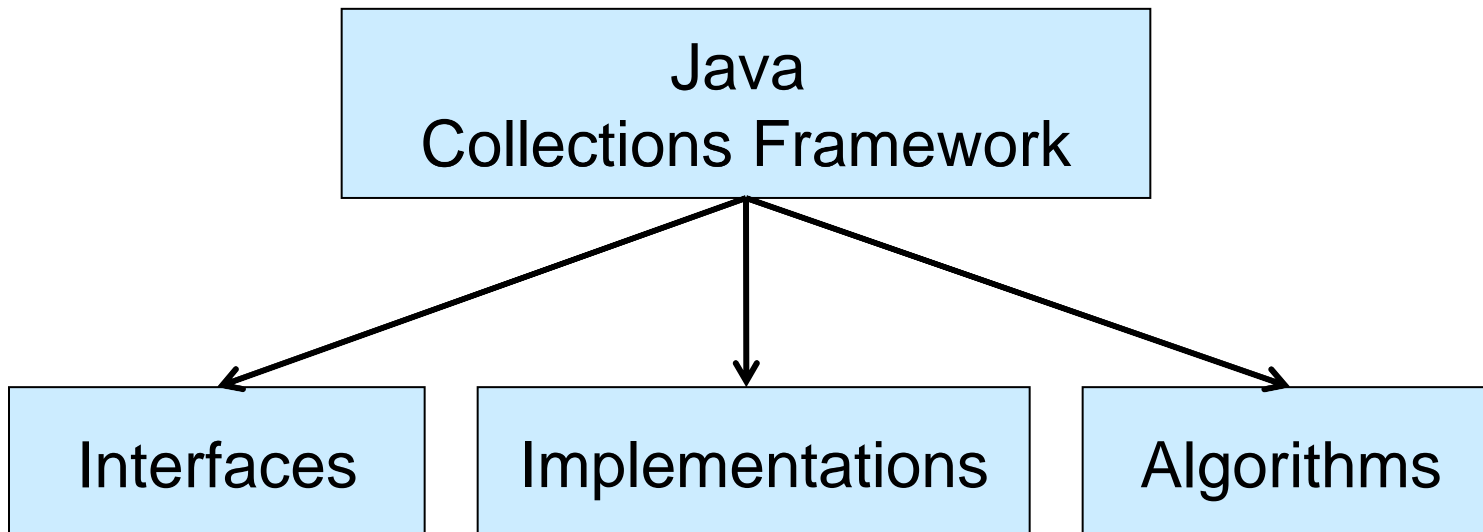
תוכנה 1

תרגול 8 – מבני נתונים גנריים

Java Collections Framework

- **Collection**:
  a group of elements

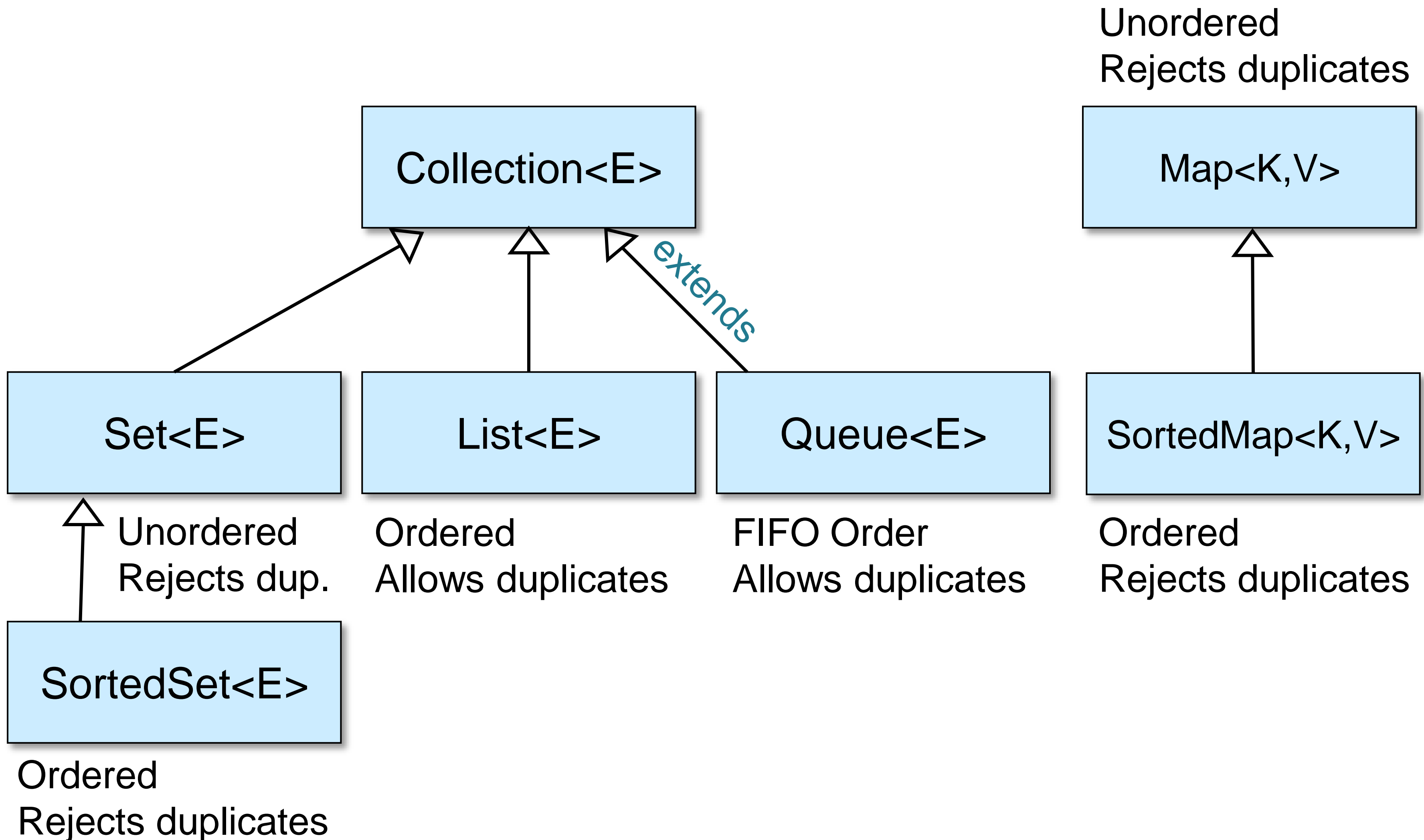
- <u>Interface Based Design</u>:



Online Resources

- Java 7 API Specification of the Collections Framework: https://docs.oracle.com/javase/8/docs/technotes/guides/collections/reference.html
- Oracle Tutorial: http://docs.oracle.com/javase/tutorial/collections/

Collection Interfaces



A Simple Example

```
Collection<String> stringCollection = …
Collection<Integer> integerCollection = …

stringCollection.add("Hello");
integerCollection.add(5);
integerCollection.add(new Integer(6));

stringCollection.add(7);
integerCollection.add("world");
stringCollection = integerCollection;
```

A Simple Example

```
Collection<String> stringCollection = …
Collection<Integer> integerCollection = …

stringColle
integerColl
integerCollection.add(new Integer(6));

stringCollection.add(7);
integerCollection.add("world");
stringCollection = integerCollection;
```

- מצביעים ל Collection של מחרוזות ושל מספרים
- Collection אינו מחזיק טיפוסים פרימיטיביים, לכן נשתמש ב Integer, Double, Float וכדומה
- נראה בהמשך אילו מחלקות ממשות מנשק זה

