

# Collections & Sorting



covering

- \*\* Java Collections Framework
- \*\* **Comparable** interface
- \*\* **ArrayList** // 2D arrays
- \*\* (Brief introduction to) Sorting Algorithms:  
*Bubble Sort, Insertion Sort*



Chapter 9 (sections 9.1-9.4, 9.6) – “Core Java” book

Chapter 16, Appendix B – “Head First Java” book

Chapters 6, 25 (sections 6.10-6.11, 25.1-25.4) – “Introduction to Java Programming” book

Chapter 8 – “Java in a Nutshell” book

# Java's Collection Classes

- Most programs utilise *collections of data* e.g.,

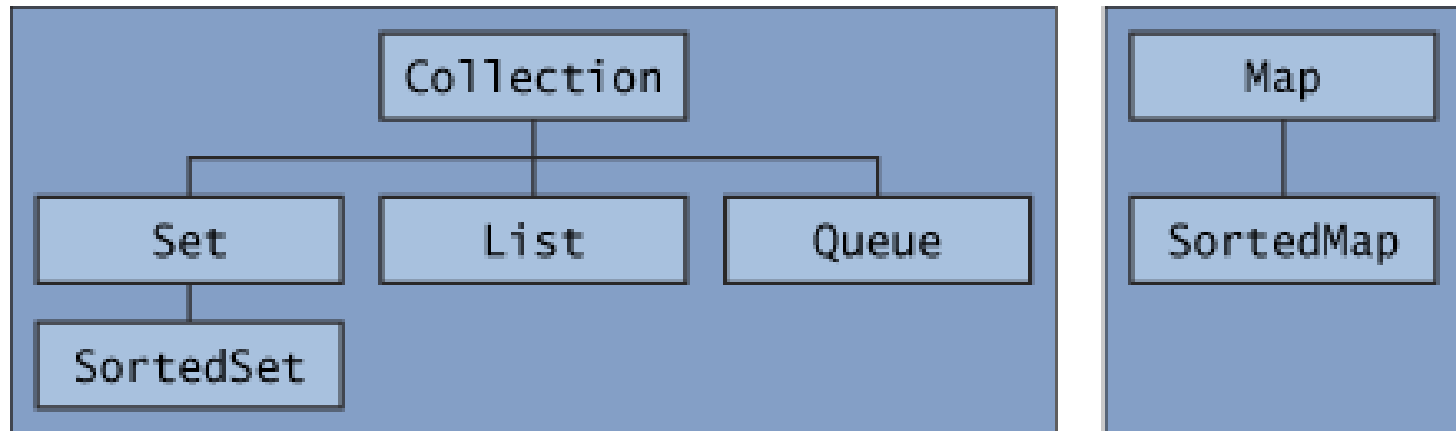
- a set of users;
- words in a dictionary.



Example of another data structure?

- **Collection in Java**: “an object that groups multiple elements into a single unit”.
  - **Can be used to**: store, retrieve, manipulate data.
  - **Examples**: a poker hand, a mail folder, a telephone directory.
- Java provides several **interfaces**, **implementations** and **algorithms** for handling collections of objects, via its **Java Collections Framework** (see **java.util** package).

# Collection Framework: Interfaces



- **Set**: A collection that contains no duplicate elements; it models the mathematical *set* abstraction.
- **List**: An ordered collection (also known as a *sequence*). Elements can be accessed by their position in the list, and it is possible to search for elements in the list. Lists allow for duplicate elements.
- **Map**: An object that maps keys to values. A map does not contain duplicate keys; each key can map to at most one value.



See descriptions of the other interfaces in the [Java API](#).

# Choosing a Collection ...

- Which **collection you choose** will depend on many factors e.g.,
  - whether the collection needs to be of **fixed size** *or* **dynamic**;
  - whether it has a **natural order** *or* **not**;
  - whether we want to **insert/delete** at arbitrary places, *or* **only at the start or end**;
  - whether we want to be able to **search** through a large amount of **data very quickly**;
  - whether we want **random access** to elements *or* **sequential access**;
  - whether we need to maintain **key/value pairs**.

# Collection Framework: Implementations

Interfaces	Implementations				
	Hash table	Resizable array	Tree	Linked list	Hash table + Linked list
Set	HashSet		TreeSet		LinkedHashSet
List		ArrayList		LinkedList	
Queue					
Map	HashMap		TreeMap		LinkedHashMap

- **Array** versus **ArrayList**:
  - An array needs to know its size at time of creation, but an **ArrayList** does not,  

```
String[] myStringArray = new String[6];  
ArrayList<String> myArrayList = new ArrayList<String>();
```
  - To assign an object in a regular array, you must assign it to a specific index, but with an **ArrayList** you needn't,  

```
anotherList[4] = b;                      anotherArrayList.add(b);
```

# Map and HashMap

- The **Map** interface associates **keys** (which are like *indexes*) to **elements**.
  - It cannot contain duplicate keys.
  - Each key maps to one value only.
- The **HashMap** class implements **Map** and is efficient for locating a value, as well as inserting and deleting a mapping.
  - Entries are not ordered.

