

CSC148, Assignment #2
Operation Sahure
Due July 22nd, 4:30 pm
Late submissions are not accepted.

1 Introduction

Pyramid schemes¹ are large scale scam operations that fool ordinary people with little to no experience in investment or marketing. Such organizations promise new members that if they can convince other people to join, they will receive commissions or other bonuses. This idea benefits people who joined early (usually the directors of the organization) but leaves most members with great losses, simply because no new member will join after some time. There are also some variations that try to make it look legal, such as advertising themselves as a marketing company that sells collectibles, which do not have any real value.

Recently², Toronto police uncovered a pyramid scheme network in Toronto. The information came from *John Doe*, a recently arrested criminal who was the main bookkeeper of the network. While *Doe* was arrested on drug charges, police found evidence of a running pyramid network on his computer. He kept detailed logs of who joined the network, how and when, as well as how much assets they currently have.

Toronto police is now planning for *Operation Sahure*³ to crack down on this pyramid scheme. However, due to recent budget cuts, there is only one unit to be sent to make arrests. So, they can only arrest one person at a time. After arresting a person, all of their illegal assets will be seized. Considering that the news of arrest will be public in a few hours after the first arrest, the police only have time to arrest at most a specific number of suspects. They want to maximize the amount of assets that they seize from suspects.

Furthermore, they do not have the location of members. The *Crown Attorney* prepared a deal for any arrested member to receive reduced charges when they reveal the location of another member to police. However, each member only knows a few other members in the network, a policy that was strictly enforced to protect the network from mass arrests. Every arrested member will accept the deal, if offered.

Doe also accepted a deal from the *Crown Attorney* to disclose the location of one member to the police in exchange for a reduced sentence. Now the police want to decide which group member they should select to arrest, to maximise the seized assets considering all limitations. So, they are asking you to help them find the answer.

¹ For more information, take a look at https://en.wikipedia.org/wiki/Pyramid_scheme

² Note that this is a fictional scenario, and all names and events are not real.

³ Sahure is an ancient pharaoh, which built a great pyramid for himself. You can read more about him on <https://en.wikipedia.org/wiki/Sahure>

2 Network Structure

The pyramid network has a hierarchical structure, and uses special terms to refer to users. Consider the sample network topology shown in Figure 1. The number under each name is the illegal asset that the member has and can be seized if police arrested that member.

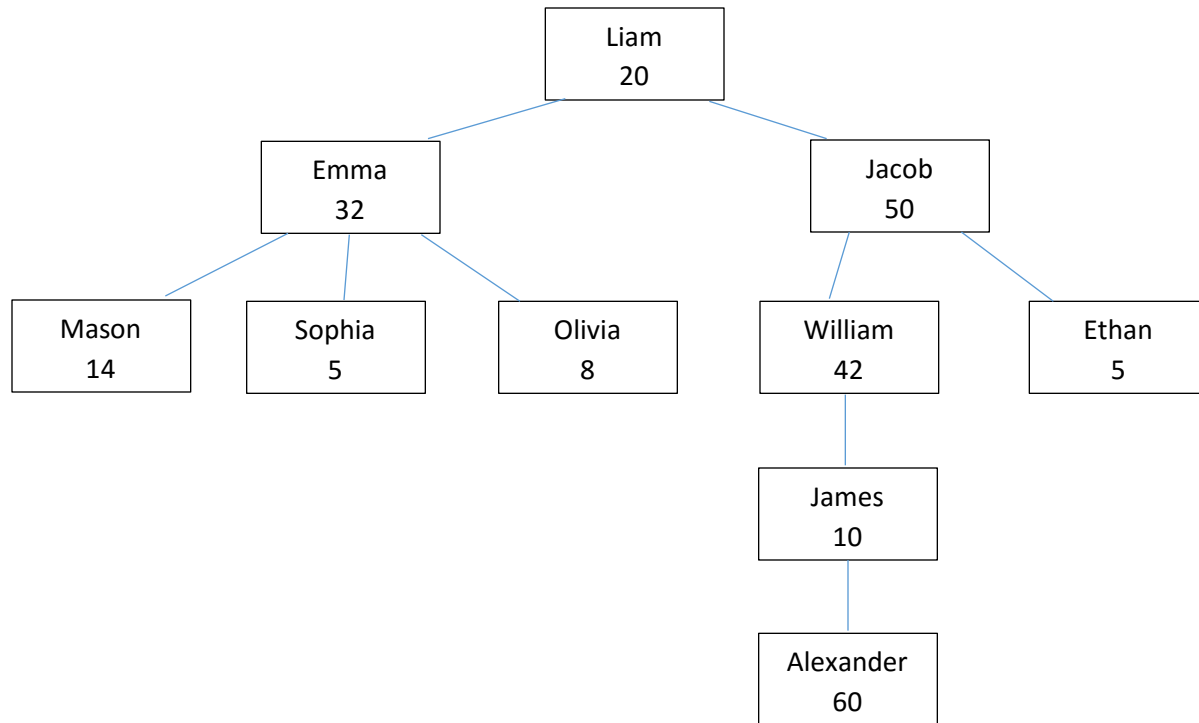
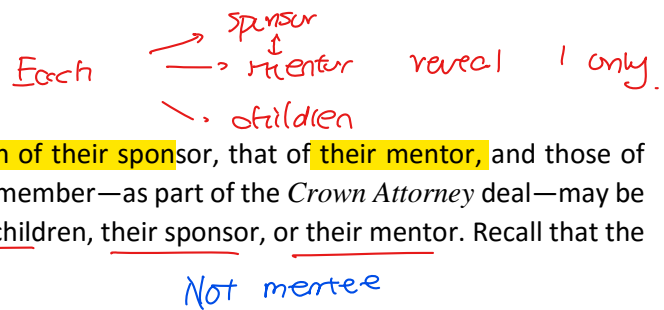