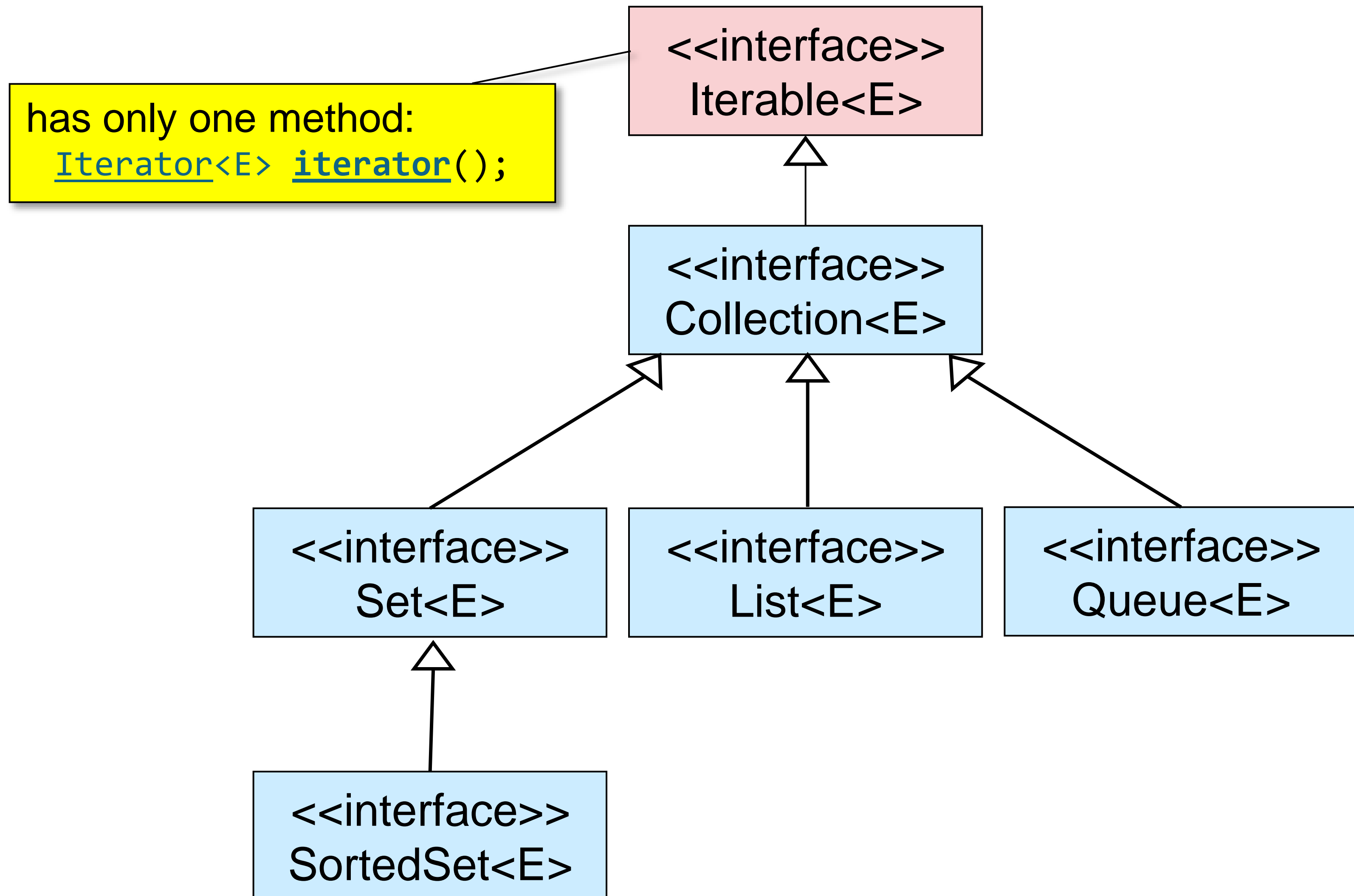
A Simple Example

```
Collection<String> stringCollection = …
Collection<Integer> integerCollection = …

stringCollection.add("Hello");
integerCollection.add(5);
integerCollection.add(new Integer(6));

stringCollection.add(7);
integerCollection.add("world");
stringCollection = integerCollection;
```

Collection extends Iterable



The `Iterator` Interface

- Provide a way to access the elements of a collection sequentially without exposing the underlying representation

- Methods:
  - `hasNext()` - Returns true if there are more elements
  - `next()` - Returns the next element
  - `remove()` - Removes the last element returned by the iterator (optional operation)

Command and Query!

