A4 – Modeling Bugs with Trees
Developed by Michael Patashnik

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1. Introduction

Note: Keep track of the time you spend on this assignment. You have to give it to us when you submit.

We all get bugs, or infections, from time to time. Sometimes they are just an annoyance. Sometimes they are dangerous —like the current zika virus. For a dangerous one, the United States Centers for Disease Control and Prevention (CDC) may track how it is spreading and attempt to determine where it will spread next, so preparations can be made to fight it. People develop programs to simulated the spread of bugs in order to learn about them, just as program are written to simulate weather. If you are interested in learning more about using Math/CS to model and understand infectious bugs, check out some of these resources:

- http://idmod.org/home
- https://en.wikipedia.org/wiki/Mathematical_modelling_of_infectious_disease
- http://ocw.jhsph.edu/courses/epiinfectiousdisease/pdfs/eid_lec4_aron.pdf

Assignment A4 uses trees to model the spread of an infectious bug. The root of the tree represents the first person to get the bug; the children of each node represent the people who were infected by contact with the person represented by that node.

Most of the code you write for A4 involves using recursion to explore a tree. We have supplied you with starter code, developed by Michael Patashnik, that simulates the propagation of a bug as well as a GUI (Graphical User Interface) that allows you to set parameters and visualize the results on the screen. But Michael's simulation won't work until you write recursive methods to process the tree.

Learning objective: Become fluent in using recursion to process data structures such as trees.

Collaboration policy: You may do A4 with one other person. If you are going to work together, then, as soon as possible —and certainly before you submit the assignment— visit the CMS for the course and form a group. Both people must do something to form a group: one person proposes and the other accepts. Need help with the CMS? Visit www.cs.cornell.edu/Projects/CMS/userdoc/.

If you do this assignment with another person, you must work together. It is against the rules for one person to do some programming on this assignment without the other person sitting nearby and helping. You should take turns driving —using the keyboard and mouse— and navigating —reading and reviewing the code on the screen.

Academic Integrity: With the exception of your CMS-registered partner, you may not look at anyone else's code from this semester or from a similar assignment in a previous semester, in any form, or show your code to anyone else, in any form. You may not show or give your code to others until after the last deadline for submission.

Getting help: If you don't know where to start, if you don't understand, if you are lost, etc., See someone IMMEDIATELY—a course instructor, a TA, a consultant, the Piazza for the course. Do not wait.

2. Bug propagation

In A4, we use an extremely simple model of an infectious bug. In each time step, an individual may become infected with some probability given as a parameter. This model provides a real world example of the general tree data structure.

You are not responsible for writing any of the code that implements the simulation of the bug spreading.

The model is initialized with a population of people —1, 2, 10, 50— however many you choose. Each human has a health range, say 0..10. Here, a health of 10 means the human is very healthy and 0 means the human has died. At each time frame during the simulation, an infected human either becomes healthy or their health decreases by 1. Generally speaking, the larger the health range, the longer the program will run since there are more possible states of the simulation.

