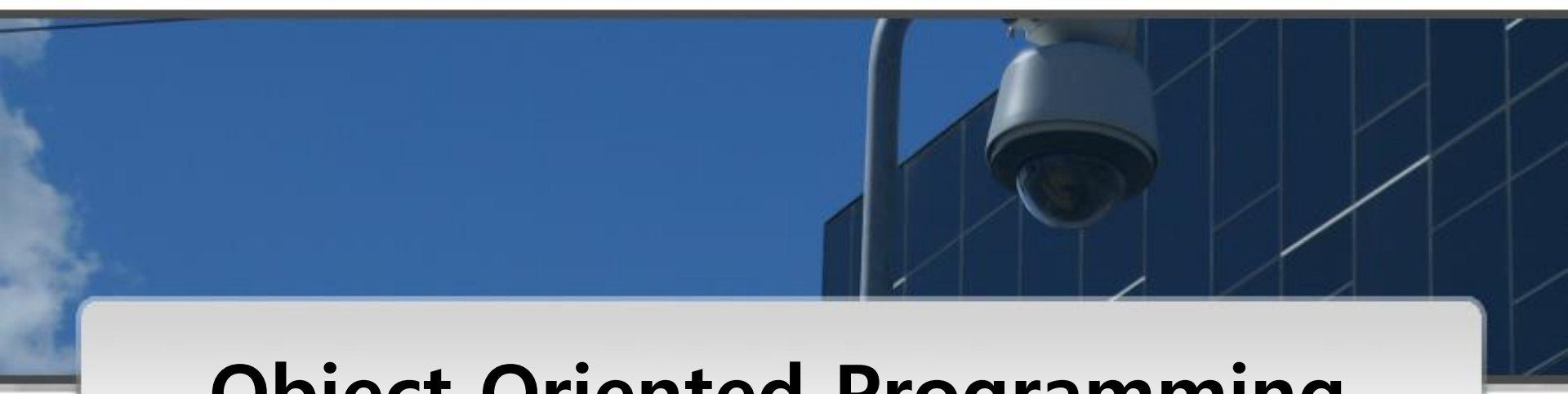


Object Oriented Programming

Generics and ArrayLists

Lab 12

Content

- ArrayLists
- Generics

ArrayList Class

- **An ArrayList is a dynamic data structure. This means**
  - items can be added and removed from the list.
  - The length can grow or shrink as items are added and removed
- **ArrayList is a class in the standard Java libraries**
  - Java.util.ArrayList.

ArrayList vs Arrays

- A normal array in java is a static data structure, because you stuck with the initial size of your array.
- An ArrayList serves the same purpose as an array, except that an ArrayList can change length while the program is running

ArrayList Class

- The class ArrayList is implemented using an array as a private instance variable

```
public class ArrayList<E> extends AbstractList<E>
        implements List<E>, RandomAccess, Cloneable, java.io.Serializable
{
    private static final long serialVersionUID = 8683452581122892189L;

    /**
     * The array buffer into which the elements of the ArrayList are stored.
     * The capacity of the ArrayList is the length of this array buffer.
     */
    private transient Object[] elementData;

    /**
```

- When this hidden array is full, a new larger hidden array is created and the data is transferred to this new array

ArrayList Class

- **Things to know about ArrayLists.**
  - The **base type** of an ArrayList must be a class type (or other reference type):
  - it cannot store primitive types.
  - Primitive types must be boxed into their Wrapper class before they can be used.
  - ArrayLists are less efficient than Arrays.

Using ArrayLists

- **To set up an ArrayList, you first have to**
  - import the package from the java.util library:
    - *import java.util.ArrayList;*
  - Specify the base type
    - *ArrayList<BaseType> aList = new ArrayList<BaseType>();*
- **It is possible to specify the initial size of the ArrayList.**
  - *ArrayList<String> aList = new ArrayList<String>(20);*

ArrayList Notation

- **With regular Arrays it is easy to access items at specific indices of the array using [ ].**
  - *String str = myArray[i];*
    myArray[j] = "Hello";

- **ArrayLists do not provide the convenient [ ] notation. Instead the get(index), set(index, object) and add(object) methods may be used.**
  - *String str = myArrayList.get(i);*
    myArrayList.set(j, "Hello");

☐ Note: set cannot be used to initialize an item. It can only replace existing items.

