Red-Black Tree Using Java

Homework #8

By:

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CS 303L – L1A

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### Problem Specification

The objectives included implementing rotation methods, inserting elements in a Red-Black Tree (RBT), utilizing RBT to print elements in a sorted order, and using RBT in a real application; such as, UPC-random.csv and input.dat.

### Program Design

This program required the following: class RBNode, class RBTree, class Lab8 (driver program), io. File class, io. FileNotFoundException class, Scanner class, and Random class

The following steps were required to develop the program:

1. create a RBNode class to add a color field and a value field to each node
2. create a RBTree class to include the following methods: inOrderTreeWalk (), treeSearch (), leftRotate (), rightRotate (), RBInsert (), RBInsertFixup ()
3. create a driver program to test the RBTree class the driver to read through the UPC.csv and input.dat file
4. build a search tree using UPC.csv and input.dat file
5. test the program for the given search keys
6. print out the description associated with the search keys
7. print out the total time it takes to complete the search

The following constructors and methods were defined within the class:

1. RBNode ()

Basic method that adds color field and value field to each node.

b) inOrderTreeWalk ()

Basic method that walks the tree in order.

c) treeSearch ()

Basic method that returns the results of RB tree search.

d) leftRotate ()

Basic method that places x on y’s left.

d) rightRotate ()

Basic method that places x on y’s right.

e) RBInsert ()

Basic method that inserts a node in the RB tree.

f) RBInsertFixup ()

Basic method where the fix is dependent on whether or not y is black.

g) x (), y (), z (), root ()

Constructors in RBTree class that instantiate objects.

h) main ()

Driver method in Lab8 class.

i) tree (), input (), searchList (), UPC ()

Constructors in Lab8 class that instantiate objects.

The println method of the System.out object displays the inputs and results for the driver program.

### Testing Plan

The test plan involved building an RBT. The UPC-random.csv and input.dat files were used in order to search the program for the description associated with the given search keys and then the total time (in nanoseconds) was recorded.

|  |  |
| --- | --- |
| Total Time for Searching Tree (in nanoseconds): | 242502 |
| Input | **Output** |
| 79,,INDIANA LOTTO 93,,treo 700w 123,,Wrsi Riversound cafe cd 161,,Dillons/Kroger Employee Coupon ($1.25 credit) 2140000070,,Rhinestone Watch 2140118461,,"""V"": Breakout/The Deception  VHS Tape" 2144209103,VHS,Tintorera - Tiger Shark 2144622711,,Taxi : The Collector's Edition VHS 2147483647,,Toshiba 2805 DVD player 2158242769,288/1.12Z,GREEN SUGAR COOKIES4276 2158561631,,HOT COCOA W/BKMK 2158769549,njhjhn,gjfhjbgkj 2160500567,2.25 oz (64)g,Dollar Bar Rich Raspberry 2172307284,,Mixed seasonal flower bouquet 2177000074,,4 way 13 AMP Extension Lead (Wilkinson UK) 2184000098,21 oz,Christopher's Assorted Fruit Jellies 2187682888,,fairway | **INDIANA LOTTO treo 700w Wrsi Riversound cafe cd Dillons/Kroger Employee Coupon ($1.25 credit) Rhinestone Watch """V"": Breakout/The Deception VHS Tape" Tintorera - Tiger Shark Taxi : The Collector's Edition VHS Toshiba 2805 DVD player GREEN SUGAR COOKIES4276 HOT COCOA W/BKMK**  **gjfhjbgkj Dollar Bar Rich Raspberry Mixed seasonal flower bouquet 4 way 13 AMP Extension Lead (Wilkinson UK) Christopher's Assorted Fruit Jellies fairway** |

### Results

**Figure 1: Binary Search Tree (BST) Implementation in Java**

### Figure 2: Red-Black Tree (RBT) Implementation in Java

|  |  |
| --- | --- |
| Total Time for Building Tree (in nanoseconds): | 1655137807 |
| Total Time for Searching Tree(in nanoseconds): | 404006 |
| Input | **Output** |
| 79,,INDIANA LOTTO 93,,treo 700w 123,,Wrsi Riversound cafe cd 161,,Dillons/Kroger Employee Coupon ($1.25 credit) 2140000070,,Rhinestone Watch 2140118461,,"""V"": Breakout/The Deception  VHS Tape" 2144209103,VHS,Tintorera - Tiger Shark 2144622711,,Taxi : The Collector's Edition VHS 2147483647,,Toshiba 2805 DVD player 2158242769,288/1.12Z,GREEN SUGAR COOKIES4276 2158561631,,HOT COCOA W/BKMK 2158769549,njhjhn,gjfhjbgkj 2160500567,2.25 oz (64)g,Dollar Bar Rich Raspberry 2172307284,,Mixed seasonal flower bouquet 2177000074,,4 way 13 AMP Extension Lead (Wilkinson UK) 2184000098,21 oz,Christopher's Assorted Fruit Jellies 2187682888,,fairway | **INDIANA LOTTO treo 700w Wrsi Riversound cafe cd Dillons/Kroger Employee Coupon ($1.25 credit) Rhinestone Watch """V"": Breakout/The Deception VHS Tape" Tintorera - Tiger Shark Taxi : The Collector's Edition VHS Toshiba 2805 DVD player GREEN SUGAR COOKIES4276 HOT COCOA W/BKMK**  **gjfhjbgkj Dollar Bar Rich Raspberry Mixed seasonal flower bouquet 4 way 13 AMP Extension Lead (Wilkinson UK) Christopher's Assorted Fruit Jellies fairway** |

### Analysis and Conclusions

In this program, the input file UPC.csv provided a vast list of keys with corresponding descriptions. The comma-separated input.dat file contained the various search keys that needed to be found. The results section displayed the output of the description for each key mentioned in the input.dat file for BST (Figure 1) and RBT (Figure 2). The time for building an RB tree was 1,655,137,807 nanoseconds and the total time to search the RB tree was 404,006 nanoseconds. Meanwhile, searching the BST was relatively quicker since it only took 242,502 nanoseconds. The difference in time for BST and RBT might have been caused by using UPC.csv file for BST and UPC-random.csv file for RBT. The time complexity for building an RB tree was O (log2n). While, the time complexity for worst-case and average-case scenario for operations, such as, insertion and deletion for RBT was O (log2n). This type of tree search should be utilized when desiring a worst-case guarantee. The negative attribute of utilizing an RBT was that a significant amount of cases must be considered and the rotations involving those cases could get quite complicated.

### References

The parameters and input files (UPC.csv and input.dat) was provided in the homework assignment (by Dr. Bangalore) and Introduction to Algorithms (3rd ed.) was used to do the lab report.