

# **BBM 102 – Introduction to Programming II**

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## **Collections Framework**

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# Today

- The `java.util.Arrays` class
- Java Collection Framework
  - `java.util.Collection` interface
  - `java.util.List` interface
    - `java.util.ArrayList` class
  - `java.util.Set` interface
    - `java.util.HashSet` class
  - `java.util.Map` interface
    - `java.util.HashMap` class
    - `java.util.Hashtable` class
    - `java.util.Properties` class

# java.util.Arrays

- Provides high-level static methods for manipulating arrays, such as:
  - **sort** for sorting an array,
  - **binarySearch** for searching a sorted array,
  - **equals** for comparing arrays
  - **fill** for placing values into an array

# Arrays – Example

```
3 import java.util.Arrays;
4
5 public class UsingArrays
6 {
7     private int intArray[] = { 1, 2, 3, 4, 5, 6 };
8     private double doubleArray[] = { 8.4, 9.3, 0.2, 7.9, 3.4 };
9     private int filledIntArray[], intArrayCopy[];
10
11     // constructor initializes arrays
12     public UsingArrays()
13     {
14         filledIntArray = new int [ 10 ]; // create int array with 10 elements
15         intArrayCopy = new int [ intArray.length ];
16
17         Arrays.fill( filledIntArray, 7 ); // fill with 7s
18         Arrays.sort( doubleArray ); // sort doubleArray ascending
19
20         // copy array intArray into array intArrayCopy
21         System.arraycopy( intArray, 0, intArrayCopy,
22             0, intArray.length );
23     } // end UsingArrays constructor
```

# Arrays – Example (continued)

```
47     // find value in array intArray
48     public int searchForInt( int value )
49     {
50         return Arrays.binarySearch( intArray, value );
51     } // end method searchForInt
52
53     // compare array contents
54     public void printEquality()
55     {
56         boolean b = Arrays.equals( intArray, intArrayCopy );
57         System.out.printf( "intArray %s intArrayCopy\n",
58             ( b ? "==" : "!=" ) );
59
60         b = Arrays.equals( intArray, filledIntArray );
61         System.out.printf( "intArray %s filledIntArray\n",
62             ( b ? "==" : "!=" ) );
63     } // end method printEquality
```

# Arrays – Example (continued)

```
26     public void printArrays()
27     {
28         System.out.print( "doubleArray: " );
29         for ( double doubleValue : doubleArray )
30             System.out.printf( "%.1f ", doubleValue );
31
32         System.out.print( "\nintArray: " );
33         for ( int intValue : intArray )
34             System.out.printf( "%d ", intValue );
35
36         System.out.print( "\nfilledIntArray: " );
37         for ( int intValue : filledIntArray )
38             System.out.printf( "%d ", intValue );
39
40         System.out.print( "\nintArrayCopy: " );
41         for ( int intValue : intArrayCopy )
42             System.out.printf( "%d ", intValue );
43
44         System.out.println( "\n" );
45     } // end method printArrays
```

# Arrays – Example (continued)

```
65     public static void main( String args[] )
66     {
67         UsingArrays usingArrays = new UsingArrays();
68
69         usingArrays.printArrays();
70         usingArrays.printEquality();
71
72         int location = usingArrays.searchForInt( 5 );
73         if ( location >= 0 )
74             System.out.printf(
75                 "Found 5 at element %d in intArray\n", location );
76         else
77             System.out.println( "5 not found in intArray" );
78
79         location = usingArrays.searchForInt( 8763 );
80         if ( location >= 0 )
81             System.out.printf(
82                 "Found 8763 at element %d in intArray\n", location );
83         else
84             System.out.println( "8763 not found in intArray" );
85     } // end main
86 } // end class UsingArrays
```

# Java Collections Framework

- Group of objects can be kept in an array, but arrays are not feasible when number of objects increase or decrease during the execution of the program
- The *Java Collections Framework* is a collection of interfaces and classes that may be used to manipulate groups of objects
- The classes implemented in the *Java Collections Framework* serve as reusable data structures and include algorithms for common tasks such as sorting or searching
- The framework uses parameterized classes so you can use them with the classes of your choice
- The framework is largely contained in the package `java.util`



