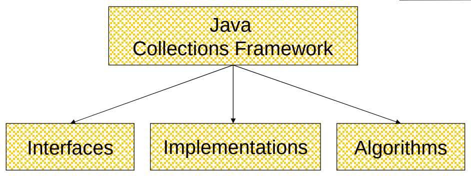
Software 1 with Java

Recitation No. 6
(Collections)

Java Collections Framework

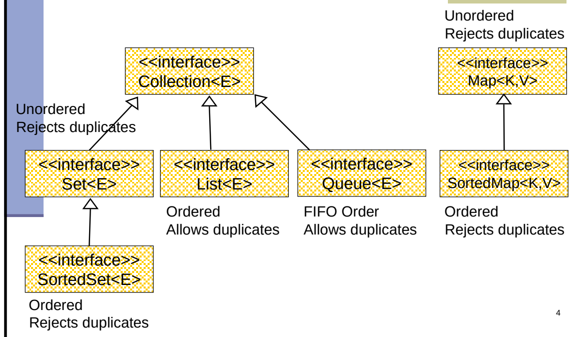
- **Collection**: a group of elements
- Interface Based Design:



Online Resources

- Java 5 API Specification:
  http://java.sun.com/j2se/1.5.0/docs/api/index.html
- Sun Tutorial:
  http://java.sun.com/docs/books/tutorial/collections/

Collection Interfaces



The Collection Interface

- Doesn't hold primitives
  - Use wrapper classes
- Before Java5:
  - No type safety
  - Need to use casting
- Since Java5:
  - Collections can be type safe
  - i.e. the type of the elements in the collection can be specified (using generics)

The Collection Interface

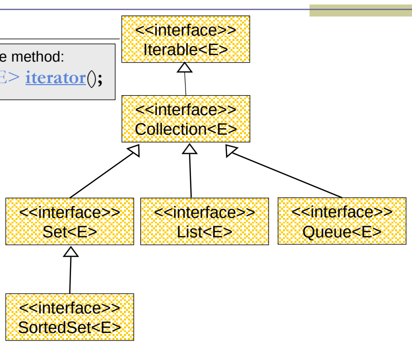
```
Collection<String> stringCollection = new LinkedList<String>();
Collection<Integer> integerCollection = new LinkedList<Integer>();

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

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

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>

The Iterator Interface

- Provide a way to access the elements of a collection sequentially without exposing its 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`

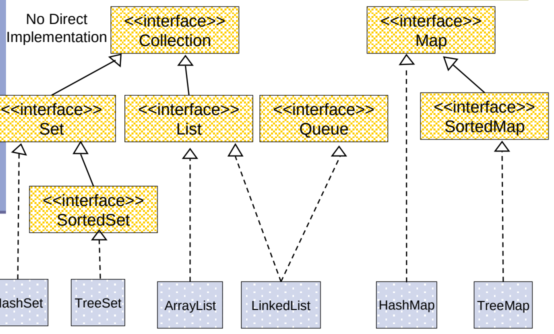
```
for (Iterator<String> iter = collection.iterator() ;
   iter.hasNext( ); )  {
        System.out.println(iter.next());
}
```

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				LinkedList
	List		ArrayList		LinkedList
	Map	HashMap		TreeMap (SortedMap)	

General Purpose Implementations



Best Practice <with generics>

- Specify an implementation only when a collection is constructed:
- `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

Best Practice (Before Java 5.0)

- Specify an implementation only when a collection is constructed:
  - `Set s = new HashSet();`

$\underbrace{\texttt{Set}}_{\text{Interface}}$ s = new $\underbrace{\texttt{HashSet()}}_{\text{Implementation}}$

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

Works, but...

Better!

polymorphism

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);
```

Interface

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]

Insertion order is not guaranteed

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 to the tail 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);
```

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

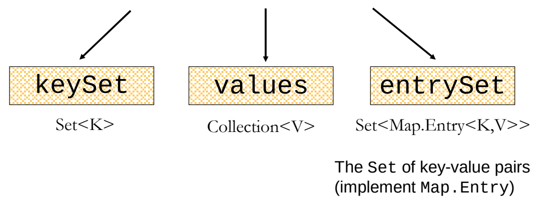
Output:

{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



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());
}
```

Output:

```
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
- Main algorithms:
  - sort
  - binarySearch
  - reverse
  - shuffle
  - min
  - max

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 o);
}
```

- Exception when sorting a list whose elements
  - do not implement `Comparable` or
  - are not *mutually comparable*.

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.

<u>Arguments</u>: A C D B
<u>Output</u>: [A, B, C, D]

lexicographic order