Implementing our Own Hash Table with Separate Chaining in Java

Difficulty Level : Medium • Last Updated : 15 May, 2021

All data structure has its own special characteristics, for example, a BST is used when quick searching of an element (in log(n)) is required. A heap or a priority queue is used when the minimum or maximum element needs to be fetched in constant time. Similarly, a hash table is used to fetch, add and remove an element in constant time. Anyone must be clear with the working of a hash table before moving on to the implementation aspect. So here is a brief background on the working of a hash table, and also it should be noted that we will be using Hash Map and Hash Table terminology interchangeably though in Java HashTables are thread-safe while HashMaps are not.

The code we are going to implement is available at Link 1 and Link2

But it is strongly recommended that one must read this blog completely and try and decipher the nitty-gritty of what goes into implementing a hash map and then try to write the code yourself.

Background

Every hash-table store data in the form of a (key, value) combination. Interestingly every key is unique in a Hash Table but values can repeat which means values can be the same for different keys present in it. Now as we observe in an array to fetch a value we provide the position/index corresponding to the value in that array. In a Hash Table, instead of an index, we use a key to fetch the value corresponding to that key. Now the entire process is described below

very time a key is generated. The key is passed to a hash function. Every hash function as two parts a **Hash code and a Compressor**.

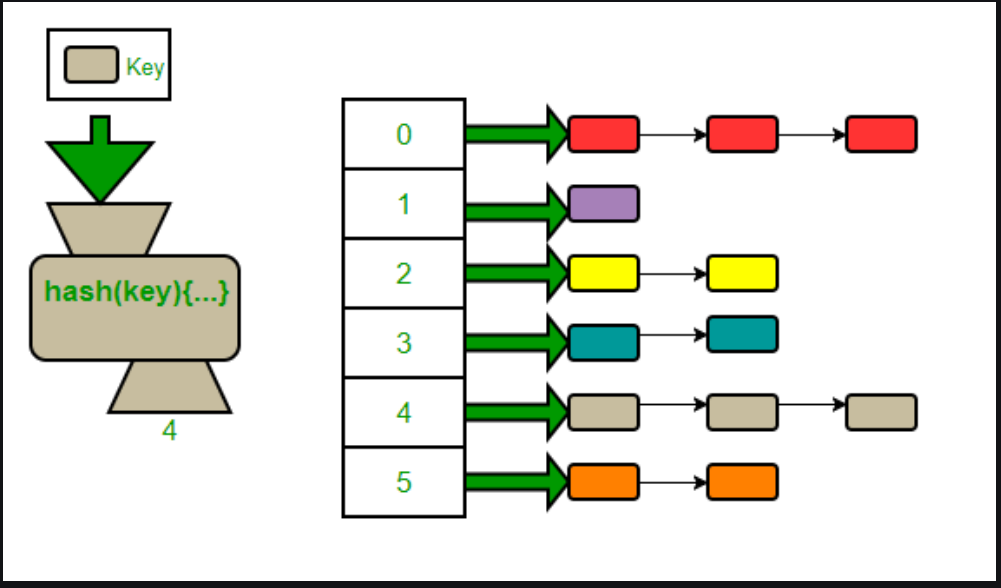
Hash code is an Integer number (random or non-random). In Java, every object has its own hash code. We will use the hash code generated by JVM in our hash function and compress the hash code we modulo(%) the hash code by the size of the hash table. *So modulo operator is* a *compressor in our implementation.*

The entire process ensures that for any key, we get an integer position within the size of the Hash Table to insert the corresponding value.

So the process is simple, the user gives a (key, value) pair set as input, and based on the value generated by the hash function an index is generated to where the value corresponding to the particular key is stored. So whenever we need to fetch a value corresponding to a key, that is just O(1).

This picture stops being so rosy and perfect when the concept of a hash collision is introduced. Imagine for different key values same block of the hash table is allocated now where do they previously store values corresponding to some other previous key go. We certainly can't replace it. That will be disastrous! To resolve this issue we will use the Separate Chaining Technique, Please note there are other open addressing techniques like double hashing and linear probing whose efficiency is almost the same as that of separate chaining, and you can read more about them at Link 1 Link 2 Link3

Now what we do is make a linked list corresponding to the particular bucket of the Hash Table, to accommodate all the values corresponding to different keys that map to the same bucket.



Now there may be a scenario that all the keys get mapped to the same bucket, and we have a linked list of n(size of the hash table) size from one single bucket, with all the other buckets empty and this is the worst case where a hash table acts a linked list and searching is O(n). So what do we do?

Load Factor

If n be the total number of buckets we decided to fill initially say 10 and let's say 7 of them got filled now, so the load factor is 7/10=0.7.

In our implementation whenever we add a key-value pair to the Hash Table we check the load factor if it is greater than 0.7 we double the size of our hash table.

Implementation

Hash Node Data Type

We will try to make a generic map without putting any restrictions on the data type of the key and the value. Also, every hash node needs to know the next node it is pointing to in the linked list so a next pointer is also required.

The functions we plan to keep in our hash map are

- **get(K key)** : returns the value corresponding to the key if the key is present in **HT** (**H**ast **T**able)
- **getSize()** : return the size of the HT
- **add()** : adds new valid key, value pair to the HT, if already present updates the value
- **remove()** : removes the key, value pair
- **isEmpty()** : returns true if size is zero

```
ArrayList<HashNode<K, V>> bucket = new ArrayList<>();
```

A **Helper Function** is implemented to get the index of the key, to avoid redundancy in other functions like get, add and remove. This function uses the inbuilt java function to generate a hash code, and we compress the hash code by the size of the HT so that the index is within the range of the size of the HT

get()

The get function just takes a key as an input and returns the corresponding value if the key is present in the table otherwise returns null. Steps are:

- Retrieve the input key to find the index in the HT
- Traverse the liked list corresponding to the HT if you find the value then return it else if you fully traverse the list without returning it means the value is not present in the table and can't be fetched so return null

remove()

- Fetch the index corresponding to the input key using the helper function
- The traversal of the linked list similar to in get() but what is special here is that one needs to remove the key along with finding it and two cases arise
- If the key to be removed is present at the head of the linked list
- If the key to be removed is not present at the head but somewhere else

add()

Now to the most interesting and challenging function of this entire implementation. It is interesting because we need to dynamically increase the size of our list when the load factor is above the value we specified.

