



JAVA Programming

Course Instructor: Dr. N Nandini Devi

School of Computer Science

UPES Dehradun

TOPICS to be discussed

- Set Interface

 - ❑ HashSet

 - ❑ LinkedHashSet

- SortedSet Interface

 - ❑ TreeSet

- Map Interface

 - ❑ HashMap

 - ❑ LinkedHashMap

- SortedMap Interface

 - ❑ TreeMap

Let's START ...!!!

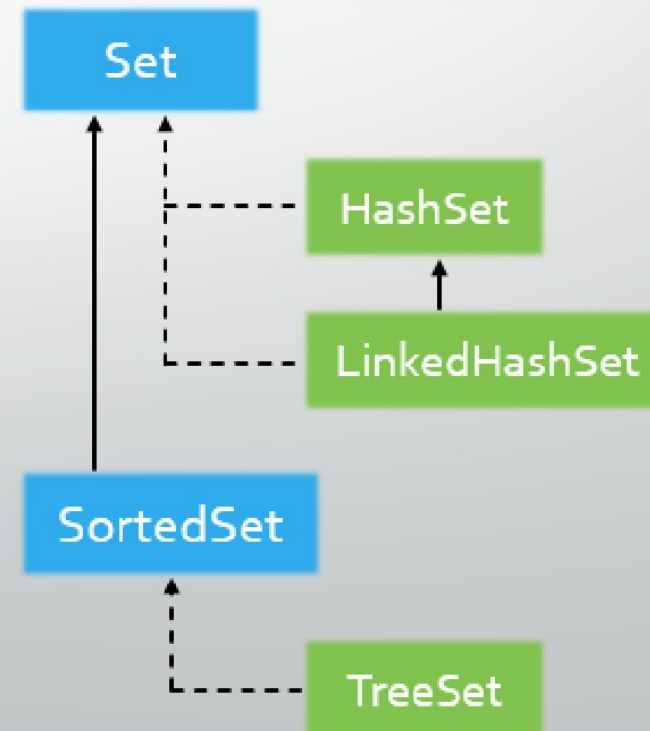


Set Interface

- The **Set interface** represents a **collection** of unique elements (no duplicates).
- It is part of the **java.util** package.
- It allows at most one **null element** (depending on the implementation).

Implementation

- ❑ HashSet
- ❑ LinkedHashSet
- ❑ TreeSet (implements **SortedSet interface** that extends **Set Interface**)



HashSet

- The **HashSet class** in **Java** is a part of the **Java Collection Framework**, implementing the **Set interface**.
- It is one of the most used implementations of the **Set interface**.

Key Features of HashSet

- Uses hashing for storage, making **add()**, **remove()**, and **contains()** operations $O(1)$ on average.
- Does not maintain the order of elements.
- Allows a single **null element**.
- Not synchronized. If **thread safety** is needed, use [Collections.synchronizedSet\(\)](#).

HashSet (Example)

```
import java.util.HashSet;
class HashSetDemo {
    public static void main(String[] args) {
        HashSet<String> hashSet = new HashSet<>();
        //Adding elements to the HashSet
        hashSet.add("Apple"); hashSet.add("Banana");
        hashSet.add("Cherry");
        hashSet.add("Apple"); //Duplicate, will not be added
        //Checking for an element
        System.out.println("Contains 'Banana': " +
hashSet.contains("Banana"));
        //Iterating through the HashSet
        for (String item : hashSet)
            System.out.println(item);
        //Removing an element
        hashSet.remove("Cherry");
        System.out.println("After removal: " + hashSet);
        //Checking size
        System.out.println("Size: " + hashSet.size());
    }
}
```

Output:

Contains 'Banana': true

Apple

Cherry

Banana

After removal: [Apple, Banana]

Size: 2

Note: The order of elements while printing can be anything, as it is not maintained in HashSets

LinkedHashSet

- The **LinkedHashSet** class in **Java** is a part of the **java.util** package.
- It extends **HashSet** and implements the **Set** interface, maintaining the insertion order of elements. This makes it different from **HashSet**, which does not guarantee any specific order.

Key Features of LinkedHashSet

- Internally, it uses a combination of a **hash table** (for fast operations like **add()**, **remove()**, **contains()**) and a **linked list** (to maintain the order).
- Allows a single **null element**.
- Like **HashSet**, it is not thread-synchronized. Requires external **synchronization** for concurrent access using [Collections.synchronizedSet\(\)](#).

