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An introduction to the Java Collections Framework

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2.2.1

A case for Iterators

java.util.Iterator

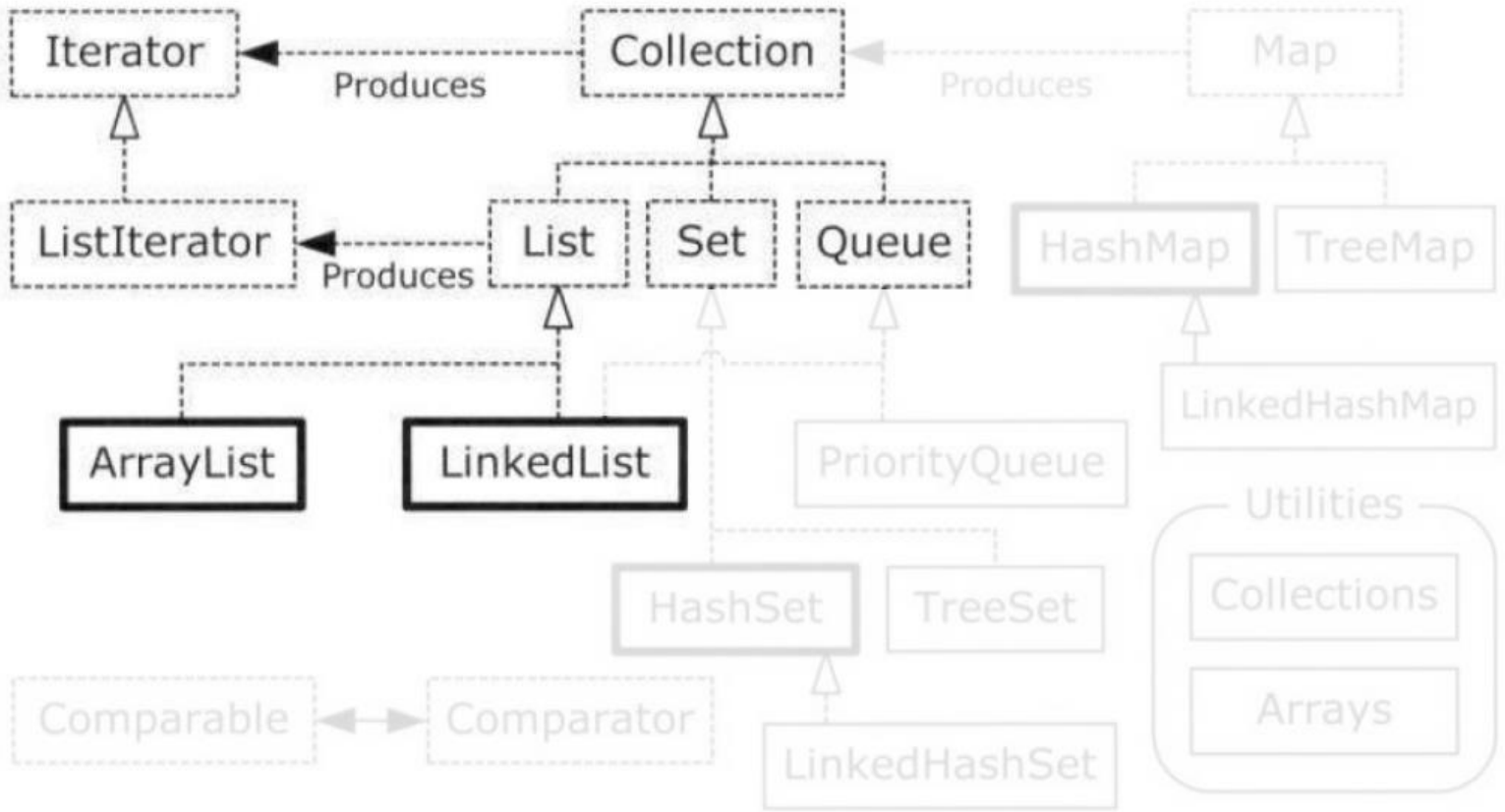

Image source: Thinking in Java (4th Edition), Bruce Eckel

java.util.Iterator – Notes (2)

