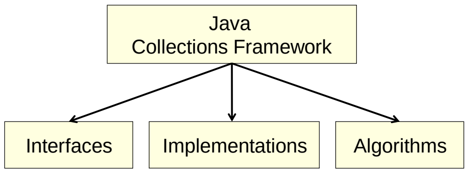
תוכנה 1

תרגול 8 – מבני נתונים גנריים

Java Collections Framework

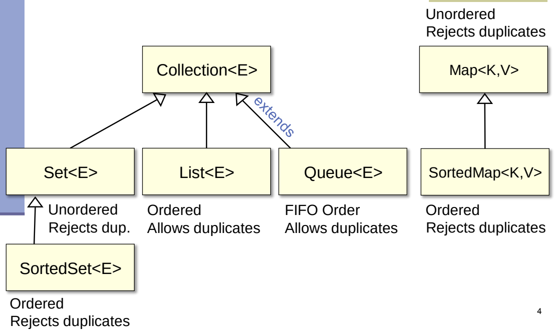
- **Collection**: a group of elements
- Interface Based Design:



Online Resources

- Java 7 API Specification:
  http://docs.oracle.com/javase/7/docs/api/
  - The Collections framework is in java.util
- 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;
```

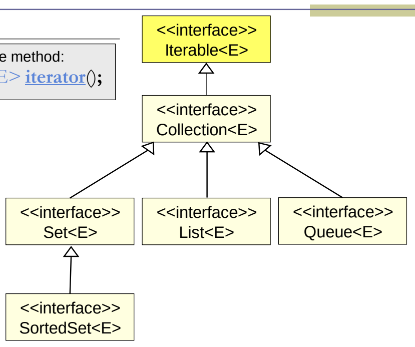
A Simple Example

```
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 מממשות מנשק זה

`Collection` extends `Iterable`

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


<<interface>> Iterable<E>
<<interface>> Collection<E>
<<interface>> Set<E>
<<interface>> List<E>
<<interface>> Queue<E>
<<interface>> SortedSet<E>

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A Simple Example

```
Collection<String> stringCollection = …
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integerCollection.add("world");
stringCollection = integerCollection;
```

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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);
}
```

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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!

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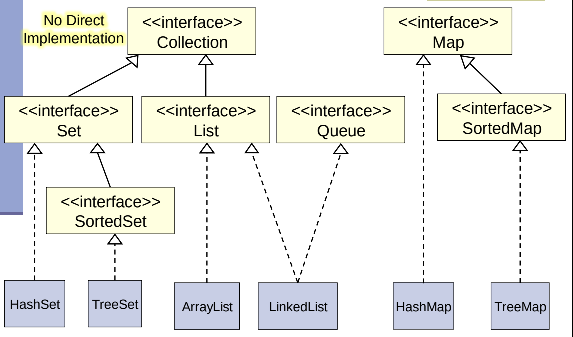
General Purpose Implementations



Collection 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

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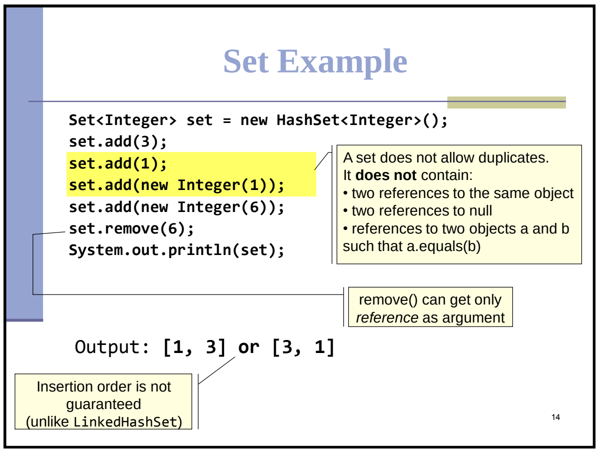

Set Example

```
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`)