Figure 1: Sample Network Topology

There is one great boss (*Liam* in Figure 1) that has created and ruled the network. Other than him, each person who joined the network is sponsored by a network member. For example, *Emma* and *Jacob* are sponsored by *Liam*, to join the network. A new member is called a child of their sponsor in the network. For example, *Emma* and *Jacob* are *Liam*'s children in Figure 1.

When a new person joins the network, another member is appointed as their mentor and will teach the new member different techniques of recruiting more people. If the new member is the first child of their sponsor, the sponsor will also act as the mentor. As examples, *Alexander* is the first (and only) child of *James*, so *James* is both the sponsor and the mentor of *Alexander*; or, *Emma* is the first child of *Liam*, so *Liam* is both her sponsor and mentor.

If a member is not the first child of the sponsor, then the youngest child of the sponsor (the child who joined the network more recently) will be the mentor. For example, *Emma* is *Jacob*'s mentor as she has been the last person sponsored by *Liam* when *Jacob* joined the network. Similarly, *Mason* is *Sophia*'s mentor, and *Sophia* is *Olivia*'s mentor. (In Figure 1, the left-to-right order of children represents the order that they joined the network).



In this topology, each member knows the location of their sponsor, that of their mentor, and those of their children. When police arrest a member, that member—as part of the *Crown Attorney* deal—may be asked to reveal the location of either one of their children, their sponsor, or their mentor. Recall that the mentor of the first-child members is their sponsor.

3 Arrest Operation

The police will ask *Doe* to reveal the location of a network member, called “target zero”. They will arrest target zero first, and ask him/her to reveal the location of another member (either their sponsor, mentor, or one of their children). Then, they will arrest that member, and continue the operation in the same manner until either they arrest the maximum members that they can arrest (due to time limit on overall operation), or the last arrested member cannot reveal the location of any other member that is not arrested already.

For example, consider Figure 1. Assume the maximum number of arrests is 4. Then, police may start by arresting *Mason*, then arrest *Emma*, *Liam*, and *Jacob*. However, if they arrest *Mason*, *Emma* and *Sophia*, they cannot arrest any fourth member, because *Sophia* cannot help them to arrest any new member: she does not have any child, and she only knows the location of *Emma* (her sponsor) and *Mason* (her mentor), both of whom are already arrested.