- An **iterator** is a *lightweight object* that **moves** through a **sequence**.
- It **selects each element** of that **sequence** without having the programmer worry about the underlying type (i.e. enforces *loose coupling*).
- A usual interaction with an iterator would look like:
  1. Ask a `Collection` for an `Iterator`, by calling `iterator()`
  2. Get the next object in the sequence using `next()`
  3. See if there are more elements with `hasNext()`
  4. Remove the last element returned using `remove()`

java.util.Iterator – Quick example

```
public static void main(String[] args) {
    List<Pet> pets = Pets.arrayList(12);
    // Iteration via iterator
    Iterator<Pet> it = pets.iterator();
    while (it.hasNext()) {
        Pet p = it.next();
        System.out.print(p.id() + ":" + p + " ");
    }
    System.out.println();
    // A simpler approach, when possible:
    for (Pet p : pets)
        System.out.print(p.id() + ":" + p + " ");
    System.out.println();
    // An Iterator can also remove elements:
    it = pets.iterator();
    for (int i = 0; i < 6; i++) {
        it.next();
        it.remove();
    }
    System.out.println(pets);
}
```

ask for the collection's Iterator

if there are elements in the sequence

retrieve an element

use *foreach* when *reading*

remove the current element

Code source: Thinking in Java (4th Edition), Bruce Eckel

java.util.Iterator – A (better) typical use case

```
public class CrossContainerIteration {
    public static void display(Iterator<Pet> it) {
        while (it.hasNext()) {
            Pet p = it.next();
            System.out.print(p.id() + ":" + p + " ");
        }
        System.out.println();
    }

    public static void main(String[] args) {
        ArrayList<Pet> pets = Pets.arrayList(8);
        LinkedList<Pet> petsLL = new LinkedList<Pet>(pets);
        HashSet<Pet> petsHS = new HashSet<Pet>(pets);
        TreeSet<Pet> petsTS = new TreeSet<Pet>(pets);
        display(pets.iterator());
        display(petsLL.iterator());
        display(petsHS.iterator());
        display(petsTS.iterator());
    }
}
```

if there are elements in the sequence

retrieve an element via next()

ask for each container's Iterator

Code source: Thinking in Java (4th Edition), Bruce Eckel

2.4

Maps in Java

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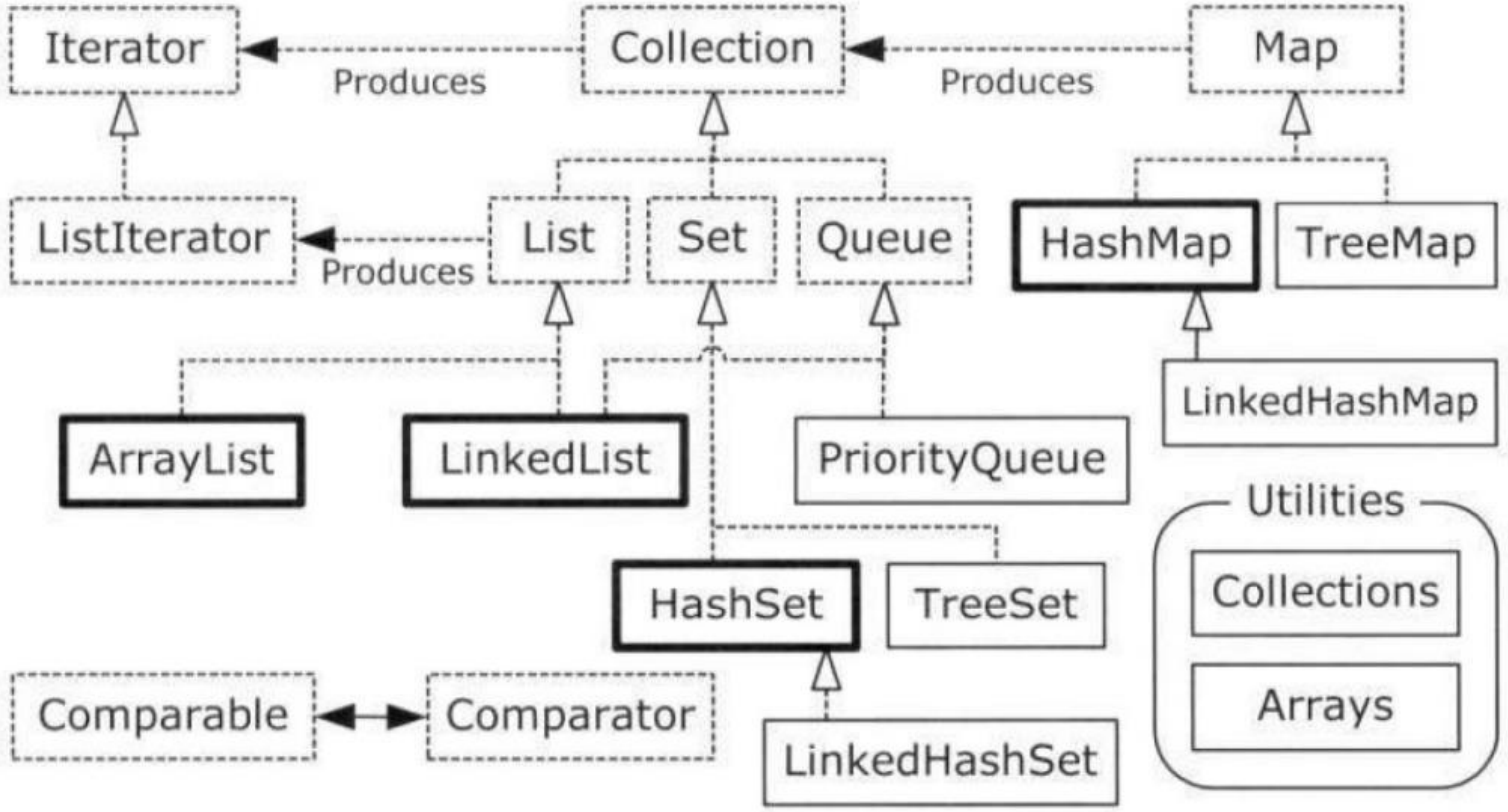
The java.util “toolbox”

