How HashMap works in Java

HashMap in Java works on hashing principle. It is a data structure which allows us to store object and retrieve it in constant time `O(1)` provided we know the key. In hashing, hash functions are used to link key and value in HashMap. Objects are stored by calling `put(key, value)` method of HashMap and retrieved by calling `get(key)` method. When we call put method, hashcode() method of key object is called so that hash function of map can find a bucket location to store value object, which is actually index of internal array, known as table. HashMap internally store mapping in form of Map.Entry object which contains both key and value object. When you want to retrieve the object, you call get() method and again pass key object. This time again key object generate same hash code (it's mandatory for it to do so to retrieve object and that's why HashMap keys are immutable e.g. String) and we end up at same bucket location. If there is only one object then it is returned and that's your value object which you have stored earlier. Things get little tricky when collisions occurs. Since internal array of HashMap is of fixed size, and if you keep storing objects, at some point of time hash function will return same bucket location for two different keys, this is called collision in HashMap. In this case, a linked list is formed at that bucket location and new entry is stored as next node. If we try to retrieve object from this linked list, we need an extra check to search correct value, this is done by equals() method. Since each node contains an entry, HashMap keep comparing entry's key object with passed key using equals() and when it return true, Map returns corresponding value. Since searching in lined list is O(n) operation, in worst case hash collision reduce a map to linked list. This issue is recently addressed in Java 8 by replacing linked list to tree to search in `O(logN)` time. By the way, you can easily verify how HashMap work by looking at code of `HashMap.java` in your Eclipse IDE, if you know how to attach source code of JDK in Eclipse.

How HashMap works in Java or sometime how get method work in HashMap is a very common question on Java interviews now days. Almost everybody who worked in Java knows about HashMap, where to use HashMap and difference between Hashtable and

HashMap then why this interview question becomes so special? Because of the depth it offers. It has become very popular Java interview question in almost any senior or mid-senior level Java interviews. Investment banks mostly prefer to ask this question and some time even ask you to implement your own HashMap based upon your coding aptitude. Introduction of ConcurrentHashMap and other concurrent collections has also made this questions as starting point to delve into more advanced feature. let's start the journey.

How HashMap Internally Works in Java

Questions start with simple statement :

Have you used HashMap before or **What is HashMap? Why do you use it**
Almost everybody answers this with yes and then interviewee keep talking about common facts about HashMap like HashMap accept null while Hashtable doesn't, HashMap is not synchronized, `HashMap` is fast and so on along with basics like its stores key and value pairs etc. This shows that person has used HashMap and quite familiar with the functionality it offers, but interview takes a sharp turn from here and next set of follow-up questions gets more detailed about fundamentals involved with HashMap in Java . Interviewer strike back with questions like :

Do you Know how HashMap works in Java or **How does get () method of HashMap works in Java**
And then you get answers like, I don't bother its standard Java API, you better look code on Java source or Open JDK; I can find it out in Google at any time etc. But some interviewee definitely answer this and will say **HashMap works on principle of hashing**, we have `put(key, value)` and `get(key)` method for storing and retrieving Objectsfrom HashMap. When we pass Key and Value object to `put()` method on Java HashMap, HashMap implementation calls hashCode method on Key object and applies returned hashcode into its own hashing function to find a bucket location for storing Entry object, important point to mention is that HashMap in Java stores both key and value object as`Map.Entry` in bucket which is essential to understand the retrieving logic. If people fails to recognize this and say it

only stores Value in the bucket they will fail to explain the retrieving logic of any object stored in Java HashMap . This answer is very much acceptable and does make sense that interviewee has fair bit of knowledge on how hashing works and how HashMap works in Java. But this is just start of story and confusion increases when you put interviewee on scenarios faced by Java developers on day by day basis. Next question could be about collision detection and collision resolution in Java HashMap e.g.

What will happen if two different objects have same hashcode?

