Building Java Programs

Chapter 15

testing ArrayIntList;
pre/post conditions and exceptions

reading: 4.4 15.1 - 15.3
• Warm Up: What is the output of this code?

```java
ArrayIntList list1 = new ArrayIntList();
ArrayIntList list2 = new ArrayIntList();
list1.add(1);
list2.add(2);
list1.add(3);
list2.add(4);
System.out.println(list1);
System.out.println(list2);
```
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.
Searching methods

- Implement the following methods:
  - `indexOf` - returns first index of element, or -1 if not found
  - `contains` - returns true if the list contains the given int value

- Why do we need `isEmpty` and `contains` when we already have `indexOf` and `size`?
  - Adds convenience to the client of our class:

```java
// less elegant                   // more elegant
if (myList.size() == 0) {       if (myList.isEmpty()) {
    if (myList.indexOf(42) >= 0) { if (myList.contains(42)) {
```
Class constants

public static final type name = value;

- **class constant**: a global, unchangeable value in a class
  - used to store and give names to important values used in code
  - documents an important value; easier to find and change later

- classes will often store constants related to that type
  - Math.PI
  - Integer.MAXVALUE, Integer.MINVALUE
  - Color.GREEN

// default array length for new ArrayIntLists
public static final int DEFAULT_CAPACITY = 10;
Preconditions

- **precondition**: Something your method *assumes is true* at the start of its execution.
  - Often documented as a comment on the method's header:

    ```java
    // Returns the element at the given index.
    // Precondition: 0 <= index < size
    public int get(int index) {
        return elementData[index];
    }
    ```

- Stating a precondition doesn't really "solve" the problem, but it at least documents our decision and warns the client what not to do.

- What if we want to actually enforce the precondition?
Bad precondition test

- What is wrong with the following way to handle violations?

```java
// Returns the element at the given index.
// Precondition: 0 <= index < size
public int get(int index) {
    if (index < 0 || index >= size) {
        System.out.println("Bad index! " + index);
        return -1;
    }
    return elementData[index];
}
```

- returning -1 no better than returning 0 (could be legal value)
- println is not a very strong deterrent to the client (esp. GUI)
Throwing exceptions (4.4)

```java
throw new ExceptionType();
throw new ExceptionType("message");
```

- Generates an exception that will crash the program, unless it has code to handle ("catch") the exception.

- **Common exception types:**
  - `ArithmeticException`, `ArrayIndexOutOfBoundsException`, `FileNotFoundException`, `IllegalArgumentException`, `IllegalStateException`, `IOException`, `NoSuchElementException`, `NullPointerException`, `RuntimeException`, `UnsupportedOperationException`

- Why would anyone ever *want* a program to crash?
public int get(int index) {
    if (index < 0 || index >= size) {
        throw new ArrayIndexOutOfBoundsException(index);
    }
    return elementData[index];
}

• Exercise: Modify the rest of ArrayIntList to state preconditions and throw exceptions as appropriate.
Private helper methods

```java
private type name (type name, ..., type name) {
    statement(s);
}
```

- a **private method** can be seen/called only by its own class
  - your object can call the method on itself, but clients cannot call it
  - useful for "helper" methods that clients shouldn't directly touch

```java
private void checkIndex(int index, int min, int max) {
    if (index < min || index > max) {
        throw new IndexOutOfBoundsException(index);
    }
}
```
Postconditions

- **postcondition**: Something your method *promises will be true* at the end of its execution.
  - Often documented as a comment on the method's header:

```
// Precondition : size() < capacity
// Postcondition: value is added at the end of the list
public void add(int value) {
    elementData[size] = value;
    size++;
}
```

- If your method states a postcondition, clients should be able to rely on that statement being true after they call the method.
Not enough space

- What to do if client needs to add more than 10 elements?

```
list.add(15);  // add an 11th element
```

- Possible solution: Allow the client to construct the list with a larger initial capacity.
Multiple constructors

- Our list class has the following constructor:

  ```java
  public ArrayIntList() {
      elementData = new int[10];
      size = 0;
  }
  ```

- Let's add a new constructor that takes a capacity parameter:

  ```java
  public ArrayIntList(int capacity) {
      elementData = new int[capacity];
      size = 0;
  }
  ```

- The constructors are very similar. Can we avoid redundancy?
**this keyword**

- **this**: A reference to the *implicit parameter* (the object on which a method/constructor is called)

- **Syntax:**
  - To refer to a field: `this.field`
  - To call a method: `this.method(parameters)`
  - To call a constructor from another constructor: `this(parameters)`
Revised constructors

// Constructs a list with the given capacity.
public ArrayIntList(int capacity) {
    elementData = new int[capacity];
    size = 0;
}

// Constructs a list with a default capacity of 10.
public ArrayIntList() {
    this(10);  // calls (int) constructor
}
**ArrayList of primitives?**

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

  ```java
  // 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.

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

- 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:

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

<table>
<thead>
<tr>
<th>Primitive Type</th>
<th>Wrapper Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>int</td>
<td>Integer</td>
</tr>
<tr>
<td>double</td>
<td>Double</td>
</tr>
<tr>
<td>char</td>
<td>Character</td>
</tr>
<tr>
<td>boolean</td>
<td>Boolean</td>
</tr>
</tbody>
</table>
Thinking about testing

- If we wrote `ArrayIntList` and want to give it to others, we must make sure it works adequately well first.

- Some programs are written specifically to test other programs.
  - We could write a client program to test our list.
  - Its `main` method could construct several lists, add elements to them, call the various other methods, etc.
  - We could run it and look at the output to see if it is correct.

- Sometimes called a **unit test** because it checks a small unit of software (one class).
  - **black box**: Tests written without looking at the code being tested.
  - **white box**: Tests written after looking at the code being tested.
Tips for testing

- You cannot test every possible input, parameter value, etc.
  - Think of a limited set of tests likely to expose bugs.

- Think about boundary cases
  - Positive; zero; negative numbers
  - Right at the edge of an array or collection's size

- Think about empty cases and error cases
  - 0, -1, null; an empty list or array

- test behavior in combination
  - Maybe add usually works, but fails after you call remove
  - Make multiple calls; maybe size fails the second time only
Example `ArrayIntList` test

```java
public static void main(String[] args) {
    int[] a1 = {5, 2, 7, 8, 4};
    int[] a2 = {2, 7, 42, 8};
    int[] a3 = {7, 42, 42};
    helper(a1, a2);
    helper(a2, a3);
    helper(new int[] {1, 2, 3, 4, 5}, new int[] {2, 3, 42, 4});
}

public static void helper(int[] elements, int[] expected) {
    ArrayIntList list = new ArrayIntList(elements);
    for (int i = 0; i < elements.length; i++) {
        list.add(elements[i]);
    }
    list.remove(0);
    list.remove(list.size() - 1);
    list.add(2, 42);
    for (int i = 0; i < expected.length; i++) {
        if (list.get(i) != expected[i]) {
            System.out.println("fail; expect " + Arrays.toString(expected) + ", actual " + list);
        }
    }
}
```