WEEK NINE

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FILES

- Sequence of binary digits
  - May represent integers, text characters, etc.
- Files have many different types that define how to read the information inside
  - Text file: ASCII/UNICODE characters
  - Binary file: pretty much everything else

FILE I/O AND THE OS

- Operating System (OS) handles file operations for programs
  - Interacts with the storage device
  - Polices who can access/write to a file
  - Handles file properties (size, permissions, name)
- OS must open files so a program can use them
  - Programs use method calls to invoke OS routines
    - Create and open a new file to write to it (output)
    - Open an existing file to read it (input)
    - Open an existing file and write/append information to it (output)
    - Destroy an existing file
  - If the OS runs into a problem, it throws (creates) an exception

EXCEPTIONS

- Describes a problem that occurs in the code (or in this case with the OS)
- This allows the program to respond accordingly to an unexpected issue
- Some exceptions, (particularly file I/O exceptions) are **checked exceptions**
  - We must deal with these in some way, otherwise we will get an error
  - EX: `IOException`, `FileNotFoundException`
- When we encounter an exception, we must either:
  - Handle the exception (try/catch: we will discuss this later) OR
  - Pass the exception up a level
- To pass it up a level, we need to add a throw clause to the method header

```
public static void main (String[] args) throws Exception {
```

FILE BUFFERS

- Program calls a method to ask the OS to open the file
  - OS creates an area in memory (a buffer) that the program can access
  - OS provides the program with a reference to the buffer (a file handle)
  - OS checks if the program is permitted to receive the file handle
    - Permissions, is the file already open?
- Buffer improves performance
  - Memory is faster than accessing storage device where the file is stored
  - If file is opened, OS copies file contents into buffer
  - If file write occurs, change occurs in buffer
  - Eventually, OS will copy buffer back into the file
  - OS will flush the buffer and close the file
  - Open files are closed when program exits, thus we need to explicitly close files that are open

FILE POINTERS

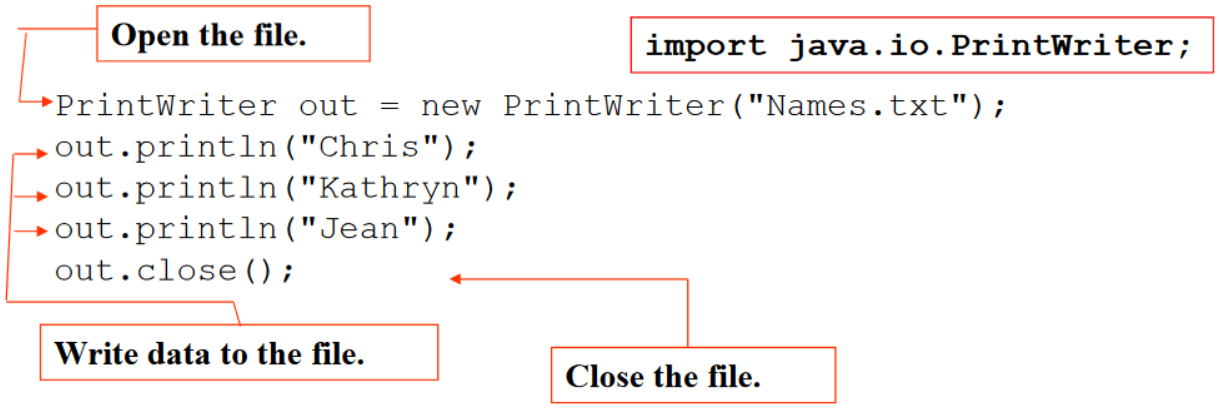
- File pointer indicates where the next read or write operation will take place
- Each file is treated as a one-dimensional sequence of characters
  - Non-printing characters for newlines
- Read position indicates what characters are returned on the next read operation
  - Read position is updated to the next character each time a character is read
  - Most languages also provide methods to move the read pointer
  - EX: ‘1501 245’
  - nextInt() would read in ‘1501’
  - Read pointer is now on the white space between the two numbers
  - nextLine() would read in ‘ 245’

FILENAME CONVENTIONS

- Dependent on the OS
- Two different ways to reference file locations
  - Relative reference: specified from a default working directory (no absolute path)
    - `String filename = "Data.txt";`
  - Absolute reference: entire path specified from the root directory
    - `String filename = "C:\\Users\\ClarissaMilligan\\Documents\\FA24\\data.txt";`
    - Since '\' is the escape character in ASCII/UNICODE, we must use '\\'
    - Unix-type OSs use forward slash '/'