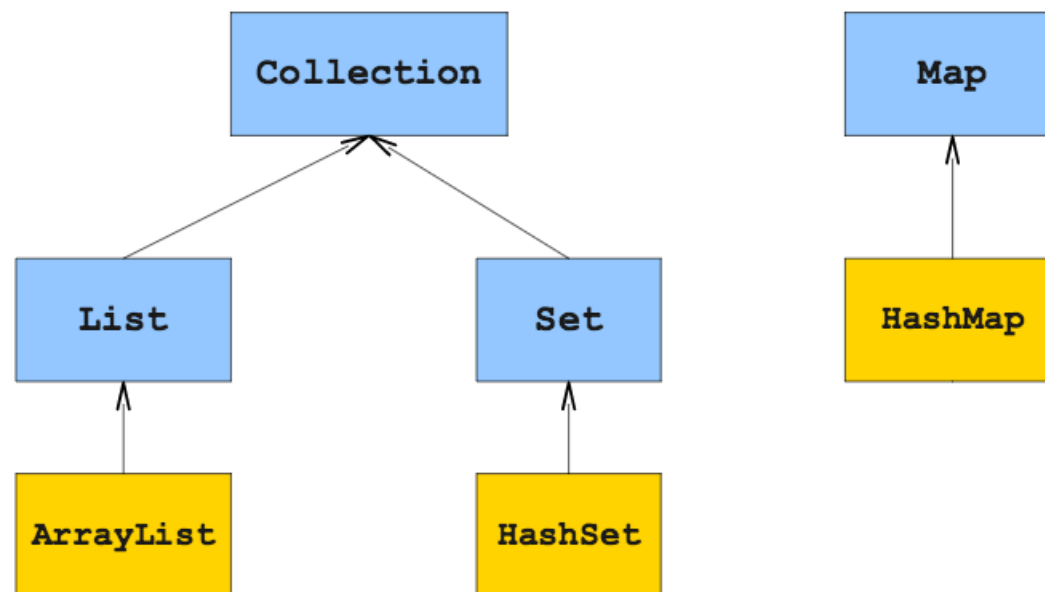
# Basic collections

## *The three major collections in Java:*

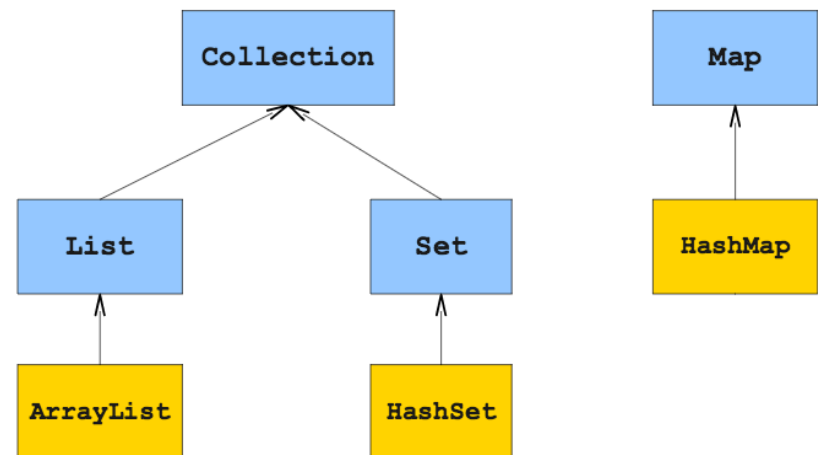
- **Set:** A collection of elements that is guaranteed to contain no duplicates.
- **List:** An ordered collection of elements, often accessed by integer indexes or by iteration.
- **Map:** A collection of key/value pairs in which each key is associated with a corresponding value.

# java.util.Collection interface

- It is the highest level of Java's framework for collection classes
- It describes the basic operations that all collection classes (except **Map**) should implement (listed in the next page)
- The JDK does not provide any *direct* implementations of this interface: it provides implementations of more specific sub-interfaces like Set and List as in the example diagram below:

