CS 106A, Lecture 19
ArrayLists

suggested reading:
Java Ch. 11.8
We are here

ArrayLists

HashMaps

Classes

More Classes

Interactors

The River of Java
Learning Goals

• Know how to store data in and retrieve data from an ArrayList.
Plan for today

• Recap: Tic-Tac-Toe
• ArrayLists
• *Example*: reversible writing
• *Example*: planner
• ArrayLists vs. arrays
• Recap
Plan for today

• Recap: Tic-Tac-Toe
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Let’s use 2D arrays to create a ConsoleProgram version of Tic-Tac-Toe.
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Limitations of Arrays

- Size must be specified upon creation
- Can’t add/remove/insert elements later
- No built-in methods for searching, etc.
- Can’t print arrays without Arrays.toString (or Arrays.deepToString)
Introducing... ArrayLists!

• A variable type that represents a list of items.
• You access individual items by index.
• Store a single type of object (String, GRect, etc.)
• Resizable – can add and remove elements
• Has helpful methods for searching for items
Our First ArrayList

```java
ArrayList<String> myArrayList = new ArrayList<>();
```
import java.util.*;

ArrayList<String> myArrayList = new ArrayList<>();
Our First ArrayList

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Our First ArrayList

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Type of items your ArrayList will store.
Our First ArrayList

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```java
ArrayList<String> myArrayList = new ArrayList<>();
```
// Create an (initially empty) list
ArrayList<String> list = new ArrayList<>();
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// Add an element to the back
list.add("Hello"); // now size 1

"Hello"
Our First ArrayList

// Create an (initially empty) list
ArrayList<String> list = new ArrayList<>();

// Add an element to the back
list.add("Hello"); // now size 1

“Hello”

list.add("there!"); // now size 2

“Hello” “there!”
Our First ArrayList

// Add an element to the back
list.add("Hello");  // now size 1

"Hello"

list.add("there!");  // now size 2

"Hello"  "there!"

// Access elements by index (starting at 0!)
println(list.get(0));  // prints "Hello"
println(list.get(1));  // prints "there!"
println(list);  // prints ["Hello", "there!"]
Our First ArrayList

// Add an element to the back
list.add("Hello");    // now size 1

"Hello"

list.add("there!");  // now size 2

"Hello"  "there!"

// Access elements by index (starting at 0!)
for (int i = 0; i < list.size(); i++) {
    println(list.get(i));
}
Our First ArrayList

// Add an element to the back
list.add("Hello");  // now size 1

"Hello"

list.add("there!");  // now size 2

"Hello"  "there!"

// Access elements by index (starting at 0!)
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"Hello"

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"Hello"  "there!"

// Access elements in order (also for arrays!)
for (String str : list) {
    println(str);
}
// Access elements in order (also for arrays!)
for (String str : list) {
    println(str);
}

// equivalent to

for (int i = 0; i < list.size(); i++) {
    String str = list.get(i);
    println(str);
}
// Access elements in order (also for arrays!)
for (String str : list) {
    println(str);
}

// equivalent to
for (int i = 0; i < list.size(); i++) {
    String str = list.get(i);
    println(str);
}
// Create an (initially empty) list
ArrayList<String> list = new ArrayList<>();

// Wrong type – bad times! Won’t compile
GLabel label = new GLabel("Hello there!");
list.add(label);

// Invalid index! IndexOutOfBoundsException Exception
println(list.get(2));
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Example: Reversible Writing

Let’s write a program that reverses a text file.

I am not a person who contributes
And I refuse to believe that
I will be useful
Example: Reversible Writing

Let’s write a program that reverses a text file.

I am not a person who contributes
And I refuse to believe that
I will be useful

I will be useful
And I refuse to believe that
I am not a person who contributes

"I Have a Dream" by Antonia Lee, Sara Fung, Christy Fung, Rachel Lam
Example: Reversible Writing

Let's write a program that reverses a text file.

“I am not a person who contributes”
Example: Reversible Writing

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Example: Reversible Writing

Let’s write a program that reverses a text file.

| “I am not a person who contributes” |
| "And I refuse to believe that" |
| “I will be useful” |

Key idea: fill an ArrayList with each line in the file
Let’s write a program that reverses a text file.

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Example: Reversible Writing

Let’s write a program that reverses a text file.

| “I am not a person who contributes” |
| "And I refuse to believe that" |
| “I will be useful” |

Key idea: print the ArrayList items in reverse order
Example: Reversible Writing

