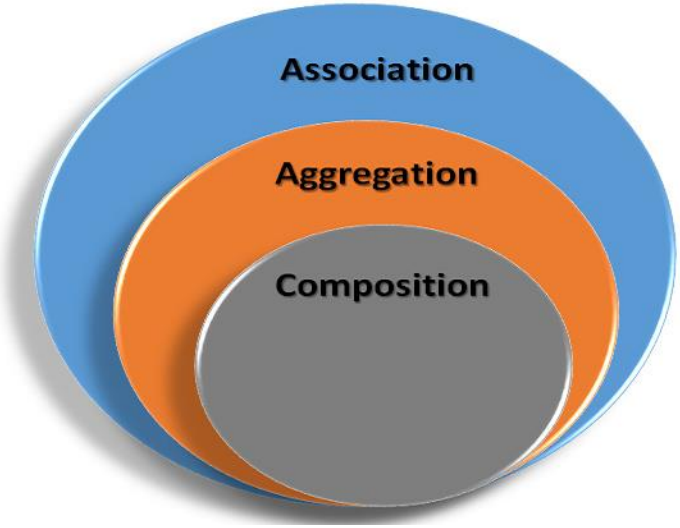
CMPS 251

Relations between Classes



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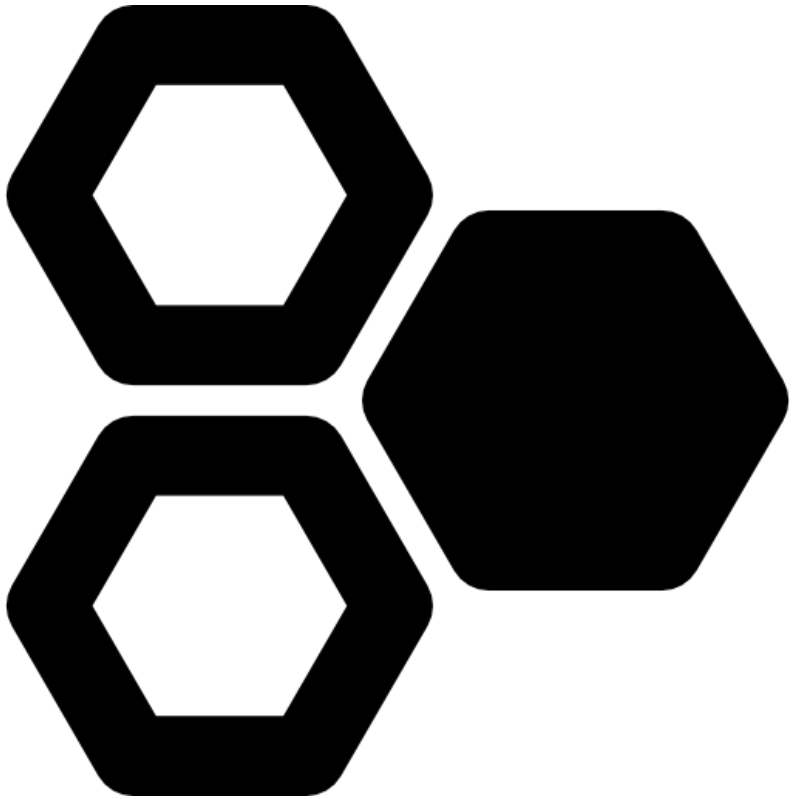
CSE@QU

Outline

- **Relations between Classes**
- **Introduction to Arrays and Lists**

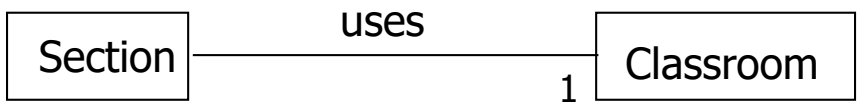
Relations between Classes



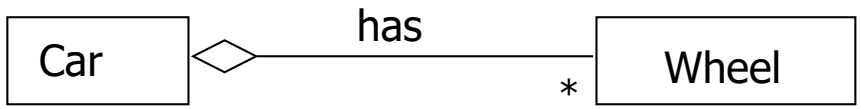
Relations between Classes

- Classes can be related to other classes in 4 ways:

- Association (**uses** without ownership)

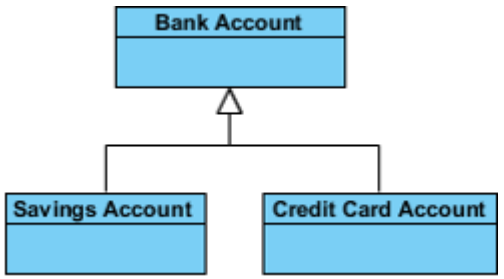


- **Aggregation** (**has-a** + Whole-Part relationship)



