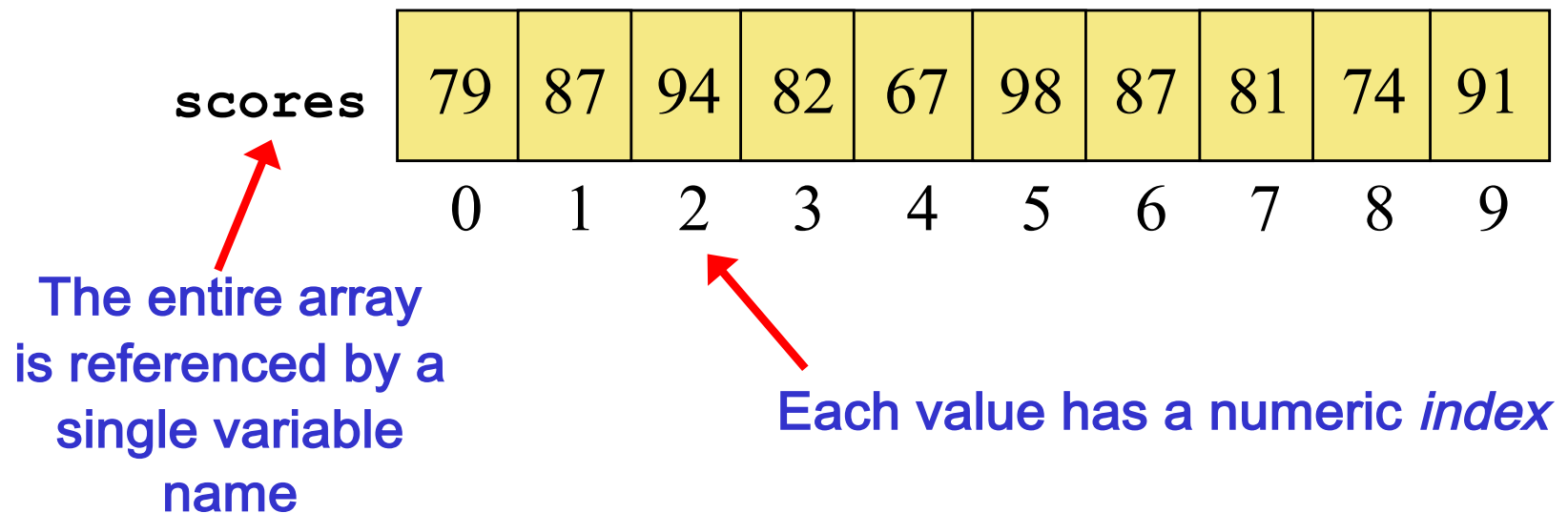


8. Arrays

- Objectives - when we have completed this set of notes, you should be familiar with:
 - array declaration and use
 - bounds checking and capacity
 - arrays that store object references
 - command-line arguments
 - variable length parameter lists
 - multidimensional arrays

Arrays

- An *array* is a container object that holds a fixed number of values of a single type.



An array of length **n** is indexed from **0** to **n-1**

This array holds **10** values that are indexed from **0** to **9**

Declaring Arrays

- The `scores` array could be declared as follows:

```
int[] scores = new int[10];
```

- The type of the variable `scores` is `int[]` (an array of `int` or an **int array**); when you see `[]`, think or say array
- The reference variable `scores` is set to a new array object that holds 10 integers; note the use of the **new** operator with the *type[length]*
- The array is part of the Java language (whereas `ArrayList` is a class in the Java class libraries as described in the Java API)

Alternate Array Syntax

- The brackets of the array type can be associated with the element type or with the name of the array:

```
float[] prices;
```

```
float prices[];
```

- The first format generally is more readable and should be used
- **Remember** - Whenever you see [] brackets (a.k.a., square brackets) in Java, think or say array!

