Advanced Algorithms and Data Structures

Lab 3: Binary Tree

Return to: Part 3: Trees

This lab will give you practice about basic binary tree processing.

Part 1: introduction to binary trees

In this part you have to write the basic methods inside the BinaryNode class. Check carefully this class and look at the provided height method. You are to complete the following methods:

- size: returns the number of non null node in the tree
- lowness: returns the lowness of the tree (i.e. the length of a *shortest* path from the root to a leaf)
- leaves: returns the number of leaves of the tree (remember that a leaf is a non null node with two null sub-tree)
- isomorphic: two binary trees are said to be isomorphic if they have exactly the same structure, no matter the elements they hold. Same structure means same number of nodes, and all nodes at the same place in both trees

For all these methods, you must give the worst case run time complexity.

Supporting files:

- BinaryNode.java
- TestBinaryNode.java

Part 2: more methods on binary trees

In this part you have to implement more algorithms on binary trees. All the methods to complete are still in the BinaryNode class.

A binary tree is said to be ***balanced*** if, for each of its sub-trees, the absolute value of the difference between the height of the left sub-tree and the height of the right sub-tree is at most 1. You are to complete the following method:

- balanced1: check if a binary tree is balanced. To write this method, you must use the height method

A binary tree is said to be ***shapely*** if, for each of its sub-trees, the height is less or equal than the double of the lowness. You are to complete the following method:

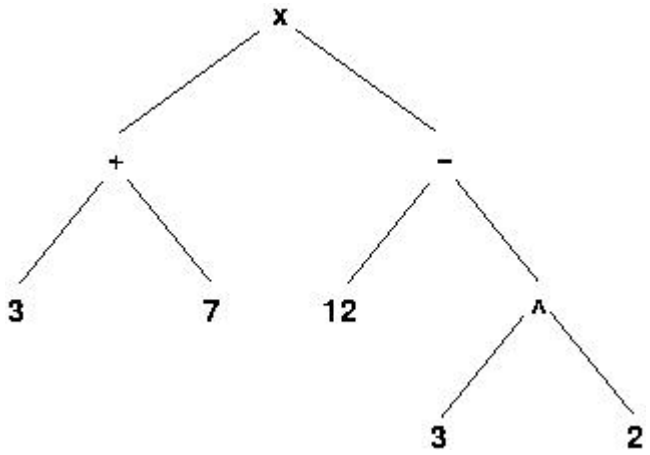
- shapely1: check if a binary search tree is shapely. To write this method, you must use the height and the lowness methods

What is the worst case complexity for the methods balanced1 and shapely1? Explain why and how we can improve this complexity. Finally, complete the following methods;

- balanced2: same as balanced1 but this new version does not use the method height
- shapely2: same as shapely1 but this new version does not use the methods height and lowness

Part 3: mathematical expression tree

A mathematical expression can be represented as a binary tree whose internal nodes (non leaf nodes) are operators and leaves are values. For example, the expression (3 + 7) x (12 - 3^2) can be implemented as the following binary tree:



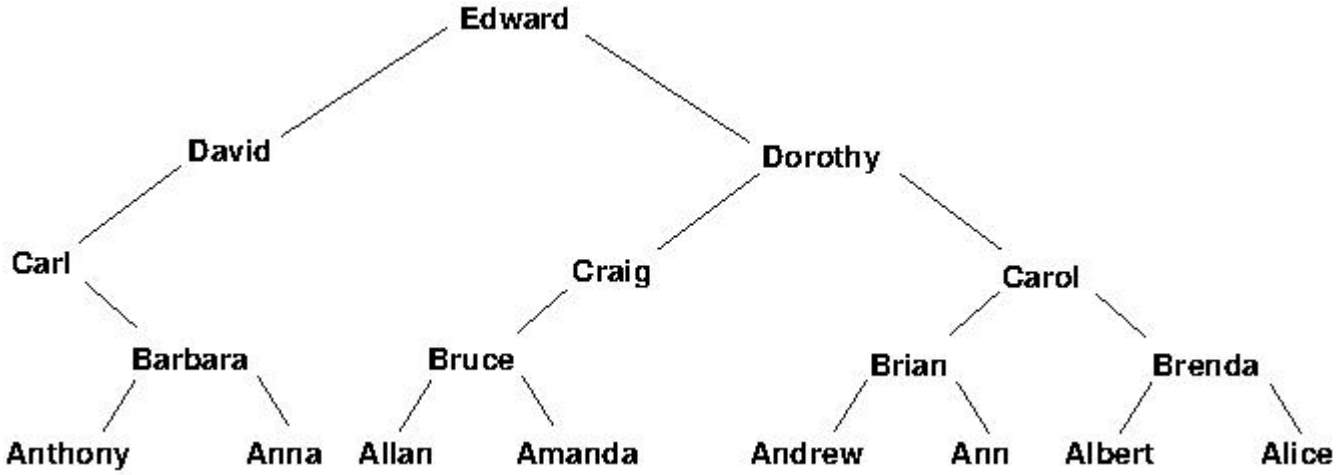
Complete the class ExpressionTree such that the method eval returns the result of evaluation of an expression tree. For example, if e is the ExpressionTree implementing the expression of the previous picture, e.eval() would return 30.

Supporting file:

- ExpressionTree.java

Part 4: genealogy tree

The *genealogy tree* of a person can be implemented by a binary tree: the root node holds the person's data (to simplify, we consider just the name of a person), the left sub-tree being the genealogy of her/his father and the right sub-tree the genealogy of her/his mother. For example, the following binary tree:



is the genealogy of Edward. The father of Edward is David and the mother of Edward is Dorothy. Carl and Craig are the two grand-fathers of Edward but for some reason Edward only knows about his grand-mother from his mother side, Carol. Using the class GenealogyTree, you are to complete the following methods:

- ancestors: returns the list of ancestors of the person at the root of the genealogy tree at a given level. For example, for the previous genealogy (the genealogy of Edward), the ancestors at level 2 (the grand-parents) are Carl, Craig and Carol.
- maleAncestors: same as ancestors but prints only the male ancestors. For example, for the previous genealogy (the genealogy of Edward), the male ancestors at level 2 (the grand-fathers) are Carl and Craig.
- displayGenerations: prints the ancestors line by line, each line being a generation. For example, for the previous genealogy (the genealogy of Edward), the result of displayGenerations should be:

```
Edward
  David Dorothy
  Carl Craig Carol
  Barbara Bruce Brian Brenda
  Anthony Anna Allan Amanda Andrew Ann Albert Alice
```

The complexity of displayGenerations must be *linear in the number of nodes* of the genealogy tree!
(Hint: you must use a queue and perform a breadth-first traversal of the tree)

Supporting file

- GenealogyTree.java

Supporting files

lab3.zip	4 September 2024, 4:07 PM

Submission status

Submission status	No attempt
Grading status	Not graded
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◀ Lesson 7: Binary Tree

Return to: Part 3: Trees