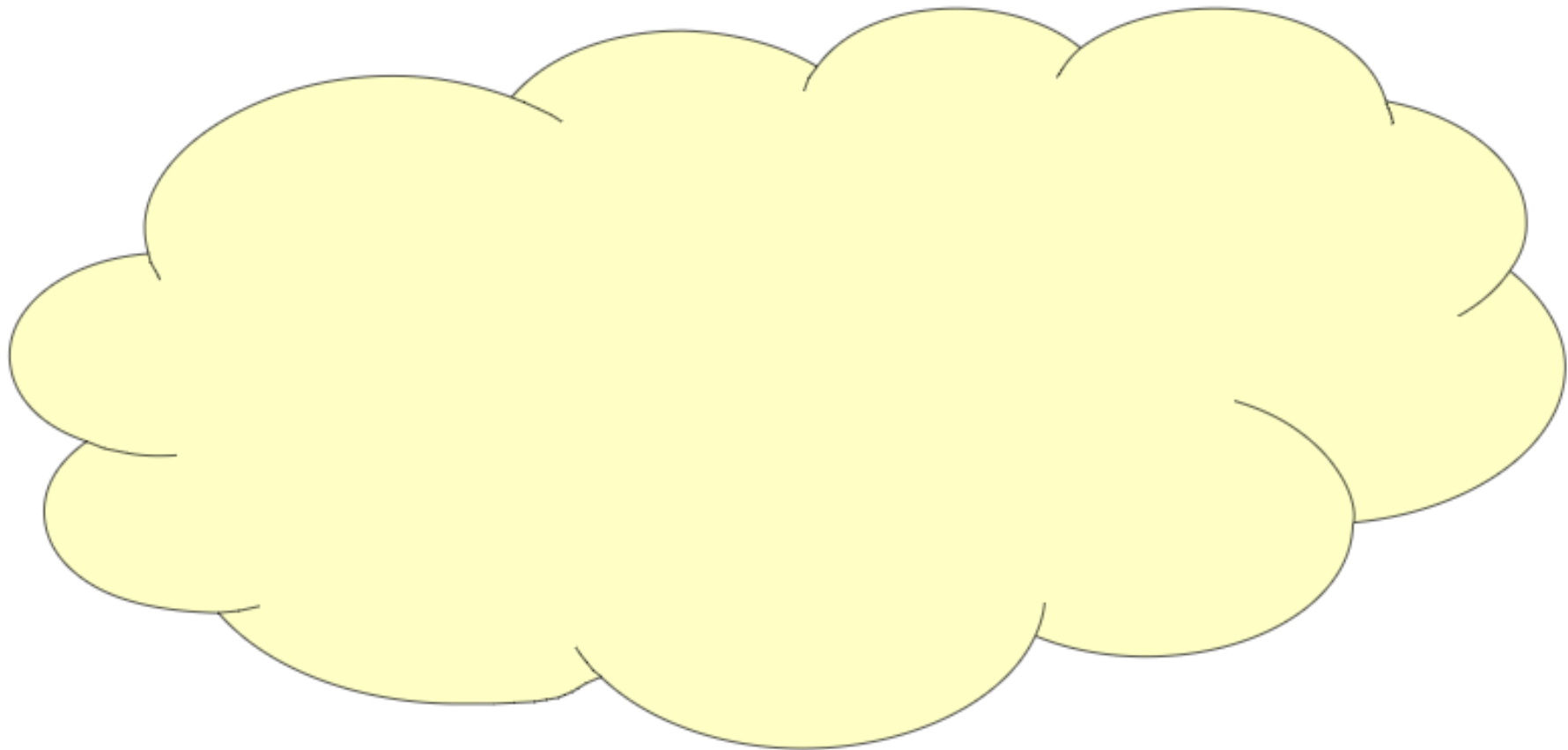


# What is a Set?

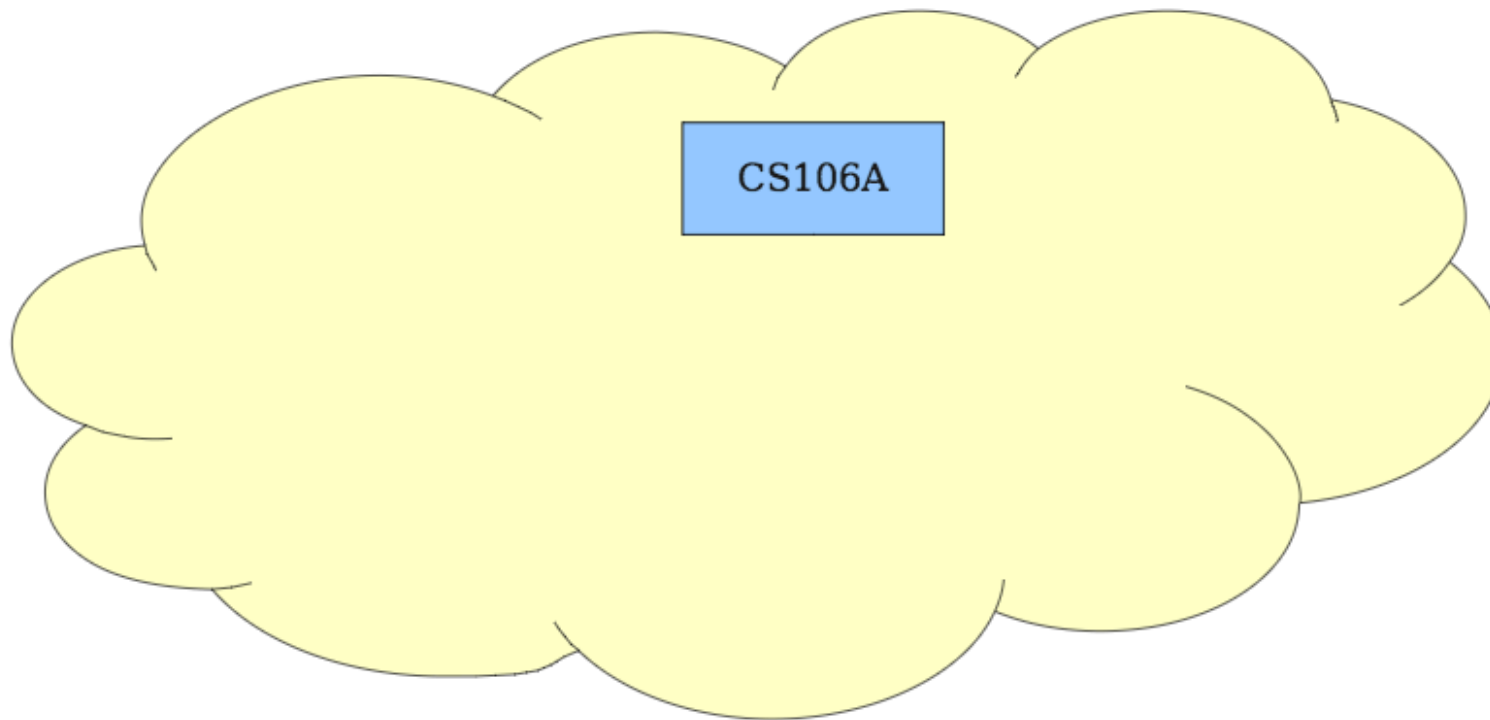


# java.util.Set interface

- A **Set** is a **Collection** that contains unique elements (i.e., no duplicate elements).
- The collections framework contains several **Set** implementations, including **HashSet**
- Major operations are:
  - **Adding** an element
  - **Removing** an element
  - **Checking** whether an element exists
- Useful for answering questions of the form “have I seen this before?”