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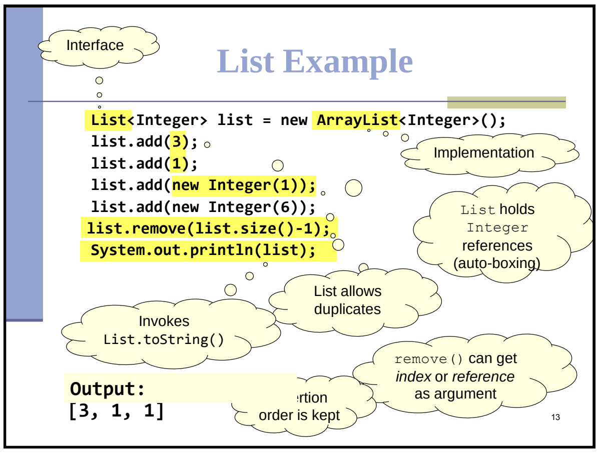

List Example

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

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

rtion order is kept

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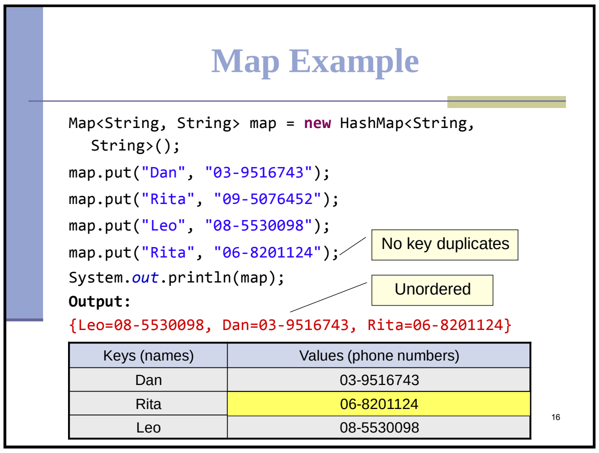

Map Example

```
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

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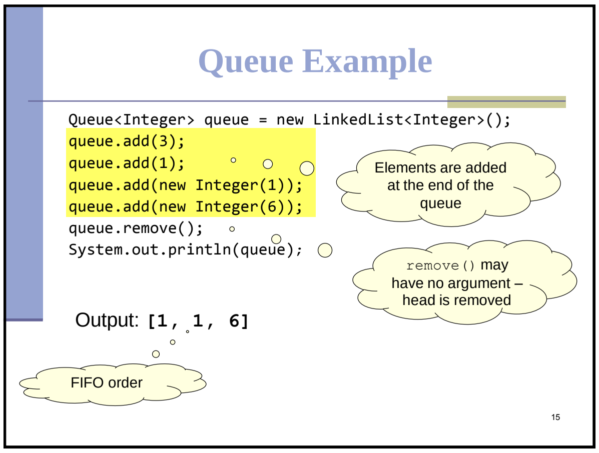

Queue Example

```
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

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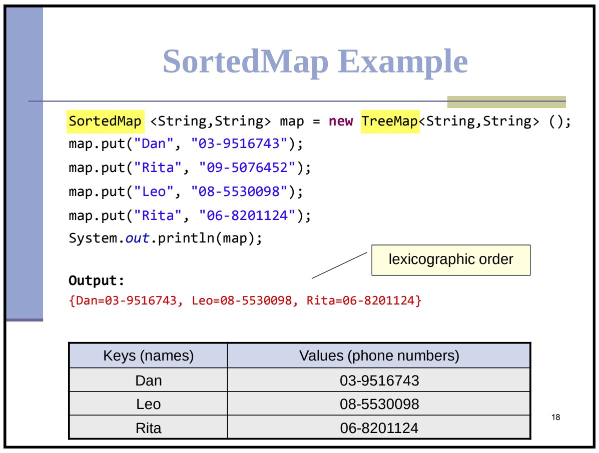