- Composition (**has-a** + Part cannot exist without the Whole)

- Inheritance (**is-a** relation)

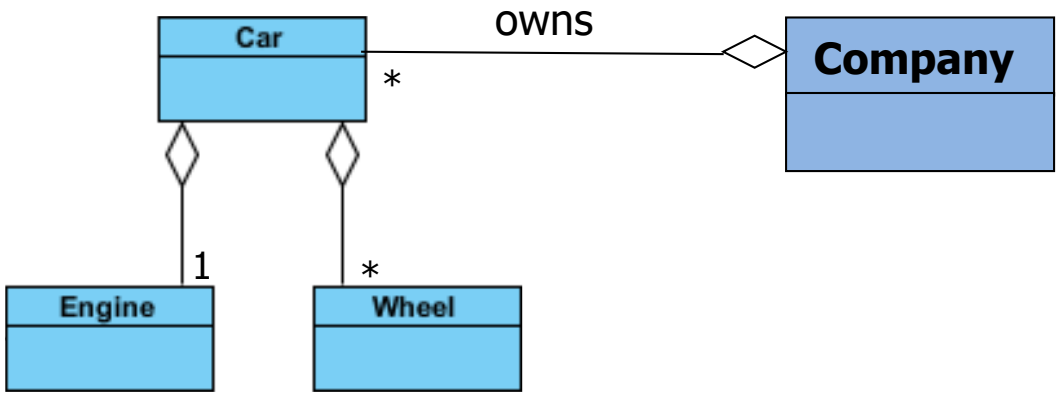


Association

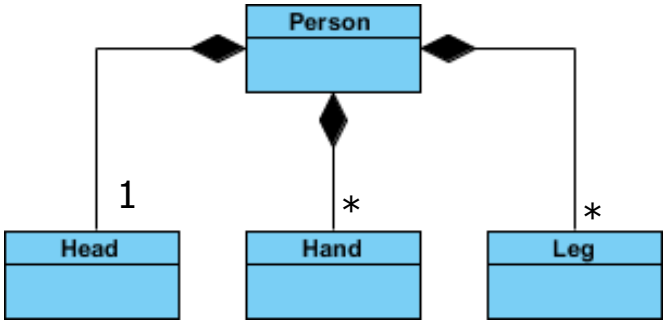
- Association is a very generic relationship used when one class **uses** the functionalities provided by another class
- **No ownership** between the objects and both have their own lifecycle. Both can be created and deleted independently

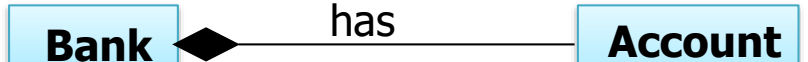
Aggregation vs. Composition

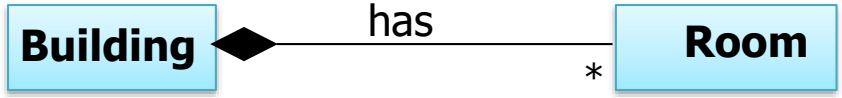
- **Aggregation** = WHOLE-PART relationship. PART can exist without the WHOLE.