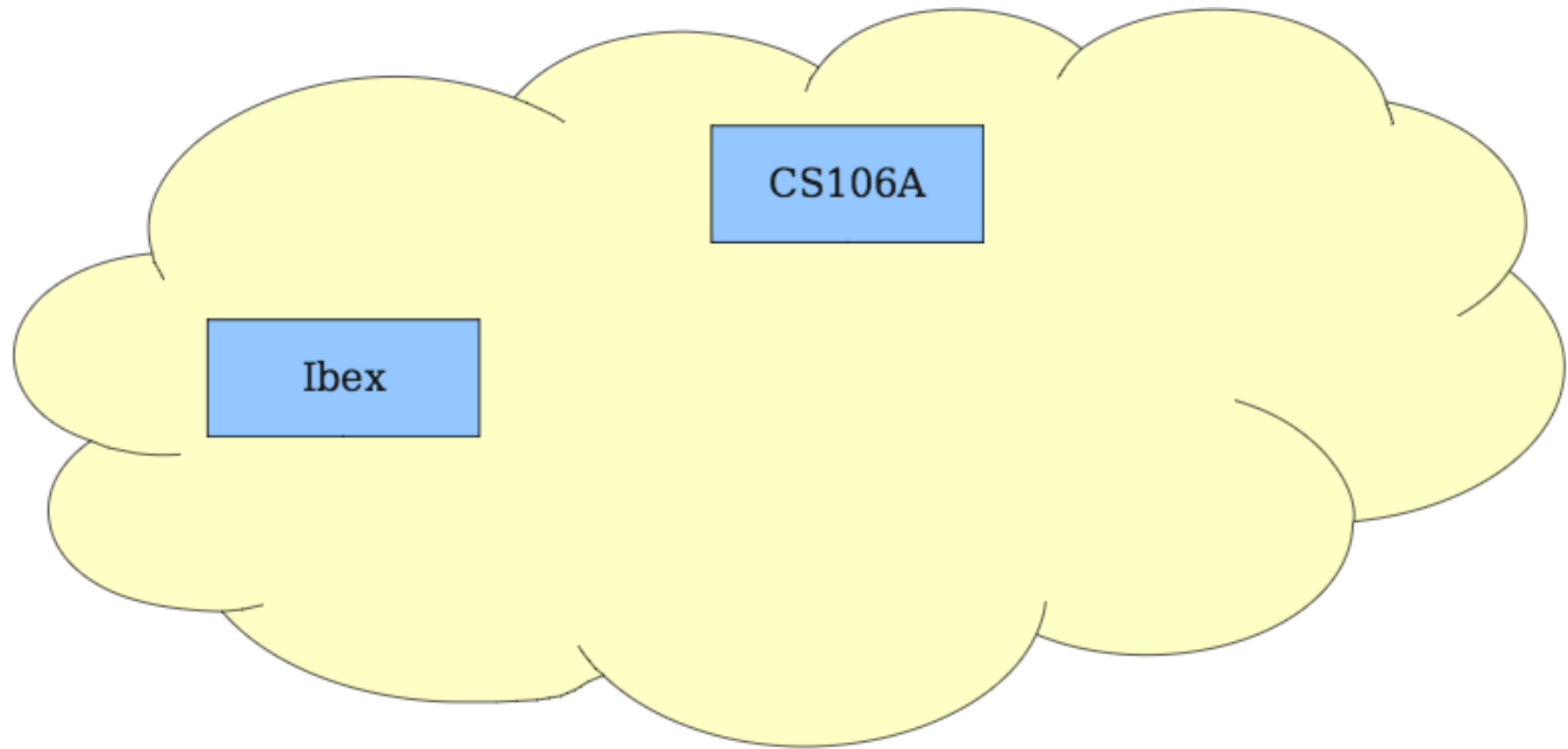
```
HashSet<String> mySet = new HashSet<String>();
```



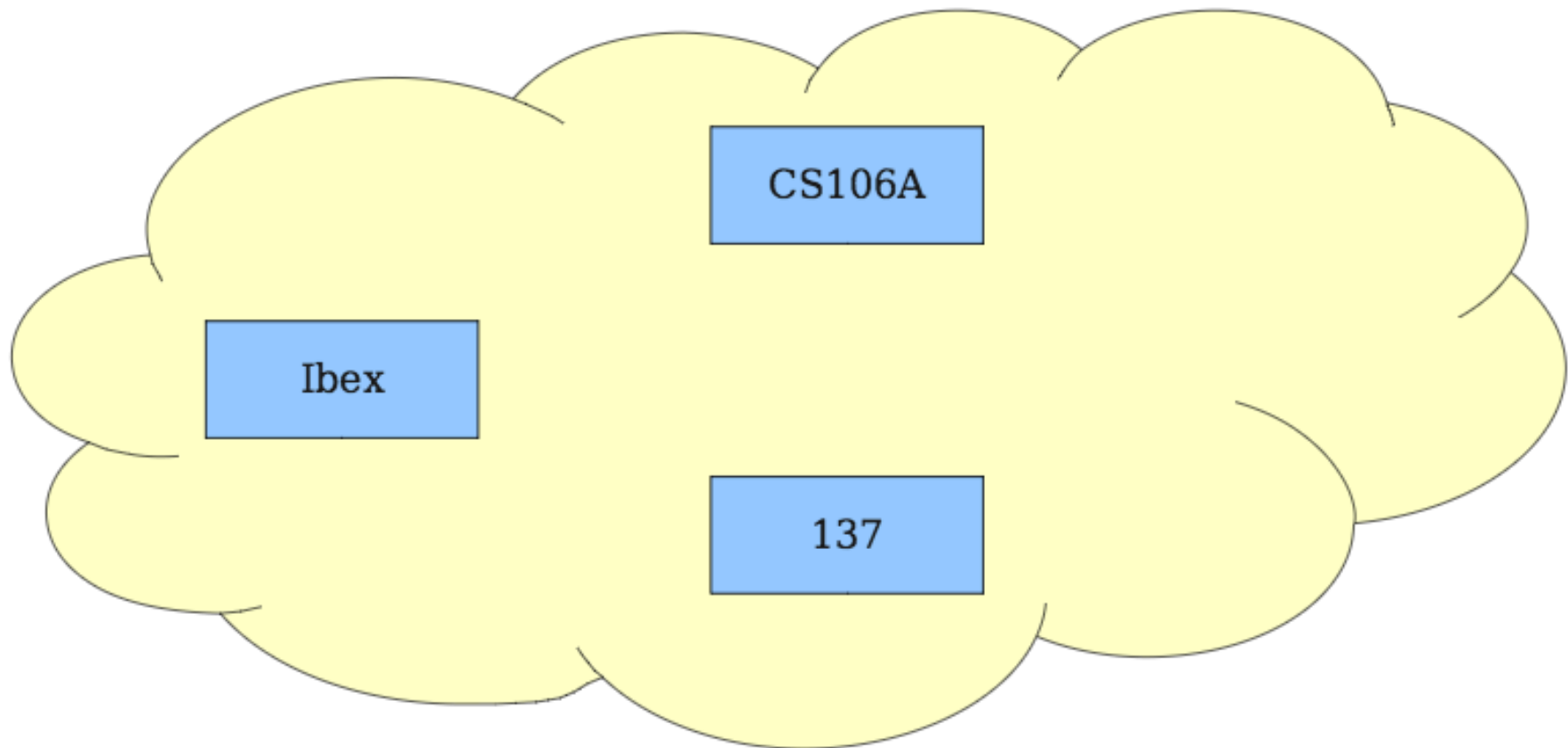
```
HashSet<String> mySet = new HashSet<String>();  
mySet.add("CS106A");
```