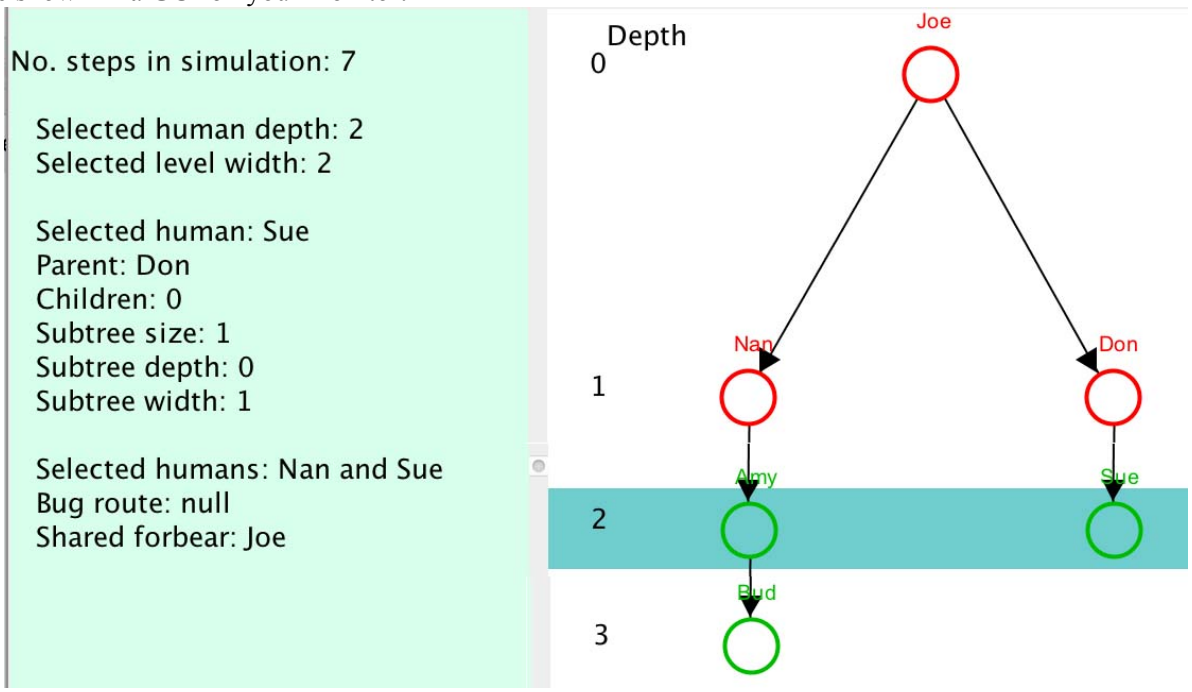
At the beginning of the simulation, a graph is constructed with humans as nodes and random edges between human, indicating they are in close proximity. You may supply a probability indicating that any two humans are close. A probability of 1 means everyone is close to everyone, a probability of 0 means there are no edges. When you start the program, you supply two other probabilities: the probability that a human will get the bug and the probability that a human will become immune (and thus healthy).

Once you have given this input, the program starts by making one random person sick and making that person the root of a new bugtree. Initially, that is the only node in the tree.

A series of time steps follows. In each time step, several things happen.

(1) one random healthy neighbor of each sick human may get the bug and be added to the bug tree as the sick human's child.
(2) Each sick human either gets well and henceforth immune from the bug or will get sicker (their health decreases).
(3) A sick human whose health decreases to 0 dies.

These time steps continue until everyone in the bug tree is either healthy or dead. At that time, the results are shown in a GUI on your monitor.



Above is an example of the output in the GUI. Joe is at depth 0 (the root); Nan and Don are at depth 1, Amy and Sue are at depth 2, and Bud is at depth 3.

Joe got the bug first; he infected Nan and Don; Nan infected Amy, Amy infected Bud, and Don infected Sue. All six got ill and three of them died (Joe, Nana, and Don).

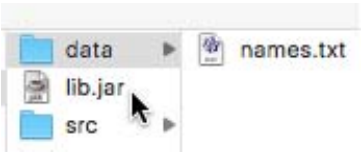
To the left in the image above is data that comes from selecting (with your mouse) Nan and then Sue. It shows: Sue's depth, 2; the width at (number of nodes at) that level, 2; Sue's parent; number of children; subtree size, depth, and width; and the shared forbear, or ancestor, of Nan and Sue.

A run may result in a tree with one node, as shown to the right. This happens when the one human with the bug doesn't infect anyone, either because they have no neighbors or because when generating a random number to test whether a neighbor is sickened, the result is always "no".

3. Installation

1. Download the A4 assignment zip file from the CMS or the course website.

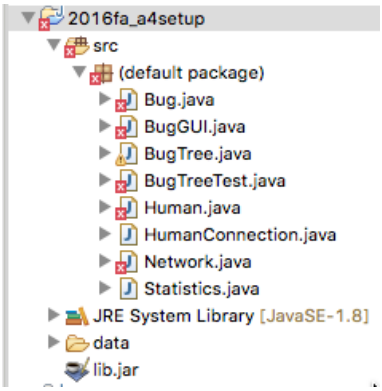
2. Unzip the downloaded file. The folder should contain two folders, data and src; and a file lib.jar. Folder data should look as shown to the right.



