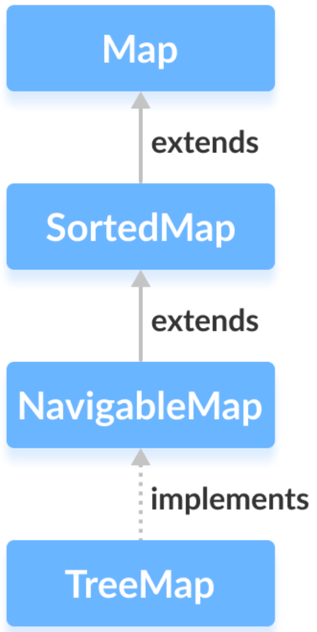
Java TreeMap

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,

```java
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,

```java
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,

```java
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,

```java
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,

```java
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,

```java
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,

```java
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,

```java
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,

```java
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,

```java
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;
```

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.