Programming in Java – Day 9 Recap

Java Collections, wildcards

School of Computing and Mathematical Sciences
Birkbeck, University of London

Topics on Day 9

- Java Collections.
- Maps.
- Type wildcards.

Java Collections

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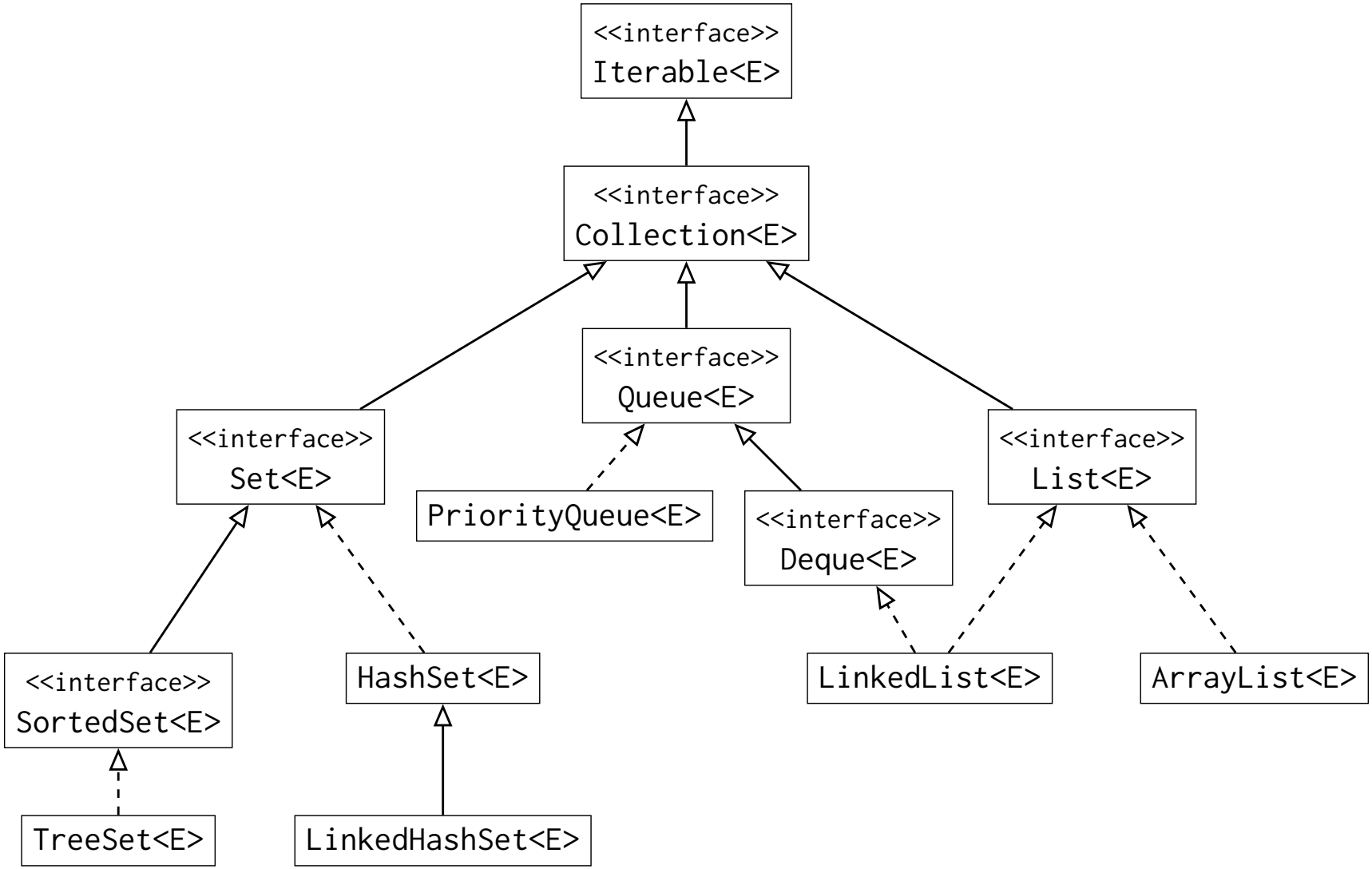
- It provides collections and maps to store elements grouped together.
- It sets some requirements on the elements that are worth knowing.