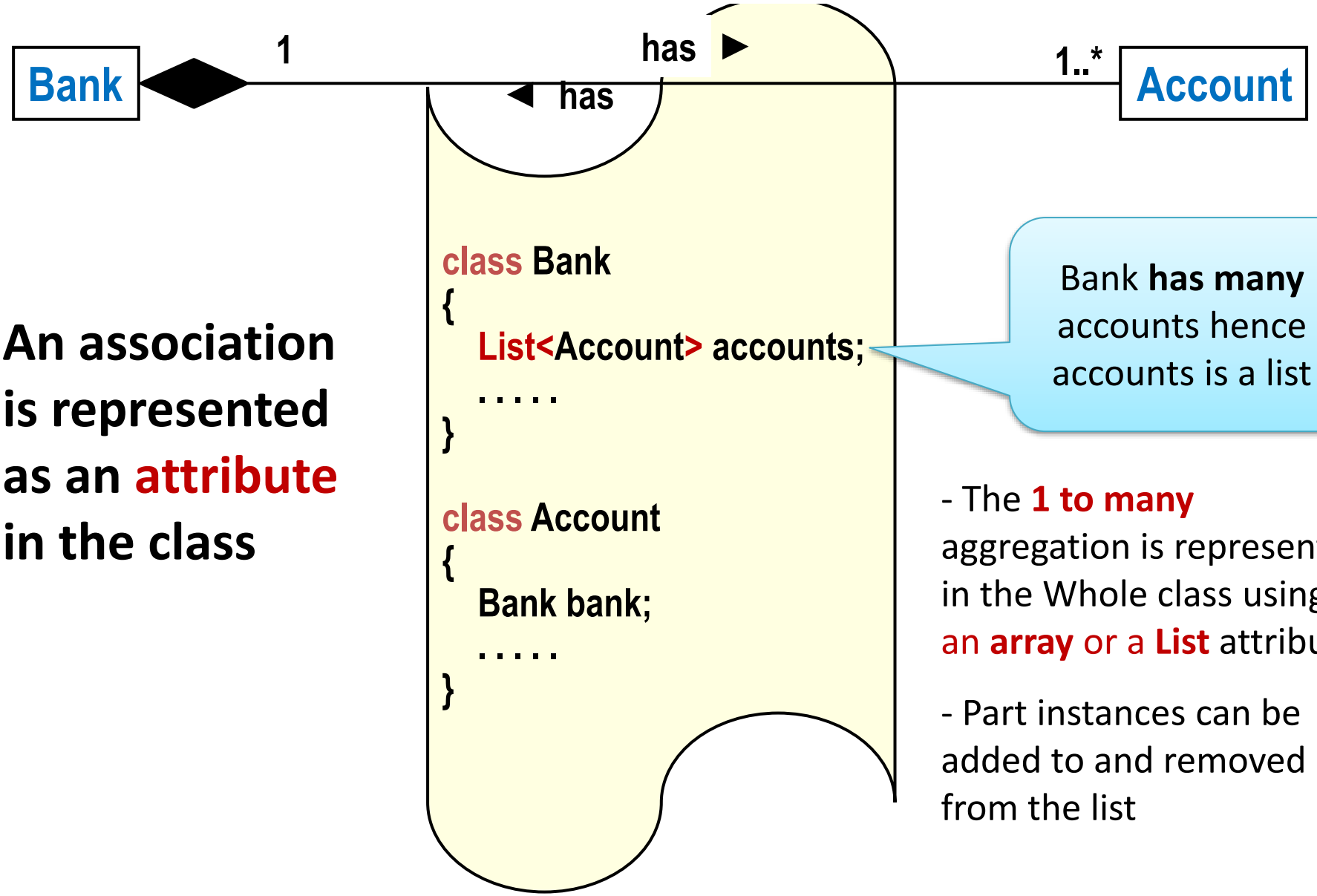
- **Composition** = WHOLE-PART relationship. PART cannot meaningfully exist without the WHOLE







Implementation of bidirectional association

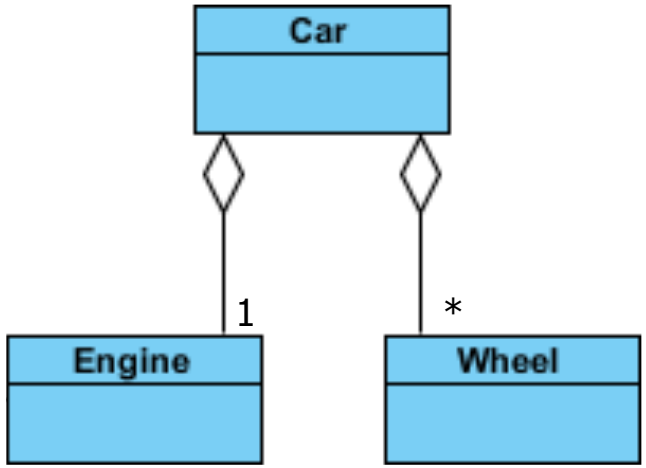


An association is represented as an attribute in the class

- The **1 to many** aggregation is represented in the Whole class using an **array** or a **List** attribute

