CSE 143: Computer Programming II — Winter 2019

HW7: 20 Questions (due Thursday, March 7, 2019 11:30pm)

This assignment focuses on binary trees and recursion. Turn in the following files using the link on the course website:

- `QuestionsGame.java` – A class that represents a tree of questions and answers

You will need the support files `QuestionMain.java`, `spec-questions.txt`, and `big-questions.txt`; place these in the same folder as your program or project. You should not modify the provided files. Your code must work properly with the unmodified versions of the provided files.

The Game of Twenty Questions

20 Questions is a guessing game in which the objective is to ask yes/no questions to determine an object. In our version, the human begins a round by choosing some object, and the computer attempts to guess that object by asking a series of yes/no questions until it thinks it knows the answer. Then, the computer makes a guess; if its guess is correct, the computer wins, and otherwise you win. If the computer loses, it will add the object you were thinking of to its knowledge base.

In this assignment, you will create a class named `QuestionsGame` to represent the computer's tree of yes/no questions and answers for playing games of 20 Questions. Your `QuestionsGame` class **MUST** contain a private static inner class named `QuestionNode`.
You are provided with a client `QuestionMain.java` that handles user interaction and calls your tree's methods to play the games.

`QuestionNode`

The contents of the `QuestionNode` class are up to you. Though we have studied trees of `ints`, you *should* create nodes specific to solving this problem. Your `QuestionNode` class should have at least one constructor used by your tree. Don't include constructors that are not actually used in your program. Your `QuestionNode` class must be private static inner class within `QuestionsGame`. Your node's fields *must* be public. `QuestionNode` should not contain *any actual game logic*. It should only represent a single node of the tree. For reference, you can look at the `AssassinNode` class from HW3 or the `IntTreeNode` class from lecture.

`QuestionsGame`

This class represents a game of 20 Questions. It keeps track of a binary tree whose nodes represent questions and answers. (Every node's data is a string representing the text of the question or answer.) Note that even though the name of the game is "20 questions", the computer will *not* be limited to only *twenty*; the tree may have a larger height.

The *leaves* of the tree represent possible answers (guesses) that the computer might make. All the other nodes represent questions that the computer will ask to narrow the possibilities. The left branch indicates the next question the computer asks if the answer is *yes*, and the right branch is the next question if the answer is *no*. The game is played by starting at the root and asking questions for each of the branch nodes, going down the the tree based on the user's answer. Once a leaf node is reached, the computer will ask if that answer is the correct one. Page 3 walks through a full example of a game.

`QuestionsGame` should have the following constructor:

`public` **`QuestionsGame`**`()`
This constructor should initialize a new `QuestionsGame` object with a *single leaf node* representing the object `"computer"`.

`QuestionsGame` should also implement the following methods:

`public void` **`read`**`(Scanner input)`
This method will be called if the client wants to replace the current tree by reading another tree from a file. Your method will be passed a `Scanner` that is linked to the file and should replace the current tree with a new tree using the information in the file. Assume the file is legal and in standard format. Make sure to read entire lines of input using calls on `Scanner`'s `nextLine`.

`public void` **`write`**`(PrintStream output)`
This method should store the current questions tree to an output file represented by the given `PrintStream`. This method can be used to later play another game with the computer using questions from this one.

`public void` **`askQuestions`**`()`
This method should use the current question tree to play one complete guessing game with the user, asking yes/no questions until reaching an answer object to guess. A game begins with the root node of the tree and ends upon reaching an answer leaf node. **If the computer wins the game**, this method should print a message saying so. **Otherwise**, this method should ask the user for the following: ▪ what object they were thinking of, ▪ a question to distinguish that object from the player's guess, and ▪ whether the player's object is the yes or no answer for that question.

`public boolean` **`yesTo`**`(String prompt)`
This method asks the given question until the user types "y" or "n". Returns true if "y", false if "n".

User Input: Yes and No

At various points in this assignment, you will need to get a yes or no answer from the user. You must construct a **single console `Scanner` attached to `System.in` that you store in a data field and use throughout your class**. All calls to this `Scanner` should be on the `nextLine` method.