THE PRINTWRITER CLASS

- Under the java.io library
- PrintWriter class allows for writing to files using `print` and `println` methods, like we use for the console
- Constructor takes in a filename (`String`) or file handle (`FileWriter`)
  - WARNING: If PrintWriter is just given a filename, it will always overwrite that file completely



THE FILEWRITER CLASS

- Also, in the java.io library
- FileWriter is used to avoid erasing an existing file
  - `FileWriter fwriter = new FileWriter("filename.txt", true);`
  - Boolean argument indicates whether or not we will be appending data to the file
  - If we choose true, buffer will be created in a way so output will be appended to the end of the file
- FileWriter object can be passed into a PrintWriter

THE FILE CLASS

- Also in the java.io library
- Used to create a file handle
  - `File fileHandle = new File("filename.txt");`
- Scanner object can be used to parse the associated buffer (read the contents)
  - `Scanner inputFile = new Scanner(fileHandle);`
- Data can then be read with the same methods we use for the console:
  - `nextLine(), nextInt(), nextDouble(),` etc.
  - `hasNextLine(), hasNextInt(), hasNextDouble(),` etc.

FILE CLASS METHODS

- Sanity checking methods
  - `exists(), canWrite(), canRead(), canExecute()`
- Other useful methods
  - `createNewFile(), delete(), getPath(), getAbsolutePath()`
- Set OS properties
  - `setExecutable(), setReadable(), setWritable(), setLastModificationDate()`

HANDLING EXCEPTIONS

- Using a try/catch block allows us to handle issues without our program crashes
- Try block
  - Should surround any of the code that could generate an exception
  - Any code that is dependent on the code above also needs to be in the try block
  - Once an exception is thrown from the try block the execution halts and jumps to the corresponding catch block
- Catch block
  - Can be more than one for different exceptions
- Finally block
  - Executes last regardless of whether an exception is thrown

TRY/CATCH/FINALLY

```
try {
	// code that can cause an exception
} catch (Exception e) {
	// code that happens if that exception occurs
} finally {
	// code that happens regardless of what happens above
}
```

ACTIVITY

- Write code that:
  - Reads in 5 numbers from a file called “nums.txt”
  - Stores them in an array
  - Prints out the sum of the numbers
- File will look like this:

```
4
23
17
16.5
-8.3
```

FILEOUTPUTSTREAM

- Also, part of java.io
- FileOutputStream can be used in place of a FileWriter

```
FileOutputStream fileStream = new FileOutputStream("data.txt", true);
PrintWriter fileOut = new PrintWriter(fileStream);

fileOut.println("Hello File!");
fileOut.close();
fileStream.close();
```

FILEINPUTSTREAM

- Also, part of java.io
- FileInputStream can be used in place of File

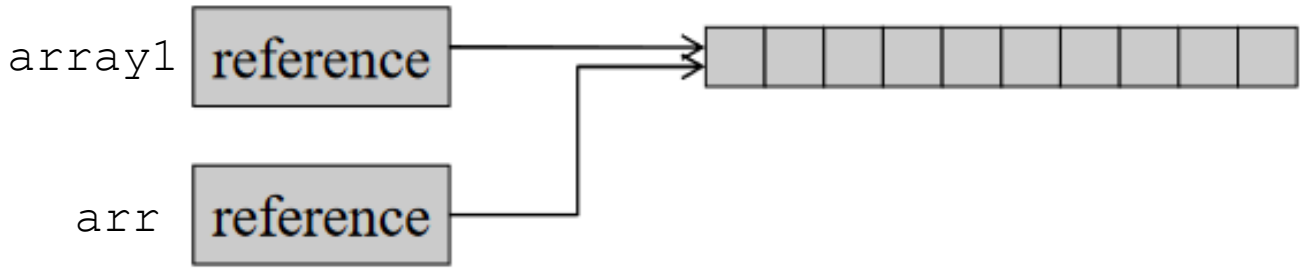
```
FileInputStream fileByteStream = new FileInputStream("data.txt");
Scanner fileInput = new Scanner(fileByteStream);

while (fileInput.hasNextLine()) {
       System.out.println(fileInput.nextLine());
}
fileInput.close();
fileByteStream.close();
```