Now from here onwards real confusion starts, Some time candidate will say that since hashcode is equal, both objects are equal and HashMap will throw exception or not store them again etc, Then you might want to remind them about equals() and hashCode() contract that two unequal object in Java can have same hash code. Some will give up at this point and few will move ahead and say "Since hashcode is same, bucket location would be same and collision will occur in HashMap,
Since `HashMap` use LinkedList to store object, this entry (object of `Map.Entry` comprise key and value) will be stored inLinkedList. Great this answer make sense though there are many collision resolution methods available like linear probing and chaining, this is simplest and HashMap in Java does follow this. But story does not end here and interviewer asks

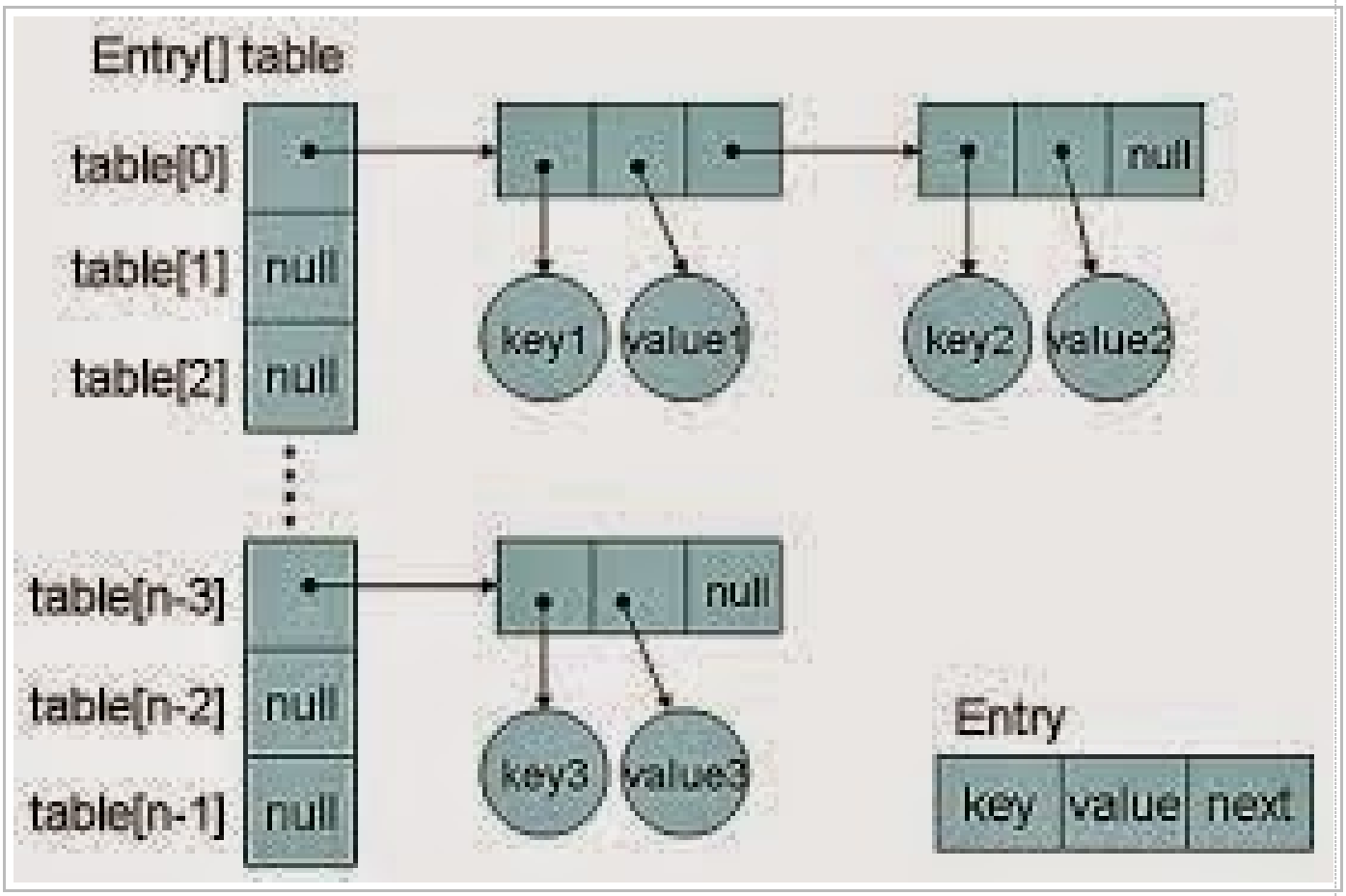
How will you retrieve Value object if two Keys will have same hashcode?