Inheritance Relations in the Collections Framework



Let's walk through these ...

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Ok, and what's an Iterator<E>?

Iterators allow us to access the elements in a container data structure, one by one.

```
1 public interface Iterator<E> {
2     boolean hasNext(); // are there elements left to visit?
3     E next();          // give me the next element
4     void remove();     // remove last visited element
5     ...
6 }
```

Interface Iterator<E> I

Standard use until Java 1.4:

```
1 // Assuming there is a collection (list, set, etc) of MyClass
2 // called "elements"
3 for (Iterator<MyClass> iter = elements.iterator(); iter.hasNext(); ) {
4     MyClass next = iter.next();
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Since Java 1.5:

used implicitly in **enhanced for loop over Iterable<E>**

(e.g., ArrayList<E>) as shorthand:

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- We do not need the current value of the index `i` in the loop.
- We do not want to write into `myArray` in the loop.

Interface `Iterator<E>` II

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Can also **remove** elements via an iterator:

```
1  // Assuming there is a collection (list, set, etc) of MyClass
2  // called "elements"
3  for (Iterator<MyClass> iter = elements.iterator(); iter.hasNext(); ) {
4      MyClass next = iter.next();
5
6      // Assuming we have a method shouldBeRemoved(MyClass)
7      // that returns whether we want to remove an element
8      if (shouldBeRemoved(next)) {
9          iter.remove();
10
11         // call iter.remove() only after iter.next(),
12         // but not more than once
13     }
14 }
```

Interface Iterator<E> III

Iterators are sensitive to modifications of their underlying container:

```
1 List<String> container = new ArrayList<>(Arrays.asList("A", "B"));
2 for (String s : container) { // uses Iterator over container to get s
3     container.add("C");      // modifies container
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- Similar:

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- When we are iterating over a collection, we are (usually) supposed to modify it **only** via the iterator.

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16     Object[] toArray();
17     <T> T[] toArray(T[] a);
18     ...
19 }
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Set<E> are collections
without duplicate elements ([1] and [1,1] are **equal**)
whose order does not matter for equality ([1,2] and [2,1] are **equal**).

Examples:
HashSet<E>, LinkedHashSet<E>, TreeSet<E>.

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Caveat: for `ArrayList<E>` and `LinkedList<E>`, the `contains` method is **slow** (linear time).

Interface Queue<E> and Deque<E>

- Queue: First-In-First-Out data structure

```
1 Queue<String> myQueue = new LinkedList<>();
2 myQueue.add("Hello");
3 myQueue.add("World");
4 String x = myQueue.remove(); // "Hello"
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```

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- Deque: a "double-ended queue", can also be used as a stack (Last-In-First-Out data structure)

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1 Deque<String> myDeque = new LinkedList<>();
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- Use `isEmpty()` to check if there is something to retrieve.

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- Benefit: **Fast** `contains` check.
- Caveat: do not modify elements of a `Set` (for `equals`) while they are in the `Set` — **strange** things may happen to the `Set`.

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- Holds for `Object`, but when we override `boolean equals(Object)`, we must take care to also override `int hashCode()` accordingly so that the HashSet gives correct answers.
- Caveat: iteration over HashSet<E> in **chaotic order** (may change for different iterations), inconvenient for users and debugging.

Class LinkedHashSet<E>

Improved subclass of HashSet<E> (since Java 1.4).

- Like HashSet<E>, but iteration over elements is
  in the **same order** as the (first) insertions of the elements.
- LinkedHashSet<E> internally uses an additional linked list between the elements, which hardly affects performance.
- LinkedHashSet<E> usually the better choice over HashSet<E>
  (unless you know for sure that no one will ever iterate over elements).

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(in java.util package) to provide an **alternative** order, e.g.,

```
1 public class MyComparator implements java.util.Comparator<Integer>() {
2     public int compare(Integer o1, Integer o2) {
3         return o2 - o1; // descending order
4     }
5 }
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x.compareTo(y) == 0 if and only if x.equals(y) or
comparator.compare(x,y) == 0 if and only if x.equals(y).

