# Collection Framework

# Objective

- Collection Framework
- Core Interfaces

# Java Collections Framework

- The **Java Collections Framework** is a collection of
  - interfaces and classes 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.

# Collections Framework

*Collections Framework* is a unified architecture for managing collections

This framework is provided in the java.util package

Main Parts of Collections Framework

-Interfaces

- Core interfaces defining common functionality exhibited by collections

-Implementations

- Concrete classes of the core interfaces providing data structures

# Interfaces

| *Core Interface* | *Description* |
|---|---|
| `Collection` | specifies contract that all collections should implement |
| `Set` | defines functionality for a *set* of unique elements |
| `SortedSet` | defines functionality for a *set* where elements are sorted |
| `List` | defines functionality for an ordered *list* of non- unique elements |
| `Map` | defines functionality for mapping of unique keys to values |
| `SortedMap` | defines functionality for a *map* where its keys are sorted |

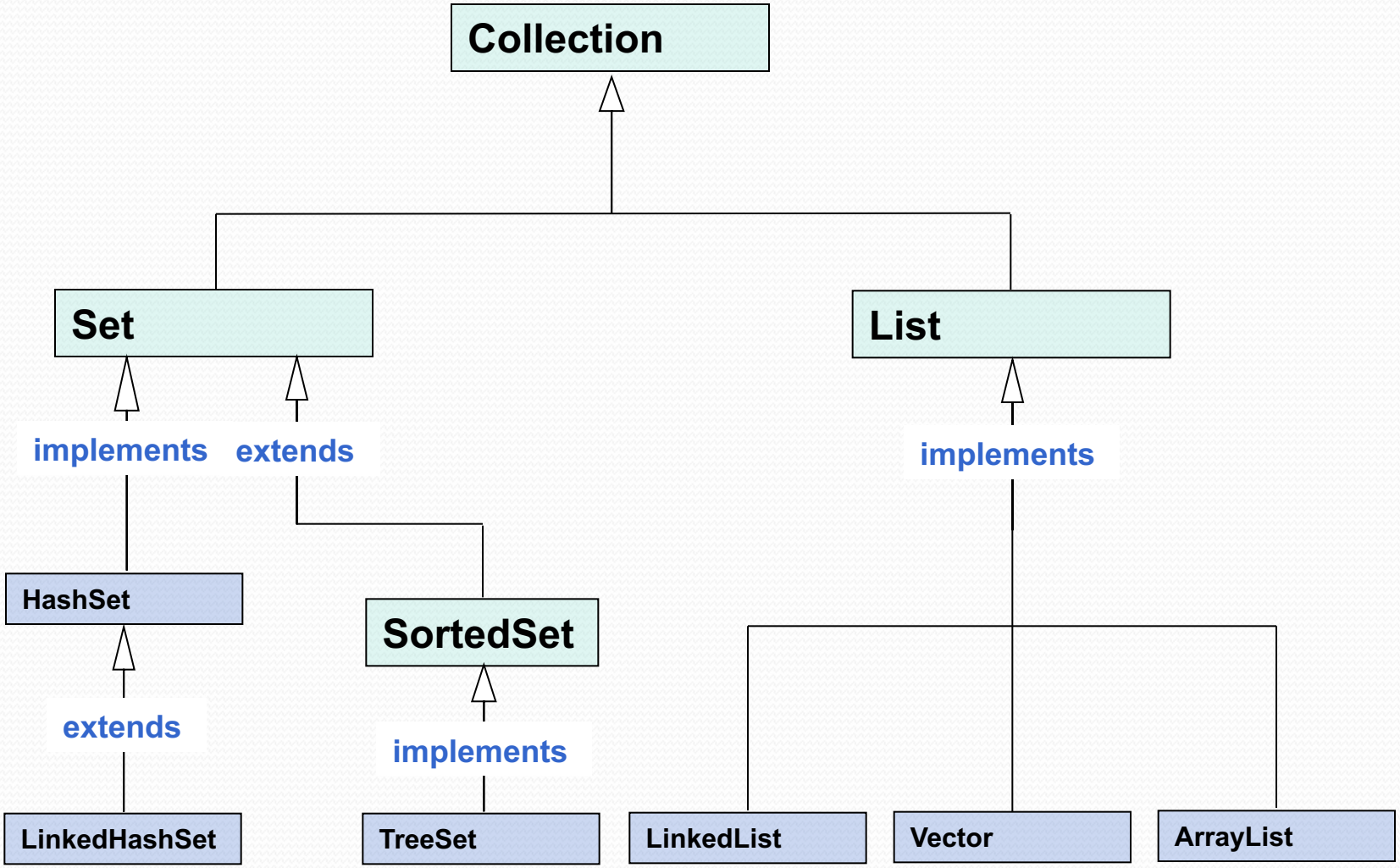
# Collections Framework Implementations

| Set | List | Map |
|---|---|---|
| **`HashSet`** | **`ArrayList`** | **`HashMap`** |
| **`LinkedHashSet`** | **`LinkedList`** | **`LinkedHashMap`** |
| **`TreeSet`** | **`Vector`** | **`Hashtable`** |
| | | **`Tree Map`** |

Note: Hashtable uses a lower-case “t”

