
Java Map Interface

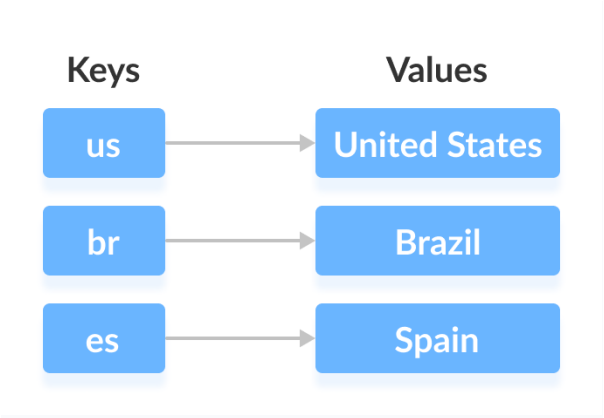
In this tutorial, we will learn about the Java Map interface and its methods.

The `Map` interface of the Java collections framework provides the functionality of the map data structure.

Working of Map

In Java, elements of `Map` are stored in **key/value** pairs. **Keys** are unique values associated with individual **Values**.

A map cannot contain duplicate keys. And, each key is associated with a single value.



We can access and modify values using the keys associated with them.

In the above diagram, we have values: `United States`, `Brazil`, and `Spain`. And we have corresponding keys: `us`, `br`, and `es`.

Now, we can access those values using their corresponding keys.

Note: The `Map` interface maintains 3 different sets:

- the set of keys
- the set of values
- the set of key/value associations (mapping).

Hence we can access keys, values, and associations individually.

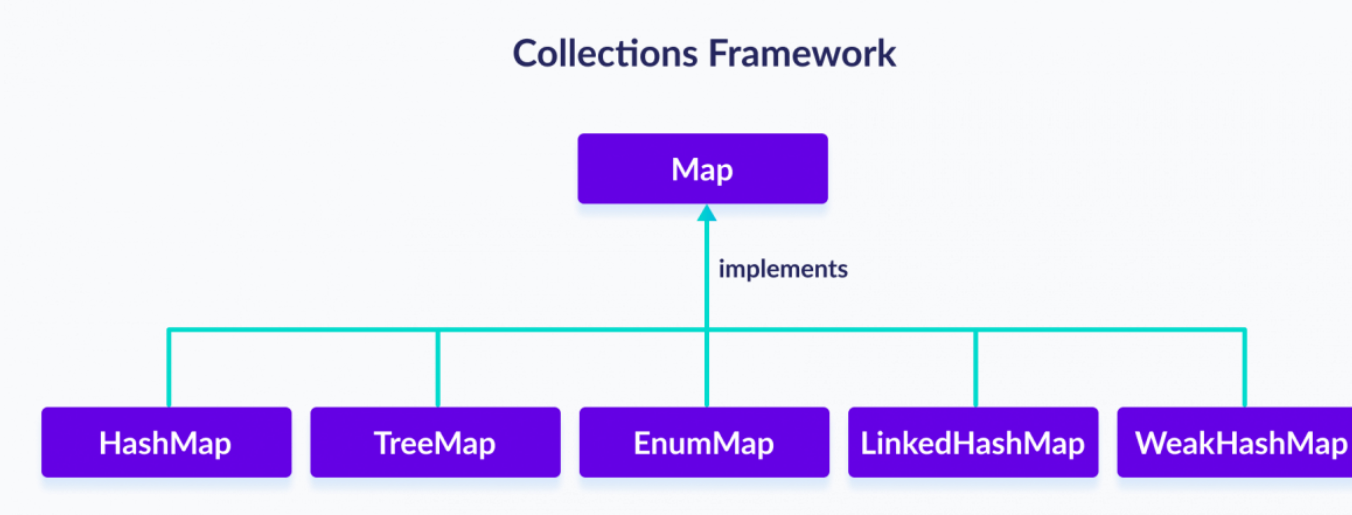
Classes that implement Map

Since `Map` is an interface, we cannot create objects from it.

In order to use functionalities of the `Map` interface, we can use these classes:

- HashMap
- EnumMap
- LinkedHashMap
- WeakHashMap
- TreeMap

These classes are defined in the collections framework and implement the `Map` interface.

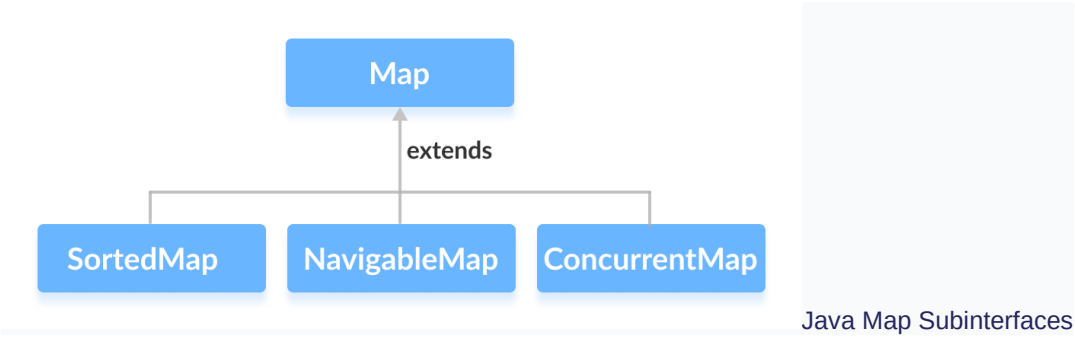


Java Map Subclasses

Interfaces that extend Map

The `Map` interface is also extended by these subinterfaces:

- SortedMap
- NavigableMap
- ConcurrentMap



Java Map Subinterfaces

How to use Map?

In Java, we must import the `java.util.Map` package in order to use `Map`. Once we import the package, here's how we can create a map.

```
// Map implementation using HashMap

Map<Key, Value> numbers = new HashMap<>();
```

In the above code, we have created a `Map` named `numbers`. We have used the `HashMap` class to implement the `Map` interface.

Here,

- `Key` - a unique identifier used to associate each element (value) in a map
- `Value` - elements associated by keys in a map

Methods of Map

The `Map` interface includes all the methods of the `Collection` interface. It is because `Collection` is a super interface of `Map`.

Besides methods available in the `Collection` interface, the `Map` interface also includes the following methods:

- **put(K, V)** - Inserts the association of a key `K` and a value `V` into the map. If the key is already present, the new value replaces the old value.
- **putAll()** - Inserts all the entries from the specified map to this map.

- **putIfAbsent(K, V)** - Inserts the association if the key `K` is not already associated with the value `V`.
- **get(K)** - Returns the value associated with the specified key `K`. If the key is not found, it returns `null`.
- **getOrDefault(K, defaultValue)** - Returns the value associated with the specified key `K`. If the key is not found, it returns the `defaultValue`.
- **containsKey(K)** - Checks if the specified key `K` is present in the map or not.
- **containsValue(V)** - Checks if the specified value `V` is present in the map or not.
- **replace(K, V)** - Replace the value of the key `K` with the new specified value `V`.
- **replace(K, oldValue, newValue)** - Replaces the value of the key `K` with the new value `newValue` only if the key `K` is associated with the value `oldValue`.
- **remove(K)** - Removes the entry from the map represented by the key `K`.
- **remove(K, V)** - Removes the entry from the map that has key `K` associated with value `V`.
- **keySet()** - Returns a set of all the keys present in a map.
- **values()** - Returns a set of all the values present in a map.
- **entrySet()** - Returns a set of all the key/value mapping present in a map.

Implementation of the Map Interface

1. Implementing HashMap Class

```
import java.util.Map;import java.util.HashMap;

class Main {



    public static void main(String[] args) {

        // Creating a map using the HashMap

        Map<String, Integer> numbers = new HashMap<>();



        // Insert elements to the map

        numbers.put("One", 1);
```

```
        numbers.put("Two", 2);
        System.out.println("Map: " + numbers);

        // Access keys of the map
        System.out.println("Keys: " + numbers.keySet());

        // Access values of the map
        System.out.println("Values: " + numbers.values());

        // Access entries of the map
        System.out.println("Entries: " + numbers.entrySet());

        // Remove Elements from the map
        int value = numbers.remove("Two");
        System.out.println("Removed Value: " + value);
    }
}
```

Output

```
Map: {One=1, Two=2}
Keys: [One, Two]
Values: [1, 2]
Entries: [One=1, Two=2]
Removed Value: 2
```

To learn more about `HashMap`, visit Java HashMap.

---

2. Implementing TreeMap Class

```
import java.util.Map;import java.util.TreeMap;
class Main {
```

```
    public static void main(String[] args) {
        // Creating Map using TreeMap
        Map<String, Integer> values = new TreeMap<>();

        // Insert elements to map
        values.put("Second", 2);
        values.put("First", 1);
        System.out.println("Map using TreeMap: " + values);

        // Replacing the values
        values.replace("First", 11);
        values.replace("Second", 22);
        System.out.println("New Map: " + values);

        // Remove elements from the map
        int removedValue = values.remove("First");
        System.out.println("Removed Value: " + removedValue);
    }
}
```

Output

```
Map using TreeMap: {First=1, Second=2}
New Map: {First=11, Second=22}
Removed Value: 11
```

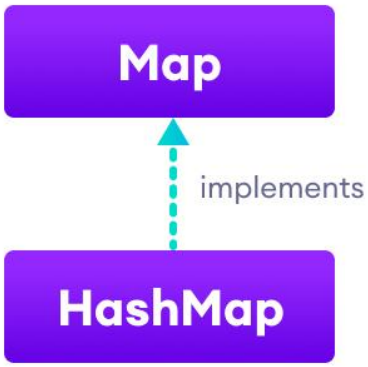
Java HashMap

In this tutorial, we will learn about the Java HashMap class and its various operations with the help of examples.

The `HashMap` class of the Java collections framework provides the functionality of the hash table data structure.

It stores elements in **key/value** pairs. Here, **keys** are unique identifiers used to associate each **value** on a map.

The `HashMap` class implements the Map interface.



Java HashMap Implementation

Create a HashMap

In order to create a hash map, we must import the `java.util.HashMap` package first. Once we import the package, here is how we can create hashmaps in Java.

```
// hashMap creation with 8 capacity and 0.6 load factor

HashMap<K, V> numbers = new HashMap<>();
```

In the above code, we have created a hashmap named `numbers`. Here, **K** represents the key type and **V** represents the type of values. For example,

```
HashMap<String, Integer> numbers = new HashMap<>();
```

Here, the type of **keys** is `String` and the type of **values** is `Integer`.

Example 1: Create HashMap in Java

```
import java.util.HashMap;

class Main {

  public static void main(String[] args) {


    // create a hashmap

    HashMap<String, Integer> languages = new HashMap<>();


    // add elements to hashmap

    languages.put("Java", 8);

    languages.put("JavaScript", 1);

    languages.put("Python", 3);

    System.out.println("HashMap: " + languages);

  }

}
```

Output

```
HashMap: {Java=8, JavaScript=1, Python=3}
```

In the above example, we have created a `HashMap` named `languages`.

Here, we have used the `put()` method to add elements to the hashmap. We will learn more about the `put()` method later in this tutorial.