LinkedHashSet (Example)

```
import java.util.LinkedHashSet;
class LinkedHashSetDemo {
    public static void main(String[] args) {
        LinkedHashSet<String> linkedHashSet =

            new LinkedHashSet<>();
            //Adding elements to the HashSet
            linkedHashSet.add("Apple");
            linkedHashSet.add("Banana");
            linkedHashSet.add("Cherry");
            linkedHashSet.add("Apple"); //Duplicate, will not be added
            //Checking for an element
            System.out.println("Contains 'Banana': " +

linkedHashSet.contains("Banana"));
            //Iterating through the HashSet
            for (String item : linkedHashSet)
                System.out.println(item);
            //Removing an element
            linkedHashSet.remove("Cherry");
            System.out.println("After removal: " + linkedHashSet);
            //Checking size
            System.out.println("Size: " + linkedHashSet.size());
    }
}
```

Output:

Contains 'Banana': true

Apple

Banana

Cherry

After removal: [Apple, Banana]

Size: 2

Note: The order of elements while printing is maintained in LinkedHashSets as the order of insertion of the elements

SortedSet Interface

- The [SortedSet interface](#) is part of the [java.util](#) package in **Java**.
- It extends the [Set interface](#) and represents a **collection** of unique elements that are maintained in sorted order.
- Sorting can be based on the natural order of the elements (if they implement [Comparable](#)) or a custom order defined by a [Comparator](#).

Implementation

- ☐ TreeSet
- ☐ ConcurrentSkipListSet

Method	Description
E first()	Returns First Element in the SortedSet.
E last()	Returns Last Element in the SortedSet.
SortedSet<E> HeadSet(E to)	Returns SortedSet in which all elements are lesser than the 'to' element.
SortedSet<E> TailSet(E from)	Returns SortedSet in which all elements are higher than the 'from' element or equal to 'from' element.
SortedSet<E> SubSet(E from, E to)	Returns SortedSet which is between 'from' & 'to'.

TreeSet

- The **TreeSet** class in **Java** is part of the **java.util** package and implements the **SortedSet** and **NavigableSet** interfaces.
- It is a **collection** that maintains unique elements in sorted order. Internally, it uses a **red-black tree**, which is a self-balancing **binary search tree**, to store elements.

Key Features of TreeSet

- Operations like **add()**, **remove()**, and **contains()** take **$O(\log n)$** time due to the underlying **red-black tree**.
- Elements are stored in ascending order by default. A custom Comparator can be used for user-defined sorting. (e.g., `Comparator.reverseOrder()` in param. constructor)
- does not allow **null elements** (else would have thrown **NullPointerException**).
- Not synchronized. For **thread safety** (if needed), use [`Collections.synchronizedSet\(\)`](#).
- Provides methods for navigation like **higher()**, **lower()**, **ceiling()**, **floor()**, and range views like **subSet()**, **headSet()**, and **tailSet()**.

TreeSet (Example)

```
import java.util.TreeSet;
class TreeSetDemo {
    public static void main(String[] args) {
        //Creating a TreeSet
        TreeSet<Integer> treeSet = new TreeSet<>();
        //Adding elements
        treeSet.add(50);    treeSet.add(20);
        treeSet.add(30);    treeSet.add(10);
        //Displaying elements (sorted order)
        System.out.println("TreeSet: " + treeSet);
        //Accessing first and last elements
        System.out.println("First: " + treeSet.first());
        System.out.println("Last: " + treeSet.last());
        //Subsets
        System.out.println("less than 30: " + treeSet.headSet(30));
        System.out.println("30 or greater: " + treeSet.tailSet(30));
        System.out.println("20 to 50: " + treeSet.subSet(20, 50));
        //Navigable methods
        System.out.println("Ceiling of 20: " + treeSet.ceiling(20));
        System.out.println("Floor of 20: " + treeSet.floor(20));
        System.out.println("Higher than 20: " + treeSet.higher(20));
        System.out.println("Lower than 20: " + treeSet.lower(20));
    }
}
```

Output:

TreeSet: [10, 20, 30, 50]

First: 10

Last: 50

less than 30: [10, 20]

30 or greater: [30, 50]

20 to 50: [20, 30]

