CMSC 131: Chapter 11 (Supplement)

Arrays

Arrays

Array: A structure used for storing and processing a collection of data all of a common type.

Example: Store a list of 100 integer scores.

- **How to store them?** We could create 100 variables: `score0, score1, score2, ...` but this would be quite tedious.

- **Array:** Allows us to store a collection of items under a single name, and refer to individual items by an integer index.

- **Array indices:** Array indices start with 0. So a 100-element array would be indexed from 0 to 99.

- **Array elements:** Are accessed and manipulated just as any variable.

Creating Arrays

An array is a special type of object.

- The notation `[]` is Java's way of declaring an identifier to be an array.

- We must invoke "new" to allocate storage for each array that we want to use.

- When we allocate a new array, we need to specify how many elements we want in the array. This value is put in square brackets.

Example: This declares `score` to be a 100-element array of ints.

```java
int[] score = new int[100];
```

```java
int[] score; // this is equivalent to the above
score = new int[100];
```
Square Brackets

Don’t confuse the three uses of square brackets:

- **Declare** a variable to an array:

  ```java
  int score[ ];
  ```

  The base type of the array is int.

- **Specify the size** of a newly created array:

  ```java
  score = new int[100];
  ```

- **Access an individual element** of the array:

  ```java
  System.out.println( "Last score: " + score[99] );
  ```

Example

Example: Input a list of 4 doubles and print them in reverse order.

```java
  double[ ] value = new double[4];

  for ( int i = 0; i < 4; i++ )
    value[i] = readDouble( );

  for ( int i = 3; i >= 0; i-- )
    System.out.println( value[i] );

  public static double readDouble( ) {
    return Double.parseDouble( JOptionPane.showInputDialog( "Next value:" ) );
  }
```
Array Length

You can determine the number of elements of an array using the length instance variable:

```java
float[] a = new float[5]; // creates a[0] ... a[4]
char[] b = new char[4]; // creates b[0] ... b[3]
int x = a.length; // x = 5
int y = b.length; // y = 4
```

Since a and b are only references to an array, you can change them.

```java
a = new float[6]; // (can assign to any float array)
int z = a.length; // z = 6
```

Array Length

You can access an array's length, but you cannot change it:

```java
a.length = 40; // Illegal Cannot change length
```

What if I need a bigger array?

Sorry, you must create an entirely new array. We will discuss this later.

What do think this does? Outputs 0? Compiler/run-time error?

```java
float[] c;
c = null;
System.out.println(c.length);
```

Index Out of Bounds

Index out of bounds: If an array is of length m, then valid indices are 0, 1, 2, ..., m-1. An attempt to use any other value results in a run-time error: ArrayIndexOutOfBoundsException.

Example: Attempt to initialize a 10-element array of doubles:

```java
double[] list = new double[10]; // valid indices are [0 ... 9]
for (int i = 0; i <= 10; i++)
    list[i] = 1.0;
```

Fixed:

```java
double[] list = new double[10];
for (int i = 0; i < 10; i++)
    list[i] = 1.0;
```

Better array loop:

```java
for (int i = 0; i < list.length; i++) ...
```
Alternate Declaration Syntax

Java provides two ways to declare a variable to be an array:

- **Java style:**
  ```java
  int[] grade;
  ```

- **C and C++ style** (old, but still Java allows):
  ```java
  int grade[];
  ```

- **Java style is preferred** (but old C and C++'s programmers sometimes slip into the old style).
  ```java
  int[] a, b, c; // a, b, c are all int arrays
  int a[], b, c[]; // a and c are int arrays, and b is just an int
  ```

Array Initializers

An array can be initialized **when it is declared**. This is done by giving an **initializer list**.

```java
int[] cutOffs = { 90, 82, 75, 66 };
```

This does a number of things:

- **Counts** the number of elements in the initializer (4 in this case) and automatically invokes new: "new int[4]."

- **Initializes** the array values.