Basic Operations on Java HashMap

The `HashMap` class provides various methods to perform different operations on hashmaps. We will look at some commonly used arraylist operations in this tutorial:

- Add elements
- Access elements
- Change elements
- Remove elements

---

1. Add elements to a HashMap

To add a single element to the hashmap, we use the `put()` method of the `HashMap` class. For example,

```
import java.util.HashMap;

class Main {

  public static void main(String[] args) {


    // create a hashmap

    HashMap<String, Integer> numbers = new HashMap<>();


    System.out.println("Initial HashMap: " + numbers);

    // put() method to add elements

    numbers.put("One", 1);

    numbers.put("Two", 2);

    numbers.put("Three", 3);

    System.out.println("HashMap after put(): " + numbers);

  }

}
```

Output

```
Initial HashMap: {}

HashMap after put(): {One=1, Two=2, Three=3}
```

In the above example, we have created a `HashMap` named `numbers`. Here, we have used the `put()` method to add elements to numbers.

Notice the statement,

```
numbers.put("One", 1);
```

Here, we are passing the `String` value `One` as the key and `Integer` value `1` as the value to the `put()` method.

Recommended Readings

- Java HashMap put()
- Java HashMap putAll()
- Java HashMap putIfAbsent()

---

2. Access HashMap Elements

We can use the `get()` method to access the value from the hashmap. For example,

```
import java.util.HashMap;

class Main {

  public static void main(String[] args) {


    HashMap<Integer, String> languages = new HashMap<>();

    languages.put(1, "Java");

    languages.put(2, "Python");

    languages.put(3, "JavaScript");

    System.out.println("HashMap: " + languages);


    // get() method to get value

    String value = languages.get(1);

    System.out.println("Value at index 1: " + value);

  }

}
```

Output

```
HashMap: {1=Java, 2=Python, 3=JavaScript}

Value at index 1: Java
```

In the above example, notice the expression,

```
languages.get(1);
```

Here, the `get()` method takes the **key** as its argument and returns the corresponding **value** associated with the key.

We can also access the **keys**, **values**, and **key/value** pairs of the hashmap as set views using `keySet()`, `values()`, and `entrySet()` methods respectively. For example,

```
import java.util.HashMap;

class Main {

  public static void main(String[] args) {

    HashMap<Integer, String> languages = new HashMap<>();


    languages.put(1, "Java");

    languages.put(2, "Python");

    languages.put(3, "JavaScript");

    System.out.println("HashMap: " + languages);


    // return set view of keys

    // using keySet()

    System.out.println("Keys: " + languages.keySet());


    // return set view of values

    // using values()

    System.out.println("Values: " + languages.values());


    // return set view of key/value pairs

    // using entrySet()

    System.out.println("Key/Value mappings: " + languages.entrySet());

  }

}
```

Output

```
HashMap: {1=Java, 2=Python, 3=JavaScript}
```

```
Keys: [1, 2, 3]

Values: [Java, Python, JavaScript]

Key/Value mappings: [1=Java, 2=Python, 3=JavaScript]
```

In the above example, we have created a hashmap named `languages`. Here, we are accessing the **keys**, **values**, and **key/value** mappings from the hashmap.

Recommended Readings

- Java HashMap get()
- Java Hashmap getOrDefault()
- Java HashMap keySet()
- Java HashMap values()
- Java HashMap entrySet()

---

3. Change HashMap Value

We can use the `replace()` method to change the value associated with a key in a hashmap. For example,

```
import java.util.HashMap;

class Main {

  public static void main(String[] args) {


    HashMap<Integer, String> languages = new HashMap<>();

    languages.put(1, "Java");

    languages.put(2, "Python");

    languages.put(3, "JavaScript");

    System.out.println("Original HashMap: " + languages);


    // change element with key 2

    languages.replace(2, "C++");

    System.out.println("HashMap using replace(): " + languages);
```

```
  }
}
```

Output

```
Original HashMap: {1=Java, 2=Python, 3=JavaScript}

HashMap using replace(): {1=Java, 2=C++, 3=JavaScript}
```

In the above example, we have created a hashmap named `languages`. Notice the expression,

```
languages.replace(2, "C++");
```

Here, we are changing the value referred to by key **2** with the new value `C++`.

The `HashMap` class also provides some variations of the `replace()` method. To learn more, visit

- Java HashMap replace()
- Java HashMap replaceAll()

---

4. Remove HashMap Elements

To remove elements from a hashmap, we can use the remove() method. For example,

```
import java.util.HashMap;

class Main {

  public static void main(String[] args) {


    HashMap<Integer, String> languages = new HashMap<>();

    languages.put(1, "Java");

    languages.put(2, "Python");

    languages.put(3, "JavaScript");

    System.out.println("HashMap: " + languages);


    // remove element associated with key 2
```

```
    String value = languages.remove(2);
    System.out.println("Removed value: " + value);


    System.out.println("Updated HashMap: " + languages);
  }
}
```

Output

```
HashMap: {1=Java, 2=Python, 3=JavaScript}
Removed value: Python
Updated HashMap: {1=Java, 3=JavaScript}
```

Here, the `remove()` method takes the **key** as its parameter. It then returns the **value** associated with the **key** and removes the **entry**.

We can also remove the entry only under certain conditions. For example,

```
remove(2, "C++");
```

Here, the `remove()` method only removes the **entry** if the **key 2** is associated with the **value C++**. Since **2** is not associated with **C++**, it doesn't remove the entry.

To learn more, visit Java HashMap remove().

Other Methods of HashMap

Method	Description
clear()	removes all mappings from the `HashMap`
compute()	computes a new value for the specified key
computeIfAbsent()	computes value if a mapping for the key is not present
computeIfPresent()	computes a value for mapping if the key is present

---

merge()	merges the specified mapping to the `HashMap`
clone()	makes the copy of the `HashMap`
containsKey()	checks if the specified key is present in Hashmap
containsValue()	checks if `Hashmap` contains the specified value
size()	returns the number of items in `HashMap`
isEmpty()	checks if the `Hashmap` is empty

Iterate through a HashMap

To iterate through each entry of the hashmap, we can use Java for-each loop. We can iterate through **keys only**, **vales only**, and **key/value mapping**. For example,

```
import java.util.HashMap;import java.util.Map.Entry;

class Main {

  public static void main(String[] args) {


    // create a HashMap

    HashMap<Integer, String> languages = new HashMap<>();

    languages.put(1, "Java");

    languages.put(2, "Python");

    languages.put(3, "JavaScript");

    System.out.println("HashMap: " + languages);


    // iterate through keys only

    System.out.print("Keys: ");

    for (Integer key : languages.keySet()) {

      System.out.print(key);

      System.out.print(", ");

    }
```

```
    // iterate through values only
    System.out.print("\nValues: ");
    for (String value : languages.values()) {
      System.out.print(value);
      System.out.print(", ");
    }

    // iterate through key/value entries
    System.out.print("\nEntries: ");
    for (Entry<Integer, String> entry : languages.entrySet()) {
      System.out.print(entry);
      System.out.print(", ");
    }
  }
}
```

Output

```
HashMap: {1=Java, 2=Python, 3=JavaScript}
Keys: 1, 2, 3,
Values: Java, Python, JavaScript,
Entries: 1=Java, 2=Python, 3=JavaScript,
```

Note that we have used the `Map.Entry` in the above example. It is the nested class of the `Map` interface that returns a view (elements) of the map.

We first need to import the `java.util.Map.Entry` package in order to use this class.

This nested class returns a view (elements) of the map.

Creating HashMap from Other Maps

In Java, we can also create a hashmap from other maps. For example,

---

```
import java.util.HashMap;import java.util.TreeMap;

class Main {

  public static void main(String[] args) {


    // create a treemap

    TreeMap<String, Integer> evenNumbers = new TreeMap<>();

    evenNumbers.put("Two", 2);

    evenNumbers.put("Four", 4);

    System.out.println("TreeMap: " + evenNumbers);


    // create hashmap from the treemap

    HashMap<String, Integer> numbers = new HashMap<>(evenNumbers);

    numbers.put("Three", 3);

    System.out.println("HashMap: " + numbers);

  }

}
```

Output

```
TreeMap: {Four=4, Two=2}

HashMap: {Two=2, Three=3, Four=4}
```

In the above example, we have created a `TreeMap` named `evenNumbers`. Notice the expression,

```
numbers = new HashMap<>(evenNumbers)
```

Here, we are creating a `HashMap` named numbers using the `TreeMap`. To learn more about treemap, visit Java TreeMap.

Note: While creating a hashmap, we can include optional parameters: **capacity** and **load factor**. For example,

```
HashMap<K, V> numbers = new HashMap<>(8, 0.6f);
```

Here,

- **8** (capacity is 8) - This means it can store 8 entries.
- **0.6f** (load factor is 0.6) - This means whenever our hash table is filled by 60%, the entries are moved to a new hash table double the size of the original hash table.

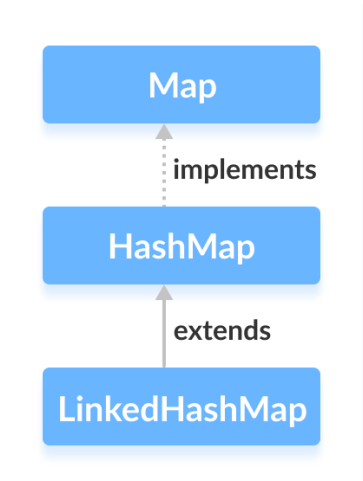
If the optional parameters not used, then the default **capacity** will be **16** and the default **load factor** will be **0.75**.

Java LinkedHashMap

In this tutorial, we will learn about the Java LinkedHashMap class and its operations with the help of examples.

The `LinkedHashMap` class of the Java collections framework provides the hash table and linked list implementation of the Map interface.

The `LinkedHashMap` interface extends the HashMap class to store its entries in a hash table. It internally maintains a doubly-linked list among all of its entries to order its entries.



Creating a LinkedHashMap

In order to create a linked hashmap, we must import the `java.util.LinkedHashMap` package first. Once we import the package, here is how we can create linked hashmaps in Java.

```
// LinkedHashMap with initial capacity 8 and load factor 0.6

LinkedHashMap<Key, Value> numbers = new LinkedHashMap<>(8, 0.6f);
```

In the above code, we have created a linked hashmap named `numbers`.

Here,

- `Key` - a unique identifier used to associate each element (value) in a map
- `Value` - elements associated by the keys in a map

Notice the part `new LinkedHashMap<>(8, 0.6)`. Here, the first parameter is **capacity** and the second parameter is **loadFactor**.

- **capacity** - The capacity of this linked hashmap is 8. Meaning, it can store 8 entries.
- **loadFactor** - The load factor of this linked hashmap is 0.6. This means, whenever our hash map is filled by 60%, the entries are moved to a new hash table of double the size of the original hash table.

Default capacity and load factor

It's possible to create a linked hashmap without defining its capacity and load factor. For example,

```
//LinkedHashMap with default capacity and load factor

LinkedHashMap<Key, Value> numbers1 = new LinkedHashMap<>();
```

By default,

- the capacity of the linked hashmap will be 16
- the load factor will be 0.75

Note: The `LinkedHashMap` class also allows us to define the order of its entries. For example

```
// LinkedHashMap with specified order

LinkedHashMap<Key, Value> numbers2 = new LinkedHashMap<>(capacity, loadFactor, accessOrder);
```

Here, `accessOrder` is a boolean value. Its default value is `false`. In this case entries in the linked hashmap are ordered on the basis of their insertion order.

However, if `true` is passed as `accessOrder`, entries in the linked hashmap will be ordered from least-recently accessed to most-recently accessed.