Ceiling of 20: 20

Floor of 20: 20

Higher than 20: 30

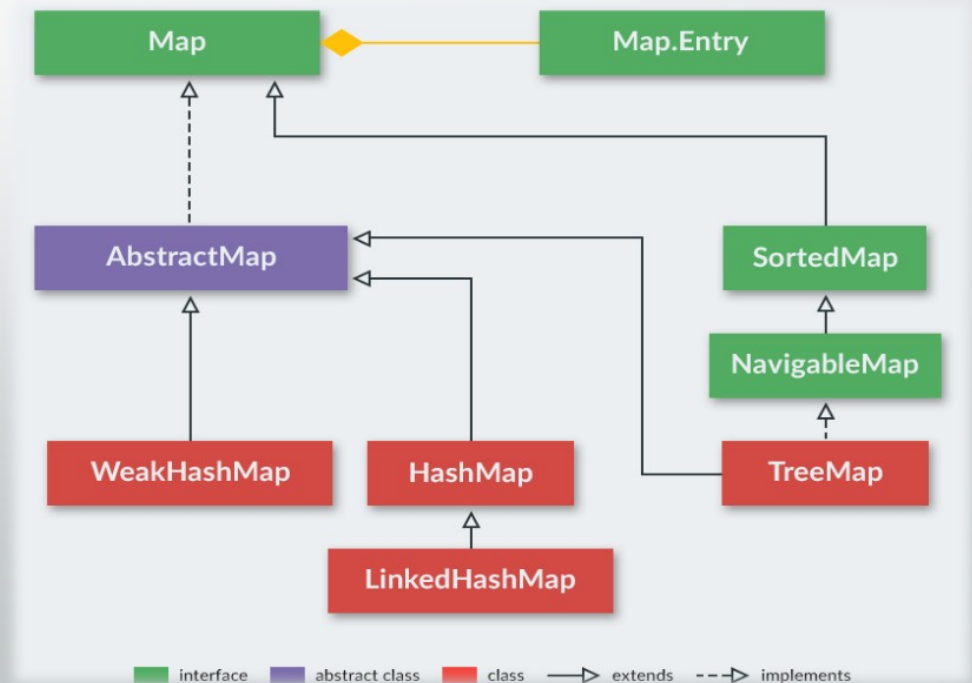
Lower than 20: 10

Map Interface

- The **Map** interface in **Java**, part of the **java.util** package, represents a collection of key-value pairs.
- It is designed for scenarios where data is stored and accessed using unique keys.
- Unlike other **collection interfaces** such as **List** or **Set**, a **Map** is not a subtype of **Collection**.

Implementation

- ❑ HashMap
- ❑ LinkedHashMap
- ❑ TreeMap (implements **SortedMap interface** that extends **Map Interface**)
- ❑ WeakHashMap
- ❑ ConcurrentHashMap



Map Features & Methods

Key Features of Map Interface

- ❑ Each **key** maps to exactly one **value**. **Keys** must be unique, while **values** can be duplicated.
- ❑ The order of keys and values is not guaranteed in a general Map. However, specific implementations like **LinkedHashMap** maintain insertion order, and **TreeMap** maintains sorted order based on keys.
- ❑ Depending on the implementation, allows one (**HashMap** and **LinkedHashMap**) or no (**TreeMap**) null key and multiple null values.

Method	Description
<code>put(K key, V value)</code>	Adds a key-value pair to the map. If the key already exists, updates its value.
<code>get(Object key)</code>	Returns the value associated with the specified key, or <code>null</code> if the key is not found.
<code>remove(Object key)</code>	Removes the entry for the specified key.
<code>containsKey(Object key)</code>	Checks if the map contains the specified key.
<code>containsValue(Object value)</code>	Checks if the map contains the specified value.
<code>keySet()</code>	Returns a <code>Set</code> view of the keys in the map.
<code>values()</code>	Returns a <code>Collection</code> view of the values in the map.
<code>entrySet()</code>	Returns a <code>Set</code> view of the key-value pairs (entries) in the map.
<code>size()</code>	Returns the number of key-value pairs in the map.
<code>isEmpty()</code>	Checks if the map is empty.
<code>clear()</code>	Removes all entries from the map.