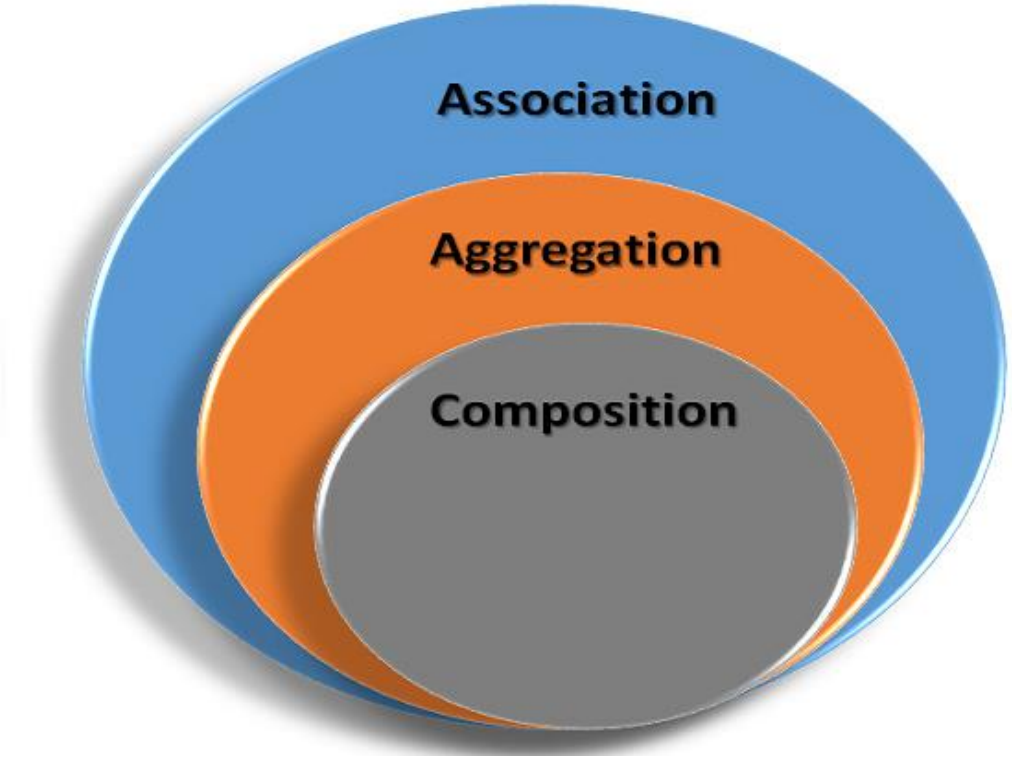
- Part instances can be added to and removed from the list

```
public class Car {
    private Engine engine;
    private List<Wheel> wheels;

    public Car(Engine engine){
        this.engine  = engine;
        this.wheels = new ArrayList<>();
    }

    public addWheel(Wheel wheel){
        wheels.add(wheel);
    }
}

class Engine {
    private String type;
}

class Wheel {
    private int size;
}
```



Association vs. Aggregation vs. Composition

- A relationship between two classes is referred as an **Association**
- **Aggregation** is a special form of Association
- **Composition** is a strong form of Aggregation



Arrays and Lists

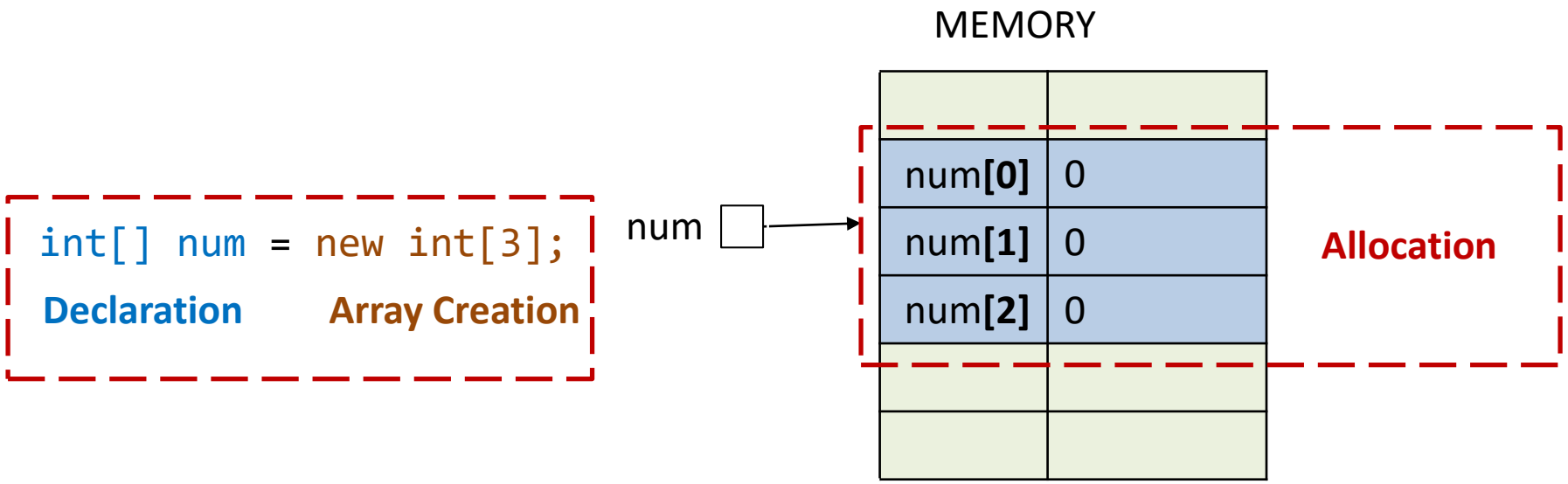
A simple variable stores a single value

```
int num1 = 10;
int num2 = 20;
int num3 = 30;
```