3. Create a new Java project (called A4). **IMPORTANT** – you must use java 1.8 for this project. Some of the code relies on functionality specific to java 1.8.

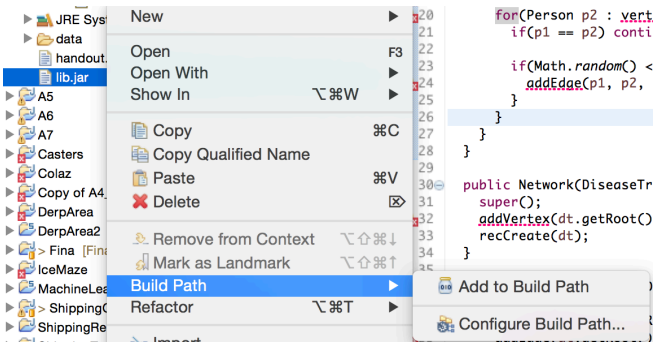
Copy-paste all three items in the downloaded folder into the root of the new Java project in Eclipse (i.e. data, lib.jar, and src). When asked how to copy, select "Copy files and folders", then OK. Also, if asked to replace src, do it.

To the right, you see what folder src should be. Note that many of the files have syntax errors that will be fixed in a moment.



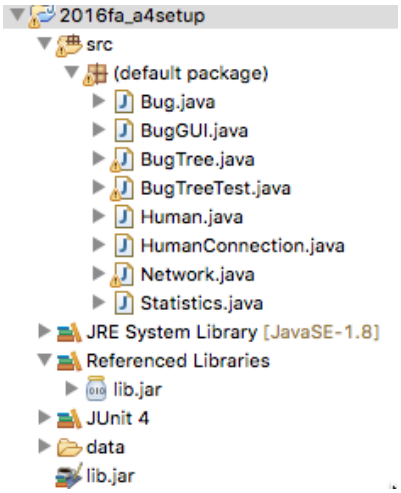
4. Add lib.jar to the build path by right clicking lib.jar and selecting Build Path → Add to build path.

After this, the only file that should show an error if silfe BugTreeTest.java.



5. Create a new JUnit testing class as usual (File → New → JUnit Test Case), making sure to say "yes" when it asks whether JUnit 4 should be added to the build path. Then delete the newly added JUNit test case file (because you don't need it).

Your project should now look as shown to the right, and you're ready to go!

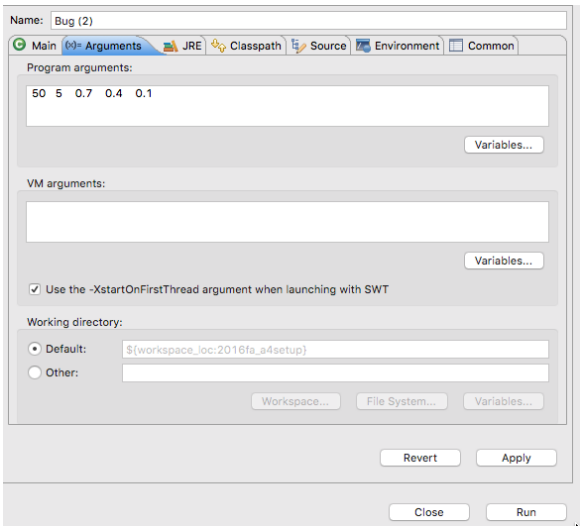


4. Running

The executable class of this project is Bug.java. To run the project, open Bug.java and click run (green button with white arrow) or use menu item Run -> Run. You will be prompted for a few seeding values via the console at the bottom of Eclipse. These are:

1. Size of population: how many humans to model. A positive integer. A higher number may result in a larger tree.
2. Amount of health per human: how long a human can have the bug before dying. A positive integer. A higher number may result in a larger tree.
3. Probability of connection: how likely two random humans are to come into contact with one another. (On page 2, we called them neighbors). A float in the range [0,1]. A higher number may result in a larger tree.
4. Probability of getting the bug: how likely a human is to get the bug when in contact with an infected human. A float in the range [0,1]. A higher may number result in a larger tree.
5. Probability of becoming immune: how likely a human with the bug will become immune (fight off the bug). A float in the range [0,1]. A *lower* number may result in a larger tree.