MORE ON ARRAYS

- Remember, arrays are objects
- Variable name points to a memory address where the array is stored
- To print an array,
  - Loop through the array and print each index
  - Use `Arrays.toString(array1);`
- To test equality of two arrays,
  - Loop through one array and check equality index by index
  - Use `Arrays.equals(array1, array2);`

PASSING ARRAYS AS ARGUMENTS

- Applies to any object not just arrays
- Objects are passed by reference in Java
- Thus, they can be modified in a method and the actual object being passed in will also be modified
- This is different from when we pass primitive types into a method (pass by value)
- `array1` is the name in main
- `arr` is the argument name



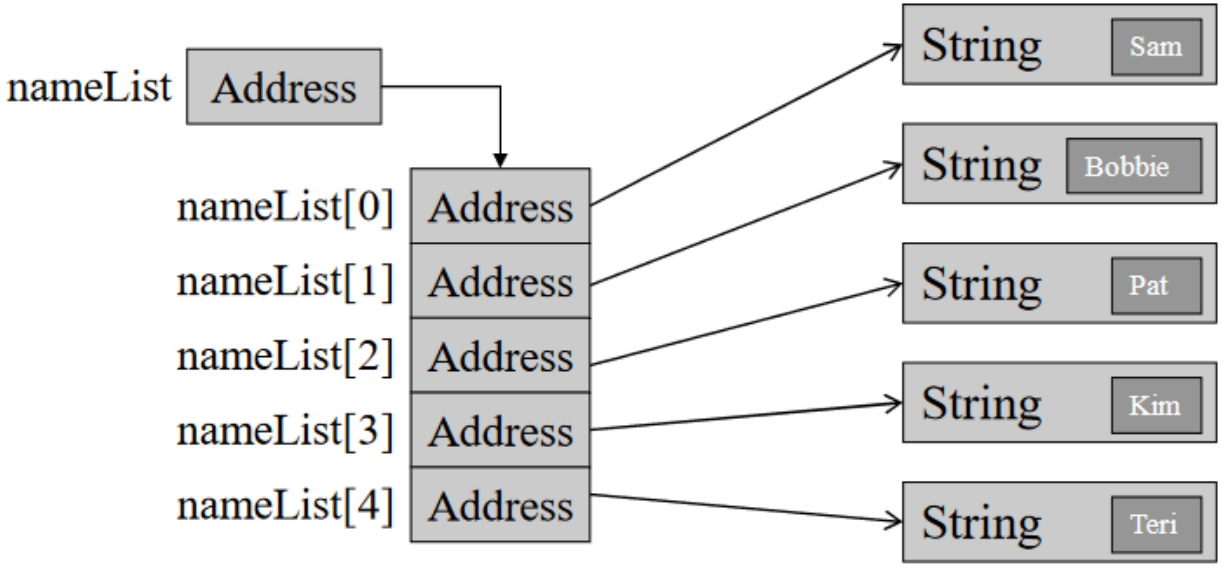
PASSING ARRAYS AS ARGUMENTS

```
public static void main(String[] args) {
        int[] array1 = {1, 2, 3};
        zeroArray(array1);
        System.out.println(Arrays.toString(array1));
    }

    public static void zeroArray (int[] arr) {
        for (int i = 0; i < arr.length; i++) {
            arr[i] = 0;
        }
    }
```

ARRAYS OF OBJECTS

```
String[] nameList = {"Sam", "Bobbie", "Pat", "Kim", "Teri"};
```

