CSE 231 Spring 2017

Programming Project 11

Update: Fixed description of item #4: especially set *union* instead of intersection.

This assignment is worth 55 points (5.5% of the course grade) and must be **completed and turned in before 11:59 on Monday, April 24, 2017.**

Assignment Overview
This assignment focuses on the implementation of Python programs using classes. We reuse the concept of an adjacency matrix from Project 7 and set intersection from Project 9.

Assignment Background

CSE 231 TAs are to be distributed among many help rooms running simultaneously. Each TA can serve the room they are in AND the neighboring rooms. Here neighboring rooms to a room are the ones where there is a direct path (connection) between the rooms. You are given a map of CSE help rooms and your task is to determine the minimum number of TAs that are needed to serve all of the help rooms.
Your program takes as input: the total number of CSE help rooms, the number of paths (connections) between help rooms, and each connection in the following input format. Connections are bidirectional in the sense that if we specify a connection between rooms 2 and 3 that implies that there is a connection both ways: from 2 to 3 and 3 to 2.

Example 1: Consider this map of the CSE help rooms: 1—2—3—4—5—6

Test 1
Input file `test1.txt`:

```
6
1 2
2 3
3 4
4 5
5 6
```

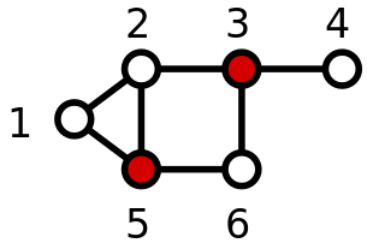
Output:

```
Enter a file name: test1.txt
TAs needed: 2
TAs assigned to rooms: 2, 5
```

Explanation:

We can place a TA in room 2 and room 5. The TA in room 2 can serve rooms 2, 1 and 3, and the TA in room 5 can serve rooms 4, 5 and 6. One TA is insufficient.

Example 2: Consider this map of the CSE help rooms:



Test 2:
Input file `test2.txt`

```
6
1 2
1 5
2 3
2 5
5 6
3 6
3 4
```

Output:

```
Enter a file name: test2.txt
TAs needed: 2
TAs assigned to rooms: 3, 5
```

Explanation: TA in room 5 can serve room 5 and 1. TA in room 3 can serve rooms: 2, 3, 4 and 6. Note that there are multiple other possible explanations such as the TA in room 5 can serve rooms 1, 2, 5, and 6 while the TA in room 3 can serve rooms 3 and 4. One TA is insufficient in either case. The result is the same: 2 TAs are needed. Also, there are other, equally valid solutions such as placing the 2 TAs in rooms 1 and 3. You only need to determine one valid solution.

Implementation

1. You are required to implement your solution using classes (any program using classes can be created without classes, but there will be no credit for such a solution).
2. Use what is known as the Greedy Algorithm to find the minimum number of TA. In this case a Greedy Algorithm is:
    a. Try to solve the problem using 1 TA.
    b. If 1 TA can cover all rooms, you are done.
    If 1 TA cannot reach all rooms, try 2 TAs.
    c. Then try 3 TAs and so on until you find that N TAs together can cover all rooms.
3. What does it mean to "solve the problem using 3 TAs"?
    Try every *combination* of mapping 3 TAs to the rooms. Finding all combinations to try is

messy, but we can `import itertools` and use
`itertools.combinations(list_of_rooms, TAs)`
The first argument is a list of ints (list of room numbers), the second argument is an int (number of TAs). For example try the following in the shell:

```
print( list(itertools.combinations([1,2,3,4,5],3)))
```

which produces the following output that represents every way you can place three TAs into five rooms. That is: (2,3,5) means that there is a TA in each room: 2, 3, and 5.

```
[(1, 2, 3), (1, 2, 4), (1, 2, 5), (1, 3, 4), (1, 3, 5), (1, 4, 5), (2, 3, 4), (2, 3, 5), (2, 4, 5), (3, 4, 5)]
```