MEMORY

num1	10
num2	20
num3	30

An array object stores multiple values of the same type



- Array elements are **auto initialized** with the type's default value:
  - 0 for the numeric primitive-type elements, false for boolean elements and null for references

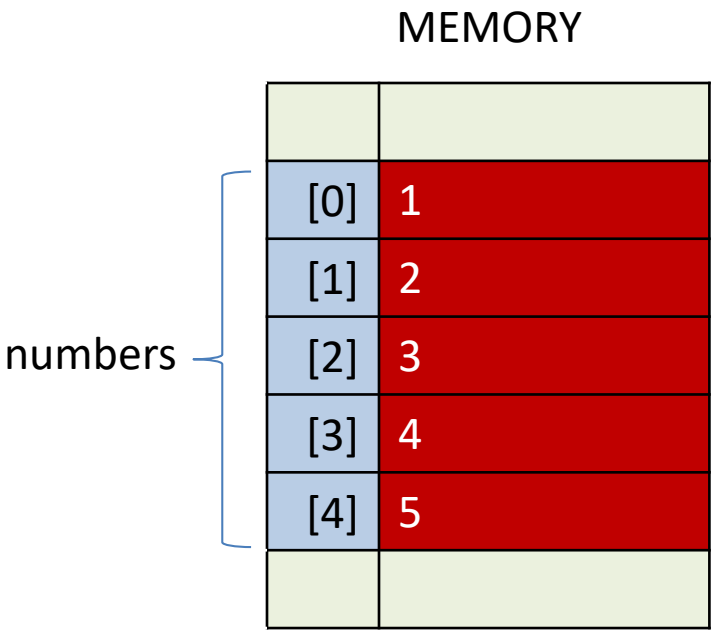
Array stores values of the same type

```
int[] number = new int[100];          // stores 100 integers

double[] salesTax = new double[10];  // stores 10 doubles

char[] alphabet = new char[26];       // stores 26 characters

Student[] students = new Student[40];   // stores 40 students
```

- The array **size** determines the number of elements in the array.
- The **size** must be specified in the array declaration and it cannot change once the array is created

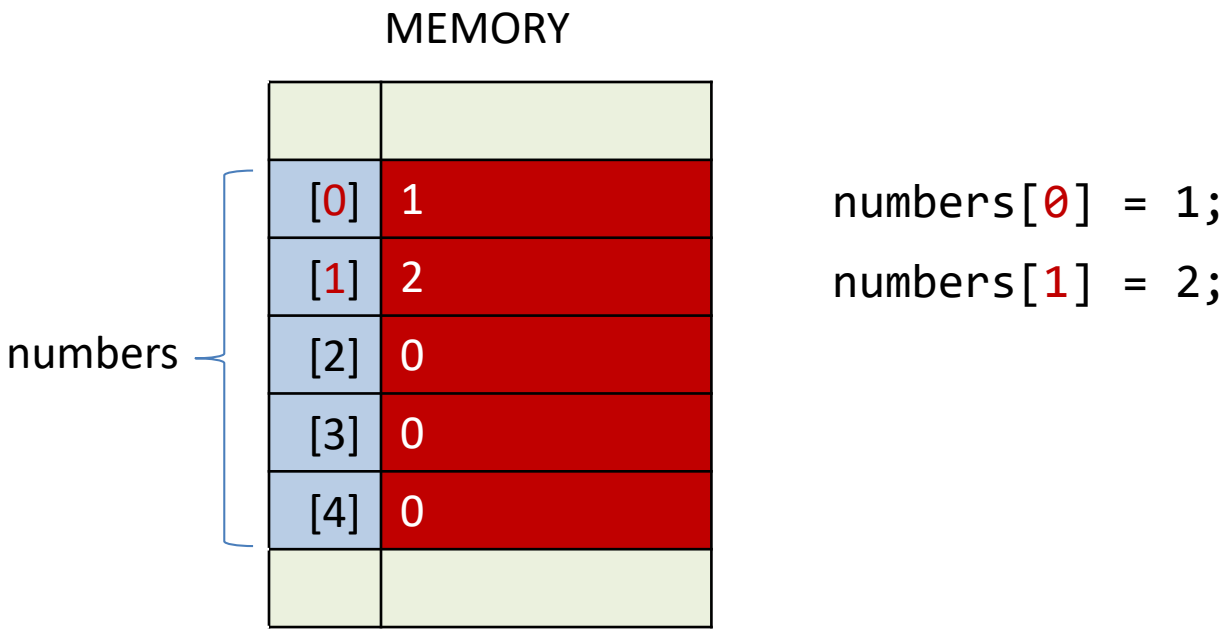
You may initialize an array explicitly

```
int[] numbers = {1, 2, 3, 4, 5};  // Array initializer
```