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Let's zoom out again ...

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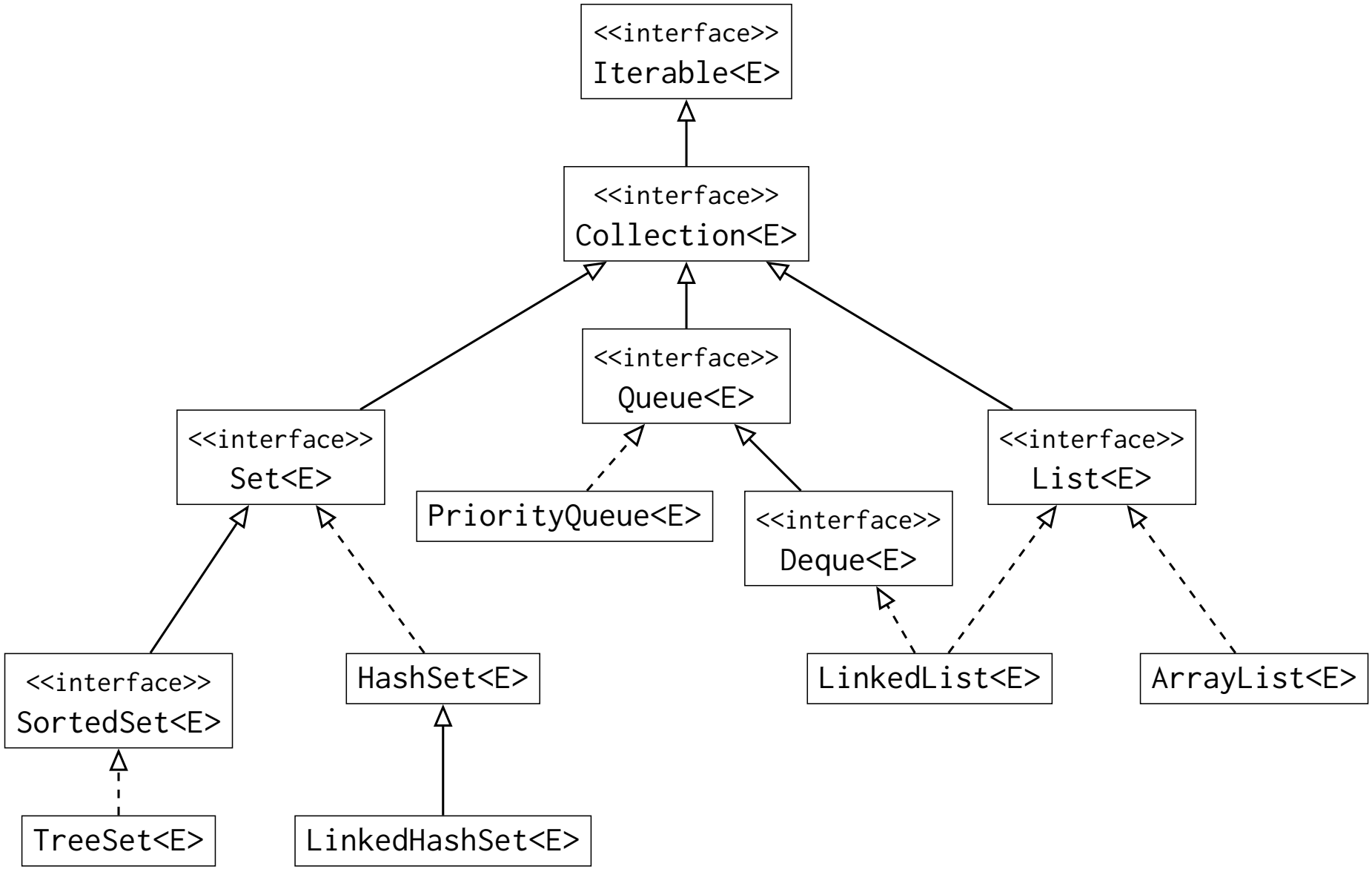