Interviewee will say we will call `get()` method and then HashMap uses Key Object's hashcode to find out bucket location and retrieves Value object but then you need to remind him that there are two Value objects are stored in same bucket , so they will say about traversal in LinkedList until we find the value object , then you ask *how do you identify value object because you don't have value object to compare* ,Until they know that HashMap stores both Key and Value in`LinkedList` node or as `Map.Entry` they won't be able to resolve this issue and will try and fail.

But those bunch of people who remember this key information will say that after finding bucket location , we will **call keys.equals() method** to identify correct node in

LinkedList and return associated value object for that key in Java HashMap . Perfect this is the correct answer.

In many cases interviewee fails at this stage because they get confused betweenhashCode() and equals() or keys and values object in Java HashMap which is pretty obvious because they are dealing with the `hashcode()` in all previous questions and `equals()` come in picture only in case of retrieving value object from HashMap in Java. Some good developer point out here that using immutable, final object with proper `equals()` and`hashcode()` implementation would act as perfect Java HashMap keys and **improve performance of Java HashMap by reducing collision**. Immutability *also allows caching there hashcode of different keys* which makes overall retrieval process very fast and suggest that String and various wrapper classes e.g. Integer very good keys in Java HashMap.



Now if you clear this entire Java HashMap interview, You will be surprised by this very interesting question "**What happens On HashMap in Java if the size of the HashMap exceeds a given threshold defined by load factor ?**". Until you know how HashMap works exactly you won't be able to answer this question. If the size of the Map exceeds

a given threshold defined by load-factor e.g. if load factor is `.75` it will act to re-size the map once it filled 75%. Similar to other collection classes like ArrayList, Java HashMap re-size itself by creating a new bucket array of size twice of previous size of HashMap , and then start putting every old element into that new bucket array. This process is called`rehashing` because it also applies hash function to find new bucket location.

If you manage to answer this question on HashMap in Java you will be greeted by **"do you see any problem with resizing of HashMap in Java"** , you might not be able to pick the context and then he will try to give you hint about multiple thread accessing the Java`HashMap` and potentially looking for **race condition on HashMap in Java**.

So the answer is Yes there is potential race condition exists while resizing `HashMap` in Java, if two thread at the same time found that now `HashMap` needs resizing and they both try to resizing. on the process of resizing of `HashMap` in Java , the element in bucket which is stored in linked list get reversed in order during there migration to new bucket because Java HashMap doesn't append the new element at tail instead it append new element at head *to avoid tail traversing*. If race condition happens then you will end up with an infinite loop. Though this point you can potentially argue that what the hell makes you think to use HashMap in multi-threaded environment to interviewer :)

Some more Hashtable and HashMap Questions

Few more question on HashMap in Java which is contributed by readers of Javarevisited blog :

1) Why String, Integer and other wrapper classes are considered good keys ?
`String`, `Integer` and other wrapper classes are natural candidates of `HashMap` key, and`String` is most frequently used key as well because String is immutable and final,and overrides `equals` and `hashcode()` method. Other wrapper class also shares similar property. Immutabiility is required, in order to prevent changes on fields used to calculate`hashCode()` because if key object return different hashCode during

insertion and retrieval than it won't be possible to get object from `HashMap`. Immutability is best as it offers other advantages as well like thread-safety, If you can keep your hashCode same by only making certain fields final, then you go for that as well. Since `equals()` and`hashCode()` method is used during reterival of value object from `HashMap`, its important that key object correctly override these methods and follow contact. If unequal object return different hashcode than chances of collision will be less which subsequently improve performance of HashMap.

