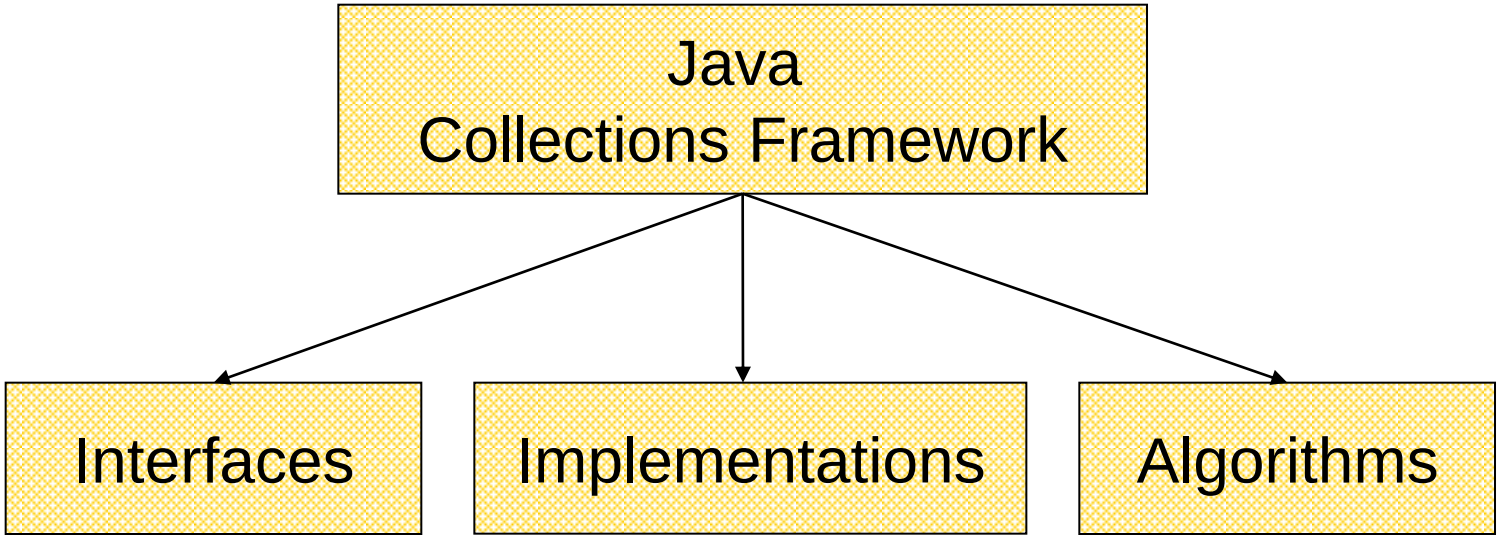
תוכנה 1

תרגול 6 – מבני נתונים גנריים

הדס צור ואסף זריצקי

Java Collections Framework

- **Collection**: a group of elements
- <u>Interface Based Design</u>:

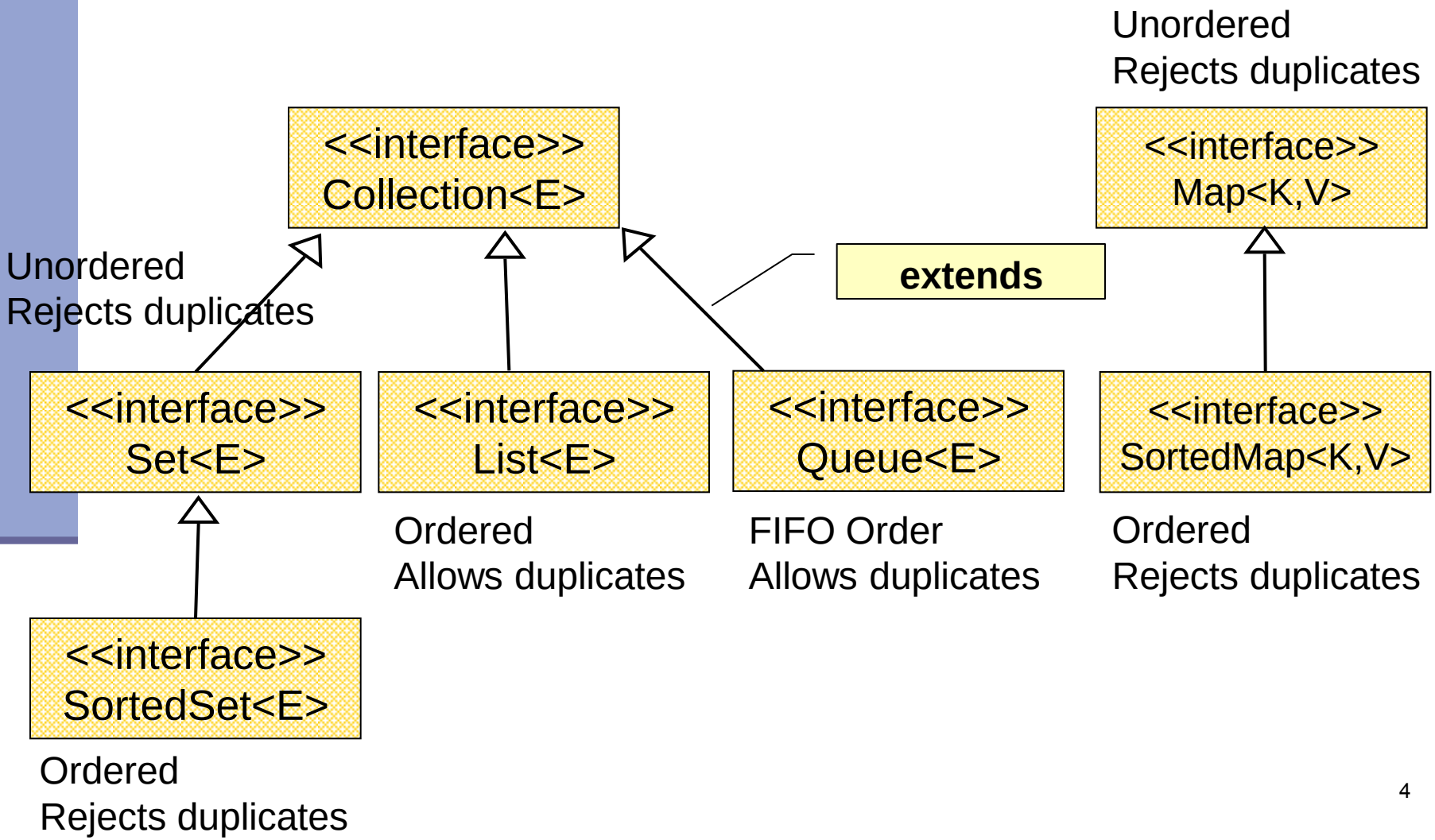


Online Resources

- Java 6 API Specification:
  http://java.sun.com/javase/6/docs/api/
  - The Collections framework in java.util

- Sun Tutorial:
  http://java.sun.com/docs/books/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 = ...