The details of for asking the user to input yes/no are fairly uninteresting, so it is being provided for you as a method called `yesTo` (the code assumes there is a data field called `console` has been initialized). You are to include this method without modification to your `QuestionsGame` class and use it whenever possible to read user input. **The code for `yesTo` can be found in the starter code on the homework page of the course website**

Question Tree "Standard Format"

In `read` and `write`, your class will be interacting with files containing questions. Just like with BNF where we used a common format so everyone could share the same grammars, here, we specify a common question tree format.

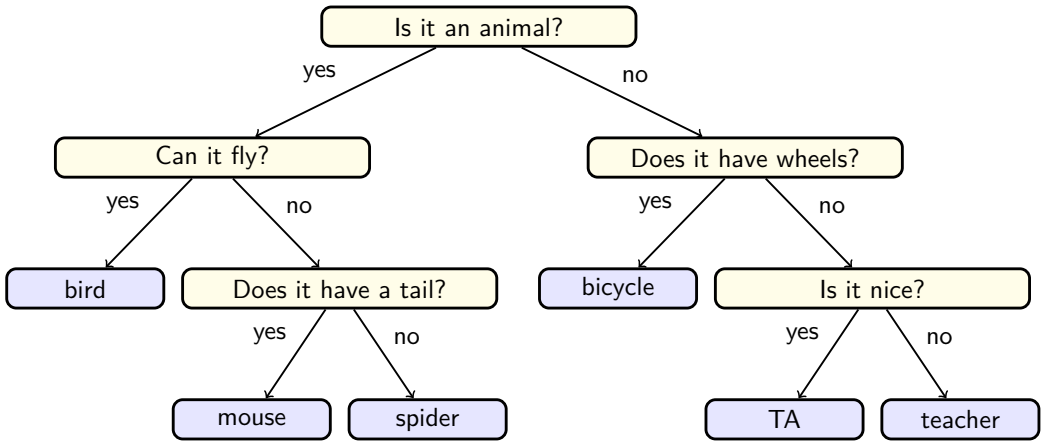
A single `QuestionNode` should be represented as a non-empty sequence of line pairs. The first line of the pair should contain either "Q:" or "A:" to differentiate between questions (branches) and answers (leaves). The second line of the pair should contain the text for that node (the *actual* question or answer).

The nodes of the tree should appear in *pre-order*. The `readTree` and `writeTree` methods from section will be *very helpful* for any method that deals with this format.

Full Example Walk-Through

questions.txt

```
Q:
Is it an animal?
Q:
Can it fly?
A:
bird
Q:
Does it have a tail?
A:
mouse
A:
spider
Q:
Does it have wheels?
A:
bicycle
Q:
Is it nice?
A:
TA
A:
teacher
```



The following output log shows one game being played on the above tree:

```
>> Welcome to the cse143 question program.
>>
>> Do you want to read in the previous tree? (y/n)? y
>>
>> Please think of an object for me to guess.
>> Is it an animal? (y/n)? n
>> Does it have wheels? (y/n)? y
>> Would your object happen to be bicycle? (y/n)? y
>> Great, I got it right!
>>
>> Do you want to go again? (y/n)? n
```

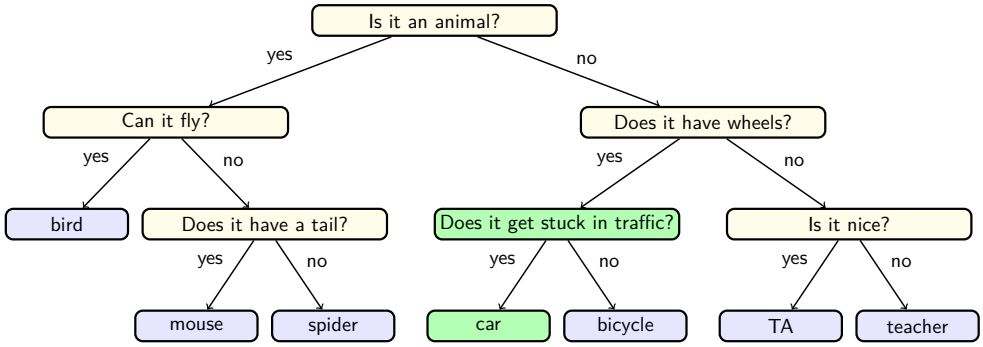
Initially, the computer is not very intelligent, but it grows smarter each time it loses a game. If the computer guesses incorrectly, it asks you to give it a new question to help in future games. For example, suppose in the preceding log that the player was thinking of a car instead. You might get this game log:

```
>> Welcome to the cse143 question program.
>>
>> Do you want to read in the previous tree? (y/n)? y
>>
>> Please think of an object for me to guess.
>> Is it an animal? (y/n)? n
>> Does it have wheels? (y/n)? y
>> Would your object happen to be bicycle? (y/n)? n
>> What is the name of your object? car
>> Please give me a yes/no question that
>> distinguishes between your object
>> and mine--> Does it get stuck in traffic?
>> And what is the answer for your object? (y/n)? y
>>
>> Do you want to go again? (y/n)? n
```