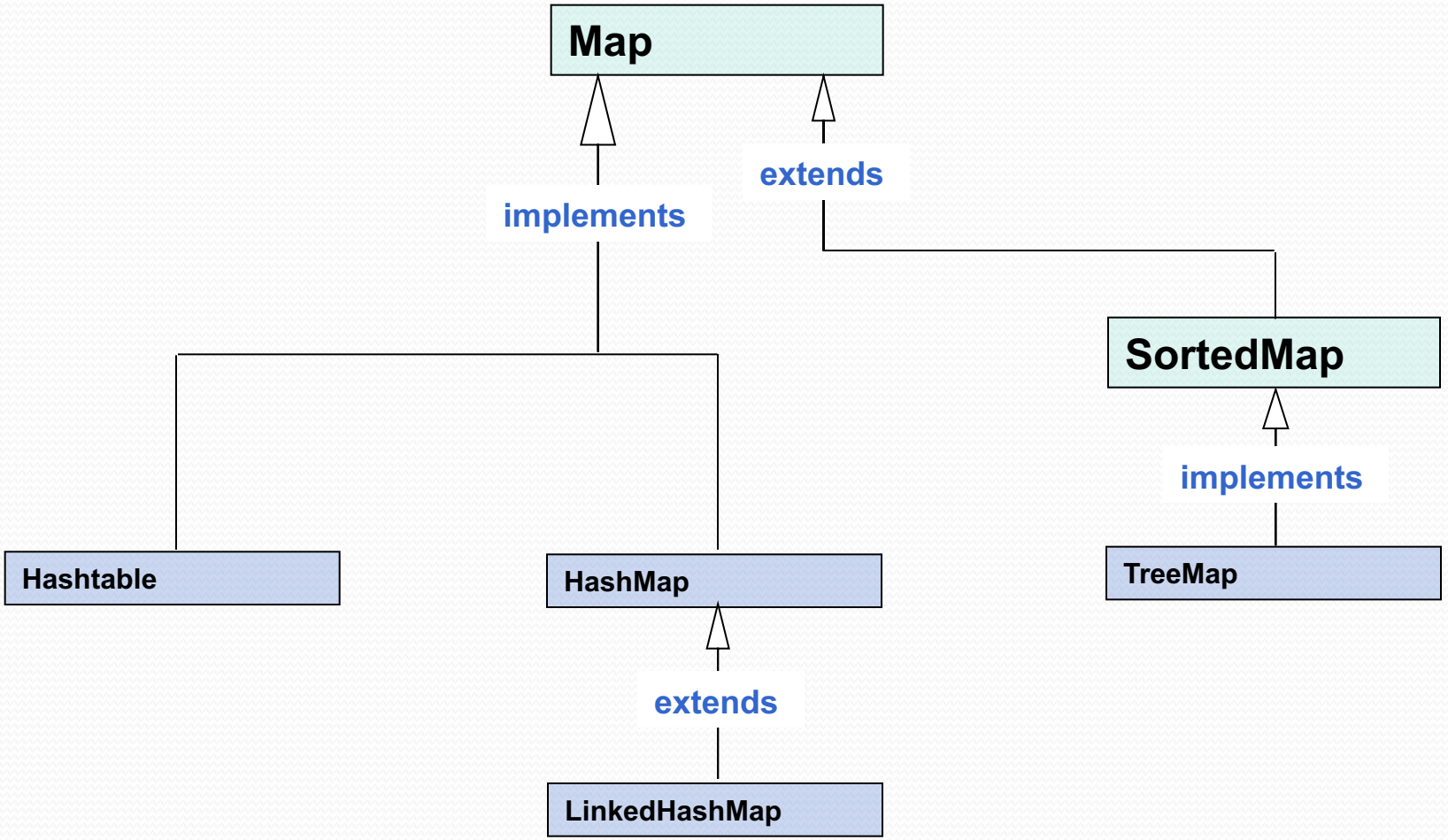
# Collections Hierarchy

## Set and List



# Collections Hierarchy

# Map



# Operations

Basic collection operations:

- Check if collection is empty
- Check if an object exists in collection.
- Retrieve an object from collection
- Add object to collection
- Remove object from collection
- Iterate collection and inspect each object

- Each operation has a corresponding method implementation for each collection type

# Collections Methods

- Class `Collections` provides several high-performance algorithms for manipulating collection elements.
- The algorithms (Fig. 20.5) are implemented as `static` methods.
- Note that Collection is a base interface for most collection classes, whereas Collections is a utility class.

Collection : The root interface of Java Collections Framework.

Collections : A utility class that is a member of the Java Collections Framework.

| Method | Description |
|---|---|
| `sort` | Sorts the elements of a `List`. |
| `binarySearch` | Locates an object in a `List`. |
| `reverse` | Reverses the elements of a `List`. |
| `shuffle` | Randomly orders a `List`'s elements. |
| `fill` | Sets every `List` element to refer to a specified object. |
| `copy` | Copies references from one `List` into another. |
| `min` | Returns the smallest element in a `Collection`. |
| `max` | Returns the largest element in a `Collection`. |
| `addAll` | Appends all elements in an array to a `Collection`. |
| `frequency` | Calculates how many collection elements are equal to the specified element. |
| `disjoint` | Determines whether two collections have no elements in common. |