To add a value to a  
**HashSet**, use the syntax

**set.add(value)**

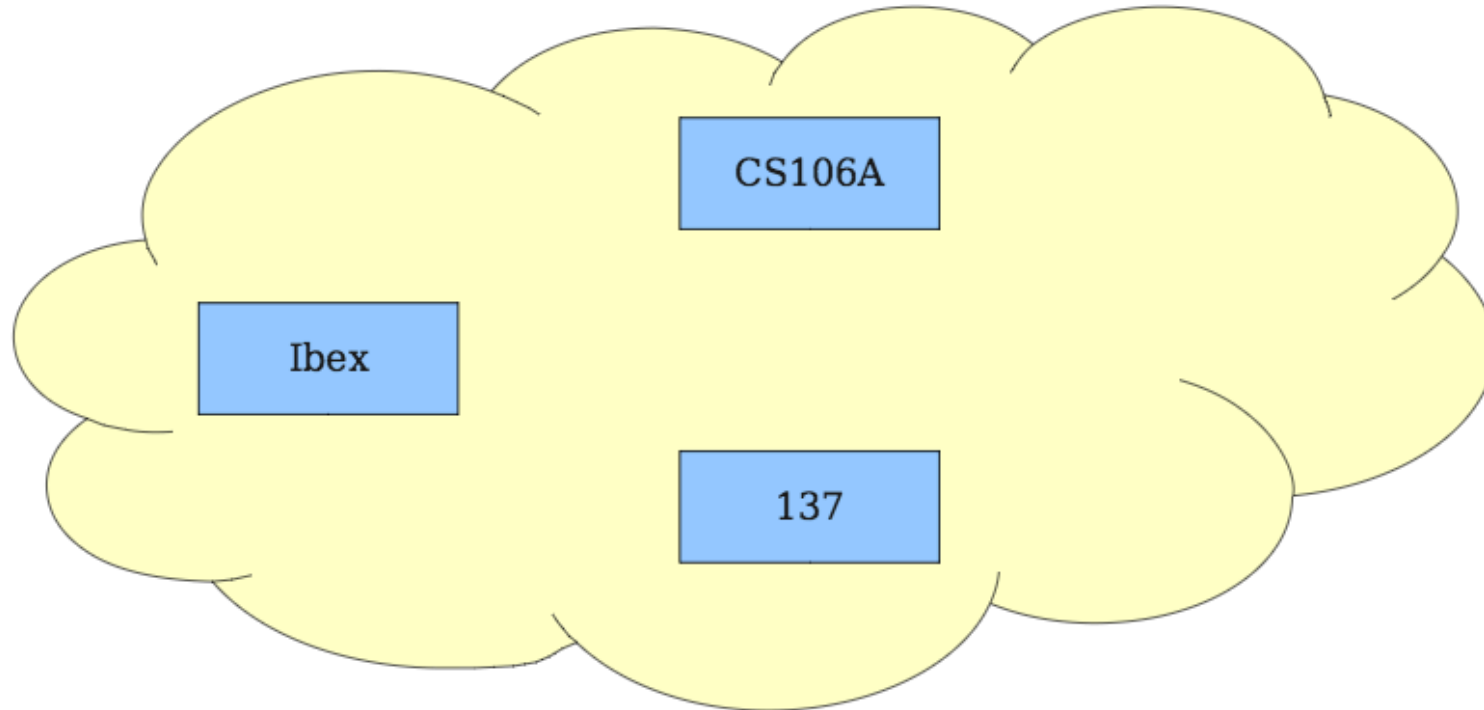


```
HashSet<String> mySet = new HashSet<String>();  
mySet.add("CS106A");  
mySet.add("Ibex");
```



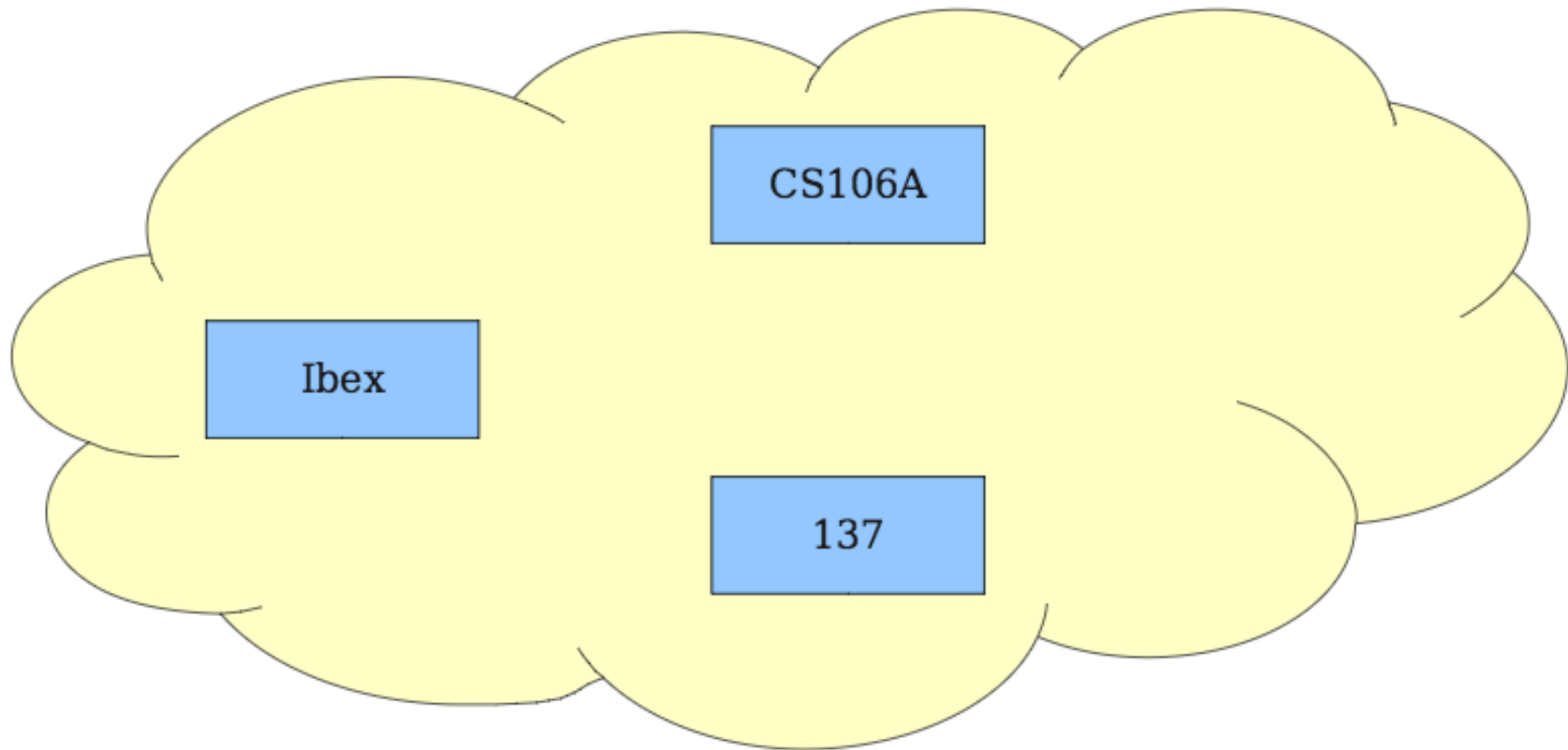
```
HashSet<String> mySet = new HashSet<String>();  
mySet.add("CS106A");  
mySet.add("Ibex");  
mySet.add("137");
```





```
HashSet<String> mySet = new HashSet<String>();  
mySet.add("CS106A");  
mySet.add("Ibex");  
mySet.add("137");  
mySet.add("CS106A");
```