Here’s an overview of the most often used Java containers:



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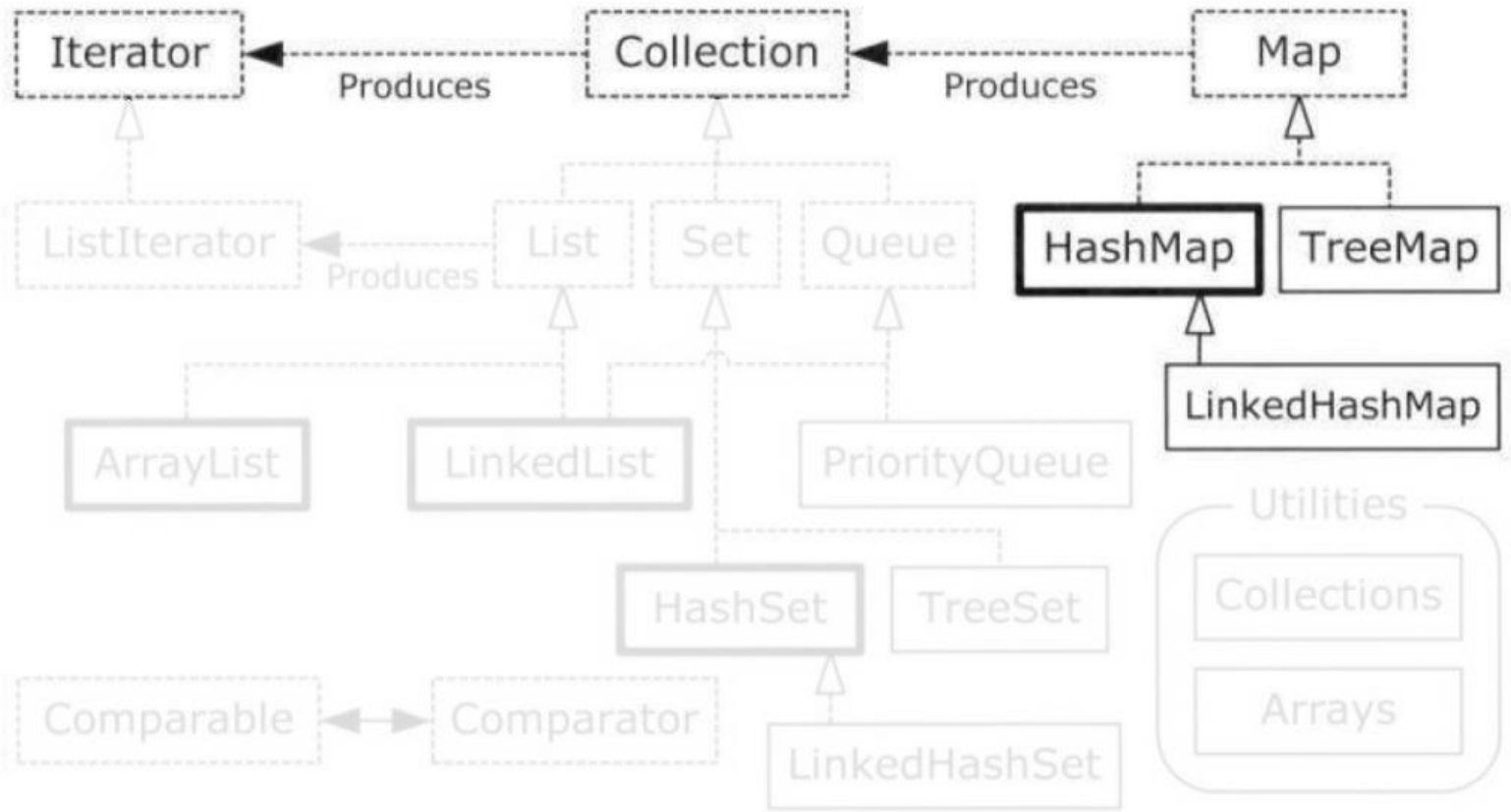
java.util.Map(s)