Creating LinkedHashMap from Other Maps

Here is how we can create a linked hashmap containing all the elements of other maps.

```
import java.util.LinkedHashMap;

class Main {

    public static void main(String[] args) {

        // Creating a LinkedHashMap of even numbers

        LinkedHashMap<String, Integer> evenNumbers = new LinkedHashMap<>();

        evenNumbers.put("Two", 2);

        evenNumbers.put("Four", 4);

        System.out.println("LinkedHashMap1: " + evenNumbers);


        // Creating a LinkedHashMap from other LinkedHashMap

        LinkedHashMap<String, Integer> numbers = new LinkedHashMap<>(evenNumbers);

        numbers.put("Three", 3);

        System.out.println("LinkedHashMap2: " + numbers);

    }

}
```

Output

```
LinkedHashMap1: {Two=2, Four=4}

LinkedHashMap2: {Two=2, Four=4, Three=3}
```

Methods of LinkedHashMap

The `LinkedHashMap` class provides methods that allow us to perform various operations on the map.

Insert Elements to LinkedHashMap

- `put()` - inserts the specified key/value mapping to the map
- `putAll()` - inserts all the entries from the specified map to this map
- `putIfAbsent()` - inserts the specified key/value mapping to the map if the specified key is not present in the map

For example,

```
import java.util.LinkedHashMap;

class Main {

    public static void main(String[] args) {

        // Creating LinkedHashMap of even numbers

        LinkedHashMap<String, Integer> evenNumbers = new LinkedHashMap<>();


        // Using put()

        evenNumbers.put("Two", 2);

        evenNumbers.put("Four", 4);

        System.out.println("Original LinkedHashMap: " + evenNumbers);


        // Using putIfAbsent()

        evenNumbers.putIfAbsent("Six", 6);

        System.out.println("Updated LinkedHashMap(): " + evenNumbers);


        //Creating LinkedHashMap of numbers

        LinkedHashMap<String, Integer> numbers = new LinkedHashMap<>();

        numbers.put("One", 1);


        // Using putAll()
```

```
        numbers.putAll(evenNumbers);

        System.out.println("New LinkedHashMap: " + numbers);

    }

}
```

Output

```
Original LinkedHashMap: {Two=2, Four=4}

Updated LinkedHashMap: {Two=2, Four=4, Six=6}

New LinkedHashMap: {One=1, Two=2, Four=4, Six=6}
```

Access LinkedHashMap Elements

1. Using entrySet(), keySet() and values()

- `entrySet()` - returns a set of all the key/value mapping of the map
- `keySet()` - returns a set of all the keys of the map
- `values()` - returns a set of all the values of the map

For example,

```
import java.util.LinkedHashMap;

class Main {

    public static void main(String[] args) {

        LinkedHashMap<String, Integer> numbers = new LinkedHashMap<>();


        numbers.put("One", 1);

        numbers.put("Two", 2);

        numbers.put("Three", 3);

        System.out.println("LinkedHashMap: " + numbers);


        // Using entrySet()

        System.out.println("Key/Value mappings: " + numbers.entrySet());
```

```
        // Using keySet()
        System.out.println("Keys: " + numbers.keySet());

        // Using values()
        System.out.println("Values: " + numbers.values());
    }
}
```

Output

```
LinkedHashMap: {One=1, Two=2, Three=3}
Key/Value mappings: [One=1, Two=2, Three=3]
Keys: [One, Two, Three]
Values: [1, 2, 3]
```

2. Using get() and getOrDefault()

- `get()` - Returns the value associated with the specified key. If the key is not found, it returns `null`.
- `getOrDefault()` - Returns the value associated with the specified key. If the key is not found, it returns the specified default value.

For example,

```
import java.util.LinkedHashMap;
class Main {
    public static void main(String[] args) {

        LinkedHashMap<String, Integer> numbers = new LinkedHashMap<>();
        numbers.put("One", 1);
        numbers.put("Two", 2);
        numbers.put("Three", 3);
        System.out.println("LinkedHashMap: " + numbers);

        // Using get()
```

```
        int value1 = numbers.get("Three");
        System.out.println("Returned Number: " + value1);


        // Using getOrDefault()
        int value2 = numbers.getOrDefault("Five", 5);
        System.out.println("Returned Number: " + value2);
    }
}
```

Output

```
LinkedHashMap: {One=1, Two=2, Three=3}
Returned Number: 3
Returned Number: 5
```

Removed LinkedHashMap Elements

- `remove(key)` - returns and removes the entry associated with the specified `key` from the map
- `remove(key, value)` - removes the entry from the map only if the specified `key` mapped to be the specified `value` and return a boolean value

For example,

```
import java.util.LinkedHashMap;
class Main {
    public static void main(String[] args) {


        LinkedHashMap<String, Integer> numbers = new LinkedHashMap<>();
        numbers.put("One", 1);
        numbers.put("Two", 2);
        numbers.put("Three", 3);
        System.out.println("LinkedHashMap: " + numbers);
```

```
        // remove method with single parameter
        int value = numbers.remove("Two");
        System.out.println("Removed value: " + value);

        // remove method with two parameters
        boolean result = numbers.remove("Three", 3);
        System.out.println("Is the entry Three removed? " + result);

        System.out.println("Updated LinkedHashMap: " + numbers);
    }
}
```

Output

```
LinkedHashMap: {One=1, Two=2, Three=3}
Removed value: 2
Is the entry {Three=3} removed? True
Updated LinkedHashMap: {One=1}
```

Other Methods of LinkedHashMap

Method	Description
`clear()`	removes all the entries from the map
`containsKey()`	checks if the map contains the specified key and returns a boolean value
`containsValue()`	checks if the map contains the specified value and returns a boolean value
`size()`	returns the size of the map

`isEmpty()`	checks if the map is empty and returns a boolean value

LinkedHashMap Vs. HashMap

Both the `LinkedHashMap` and the `HashMap` implements the `Map` interface. However, there exist some differences between them.

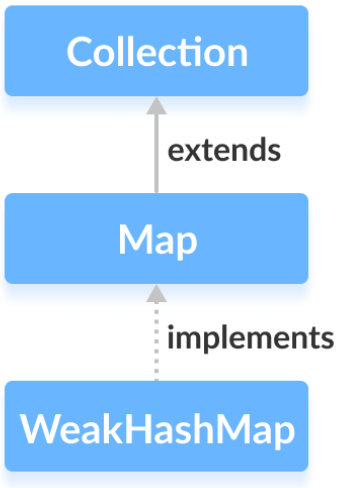
- `LinkedHashMap` maintains a doubly-linked list internally. Due to this, it maintains the insertion order of its elements.
- The `LinkedHashMap` class requires more storage than `HashMap`. This is because `LinkedHashMap` maintains linked lists internally.
- The performance of `LinkedHashMap` is slower than `HashMap`.

Java WeakHashMap

In this tutorial, we will learn about Java WeakHashMap and its operations with the help of examples. We will also learn about the differences between WeakHashMap and HashMap

The `WeakHashMap` class of the Java collections framework provides the feature of the hash table data structure..

It implements the Map interface.



> **Note**: Keys of the weak hashmap are of the **WeakReference** type.

The object of a weak reference type can be garbage collected in Java if the reference is no longer used in the program.

Let us learn to create a weak hash map first. Then, we will learn how it differs from a hashmap.

Create a WeakHashMap

In order to create a weak hashmap, we must import the `java.util.WeakHashMap` package first. Once we import the package, here is how we can create weak hashmaps in Java.

```
//WeakHashMap creation with capacity 8 and load factor 0.6

WeakHashMap<Key, Value> numbers = new WeakHashMap<>(8, 0.6);
```

In the above code, we have created a weak hashmap named `numbers`.

Here,

- `Key` - a unique identifier used to associate each element (value) in a map
- `Value` - elements associated by keys in a map

Notice the part `new WeakHashMap<>(8, 0.6)`. Here, the first parameter is **capacity** and the second parameter is **loadFactor**.

- **capacity** - The capacity of this map is 8. Meaning, it can store 8 entries.
- **loadFactor** - The load factor of this map is 0.6. This means whenever our hash table is filled by 60%, the entries are moved to a new hash table of double the size of the original hash table.

Default capacity and load factor

It is possible to create a weak hashmap without defining its capacity and load factor. For example,

```
// WeakHashMap with default capacity and load factor

WeakHashMap<Key, Value> numbers1 = new WeakHashMap<>();
```

By default,

- the capacity of the map will be 16
- the load factor will be 0.75

Differences Between HashMap and WeakHashMap

Let us see the implementation of a weak hashmap in Java.

```
import java.util.WeakHashMap;

class Main {

    public static void main(String[] args) {

        // Creating WeakHashMap of numbers

        WeakHashMap<String, Integer> numbers = new WeakHashMap<>();


        String two = new String("Two");

        Integer twoValue = 2;

        String four = new String("Four");

        Integer fourValue = 4;


        // Inserting elements

        numbers.put(two, twoValue);
```

```
        numbers.put(four, fourValue);
        System.out.println("WeakHashMap: " + numbers);

        // Make the reference null
        two = null;

        // Perform garbage collection
        System.gc();

        System.out.println("WeakHashMap after garbage collection: " + numbers);
    }
}
```

Output

```
WeakHashMap: {Four=4, Two=2}
WeakHashMap after garbage collection: {Four}
```

As we can see, when the key `two` of a weak hashmap is set to `null` and perform garbage collection, the key is removed.

It is because unlike hashmaps, keys of weak hashmaps are of **weak reference** type. This means the entry of a map are removed by the garbage collector if the key to that entry is no longer used. This is useful to save resources.

Now let us see the same implementation in a hashmap.

```
import java.util.HashMap;
class Main {
    public static void main(String[] args) {
        // Creating HashMap of even numbers
        HashMap<String, Integer> numbers = new HashMap<>();

        String two = new String("Two");
        Integer twoValue = 2;
        String four = new String("Four");
```

```
        Integer fourValue = 4;


        // Inserting elements
        numbers.put(two, twoValue);
        numbers.put(four, fourValue);
        System.out.println("HashMap: " + numbers);


        // Make the reference null
        two = null;


        // Perform garbage collection
        System.gc();


        System.out.println("HashMap after garbage collection: " + numbers);
    }
}
```

Output

```
HashMap: {Four=4, Two=2}
HashMap after garbage collection: {Four=4, Two=2}
```

Here, when the key `two` of the hashmap is set to `null` and perform garbage collection, the key is not removed.

This is because unlike weak hashmaps keys of hashmaps are of **strong reference** type. This means the entry of a map is not removed by the garbage collector even though the key to that entry is no longer used.

> **Note**: All functionalities of hashmaps and weak hashmaps are similar except keys of a weak hashmap are of weak reference, whereas keys of a hashmap are of strong reference.

Creating WeakHashMap from Other Maps

Here is how we can create a weak hashmap from other maps.

```
import java.util.HashMap;import java.util.WeakHashMap;

class Main {

    public static void main(String[] args) {

        // Creating a hashmap of even numbers

        HashMap<String, Integer> evenNumbers = new HashMap<>();


        String two = new String("Two");

        Integer twoValue = 2;

        evenNumbers.put(two, twoValue);

        System.out.println("HashMap: " + evenNumbers);


        // Creating a weak hash map from other hashmap

        WeakHashMap<String, Integer> numbers = new WeakHashMap<>(evenNumbers);


        System.out.println("WeakHashMap: " + numbers);

    }

}
```

Output

```
HashMap: {Two=2}

WeakHashMap: {Two=2}
```

Methods of WeakHashMap

The `WeakHashMap` class provides methods that allow us to perform various operations on the map.