HashMap

- The **HashMap** class in **Java**, part of the **java.util** package, is a widely used implementation of the **Map** interface.
- It provides a way to store and retrieve key-value pairs with efficient performance (**O(1)**).
- Internally, it uses a **hash table** to store data.

```
import java.util.HashMap;
class HashMapDemo {
    public static void main(String[] args) {
        //Creating a HashMap
        HashMap<String, Integer> map = new HashMap<>();
        //Adding key-value pairs
        map.put("Apple", 50);    map.put("Banana", 20);
        map.put("Cherry", 30);  map.put("Orange", 70);
        //Retrieving a value
        System.out.println("Price of Apple: " + map.get("Apple"));
        //Checking for a key
        System.out.println("Contains 'Banana'? " + map.containsKey("Banana"));
        //Iterating through the map
        for(HashMap.Entry<String, Integer> entry : map.entrySet())
            System.out.println(entry.getKey() + ": " + entry.getValue());
    }
}
```

Output:

Price of Apple: 50
Contains 'Banana'? true
Apple: 50
Cherry: 30
Orange: 70
Banana: 20

LinkedHashMap

- The **LinkedHashMap** class is a part of the **java.util** package.
- It extends **HashMap** and implements the **Map** interface.
- Unlike **HashMap**, it maintains the insertion order of its elements using a **doubly-linked list** running through its entries.

```
import java.util.LinkedHashMap;
class LinkedHashMapDemo {
    public static void main(String[] args) {
        //Creating a LinkedHashMap
        LinkedHashMap<String, Integer> map = new LinkedHashMap<>();
        //Adding key-value pairs
        map.put("Apple", 50);    map.put("Banana", 20);
        map.put("Orange", 70);  map.put("Cherry", 30);
        //Retrieving a value
        System.out.println("Price of Apple: " + map.get("Apple"));
        //Checking for a key
        System.out.println("Contains 'Banana'? " + map.containsKey("Banana"));
        //Showing the Map
        System.out.println(map);
    }
}
```

Output:

Price of Apple: 50

Contains 'Banana'? true

{Apple=50, Banana=20,
Orange=70, Cherry=30}

SortedMap Interface

- The **SortedMap interface** is a part of the **java.util** package.
- It is a specialized version of the **Map interface** that maintains its **key-value** pairs in sorted order.
- The **keys** are sorted based on their natural ordering (if the **keys** implement **Comparable**) or by a specified Comparator.

Implementation

- ☐ TreeMap
- ☐ ConcurrentSkipListMap

Method	Description
<code>firstKey()</code>	Returns the first (lowest) key in the map.
<code>lastKey()</code>	Returns the last (highest) key in the map.
<code>headMap(K toKey)</code>	Returns a view of the map with keys less than <code>toKey</code> .
<code>tailMap(K fromKey)</code>	Returns a view of the map with keys greater than or equal to <code>fromKey</code> .
<code>subMap(K fromKey, K toKey)</code>	Returns a view of the map within the range <code>[fromKey, toKey)</code> .

TreeMap

- The **TreeMap class** is the most commonly used implementation of the **SortedMap interface**.
- It is a part of the **java.util** package and is based on a **red-black tree** (a self-balancing **binary search tree**).
- Basic operations like **put()**, **get()**, **remove()**, and **containsKey()** have a time complexity of **O(log n)**.

```
import java.util.TreeMap;
class TreeMapDemo {
    public static void main(String[] args) {
        //Creating a TreeMap
        TreeMap<Integer, String> map = new TreeMap<>();
        //Adding key-value pairs
        map.put(10, "Ten");    map.put(20, "Twenty");
        map.put(40, "Forty");    map.put(30, "Thirty");
        //Printing the map
        System.out.println(map);
        //Subset view
        System.out.println("SubMap(10 to 30): " + map.subMap(10, 30));
        System.out.println("HeadMap(less than 30): " + map.headMap(30));
        System.out.println("TailMap (30 and above): " + map.tailMap(30));
    }
}
```

Output:

{10=Ten, 20=Twenty,
30=Thirty, 40=Forty}

SubMap(10 to 30):
{10=Ten, 20=Twenty}

HeadMap(less than 30):
{10=Ten, 20=Twenty}

TailMap (30 and above):
{30=Thirty, 40=Forty}

Summary

Today, we learned about

- Set interface (HashSet, LinkedHashSet classes, their properties methods)
- SortedSet interface (TreeSet class, its properties and methods)
- Map interface (HashMap, LinkedHashMap classes, their properties methods)
- SortedMap interface (TreeMap class, its properties and methods)



Thank You!