ArrayList Notation

- **To insert items into the ArrayList for the first time you can use the .add() method.**
  - *myArrayList.add("Goodbye");*
    myArrayList.add("cruel");
    myArrayList.add("world.");

☐ This adds items sequentially into the ArrayList i.e. 0,1,2…

Goodbye	cruel	world			
0	1	2	3	4	…

ArrayList Notation

- **The add() method is overloaded and can accept another parameter. This allows you to insert at a specific index.**

  add(index, object);

☐ The items from index 1 are s hifted to allow for the word "cruel" to be inserted.

myArrayList.add("Goodbye");
myArrayList.add("world");
*myArrayList.**add**(1,"cruel.");*

Goodbye	world				
0	1	2	3	4	…

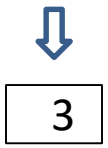
⇩

Goodbye	cruel	world			
0	1	2	3	4	…

ArrayList Notation

- **Return the number of elements stored in the ArrayList by using the .size() method.**

  - *System.out.println(myArrayList.size());*



Goodbye	cruel	world			
0	1	2	3	4	...

ArrayList Class

Display 14.1 Some Methods in the Class `ArrayList`

CONSTRUCTORS
`public ArrayList<Base_Type>(int initialCapacity)` Creates an empty `ArrayList` with the specified *Base_Type* and initial capacity.
`public ArrayList<Base_Type>()` Creates an empty `ArrayList` with the specified *Base_Type* and an initial capacity of 10.

(continued)

ArrayList Class

Display 14.1 Some Methods in the Class ArrayList

ARRAYLIKE METHODS

```
public Base_Type set( int index, Base_Type newElement)
```

Sets the element at the specified `index` to `newElement`. Returns the element previously at that position, but the method is often used as if it were a `void` method. If you draw an analogy between the `ArrayList` and an array `a`, this statement is analogous to setting `a[index]` to the value `newElement`. The `index` must be a value greater than or equal to `0` and less than the current size of the `ArrayList`. Throws an `IndexOutOfBoundsException` if the `index` is not in this range.

```
public Base_Type get(int index)
```

Returns the element at the specified index. This statement is analogous to returning `a[index]` for an array `a`. The `index` must be a value greater than or equal to `0` and less than the current size of the `ArrayList`. Throws `IndexOutOfBoundsException` if the `index` is not in this range.

(continued)

ArrayList Class

Display 14.1 Some Methods in the Class ArrayList

METHODS TO ADD ELEMENTS

```
public boolean add(Base_Type newElement)
```

Adds the specified element to the end of the calling `ArrayList` and increases the `ArrayList`'s size by one. The capacity of the `ArrayList` is increased if that is required. Returns `true` if the add was successful. (The return type is `boolean`, but the method is typically used as if it were a `void` method.)

```
public void add( int index, Base_Type newElement)
```

Inserts `newElement` as an element in the calling `ArrayList` at the specified index. Each element in the `ArrayList` with an index greater or equal to `index` is shifted upward to have an index that is one greater than the value it had previously. The `index` must be a value greater than or equal to `0` and less than *or equal* to the current size of the `ArrayList`. Throws `IndexOutOfBoundsException` if the index is not in this range. Note that you can use this method to add an element after the last element. The capacity of the `ArrayList` is increased if that is required.

(continued)

ArrayList Class

Display 14.1 Some Methods in the Class `ArrayList`

METHODS TO REMOVE ELEMENTS

```
public Base_Type remove(int index)
```

Deletes and returns the element at the specified index. Each element in the `ArrayList` with an index greater than `index` is decreased to have an index that is one less than the value it had previously. The `index` must be a value greater than or equal to `0` and less than the current size of the `ArrayList`. Throws `IndexOutOfBoundsException` if the `index` is not in this range. Often used as if it were a `void` method.