If you **add** a value pair where the value exists, nothing happens.



```
HashSet<String> mySet = new HashSet<String>();  
mySet.add("CS106A");  
mySet.add("Ibex");  
mySet.add("137");  
mySet.add("CS106A");  
  
mySet.contains("Ibex");
```

# Basic Set Operations

- To insert an item:
  - `set.add(value)`
- To check whether a value exists
  - `set.contains(value)`
- To remove an item
  - `set.remove(value)`

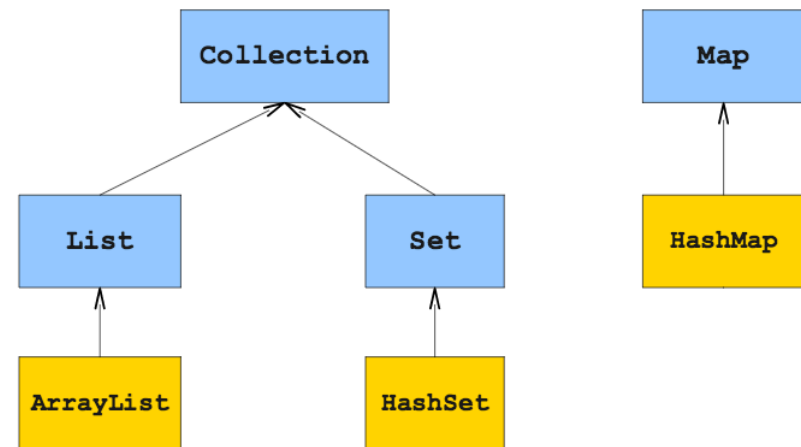
# HashSet - Example

```
3 import java.util.List;
4 import java.util.Arrays;
5 import java.util.HashSet;
6 import java.util.Set;
7 import java.util.Collection;
8
9 public class SetTest
10 {
11     private static final String colors[] = { "red", "white", "blue",
12         "green", "gray", "orange", "tan", "white", "cyan",
13         "peach", "gray", "orange" };
14
15     // create and output ArrayList
16     public SetTest()
17     {
18         List< String > list = Arrays.asList( colors );
19         System.out.printf( "ArrayList: %s\n", list );
20         printNonDuplications( list );
21     } // end SetTest constructor
```

# HashSet – Example (continued)

```
23     // create set from array to eliminate duplicates
24     private void printNonDuplicates( Collection< String > collection )
25     {
26         // create a HashSet
27         Set< String > set = new HashSet< String >( collection );
28
29         System.out.println( "\nNonDuplicates are: " );
30
31         for ( String s : set )
32             System.out.printf( "%s ", s );
33
34         System.out.println();
35     } // end method printNonDuplicates
36
37     public static void main( String args[] )
38     {
39         new SetTest();
40     } // end main
41 } // end class SetTest
```

# What is a List?



# java.util.List interface

- A List (sometimes called a **sequence**) is an ordered Collection
- It can contain duplicate elements
- Like array indices, List indices are zero based (i.e., the first element's index is zero)
- In addition to the methods inherited from Collection, List provides methods for;
  - manipulating elements via their indices
  - manipulating a specified range of elements
  - searching for elements
  - getting a **ListIterator** to access the elements.

# Iterators

- To visit every element of a collection, you can use the “for each” loop:

```
for (ElemType elem: collection) {  
    ...  
}
```

- Alternatively, you can use an **iterator**, an object whose job is to walk over the elements of a collection.
- The iterator has two commands:
  - **hasNext()** returns true if there are more items to visit.
  - **next()** returns the next item and moves the iterator to the next position.