2) Can we use any custom object as key in HashMap ?
This is an extension of previous questions. Ofcourse you can use any `Object` as key in Java`HashMap` provided it follows `equals and hashCode contract` and its hashCode should not vary once the object is inserted into Map. If custom object is Immutable than this will be already taken care because you can not change it once created.

3) Can we use ConcurrentHashMap in place of Hashtable ?
This is another question which getting popular due to increasing popularity ofConcurrentHashMap. Since we know Hashtable is synchronized but ConcurrentHashMapprovides better concurrency by only locking portion of map determined by concurrency level. ConcurrentHashMap is certainly introduced as Hashtable and can be used in place of it but Hashtable provide stronger thread-safety than ConcurrentHashMap. See my postdifference between Hashtable and ConcurrentHashMap for more details.

Personally, I like this question because of its depth and number of concept it touches indirectly, if you look at questions asked during interview this HashMap questions has verified

- Concept of hashing
- Collision resolution in HashMap
- Use of equals () and hashCode () and there importance in HashMap?
- Benefit of immutable object?
- Race condition on HashMap in Java
- Resizing of Java HashMap

Just to summarize here are the answers which does makes sense for above questions

How HashMap works in Java

HashMap works on principle of hashing, we have `put()` and `get()` method for storing and retrieving object form HashMap .When we pass an both key and value to put() method to store on HashMap , it uses key object hashcode() method to calculate hashcode and they by applying hashing on that hashcode it identifies bucket location for storing value object. While retrieving it uses key object equals method to find out correct key value pair and return value object associated with that key. HashMap uses linked list in case of collision and object will be stored in next node of linked list. Also HashMap stores both key and value tuple in every node of linked list in form of Map.Entry object.

What will happen if two different HashMap key objects have same hashcode?

They will be stored in same bucket but no next node of linked list. And keys equals () method will be used to identify correct key value pair in HashMap .

How null key is handled in HashMap? Since equals() and hashCode() are used to store and retrieve values, how does it work in case of null key?

Null key is handled specially in HashMap, there are two separate method for that`putForNullKey(V value)` and `getForNullKey()`. Later is offloaded version of get() to look up null keys. Null keys always map to index 0. This null case is split out into separate methods for the sake of performance in the two most commonly used operations (get and put), but incorporated with conditionals in others. In short, `equals()` and`hashcode()` method are not used in case of null keys in HashMap.

here is how nulls are retreived from HashMap

```
private V getForNullKey() {

        if (size == 0) {
            return null;
        }
        for (Entry<K,V> e = table[0]; e != null; e = e.next) {
            if (e.key == null)
                return e.value;
```

```
        }
        return null;
    }
```

In terms of usage Java HashMap is very versatile and I have mostly used HashMap as cache in electronic trading application I have worked . Since finance domain used Java heavily and due to performance reason we need
caching HashMap and ConcurrentHashMap comes as very handy there. You can also check following articles form Javarevisited to learn more about HashMap and Hashtable in Java :

HashMap Changes in JDK 1.7 and JDK 1.8

There is some performance improvement done on HashMap and ArrayList from JDK 1.7, which reduce memory consumption. Due to this empty Map are lazily initialized and will cost you less memory. Earlier, when you create HashMap e.g. new HashMap() it automatically creates array of default length e.g. 16. After some research, Java team founds that most of this Map are temporary and never use that many elements, and only end up wasting memory. Also, From JDK 1.8 onwards HashMap has introduced an improved strategy to deal with high collision rate. Since a poor hash function e.g. which always return location of same bucket, can turn a HashMap into linked list, i.e. converting get() method to perform in O(n) instead of O(1) and someone can take advantage of this fact, Java now internally replace linked list to a binary true once certain threshold is breached. This ensures performance or order O(log(n)) even in worst case where hash function is not distributing keys properly.