(continued)

ArrayList Class

Display 14.1 Some Methods in the Class ArrayList

```
protected void removeRange(int fromIndex, int toIndex)
```

Deletes all the element with indices *i* such that `fromIndex` $\leq i <$ `toIndex`. Element with indices greater than or equal to `toIndex` are decreased appropriately.

```
public boolean remove(Object theElement)
```

Removes one occurrence of `theElement` from the calling `ArrayList`. If `theElement` is found in the `ArrayList`, then each element in the `ArrayList` with an index greater than the removed element's index is decreased to have an index that is one less than the value it had previously. Returns `true` if `theElement` was found (and removed). Returns `false` if `theElement` was not found in the calling `ArrayList`.

```
public void clear()
```

Removes all elements from the calling `ArrayList` and sets the `ArrayList`'s size to zero.

(continued)

ArrayList Class

Display 14.1 Some Methods in the Class ArrayList

SEARCH METHODS

```
public boolean contains(Object target)
```

Returns `true` if the calling `ArrayList` contains `target`; otherwise, returns `false`. Uses the method `equals` of the object `target` to test for equality with any element in the calling `ArrayList`.

```
public int indexOf(Object target)
```

Returns the index of the first element that is equal to `target`. Uses the method `equals` of the object `target` to test for equality. Returns `-1` if `target` is not found.

ArrayList Class

Display 14.1 Some Methods in the Class `ArrayList`

MEMORY MANAGEMENT (SIZE AND CAPACITY)
`public boolean isEmpty()` Returns `true` if the calling `ArrayList` is empty (that is, has size `0`); otherwise, returns `false`.
`public int size()` Returns the number of elements in the calling `ArrayList`.

Golf Score Program (Part 1 of 6)

Display 14.3 Golf Score Program

```
1  import java.util.ArrayList;
2  import java.util.Scanner;

3  public class GolfScores
4  {
5      /**
6       Shows differences between each of a list of golf scores and their average.
7      */
8      public static void main(String[] args)
9      {
10       ArrayList<Double> score = new ArrayList<Double>();

11         System.out.println("This program reads golf scores and shows");
12         System.out.println("how much each differs from the average.");

13         System.out.println("Enter golf scores:");
14         fillArrayList(score);
15         showDifference(score);
16     }
```

Parameters of type `ArrayList<Double>()` *are handled just like any other class parameter.*

(continued)

Golf Score Program (Part 2 of 6)

Display 14.3 **Golf Score Program**

```
17      /**
18       Reads values into the array a.
19      */
20      public static void fillArrayList(ArrayList<Double> a)
21      {
22          System.out.println("Enter a list of nonnegative numbers.");
23          System.out.println("Mark the end of the list with a negative number.");
24          Scanner keyboard = new Scanner(System.in);
```

(continued)

Golf Score Program (Part 3 of 6)

Display 14.3 Golf Score Program

```
25          double next;
26          int index = 0;
27          next = keyboard.nextDouble();
28          while (next >= 0)
29          {
30              a.add(next);
31              next = keyboard.nextDouble();
32          }
33      }
34      /**
35        Returns the average of numbers in a.
36      */
37      public static double computeAverage(ArrayList<Double> a)
38      {
39          double total = 0;
40          for (Double element : a)
41              total = total + element;
```

Because of automatic boxing, we can treat values of type `double` *as if their type were* `Double`.

A for-each loop is the nicest way to cycle through all the elements in an `ArrayList`.

(continued)

Golf Score Program (Part 4 of 6)

Display 14.3 Golf Score Program

```
42          int numberOfScores = a.size();
43          if (numberOfScores > 0)
44          {
45              return (total/numberOfScores);
46          }
47          else
48          {
49              System.out.println("ERROR: Trying to average 0 numbers.");
50              System.out.println("computeAverage returns 0.");
51              return 0;
52          }
53      }
```

(continued)

Golf Score Program (Part 5 of 6)

Display 14.3 Golf Score Program

```
54      /**
55        Gives screen output showing how much each of the elements
56        in a differ from their average.
57      */
58      public static void showDifference(ArrayList<Double> a)
59      {
60          double average = computeAverage(a);
61          System.out.println("Average of the " + a.size()
62                                              + " scores = " + average);
63          System.out.println("The scores are:");
64          for (Double element : a)
65              System.out.println(element + " differs from average by "
66                                              + (element – average));
67      }
68  }
```

(continued)

Golf Score Program (Part 6 of 6)