stringCollectio
integerCollect
integerCollect

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 מממשות 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;
```

Best Practice <with generics>

- Specify an element type only when a collection is instantiated:
  - `Set<String> s = new HashSet<String>();`

    Interface — Implementation

Works, but…

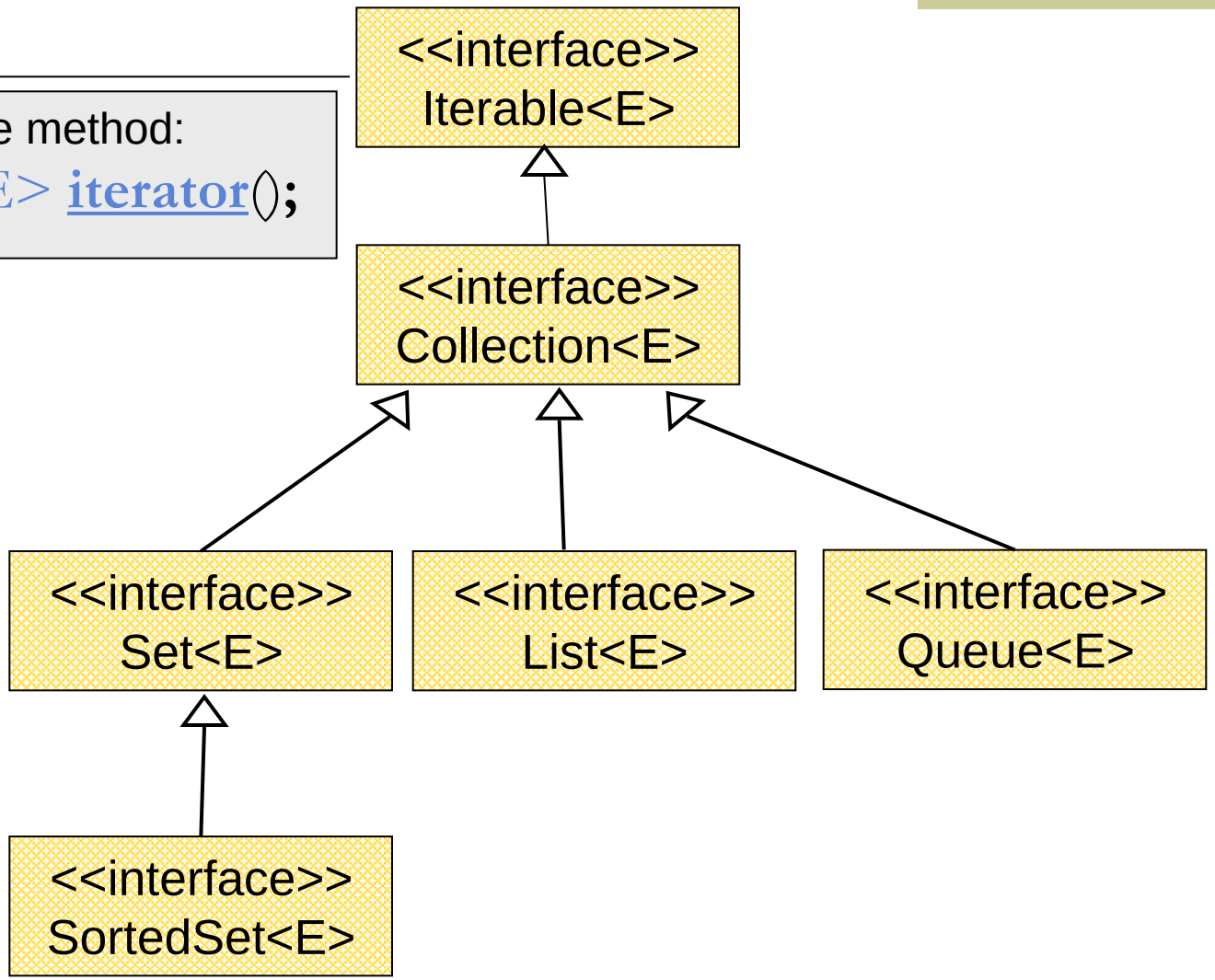
  - `public void foo(HashSet<String> s){…}`
  - `public void foo(Set<String> s) {…}`