A nice set of starting values is: (50, 5, 0.7, 0.4, 0.1)



If you want to run Bug.java repeatedly with the same five arguments, put them in the program arguments instead of having to type them into the console every time you run the program. This is done the usual way (Run Configurations… → arguments). For example, the run configurations shown to the right would run the program with the above arguments every time the run button is clicked.

If there is any issue with the arguments provided, either though the console or the program arguments (health is less than 0, for

example), you will be re-prompted to enter the arguments through the console. Thus, if you have entered arguments in the arguments tab but are still prompted to enter arguments via the console, there may be something wrong with the arguments you entered.

From there, the bug infection will run —starting with a randomly chosen patient and spreading across that human's connections until no one is left alive and infected.

After the simulation has finished, the full tree is printed out by calling toStringVerbose(); then the tree explorer GUI pops up.

5. Your Tasks

All the code you write is in BugTree.java. In order to complete the assignment, complete each method marked with a //TODO comment (in Eclipse, they are marked in blue on the right of the text). Complete and test them in the order in which they are numbered. Do not delete the //TODO comments. If a precondition is false, any behavior is acceptable. Do the following before you code:

1. Read the comments at the top of BugTree.java.
2. Study the already written methods in BugTree.java. You will learn a lot by that.
3. You *must* read the Piazza pinned A4 FAQs note. It continues useful and necessary info.

Recursion is your friend! The bulk of these functions are best and most easily written using recursion. Iteration (using loops instead of recursive calls) may be possible but will certainly be more work both to reason through and to debug.

Hint: Some of the functions you are asked to write can be written very simply or even trivially (one or two lines) simply by relying on previous functions you have already written or ones that we wrote.

Warning: Every time application Bug (i.e. method main in Bug.java) is called, a new, random, unrepeatable BugTree is created, so you cannot debug the methods you are writing using that application. It is best to use a JUnit testing class to test your methods and to run the program only when you know your methods are correct. See the Piazza A4 FAQs note.

Dos and Don'ts:

- Do read all the Javadoc in BugTree.java thoroughly. You may choose to read the Javadoc in other files, but it should not be too important. Read the files outside the default package only if you are particularly interested in them —you don't need to know more than their javadocs in order to complete the assignment.
- Do not alter any of the other files given to you. You won't be able to submit them, so your BugTree.java must work with unaltered versions of the other files.
- Do not change the method signatures of any method in BugTree. The name and types of parameters should not be changed.
- Do not leave println statements (which you may have added to help debug) in your code when you submit. You will lose up to 5 points. Comment them out or delete them before submitting.

- You may add new methods to BugTree to help complete the required functions (some are only workable with the use of helper methods). Make sure that methods you add are **private** and have good javadoc (/** … */) specifications.

6. Debugging

We strongly recommend that you create a JUnit test file to systematically test the functionality of BugTree. Use the same testing practices you learned since A1 and used in A2 and A3. Read the Piazza A4 FAQs note for information on testing.

Debugging a tree method can be difficult. It's harder than with linked lists, where we were easily able to test *all* fields using toString(), toStringRev(), and size().

7. What to submit

Complete the information at the top of file BugTree.java: your netid(s), the hours and minutes that you spent on this assignment, and any comments you would like to make on this assignment. Please be careful doing this. We run a program to extract the times and compute statistics. If you are not careful, we have to manually go in and fix you comment. Save us work; be careful.

Submit file BugTree.java on the CMS.