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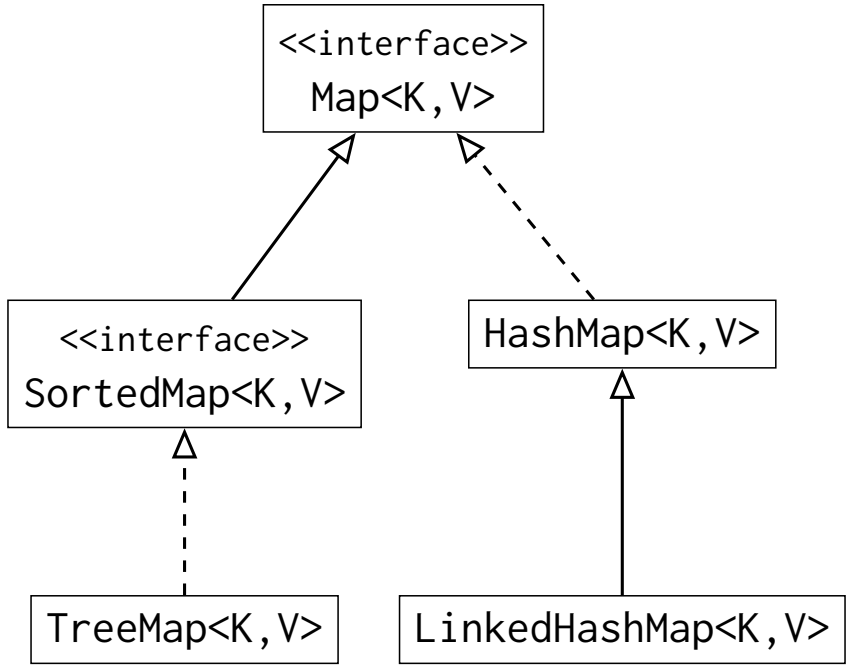
```
1  public interface Map<K,V> {
2      V get(Object key);      // return the value for key, or null
3      V put(K key, V value); // update so that key is mapped to value
4      V remove(Object key);  // remove key-value pair for key
5      ...
6      // collection views
7      Set<Map.Entry<K,V>> entrySet();
8      Set<K> keySet();
9      Collection<V> values();
10 }
```

Some Inheritance Relations on Maps



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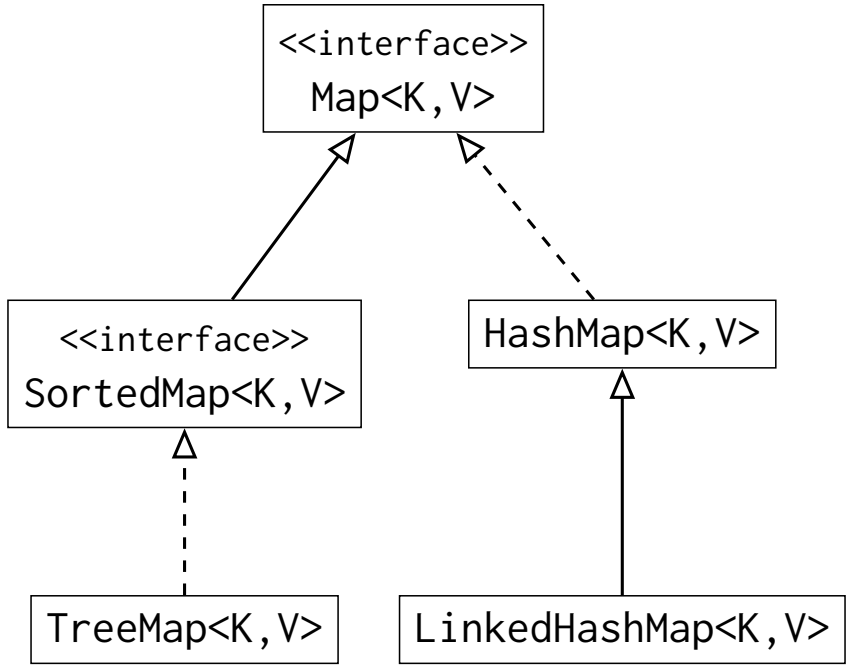