Array elements are indexed

```
int[] numbers = new int[5];
```



- Array index range is 0 to array size -1

Arrays can be instance variables

```
public class Department {
    private Employee[] employee;
    ...
}
```

Arrays can be local variables

```
public void getHourlyEmployees() {
    Employee[] hourlyEmployee;
    ...
}
```

Arrays can be parameters

```
public static void main(String[] args) {
    ...
}
```

Arrays can be return values

```
public Employee[] getEmployees() {
    ...
}
```

Example - Method that returns an array

```
public int[] initArray(int size, int initValue) {
   int[] array = new int[size];

   for (int i = 0; i < array.length; i++) {
      array[i] = initValue;
   }

   return array;
}
```

Arrays are objects, thus

```
int[] a = {1, 2, 3};
int[] b;

b = a;                  // makes b and a refer to the same
                        // memory location
```

- Arrays are objects so they are **reference types**.
- Elements can be either primitive or reference types.

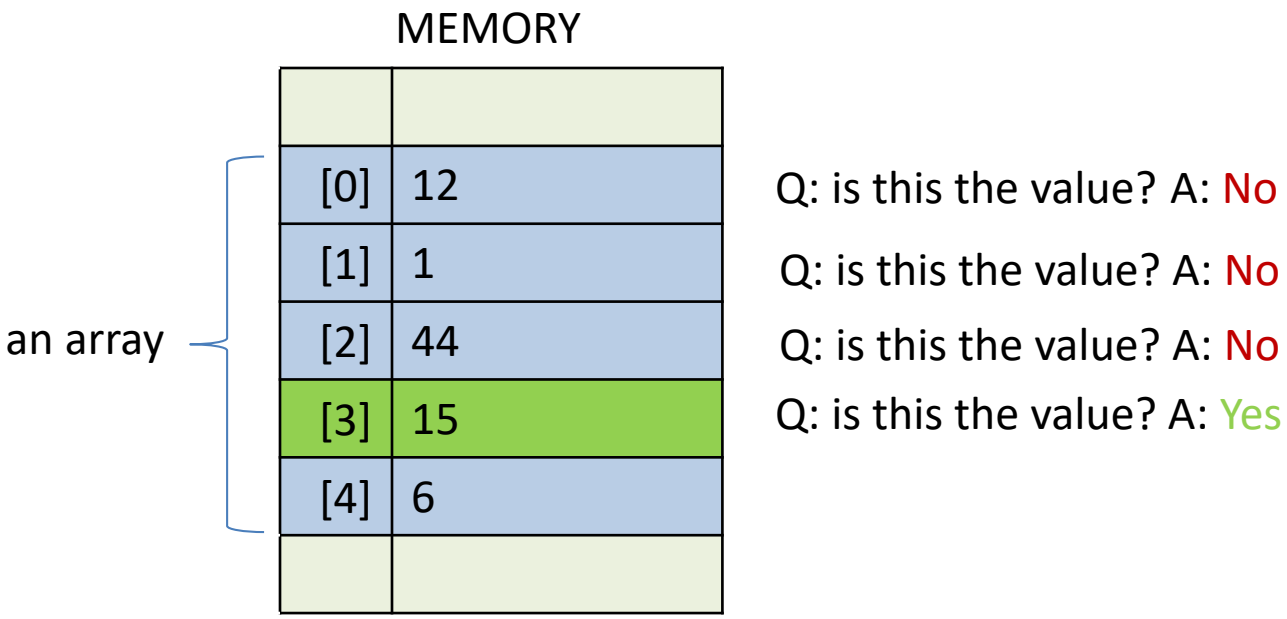
Arrays are objects, thus

```
int[] a = {1, 2, 3};
int[] b = {1, 2, 3};

if (a == b) {...}   // evaluates to false
                    // since a and b refer to two
                    // different memory locations
```