  - `s.add()` invokes `HashSet.add()`

Better!

polymorphism

Collection extends Iterable

has only one method:
Iterator<E> **iterator**();



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

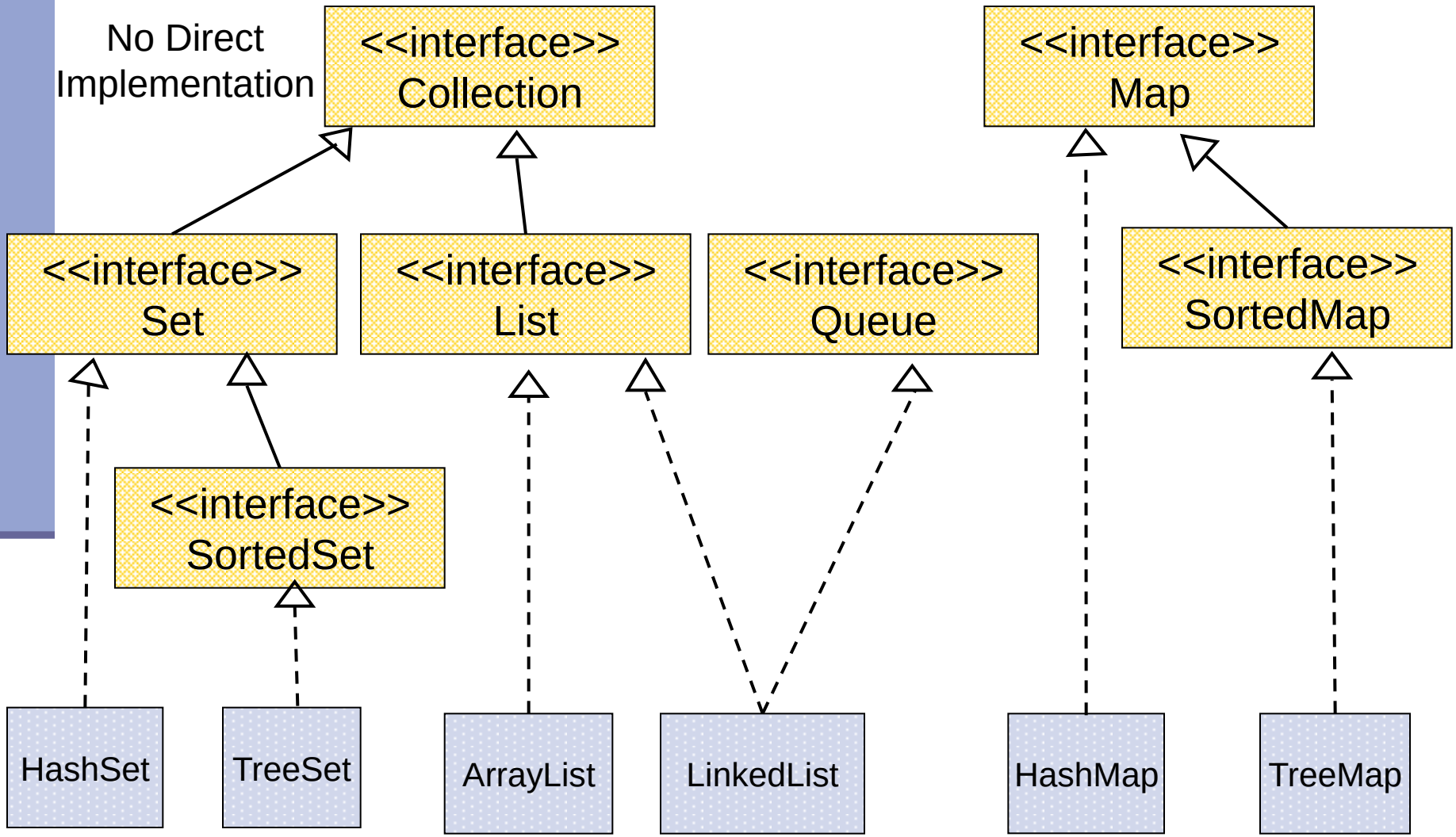
```
for (String str : stringCollection) {
    System.out.println(str);
}
```

Collection Implementations

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

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

General Purpose Implementations



List Example

Interface