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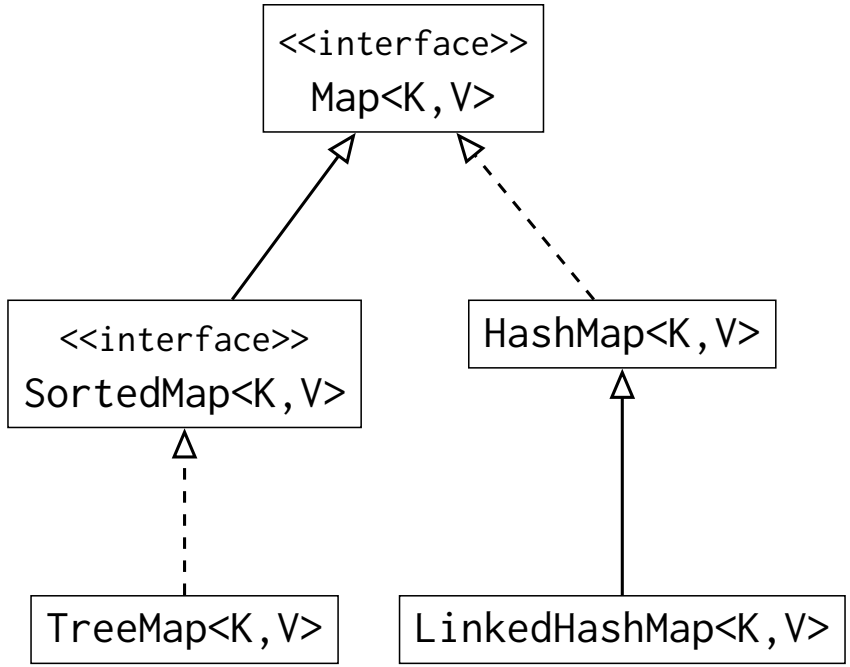

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That's no coincidence: the X-Set<K> classes that we've just seen are implemented via a X-Map<K,V> that maps to a dummy object. The map's keys have the role of the set elements.

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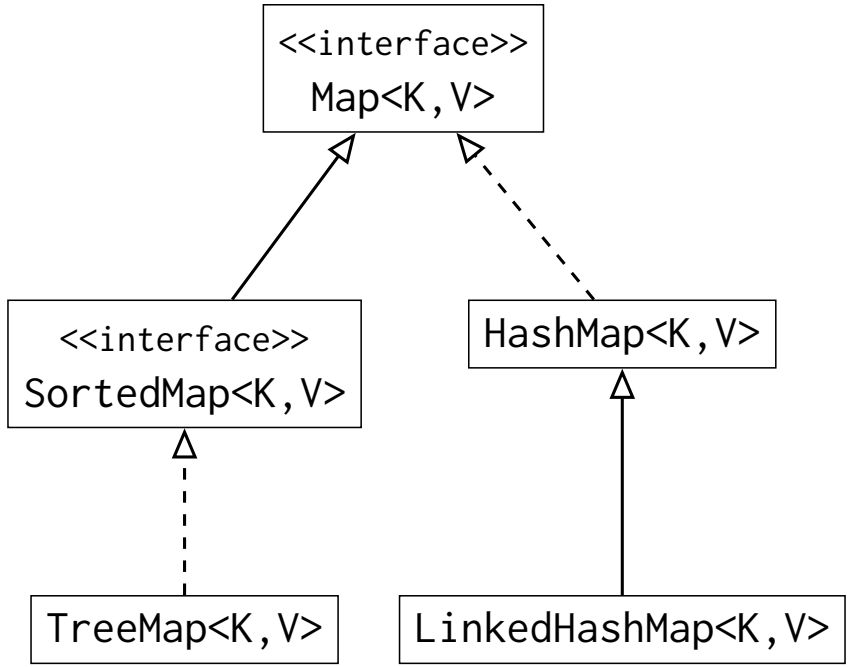

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That's no coincidence: the X-Set<K> classes that we've just seen are implemented via a X-Map<K,V> that maps to a dummy object. The map's keys have the role of the set elements.