Display 14.3 **Golf Score Program**

SAMPLE DIALOGUE

```
This program reads golf scores and shows
how much each differs from the average.
Enter golf scores:
Enter a list of nonnegative numbers.
Mark the end of the list with a negative number.
69  74  68  -1
Average of the 3 scores = 70.3333
The scores are:
69.0 differs from average by -1.33333
74.0 differs from average by 3.66667
68.0 differs from average by -2.33333
```

For each loop

- **As with arrays, the For-each loop can be used to cycle through (iterate) all the elements in an collection (like an ArrayList)**
  - *for(variable : collection) {*
    Statements;
    }

For each loop

```java
import java.util.ArrayList;

public class ArrayListTest {
    public static void main(String[] args){
        //create the ArrayList
        ArrayList<Integer> aList = new ArrayList<Integer>();

        //Load objects into the list
        for(int i = 0; i < 20; i++){
            aList.add(new Integer(i));
        }
        System.out.println("Loaded integers into list.");

        //using the the for-each loop data can be retrieved
        for (Integer itger:aList){
            System.out.println(itger.intValue());
        }
    }
}
```

```
Loaded integers into list.
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
```

Why is the for-each loop not used here?

ArrayList Iterator

- An iterator is an object that is used with a collection to provide sequential access to the collection's elements
- This access allows examination and possible modification of the elements

ArrayList Iterator

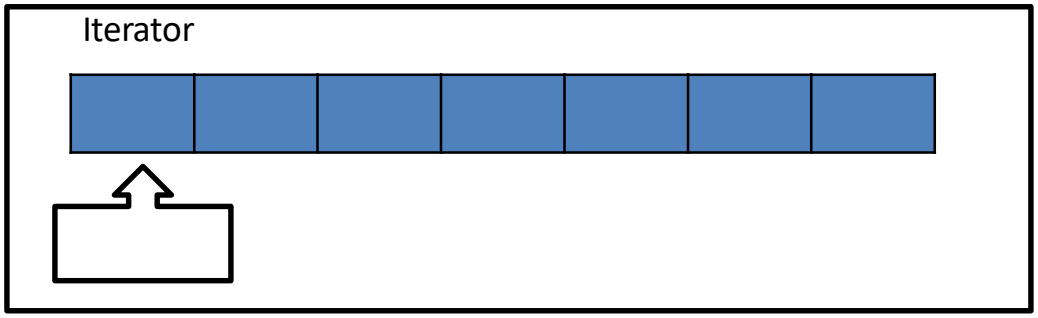
- **Java provides an Iterator<T> interface**
  - Any object of any class that satisfies the Iterator<T> interface is an Iterator<T>
- **An Iterator<T>does not stand on its own**
- **It must be associated with some collection object using the method iterator {usually inner classes of collections}**

ArrayList Iterator

- **Iterators know how to iterate the internal data structure.**
  - For ArrayLists the iterator knows how to iterate the list.
- **To use an Iterator you must obtain it from the ArrayList.**
- *Iterator iterator = myArrayList.iterator();*

☐ Obtain an iterator over the ArrayList named m ArrayList

ArrayList Iterator



- **Iterators provide methods for traversing the internal structure:**
  - *boolean* ***next()***
  - *Object* ***hasNext()***
  - *void* ***remove()***

☐ Returns the next item from the internal structure
☐ Returns true if there are mor e items in the structure
☐ Removes the current item from the structure.

Iterators

```
public class GenericManager <T>{

    private Collection<T> cList;

    public GenericManager(){
        cList = new ArrayList<T>();
    }

    public void add(T item){

    }

    public String find(T item){
        String toReturn = "";
        for(Iterator<T>myIterator = cList.iterator(); myIterator.hasNext();){
            T listContact = myIterator.next();
            if (listContact.equals(item))
                toReturn +=listContact+"\n";
        }
        return toReturn;
    }

}
```

A look at our Generic Manager implemented with an ArrayList.
We are using an Iterator to iterate the list.

- ☐ Notice the structure of the for loop is different.
- ☐ This for loop structure is used specifically with iterators to prevent ConcurrentModificationException.

Generics

- It would be nice if we could write a single sort method that could sort the elements in an Integer array, a String array or an array of any type that supports ordering.

- Using Java Generic concept we might write a generic method for sorting an array of objects, then invoke the generic method with Integer arrays, Double arrays, String arrays and so on, to sort the array elements.