Example - Method that tests for array equality

```
public boolean areEqual(int[] array1, int[] array2) {
   if (array1.length != array2.length) {
      return false;
   } else {
      for(int i = 0; i < array1.length; i++) {
         if(array1[i] != array2[i])
             return false;
      }// end for
   }// end if
   return true;
}
```

Use linear (sequential) search to locate values



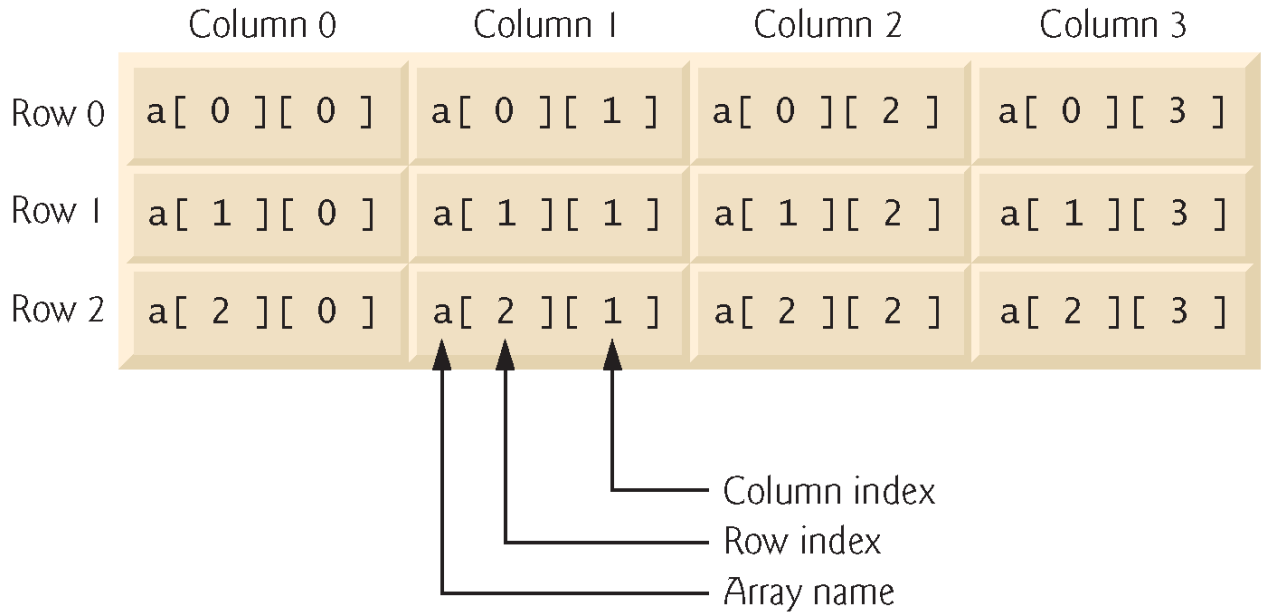
Q: is this the value 15 in the array?

Linear Search

```
// Returns true if array contains item, false otherwise.
private boolean contains(String[] items, String item) {
   for(int i = 0; i < items.length; i++) {
         if (items[i].equalsIgnoreCase(item)) {
            return true;
        }
    }// end for
    return false;
}
```

Multidimensional Arrays

- **Two-dimensional arrays** are often used to represent tables of values with data arranged in *rows* and *columns*.
- Example two-dimensional arrays with 3 rows and 4 columns



Multidimensional Arrays (Cont.)

- A multidimensional array **b** with 3 rows and 4 columns

```
int[][] b = new int[3][4];
```

- A two-dimensional array **b** with 2 rows and 3 columns could be declared and initialized with nested array initializers as follows:

```
int[][] b = {{1, 2, 9}, {3, 4, 8}};
```

  - The initial values are *grouped by row* in braces.
  - The number of nested array initializers (represented by sets of braces within the outer braces) determines the number of *rows*.
  - The number of initializer values in the nested array initializer for a row determines the number of *columns* in that row.

Lists

- Problem
  - You must know the array size when you create the array
  - Array size cannot change once created.