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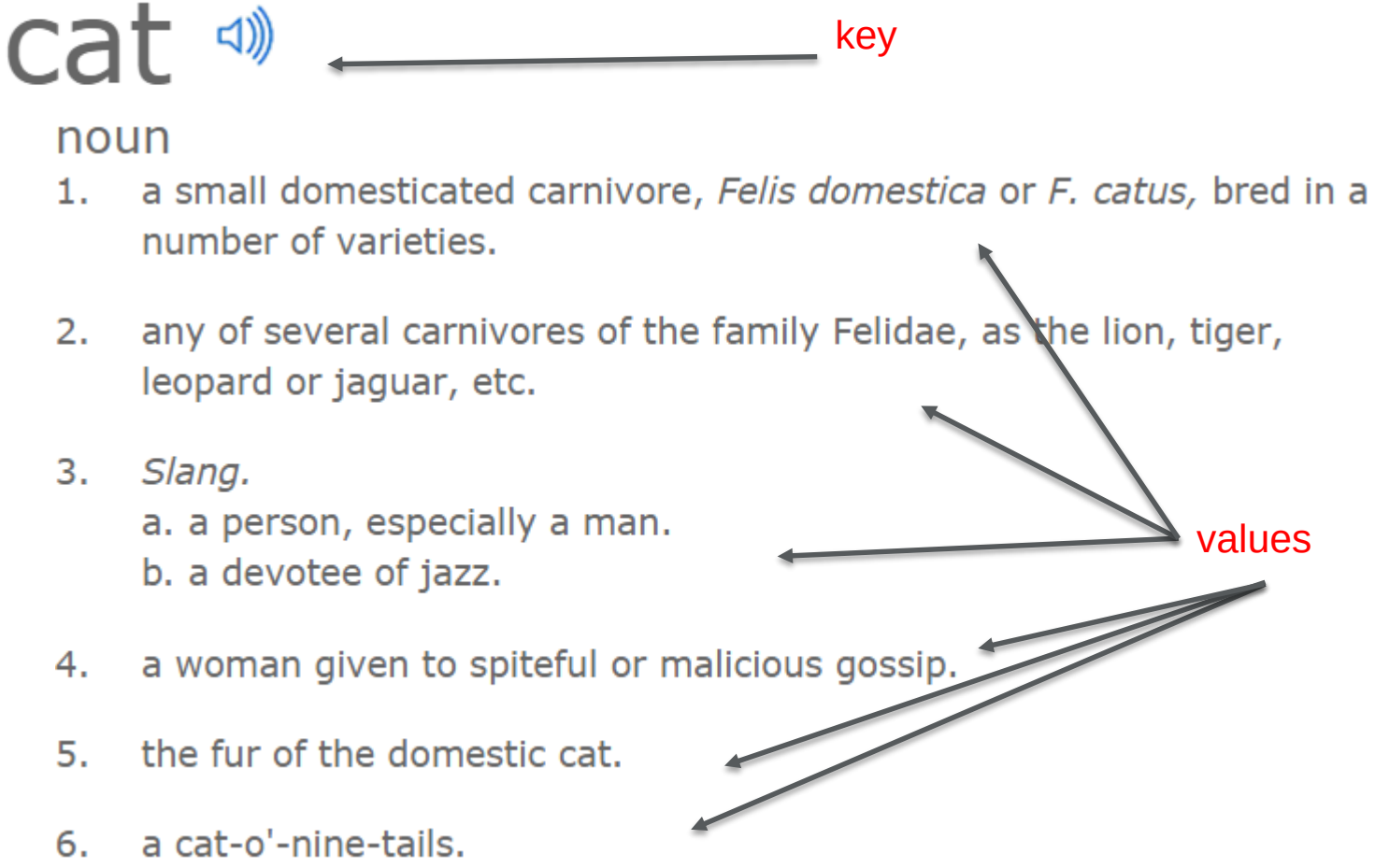
java.util.Map(s) – Notes