```
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);
```

Implementation

`List` holds `Integer` references (auto-boxing)

List allows duplicates

Invokes `List.toString()`

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

Insertion order is kept

Output:
[3, 1, 1]

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

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);
```

No duplicates

Unordered

Output:

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

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

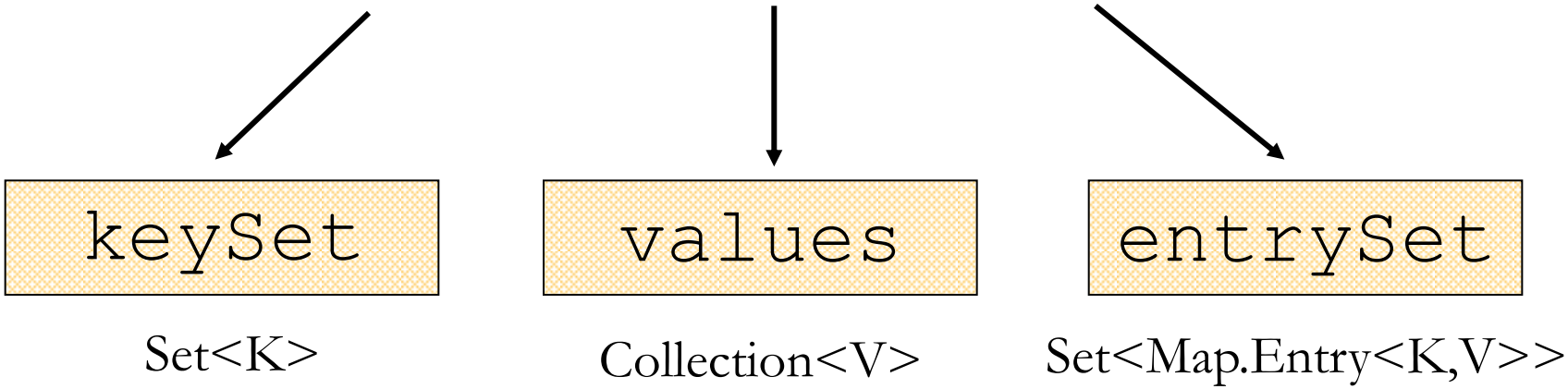
Output:

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

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

Map Collection Views

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

<u>Output</u>:

```
Leo
Dan
Rita
```

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 (Iterator<Map.Entry<String,String>> iter= map.entrySet().iterator();
    iter.hasNext(); ) {
    Map.Entry<String,String> entry = iter.next();
    System.out.println(entry.getKey() + ": " + entry.getValue());
}
```

Output:

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

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
  - Similar to Arrays
- Main algorithms:
  - sort
  - binarySearch
  - reverse
  - shuffle
  - min / max

Sorting

bridge between array-based and collection-based APIs

```
public class SortExample {
    public static void main(String args[]) {
        List<String> list = Arrays.asList(args);

        System.out.println("Before sort: " + list);
        Collections.sort(list);
        System.out.println("After sort: " + list);
    }
}
```

- Sorts the list according to the *natural ordering* of its elements
- All elements in the list must implement the Comparable interface

Sorting User Defined Class

- We need to implement the *Comparable* interface

Can compare two Student objects

```
public class Student implements Comparable<Student> {
    private int id;
    private String name;

    @Override
    public int compareTo(Student o) {
        return id - o.id;
    }

    // more methods ...
}
```

id based comparison

Sorting User Defined Class

- Now we can use Collections.sort

```
public static void main(String[] args) {
    List<Student> students = new ArrayList<Student>();
    students.add(new Student(100, "Hadas"));
    students.add(new Student(50, "Lior"));
    students.add(new Student(1, "Mati"));
    students.add(new Student(200, "Assaf"));

    System.out.println("Before sort: " + students);
    Collections.sort(students);
    System.out.println("After sort: " + students);
}
```

Before sort: [<Hadas, 100>, <Lior, 50>, <Mati, 1>, <Assaf, 200>]
After sort: [<Mati, 1>, <Lior, 50>, <Hadas, 100>, <Assaf, 200>]

Unnatural Sort

- Sort objects that don't implement *Comparable*
- Define a different ordering (e.g. students by name)
- Provide the *sort* algorithm a comparison function
  - implement ***Comparator<T>***

```
public class StudentNameComparator
   implements Comparator<Student> {

    public int compare(Student s1, Student s2) {
        return s1.getName().compareTo(s2.getName());
    }
}
```