The computer takes the new information from a lost game and uses it to replace the old incorrect answer node with a new question node that has the old incorrect answer and new correct answer as its children. After the preceding log, the computer's overall game tree would be the following:

questions.txt

```
Q:
Is it an animal?
Q:
Can it fly?
A:
bird
Q:
Does it have a tail?
A:
mouse
A:
spider
Q:
Does it have wheels?
Q:
Does it get stuck in traffic?
A:
car
A:
bicycle
Q:
Is it nice?
A:
TA
A:
teacher
```



As usual, your output must match the output in the specification exactly. The output comparison tool will be helpful to make sure that your output is identical.

Note that `QuestionMain` will always read and write to a file named `questions.txt`. If you want to start with the tree from `spec-questions.txt` or `big-questions.txt`, then you should copy the contents of those files to a file named `questions.txt`. Be careful, since the program will write the tree to this file every time.

Development Strategy

We suggest that you develop the program in the following stages:

(1) Before you begin, you should "stub" the methods you intend to write. In other words, you want to be able to test using `QuestionMain`; so, you should provide "dummy" methods that do nothing for it to call.

(2) First, you should decide what fields belong in the `QuestionNode` and `QuestionsGame` classes. Once you've chosen the fields, you should implement the constructor for `QuestionsGame`.

(3) Next, you should implement `write` (because it's easier than loading them). Make sure to look back at `writeTree` from the section handout!

(4) Then, you should implement `read` which reads in a question tree. Make sure to look back at `readTree` from the section handout!

(5) Finally, you should implement `askQuestions`. At this point, you'll be able to play the game. When you play, you can add questions one by one and play with your game to check if it's working.

Style Guidelines and Grading

Part of your grade will come from appropriately utilizing binary trees and recursion to implement 20 questions as described previously. Every method with complex code flow should be implemented recursively, rather than with loops. A full-credit solution must have zero loops. We will also grade on the elegance of your recursive algorithm; don't create special cases in your recursive code if they are unnecessary.

`x = change(x)`

An important concept introduced in lecture was called `x = change(x)`. This idea is related to proper design of recursive methods that manipulate the structure of a binary tree. You must follow this pattern where necessary on this assignment to receive full credit.

For example, at the end of a game lost by the computer, you might be tempted to "morph" what used to be an answer node of the tree into a question node. This is considered bad style because question nodes and answer nodes are fundamentally different kinds of data. You can rearrange where nodes appear in the tree, but you shouldn't turn a answer node into a question node just to simplify the programming you need to perform.

Avoid Redundancy

Create "helper" method(s) to capture repeated code. As long as all extra methods you create are `private` (so outside code cannot call them), you can have additional methods in your class beyond those specified here. If you find that multiple methods in your class do similar things, you should create helper method(s) to capture the common code.

Data Fields

Properly encapsulate your objects by making your fields `private`. (You can and *should* make your fields in `QuestionNode` public.) Avoid unnecessary fields; use fields to store important data of your objects but not to store temporary values only used in one place. Fields should always be initialized inside a constructor or method, never at declaration.

Java Style Guidelines

Appropriately use control structures like loops and if/else statements. Avoid redundancy using techniques such as methods, loops, and factoring common code out of if/else statements. Properly use indentation, good variable names, and types. Do not have any lines of code longer than 100 characters. Please refer to the Style Guide and the General Style Deductions for a more complete list.