Arrays

AP Computer Science

Credit: Slides are modified with permission from Barry Wittman at Elizabethtown College

Arrays

Why Arrays?

- Variables are nice
- Loops are great
- Without a way to talk about a **set** of variables, we cannot get the full potential out of a loop
- Enter: **arrays**

Definition of an Array

- An array is a set or list of data that is the same type: **`int`**, **`double`**, **`String`**, etc.
- The size of the array is fixed when you create it meaning it cannot adjust once it is created
- This is similar to a String if you think of how it contains a list of chars and the String is immutable

Array Syntax

Declaration of an Array

- To declare an array of a specified **`type`** with a given **`name`**:

```
type[] name;
```

- Example with a list of type **`int`**:

```
int[] list;
```

- Like any variable declaration, but with **`[]`**

Instantiation of an Array

- When you declare an array, you are creating a variable that can hold an array
- At first, it holds nothing, also know as **`null`**
- To use it, you have to instantiate an array, supplying a specific size:

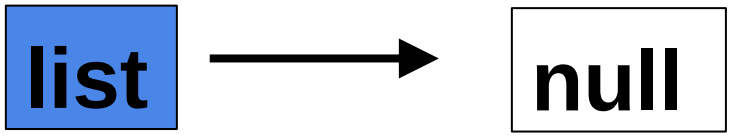
```
int[] list; // declaration
list = new int[10]; // instantiation
```

- This code creates an array of 10 **`int`**s

Arrays are Objects

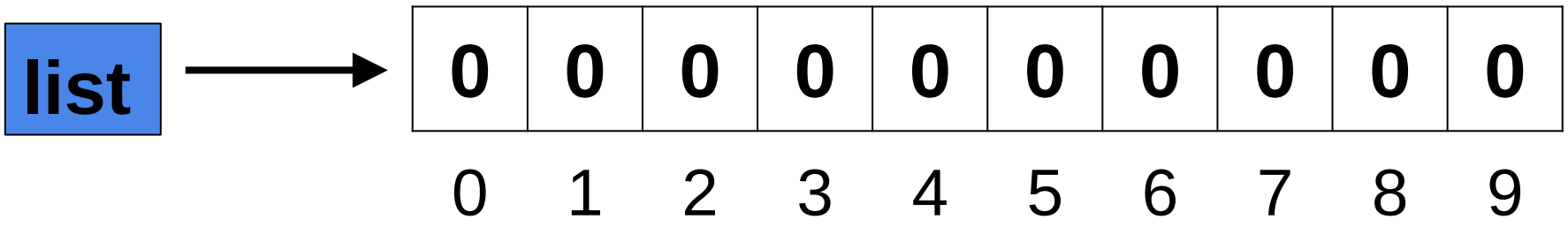
- Declares array, but assigned to null

```
int[] arr;
```



- Instantiates an existing array

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



Accessing Array Elements

- You can access an element of an array by using the index inside brackets

```
list[9] = 142;
System.out.println(list[9]);
```

- Once you have indexed into an array, that variable behaves exactly like any other variable of that type
- **Indexing starts at 0 and stops at 1 less than the length**
- The index can be any number, variable, or expression that equates to an **integer**

Assigning an Array Element

Array Before:

0	0	0	0	0	0	0	0	0	0
0	1	2	3	4	5	6	7	8	9

```
int[] list = new list[10];
list[0] = 73;
list[4] = 2;
list[9] = 14;
System.out.println(list[0]);
System.out.println(list[4]);
System.out.println(list[7]);
System.out.println(list[9]);
```

Output

```
73
2
0
14
```

Array After:

73	0	0	0	2	0	0	0	0	14
0	1	2	3	4	5	6	7	8	9

Length of an Array

- You can use the **`length`** member to find out how many elements are in the array
- Please note the difference from the **`length()`** method for Strings and the **`length`** member for Arrays
- One is a method and one is a member

```
int[] list = new int[42];
int size = list.length;
System.out.println("List has " + size +
     " elements");
```

Output
42

Automatic Initialization

- When you create an **`int`**, **`double`**, **`char`**, or **`boolean`** array, the array is automatically filled with certain values

Type	Value
`int`	`0`
`double`	`0.0`
`char`	`'\0'`
`boolean`	`false`

- For other types, including **`String`**s, each index in the array must be filled explicitly

Explicit Initialization

- Explicit initialization can be done with a list:

```
String[] days = {"Monday", "Tuesday",
"Wednesday", "Thursday", "Friday",
"Saturday", "Sunday"};
```

- Or, a loop could be used to set all the values:

```
String[] numbers = new String[100];
for(int i = 0; i < numbers.length; i++)
  numbers[i] = "" + (i + 1);
```

Connection to `for`-loops

`for` loops + arrays = power

- Arrays are a fixed size list of a single kind of data
- A **`for`** loop is ideal for iterating over every item and performing some operation
- **`for`** loops and arrays will come up again and again

`for` loop going through an array

- Here is an array of **`ints`** called **`list`**
- We can use a for loop to go through the array

```
int[] list = {1, 2, 3, 4};
for( int i = 0; i < list.length; i++ )
{
  System.out.print(list[i] + " ");
}
```

Output
1 2 3 4

- Using the length parameter we do not need to know how big the array is ahead of time

