Efi Arazi School of Computer Science

Introduction to Computer Science

Midterm Examination 2024

• The exam lasts 90 minutes. There will be no time extension.

• Use your time efficiently. If you get stuck somewhere, leave the question and move on to another question.

• Use of digital devices, books, lecture notes, and anything other than the exam pages is forbidden. All the materials that you need for answering this exam are supplied with the exam. You can use a paper-based dictionary, if you want.

• **Answer all the questions on the exam pages, using a pen. Don’t write anything on the back of the pages.** Only the front pages are scanned for grading. You can use blank pages for draft (טיוטה(, which will not be graded.

• You can answer any question in either English or Hebrew.

• If you feel a need to make an assumption, you may do so as long as the assumption is reasonable and clearly stated.

• If you can't give a complete answer, give a partial answer. A partial answer will award partial points.

• If you are asked to write code and you feel that you can't write it, you may describe what you wish to do in English or in Hebrew. A good explanation will award partial credit.

• If you are asked to write code that operates on some input, there is no need to validate the input unless you are explicitly asked to do so. Likewise, if you are asked to write a function that operates on some arguments, there is no need to validate the arguments unless you are explicitly asked to do so.

• There is no need to document the code that you write, unless you want to communicate something to us.

• The code that you write will be judged, among other things, on its conciseness, elegance, and efficiency. Unnecessarily long or cumbersome code will cause loss of points, even if it provides the correct answer.

• No points will be taken for trivial syntax errors. For example, instead of writing System.out.println(x) you can write println(x).

Good Luck!

1

Page number 2 Question 1 (20 points)

Consider the following mystery function:

public static String mystery(String input) {

String result = "";

char current = input.charAt(0);

int count = 1;

for (int i = 1; i < input.length(); i++) {

char next = input.charAt(i);

if (next == current) {

count++;

} else {

result = result + "" + count + current;

current = next;

count = 1;

}

}

result = result + "" + count + current;

return result;

}

(a) (10 points)

Suppose we call mystery(“aabb”). What will the function return?

Answer: “2a2b”

Suppose we call mystery(“aabba”). What will the function return?

Answer: “2a2b1a”

(b) (10 points) Explain in your own words what the mystery function is doing.

Answer: The function returns an output string. For each sequence (רצף (of repeating characters in the input, including the case where the sequence has length 1, the output consists of the number of times that the character is repeated, followed by the character.

Note: Answers that describe this operation correctly using other words are also acceptable. At the same time, we penalized up to 3 points for inaccurate or unclear description. The test is this: If someone who hasn’t seen this function reads the description, will s/he understand completely and clearly what the function does? If the answer is No, it means that the description is problematic.

Page number 3 The Social Network Model

All the remaining questions in the exam deal with the following simple social network model. A set of users is represented by the integers 0, 1, 2, ..., N – 1. For example, if N = 5, the users are 0, 1, 2, 3, 4. Each user has a (possibly empty) set of users that s/he follows, and a (possibly empty) set of users that follow her/him. We represent these relationships using an N by N table named socialNet, as follows. If user i follows user j, we set socialNet[i][j] = 1. Otherwise, socialNet[i][j] = 0 by default. For example, consider the following social network:

**0 1 2 3 4**

**0 1 2 3 4**

|  | 1 |  |  | 1 |
| --- | --- | --- | --- | --- |
|  |  |  | 1 |  |
|  | 1 |  |  | 1 |
|  | 1 |  |  |  |
|  |  |  |  |  |

(Empty cells contain 0 values)

We see that user 0 follows users 1 and 4, user 1 follows user 3, and so on. User 4 follows no-one. We also see that user 0 is followed by no-one, user 1 is followed by users 0, 2, and 3, and so on. Here are some possible questions about this model, and their answers:

• How many users user 2 follows? Answer: 2

• How many users follow user 1? Answer: 3

• Who is the most popular user? Answer: user 1

• Which users user 2 follows? Answer: users 1 and 4

The social network model is represented by a class named SocialNetwork. The code of this class is given in the two help pages. **Take 10 minutes** to read and understand the class code. **Do it now, before reading the questions below**.

Question 2 (10 points)

Implement the nFollowers function, that returns the number of followers of a given user.

Tip 1: This function is very similar to the nFollows function, which is given. Tip 2: if you want, the code that you write can call any other function in the class. This general guideline is true for any question that follows.

// Returns the number of followers that the given user has.

public static int nFollowers(int user) {

int n = 0;

for (int i = 0; i < N; i++) {

if (socialNet[i][user] == 1)

n = n + 1;

}

return n;

Page number 4 }

}

Page number 5 Question 3 (30 points)

Implement the mostPopularUser function, that returns the user that has the largest number of followers.

We repeat: The code that you write can call any other function in the class. This general guideline is true for any question that follows, and we will not say it again.

// Returns the user that has the largest number of followers.

public static int mostPopularUser() {

int maxFollowers = -1;

int mostPopularUserUser = -1;

for (int user = 0; user < N; user++) {

int followers = nFollowers(user);

if (followers > maxFollowers) {

maxFollowers = followers;

mostPopularUserUser = user;

}

}

return mostPopularUserUser;

}

Note: Some students used Math.max(int, int) function. This is an unnecessary overkill that makes the code less efficient. Normally we would reduce 2-3 points for suce a misuse. But in this midterm we are letting it pass.

Question 4 (30 points)

Implement the follows function, that returns all the users that a given user follows, as an array of int values.

Tip: Create a one-dimensional array, and then fill it with the user numbers.

// Returns an array containing all the users that the given user follows.

// The array's length is the number of users that the given user follows.

public static int[] follows(int user) {

int n = nFollows(user);

int[] follows = new int[n];

int i = 0;

for (int j = 0; j < N; j++) {

if (socialNet[user][j] == 1) {

follows[i] = j;

i++;

}

}

return follows;

}

Page number 6 **\*\* Answer only one of the next two questions: Question 5 or Question 6.**

Question 5 (10 points)

Implement the randomElement function, that returns a randomly selected element from a given array. For example, if the array is [5,3,0,1], the function returns, randomly, one of the numbers 5, 3, 0, or 1. Note that this is a general-purpose function.

// Returns a random element from the given array.

public static int randomElement(int[] arr) {

return arr[(int) (arr.length \* Math.random())];

}

Note: Can be done in one statement (above), two statements (first getting a random index, and then returning the value at that index), or three statement (separate return statement). Each one of this options is accepatble, although (1) is preferred.

Question 6 (10 points)

The social network model allows users to invite other users to become their friends. To do so, we select at random one of the users that we follow, and then we select at random one of the followers of that user. For example, suppose that user 2 wants to invite someone. To do so, we select at random one of the users that user 2 follows. Since he happens to follow users 1 and 4, we’ll get either 1, or 4. Suppose we got 1. Next, we select and return one of the followers of user 1. Since he is followed by users 0, 2, and 3, we’ll get and return one of these numbers, randomly. What should we do if user 2 already follows the randomly selected user? To make life simple, we’ll assume that this is not the case. Also, note that we don’t make any change in the network. We simply return a user number. Implement the following function:

// Selects at random one of the users that the given user follows, and

// then selects at random, and returns, one of the followers of that user.

public static int invite(int user) {

int rndUser = randomElement(follows(user));

return randomElement(followersOf(rndUser));

}

Note: Can be done by writing code directly, without using function calls. This approach is problematic, since writing code unnecessarily is cumbersome and error-prone.