- A way to re-use the same code with different inputs

Parameterized Classes and Generics

- **The class ArrayList is a *parameterized class***
- **It has a parameter, denoted by Base_Type, that can be replaced by any reference type to obtain a class for ArrayLists with the specified base type**

```
ArrayList<BaseType> aList = new ArrayList<BaseType>();
```

- **Starting with version 5.0, Java allows class definitions with parameters for types**
  - These classes that have type parameters are called parameterized class or generic definitions, or simply, generics

Generics Class

- **A class definition with a type parameter is called a generic class**
  - The type parameter is included in angular brackets after the class name in the class definition heading
  - The type parameter can be used like other types used in the definition of a class

```
Public class myClass<T> {
        // the generic type is used in here
}
```

- **The type plugged in for a type parameter must always be a reference type**
  - It cannot be a primitive type such as **int**, **double**, or **char**

Defining Generic Class

Display 14.4 A Class Definition with a Type Parameter

```
1   public class Sample<T>
2   {
3       private T data;

4       public void setData(T newData)
5       {
6           data = newData;
7       }

8       public T getData()
9       {
10          return data;
11      }
12  }
```

T is a parameter for a type.

- Constructor does not have a parameter

Using Generic Class

- **To use a generic class you must**
  - Plug the type of the parameter.
  - This is done by using < >.

- **e.g. if we would like to create a sample object from previous slide we can do this.**
  - **Sample<String> object = new Sample<String>();**

Generic Class

- It is possible to use multiple generic parameters in a single class. This may be done by listing the parameters.

```
public class myClass <T, U> {
        // the generic types are used in here
}
```

Bounds with Generic Class

- **You can have Java enforce this restriction on the possible types that can be plugged in for T.**
- **With a regular Type we can simply**
  - extend a base Type
  - implement an interface.

- **Generics can be made to conform by using the keyword extends. When extends is used the generic becomes bound to a particular**
  - interface
  - parent class

Bounds with Generic Class

```
Public class myClass <T extends Comparable>{
        // this forces T to be only Comparable types
}
```

- **You may also bind the generic to multiple types however as with regular types you can**
  - Be bound to multiple interfaces
  - Be bound to only one class

```
Public class myClass <T extends Employee & Comparable & Iterable >{
        // this forces T to be only Comparable types and
        // T must be a descendant (sub-class) of Employee
        // The extended class (Employee) must be listed first.
}
```

Generic Methods

- **When a generic class is defined, the type parameter can be used in the definitions of the methods for that generic class**

- **In addition, a generic method can be defined that has its own type parameter that is not the type parameter of any class**
  - A generic method can be a member of an ordinary class or a member of a generic class that has some other type parameter
  - The type parameter of a generic method is local to that method, not to the class

Generic Methods

- **The type parameter must be placed (in angular brackets) after all the modifiers, and before the returned type**

```
public static <T> T genMethod(T[] a)
```

☐ Accepts T array as a parameter and returns type T

- **When one of these generic methods is invoked, the method name is prefaced with the type to be plugged in, enclosed in angular brackets**

```
String s = NonGenClass.<String>genMethod(c);
```

Generics

```
public class Utility{
    //…

    public static <T> T getMidpoint(T[] a){
        return a[a.length/2];
    }

    public static <T> T getFirst(T[] a){
        return a[0];
    }
    //…
}

String midString = Utility.<String>getMidpoint(b);
double firstNumber = Utility.<Double>getFirst(c);
```

Self-Test

- 고객과의 상담 정보를 관리하는 Contact management 프로그램을 작성할 것
- Contact 클래스를 작성할 것. 이 클래스는 Comparable을 implements하며, String name, String telNum, String email 3개의 instance variable을 갖는다.
- 두 개의 생성자를 만들 것
  - 첫번째 생성자는 모든 instance variable을 인자로 받는다.
  - 두번째 생성자는 name을 인자로 받으며 나머지 변수는 null로 설정한다.
- 매개변수를 적절히 사용하여 accessor와 mutator 메소드를 작성할 것 (getTelNum(), setTelNum(), getEmail(), setEmail(), getName(), setName())
- name과 telNum, email이 포함된 문자열을 반환하는 toString() (작성되어 있음)
- name이 같은지 비교하는 equals() 메소드를 작성할 것
- name을 알파벳 오름차순으로 비교하는 compareTo() 메소드 (작성되어 있음)