Insert Elements to WeakHashMap

- `put()` - inserts the specified key/value mapping to the map
- `putAll()` - inserts all the entries from specified map to this map
- `putIfAbsent()` - inserts the specified key/value mapping to the map if the specified key is not present in the map

For example,

```
import java.util.WeakHashMap;

class Main {

    public static void main(String[] args) {

        // Creating WeakHashMap of even numbers

        WeakHashMap<String, Integer> evenNumbers = new WeakHashMap<>();


        String two = new String("Two");

        Integer twoValue = 2;


        // Using put()

        evenNumbers.put(two, twoValue);


        String four = new String("Four");

        Integer fourValue = 4;


        // Using putIfAbsent()

        evenNumbers.putIfAbsent(four, fourValue);

        System.out.println("WeakHashMap of even numbers: " + evenNumbers);


        //Creating WeakHashMap of numbers

        WeakHashMap<String, Integer> numbers = new WeakHashMap<>();


        String one = new String("One");
```

```
        Integer oneValue = 1;
        numbers.put(one, oneValue);

        // Using putAll()
        numbers.putAll(evenNumbers);
        System.out.println("WeakHashMap of numbers: " + numbers);
    }
}
```

Output

```
WeakHashMap of even numbers: {Four=4, Two=2}
WeakHashMap of numbers: {Two=2, Four=4, One=1}
```

Access WeakHashMap Elements

1. Using entrySet(), keySet() and values()

- `entrySet()` - returns a set of all the key/value mapping of the map
- `keySet()` - returns a set of all the keys of the map
- `values()` - returns a set of all the values of the map

For example,

```
import java.util.WeakHashMap;
class Main {
    public static void main(String[] args) {
        // Creating WeakHashMap of even numbers
        WeakHashMap<String, Integer> numbers = new WeakHashMap<>();

        String one = new String("One");
        Integer oneValue = 1;
        numbers.put(one, oneValue);
```

```
        String two = new String("Two");
        Integer twoValue = 2;
        numbers.put(two, twoValue);

        System.out.println("WeakHashMap: " + numbers);

        // Using entrySet()
        System.out.println("Key/Value mappings: " + numbers.entrySet());

        // Using keySet()
        System.out.println("Keys: " + numbers.keySet());

        // Using values()
        System.out.println("Values: " + numbers.values());
    }
}
```

Output

```
WeakHashMap: {Two=2, One=1}
Key/Value mappings: [Two=2, One=1]
Keys: [Two, One]
Values: [1, 2]
```

2. Using get() and getOrDefault()

- `get()` - Returns the value associated with the specified key. Returns `null` if the key is not found.
- `getOrDefault()` - Returns the value associated with the specified key. Returns the specified default value if the key is not found.

For example,

```
import java.util.WeakHashMap;
class Main {
```

```
    public static void main(String[] args) {

        // Creating WeakHashMap of even numbers

        WeakHashMap<String, Integer> numbers = new WeakHashMap<>();


        String one = new String("One");

        Integer oneValue = 1;

        numbers.put(one, oneValue);


        String two = new String("Two");

        Integer twoValue = 2;

        numbers.put(two, twoValue);


        System.out.println("WeakHashMap: " + numbers);


        // Using get()

        int value1 = numbers.get("Two");

        System.out.println("Using get(): " + value1);


        // Using getOrDefault()

        int value2 = numbers.getOrDefault("Four", 4);

        System.out.println("Using getOrDefault(): " + value2);


    }
}
```

Output

```
WeakHashMap: {Two=2, One=1}

Using get(): 2

Using getOrDefault(): 4
```

Remove WeakHashMap Elements

- `remove(key)` - returns and removes the entry associated with the specified key from the map
- `remove(key, value)` - removes the entry from the map only if the specified key mapped to the specified value and return a boolean value

For example,

```
import java.util.WeakHashMap;

class Main {

    public static void main(String[] args) {

        // Creating WeakHashMap of even numbers

        WeakHashMap<String, Integer> numbers = new WeakHashMap<>();


        String one = new String("One");

        Integer oneValue = 1;

        numbers.put(one, oneValue);


        String two = new String("Two");

        Integer twoValue = 2;

        numbers.put(two, twoValue);


        System.out.println("WeakHashMap: " + numbers);


        // Using remove() with single parameter

        int value = numbers.remove("Two");

        System.out.println("Removed value: " + value);


        // Using remove() with 2 parameters

        boolean result = numbers.remove("One", 3);

        System.out.println("Is the entry {One=3} removed? " + result);


        System.out.println("Updated WeakHashMap: " + numbers);
```

```
    }
}
```

Output

```
WeakHashMap: {Two=2, One=1}
Removed value: 2
Is the entry {One=3} removed? False
Updated WeakHashMap: {One=1}
```

Other Methods of WeakHashMap

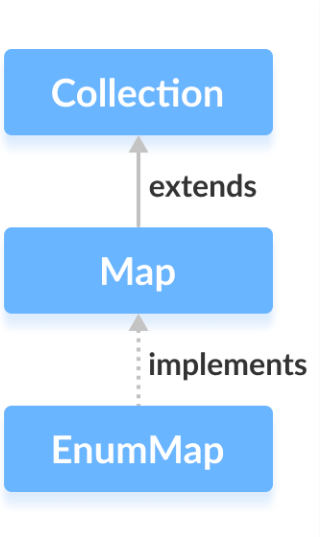
Method	Description
`clear()`	Removes all the entries from the map
`containsKey()`	Checks if the map contains the specified key and returns a boolean value
`containsValue()`	Checks if the map contains the specified value and returns a boolean value
`size()`	Returns the size of the map
`isEmpty()`	Checks if the map is empty and returns a boolean value

Java EnumMap

In this tutorial, we will learn about the Java EnumMap class and its operations with the help of examples.

The `EnumMap` class of the Java collections framework provides a map implementation for elements of an enum.

In `EnumMap`, enum elements are used as **keys**. It implements the Map interface.



Before we learn about `EnumMap`, make sure to know about the Java Enums.

Creating an EnumMap

In order to create an enum map, we must import the `java.util.EnumMap` package first. Once we import the package, here is how we can create enum maps in Java.

```
enum Size {

    SMALL, MEDIUM, LARGE, EXTRALARGE

}


EnumMap<Size, Integer> sizes = new EnumMap<>(Size.class);
```

In the above example, we have created an enum map named `sizes`.

Here,

- `Size` - **keys** of the enum that map to values
- `Integer` - **values** of the enum map associated with the corresponding keys

---

Methods of EnumMap

The `EnumMap` class provides methods that allow us to perform various elements on the enum maps.

Insert Elements to EnumMap

- `put()` - inserts the specified key/value mapping (entry) to the enum map
- `putAll()` - inserts all the entries of a specified map to this map

For example,

```
import java.util.EnumMap;

class Main {


    enum Size {

        SMALL, MEDIUM, LARGE, EXTRALARGE

    }

    public static void main(String[] args) {


        // Creating an EnumMap of the Size enum

        EnumMap<Size, Integer> sizes1 = new EnumMap<>(Size.class);


        // Using the put() Method

        sizes1.put(Size.SMALL, 28);

        sizes1.put(Size.MEDIUM, 32);

        System.out.println("EnumMap1: " + sizes1);


        EnumMap<Size, Integer> sizes2 = new EnumMap<>(Size.class);


        // Using the putAll() Method
```

```
        sizes2.putAll(sizes1);

        sizes2.put(Size.LARGE, 36);

        System.out.println("EnumMap2: " + sizes2);

    }

}
```

Output

```
EnumMap1: {SMALL=28, MEDIUM=32}

EnumMap2: {SMALL=28, MEDIUM=32, LARGE=36}
```

In the above example, we have used the `putAll()` method to insert all the elements of an enum map `sizes1` to an enum map of `sizes2`.

It is also possible to insert elements from other maps such as `HashMap`, `TreeMap`, etc. to an enum map using `putAll()`. However, all maps should be of the same enum type.

Access EnumMap Elements

1. Using entrySet(), keySet() and values()

- `entrySet()` - returns a set of all the keys/values mapping (entry) of an enum map
- `keySet()` - returns a set of all the keys of an enum map
- `values()` - returns a set of all the values of an enum map

For example,

```
import java.util.EnumMap;

class Main {


    enum Size {

        SMALL, MEDIUM, LARGE, EXTRALARGE

    }

    public static void main(String[] args) {
```

```
        // Creating an EnumMap of the Size enum
        EnumMap<Size, Integer> sizes = new EnumMap<>(Size.class);
        sizes.put(Size.SMALL, 28);
        sizes.put(Size.MEDIUM, 32);
        sizes.put(Size.LARGE, 36);
        sizes.put(Size.EXTRALARGE, 40);
        System.out.println("EnumMap: " + sizes);

        // Using the entrySet() Method
        System.out.println("Key/Value mappings: " + sizes.entrySet());

        // Using the keySet() Method
        System.out.println("Keys: " + sizes.keySet());

        // Using the values() Method
        System.out.println("Values: " + sizes.values());
    }
}
```

Output

```
EnumMap: {SMALL=28, MEDIUM=32, LARGE=36, EXTRALARGE=40}
Key/Value mappings: [SMALL=28, MEDIUM=32, LARGE=36, EXTRALARGE=40]
Keys: [SMALL, MEDIUM, LARGE, EXTRALARGE]
Values: [28, 32, 36, 40]
```

2. Using the get() Method

The `get()` method returns the value associated with the specified key. It returns `null` if the specified key is not found.

For example,

```
import java.util.EnumMap;
class Main {
```

```
    enum Size {

        SMALL, MEDIUM, LARGE, EXTRALARGE

    }

    public static void main(String[] args) {



        // Creating an EnumMap of the Size enum

        EnumMap<Size, Integer> sizes = new EnumMap<>(Size.class);

        sizes.put(Size.SMALL, 28);

        sizes.put(Size.MEDIUM, 32);

        sizes.put(Size.LARGE, 36);

        sizes.put(Size.EXTRALARGE, 40);

        System.out.println("EnumMap: " + sizes);



        // Using the get() Method

        int value = sizes.get(Size.MEDIUM);

        System.out.println("Value of MEDIUM: " + value);

    }

}
```

Output

```
EnumMap: {SMALL=28, MEDIUM=32, LARGE=36, EXTRALARGE=40}

Value of MEDIUM: 32
```

Remove EnumMap Elements

- `remove(key)` - returns and removes the entry associated with the specified key from the map
- `remove(key, value)` - removes the entry from the map only if the specified key mapped to the specified value and return a boolean value

For example,

```
import java.util.EnumMap;

class Main {


    enum Size {

        SMALL, MEDIUM, LARGE, EXTRALARGE

    }

    public static void main(String[] args) {


        // Creating an EnumMap of the Size enum

        EnumMap<Size, Integer> sizes = new EnumMap<>(Size.class);

        sizes.put(Size.SMALL, 28);

        sizes.put(Size.MEDIUM, 32);

        sizes.put(Size.LARGE, 36);

        sizes.put(Size.EXTRALARGE, 40);

        System.out.println("EnumMap: " + sizes);


        // Using the remove() Method

        int value = sizes.remove(Size.MEDIUM);

        System.out.println("Removed Value: " + value);


        boolean result = sizes.remove(Size.SMALL, 28);

        System.out.println("Is the entry {SMALL=28} removed? " + result);


        System.out.println("Updated EnumMap: " + sizes);

    }

}
```