- Just like remove steps till traversal and adding and two cases (addition at head spot or non-head spot) remain the same.
- Towards the end, if the load factor is greater than 0.7
- We double the size of the array list and then recursively call add function on existing keys because in our case hash value generated uses the size of the array to compress the inbuilt JVM hash code we use, so we need to fetch new indices for the existing keys. This is very important to understand please re-read this paragraph till you get a hang of what is happening in the add function.

Java does in its own implementation of Hash Table uses Binary Search Tree if linked list corresponding to a particular bucket tend to get too long.

Java

```
// Java program to demonstrate implementation of our
// own hash table with chaining for collision detection
import java.util.ArrayList;
import java.util.Objects;

// A node of chains
class HashNode<K, V> {
    K key;
    V value;
      final int hashCode;

    // Reference to next node
    HashNode<K, V> next;

    // Constructor
    public HashNode(K key, V value, int hashCode)
    {
        this.key = key;
        this.value = value;
```

```
            this.hashCode = hashCode;
        }
    }

    // Class to represent entire hash table
    class Map<K, V> {
        // bucketArray is used to store array of chains
        private ArrayList<HashNode<K, V> > bucketArray;

        // Current capacity of array list
        private int numBuckets;

        // Current size of array list
        private int size;

        // Constructor (Initializes capacity, size and
        // empty chains.
        public Map()
        {
            bucketArray = new ArrayList<>();
            numBuckets = 10;
            size = 0;

            // Create empty chains
            for (int i = 0; i < numBuckets; i++)
                bucketArray.add(null);
        }

        public int size() { return size; }
        public boolean isEmpty() { return size() == 0; }

          private final int hashCode (K key) {
            return Objects.hashCode(key);
        }

        // This implements hash function to find index
        // for a key
        private int getBucketIndex(K key)
        {
            int hashCode = hashCode(key);
            int index = hashCode % numBuckets;
            // key.hashCode() coule be negative.
            index = index < 0 ? index * -1 : index;
            return index;
        }

        // Method to remove a given key
        public V remove(K key)
        {
            // Apply hash function to find index for given key
            int bucketIndex = getBucketIndex(key);
            int hashCode = hashCode(key);
            // Get head of chain
            HashNode<K, V> head = bucketArray.get(bucketIndex);

            // Search for key in its chain
            HashNode<K, V> prev = null;
```

```
        while (head != null) {
            // If Key found
            if (head.key.equals(key) && hashCode == head.hashCode)
                break;

            // Else keep moving in chain
            prev = head;
            head = head.next;
        }

        // If key was not there
        if (head == null)
            return null;

        // Reduce size
        size--;

        // Remove key
        if (prev != null)
            prev.next = head.next;
        else
            bucketArray.set(bucketIndex, head.next);

        return head.value;
    }

    // Returns value for a key
    public V get(K key)
    {
        // Find head of chain for given key
        int bucketIndex = getBucketIndex(key);
          int hashCode = hashCode(key);

        HashNode<K, V> head = bucketArray.get(bucketIndex);

        // Search key in chain
        while (head != null) {
            if (head.key.equals(key) && head.hashCode == hashCode)
                return head.value;
            head = head.next;
        }

        // If key not found
        return null;
    }

    // Adds a key value pair to hash
    public void add(K key, V value)
    {
        // Find head of chain for given key
        int bucketIndex = getBucketIndex(key);
          int hashCode = hashCode(key);
        HashNode<K, V> head = bucketArray.get(bucketIndex);

        // Check if key is already present
        while (head != null) {
            if (head.key.equals(key) && head.hashCode == hashCode) {
```

```
                head.value = value;
                return;
            }
            head = head.next;
        }

        // Insert key in chain
        size++;
        head = bucketArray.get(bucketIndex);
        HashNode<K, V> newNode
            = new HashNode<K, V>(key, value, hashCode);
        newNode.next = head;
        bucketArray.set(bucketIndex, newNode);

        // If load factor goes beyond threshold, then
        // double hash table size
        if ((1.0 * size) / numBuckets >= 0.7) {
            ArrayList<HashNode<K, V> > temp = bucketArray;
            bucketArray = new ArrayList<>();
            numBuckets = 2 * numBuckets;
            size = 0;
            for (int i = 0; i < numBuckets; i++)
                bucketArray.add(null);

            for (HashNode<K, V> headNode : temp) {
                while (headNode != null) {
                    add(headNode.key, headNode.value);
                    headNode = headNode.next;
                }
            }
        }
    }

    // Driver method to test Map class
    public static void main(String[] args)
    {
        Map<String, Integer> map = new Map<>();
        map.add("this", 1);
        map.add("coder", 2);
        map.add("this", 4);
        map.add("hi", 5);
        System.out.println(map.size());
        System.out.println(map.remove("this"));
        System.out.println(map.remove("this"));
        System.out.println(map.size());
        System.out.println(map.isEmpty());
    }
}
```

The entire code is available at https://github.com/ishaan007/Data-Structures/blob/master/HashMaps/Map.java