



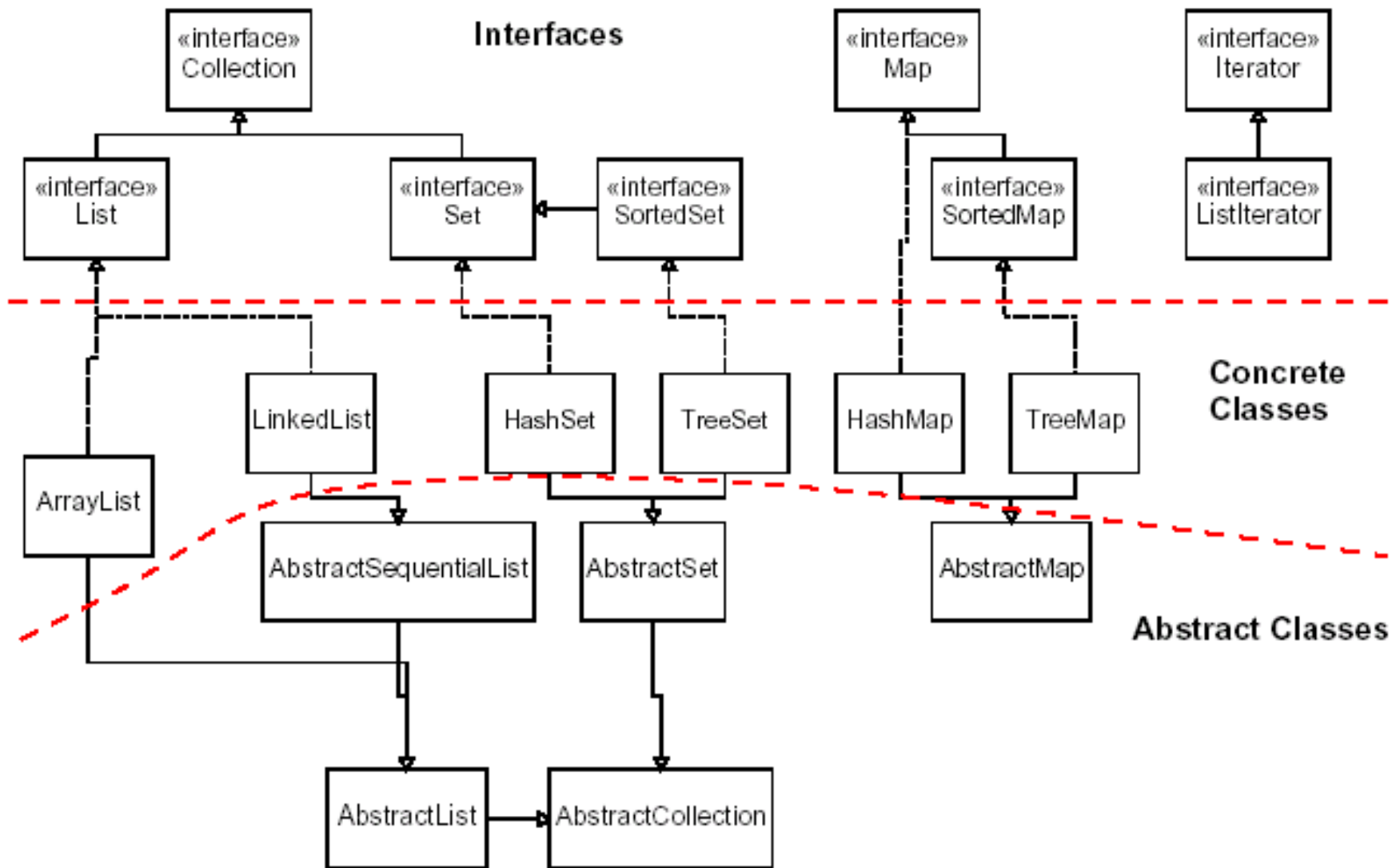
ArrayLists: Our Collection Class

Subset of the Supplement Lesson slides from: [Building Java Programs](http://www.buildingjavaprograms.com/), Chapter 10
by Stuart Reges and Marty Stepp (<http://www.buildingjavaprograms.com/>) & thanks to Ms Martin.