Self-Test (Contd)

- GenericManager 클래스를 작성할 것. 이 클래스는 generic 매개변수 T를 갖는다. generic 매개변수 T는 Comparable을 extends 한다.
- 이 클래스는 ArrayList cList라는 instance variable 갖는다. 이 ArrayList의 base type은 T이다.
- 매개변수를 받지 않는 생성자를 만들 것. 생성자는 새로운 ArrayList 객체를 만든다.
- add() 메소드를 작성할 것. 이 메소드는 generic type을 매개변수로 가지며 이를 ArrayList에 추가한다. 반환 형은 void이다.
- CompareTo() 메소드를 통해 ArrayList를 정렬하는 sort() 메소드 (작성되어 있음)
- find() 메소드를 작성할 것. 이 메소드는 generic type을 매개변수로 가지며 매개변수와 동일한 모든 객체의 문자열을 반환한다.
- toString() 메소드를 작성할 것. 이 메소드는 ArrayList의 각 항목을 모두 거치며 ArrayList 안에 있는 모든 객체의 문자열을 반환한다.

Self-Test (Contd)

```
*******Contact Management System*******
(1) Add a contact:
(2) Display all contacts:
(3) Search for contacts
(4) Sort the contacts
(5) Exit the program
**************************************
1
Please enter the name:
IronMan
Please enter the tell#:
01000000000
Please enter the email:
Rich@gmail.com
*******Contact Management System*******
(1) Add a contact:
(2) Display all contacts:
(3) Search for contacts
(4) Sort the contacts
(5) Exit the program
**************************************
1
Please enter the name:
Thor
Please enter the tell#:
01011111111
Please enter the email:
KingofAsgard@gmail.com
```

```
*******Contact Management System*******
(1) Add a contact:
(2) Display all contacts:
(3) Search for contacts
(4) Sort the contacts
(5) Exit the program
**************************************
1
Please enter the name:
DoctorStrange
Please enter the tell#:
01022222222
Please enter the email:
Dormammu@gmail.com
*******Contact Management System*******
(1) Add a contact:
(2) Display all contacts:
(3) Search for contacts
(4) Sort the contacts
(5) Exit the program
**************************************
1
Please enter the name:
Thanos
Please enter the tell#:
01033333333
Please enter the email:
Balance@gmail.com
```

Self-Test (Contd)

```
*******Contact Management System*******
(1) Add a contact:
(2) Display all contacts:
(3) Search for contacts
(4) Sort the contacts
(5) Exit the program
**************************************
2
**********Contact List**********
Name: IronMan    telNum: 01000000000     email: Rich@gmail.com
Name: Thor       telNum: 01011111111     email: KingofAsgard@gmail.com
Name: DoctorStrange     telNum: 01022222222     email: Dormammu@gmail.com
Name: Thanos     telNum: 01033333333     email: Balance@gmail.com

******************************
*******Contact Management System*******
(1) Add a contact:
(2) Display all contacts:
(3) Search for contacts
(4) Sort the contacts
(5) Exit the program
**************************************
3
Please enter the name to search for:
IronMan
**********Search Results**********
Name: IronMan    telNum: 01000000000     email: Rich@gmail.com

******************************
```

```
*******Contact Management System*******
(1) Add a contact:
(2) Display all contacts:
(3) Search for contacts
(4) Sort the contacts
(5) Exit the program
**************************************
4
*******Contact Management System*******
(1) Add a contact:
(2) Display all contacts:
(3) Search for contacts
(4) Sort the contacts
(5) Exit the program
**************************************
2
**********Contact List**********
Name: DoctorStrange     telNum: 01022222222     email: Dormammu@gmail.com
Name: IronMan    telNum: 01000000000     email: Rich@gmail.com
Name: Thanos     telNum: 01033333333     email: Balance@gmail.com
Name: Thor       telNum: 01011111111     email: KingofAsgard@gmail.com

******************************
*******Contact Management System*******
(1) Add a contact:
(2) Display all contacts:
(3) Search for contacts
(4) Sort the contacts
(5) Exit the program
**************************************
5
Exiting Program... Goodbye.
```