Hashing: Linear Probing and Quadratic Probing

Homework #9

By:

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CS 303L – L1A

October 30, 2018

### Problem Specification

The objectives included implementing a hashing function, utilizing the hashing function to create a hashmap implementation, and using linear and quadratic probing methods, and then comparing the methods’ performance with Red-Black Trees.

### Program Design

This program required the following: class HashEntry, class HashMap, class HashMapTester (driver program), BufferedReader class, FileInputStream class, InputStreamReader class, Scanner class, input.dat file, and UPC.csv file.

The following steps were required to develop the program:

1. create a hashmap with the size set to 100
2. create put () method and get () method to insert key at appropriate index and obtain the value associated with the key
3. create linearProbingSearch () method and quadraticProbing() method to get the remainder
4. write a driver program to test the implementation of hashmap
5. use the hashmap implementation to store values from input.data and UPC.csv
6. print out the description associated with the search keys for linear probing and quadratic probing
7. print out the total time it takes to complete the search for linear probing and quadratic probing

The following constructors and methods were defined within the class:

1. HashEntry ()

Basic method that sets length of key and value.

b) getKey ()

Basic method that returns key.

c) getValue ()

Basic method that returns value.

d) setValue ()

Basic method that sets value.

e) value (), key ()

Constructors that instantiate value and key in HashEntry.java.

f) HashMap ()

Basic method that sets table size.

g) get ()

Basic method that returns remainder.

h) put ()

Basic method that returns collision.

i) linearProbing () and linearProbingSearch ()

Basic method that implements linear probing and basic method that returns table values.

j) quadraticProbing () and quadraticProbingSearch ()

Basic method that implements quadratic probing and basic method that returns the table values.

k) table[tableIndex]

Constructor that instantiates the values in table in HashMap.java.

l) tree (), input (), searchList (), UPC ()

Constructors in Lab8 class that instantiate objects.

m) basicTester ()

Basic method that tests linear probing and quadratic probing using superheroes.

n) fullComparision ()

Basic method that tests linear probing and quadratic probing using input.data and UPC.csv.

o) hashmap (), inputArray (), searchArray (), bufferedReader (), fileInput ()

Constructors that are used to instantiate objects in HashMapTester.java.

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

### Testing Plan

The test plan involved creating and searching hashtable using linear probing and quadratic probing. The UPC.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.

### Results

### Figure 1: 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** |

|  |  |
| --- | --- |
| Time to create using Linear Probing (in nanoseconds):  Time to search using Linear Probing (in nanoseconds):  Collisons: | 642846675  37645882  309692 |
| 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 | ***Found key 79: INDIANA LOTTO,***  ***Found key 93: treo 700w,  Found key 123: Wrsi Riversound cafe cd,  Found key 161: Dillons/Kroger Employee Coupon ($1.25 credit),  Found key 2140000070: Rhinestone Watch,  Found key 2140118461: """V"": Breakout/The Deception  VHS Tape",  Found key 2144209103: Tintorera - Tiger Shark, VHS Found key 2144622711: Taxi : The Collector's Edition VHS,  Found key 2147483647: Toshiba 2805 DVD player,  Found key 2158242769: GREEN SUGAR COOKIES4276, 288/1.12Z Found key 2158561631: HOT COCOA W/BKMK,  Found key 2158769549: gjfhjbgkj, njhjhn Found key 2160500567: Dollar Bar Rich Raspberry, 2.25 oz (64)g Found key 2172307284: Mixed seasonal flower bouquet,  Found key 2177000074: 4 way 13 AMP Extension Lead (Wilkinson UK),  Found key 2184000098: Christopher's Assorted Fruit Jellies, 21 oz Found key 2187682888: fairway*** |

### Figure 2: Linear Probing Implementation in Java

### Figure 3: Quadratic Probing Implementation in Java

|  |  |
| --- | --- |
| Time to create using Quadratic Probing (in nanoseconds):  Time to search using Quadratic robing (in nanoseconds):  Collisons: | 262306337  2958620  283765 |
| 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 | ***Found key 79: INDIANA LOTTO,***  ***Found key 93: treo 700w,  Found key 123: Wrsi Riversound cafe cd,  Found key 161: Dillons/Kroger Employee Coupon ($1.25 credit),  Found key 2140000070: Rhinestone Watch,  Found key 2140118461: """V"": Breakout/The Deception  VHS Tape",  Found key 2144209103: Tintorera - Tiger Shark, VHS Found key 2144622711: Taxi : The Collector's Edition VHS,  Found key 2147483647: Toshiba 2805 DVD player,  Found key 2158242769: GREEN SUGAR COOKIES4276, 288/1.12Z Found key 2158561631: HOT COCOA W/BKMK,  Found key 2158769549: gjfhjbgkj, njhjhn Found key 2160500567: Dollar Bar Rich Raspberry, 2.25 oz (64)g Found key 2172307284: Mixed seasonal flower bouquet,  Found key 2177000074: 4 way 13 AMP Extension Lead (Wilkinson UK),  Found key 2184000098: Christopher's Assorted Fruit Jellies, 21 oz Found key 2187682888: 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 Red-Black Trees (Figure 1) and hashtables (Figure 2, 3). 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. Hashtable was built using linear probing method (i.e. took 642,842,675 nanoseconds) and quadratic probing method (i.e. 262,306,337 nanoseconds). Quadratic probing method was more efficient at building a hashtable than the linear probing method. Quadratic probing was the quickest at searching for a key, while RBT was the slowest at searching for a key (Figure 1, 2, 3). There were also less collisions using the quadratic probing method than the linear probing method. The time complexity for worst-case and average-case scenario for operations, such as, insertion and deletion for RBT was O (log2n). The time complexity for searching and building for the two probing methods was O(n) since there was multiple collisions. In average- scenario, the time complexity would be O (1) for both probing methods.

### 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.