**Fig. 20.5** | `Collections` methods.

**Software Engineering Observation 20.4**

*The collections framework methods are polymorphic. That is, each can operate on objects that implement specific interfaces, regardless of the underlying implementations.*

# Lists

- A List (sometimes called a **sequence**) is an ordered Collection that can contain duplicate elements.

- Like array indices, List indices are zero based (i.e., the first element's index is zero).

- Interface List is implemented by several classes, including **ArrayList**, **LinkedList** and **Vector**

# Array List

- An instance of ArrayList is created and named in the same way
- As objects of any class are created and named, except that you specify the base type using a different notation< >.
- Example

```
ArrayList<String>list = new ArrayList<String>(20);
```

# Array List

- `ArrayList` collection
  - Similar to arrays
  - Dynamic resizing
    - They automatically increase their size at execution time to accommodate additional elements

# Introduction to Collections and Class `ArrayList`

- Java API provides several predefined data structures, called collections, used to store groups of related objects.
  - Each provides efficient methods that organize, store and retrieve your data without requiring knowledge of how the data is being stored.
  - Reduce application-development time.
- Arrays do not automatically change their size at execution time to accommodate additional elements.
- ArrayList<T> (package `java.util`) can dynamically change its size to accommodate more elements.
  - `T` is a placeholder for the type of element stored in the collection.
  - This is similar to specifying the type when declaring an array, except that only nonprimitive types can be used with these collection classes.
- Classes with this kind of placeholder that can be used with any type are called generic classes.