So, X-Map<K,V> has similar requirements on its keys as X-Set<K> has on its elements.

Helper class: `Collections`

Class `Collections` in package `java.util` contains many useful **`public static`** helper methods for sorting, checking that there are no common elements, ...

https://docs.oracle.com/en/java/javase/17/docs/api/java.base/java/util/Collections.html

“Cheat Sheet”: Avoiding Collection Pitfalls in Java

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- Holds for `equals` and `hashCode` in a new class (that inherits them from `Object`). But if you override `equals(Object o)`, do **remember** to override also `hashCode()`!

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- When in doubt between `HashSet` and `LinkedHashSet`: use `HashSet` only if you know that you (or code called by you, or your users) will **never** iterate over the set — `LinkedHashSet` (since Java 1.4) is almost always the better choice.

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- `SortedSet<E>` needs an order over `E` that is consistent with `equals`: `x.compareTo(y) == 0` if and only if `x.equals(y)`.
- Same considerations as for `X-Set<E>` also hold for `X-Map<E,V>` (and iteration over their `entrySet()`/`keySet()` views).

Type wildcards

Will the compiler accept this?

```
1 List<Animal> animals1 = new ArrayList<Animal>();
```

Type wildcards

Will the compiler accept this?

```
1 List<Animal> animals1 = new ArrayList<Animal>();
```

And this?

```
1 List<Animal> animals2 = new ArrayList<Dog>();
```

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And this?

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Problem:

```
1 List<Dog> dogs = new ArrayList<Dog>();
2 List<Animal> animals = dogs; // compiler says "no" here.
3 animals.add(new Cat()); // ok, Cat is a subclass of Animal
4 Dog d = dogs.get(0); // Type error! That's a Cat, not a Dog!
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```

Solution:

```
1 List<? extends Animal> myAnimals = new ArrayList<Dog>();
```

Type wildcards

Will the compiler accept this?

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Solution:

```
1 List<? extends Animal> myAnimals = new ArrayList<Dog>();
```

upper-bounded wildcard

Type wildcards

Solution:

```
1 List<? extends Animal> myAnimals1 = new ArrayList<Dog>();
2 List<? extends Animal> myAnimals2 = new ArrayList<Animal>();
```

Type wildcards

Solution:

```
List<? extends Animal> myAnimals1 = new ArrayList<Dog>();
List<? extends Animal> myAnimals2 = new ArrayList<Animal>();
```

Wildcards are useful for method parameters:

```
    public void makeThemBark(List<? extends Dog> dogs) {
        for (Dog d : dogs) {
            d.bark();
        }
    }
```

Type wildcards

Solution:

```
List<? extends Animal> myAnimals1 = new ArrayList<Dog>();
List<? extends Animal> myAnimals2 = new ArrayList<Animal>();
```

Wildcards are useful for method parameters:

```
    public void makeThemBark(List<? extends Dog> dogs) {
        for (Dog d : dogs) {
            d.bark();
        }
    }
```

Elsewhere:

```
List<Dog> dogs = getDogs();
List<Labrador> labradors = getLabradors();
makeThemBark(dogs);      // same method for both List<Dog>
makeThemBark(labradors); // and List<Labrador>!
```

Type wildcards

Solution:

```
1 List<? extends Animal> myAnimals1 = new ArrayList<Dog>();
2 List<? extends Animal> myAnimals2 = new ArrayList<Animal>();
```

Wildcards are useful for method parameters:

```
1     public void makeThemBark(List<? extends Dog> dogs) {
2         for (Dog d : dogs) {
3             d.bark();
4         }
5     }
```

Elsewhere:

```
1 List<Dog> dogs = getDogs();
2 List<Labrador> labradors = getLabradors();
3 makeThemBark(dogs);      // same method for both List<Dog>
4 makeThemBark(labradors); // and List<Labrador>!
```

But:

```
1     public void doSomething(List<? extends Animal> animals) {
2         animals.add(new Cat()); // compiler says "no"
3     }
```

Topics on Day 9

- Java Collections.
- Maps.
- Type wildcards.