Output

```
EnumMap: {SMALL=28, MEDIUM=32, LARGE=36, EXTRALARGE=40}

Removed Value: 32

Is the entry {SMALL=28} removed? True
```

```
Updated EnumMap: {LARGE=36, EXTRALARGE=40}
```

Replace EnumMap Elements

- `replace(key, value)` - replaces the value associated with the specified `key` by the new `value`
- `replace(key, old, new)` - replaces the `old` value with the `new` value only if the `old` value is already associated with the specified `key`
- `replaceAll(function)` - replaces each value of the map with the result of the specified `function`

```
import java.util.EnumMap;

class Main {


    enum Size {

        SMALL, MEDIUM, LARGE, EXTRALARGE

    }

    public static void main(String[] args) {


        // Creating an EnumMap of the Size enum

        EnumMap<Size, Integer> sizes = new EnumMap<>(Size.class);

        sizes.put(Size.SMALL, 28);

        sizes.put(Size.MEDIUM, 32);

        sizes.put(Size.LARGE, 36);

        sizes.put(Size.EXTRALARGE, 40);

        System.out.println("EnumMap: " + sizes);


        // Using the replace() Method

        sizes.replace(Size.MEDIUM, 30);

        sizes.replace(Size.LARGE, 36, 34);

        System.out.println("EnumMap using replace(): " + sizes);
```

```
        // Using the replaceAll() Method
        sizes.replaceAll((key, oldValue) -> oldValue + 3);
        System.out.println("EnumMap using replaceAll(): " + sizes);
    }
}
```

Output

```
EnumMap: {SMALL=28, MEDIUM=32, LARGE=36, EXTRALARGE=40}
EnumMap using replace(): {SMALL=28, MEDIUM=30, LARGE=34, EXTRALARGE=40}
EnumMap using replaceAll(): {SMALL=31, MEDIUM=33, LARGE=37, EXTRALARGE=43}
```

In the above program, notice the statement

```
sizes.replaceAll((key, oldValue) -> oldValue + 3);
```

Here, the method accesses all the entries of the map. It then replaces all the values with the new values provided by the lambda expressions.

Other Methods

Method	Description
`clone()`	Creates a copy of the `EnumMap`
`containsKey()`	Searches the `EnumMap` for the specified key and returns a boolean result
`containsValue()`	Searches the `EnumMap` for the specified value and returns a boolean result
`size()`	Returns the size of the `EnumMap`
`clear()`	Removes all the entries from the `EnumMap`

EnumSet Vs. EnumMap

Both the EnumSet and `EnumMap` class provides data structures to store enum values. However, there exist some major differences between them.

- Enum set is represented internally as a sequence of bits, whereas the enum map is represented internally as arrays.
- Enum set is created using its predefined methods like `allOf()`, `noneOf()`, `of()`, etc. However, an enum map is created using its constructor.

Clonable and Serializable Interfaces

The `EnumMap` class also implements `Cloneable` and `Serializable` interfaces.

Cloneable Interface

It allows the `EnumMap` class to make a copy of instances of the class.

Serializable Interface

Whenever Java objects need to be transmitted over a network, objects need to be converted into bits or bytes. This is because Java objects cannot be transmitted over the network.

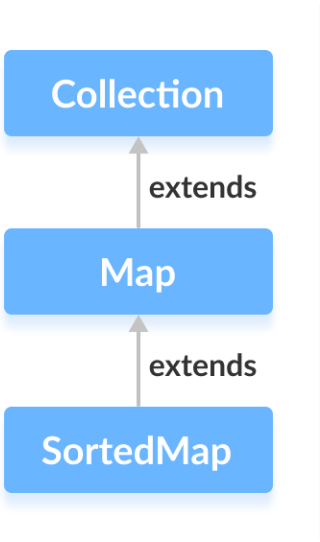
The `Serializable` interface allows classes to be serialized. This means objects of the classes implementing `Serializable` can be converted into bits or bytes.

Java SortedMap Interface

In this tutorial, we will learn about the Java SortedMap interface and its methods.

The `SortedMap` interface of the Java collections framework provides sorting of keys stored in a map.

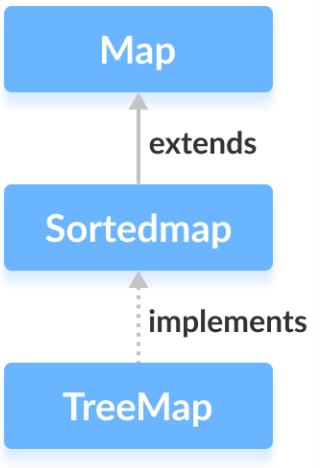
It extends the Map interface.



Class that implements SortedMap

Since `SortedMap` is an interface, we cannot create objects from it.

In order to use the functionalities of the `SortedMap` interface, we need to use the class `TreeMap` that implements it.



How to use SortedMap?

To use the `SortedMap`, we must import the `java.util.SortedMap` package first. Once we import the package, here's how we can create a sorted map.

```
// SortedMap implementation by TreeMap class

SortedMap<Key, Value> numbers = new TreeMap<>();
```

We have created a sorted map called `numbers` using the `TreeMap` class.

Here,

- `Key` - a unique identifier used to associate each element (value) in a map
- `Value` - elements associated by keys in a map

Here, we have used no arguments to create a sorted map. Hence the map will be sorted naturally (ascending order).

Methods of SortedMap

The `SortedMap` interface includes all the methods of the `Map` interface. It is because `Map` is a super interface of `SortedMap`.

Besides all those methods, here are the methods specific to the `SortedMap` interface.

- **comparator()** - returns a comparator that can be used to order keys in a map
- **firstKey()** - returns the first key of the sorted map
- **lastKey()** - returns the last key of the sorted map
- **headMap(key)** - returns all the entries of a map whose keys are less than the specified `key`
- **tailMap(key)** - returns all the entries of a map whose keys are greater than or equal to the specified `key`
- **subMap(key1, key2)** - returns all the entries of a map whose keys lies in between `key1` and `key2` including `key1`

To learn more, visit Java SortedMap (official Java documentation).

Implementation of SortedMap in TreeMap Class

```
import java.util.SortedMap;import java.util.TreeMap;

class Main {


    public static void main(String[] args) {

        // Creating SortedMap using TreeMap

        SortedMap<String, Integer> numbers = new TreeMap<>();


        // Insert elements to map

        numbers.put("Two", 2);

        numbers.put("One", 1);

        System.out.println("SortedMap: " + numbers);




        // Access the first key of the map

        System.out.println("First Key: " + numbers.firstKey());


        // Access the last key of the map

        System.out.println("Last Key: " + numbers.lastKey());


        // Remove elements from the map

        int value = numbers.remove("One");

        System.out.println("Removed Value: " + value);

    }

}
```

Output

```
SortedMap: {One=1, Two=2}

First Key: One

Last Key: Two

Removed Value: 1
```

Java NavigableMap Interface

In this tutorial, we will learn about the Java NavigableMap interface and its methods with the help of a example.

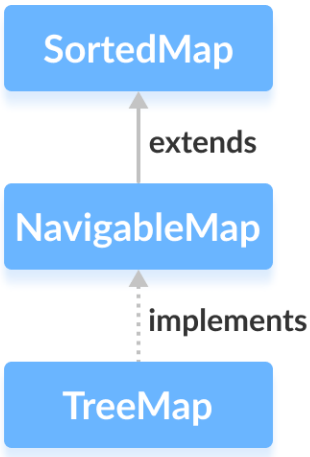
The `NavigableMap` interface of the Java collections framework provides the features to navigate among the map entries.

It is considered as a type of SortedMap.

Class that implements NavigableMap

Since `NavigableMap` is an interface, we cannot create objects from it.

In order to use the functionalities of the `NavigableMap` interface, we need to use the `TreeMap` class that implements `NavigableMap`.



How to use NavigableMap?

In Java, we must import the `java.util.NavigableMap` package to use `NavigableMap`. Once we import the package, here's how we can create a navigable map.

```
// NavigableMap implementation by TreeMap class

NavigableMap<Key, Value> numbers = new TreeMap<>();
```

In the above code, we have created a navigable map named `numbers` of the `TreeMap` class.

Here,

- `Key` - a unique identifier used to associate each element (value) in a map
- `Value` - elements associated by keys in a map

Methods of NavigableMap

The `NavigableMap` is considered as a type of `SortedMap`. It is because `NavigableMap` extends the `SortedMap` interface.

Hence, all `SortedMap` methods are also available in `NavigableMap`. To learn how these methods are defined in `SortedMap`, visit Java SortedMap.

However, some of the methods of `SortedMap` (`headMap()`, `tailMap()`, and `subMap()`) are defined differently in `NavigableMap`.

Let's see how these methods are defined in `NavigableMap`.

---

headMap(key, booleanValue)

The `headMap()` method returns all the entries of a navigable map associated with all those keys before the specified `key` (which is passed as an argument).

The `booleanValue` is an optional parameter. Its default value is `false`.

If `true` is passed as a `booleanValue`, the method returns all the entries associated with all those keys before the specified `key`, including the entry associated with the specified `key`.

---

tailMap(key, booleanValue)

The `tailMap()` method returns all the entries of a navigable map associated with all those keys after the specified `key` (which is passed as an argument) including the entry associated with the specified `key`.

The `booleanValue` is an optional parameter. Its default value is `true`.

If `false` is passed as a `booleanValue`, the method returns all the entries associated with those keys after the specified `key`, without including the entry associated with the specified `key`.

---

subMap(k1, bv1, k2, bv2)

The `subMap()` method returns all the entries associated with keys between `k1` and `k2` including the entry associated with `k1`.

The `bv1` and `bv2` are optional parameters. The default value of `bv1` is true and the default value of `bv2` is `false`.

If `false` is passed as `bv1`, the method returns all the entries associated with keys between `k1` and `k2`, without including the entry associated with `k1`.

If `true` is passed as `bv2`, the method returns all the entries associated with keys between `k1` and `k2`, including the entry associated with `k1`.

Other Methods

The `NavigableMap` provides various methods that can be used to locate the entries of maps.

- **descendingMap()** - reverse the order of entries in a map
- **descendingKeyMap()** - reverses the order of keys in a map
- **ceilingEntry()** - returns an entry with the lowest key among all those entries whose keys are greater than or equal to the specified key
- **ceilingKey()** - returns the lowest key among those keys that are greater than or equal to the specified key
- **floorEntry()** - returns an entry with the highest key among all those entries whose keys are less than or equal to the specified key

---

- **floorKey()** - returns the highest key among those keys that are less than or equal to the specified key
- **higherEntry()** - returns an entry with the lowest key among all those entries whose keys are greater than the specified key
- **higherKey()** - returns the lowest key among those keys that are greater than the specified key
- **lowerEntry()** - returns an entry with the highest key among all those entries whose keys are less than the specified key
- **lowerKey()** - returns the highest key among those keys that are less than the specified key
- **firstEntry()** - returns the first entry (the entry with the lowest key) of the map
- **lastEntry()** - returns the last entry (the entry with the highest key) of the map
- **pollFirstEntry()** - returns and removes the first entry of the map
- **pollLastEntry()** - returns and removes the last entry of the map

To learn more, visit Java NavigableMap (official Java documentation).