The police goal is to maximize the amount of seized money. So, if they follow the *Mason*, *Emma*, *Liam*, and *Jacob* scenario, they will seize a total of $116 = 14 + 32 + 20 + 50$. But, by the *Mason*, *Emma*, and *Sophia* scenario, the seized asset will be $51 = 14 + 32 + 5$. In this case, the best scenario is *Alexander*, *James*, *William*, and *Jacob* that will seize $162 = 60 + 10 + 42 + 50$. Your goal in this assignment is to help the police find the best scenario.

4 Network Log Format

Here, we describe the format of network log that police found on *Doe*’s computer. Each line of the file describes one member: i.e. the lines represent the order that members joined the network: the first line represents the first member, and the last line is the newest member of the network. Each line provides three pieces of information about the user: user name, their sponsor, and their illegal asset. The great boss does not have any sponsor, so that field is not present for him. These three parts are separated by a number sign (“#”). Here is the network log of the network shown in Figure 1:

Liam#20
 Emma#Liam#32
 Mason#Emma#14
 Jacob#Liam#50
 Sophia#Emma#5
 William#Jacob#42
 James#William#10
 Ethan#Jacob#5
 Olivia#Emma#8
 Alexander#James#60

5 Starter Code

In this assignment, you should implement one class named `Network` in the file `"network.py"`. The starter code has signature of the class methods that you should complete. Here is a short description of what each function does:

`load_log`: This function reads the network log file and prepares the network object for future operations.

`sponsor`: This function returns the name of the sponsor of the specified member. For example, calling `sponsor("Emma")` will return `"Liam"`. This function should return `None` if it is called for the great boss.

`mentor`: Similar to the `sponsor` function, this function returns the name of the mentor for the requested member. For example, `mentor("Mason")` returns `"Emma"`, and `mentor("Sophia")` returns `"Mason"`.

`assets`: This function returns the current assets of a member. For example, `assets("Emma")` returns 32, and `assets("Olivia")` returns 8.

`children`: This function returns a list of all children's name for a user. For example, `children("Emma")` returns `["Mason", "Sophia", "Olivia"]`. If the member does not have any children, it returns an empty list.

`Best_arrest_seize`: This function returns the maximum amount that police can seize for the given maximum number of allowed arrests. For example, `best_arrest_seize(4)` returns 162 (as discussed previously). As more examples, `best_arrest_seize(2)` returns 92 (by arresting *Jacob* and *William*), and `best_arrest_seize(1)` returns 60 (arresting *Alexander*).

`best_arrest_order`: This function returns a list of members that should be arrested in order to achieve the maximum possible seized assets. For example, `best_arrest_order(4)` should return `["Alexander", "James", "William", "Jacob"]`. Note that there may be more than one way to achieve the maximum seized assets, and this function should return one of them. For example, we may arrest members in a different order to achieve the same output: `["Jacob", "William", "James", "Alexander"]`. As another example, `best_arrest_order(2)` returns `["Jacob", "William"]`.

6 Declaring your assignment team

You may do this assignment alone or in a team of 2 students. Your teammate should be different from any other partners that you have had (or going to have) in the labs (tutorials) and Assignment 1. You must declare your team (even if you are working solo) using the [MarkUs](#) online system. Assignment and team declaration will be active from June 30. Teams are required to be declared from June 30th to July 16th.

Navigate to the [MarkUs](#) page for the assignment and find "Group Information". If you are working solo, say so. If you are working with other(s):

First: one of you needs to "invite" the other to be a partner, providing MarkUs with their CDF user name.

Second: the invited student must accept the invitation.

Important: there must be only one inviter, and the other group member accepts after being invited, if you want MarkUs to set up your group properly.

To accept an invitation, find "Group Information" on the appropriate Assignment page, find the invitation listed there, and click on "Join".

7 Submitting your work

Submit the following file on **MarkUs** by 4:30 p.m. July 22:

`network.py`

Click on the "Submissions" tab near the top. Click "Add a New File" and either type the file name or use the "Browse" button to choose one. Then, click "Submit". You can submit a new version of a file later (before the deadline, of course); look in the "Replace" column.

8 Special Office Hours

There will be special office hours for this assignment on **July 15**, from **1 to 5**, in BA3201. This will be the best time to discuss your questions in person with the Assignment Lead TA. In particular, we will NOT answer questions asked one day before the deadline (in person or online).

Start Early!