Iterating over a Collection

- Explicitly using an Iterator

```
for (Iterator<String> iter = stringCollection.iterator();
     iter.hasNext(); ) {
    System.out.println(iter.next());
}
```

- Using foreach synatx

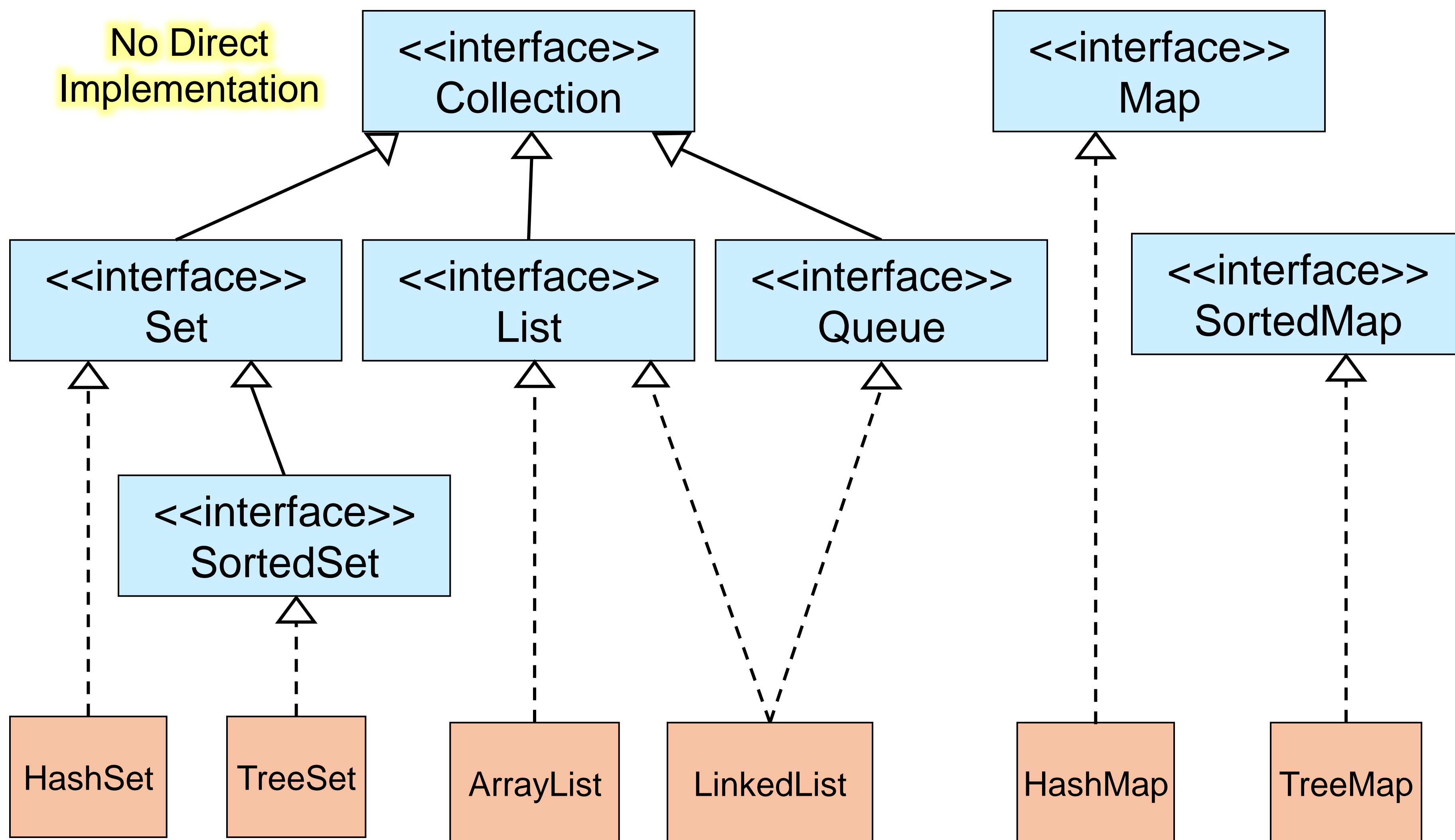
```
for (String str : stringCollection) {
    System.out.println(str);
}
```