Collections

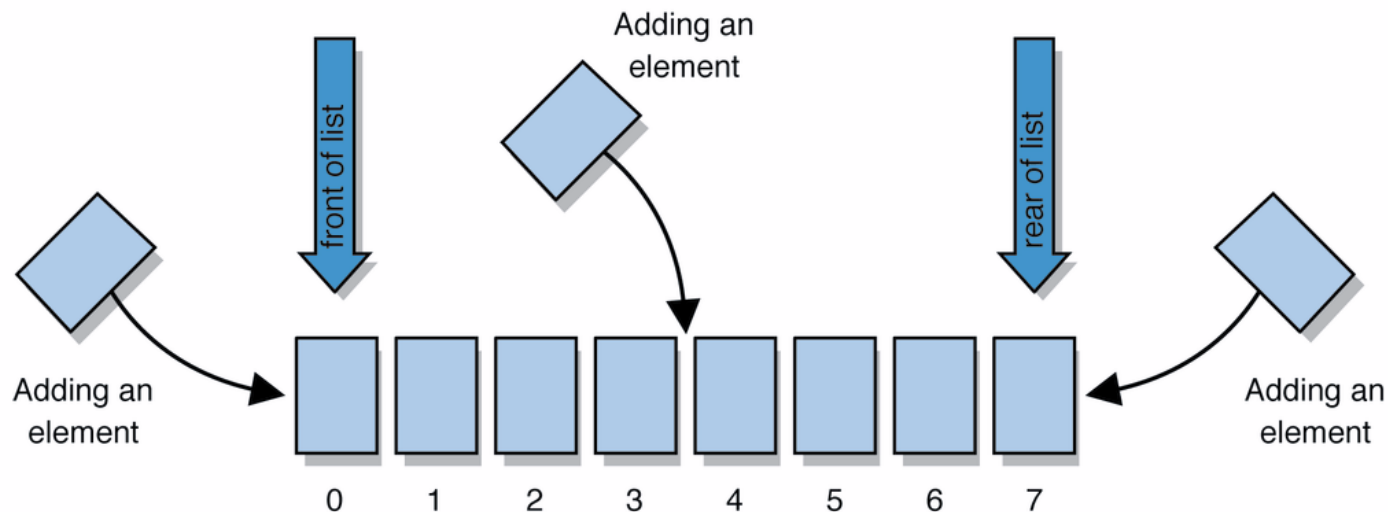
- **collection**: an object that stores data; a.k.a. "data structure"
 - the objects stored are called **elements**
 - some collections maintain an ordering; some allow duplicates
 - typical operations: *add, remove, clear, contains* (search), *size*
 - examples found in the Java class libraries:
 - `ArrayList, LinkedList, HashMap, TreeSet, PriorityQueue`
 - all collections are in the `java.util` package
 - `import java.util.*;`

Java collections framework



Lists

- **list**: a collection storing an ordered sequence of elements
 - each element is accessible by a 0-based **index**
 - a list has a **size** (number of elements that have been added)
 - elements can be added to the front, back, or elsewhere
 - in Java, a list can be represented as an **ArrayList** object



Idea of a list

- Rather than creating an array of boxes, create an object that represents a "list" of items. (initially an empty list.)

```
[]
```

- You can add items to the list.
 - The default behavior is to add to the end of the list.

```
[hello, ABC, goodbye, okay]
```

- The list object keeps track of the element values that have been added to it, their order, indexes, and its total size.
 - Think of an "array list" as an automatically resizing array object.
 - Internally, the list is implemented using an array and a size field.

Type Parameters (Generics)

```
ArrayList<Type> name = new ArrayList<Type>();
```

- When constructing an `ArrayList`, you must specify the type of elements it will contain between `<` and `>`.
 - This is called a *type parameter* or a *generic class*.
 - Allows the same `ArrayList` class to store lists of different types.

```
ArrayList<String> names = new ArrayList<String>();  
names.add("Marty Stepp");  
names.add("Stuart Reges");
```

ArrayList methods (10.1)

<code>add (value)</code>	appends value at end of list
<code>add (index, value)</code>	inserts given value just before the given index, shifting subsequent values to the right
<code>clear ()</code>	removes all elements of the list
<code>indexOf (value)</code>	returns first index where given value is found in list (-1 if not found)
<code>get (index)</code>	returns the value at given index
<code>remove (index)</code>	removes/returns value at given index, shifting subsequent values to the left
<code>set (index, value)</code>	replaces value at given index with given value
<code>size ()</code>	returns the number of elements in list
<code>toString ()</code>	returns a string representation of the list such as "[3, 42, -7, 15]"