```java
String filename = promptUserForFile("Filename: ", "res");
try {
    Scanner s = new Scanner(new File(filename));
    ArrayList<String> lines = new ArrayList<>();

    // Read all lines and store in our ArrayList
    while (scanner.hasNextLine()) {
        lines.add(scanner.nextLine());
    }

    // Output the lines from back to front
    for (int i = lines.size() - 1; i >= 0; i--) {
        println(lines.get(i));
    }
} catch (IOException ex) {
    println("Could not read file.");
}
```
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**ArrayList Methods**

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>list.add(value);</code></td>
<td>appends value at end of list</td>
</tr>
<tr>
<td><code>list.add(index, value);</code></td>
<td>inserts given value just before the given index, shifting subsequent values to the right</td>
</tr>
<tr>
<td><code>list.clear();</code></td>
<td>removes all elements of the list</td>
</tr>
<tr>
<td><code>list.get(index)</code></td>
<td>returns the value at given index</td>
</tr>
<tr>
<td><code>list.indexOf(value)</code></td>
<td>returns first index where given value is found in list (-1 if not found)</td>
</tr>
<tr>
<td><code>list.isEmpty()</code></td>
<td>returns <code>true</code> if the list contains no elements</td>
</tr>
<tr>
<td><code>list.remove(index);</code></td>
<td>removes/returns value at given index, shifting subsequent values to the left</td>
</tr>
<tr>
<td><code>list.remove(value);</code></td>
<td>removes the first occurrence of the value, if any</td>
</tr>
<tr>
<td><code>list.set(index, value);</code></td>
<td>replaces value at given index with given value</td>
</tr>
<tr>
<td><code>list.size()</code></td>
<td>returns the number of elements in the list</td>
</tr>
<tr>
<td><code>list.toString()</code></td>
<td>returns a string representation of the list, such as &quot;[3, 42, -7, 15]&quot;</td>
</tr>
</tbody>
</table>
• If you insert/remove in the front or middle of a list, elements **shift** to fit.

```java
list.add(2, 42);
```

• shift elements right to make room for the new element

```
<table>
<thead>
<tr>
<th>index</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>3</td>
<td>8</td>
<td>9</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>
```

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<td>value</td>
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<td>8</td>
<td>42</td>
<td>9</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>
```

```java
list.remove(1);
```

• shift elements left to cover the space left by the removed element

```
<table>
<thead>
<tr>
<th>index</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
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<td>3</td>
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<td>9</td>
<td>7</td>
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</tr>
</tbody>
</table>
```
Enter task: sleep
Enter task: prepare for lecture
Enter task: play Zelda
Enter task: go for a bike ride
Enter task: walk Daisy
Enter task: 
Great! Enter the order to complete your tasks.
Tasks remaining: [sleep, prepare for lecture, play Zelda, go for a bike ride, walk Daisy]
Next task to complete: walk Daisy
Tasks remaining: [sleep, prepare for lecture, play Zelda, go for a bike ride]
Next task to complete: play Zelda
Tasks remaining: [sleep, prepare for lecture, go for a bike ride]
Next task to complete: prepare for lecture
Tasks remaining: [sleep, go for a bike ride]
Next task to complete: go for a bike ride
Tasks remaining: [sleep]
Next task to complete: decorate room
That's not on your list - stay focused!
Tasks remaining: [sleep]
Next task to complete: sleep
Congrats! Your day is all planned out:
[walk Daisy, play Zelda, prepare for lecture, go for a bike ride, sleep]
Example: Planner