SortedMap Example

```
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);

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

lexicographic order

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

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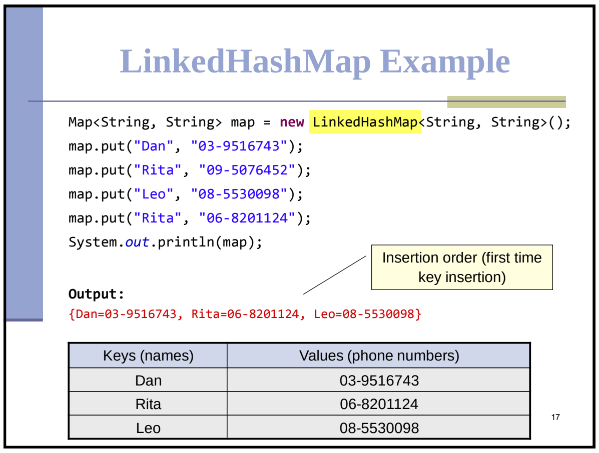

LinkedHashMap Example

```
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);

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

Insertion order (first time key insertion)

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

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Map Collection Views

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

`keySet`	`values`	`entrySet`
`Set<K>`	`Collection<V>`	`Set<Map.Entry<K,V>>`

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

```
import java.util.*;

public class Sort {
   public static void main(String args[]) {
      List<String> list = Arrays.asList(args);
      Collections.sort(list);
      System.out.println(list);
   }
}
```

import the package of `List, Collections` and `Arrays`

returns a List-view of its array argument.

Arguments: A C D B
Output: [A, B, C, D]

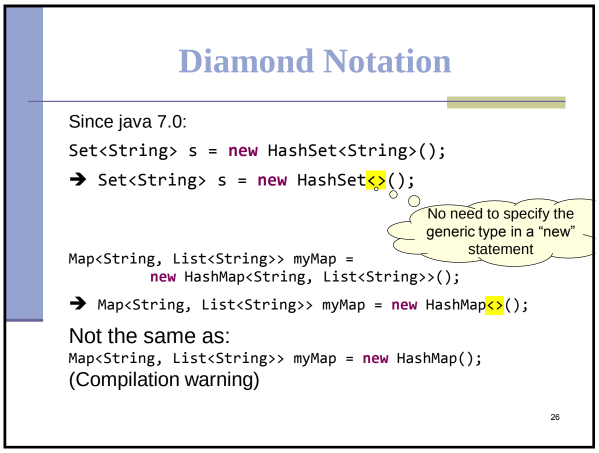
lexicographic order

Sorting (cont.)

- 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 `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);`



Diamond Notation

Since java 7.0:

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

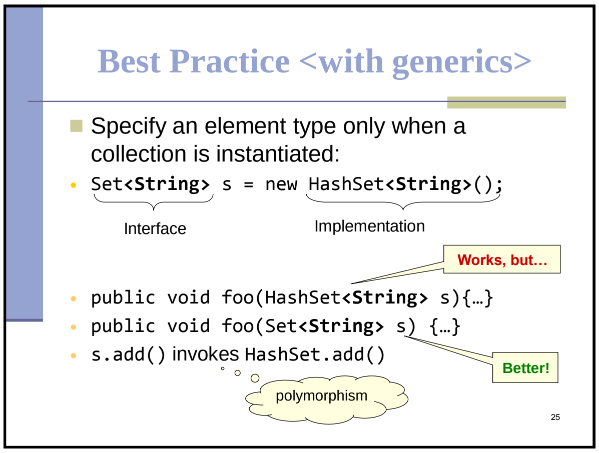
No need to specify the generic type in a “new” statement

```
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)



Best Practice <with generics>

- Specify an element type only when a collection is instantiated:
  - $\underbrace{\texttt{Set<String>}}_{\text{Interface}}\ \texttt{s = new}\ \underbrace{\texttt{HashSet<String>();}}_{\text{Implementation}}$
  - `public void foo(HashSet<String> s){…}`
  - `public void foo(Set<String> s) {…}`
  - `s.add()` invokes `HashSet.add()`

Works, but…
Better!
polymorphism