- Allows for a way to easily **associate objects with** other **objects**.
- It works on the principle of a **dictionary**: a **key maps** to one (or more) **associated value**(s).
- Maps use an inner class to store data: **`Entry<K,V>`**
- A **Map** can **return** a **`Set`** of its **keys**, a **`Collection`** of its **values** or a **`Set`** of its pairs (i.e. **entries**).
- **Automatic resizing** to accommodate new keys, if needed.

java.util.Map(s) – Notes (2)



java.util.Map(s) – Quick example

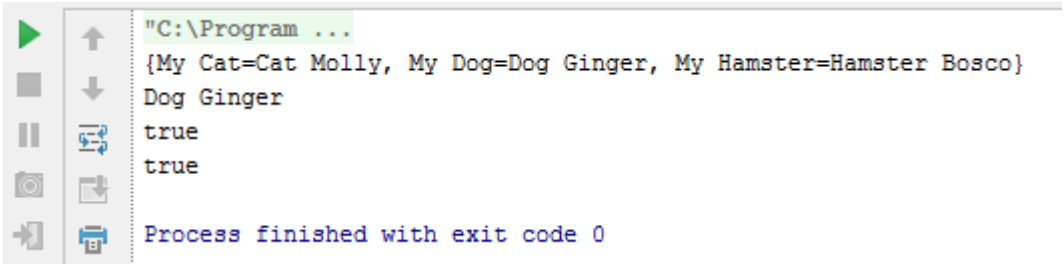
```
public static void main(String[] args) {
    Map<String, Pet> petMap = new HashMap<String, Pet>();

    petMap.put("My Cat", new Cat("Molly"));
    petMap.put("My Dog", new Dog("Ginger"));
    petMap.put("My Hamster", new Hamster("Bosco"));

    System.out.println(petMap);
    Pet dog = petMap.get("My Dog");
    System.out.println(dog);

    System.out.println(petMap.containsKey("My Dog"));
    System.out.println(petMap.containsValue(dog));
}
```

declaration establishes bounds on `<Key, Value>`

insert items via `put(key, value)`

retrieve an item via `get(key)`

keys are stored as a `Set`; values as a `Collection`



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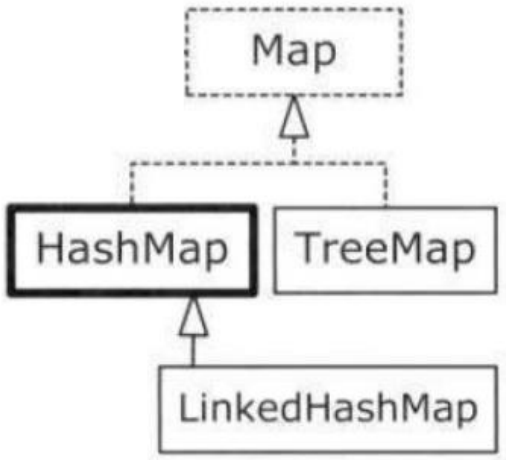
java.util.Map(s)