Arrays

- The values held in an array are called array *elements*
 - The *element type* can be a primitive type or a reference type
- The declaration of an array variable does not create the array object; but rather only the variable that will reference it

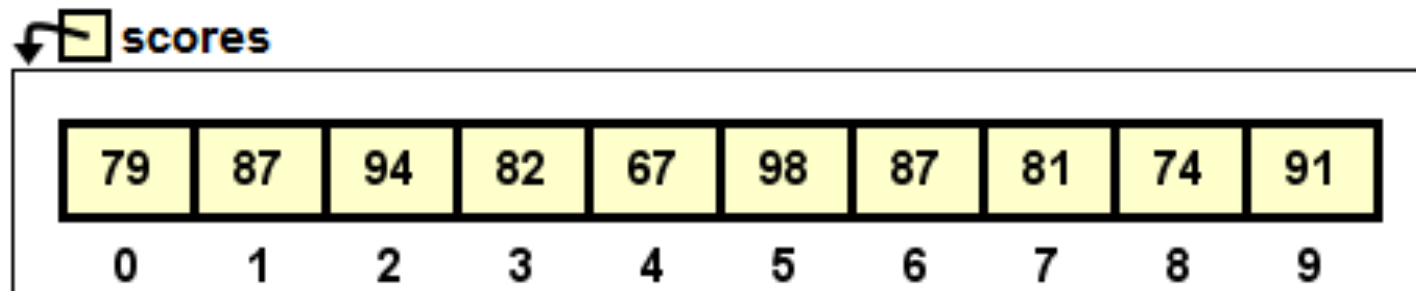
```
char[] letters;
```

- The **new** operator creates (or instantiates) the array with the specified number of elements

```
letters = new char[5];
```

Accessing Array Elements

- Elements are accessed using the array name followed by the index in brackets
- The expression `scores[2]` evaluates to the value 94

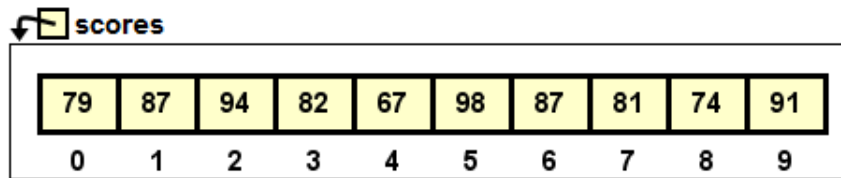


Examples:

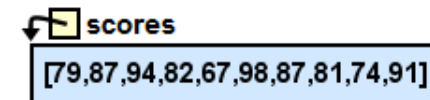
```
int singleScore = scores[2];  
System.out.println("3rd score: " + scores[2]);  
double avg = ((double) scores[0] + scores[1]) / 2;
```

Arrays

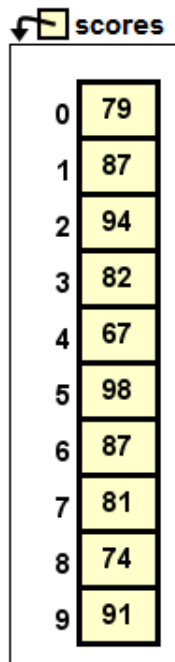
Ways to depict the `scores` array on canvas in jGRASP