# ArrayList and Iterator - Example

```
3 import java.util.List;
4 import java.util.ArrayList;
5 import java.util.Collection;
6 import java.util.Iterator;
7
8 public class CollectionTest
9 {
10     private static final String[] colors =
11         { "MAGENTA", "RED", "WHITE", "BLUE", "CYAN" };
12     private static final String[] removeColors =
13         { "RED", "WHITE", "BLUE" };
14
15     // create ArrayList, add Colors to it and manipulate it
16     public CollectionTest()
17     {
18         List< String > list = new ArrayList< String >();
19         List< String > removeList = new ArrayList< String >();
20
21         // add elements in colors array to list
22         for ( String color : colors )
23             list.add( color );
24
```

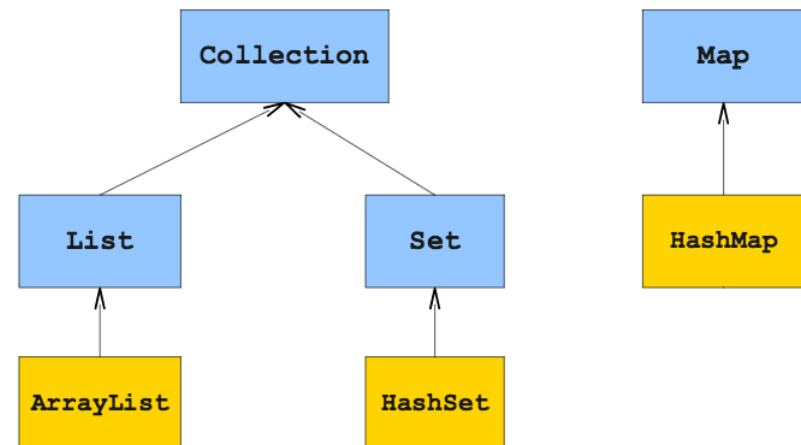
# ArrayList and Iterator – Example (continued)

```
25     // add elements in removeColors to removeList
26     for ( String color : removeColors )
27         removeList.add( color );
28
29     System.out.println( "ArrayList: " );
30
31     // output list contents
32     for ( int count = 0; count < list.size(); count++ )
33         System.out.printf( "%s ", list.get( count ) );
34
35     // remove colors contained in removeList
36     removeColors( list, removeList );
37
38     System.out.println( "\n\nArrayList after calling removeColors: " );
39
40     // output list contents
41     for ( String color : list )
42         System.out.printf( "%s ", color );
43 } // end CollectionTest constructor
```

# ArrayList and Iterator - Example (continued)

```
45     // remove colors specified in collection2 from collection1
46     private void removeColors(
47         Collection< String > collection1, Collection< String > collection2 )
48     {
49         // get iterator
50         Iterator< String > iterator = collection1.iterator();
51
52         // loop while collection has items
53         while ( iterator.hasNext() )
54
55             if ( collection2.contains( iterator.next() ) )
56                 iterator.remove(); // remove current Color
57     } // end method removeColors
58
59     public static void main( String args[] )
60     {
61         new CollectionTest();
62     } // end main
63 } // end class CollectionTest
```

# What is a Map?



# java.util.Map interface

- **Maps** associate keys to values and cannot contain duplicate keys (i.e., each key can map to only one value)
- **Maps** differ from **Sets** in that **Maps** contain keys and values, whereas **Sets** contain only values

# HashMap - Example

```
3 import java.util.StringTokenizer;
4 import java.util.Map;
5 import java.util.HashMap;
6 import java.util.Set;
7 import java.util.TreeSet;
8 import java.util.Scanner;
9
10 public class WordTypeCount
11 {
12     private Map< String, Integer > map;
13     private Scanner scanner;
14
15     public WordTypeCount()
16     {
17         map = new HashMap< String, Integer >(); // create HashMap
18         scanner = new Scanner( System.in ); // create scanner
19         createMap(); // create map based on user input
20         displayMap(); // display map content
21     } // end WordTypeCount constructor
```

# HashMap – Example (continued)

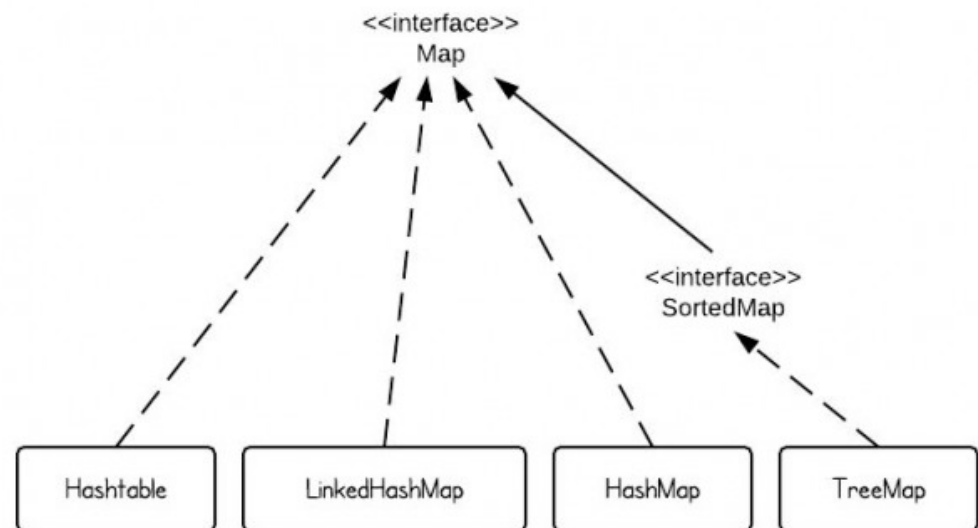
```
23 // create map from user input
24 private void createMap()
25 {
26     System.out.println( "Enter a string:" ); // prompt for user input
27     String input = scanner.nextLine();
28
29     // create StringTokenizer for input
30     StringTokenizer tokenizer = new StringTokenizer( input );
31
32     // processing input text
33     while ( tokenizer.hasMoreTokens() ) // while more input
34     {
35         String word = tokenizer.nextToken().toLowerCase(); // get word
36
37         // if the map contains the word
38         if ( map.containsKey( word ) ) // is word in map
39         {
40             int count = map.get( word ); // get current count
41             map.put( word, count + 1 ); // increment count
42         } // end if
43         else
44             map.put( word, 1 ); // add new word with a count of 1 to map
45     } // end while
46 } // end method createMap
```