Maps are available in **many** flavors. The **three** most used are:

- `HashMap`
- `LinkedHashMap`
- `TreeMap`

Legacy:

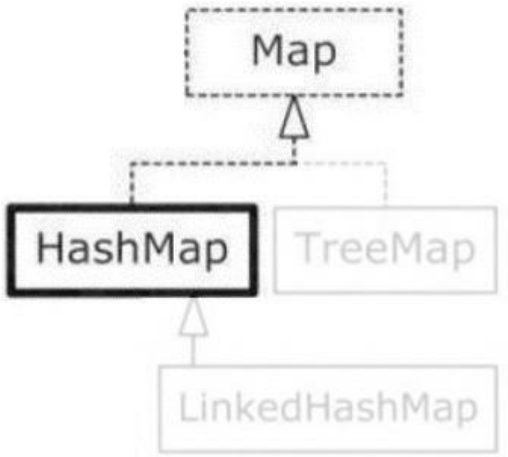
- `Hashtable`

  (old school, but offers **thread-safety**; now **replaced** by `ConcurrentHashMap`)

When and why would one use such data structures?

Image source: Thinking in Java (4th Edition), Bruce Eckel

java.util.HashMap



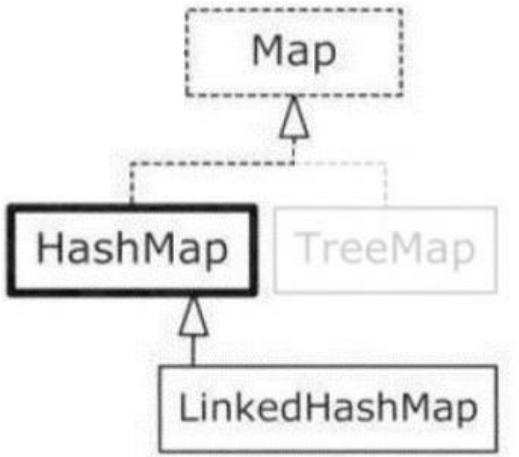
Implementation is based on the concept of a **hashtable**.

Insertion and locating of held pairs is done in near constant time – favors **lookup speed**.

Elements *appear* in no apparent **order**, because of hashing.

Image source: Thinking in Java (4th Edition), Bruce Eckel

java.util.LinkedHashMap



Similar to a `HashMap`, but keys are stored based on **insertion order**.

Can be tweaked (through a constructor param) to permit LRU behavior – useful for building *caches*.

Faster when **iterating** than a `HashMap`, because of underlying linked list used to keep internal order.

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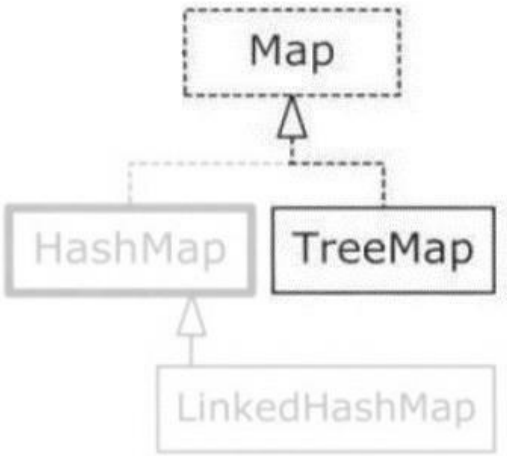
java.util.TreeMap



Underlying implementation is a **red-black tree** (holds entries, or *pairs*).

The pairs are stored in **sorted order**, based on a `Comparator`.

Slower than `HashMap` and `LinkedHashMap`.