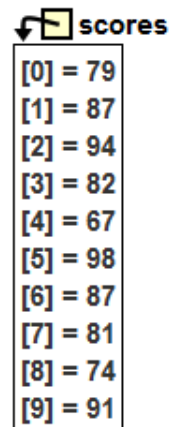
Presentation viewer



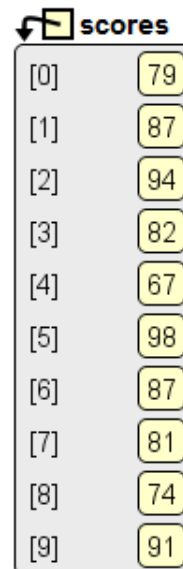
Presentation String viewer



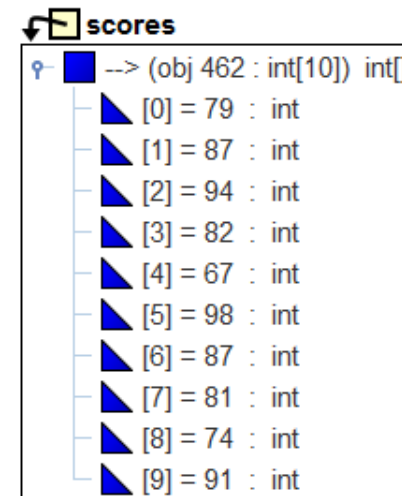
Presentation viewer (rotated)



Array Elements viewer



Basic viewer



Detail (or debug) viewer

[ScoresExample.java](#)

Setting Array Elements

- Individual array elements are also assigned using the array name followed by the index in brackets
- Example: declare a double array and assign elements

```
double[] gradeBook = new double[4];
```

0.0	0.0	0.0	0.0
0	1	2	3

```
gradeBook[0] = 94.2;
```

94.2	0.0	0.0	0.0
0	1	2	3

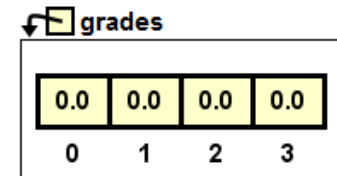
```
gradeBook[3] = 98.1;
```

94.2	0.0	0.0	98.1
0	1	2	3

Arrays

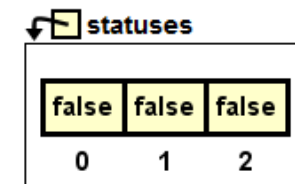
- When an array is created, the initial value of each array element depends on the type.
 - Numerical elements (including char) are initialized to zero (0, 0.0, or \0)

```
double[] grades = new double[4];
```



- boolean values are initialized to false

```
boolean[] statuses = new boolean[3];
```

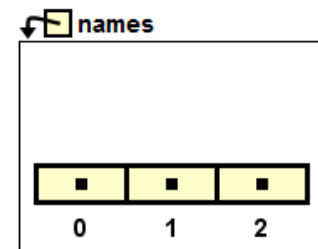


- In a reference type array, each element is initialized to null

```
String[] names = new String[3];
```

```
Coin[] change = new Coin[4];
```

```
CableAccount[] accounts = new CableAccount[3];
```



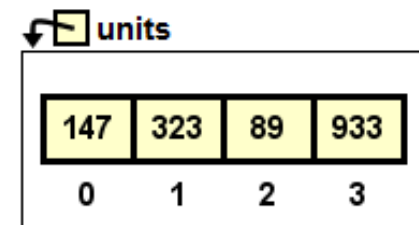
[ArrayExamples.java](#)

Initializer Lists

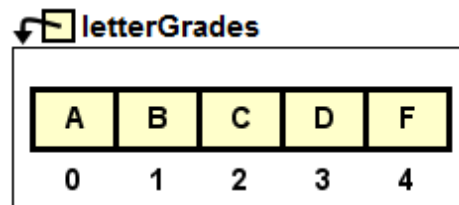
- An *initializer list* can be used to instantiate and fill an array in one step
 - The size of the array is determined by the number of items in the initializer list
 - It can only be used when declaring the array.