4. How do you find out if a TA in each room of (2,3,5) solves the problem?
Remember in Project 7 about social networks where you created a list of lists representing who was friends with whom? That list of lists is called an *adjacency matrix* and we can use a similar data structure here to represent the connections among rooms, i.e. connections among rooms just like Project 7's connections among people. In Project 7 we used a list of lists for the adjacency matrix whereas here it is best to use a **list of sets**. With the adjacency matrix in hand, sets are useful for collecting the rooms that TAs can cover: walk through each tuple of rooms (from step 3 above) and add (using set *union* , not intersection as you did in Project 9) the rooms to a set (consult the adjacency matrix to determine connected rooms). If you can reach all the rooms (what Boolean tells you that?), you have found a solution. Hint: remember to consider the rooms that the TAs are in.
5. The adjacency `Matrix` class. You are to construct a class named `Matrix` to implement your adjacency matrix. A framework for the class is provided in `proj11.py`. Two class methods are complete: `__init__` and `__repr__`. You need to implement the other methods. You may modify `__init__` if you wish, and you may add additional methods (but these should be sufficient). The methods you need to implement are:
    a. `read_file`: this method takes a file pointer as a parameter. It reads a file and fills in the matrix named `self._matrix` . The first line of the file is an integer that is the number of rooms. Each subsequent line contains two integers separated by spaces. The pair of integers indicates a connection between a pair of rooms and the connection is bi-directional. That is, the line `2 3` indicates that 2 is connected to 3 and symmetrically 3 is connected to 2. Hint: the room numbers start at 1 whereas list indices start at 0 so you need to account for that (you already knew that, right?).
    b. `__str__`: this method returns a string that represents the matrix. If you have an instance of a matrix named M, then `print(M)` calls `__str__` and prints the string returned by `__str__`. **Important**: your `__str__` method CANNOT have any `print` statements—your method builds a string that a `print` statement will use.
    c. `adjacent:` this method takes a parameter representing a room and returns one row of your matrix (that row is a set). That row represents the rooms that are adjacent to the room specified by the parameter `index`.
    d. `rooms`: this method returns the number of rooms (rows) in the matrix.
6. `open_file`: You have used an `open_file` function in previous projects so include it in this one. It should keep prompting until a file is opened.

7. `main()` The `main` function of your program opens a file, creates an instance of the adjacency matrix, call the matrix `read_file` method to fill the matrix and then loops to find the minimum number of TAs and the rooms they cover. Note that when you find a combination of assigning TAs to rooms that works you will likely be deep within a couple of loops so a simple `break` will not be sufficient. I used a Boolean named `done` that controlled multiple `breaks` to exit the multiple loops. Finally, print the adjacency matrix.
   Call to main required to be:
   ```
   if __name__ == "__main__":
       main()
   ```

Sample Output

Function Test

```
Testing __str__ by calling __str__ through print():
1: 2
2: 1 3
3: 2 4
4: 3 5
5: 4 6
6: 5

Testing adjacent method:
rooms adjacent to room 2: {1, 3}
Testing rooms method:
number of rooms: 6
```

Test 1

```
Enter a file name: test1.txt
TAs needed: 2
TAs assigned to rooms: 2, 5

Adjacency Matrix
1: 2
2: 1 3
3: 2 4
4: 3 5
5: 4 6
6: 5
```

Test 2

```
Enter a file name: test2.txt
TAs needed: 2
TAs assigned to rooms: 1, 3

Adjacency Matrix
1: 2 5
2: 1 3 5
3: 2 4 6
4: 3
5: 1 2 6
6: 3 5
```

Test 3

```
Enter a file name: test3.txt
TAs needed: 3
TAs assigned to rooms: 2, 5, 7

Adjacency Matrix
1: 2
2: 1 3 5
3: 2 4
4: 3 7
5: 2 6
6: 5
7: 8 4
8: 7
```

Scoring Rubric

General Requirements

__0__ (5 pts) Coding Standard
(descriptive comments, mnemonic identifiers, format, etc...)

Tests

__0__ (20 pts) Pass Test 1

__0__ (5 pts) Pass Test 2

__0__ (5 pts) Pass Test 3

__0__ (20 pts) Pass Function Test, i.e. class Matrix works

`TA Comments:`

Optional Testing

We provide the following frameworks for testing

1. `function_test.py` for testing your class methods.
2. `run_file.py` runs the three test cases shown in the sample above and are the three test cases that are collectively worth 30 of the project's 55 points.

Educational Research

When you have completed the project insert the 6-line comment specified below.

For each of the following statements, please respond with how much they apply to your experience completing the programming project, on the following scale:

1 = Strongly disagree / Not true of me at all
2
3
4 = Neither agree nor disagree / Somewhat true of me
5
6
7 = Strongly agree / Extremely true of me

*********Please note that your responses to these questions will not affect your project grade, so please answer as honestly as possible*.***

Q1: Upon completing the project, I felt proud/accomplished

Q2: While working on the project, I often felt frustrated/annoyed

Q3: While working on the project, I felt inadequate/stupid

Q4: Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this course.

Q5: I ran the optional test cases (choose 7=Yes, 1=No)

Please insert your answers into the bottom of your project program as a comment, formatted exactly as follows (so we can write a program to extract them).

```
# Questions
# Q1: 5
```

Q2: 3
Q3: 4
Q4: 6
Q5: 7