Implementation of NavigableMap in TreeMap Class

```
import java.util.NavigableMap;import java.util.TreeMap;

class Main {



    public static void main(String[] args) {

        // Creating NavigableMap using TreeMap

        NavigableMap<String, Integer> numbers = new TreeMap<>();



        // Insert elements to map

        numbers.put("Two", 2);

        numbers.put("One", 1);

        numbers.put("Three", 3);

        System.out.println("NavigableMap: " + numbers);
```

```
        // Access the first entry of the map
        System.out.println("First Entry: " + numbers.firstEntry());

        // Access the last entry of the map
        System.out.println("Last Entry: " + numbers.lastEntry());

        // Remove the first entry from the map
        System.out.println("Removed First Entry: " + numbers.pollFirstEntry());

        // Remove the last entry from the map
        System.out.println("Removed Last Entry: " + numbers.pollLastEntry());
    }
}
```

Output

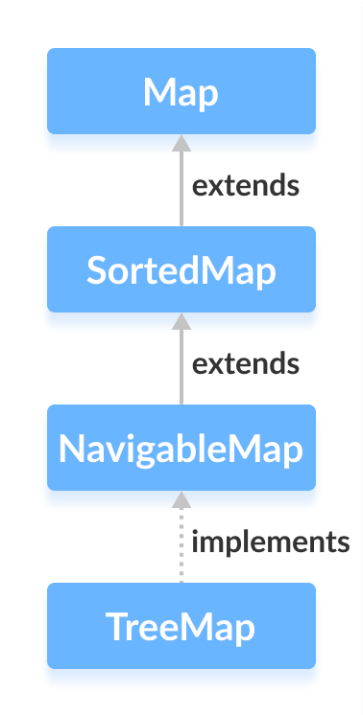
```
NavigableMap: {One=1, Three=3, Two=2}
First Entry: One=1
Last Entry: Two=2
Removed First Entry: One=1
Removed Last Entry: Two=2
```

Java TreeMap

In this tutorial, we will learn about the Java TreeMap class and its operations with the help of examples.

The `TreeMap` class of the Java collections framework provides the tree data structure implementation.

It implements the NavigableMap interface.



Creating a TreeMap

In order to create a `TreeMap`, we must import the `java.util.TreeMap` package first. Once we import the package, here is how we can create a `TreeMap` in Java.

```
TreeMap<Key, Value> numbers = new TreeMap<>();
```

In the above code, we have created a `TreeMap` named `numbers` without any arguments. In this case, the elements in `TreeMap` are sorted naturally (ascending order).

However, we can customize the sorting of elements by using the `Comparator` interface. We will learn about it later in this tutorial.

Here,

- `Key` - a unique identifier used to associate each element (value) in a map
- `Value` - elements associated by keys in a map

Methods of TreeMap

The `TreeMap` class provides various methods that allow us to perform operations on the map.

Insert Elements to TreeMap

- `put()` - inserts the specified key/value mapping (entry) to the map
- `putAll()` - inserts all the entries from specified map to this map
- `putIfAbsent()` - inserts the specified key/value mapping to the map if the specified key is not present in the map

For example,

```
import java.util.TreeMap;

class Main {

    public static void main(String[] args) {

        // Creating TreeMap of even numbers

        TreeMap<String, Integer> evenNumbers = new TreeMap<>();


        // Using put()

        evenNumbers.put("Two", 2);

        evenNumbers.put("Four", 4);


        // Using putIfAbsent()

        evenNumbers.putIfAbsent("Six", 6);

        System.out.println("TreeMap of even numbers: " + evenNumbers);


        //Creating TreeMap of numbers

        TreeMap<String, Integer> numbers = new TreeMap<>();

        numbers.put("One", 1);


        // Using putAll()

        numbers.putAll(evenNumbers);
```

```
        System.out.println("TreeMap of numbers: " + numbers);

    }

}
```

Output

```
TreeMap of even numbers: {Four=4, Six=6, Two=2}

TreeMap of numbers: {Four=4, One=1, Six=6, Two=2}
```

Access TreeMap Elements

1. Using entrySet(), keySet() and values()

- `entrySet()` - returns a set of all the key/values mapping (entry) of a treemap
- `keySet()` - returns a set of all the keys of a tree map
- `values()` - returns a set of all the maps of a tree map

For example,

```
import java.util.TreeMap;

class Main {

    public static void main(String[] args) {

        TreeMap<String, Integer> numbers = new TreeMap<>();


        numbers.put("One", 1);

        numbers.put("Two", 2);

        numbers.put("Three", 3);

        System.out.println("TreeMap: " + numbers);


        // Using entrySet()

        System.out.println("Key/Value mappings: " + numbers.entrySet());


        // Using keySet()
```

```
        System.out.println("Keys: " + numbers.keySet());


        // Using values()
        System.out.println("Values: " + numbers.values());
    }
}
```

Output

```
TreeMap: {One=1, Three=3, Two=2}
Key/Value mappings: [One=1, Three=3, Two=2]
Keys: [One, Three, Two]
Values: [1, 3, 2]
```

2. Using get() and getOrDefault()

- `get()` - Returns the value associated with the specified key. Returns null if the key is not found.
- `getOrDefault()` - Returns the value associated with the specified key. Returns the specified default value if the key is not found.

  For example,

```
import java.util.TreeMap;
class Main {
    public static void main(String[] args) {


        TreeMap<String, Integer> numbers = new TreeMap<>();
        numbers.put("One", 1);
        numbers.put("Two", 2);
        numbers.put("Three", 3);
        System.out.println("TreeMap: " + numbers);


        // Using get()
        int value1 = numbers.get("Three");
        System.out.println("Using get(): " + value1);
```

```
        // Using getOrDefault()
        int value2 = numbers.getOrDefault("Five", 5);
        System.out.println("Using getOrDefault(): " + value2);
    }
}
```

Output

```
TreeMap: {One=1, Three=3, Two=2}
Using get(): 3
Using getOrDefault(): 5
```

Here, the `getOrDefault()` method does not find the key `Five`. Hence it returns the specified default value `5`.

Remove TeeMap Elements

- `remove(key)` - returns and removes the entry associated with the specified key from a TreeMap
- `remove(key, value)` - removes the entry from the map only if the specified key is associated with the specified value and returns a boolean value

For example,

```
import java.util.TreeMap;
class Main {
    public static void main(String[] args) {

        TreeMap<String, Integer> numbers = new TreeMap<>();
        numbers.put("One", 1);
        numbers.put("Two", 2);
        numbers.put("Three", 3);
        System.out.println("TreeMap: " + numbers);
```

```
        // remove method with single parameter
        int value = numbers.remove("Two");
        System.out.println("Removed value: " + value);

        // remove method with two parameters
        boolean result = numbers.remove("Three", 3);
        System.out.println("Is the entry {Three=3} removed? " + result);

        System.out.println("Updated TreeMap: " + numbers);
    }
}
```

Output

```
TreeMap: {One=1, Three=3, Two=2}
Removed value = 2
Is the entry {Three=3} removed? True
Updated TreeMap: {One=1}
```

Replace TreeMap Elements

- `replace(key, value)` - replaces the value mapped by the specified `key` with the new `value`
- `replace(key, old, new)` - replaces the old value with the new value only if the old value is already associated with the specified key
- `replaceAll(function)` - replaces each value of the map with the result of the specified `function`

For example,

```
import java.util.TreeMap;
class Main {
```

```
    public static void main(String[] args) {


        TreeMap<String, Integer> numbers = new TreeMap<>();
        numbers.put("First", 1);
        numbers.put("Second", 2);
        numbers.put("Third", 3);
        System.out.println("Original TreeMap: " + numbers);


        // Using replace()
        numbers.replace("Second", 22);
        numbers.replace("Third", 3, 33);
        System.out.println("TreeMap using replace: " + numbers);


        // Using replaceAll()
        numbers.replaceAll((key, oldValue) -> oldValue + 2);
        System.out.println("TreeMap using replaceAll: " + numbers);
    }
}
```

Output

```
Original TreeMap: {First=1, Second=2, Third=3}
TreeMap using replace(): {First=1, Second=22, Third=33}
TreeMap using replaceAll(): {First=3, Second=24, Third=35}
```

In the above program notice the statement

```
numbers.replaceAll((key, oldValue) -> oldValue + 2);
```

Here, we have passed a lambda expression as an argument.

The `replaceAll()` method accesses all the entries of the map. It then replaces all the elements with the new values (returned from the lambda expression).

Methods for Navigation

Since the `TreeMap` class implements `NavigableMap`, it provides various methods to navigate over the elements of the treemap.

1. First and Last Methods

- `firstKey()` - returns the first key of the map
- `firstEntry()` - returns the key/value mapping of the first key of the map
- `lastKey()` - returns the last key of the map
- `lastEntry()` - returns the key/value mapping of the last key of the map

For example,

```
import java.util.TreeMap;

class Main {

    public static void main(String[] args) {

        TreeMap<String, Integer> numbers = new TreeMap<>();

        numbers.put("First", 1);

        numbers.put("Second", 2);

        numbers.put("Third", 3);

        System.out.println("TreeMap: " + numbers);


        // Using the firstKey() method

        String firstKey = numbers.firstKey();

        System.out.println("First Key: " + firstKey);


        // Using the lastKey() method

        String lastKey = numbers.lastKey();

        System.out.println("Last Key: " + lastKey);


        // Using firstEntry() method

        System.out.println("First Entry: " + numbers.firstEntry());
```

```
        // Using the lastEntry() method
        System.out.println("Last Entry: " + numbers.lastEntry());
    }
}
```

Output

```
TreeMap: {First=1, Second=2, Third=3}
First Key: First
Last Key: Third
First Entry: First=1
Last Entry: Third=3
```

---

2. Ceiling, Floor, Higher and Lower Methods

- **higherKey()** - Returns the lowest key among those keys that are greater than the specified key.
- **higherEntry()** - Returns an entry associated with a key that is lowest among all those keys greater than the specified key.
- **lowerKey()** - Returns the greatest key among all those keys that are less than the specified key.
- **lowerEntry()** - Returns an entry associated with a key that is greatest among all those keys that are less than the specified key.
- **ceilingKey()** - Returns the lowest key among those keys that are greater than the specified key. If the key passed as an argument is present in the map, it returns that key.
- **ceilingEntry()** - Returns an entry associated with a key that is lowest among those keys that are greater than the specified key. It an entry associated with the key passed an argument is present in the map, it returns the entry associated with that key.
- **floorKey()** - Returns the greatest key among those keys that are less than the specified key. If the key passed as an argument is present, it returns that key.

- **floorEntry()** - Returns an entry associated with a key that is greatest among those keys that are less than the specified key. If the key passed as argument is present, it returns that key.