General Purpose Implementations

- Class Name Convention: <Data structure> <Interface>

General Purpose Implementations		Data Structures			
		Hash Table	**Resizable Array**	**Balanced Tree**	**Linked**
Interfaces	**Set**	HashSet		TreeSet (SortedSet)	LinkedHashSet
	Queue		ArrayDeque		LinkedList
	List		ArrayList		LinkedList
	Map	HashMap		TreeMap (SortedMap)	LinkedHashMap

Adding Implementations to the Picture



List Example

```
List<Integer> list = new ArrayList<Integer>();
list.add(3);
list.add(1);
list.add(new Integer(1));
list.add(new Integer(6));
list.remove(list.size()-1);
System.out.println(list);
```

Output:
[3, 1, 1]

Interface

Implementation

List holds Integer references (auto-boxing)

List allows duplicates

Invokes List.toString()

Insertion order is kept

remove() can get *index* or *reference* as argument

Set Example

```
Set<Integer> set = new HashSet<Integer>();
set.add(3);
set.add(1);
set.add(new Integer(1));
set.add(new Integer(6));
set.remove(6);
System.out.println(set);
```

A set does not allow duplicates.
It **does not** contain:
- two references to the same object
- two references to null
- references to two objects a and b such that a.equals(b)

remove() can get only *reference* as argument

```
Output: [1, 3] or [3, 1]
```

Insertion order is not guaranteed (unlike `LinkedHashSet`)

Queue Example

```
Queue<Integer> queue = new LinkedList<Integer>();
queue.add(3);
queue.add(1);
queue.add(new Integer(1));
queue.add(new Integer(6));
queue.remove();
System.out.println(queue);
```

Elements are added at the end of the queue

`remove()` may have no argument – head is removed

Output: `[1, 1, 6]`

FIFO order

Map Example

```
Map<String, String> map = new HashMap<String,
 String>();
map.put("Dan", "03-9516743");
map.put("Rita", "09-5076452");
map.put("Leo", "08-5530098");
map.put("Rita", "06-8201124");
System.out.println(map);
```

Output:

```
{Leo=08-5530098, Dan=03-9516743, Rita=06-8201124}
```

No key duplicates

Unordered

Keys (names)	Values (phone numbers)
Dan	03-9516743
Rita	06-8201124
Leo	08-5530098

LinkedHashMap Example

```
Map<String, String> map = new LinkedHashMap<String, String>();
map.put("Dan", "03-9516743");
map.put("Rita", "09-5076452");
map.put("Leo", "08-5530098");
map.put("Rita", "06-8201124");
System.out.println(map);
```

Insertion order (first time key insertion)

Output:

```
{Dan=03-9516743, Rita=06-8201124, Leo=08-5530098}
```

Keys (names)	Values (phone numbers)
Dan	03-9516743
Rita	06-8201124
Leo	08-5530098

SortedMap Example

```
SortedMap <String,String> map = new TreeMap<String,String> ();
map.put("Dan", "03-9516743");
map.put("Rita", "09-5076452");
map.put("Leo", "08-5530098");
map.put("Rita", "06-8201124");
System.out.println(map);
```

lexicographic order

Output:

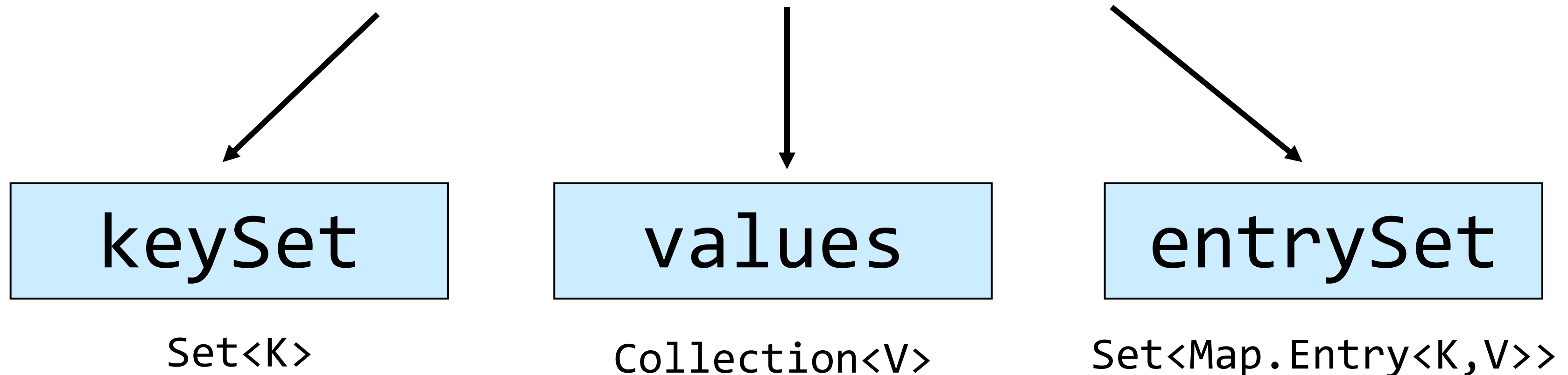
```
{Dan=03-9516743, Leo=08-5530098, Rita=06-8201124}
```

Keys (names)	Values (phone numbers)
Dan	03-9516743
Leo	08-5530098
Rita	06-8201124

Map Collection Views

A `Map` is not `Iterable`!

Three views of a `Map<K,V>` as a collection



The `Set` of key-value pairs (implement `Map.Entry`)

Iterating Over the Keys of a Map

```
Map<String,String> map = new  HashMap<String,String> ();
map.put("Dan", "03-9516743");
map.put("Rita", "09-5076452");
map.put("Leo", "08-5530098");
map.put("Rita", "06-8201124");

for (String key : map.keySet()) {
  System.out.println(key);
}
```

Output:
```
Leo
Dan
Rita
```

Iterating Over the Key-Value Pairs of a Map

```
Map<String,String> map = new HashMap<String,String> ();
map.put("Dan", "03-9516743");
map.put("Rita", "09-5076452");
map.put("Leo", "08-5530098");
map.put("Rita", "06-8201124");

for (Map.Entry<String,String> entry: map.entrySet()) {
      System.out.println(entry.getKey() + ": " +
      entry.getValue());
}
```

Output:

```
Leo: 08-5530098
Dan: 03-9516743
Rita: 06-8201124
```

Collection Algorithms

- Defined in the Collections class
- Main algorithms:
  - sort
  - binarySearch
  - reverse
  - shuffle
  - min
  - max

Sorting and Comparing

- Sort a `List l` by `Collections.sort(l);`
- If the list consists of `String` objects it will be sorted in lexicographic order. Why?
- `String` implements the interface `Comparable<String>`:

```
public interface Comparable<T> {
     public int compareTo(T other);
}
```

  - Returns

	a negative value	if this < other
	zero	if this.equals(other)
	a positive value	if this > other

- Error when sorting a list whose elements
  - do not implement `Comparable` or
  - are not *mutually comparable*.
- User defined comparator
  - `Collections.sort(List, Comparator);`

Comparable and Comparator Example

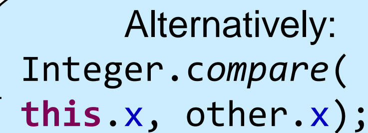
- Write the class `Point` that represents a point in the plane
- How to sort List<Point>?
  - By the x value? By the y value? Distance from the origin?...

```
public class Point {
        private int x;
        private int y;
        ...
}
```