- Examples:

```
int[] units = {147, 323, 89, 933};
```



```
char[] letterGrades = {'A', 'B', 'C', 'D', 'F'};
```



[InitializerListExample.java](#)

Using Arrays

- The length variable can be accessed to get the length of the array, for example in interactions:

```
▶ int[] scores = new int[10];  
▶ scores.length  
10
```

The `for` loop can be used when processing array elements

```
for (int i = 0; i < scores.length; i++) {  
    System.out.println (scores[i]);  
}
```

- The `for each` loop can also be used with arrays:

```
for (int currentScore : scores) {  
    System.out.println (currentScore);  
}
```

Bounds Checking

- Once an array is created, it has a fixed size
 - An index used in an array reference must specify a valid element from 0 to length - 1
- When a program runs, the Java interpreter throws an `ArrayIndexOutOfBoundsException` if an array index is out of bounds
- This is called automatic *bounds checking*
- Common in *off-by-one* errors:

```
for (int i = 0; i <= scores.length; i++) {  
    System.out.println (scores[i]);  
}
```

More on Arrays of Objects

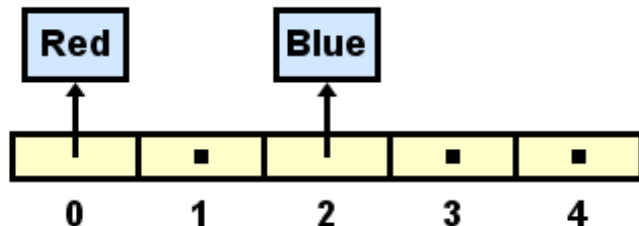
- When the elements of an array are object references, they are initialized to null (i.e., no objects are created). For example, below no String objects are created:

```
String[] colors = new String[5];
```



- Each object element stored in an array must be instantiated separately

```
colors[2] = new String("Blue");  
colors[0] = "Red"; // String objects only
```



Arrays as Parameters

- An entire array can be passed as a parameter to a method or returned to the client program (parameters are passed by value in Java).

```
public Polygon(double[] sidesIn)
```

```
public void setSides(double[] sidesIn)
```

```
public double[] getSides()
```

- See [Polygon.java](#)
- Since parameters are passed by value, the parameter `sidesIn` becomes an alias for the array passed in

“Aliases”

- Any reference variable passed as a parameter becomes an alias for the object passed in. This was not as important with Strings since they are immutable, but it can cause unexpected results with arrays and other objects.
- For example, try the following code in interactions:

```
▶ double[] sides1 = {5.4, 2.3, 5.7, 4.5};  
▶ Polygon shape = new Polygon(sides1);  
▶ double[] sides2 = shape.getSides();  
▶ sides2[0] = -1;  
▶ double[] sides3 = shape.getSides();  
▶ sides3[0]  
  -1.0
```

[PolygonCheck.java](#)

“Aliases”

- Recall that encapsulation is achieved by objects “protecting and managing” their own information.
- If you return a reference to an array object (or any object) in a method and it is modified by a client program, does it support encapsulation?
- Lesson: be very careful with reference variables.

Array vs. ArrayList

- The ArrayList class has a field named `elementData` which is an array that holds the elements in the ArrayList.
- The ArrayList class provides methods for `add`, `get`, `size`, `remove`, `isEmpty`, `contains`, etc. to manage the `elementData` array
- For array types, the programmer must manage array by providing the operations above as needed
- The array is defined in most high level languages; whereas the ArrayList is provided in the Java class library, and thus is an extension to the Java language.

Array vs. ArrayList

- Recall that the length of an array object cannot be changed. Thus, you would have to create a whole new array with the new length and copy all of the elements over.
- To insert an element at the index i of the array, you'll have to copy (move) the elements to the right to make room for the new element and increase the number of elements by one
- To delete an element at the index i in the array, you'll have to copy (move) the elements to the right of the element over one to the left and reduce the number of elements by one
- See deleteTriangle method in [TriangleList2.java](#)