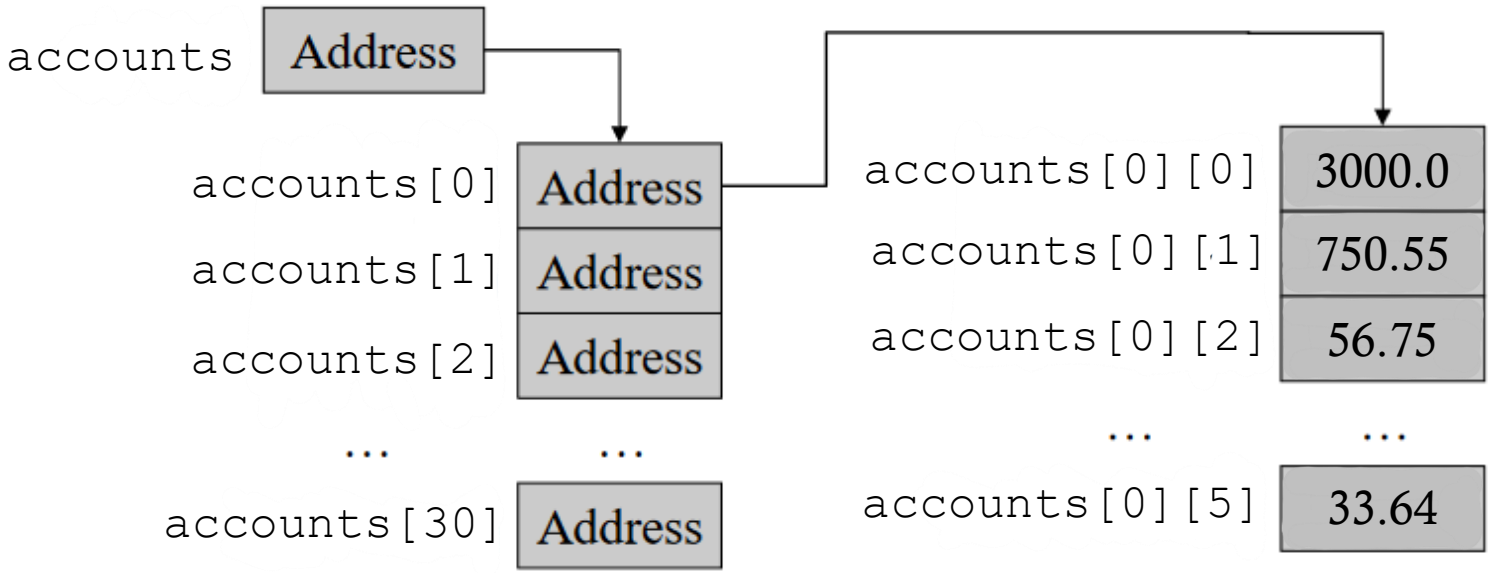
- Since String is an object, each index in the array holds the memory address of the object
- Essentially, we have an array of addresses



MULTI-DIMENSIONAL ARRAYS

- An array can also contain another array (which could contain another array and so on…)

```
double[][] accounts = new double [NUM_ACC][NUM_DEPOSITS];
```



TWO-DIMENSIONAL ARRAYS

- Can be visualized as a grid of data
- Must declare with a size for number of rows and columns (still constant)

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

	column 0	column 1	column 2	column 3
row 0	`Scores[0][0]`	`Scores[0][1]`		
row 1	`Scores[1][0]`	`Scores[1][1]`		
row 2				
row 3				`Scores[3][3]`

RAGGED ARRAYS

- We can store different data types in an array by specifying the type as Object

```
Object[][] array = { {3.0, 5.6}, {true, false}, {3, 5} };
```

- When dealing with multi-dimensional arrays, the arrays within the array can be different lengths

```
int[][] numList = { {1, 2, 3},
                    {4, 5, 6, 7, 8},
                    {9, 10} };
```

OR

```
int[][] array = { new int[3], new int[2], new int[4] };
```

ARRAYLISTS

- Found in the java.util library
- Similar to an array but with additional functionality
  - Can hold objects of different types in the same list
  - Automatically expands and reduces on demand
  - Still indexed
- Upon creation we can specify a type for the ArrayList or use Object if we want to hold any object

```
ArrayList<String> names = new ArrayList<>();
ArrayList<Object> everything = new ArrayList<>();
```

- Specifying a type helps avoid issues and avoid typecasting

ARRAYLIST METHODS

- `.size()`: returns the size of the ArrayList
- `.add( object )`: adds the reference to the object to the end of the list
- `.add( index, object )`: inserts the object reference at the specified index
- `.set( index, object )`: overwrites the current index value with the object reference
- `.get( index )`: returns the object reference at that index (not removed)
- `.remove( index )`: returns and removes the object reference
- `.clear()`: removes all elements from the list
- `.contains( object )`: checks if the specified object exists in the list
- `.indexOf( object )`: returns the index of the specified object

WRAPPER CLASSES

- If we want to create an ArrayList of `int` or `double`, we have to say `Integer` or `Double`
- Both are wrapper classes for the primitive data types
- Surround an existing class to make it an object and add additional functionality
- ArrayLists cannot take in primitive types, so we have to use the wrappers
- `Integer` and `Double` also have useful methods that allow us to cast a String to an int or double and vice versa
  - `int num = Integer.parseInt("3");`
  - `String str = Integer.toString(3);`