Image source: Thinking in Java (4th Edition), Bruce Eckel

java.util.TreeMap – Quick example

```
public static void printKeys(Map<Integer, String> map) {
    System.out.println("Size = " + map.size() + ", ");
    System.out.println("Keys: ");
    System.out.println(map.keySet()); // Produce a Set of the keys
}

public static void test(Map<Integer, String> map) {
    System.out.println(map.getClass().getSimpleName());
    // Map has 'Set' behavior for keys:
    map.putAll(new CountingMapData(25));
    // Thus, no duplicate keys are added
    map.putAll(new CountingMapData(25));
    printKeys(map);
    // Producing a Collection of the values:
    System.out.println("Values: ");
    System.out.println(map.values());

    // Operations on the Set change the Map:
    Set<Integer> keySet = map.keySet();
    keySet.removeAll(map.keySet()); // A goofy alternative to map.clear() :)
    System.out.println("map.isEmpty(): " + map.isEmpty());
}

public static void main(String[] args) {
    test(new TreeMap<Integer, String>());
}
```

a method that prints the key set nicely (works w/ any Map implementation)

retrieve implementation name

we try to add duplicate keys

retrieve values as a collection

retrieve underlying key set and modify it

Code source: Thinking in Java (4th Edition), Bruce Eckel

java.util.TreeMap – Quick example

```
public static void printKeys(Map<Integer, String> map) {
    System.out.println("Size = " + map.size() + ", ");
    System.out.println("Keys: ");
    System.out.println(map.keySet()); // Produce a Set of the keys
}

public static void test(Map<Integer, String> map) {
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    // Operations on the Set change the Map:
    Set<Integer> keySet = map.keySet();
    keySet.removeAll(map.keySet()); // A goofy alternative to map.clear() :)
    System.out.println("map.isEmpty(): " + map.isEmpty());
}

public static void main(String[] args) {
    test(new TreeMap<Integer, String>());
}
```

```
"C:\Program ...
TreeMap
Size = 25,
Keys:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24]
Values:
[A0, B0, C0, D0, E0, F0, G0, H0, I0, J0, K0, L0, M0, N0, O0, P0, Q0, R0, S0, T0, U0, V0, W0, X0, Y0]
map.isEmpty(): true

Process finished with exit code 0
```


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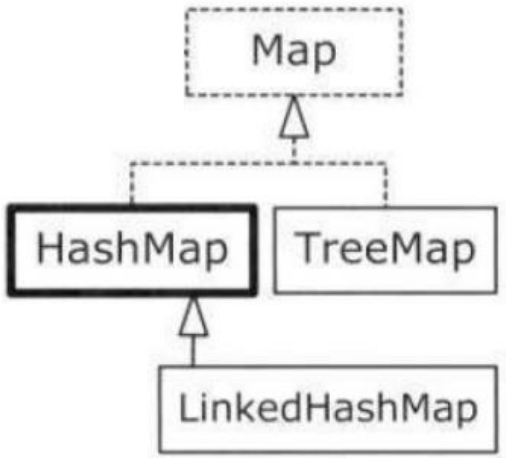
java.util.Map(s)



The most **common operations** you will do with/on a **Map** are:

- put(key, value)
- `get(key)`
- `entrySet().iterator()`
- `keySet()`
- `values()`
- `containsKey()`
- `containsValue()`
- `remove(key)`

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java.util.Map – Conclusions

- Work on the principle of a **dictionary**: a **key maps** to one (or more*) **associated value**(s).
- `HashMap(s)` are best used for **fast lookup time**.
- `LinkedHashMap(s)` have similar lookup time, and maintain an **order** based on **insertion**.
- `TreeMap(s)` focus on maintaining a **sorting order** for held keys.
- *Be aware, that the above* (`HashMap, LinkedHashMap, TreeMap`) *are not thread-safe!*

2.4.1

A word about `equals()` and `hashCode()`

`equals()` **method**

- Is inherited by all object instances from `java.lang.Object`
- Indicates whether some other object is "*equal to*" the current object, whose method is called.
- **Returns** `true` if the object is "equal to" the object that calls it and `false` otherwise

```
String s1 = "Pet";
String s2 = "Pet";
String s3 = "Pets";

System.out.println(s1.equals(s2)); // returns true
System.out.println(s1.equals(s3)); // returns false
```

`equals()` method constraints

- A proper implemented `equals()` method **must satisfy** the following **five conditions**:
  1. **Reflexive**: For any **x**, `x.equals(x)` should return `true`.
  2. **Symmetric**: For any **x** and **y**, `x.equals(y)` should return `true` if and only if `y.equals(x)` returns `true`.
  3. **Transitive**: For any **x**, **y**, and **z**, if `x.equals(y)` returns `true` and `y.equals(z)` returns `true`, then `x.equals(z)` should return `true`.