  For example,

```
import java.util.TreeMap;

class Main {

    public static void main(String[] args) {


        TreeMap<String, Integer> numbers = new TreeMap<>();

        numbers.put("First", 1);

        numbers.put("Second", 5);

        numbers.put("Third", 4);

        numbers.put("Fourth", 6);

        System.out.println("TreeMap: " + numbers);


        // Using higher()

        System.out.println("Using higherKey(): " + numbers.higherKey("Fourth"));

        System.out.println("Using higherEntry(): " + numbers.higherEntry("Fourth"));


        // Using lower()

        System.out.println("\nUsing lowerKey(): " + numbers.lowerKey("Fourth"));

        System.out.println("Using lowerEntry(): " + numbers.lowerEntry("Fourth"));


        // Using ceiling()

        System.out.println("\nUsing ceilingKey(): " + numbers.ceilingKey("Fourth"));

        System.out.println("Using ceilingEntry(): " + numbers.ceilingEntry("Fourth"));


        // Using floor()

        System.out.println("\nUsing floorKey(): " + numbers.floorKey("Fourth"));

        System.out.println("Using floorEntry(): " + numbers.floorEntry("Fourth"));
```

```
    }
}
```

Output

```
TreeMap: {First=1, Fourth=6, Second=5, Third=4}

Using higherKey(): Second

Using higherEntry(): Second=5


Using lowerKey(): First

Using lowerEntry(): First=1


Using ceilingKey(): Fourth

Using ceilingEntry(): Fourth=6


Using floorkey(): Fourth

Using floorEntry(): Fourth=6
```

---

3. pollFirstEntry() and pollLastEntry() Methods

- `pollFirstEntry()` - returns and removes the entry associated with the first key of the map
- `pollLastEntry()` - returns and removes the entry associated with the last key of the map

For example,

```
import java.util.TreeMap;

class Main {

    public static void main(String[] args) {


        TreeMap<String, Integer> numbers = new TreeMap<>();

        numbers.put("First", 1);
```

```
        numbers.put("Second", 2);
        numbers.put("Third", 3);
        System.out.println("TreeMap: " + numbers);

        //Using the pollFirstEntry() method
        System.out.println("Using pollFirstEntry(): " + numbers.pollFirstEntry());

        // Using the pollLastEntry() method
        System.out.println("Using pollLastEntry(): " + numbers.pollLastEntry());

        System.out.println("Updated TreeMap: " + numbers);

    }
}
```

Output

```
TreeMap: {First=1, Second=2, Third=3}
Using pollFirstEntry(): First=1
Using pollLastEntry(): Third=3
Updated TreeMap: {Second=2}
```

---

4. headMap(), tailMap() and subMap() Methods

headMap(key, booleanValue)

The `headMap()` method returns all the key/value pairs of a treemap before the specified `key` (which is passed as an argument).

The `booleanValue` parameter is optional. Its default value is `false`.

If `true` is passed as a `booleanValue`, the method also includes the key/value pair of the `key` which is passed as an argument.

For example,

```
import java.util.TreeMap;

class Main {

    public static void main(String[] args) {


        TreeMap<String, Integer> numbers = new TreeMap<>();

        numbers.put("First", 1);

        numbers.put("Second", 2);

        numbers.put("Third", 3);

        numbers.put("Fourth", 4);

        System.out.println("TreeMap: " + numbers);


        System.out.println("\nUsing headMap() Method:");

        // Using headMap() with default booleanValue

        System.out.println("Without boolean value: " + numbers.headMap("Fourth"));


        // Using headMap() with specified booleanValue

        System.out.println("With boolean value: " + numbers.headMap("Fourth", true));


    }

}
```

Output

```
TreeMap: {First=1, Fourth=4, Second=2, Third=3}


Using headMap() Method:

Without boolean value: {First=1}

With boolean value: {First=1, Fourth=4}
```

tailMap(key, booleanValue)

The `tailMap()` method returns all the key/value pairs of a treemap starting from the specified `key` (which is passed as an argument).

The `booleanValue` is an optional parameter. Its default value is `true`.

If `false` is passed as a `booleanValue`, the method doesn't include the key/value pair of the specified `key`.

For example,

```
import java.util.TreeMap;

class Main {

    public static void main(String[] args) {


        TreeMap<String, Integer> numbers = new TreeMap<>();

        numbers.put("First", 1);

        numbers.put("Second", 2);

        numbers.put("Third", 3);

        numbers.put("Fourth", 4);

        System.out.println("TreeMap: " + numbers);


        System.out.println("\nUsing tailMap() Method:");

        // Using tailMap() with default booleanValue

        System.out.println("Without boolean value: " + numbers.tailMap("Second"));


        // Using tailMap() with specified booleanValue

        System.out.println("With boolean value: " + numbers.tailMap("Second", false));


    }

}
```

Output

```
TreeMap: {First=1, Fourth=4, Second=2, Third=3}


Using tailMap() Method:

Without boolean value: {Second=2, Third=3}

With boolean value: {Third=3}
```

---

subMap(k1, bV1, k2, bV2)

The `subMap()` method returns all the entries associated with keys between `k1` and `k2` including the entry of `k1`.

The `bV1` and `bV2` are optional boolean parameters. The default value of `bV1` is `true` and the default value of `bV2` is `false`.

If `false` is passed as `bV1`, the method returns all the entries associated with keys between `k1` and `k2` without including the entry of `k1`.

If `true` is passed as `bV2`, the method returns all the entries associated with keys between `k1` and `k2` including the entry of `k2`.

For example,

```
import java.util.TreeMap;

class Main {

    public static void main(String[] args) {


        TreeMap<String, Integer> numbers = new TreeMap<>();

        numbers.put("First", 1);

        numbers.put("Second", 2);

        numbers.put("Third", 3);

        numbers.put("Fourth", 4);

        System.out.println("TreeMap: " + numbers);


        System.out.println("\nUsing subMap() Method:");

        // Using subMap() with default booleanValue

        System.out.println("Without boolean value: " + numbers.subMap("Fourth", "Third"));


        // Using subMap() with specified booleanValue

        System.out.println("With boolean value: " + numbers.subMap("Fourth", false, "Third",
true));


    }

}
```

Output

```
TreeMap: {First=1, Fourth=2, Second=2, Third=3}


Using subMap() Method:

Without boolean value: {Fourth=4, Second=2}

With boolean value: {Second=2, Third=3}
```

Other Methods of TreeMap

Method	Description
`clone()`	Creates a copy of the `TreeMap`
`containsKey()`	Searches the `TreeMap` for the specified key and returns a boolean result
`containsValue()`	Searches the `TreeMap` for the specified value and returns a boolean result
`size()`	Returns the size of the `TreeMap`
`clear()`	Removes all the entries from the `TreeMap`

TreeMap Comparator

In all the examples above, treemap elements are sorted naturally (in ascending order). However, we can also customize the ordering of keys.

For this, we need to create our own comparator class based on which keys in a treemap are sorted. For example,

```
import java.util.TreeMap;import java.util.Comparator;

class Main {
```

```
    public static void main(String[] args) {


        // Creating a treemap with a customized comparator
        TreeMap<String, Integer> numbers = new TreeMap<>(new CustomComparator());


        numbers.put("First", 1);
        numbers.put("Second", 2);
        numbers.put("Third", 3);
        numbers.put("Fourth", 4);
        System.out.println("TreeMap: " + numbers);
    }


    // Creating a comparator class
    public static class CustomComparator implements Comparator<String> {


        @Override
        public int compare(String number1, String number2) {
            int value =  number1.compareTo(number2);


            // elements are sorted in reverse order
            if (value > 0) {
                return -1;
            }
            else if (value < 0) {
                return 1;
            }
            else {
                return 0;
            }
        }
    }
}
```

Output

```
TreeMap: {Third=3, Second=2, Fourth=4, First=1}
```

In the above example, we have created a treemap passing `CustomComparator` class as an argument.

The `CustomComparator` class implements the `Comparator` interface.

We then override the `compare()` method to sort elements in reverse order.

Java ConcurrentMap Interface

In this tutorial, we will learn about the Java ConcurrentMap interface and its methods.

The `ConcurrentMap` interface of the Java collections framework provides a thread-safe map. That is, multiple threads can access the map at once without affecting the consistency of entries in a map.

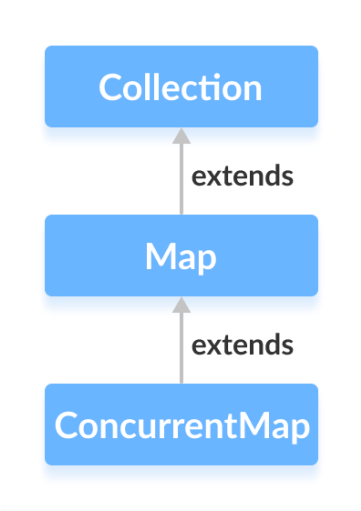
`ConcurrentMap` is known as a synchronized map.

It extends the Map interface.

Class that implements ConcurrentMap

Since `ConcurrentMap` is an interface, we cannot create objects from it.

In order to use the functionalities of the `ConcurrentMap` interface, we need to use the class `ConcurrentHashMap` that implements it.



How to use ConcurrentMap?

To use the `ConcurrentMap`, we must import the `java.util.concurrent.ConcurrentMap` package first. Once we import the package, here's how we can create a concurrent map.

```
// ConcurrentMap implementation by ConcurrentHashMap

CocurrentMap<Key, Value> numbers = new ConcurrentHashMap<>();
```

In the above code, we have created a concurrent map named `numbers`.

Here,

- `Key` - a unique identifier used to associate each element (value) in a map
- `Value` - elements associated by keys in a map

Methods of ConcurrentMap

The `ConcurrentMap` interface includes all the methods of the `Map` interface. It is because `Map` is the super interface of the `ConcurrentMap` interface.

Besides all those methods, here are the methods specific to the `ConcurrentMap` interface.

- **putIfAbsent()** - Inserts the specified key/value to the map if the specified key is not already associated with any value.

- **compute()** - Computes an entry (key/value mapping) for the specified key and its previously mapped value.
- **computeIfAbsent()** - Computes a value using the specified function for the specified key if the key is not already mapped with any value.
- **computeIfPresent()** - Computes a new entry (key/value mapping) for the specified key if the key is already mapped with the specified value.
- **forEach()** - Access all entries of a map and perform the specified actions.
- **merge()** - Merges the new specified value with the old value of the specified key if the key is already mapped to a certain value. If the key is not already mapped, the method simply associates the specified value to our key.

To learn more, visit Java ConcurrentMap (official Java documentation).

Implementation of ConcurrentMap in ConcurrentHashMap

```
import java.util.concurrent.ConcurrentMap;import java.util.concurrent.ConcurrentHashMap;

class Main {


    public static void main(String[] args) {

        // Creating ConcurrentMap using ConcurrentHashMap

        ConcurrentMap<String, Integer> numbers = new ConcurrentHashMap<>();


        // Insert elements to map

        numbers.put("Two", 2);

        numbers.put("One", 1);

        numbers.put("Three", 3);

        System.out.println("ConcurrentMap: " + numbers);


        // Access the value of specified key

        int value = numbers.get("One");

        System.out.println("Accessed Value: " + value);
```

```
        // Remove the value of specified key
        int removedValue = numbers.remove("Two");
        System.out.println("Removed Value: " + removedValue);
    }
}
```

Output

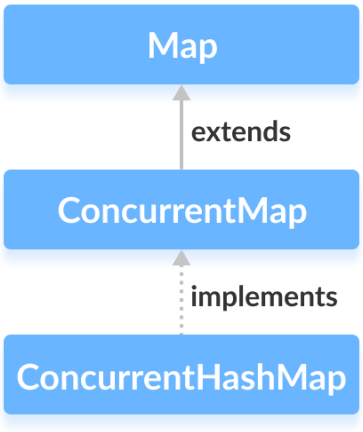
```
ConcurrentMap: {One=1, Two=2, Three=3}
Accessed Value: 1
Removed Value: 2
```

Java ConcurrentHashMap

In this tutorial, we will learn about the Java ConcurrentHashMap class and its operations with the help of examples.

The `ConcurrentHashMap` class of the Java collections framework provides a thread-safe map. That is, multiple threads can access the map at once without affecting the consistency of entries in a map.

It implements the ConcurrentMap interface.