Command-Line Arguments

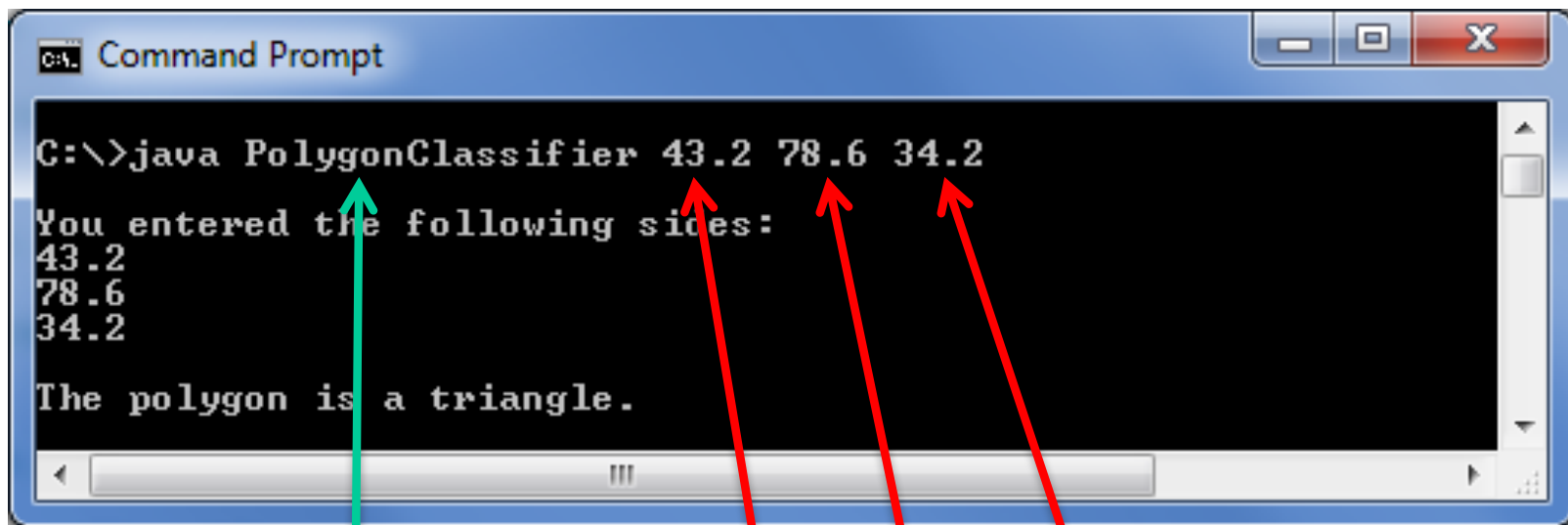
- The signature of the `main` method indicates that it takes an array of `String` objects as a parameter

```
public static void main(String[] args)
```

- The `args` array comes from *command-line arguments* that are provided when the Java interpreter is invoked (for example, in the command prompt or terminal)

Command-Line Arguments

- Consider running the PolygonClassifier program:



The screenshot shows a Windows Command Prompt window with the following text:

```
C:\>java PolygonClassifier 43.2 78.6 34.2
You entered the following sides:
43.2
78.6
34.2
The polygon is a triangle.
```

Four arrows point from labels below to specific parts of the command line: a green arrow points to 'PolygonClassifier', and three red arrows point to '43.2', '78.6', and '34.2' respectively.

Name of class

args[0]

args[1]

args[2]

- For ease of testing your program, command line arguments can also be passed in via jGRASP.

[PolygonClassifier.java](#)

Variable Length Parameter Lists

- Suppose we wanted to create a method that processed a different amount of data from one invocation to the next
- For example, let's define a method called `average` that returns the average of a set of integer parameters

```
// one call to average three values
```

```
mean1 = average (42, 69, 37);
```

```
// another call to average seven values
```

```
mean2 = average (35, 43, 93, 23, 40, 21, 75);
```

Variable Length Parameter Lists

- We could define multiple versions of the `average` method (each taking a different number of parameter inputs)
 - Downside: a separate version of the method would be needed for each parameter count
- We could define the method to accept an array of integers
 - Downside: an array would need to be created and initialized prior to calling the method each time
- Instead, Java provides a convenient way to create a *variable length parameter list*