ArrayList methods 2

<code>addAll (list)</code> <code>addAll (index, list)</code>	adds all elements from the given list to this list (at the end of the list, or inserts them at the given index)
<code>contains (value)</code>	returns true if given value is found somewhere in this list
<code>containsAll (list)</code>	returns true if this list contains every element from given list
<code>equals (list)</code>	returns true if given other list contains the same elements
<code>iterator ()</code> <code>listIterator ()</code>	returns an object used to examine the contents of the list (seen later)
<code>lastIndexOf (value)</code>	returns last index value is found in list (-1 if not found)
<code>remove (value)</code>	finds and removes the given value from this list
<code>removeAll (list)</code>	removes any elements found in the given list from this list
<code>retainAll (list)</code>	removes any elements <i>not</i> found in given list from this list
<code>subList (from, to)</code>	returns the sub-portion of the list between indexes from (inclusive) and to (exclusive)
<code>toArray ()</code>	returns the elements in this list as an array

Learning about classes

- The [Java API Specification](#) is a huge web page containing documentation about every Java class and its methods.
 - The link to the “Java 6 API” Specs is at the top of our AP CS page.



ArrayList vs. array

- construction

```
String[] names = new String[5];  
ArrayList<String> list = new ArrayList<String>();
```

- storing a value

```
names[0] = "Jessica";  
list.add("Jessica");
```

- retrieving a value

```
String s = names[0];  
String s = list.get(0);
```

ArrayList vs. array 2

- doing something to each value that starts with "B"

```
for (int i = 0; i < names.length; i++) {  
    if (names[i].startsWith("B")) { ... }  
}
```

```
for (int i = 0; i < list.size(); i++) {  
    if (list.get(i).startsWith("B")) { ... }  
}
```

- seeing whether the value "Benson" is found

```
for (int i = 0; i < names.length; i++) {  
    if (names[i].equals("Benson")) { ... }  
}
```

```
if (list.contains("Benson")) { ... }
```

ArrayList of primitives?

- The type you specify when creating an `ArrayList` must be an object type; it cannot be a primitive type.

```
// illegal -- int cannot be a type parameter  
ArrayList<int> list = new ArrayList<int>();
```

- But we can still use `ArrayList` with primitive types by using special classes called *wrapper* classes in their place.

```
// creates a list of ints  
ArrayList<Integer> list = new ArrayList<Integer>();
```

Wrapper classes



Primitive Type	Wrapper Type
int	Integer
double	Double
char	Character
boolean	Boolean

- A wrapper is an object whose sole purpose is to hold a primitive value.
- Once you construct the list, use it with primitives as normal:

```
ArrayList<Double> grades = new ArrayList<Double>();  
grades.add(3.2);  
grades.add(2.7);  
...  
double myGrade = grades.get(0);
```

ArrayList "mystery"

```
ArrayList<Integer> list = new ArrayList<Integer>();  
for (int i = 1; i <= 10; i++) {  
    list.add(10 * i);    // [10, 20, 30, 40, ..., 100]  
}
```

- What is the output of the following code?

```
for (int i = 0; i < list.size(); i++) {  
    list.remove(i);  
}  
System.out.println(list);
```

- Answer:

```
[20, 40, 60, 80, 100]
```

ArrayList "mystery" 2

```
ArrayList<Integer> list = new ArrayList<Integer>();  
for (int i = 1; i <= 5; i++) {  
    list.add(2 * i);    // [2, 4, 6, 8, 10]  
}
```

- What is the output of the following code?

```
int size = list.size();  
for (int i = 0; i < size; i++) {  
    list.add(i, 42);    // add 42 at index i  
}  
System.out.println(list);
```

- Answer:

```
[42, 42, 42, 42, 42, 2, 4, 6, 8, 10]
```

ArrayList as parameter

```
public static void name(ArrayList<Type> name) {
```

- Example:

```
// Removes all plural words from the given list.  
public static void removePlural(ArrayList<String> list) {  
    for (int i = 0; i < list.size(); i++) {  
        String str = list.get(i);  
        if (str.endsWith("s")) {  
            list.remove(i);  
            i--;  
        }  
    }  
}
```

- You can also return a list:

```
public static ArrayList<Type> methodName(params)
```


Out-of-bounds

- Legal indexes are between **0** and the **list's size() - 1**.
 - Reading or writing any index outside this range will cause an `IndexOutOfBoundsException`.

```
ArrayList<String> names = new ArrayList<String>();  
names.add("Marty");    names.add("Kevin");  
names.add("Vicki");    names.add("Larry");  
System.out.println(names.get(0));           // okay  
System.out.println(names.get(3));           // okay  
System.out.println(names.get(-1));         // exception  
names.add(9, "Aimee");                     // exception
```

<i>index</i>	0	1	2	3
<i>value</i>	Marty	Kevin	Vicki	Larry

Objects storing collections

- An object can have an array, list, or other collection as a field.

```
public class Course {  
    private double[] grades;  
    private ArrayList<String> studentNames;  
  
    public Course() {  
        grades = new double[4];  
        studentNames = new ArrayList<String>();  
        ...  
    }  
}
```

- Now each object stores a collection of data inside it.

