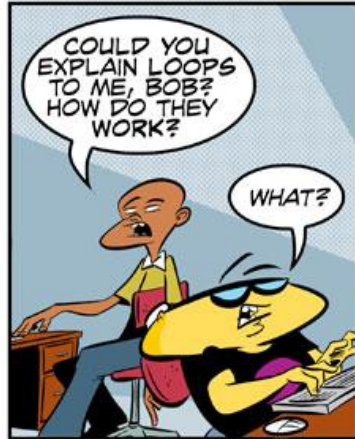


CSE 143

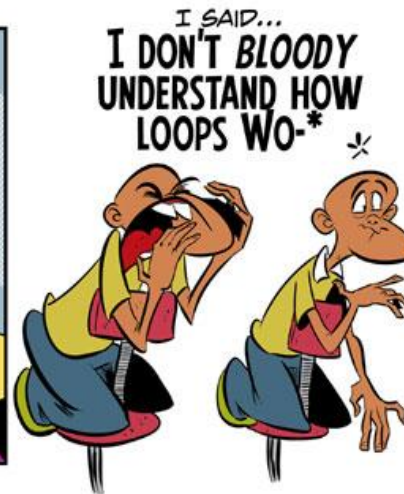
Lecture 2: Implementing `ArrayList`

reading: 15.1 - 15.3

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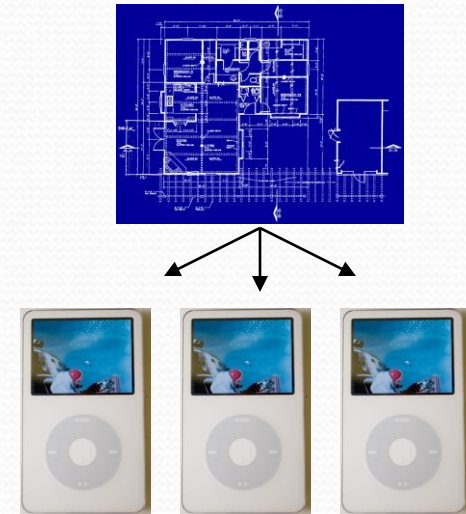


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Recall: classes and objects

- **class:** A program entity that represents:

- A complete program or module, or
- A template for a type of objects.
- (`ArrayList` is a class that defines a type.)

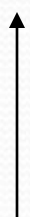


- **object:** An entity that combines **state** and **behavior**.

- **object-oriented programming (OOP):** Programs that perform their behavior as interactions between objects.
- **abstraction:** Separation between concepts and details. Objects provide abstraction in programming.

Elements of a class

```
public class BankAccount {  
    private String name;           // fields:  
    private int id;                // data encapsulated  
    private double balance;       // inside each object  
  
    public BankAccount(String name, int id) {  
        this.name = name;         // constructor:  
        this.id = id;             // initializes  
        this.balance = 0.0;       // new objects  
    }  
  
    public void deposit(double amount) {  
        this.balance += amount; // instance method:  
    }                               // each object's  
    ...                               // behavior  
}
```



"implicit parameter": object on which a method was called

ArrayList implementation

- What is an `ArrayList`'s behavior?
 - add, remove, `indexOf`, etc
- What is an `ArrayList`'s state?
 - Many elements of the same type
 - For example, unfilled array

<i>index</i>	<i>0</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>...</i>	<i>98</i>	<i>99</i>
<i>value</i>	17	932085	-32053278	100	3	0	0	...	0	0

size 5

ArrayList implementation

- Simpler than `ArrayList<E>`
 - No generics (only stores `ints`)
 - Fewer methods: `add(value)`, `add(index, value)`, `get(index)`, `set(index, value)`, `size()`, `isEmpty()`, `remove(index)`, `indexOf(value)`, `contains(value)`, `toString()`,
- Fields?
 - `int[]`
 - `int` to keep track of the number of elements added

Printing an `ArrayList`

- Let's add a method that allows clients to print a list's elements.
 - You may be tempted to write a `print` method:

```
// client code  
ArrayList list = new ArrayList();  
...  
list.print();
```

- Why is this a bad idea? What would be better?

The toString method

- Tells Java how to convert an object into a String

```
ArrayList list = new ArrayList();  
System.out.println("list is " + list);  
// ("list is " + list.toString());
```

- Syntax:

```
public String toString() {  
    code that returns a suitable String;  
}
```

- Every class has a toString, even if it isn't in your code.

- The default is the class's name and a hex (base-16) number:

```
ArrayList@9e8c34
```

toString solution

// Returns a String representation of the list.

```
public String toString() {  
    if (size == 0) {  
        return "[]";  
    } else {  
        String result = "[" + elementData[0];  
        for (int i = 1; i < size; i++) {  
            result += ", " + elementData[i];  
        }  
        result += "];"  
        return result;  
    }  
}
```


Implementing add #2

- How do we add to the middle or end of the list?
 - must *shift* elements to make room for the value (see book 7.4)

<i>index</i>	<i>0</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>
<i>value</i>	3	8	9	7	5	12	0	0	0	0
<i>size</i>	6									

- `list.add(3, 42);` **// insert 42 at index 3**

<i>index</i>	<i>0</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>
<i>value</i>	3	8	9	42	7	5	12	0	0	0
<i>size</i>	7									


- Note: The order in which you traverse the array matters!

add #2 code

```
public void add(int index, int value) {  
    for (int i = size; i > index; i--) {  
        list[i] = list[i - 1];  
    }  
    list[index] = value;  
    size++;  
}
```

<i>index</i>	0	1	2	3	4	5	6	7	8	9
<i>value</i>	3	8	9	7	5	12	0	0	0	0
<i>size</i>	6									

- `list.add(3, 42);`

<i>index</i>	0	1	2	3	4	5	6	7	8	9
<i>value</i>	3	8	9	42	7	5	12	0	0	0
<i>size</i>	7 									

Other methods

- Let's implement the following methods in our list:
 - `get (index)`
Returns the element value at a given index.
 - `set (index, value)`
Sets the list to store the given value at the given index.
 - `size ()`
Returns the number of elements in the list.
 - `isEmpty ()`
Returns `true` if the list contains no elements; else `false`.
(Why write this if we already have the `size` method?)

Implementing `remove`

- Again, we need to shift elements in the array
 - this time, it's a left-shift
 - in what order should we process the elements?
 - what indexes should we process?

<i>index</i>	0	1	2	3	4	5	6	7	8	9
<i>value</i>	3	8	9	7	5	12	0	0	0	0
<i>size</i>	6									

- `list.remove(2);` *// delete 9 from index 2*

<i>index</i>	0	1	2	3	4	5	6	7	8	9
<i>value</i>	3	8	7	5	12	0	0	0	0	0
<i>size</i>	5 ←									

Implementing `remove` code

```
public void remove(int index) {  
    for (int i = index; i < size; i++) {  
        list[i] = list[i + 1];  
    }  
    size--;  
    list[size] = 0;        // optional (why?)  
}
```

<i>index</i>	0	1	2	3	4	5	6	7	8	9
<i>value</i>	3	8	9	7	5	12	0	0	0	0
<i>size</i>	6									

- `list.remove(2);` // delete 9 from index 2

<i>index</i>	0	1	2	3	4	5	6	7	8	9
<i>value</i>	3	8	7	5	12	0	0	0	0	0
<i>size</i>	5 ←									