• Let’s write a program to help plan out our day
  – The program first prompts for things you want to do today
  – Then, it asks the user to re-input them in order of completion
  – Finally, it outputs the order the user has chosen for their tasks

```
Enter task: sleep
Enter task: prepare for lecture
Enter task: play Zelda
Enter task: go for a bike ride
Enter task: walk Daisy
Enter task: 
Great! Enter the order to complete your tasks.
Tasks remaining: [sleep, prepare for lecture, play Zelda, go for a bike ride, walk Daisy]
Next task to complete: walk Daisy
Tasks remaining: [sleep, prepare for lecture, play Zelda, go for a bike ride]
Next task to complete: play Zelda
Tasks remaining: [sleep, prepare for lecture, go for a bike ride]
Next task to complete: prepare for lecture
Tasks remaining: [sleep, go for a bike ride]
Next task to complete: go for a bike ride
Tasks remaining: [sleep]
Next task to complete: decorate room
That's not on your list - stay focused!
Tasks remaining: [sleep]
Next task to complete: sleep
Congrats! Your day is all planned out:
[walk Daisy, play Zelda, prepare for lecture, go for a bike ride, sleep]```
Planner: Approach

Todos:

“Walk Daisy”
### Planner: Approach

<table>
<thead>
<tr>
<th>Todos:</th>
<th>“Walk Daisy”</th>
<th>“Play Zelda”</th>
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**Planner: Approach**

<table>
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<td>“Walk Daisy”</td>
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<tr>
<td>“Play Zelda”</td>
</tr>
<tr>
<td>“Lunch with Avi”</td>
</tr>
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</table>
Todos:

“Walk Daisy”

“Play Zelda”

“Lunch with Avi”

Order:

“Walk Daisy”
Planner: Approach

Todos:

“Play Zelda”

“Lunch with Avi”

Order:

“Walk Daisy”
Planner: Approach

Todos: “Play Zelda”

Order: “Walk Daisy” | “Lunch with Avi”
Todos: 
DONE!

Order:

“Walk Daisy”  “Lunch with Avi”  “Play Zelda”
Plan for today

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// Doesn’t compile 😞
ArrayList<int> list = new ArrayList<>();

Unlike arrays, ArrayLists can only store objects!
<table>
<thead>
<tr>
<th>Primitive</th>
<th>“Wrapper” Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>int</td>
<td>Integer</td>
</tr>
<tr>
<td>double</td>
<td>Double</td>
</tr>
<tr>
<td>boolean</td>
<td>Boolean</td>
</tr>
<tr>
<td>char</td>
<td>Character</td>
</tr>
</tbody>
</table>
// Use wrapper classes when making an ArrayList
ArrayList<Integer> list = new ArrayList<>();

// Java converts Integer <-> int automatically!
int num = 123;
list.add(num);

int first = list.get(0); // 123

Conversion happens automatically!
# Array vs. ArrayList

<table>
<thead>
<tr>
<th>ArrayList</th>
<th>Array</th>
</tr>
</thead>
<tbody>
<tr>
<td>ArrayList&lt;Integer&gt; list =</td>
<td>int[] arr =</td>
</tr>
<tr>
<td>new ArrayList&lt;&gt;();</td>
<td>new int[2];</td>
</tr>
<tr>
<td></td>
<td>// [0, 0]</td>
</tr>
<tr>
<td>list.add(1);</td>
<td>arr[0] = 1;</td>
</tr>
<tr>
<td>// [1]</td>
<td>// [1, 0]</td>
</tr>
<tr>
<td>list.add(2);</td>
<td>arr[1] = 2;</td>
</tr>
<tr>
<td>// [1, 2]</td>
<td>// [1, 2]</td>
</tr>
<tr>
<td>list.set(0, 3);</td>
<td>arr[0] = 3;</td>
</tr>
<tr>
<td>// [3, 2]</td>
<td>// [3, 2]</td>
</tr>
<tr>
<td>int x = list.get(0);</td>
<td>int x = arr[0];</td>
</tr>
<tr>
<td>// 3</td>
<td>// 3</td>
</tr>
<tr>
<td>list.add(4);</td>
<td>[no equivalent]</td>
</tr>
<tr>
<td>// [3, 2, 4]</td>
<td></td>
</tr>
<tr>
<td>list.contains(2);</td>
<td>// true</td>
</tr>
</tbody>
</table>
Array vs. ArrayList

Why do both of these exist in the language?
– Arrays are Java's fundamental data storage
– ArrayList is a library built on top of an array

When would you choose an array over an ArrayList?
– When you need a fixed size that you know ahead of time
  – Simpler syntax for getting/setting
  – More efficient
– Multi-dimensional arrays (e.g. images)
– Histograms/tallying
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Recap

• ArrayLists are a variable type representing a list of items
• Unlike arrays, ArrayLists have:
  – The ability to resize dynamically
  – Useful methods you can call on them
• Unlike ArrayLists, arrays have:
  – The ability to store any type of item, not just objects

Next Time: HashMaps