`equals()` method constraints (2)

4. **Consistent:** For any **x** and **y**, multiple invocations of `x.equals(y)` **consistently return `true`** or **consistently return `false`**, provided no information used in equals comparisons on the object is modified.

5. For any **non-null x**, `x.equals(null)` should **return `false`.**

Alright, alright enough theory!

- As you can see, a proper implementation of `equals()` is essential for your own classes to work well with the Java Collection classes.
  So how does one implement `equals()` "properly"?

- Q: When are two objects equal?
  A: That depends on your application, the classes, and what you are trying to do.

`equals()` and `hashCode()` example

```
public class WeekDay {

    private final int id;
    private final String name;

    private static String[] daysNames = new String[]{"MON", "TUE", "WED", "THU", "FRI", "SAT", "SUN"};

    public WeekDay(int id) {...}

    public String getName() { return name; }

    @Override
    public String toString() { return name; }
}
```

- You could decide that two `WeekDay` objects are equal to each other if only their `ids` are *equal*.
- Or, you could decide that all fields must be used to establish equality (i.e. `id` and `name`, above), provided they are *immutable/unchangeable* (a.k.a. `final` as in above examples).

`equals()` example (2)

```
@Override
public boolean equals(Object o) {
    if (this == o) return true;
    if (o == null || getClass() != o.getClass()) return false;

    WeekDay weekDay = (WeekDay) o;

    if (id != weekDay.id) return false;
    if (!name.equals(weekDay.name)) return false;

    return true;
}
```

we check if object **references** match

we also check if **types** are the same

we then proceed by checking immutable fields

`String` objects already have `.equals()` implemented; so use that

`hashCode()` **method**

- Is inherited by all objects instances, from java.lang.Object
- Used when you insert an Object into a `HashSet`, `LinkedHashSet`, `HashMap` or `LinkedHashMap` to identify appropriate underlying bucket to store an entry.
- Returns an `int`, representing the `hash code` or `hash` value for the Object for which this method was called upon.

```
Integer i = 7;
Double d = 4.25;
String s = "Pets";

System.out.println(i.hashCode()); // prints 7
System.out.println(d.hashCode()); // prints 1074855936
System.out.println(s.hashCode()); // prints 2484052
```

`hashCode()` **method (2)**

- When inserting an object into a `HashSet`, `LinkedHashSet`, `HashMap` or `LinkedHashMap` you use a key.
- The hash code of this key is calculated, and used to determine where to **store** the object internally (which bucket).
- Later, when you need to lookup an object you also use a key – the same key as before.
- The hash code of this key is calculated and used to determine where to **search** for the object, in the list internal storage.

`hashCode()` **rules**

1. If `object1` and `object2` are equal according to their `equals()` method, they must also have the same hash code.

2. If `object1` and `object2` have the **same hash code**, they **do NOT have to be equal too**.

`hashCode()` **recipe** (Joshua Bloch):

1. Store some constant nonzero value, say *17*, in an `int` variable called `result`.
2. For each significant field in your object (that is, each field taken into account by the `equals()` method), calculate an `int` hash code, "`c`" :
3. For each "`c`", combine the hash code(s) computed above with `result`:

```
result = 31 * result + c;
```

4. Finally, return **result**.
5. Test/Use the resulting hash code in your code

`hashCode()` example

```
@Override
public int hashCode() {
    int result = id;
    result = 31 * result + name.hashCode();

    return result;
}
```

object of type `String` already have `.hashCode()` implemented/overridden; so use that

hashCode() recipe (2)

Field type	Calculation
boolean	**c = (f ? 0 : 1)**
byte, char, short, or **int**	**c = (int)f**
long	**c = (int)(f ^ (f>>>32))**
float	**c = Float.floatToIntBits(f);**
double	**long l = Double.doubleToLongBits(f);** **c = (int)(l ^ (l>>>32))**
Object, where **equals( )** calls **equals( )** for this field	**c = f.hashCode( )**
Array	Apply above rules to each element

lower-case “L”

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Thank you!

Questions or comments on these topics and more, are welcome:

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