- Two options --
  - Make Point implement `Comparable<Point>`, and use `Collections.sort`
  - Write a class that implements `Comparator<Point>`, and pass it as an argument to `Collections.sort`.
  - **Don't:** write a sorting algorithm yourselves!
- **Recommended Tutorial:** http://docs.oracle.com/javase/tutorial/collections/interfaces/order.html

Implementing Comparable

```
public class Point implements Comparable<Point>{
  …
  public int compareTo(Point other) {
        //comparison by the x axis
        return this.x - other.x;
  }
}
```

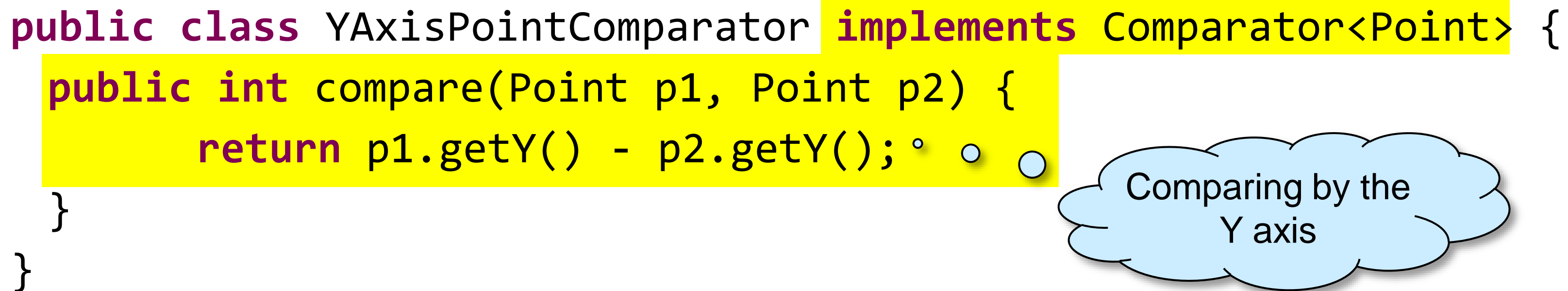


- The program:

```
List<Point> pointList = new LinkedList<Point>();
pointList.add(new Point(1, 3));
pointList.add(new Point(0, 6));
Collections.sort(pointList);
System.out.println(pointList);
```

- Output: [(0,6), (1,3)]

Writing a Comparator




```java
public class YAxisPointComparator implements Comparator<Point> {
  public int compare(Point p1, Point p2) {
      return p1.getY() - p2.getY();
  }
}
```

- The program:

```java
List<Point> pointList = new LinkedList<Point>();
pointList.add(new Point(1, 3));
pointList.add(new Point(0, 6));
Collections.sort(pointList, new YAxisPointComparator());
System.out.println(pointList);
```

- The output: [(1,3), (0,6)]
- Useful for sorting existing classes (e.g., String)

Best Practice <with generics>

- Specify an element type only when a collection is instantiated:

```
Set<String> s = new HashSet<String>();
```

Interface — Implementation

```
public void foo(HashSet<String> s){…}
public void foo(Set<String> s) {…}
```

`s.add()` invokes `HashSet.add()`

Works, but…

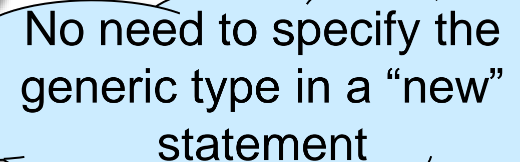
Better!

polymorphism

Diamond Notation

```
Set<String> s = new HashSet<String>();
```

```
➔ Set<String> s = new HashSet<>();
```




```
Map<String, List<String>> myMap =
        new HashMap<String, List<String>>();
```

```
➔ Map<String, List<String>> myMap = new HashMap<>();
```

Not the same as:

```
Map<String, List<String>> myMap = new HashMap();
```

(Compilation warning)