Output ...

```
> java HashMapTester
map = {mouse=Squeak, cat=Meow,
       guineaPig=Squeak, dog=Woof}
Value for key 'dog' is: Woof
```

- **Example:**

```
import java.util.*;
public class HashMapTester {
    public static void main( String[] args ) {
        Map<String, String> petSounds = new HashMap<String, String>();
        petSounds.put("cat", "Meow");  petSounds.put("mouse", "Squeak");
        petSounds.put("dog", "Woof");  petSounds.put("guineaPig", "Squeak");
        System.out.println("map = " + petSounds);
        String val = (String)petSounds.get("dog");
        System.out.println("Value for key 'dog' is: " + val);
    }
}
```

# Enumerations

- Enumerations are a Java utility class for **holding lists of objects**.
  - The idea is that we often encounter pseudo-code design like this:

```
lst is a list of objects
for each item i in lst do {
    process i
}
```
  - Enumerations allow us to code this logic directly.



**Enumeration** interface:

- a) introduced before Java 2;
- b) *superseeded* by the **Iterator** interface.

# Example using the Iterator Interface

## Iterator methods ...

Result	Method	Description
<code>b =</code>	<code>it.hasNext()</code>	true if there are more elements for the iterator.
<code>obj =</code>	<code>it.next()</code>	Returns the next object. If a generic list is being accessed, the iterator will return something of the list's type. Pre-generic Java iterators always returned type <code>Object</code> , so a downcast was usually required.
	<code>it.remove()</code>	Removes the most recent element that was returned by <code>next</code> . Not all collections support <code>delete</code> . An <i>UnsupportedOperationException</i> will be thrown if the collection does not support <code>remove()</code> .

```
ArrayList<String> alist = new ArrayList<String>();  
// Add Strings to alist  
  
for (Iterator<String> it = alist.iterator(); it.hasNext(); ) {  
    String s = it.next(); // No downcasting required.  
    System.out.println(s);  
}
```



# 2-dimensional (2D) Arrays

- Java stores a **2D array** as an array of arrays, e.g.

```
int[][] nums = new int[5][4];
```

- When declaring a 2D array:

- must *always* specify the first dimension

```
nums = new int[][]; // ILLEGAL
```

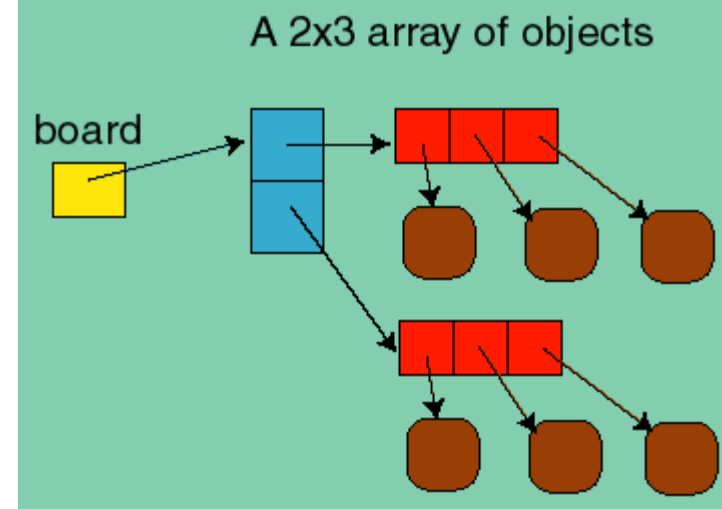
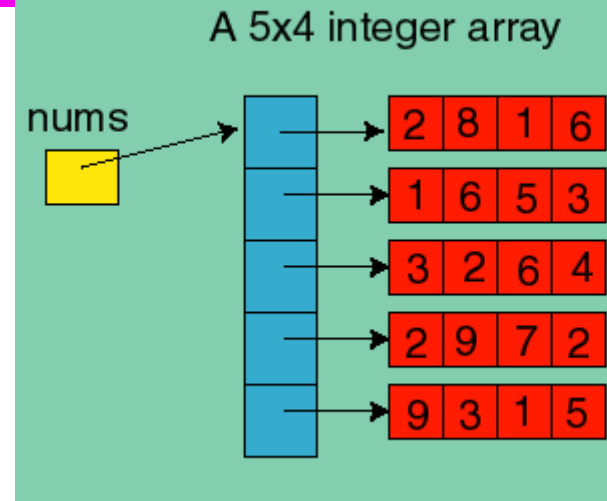
- do *not* need to specify the second dimension

```
nums = new int[5][]; // OK
```

```
nums = new int[5][4]; // OK
```

- A **2D array of objects** is an array of an array of references to objects, e.g.

```
Square[][] board = new Square[2][3];
```



Arrays are not part of the  
Collections framework.