`for` loop for summing an array

- Here is an array of **`ints`** called **`list`**
- We can use a for loop to sum up those **`ints`**

```
int sum = 0;
int[] list = {8, 5, 3, 7, 2};
for(int i = 0; i < list.length; i++)
{
   sum += list[i];
}
System.out.println(sum);
```

Output
25

- Using the length parameter we do not need to know how big the array is ahead of time

for each loop

for each loop

- There is a variation of the for loop called the for each loop
- This loop goes through some list of items
- In this case the variable x stores the actual value of an array element

```
int[] list = {1, 2, 3, 4};

for(int x : list)
{
   System.out.print(x + " ");
}
```

Output
1 2 3 4

for each loop

- Inside the loop setup you need to define a temporary variable, in this case it is **x**
- The data type for the variable must match the type of data stored in the array
- Then you have a **:** followed by the array you want to go through

```
double[] list = {2.0, 5.0, 3.0};

for (double x : list)
{
   System.out.print(x + "  ");
}
```

Output
2.0 5.0 3.0

for each loop

- To use the for each loop to go through each character in a String, you need a method to convert the String to an array of chars
- The toCharArray() method does this

```
String word = "hello";
for(char x : word.toCharArray())
{
   System.out.print(x + " ");
}
```

Output
h e l l o

Array Examples

Array Swap

- Swapping the values of two variables is a fundamental operation in programming
- It is going to become more important in arrays because now the order of variables has become important
- The simplest way to swap two variables involves using a third variable as a temporary location

Swap Code

- Here is an example of swapping two **`ints`** in an array of **`ints`** called **`arr`**

```
int[] arr = {8, 3, 6};
int temp;
temp = arr[0];
arr[0] = arr[2];
arr[2] = temp;
System.out.println(arr[0]);
System.out.println(arr[2]);
```

Output
6 8

Why the Third Variable?

- Why do we need the temporary variable?
- What would the output be from the code below?

```
int[] arr = {8, 3, 6};
arr[0] = arr[2];
arr[2] = arr[0];
System.out.println(arr[0]);
System.out.println(arr[2]);
```

Output
6
6

- Without the temporary variable we lose the value of one of the array elements

Shuffling Cards

- Using the swap code, we can do a random shuffling of a deck of cards
- To do so, we go through each element of the array, and randomly swap it with any of the later elements

```
int n = 52;
for(int i = 0; i < n; i++)
{
  exchange = i+(int)(Math.random()*(n-i));
  temp = deck[i];
  deck[i] = deck[exchange];
  deck[exchange] = temp;
}
```

Searching

- Searching through an array is an important operation
- The simplest way to do so is a linear search: check every element in the array
- Searching and sorting are really key to all kinds of problems

Searching Example

- This example goes through the array and finds the first occurrence of 4
- You could find the last occurrence by starting at the length-1 and going to 0

```
int[] arr = {8, 3, 4, 6};
for(int x = 0; x < arr.length; x++)
{
   if(arr[x] == 4)
      return x;
}
```

Output
2

Counting Occurrences

- This example goes through and counts the number of 4's located in **`arr`**

```
int[] arr = {8, 3, 4, 6, 4, 9, 4};
int count = 0;
for(int x = 0; x < arr.length; x++)
{
  if(arr[x] == 4)
    count++;
}
System.out.println(count);
```

Output
3

Removing Occurrences

- This example goes through and removes any occurrence of 4

```
int[] arr = {8, 3, 4, 6, 4, 9, 4};
int count = 0;
for(int x = 0; x < arr.length; x++){
  if(arr[x] == 4)
    count++;
}
int[] newarr = new int[arr.length-count];
int i = 0;
for(int x = 0; x < arr.length; x++){
  if(arr[x] != 4){
    newarr[i] = arr[x];
    i++;
  }
}
System.out.println(Arrays.toString(newarr));
```

Remember the array cannot be resized so we need to create a new array

Output
[8, 3, 6, 9]

Arrays.sort()

- We will cover sorting in detail later in the course
- Here is how you can sort an array
- You will need to add this import statement

```
import java.util.Arrays;
```

```
int[] list = {9, 4, 7, 2};
Arrays.sort(list);
System.out.println(Arrays.toString(list));
```

Output

[2, 4, 7, 9]

Arrays.toString()

- You have already seen toString() throughout the presentation
- The Arrays.toString() method returns a string of the array that is passed in as an argument
- You will again need this import statement

```
import java.util.Arrays;
```

```
int[] list = {9, 4, 7, 2};
System.out.println(Arrays.toString(list));
```

Output

[9, 4, 7, 2]

Common Pitfalls with Arrays

Un-initialized Arrays

- Remember, you get no initialization with arrays of **`Strings`**
- If you try to access an non-existent element, the world will explode

```
int String[] array = new String[50];

String s = array[42]; // works fine
int size = s.length(); // destroys world
```

Array Index Errors

- Accessing an element of an array that does not exist will kill your program

```
int[] numbers = new int[100];

numbers[103] = 5;    //crash
System.out.println( numbers[-3]);//crash
System.out.println( numbers[99]);//okay
for( int i = 0; i <= 100; i++ )
  numbers[i] = i;  //crash when i == 100
```