# Introduction to Collections and Class `ArrayList` (Cont.)

- Figure 7.24 demonstrates some common `ArrayList` capabilities.
- An `ArrayList`'s capacity indicates how many items it can hold without growing.
- When the `ArrayList` grows, it must create a larger internal array and copy each element to the new array.
  - This is a time-consuming operation. It would be inefficient for the `ArrayList` to grow each time an element is added.
  - An `ArrayList` grows only when an element is added and the number of elements is equal to the capacity—i.e., there is no space for the new element.

| Method | Description |
|---|---|
| `add` | Adds an element to the end of the `ArrayList`. |
| `clear` | Removes all the elements from the `ArrayList`. |
| `contains` | Returns `true` if the `ArrayList` contains the specified element; otherwise, returns `false`. |
| `get` | Returns the element at the specified index. |
| `indexOf` | Returns the index of the first occurrence of the specified element in the `ArrayList`. |
| `remove` | Overloaded. Removes the first occurrence of the specified value or the element at the specified index. |
| `size` | Returns the number of elements stored in the `ArrayList`. |
| `trimToSize` | Trims the capacity of the `ArrayList` to current number of elements. |

**Fig. 7.23** | Some methods and properties of class `ArrayList<T>`.

# Introduction to Collections and Class `ArrayList` (Cont.)

- Method add adds elements to the `ArrayList`.
  - One-argument version appends its argument to the end of the `ArrayList`.
  - Two-argument version inserts a new element at the specified position.
  - Collection indices start at zero.
- Method size returns the number of elements in the `ArrayList`.
- Method get obtains the element at a specified index.
- Method remove deletes an element with a specific value.
  - An overloaded version of the method removes the element at the specified index.
- Method contains determines if an item is in the `ArrayList`.

```
1  // Fig. 7.24: ArrayListCollection.java
2  // Generic ArrayList<T> collection demonstration.
3  import java.util.ArrayList;
4
5  public class ArrayListCollection
6  {
7     public static void main( String[] args )
8     {
9        // create a new ArrayList of Strings with an initial capacity of 10
10       ArrayList< String > items = new ArrayList< String >();
11
12       items.add( "red" ); // append an item to the list
13       items.add( 0, "yellow" ); // insert the value at index 0
14
15       // header
16       System.out.print(
17          "Display list contents with counter-controlled loop:" );
18
19       // display the colors in the list
20       for ( int i = 0; i < items.size(); i++ )
21          System.out.printf( " %s", items.get( i ) );
22
```

**Fig. 7.24** | Generic `ArrayList<T>` collection demonstration. (Part 1 of 3.)

```
23         // display colors using foreach in the display method
24         display( items,
25            "\nDisplay list contents with enhanced for statement:" );
26
27         items.add( "green" ); // add "green" to the end of the list
28         items.add( "yellow" ); // add "yellow" to the end of the list
29         display( items, "List with two new elements:" );
30
31         items.remove( "yellow" ); // remove the first "yellow"
32         display( items, "Remove first instance of yellow:" );
33
34         items.remove( 1 ); // remove item at index 1
35         display( items, "Remove second list element (green):" );
36
37         // check if a value is in the List
38         System.out.printf( "\"red\" is %sin the list\n",
39            items.contains( "red" ) ? "": "not " );
40
41         // display number of elements in the List
42         System.out.printf( "Size: %s\n", items.size() );
43      } // end main
44
```

**Fig. 7.24** | Generic `ArrayList<T>` collection demonstration. (Part 2 of 3.)

```
45      // display the ArrayList's elements on the console
46      public static void display( ArrayList< String > items, String header )
47      {
48         System.out.print( header ); // display header
49
50         // display each element in items
51         for ( String item : items )
52            System.out.printf( " %s", item );
53
54         System.out.println(); // display end of line
55      } // end method display
56   } // end class ArrayListCollection
```

```
Display list contents with counter-controlled loop: yellow red
Display list contents with enhanced for statement: yellow red
List with two new elements: yellow red green yellow
Remove first instance of yellow: red green yellow
Remove second list element (green): red yellow
"red" is in the list
Size: 2
```