# Practice Exercise 1 – 2D arrays

- What is the output?

```
public class TwoDArrayTester {
    public static void main(String[] args) {
        char[][] pic = new char[6][6];
        for (int i = 0; i < 6; i++) {
            for (int j = 0; j < 6; j++) {
                if ((i == j) || (i == 0) || (i == 5))
                    pic[i][j] = '*';
                else pic[i][j] = '.';
            }
        }
        for (int i = 0; i < 6; i++) {
            for (int j = 0; j < 6; j++)
                System.out.print(pic[i][j]);
            System.out.println();
        }
    }
}
```

Output ...

```
*****
.*....
..*...
...*.
....*
*****
```

# Practice Exercise 2 – 2D ArrayList

- What is the output?

```
import java.util.ArrayList;
public class TwoDArrayListTester {
    public static void main(String[] args) {
        ArrayList<ArrayList<Integer>> topList =
            new ArrayList<ArrayList<Integer>>();
        for (int i = 0; i < 3; i++)
            topList.add(new ArrayList<Integer>());

        for (int i = 0; i < 3; i++) {
            for (int j = 0; j < 3; j++)
                topList.get(i).add(new Integer(i+j));
        }
        for (int i = 0; i < 3; i++) {
            for (int j = 0; j < 3; j++)
                System.out.print(topList.get(i).get(j) + " ");
            System.out.println();
        }
    }
}
```

Output ...

0	1	2
1	2	3
2	3	4

# Sorting in Java

- **Sorting**: Common task when programming, e.g. displaying the words in a list in alphabetical order.
  - Algorithms for Sorting:
    - **Selection** sort
      1. Find largest number and put it in the last position.
      2. Find next largest number and put it next to last one.
      3. Repeat until finished.
    - **Insertion** sort: List of values is sorted by inserting (repeatedly) an unsorted element into a sorted sublist until the complete list is sorted.
    - **Bubble** sort (**next ...**)



See <https://www.cs.usfca.edu/~galles/visualization/ComparisonSort.html> for more sorting algorithms (with animations).

# Bubble (or *Sinking*) Sort

- **Bubble** sort:
  - Several passes are made through the array.
  - Each time, successive adjacent pairs are compared.
    - If pair is in decreasing order, order of values is swapped.
    - Otherwise, move on to next pair.

– **Algorithm:**

```
boolean changed = true;
do {
    changed = false;
    for (int j=0; j < list.length-1; j++) {
        if (list[j] > list[j+1]) {
            swap list[j] with list[j+1];
            changed = true;
        }
    }
} while (changed);
```

# Practice Exercise 3

- Write a **sort method** that uses the *bubble-sort algorithm*.
  - Use {5.0, 4.4, 1.9, 2.9, 3.4, 2.9, 3.5} to test the method.



**Homework:** Try doing *Programming Exercise 6.17* (IJP book).

# (Answer) Exercise 3

- A possible solution ...

```
public class BubbleSortProgram {
    public static void main(String[] args) {
        double[] myList = {5.0, 4.4, 1.9, 2.9, 3.4, 2.9, 3.5};
        BubbleSortProgram myBubble = new BubbleSortProgram();
        System.out.println("My list before sort:");
        myBubble.printList(myList); myBubble.bubbleSort(myList);
        System.out.println("My list after sort:");
        myBubble.printList(myList);
    }
    void printList(double[] list) {
        for (int i = 0; i < list.length; i++)
            System.out.println(list[i]);
    }
    // Method bubbleSort() here.
}

void bubbleSort(double[] list) {
    boolean changed = true;
    do {
        changed = false;
        for (int j = 0;
            j < list.length-1; j++)
            if (list[j] > list[j+1]) {
                double temp = list[j];
                list[j] = list[j + 1];
                list[j + 1] = temp;
                changed = true;
            }
    } while (changed);
}
```

# Comparing objects ... (1/2)

- Real objects are often “comparable”, e.g. you (students) are much younger than me! 😊
  - When writing OO programs, it may be necessary to **compare** instances of the same class; once instances are **comparable**, they can be **sorted** e.g.
    - Given two **Employee** objects, it may be necessary to know which one has been with the company for longer.
- 
- Java defines **two ways of comparing objects**:
    1. The objects implement the **Comparable** interface.
    2. A **Comparator** object is used to compare the two objects.
  - If the objects are **Comparable**, they are said to be **sorted by their "natural" order**.
  - A **Comparable** object can only offer **one form of sorting**.
    - To provide **multiple forms of sorting**, **Comparators** must be used.