Variable Length Parameter Lists

- We can define a method to accept any number of parameters of the same type
- The parameters are automatically put into an array with a specified variable name

Indicates a variable length parameter list

```
public double average (int ... list)
```

↑
element
type

↑
array
name

Variable Length Parameter Lists

```
public double average (int ... list)
{
    double result = 0.0;

    if (list.length != 0) {
        int sum = 0;
        for (int num : list) {
            sum += num;
        }
        result = (double) sum / list.length;
    }

    return result;
}
```

[VariableParams.java](#)

Variable Length Parameter Lists

- The type of the parameter can be any primitive type or object type

```
public String allPolygons(Polygon ... polygonSet) {  
  
    String output = "";  
    for (Polygon shape : polygonSet) {  
        output += shape + " ";  
    }  
    return output;  
}
```

Variable Length Parameter Lists

- A method that accepts a variable number of parameters can also accept other parameters
- The following method accepts an `int`, a `String` object, and a variable number of `double` values into an array called `nums`

```
public void test(int count, String name, double ... nums)
```

Variable Length Parameter Lists

- The variable number of parameters must come last in the formal arguments
- A single method cannot accept two sets of varying parameters
- Constructors can also be set up to accept a variable number of parameters
- See Family.java in the book.

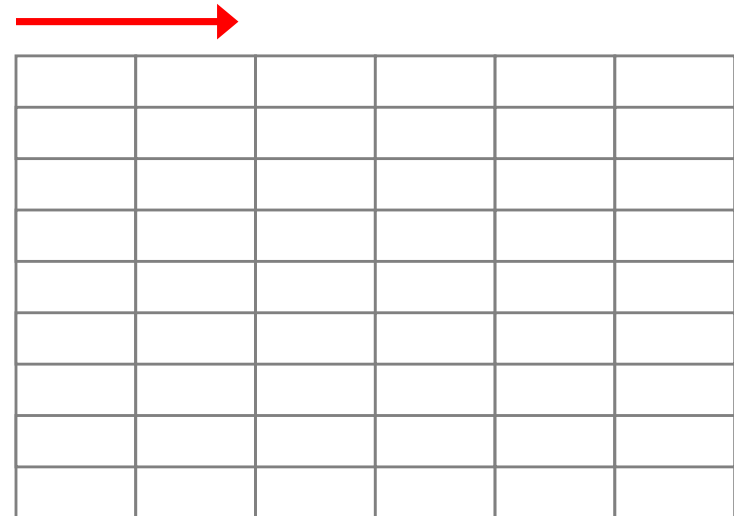
Two-Dimensional Arrays

- A *one-dimensional array* stores a list of elements
- A *two-dimensional array* can be thought of as a table of elements, with rows and columns

one
dimension



two
dimensions



Two-Dimensional Arrays

- A two-dimensional array is an “array of arrays”
- A two-dimensional array is declared by specifying the size of each dimension separately:

```
int[][] scores = new int[12][50];
```

- A single element is referenced using two index values:

```
int value = scores[3][6];
```

- The array stored in one row can be specified using one index

```
int[] valueSet = scores[3];
```

Two-Dimensional Arrays

Expression	Type	Description
<code>table</code>	<code>int[][]</code>	2D array of integers, or array of integer arrays
<code>table[5]</code>	<code>int[]</code>	array of integers
<code>table[5][12]</code>	<code>int</code>	integer

- Examples:
 - [TwoDArraySumElements.java](#)
 - [TwoDArraySumElementsForEach.java](#)
 - [TwoDArraySums.java](#)

Multidimensional Arrays

- An array can have many dimensions – if it has more than one dimension, it is called a *multidimensional array*
- Because each dimension is an array of array references, the arrays within one dimension can be of different lengths
 - these are sometimes called *ragged arrays*

```
int[][] raggedExample = { {1, 2, 3, 4},  
                           {5, 6},  
                           {7, 8, 9} };
```