**Fig. 7.24** | Generic `ArrayList<T>` collection demonstration. (Part 3 of 3.)

# Code Example: ArrayListCollection

- See code

# `ArrayList` and `Iterator`

- List method `add` adds an item to the end of a list.
- List method `size` returns the number of elements.
- List method `get` retrieves an individual element's value from the specified index.
- In Java, an iterator is an interface and is implemented by all collection classes. The Java collections framework is a group of classes and interfaces that implement reusable collection of data structures. The iterator method returns an object that implements the Iterator interface.
- Collection method iterator gets an `Iterator` for a `Collection`.
- Iterator- method hasNext determines whether a `Collection` contains more elements.
  - Returns `true` if another element exists and `false` otherwise.
- Iterator method next obtains a reference to the next element.
- `Collection` method contains determine whether a `Collection` contains a specified element.
- Iterator method remove removes the current element from a `Collection`.

# Collection Interface

- See code fig 20.2

```
42      // remove colors specified in collection2 from collection1
43      private static void removeColors( Collection< String > collection1,
44         Collection< String > collection2 )
45      {
46         // get iterator
47         Iterator< String > iterator = collection1.iterator();
48
49         // loop while collection has items
50         while ( iterator.hasNext() )
51         {
52            if ( collection2.contains( iterator.next() ) )
53               iterator.remove(); // remove current Color
54         } // end while
55      } // end method removeColors
56   } // end class CollectionTest
```

```
ArrayList:
MAGENTA RED WHITE BLUE CYAN

ArrayList after calling removeColors:
MAGENTA CYAN
```

**Fig. 20.2** | `Collection` interface demonstrated via an `ArrayList` object. (Part 3 of 3.)

# ArrayList and Iterator

- New in Java SE 7: Type Inference with the <> Notation
  - Lines 14 and 21 specify the type stored in the `ArrayList` (that is, `String`) on the left and right sides of the initialization statements.
  - Java SE 7 supports type inferencing with the <> notation in statements that declare and create generic type variables and objects. For example, line 14 can be written as:

```
List< String > list = new ArrayList <>();
```

  - Java uses the type in angle brackets on the left of the declaration (that is, `String`) as the type stored in the `ArrayList` created on the right side of the declaration.

# Method `sort`

- Method `sort` sorts the elements of a `List`
  - The elements must implement the `Comparable` interface.
  - The order is determined by the natural order of the elements' type as implemented by a `compareTo` method.
  - Method `compareTo` is declared in interface `Comparable` and is sometimes called the natural comparison method.
  - The `sort` call may specify as a second argument a `Comparator` object that determines an alternative ordering of the elements.

- Class `Arrays` provides `static` method asList to view an array as a List collection.
  - A `List` view allows you to manipulate the array as if it were a list.
  - This is useful for adding the elements in an array to a collection and for sorting array elements.
- Any modifications made through the `List` view change the array, and any modifications made to the array change the `List` view.
- List method toArray gets an array from a `List` collection.

# Collection Method Sort

- See Fig 20.6 Code

```
Unsorted array elements: [Hearts, Diamonds, Clubs, Spades]
Sorted array elements: [Clubs, Diamonds, Hearts, Spades]
```

**Fig. 20.6** | `Collections` method `sort`. (Part 2 of 2.)

# Binary Search

- java.util.Collections.binarySearch() method is a java.util.Collections class method that returns position of an object in a sorted list.

```
// Returns index of key in sorted list sorted in // ascending order

 public static int binarySearch(List slist, T key)

 // Returns index of key in sorted list sorted in
// order defined by Comparator c.

 public static int binarySearch(List slist, T key, Comparator c)
```

If key is not present, the it returns "(-(insertion point) - 1)".
The insertion point is defined as the point at which the key would be inserted into the list

```java
import java.util.*;
public class GFG {
    public static void main(String[] args)
    {
        List<Integer> al = new ArrayList<Integer>();
        al.add(1);
        al.add(2);
        al.add(3);
        al.add(10);
        al.add(20);

        // 10 is present at index 3.
        int index = Collections.binarySearch(al, 10);
        System.out.println(index);

        // 13 is not present. 13 would have been inserted
        // at position 4. So the function returns (-4-1)
        // which is -5.
        index = Collections.binarySearch(al, 13);
        System.out.println(index);
    }
}
```