Create a ConcurrentHashMap

In order to create a concurrent hashmap, we must import the `java.util.concurrent.ConcurrentHashMap` package first. Once we import the package, here is how we can create concurrent hashmaps in Java.

```
// ConcurrentHashMap with capacity 8 and load factor 0.6

ConcurrentHashMap<Key, Value> numbers = new ConcurrentHashMap<>(8, 0.6f);
```

In the above code, we have created a concurrent hashmap named `numbers`.

Here,

- `Key` - a unique identifier used to associate each element (value) in a map
- `Value` - elements associated by keys in a map

Notice the part `new ConcurrentHashMap<>(8, 0.6)`. Here, the first parameter is **capacity** and the second parameter is **loadFactor**.

- **capacity** - The capacity of this map is 8. Meaning, it can store 8 entries.
- **loadFactor** - The load factor of this map is 0.6. This means, whenever our hash table is filled by 60%, the entries are moved to a new hash table of double the size of the original hash table.

Default capacity and load factor

It's possible to create a concurrent hashmap without defining its capacity and load factor. For example,

```
// ConcurrentHashMap with default capacity and load factor

ConcurrentHashMap<Key, Value> numbers1 = new ConcurrentHashMap<>();
```

By default,

- the capacity of the map will be 16
- the load factor will be 0.75

Creating ConcurrentHashMap from Other Maps

Here is how we can create a concurrent hashmap containing all the elements of other maps.

```
import java.util.concurrent.ConcurrentHashMap;import java.util.HashMap;

class Main {

    public static void main(String[] args) {


        // Creating a hashmap of even numbers

        HashMap<String, Integer> evenNumbers = new HashMap<>();

        evenNumbers.put("Two", 2);

        evenNumbers.put("Four", 4);

        System.out.println("HashMap: " + evenNumbers);


        // Creating a concurrent hashmap from other map

        ConcurrentHashMap<String, Integer> numbers = new ConcurrentHashMap<>(evenNumbers);

        numbers.put("Three", 3);

        System.out.println("ConcurrentHashMap: " + numbers);

    }

}
```

Output

```
HashMap: {Four=4, Two=2}

ConcurrentHashMap: {Four=4, Two=2, Three=3}
```

Methods of ConcurrentHashMap

The `ConcurrentHashMap` class provides methods that allow us to perform various operations on the map.

Insert Elements to ConcurrentHashMap

- `put()` - inserts the specified key/value mapping to the map
- `putAll()` - inserts all the entries from specified map to this map
- `putIfAbsent()` - inserts the specified key/value mapping to the map if the specified key is not present in the map

For example,

```
import java.util.concurrent.ConcurrentHashMap;

class Main {

    public static void main(String[] args) {

        // Creating ConcurrentHashMap of even numbers

        ConcurrentHashMap<String, Integer> evenNumbers = new ConcurrentHashMap<>();


        // Using put()

        evenNumbers.put("Two", 2);

        evenNumbers.put("Four", 4);


        // Using putIfAbsent()

        evenNumbers.putIfAbsent("Six", 6);

        System.out.println("ConcurrentHashMap of even numbers: " + evenNumbers);


        //Creating ConcurrentHashMap of numbers

        ConcurrentHashMap<String, Integer> numbers = new ConcurrentHashMap<>();

        numbers.put("One", 1);


        // Using putAll()

        numbers.putAll(evenNumbers);

        System.out.println("ConcurrentHashMap of numbers: " + numbers);

    }

}
```

Output

```
ConcurrentHashMap of even numbers: {Six=6, Four=4, Two=2}

ConcurrentHashMap of numbers: {Six=6, One=1, Four=-4, Two=2}
```

Access ConcurrentHashMap Elements

1. Using entrySet(), keySet() and values()

- `entrySet()` - returns a set of all the key/value mapping of the map
- `keySet()` - returns a set of all the keys of the map
- `values()` - returns a set of all the values of the map

For example,

```
import java.util.concurrent.ConcurrentHashMap;

class Main {

    public static void main(String[] args) {

        ConcurrentHashMap<String, Integer> numbers = new ConcurrentHashMap<>();


        numbers.put("One", 1);

        numbers.put("Two", 2);

        numbers.put("Three", 3);

        System.out.println("ConcurrentHashMap: " + numbers);


        // Using entrySet()

        System.out.println("Key/Value mappings: " + numbers.entrySet());


        // Using keySet()

        System.out.println("Keys: " + numbers.keySet());


        // Using values()

        System.out.println("Values: " + numbers.values());

    }
```

```
}
```

Output

```
ConcurrentHashMap: {One=1, Two=2, Three=3}

Key/Value mappings: [One=1, Two=2, Three=3]

Keys: [One, Two, Three]

Values: [1, 2, 3]
```

2. Using get() and getOrDefault()

- `get()` - Returns the value associated with the specified key. Returns `null` if the key is not found.
- `getOrDefault()` - Returns the value associated with the specified key. Returns the specified default value if the key is not found.

For example,

```
import java.util.concurrent.ConcurrentHashMap;

class Main {

    public static void main(String[] args) {


        ConcurrentHashMap<String, Integer> numbers = new ConcurrentHashMap<>();

        numbers.put("One", 1);

        numbers.put("Two", 2);

        numbers.put("Three", 3);

        System.out.println("ConcurrentHashMap: " + numbers);


        // Using get()

        int value1 = numbers.get("Three");

        System.out.println("Using get(): " + value1);


        // Using getOrDefault()

        int value2 = numbers.getOrDefault("Five", 5);

        System.out.println("Using getOrDefault(): " + value2);

    }
```

```
}
```

Output

```
ConcurrentHashMap: {One=1, Two=2, Three=3}

Using get(): 3

Using getOrDefault(): 5
```

Remove ConcurrentHashMap Elements

- `remove(key)` - returns and removes the entry associated with the specified key from the map
- `remove(key, value)` - removes the entry from the map only if the specified key mapped to the specified value and return a boolean value

For example,

```
import java.util.concurrent.ConcurrentHashMap;

class Main {

    public static void main(String[] args) {


        ConcurrentHashMap<String, Integer> numbers = new ConcurrentHashMap<>();

        numbers.put("One", 1);

        numbers.put("Two", 2);

        numbers.put("Three", 3);

        System.out.println("ConcurrentHashMap: " + numbers);


        // remove method with single parameter

        int value = numbers.remove("Two");

        System.out.println("Removed value: " + value);


        // remove method with two parameters

        boolean result = numbers.remove("Three", 3);
```

```
        System.out.println("Is the entry {Three=3} removed? " + result);


        System.out.println("Updated ConcurrentHashMap: " + numbers);
    }
}
```

Output

```
ConcurrentHashMap: {One=1, Two=2, Three=3}
Removed value: 2
Is the entry {Three=3} removed? True
Updated ConcurrentHashMap: {One=1}
```

Bulk ConcurrentHashMap Operations

The `ConcurrentHashMap` class provides different bulk operations that can be applied safely to concurrent maps.

1. forEach() Method

The `forEach()` method iterates over our entries and executes the specified function.

It includes two parameters.

- `parallelismThreshold` - It specifies that after how many elements operations in a map are executed in parallel.
- `transformer` - This will transform the data before the data is passed to the specified function.

For example,

```
import java.util.concurrent.ConcurrentHashMap;
class Main {
    public static void main(String[] args) {


        ConcurrentHashMap<String, Integer> numbers = new ConcurrentHashMap<>();
```

```
        numbers.put("One", 1);
        numbers.put("Two", 2);
        numbers.put("Three", 3);
        System.out.println("ConcurrentHashMap: " + numbers);

        // forEach() without transformer function
        numbers.forEach(4, (k, v) -> System.out.println("key: " + k + " value: " + v));

        // forEach() with transformer function
        System.out.print("Values are ");
        numbers.forEach(4, (k, v) -> v, (v) -> System.out.print(v + ", "));
    }
}
```

Output

```
ConcurrentHashMap: {One = 1, Two = 2, Three = 3}
key: One value: 1
key: Two value: 2
key: Three value: 3
Values are 1, 2, 3,
```

In the above program, we have used parallel threshold **4**. This means if the map contains 4 entries, the operation will be executed in parallel.

Variation of forEach() Method

- `forEachEntry()` - executes the specified function for each entry
- `forEachKey()` - executes the specified function for each key
- `forEachValue()` - executes the specified function for each value

---

2. search() Method

The `search()` method searches the map based on the specified function and returns the matched entry.

Here, the specified function determines what entry is to be searched.

It also includes an optional parameter `parallelThreshold`. The parallel threshold specifies that after how many elements in the map the operation is executed in parallel.

For example,

```
import java.util.concurrent.ConcurrentHashMap;

class Main {

    public static void main(String[] args) {


        ConcurrentHashMap<String, Integer> numbers = new ConcurrentHashMap<>();

        numbers.put("One", 1);

        numbers.put("Two", 2);

        numbers.put("Three", 3);

        System.out.println("ConcurrentHashMap: " + numbers);


        // Using search()

        String key = numbers.search(4, (k, v) -> {return v == 3 ? k: null;});

        System.out.println("Searched value: " + key);


    }

}
```

Output

```
ConcurrentHashMap: {One=1, Two=2, Three=3}

Searched value: Three
```

Variants of search() Method

- `searchEntries()` - search function is applied to key/value mappings
- `searchKeys()` - search function is only applied to the keys
- `searchValues()` - search function is only applied to the values

---

3. reduce() Method

The `reduce()` method accumulates (gather together) each entry in a map. This can be used when we need all the entries to perform a common task, like adding all the values of a map.

It includes two parameters.

- `parallelismThreshold` - It specifies that after how many elements, operations in a map are executed in parallel.
- `transformer` - This will transform the data before the data is passed to the specified function.

For example,

```
import java.util.concurrent.ConcurrentHashMap;

class Main {

    public static void main(String[] args) {



        ConcurrentHashMap<String, Integer> numbers = new ConcurrentHashMap<>();

        numbers.put("One", 1);

        numbers.put("Two", 2);

        numbers.put("Three", 3);

        System.out.println("ConcurrentHashMap: " + numbers);



        // Using search()

        int sum = numbers.reduce(4, (k, v) -> v, (v1, v2) -> v1 + v2);

        System.out.println("Sum of all values: " + sum);



    }

}
```

Output

```
ConcurrentHashMap: {One=1, Two=2, Three=3}

Sum of all values: 6
```

In the above program, notice the statement

```
numbers.reduce(4, (k, v) -> v, (v1, v2) -> v1+v2);
```

Here,

- 4 is a parallel threshold
- `(k, v) -> v` is a transformer function. It transfers the key/value mappings into values only.
- `(v1, v2) -> v1+v2` is a reducer function. It gathers together all the values and adds all values.

Variants of reduce() Method

- `reduceEntries()` - returns the result of gathering all the entries using the specified reducer function
- `reduceKeys()` - returns the result of gathering all the keys using the specified reducer function
- `reduceValues()` - returns the result of gathering all the values using the specified reducer function

---

ConcurrentHashMap vs HashMap

Here are some of the differences between `ConcurrentHashMap` and HashMap,

- `ConcurrentHashMap` is a **thread-safe** collection. That is, multiple threads can access and modify it at the same time.
- `ConcurrentHashMap` provides methods for bulk operations like `forEach()`, `search()` and `reduce()`.

Why ConcurrentHashMap?

- The `ConcurrentHashMap` class allows multiple threads to access its entries concurrently.

- By default, the concurrent hashmap is divided into **16 segments**. This is the reason why 16 threads are allowed to concurrently modify the map at the same time. However, any number of threads can access the map at a time.
- The `putIfAbsent()` method will not override the entry in the map if the specified key already exists.
- It provides its own synchronization.