# HashMap – Example (continued)

```
48     // display map content
49     private void displayMap()
50     {
51         Set< String > keys = map.keySet(); // get keys
52
53         // sort keys
54         TreeSet< String > sortedKeys = new TreeSet< String >( keys );
55
56         System.out.println( "Map contains:\nKey\t\tValue" );
57
58         // generate output for each key in map
59         for ( String key : sortedKeys )
60             System.out.printf( "%-10s%10s\n", key, map.get( key ) );
61
62         System.out.printf(
63             "\nsize:%d\nisEmpty:%b\n", map.size(), map.isEmpty() );
64     } // end method displayMap
65
66     public static void main( String args[] )
67     {
68         new WordTypeCount();
69     } // end main
70 } // end class WordTypeCount
```




# What is a Hashtable?



keys 

Student #	Grade
107312	B+
168904	A+
...	
221655	B-

 values

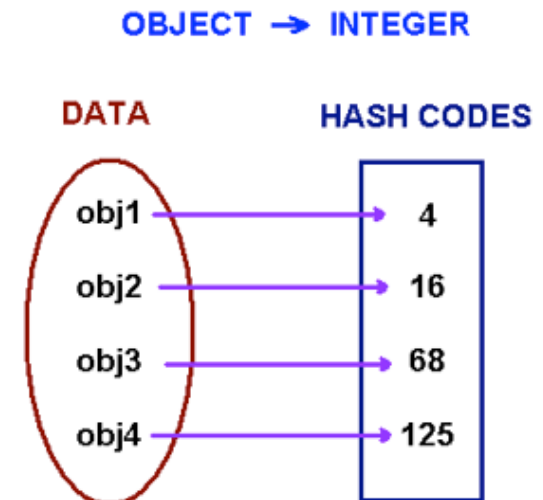
keys →

Name	Ext.
Homer	1786
Marge	8113
...	
Lisa	4321

← values

# java.util.Properties class

- A **Properties** object is a *persistent* **Hashtable** that
  - stores key-value pairs of strings
  - assumes that you use methods **setProperty** and **getProperty** to manipulate the table rather than inherited **Hashtable** methods **put** and **get**.
  - A common use of Properties objects is to maintain application-configuration data or user preferences for applications



# Properties - Example

```
3  import java.io.FileOutputStream;
4  import java.io.FileInputStream;
5  import java.io.IOException;
6  import java.util.Properties;
7  import java.util.Set;
8
9  public class PropertiesTest
10 {
11     private Properties table;
12
13     // set up GUI to test Properties table
14     public PropertiesTest()
15     {
16         table = new Properties(); // create Properties table
17
18         // set properties
19         table.setProperty( "color", "blue" );
20         table.setProperty( "width", "200" );
```

# Properties – Example (continued)

```
22     System.out.println( "After setting properties" );
23     listProperties(); // display property values
24
25     // replace property value
26     table.setProperty( "color", "red" );
27
28     System.out.println( "After replacing properties" );
29     listProperties(); // display property values
30
31     saveProperties(); // save properties
32
33     table.clear(); // empty table
34
35     System.out.println( "After clearing properties" );
36     listProperties(); // display property values
37
38     loadProperties(); // load properties
```

# Properties – Example (continued)

```
40     // get value of property color
41     Object value = table.getProperty( "color" );
42
43     // check if value is in table
44     if ( value != null )
45         System.out.printf( "Property color's value is %s\n", value );
46     else
47         System.out.println( "Property color is not in table" );
48 } // end PropertiesTest constructor
```

# Properties – Example (continued)

```
50     // save properties to a file
51     public void saveProperties()
52     {
53         // save contents of table
54         try
55         {
56             FileOutputStream output = new FileOutputStream( "props.dat" );
57             table.store( output, "Sample Properties" ); // save properties
58             output.close();
59             System.out.println( "After saving properties" );
60             listProperties();
61         } // end try
62         catch ( IOException ioException )
63         {
64             ioException.printStackTrace();
65         } // end catch
66     } // end method saveProperties
```



# Properties – Example (continued)

```
69     public void loadProperties()
70     {
71         // load contents of table
72         try
73         {
74             FileInputStream input = new FileInputStream( "props.dat" );
75             table.load( input ); // load properties
76             input.close();
77             System.out.println( "After loading properties" );
78             listProperties(); // display property values
79         } // end try
80         catch ( IOException ioException )
81         {
82             ioException.printStackTrace();
83         } // end catch
84     } // end method loadProperties
```

# Properties – Example (continued)

```
86     // output property values
87     public void listProperties()
88     {
89         Set< Object > keys = table.keySet(); // get property names
90
91         // output name/value pairs
92         for ( Object key : keys )
93         {
94             System.out.printf(
95                 "%s\t%s\n", key, table.getProperty( ( String ) key ) );
96         } // end for
97
98         System.out.println();
99     } // end method listProperties
100
101     public static void main( String args[] )
102     {
103         new PropertiesTest();
104     } // end main
105 } // end class PropertiesTest
```

# Summary

- Arrays are used for a group of objects, but maintenance is difficult when the size of the group changes during the execution of the program
- Java Collection Framework includes many interfaces and classes to easily manage groups of objects
- The interfaces and classes of the framework are mostly in **java.util** package
- Various interfaces include methods for special algorithms of various data structures
- Framework includes various implementations of these interfaces
- It is possible to implement or extend the interfaces/classes of the framework for new/different implementations of new/different data structures

# Acknowledgements

- The course material used to prepare this presentation is mostly taken/adopted from the list below:
  - Java - How to Program, Paul Deitel and Harvey Deitel, Prentice Hall, 2012
  - Building Java Programs – A Back to Basics Approach, Stuart Reges and Marty Stepp, Addison Wesley, 2011
  - Stanford, Collections – lecture notes