- **Returns a reference** to the array (stored in cutOffs)

```java
int[] cutOffs = new int[4];
cutOffs[0] = 90;
cutOffs[1] = 82;
cutOffs[2] = 75;
cutOffs[3] = 66;
```

**If not initialized:** array elements are set to their **Java default values** (0, 0.0, false, null).
Example

A static method that is given an integer numeric score from 0 to 100, and converts it into a letter grade according to a given set of cut-offs. A grade of 'F' is given if it is less than the lowest score.

```
public static char letterGrade( int numeric ) {
    int[ ] cutOffs = { 90, 82, 75, 66 };
    char[ ] letters = ( 'A', 'B', 'C', 'D' );
    for ( int i = 0; i < cutOffs.length; i++ ) {
        if ( numeric >= cutOffs[i] ) {
            return letters[i];
        }
    }
    return 'F';
}
```

Arrays of Characters and Strings

String != char[ ]: In some programming languages, a string is the same as an array of chars. Not in Java.

String:       String str = "Hello";
Array of chars: char[ ] chr = "Hello";  // Illegal Type mismatch.
               chr[ ] chr = { 'H', 'e', 'l', 'l', 'o' };

Other differences:

<table>
<thead>
<tr>
<th>Operation</th>
<th>String</th>
<th>char[ ]</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Get length</td>
<td>str.length()</td>
<td>chr.length</td>
<td>5</td>
</tr>
<tr>
<td>Set char</td>
<td>(not possible)</td>
<td>chr[0] = 'J';</td>
<td>&quot;Jello&quot;</td>
</tr>
</tbody>
</table>

Converting char[ ] to String: The String constructor is overloaded to allow a char[ ] parameter:

```
String str3 = new String( chr );
```
Array Arguments

Array and array elements: can be passed as parameters to methods, just like primitive types and object references.

Passing a Single Element: A single element of an array can be passed to any method as if it were a simple variable.

Example: Suppose fooBar(x) expects argument x of type double.

double[ ] a = new double[10];
int i = ...
// ... initializations omitted
fooBar( a[i] );  // evaluates a[i] and passes the value to fooBar

Passing an Entire Array: You can pass an entire array as an argument. As with objects, this just passes the reference.

- If the method expects an array of type double, then you can pass it an array of doubles of any size.

- Promotion does not apply. E.g., you cannot pass it an array of int’s.

Array Argument Example 1

Example: A static method, printDoubles, that is given an array of doubles and prints each, one per line.

```
public static void printDoubles( double[ ] v ) {
    System.out.println("Array contents: ");
    for ( int i = 0; i < v.length; i++ )
        System.out.println( "[" + i + "]=" + v[i] + " ");
}

double[ ] height = { 6.42, 7.10, 4.83 };
double[ ] weight = { 122, 170.5 };
printDoubles( height );
printDoubles( weight );
```
Array Argument Example 2

Example: A static method, squareValues, that is given an array of doubles and replaces each value with its square.

```java
public static void squareValues( double[ ] v ) {
    for ( int i = 0; i < v.length; i++ )
        v[i] = v[i] * v[i];
}

double[ ] height = { 6.42, 7.10, 4.83 };
squareValues( height );
printDoubles( height );
```

Pass by Value: Only the array reference, height, is passed. This reference cannot be changed, but the array contents can be.

Array Argument Example 3

Example: A static method, doubleSize, that is given an array b of char's, creates a new array b2 of twice the size of the original. It copies the values of b to b2, and sets the remainder to ''. It returns b2.

```java
public static char[ ] doubleSize( char[ ] b ) {
    char[ ] b2 = new char[ 2 * b.length ];
    for ( int i = 0; i < b.length; i++ )
        b2[i] = b[i];
    for ( int i = b.length; i < b2.length; i++ )
        b2[i] = " ";
    return b2;
}
```

Usage:

```java
char[ ] buffer = { 'J', 'a', 'v', 'a' };
char[ ] newBuffer = doubleSize( buffer );
```

(More to Come)