Exercise

- Write a program that reads a file and displays the words of that file as a list.
 - First display all words.
 - Then display them with all plurals (ending in "s") capitalized.
 - Then display them in reverse order.
 - Then display them with all plural words removed.
- Should we solve this problem using an array?
 - Why or why not?

Naive solution

```
String[] allWords = new String[1000];  
int wordCount = 0;
```

```
Scanner input = new Scanner(new File("data.txt"));  
while (input.hasNext()) {  
    String word = input.next();  
    allWords[wordCount] = word;  
    wordCount++;  
}
```

- Problem: You don't know how many words the file will have.
 - Hard to create an array of the appropriate size.
 - Later parts of the problem are more difficult to solve.
- Luckily, there are other ways to store data besides in an array.

Exercise, revisited

- Write a program that reads a file and displays the words of that file as a list.
 - First display all words.
 - Then display them in reverse order.
 - Then display them with all plurals (ending in "s") capitalized.
 - Then display them with all plural words removed.

Exercise solution (partial)

```
ArrayList<String> allWords = new ArrayList<String>();
Scanner input = new Scanner(new File("words.txt"));
while (input.hasNext()) {
    String word = input.next();
    allWords.add(word);
}
System.out.println(allWords);

// remove all plural words
for (int i = 0; i < allWords.size(); i++) {
    String word = allWords.get(i);
    if (word.endsWith("s")) {
        allWords.remove(i);
        i--;
    }
}
```

Exercise

- Write a program that reads a file full of numbers and displays all the numbers as a list, then:
 - Prints the average of the numbers.
 - Prints the highest and lowest number.
 - Filters out all of the even numbers (ones divisible by 2).

Exercise solution (partial)

```
ArrayList<Integer> numbers = new ArrayList<Integer>();
Scanner input = new Scanner(new File("numbers.txt"));
while (input.hasNextInt()) {
    int n = input.nextInt();
    numbers.add(n);
}
System.out.println(numbers);
filterEvens(numbers);
System.out.println(numbers);
...
// Removes all elements with even values from the given list.
public static void filterEvens(ArrayList<Integer> list) {
    for (int i = list.size() - 1; i >= 0; i--) {
        int n = list.get(i);
        if (n % 2 == 0) {
            list.remove(i);
        }
    }
}
```


Other Exercises

- Write a method `reverse` that reverses the order of the elements in an `ArrayList` of strings.
- Write a method `capitalizePlurals` that accepts an `ArrayList` of strings and replaces every word ending with an "s" with its uppercased version.
- Write a method `removePlurals` that accepts an `ArrayList` of strings and removes every word in the list ending with an "s", case-insensitively.

Exercise

- Write a method `addStars` that accepts an array list of strings as a parameter and places a `*` after each element.
 - Example: if an array list named `list` initially stores:
`[the, quick, brown, fox]`
 - Then the call of `addStars(list);` makes it store:
`[the, *, quick, *, brown, *, fox, *]`
- Write a method `removeStars` that accepts an array list of strings, assuming that every other element is a `*`, and removes the stars (undoing what was done by `addStars` above).

Exercise solution

```
public static void addStars(ArrayList<String> list) {  
    for (int i = 0; i < list.size(); i += 2) {  
        list.add(i, "*");  
    }  
}
```

```
public static void removeStars(ArrayList<String> list) {  
    for (int i = 0; i < list.size(); i++) {  
        list.remove(i);  
    }  
}
```

Exercise

- Write a method `intersect` that accepts two sorted array lists of integers as parameters and returns a new list that contains only the elements that are found in both lists.
 - Example: if lists named `list1` and `list2` initially store:
[1, **4**, 8, 9, **11**, 15, 17, **28**, 41, **59**]
[**4**, 7, **11**, **17**, 19, 20, 23, **28**, 37, **59**, 81]
 - Then the call of `intersect(list1, list2)` returns the list:
[4, 11, 17, 28, 59]

Other Exercises

- Write a method `reverse` that reverses the order of the elements in an `ArrayList` of strings.
- Write a method `capitalizePlurals` that accepts an `ArrayList` of strings and replaces every word ending with an "s" with its uppercased version.
- Write a method `removePlurals` that accepts an `ArrayList` of strings and removes every word in the list ending with an "s", case-insensitively.