Building Java Programs

Chapter 15

testing `ArrayIntList;`

pre/post conditions and exceptions

reading: 4.4 15.1 - 15.3

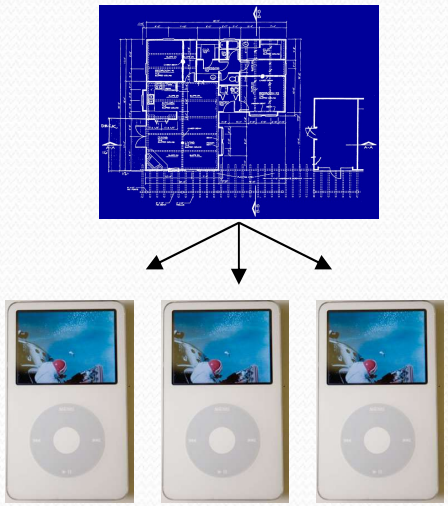
Poll Everywhere pollev.com/cse143

- Warm Up: What is the output of this code?

```
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:

```
// less elegant
if (myList.size() == 0) {
if (myList.indexOf(42) >= 0) {
```

```
// more elegant
if (myList.isEmpty()) {
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.MAX_VALUE`, `Integer.MIN_VALUE`
  - `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:

```
// 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?

```
// 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)

```
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?

Exception example

```
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

```
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

```
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?

index	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
value	3	8	9	7	5	12	4	8	1	6
size	10									

- `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:

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

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

```
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.

```
// 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);
```

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

```
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);
        }
    }
}
```