**Comparator** is *out of scope* in this course.



# Comparing objects ... (2/2)

- (Remember?) The **String** class has the method **compareTo(Object)**, which returns:
  - 0** → if the **Strings** are **equal**;
  - <0** → if this object is **less than** the specified object;
  - >0** → if this object is **greater than** the specified object.
- The **Comparable** interface contains the **compareTo()** method.
  - If you wish to provide a **natural ordering for your objects**, you must implement the **Comparable** Interface.
  - Any object which is “comparable” can be compared to another object of the same type.
- There is **only one method** defined within this interface. So there is **only one natural ordering** for objects of a given type/class.

# Example using Comparable (1/2)

```
public class Employee implements Comparable<Employee> {
    int empID;
    String eName;
    double salary;
    static int i;

    public Employee() {
        empID = i++;
        eName = "unknown";
        salary = 0.0;
    }

    public Employee(String name, double sal) {
        empID = i++;
        eName = name;
        salary = sal;
    }

    public String toString() {
        return "EmpID = " + empID + "\n" + "Ename = " + eName + "\n" +
            "Salary = " + salary;
    }
}
```

*(rest of the **Employee** class code)*

```
    public int compareTo(Employee o1) {
        if (this.salary == o1.salary) return 0;
        else if (this.salary > o1.salary) return 1;
        else return -1;
    }
}
```



**Aim:** To order employees  
by salary value.

# Example using Comparable (2/2)

```
import java.util.*;

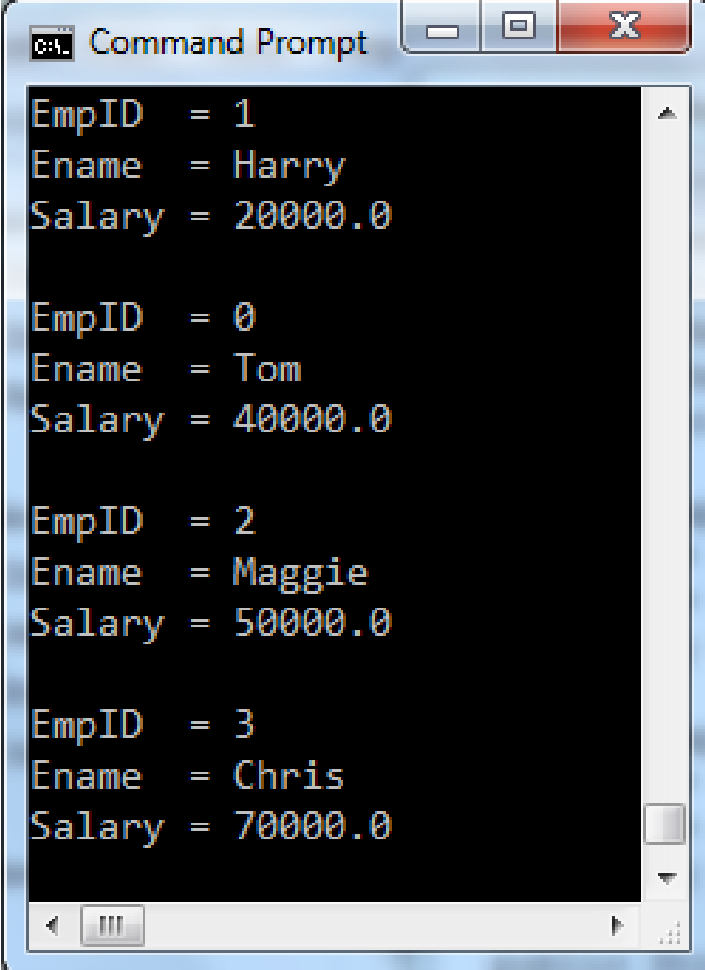
public class ComparableDemo {
    public static void main(String[] args) {
        List<Employee> ts1 = new ArrayList<Employee>();

        ts1.add(new Employee("Tom", 40000.00));
        ts1.add(new Employee("Harry", 20000.00));
        ts1.add(new Employee("Maggie", 50000.00));
        ts1.add(new Employee("Chris", 70000.00));

        Collections.sort(ts1);
        Iterator <Employee> itr = ts1.iterator();

        while(itr.hasNext()) {
            Object element = itr.next();
            System.out.println(element + "\n");
        }
    }
}
```

Output ...



```
Command Prompt

EmpID = 1
Ename = Harry
Salary = 20000.0

EmpID = 0
Ename = Tom
Salary = 40000.0

EmpID = 2
Ename = Maggie
Salary = 50000.0

EmpID = 3
Ename = Chris
Salary = 70000.0
```