.
- You are not allowed to use any external libraries and/or functions. Everything must be implemented by you from scratch.
- Any type of plagiarism will not be tolerated. Your submitted codes will be compared with other submissions and also the codes available on internet and violations will have a penalty of -100 points. (In case of copying from another student both parties will get -100)