- Solution:
  - Use **ArrayList**: they stretch as you add elements to them or shrink as you remove elements from them
  - Similar to arrays + **Dynamic resizing**

ArrayList methods

- Create empty list

  `new ArrayList<>()`
- Add entry to end

  `add(value)` (adds to end)
- Retrieve n^{th} element

  `get(index)`
- Check if element exists in list

  `contains(element)`
- Remove element

  `remove(index)` or `remove(element)`
- Find the number of elements

  `size()`
- Remove all elements

  `clear()`

ArrayList Example

```
import java.util.*;  // Don't forget this import

public class ListTest2 {
  public static void main(String[] args) {
    List<String> entries = new ArrayList<>();
    double d;
    while((d = Math.random()) > 0.1) {
      entries.add("Value: " + d);
    }
    for(String entry: entries) {
      System.out.println(entry);
    }
  }
}
```

This tells Java that the list will contain only strings.

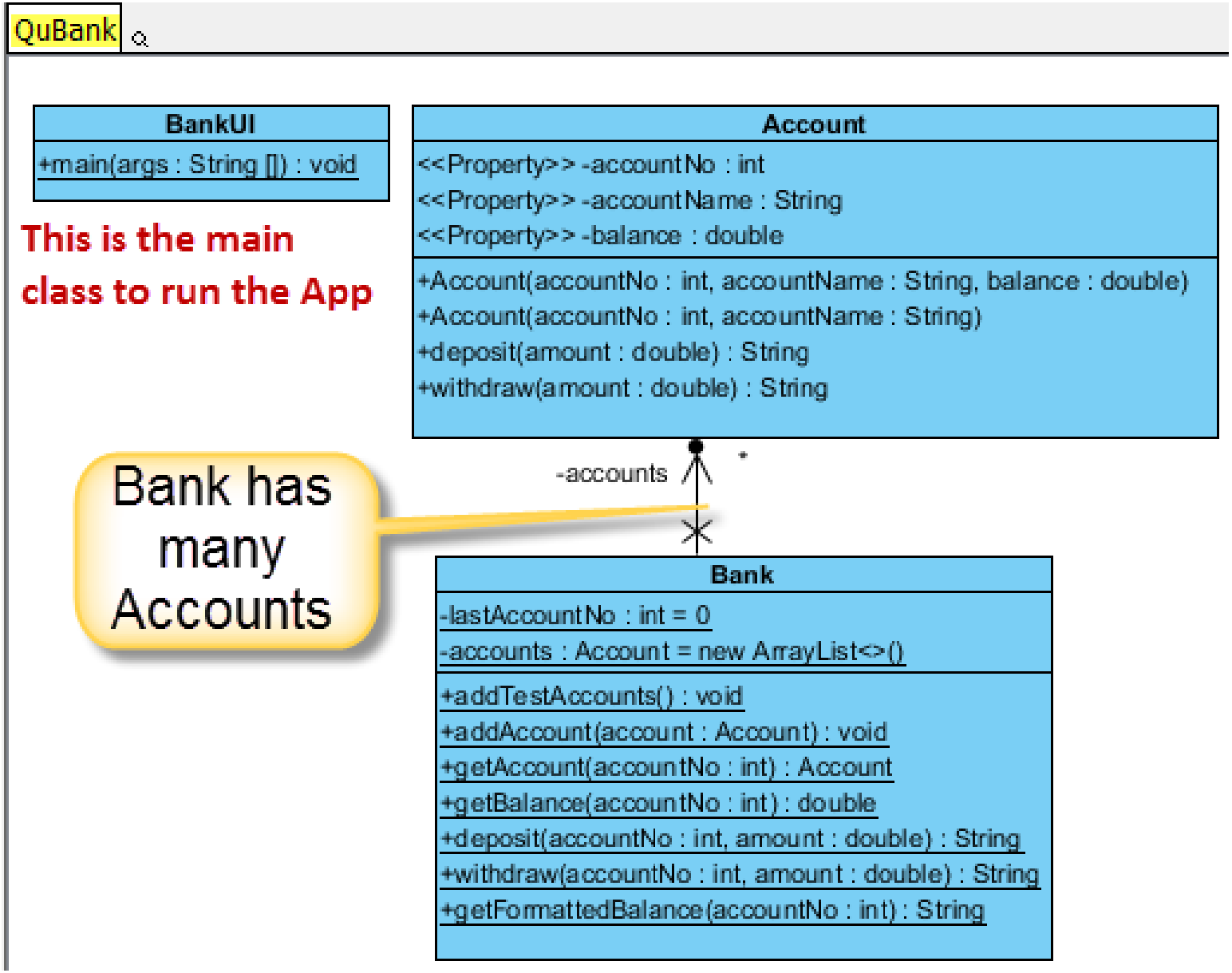
Variable-Length Argument Lists

- Variable-length argument lists can be used to create methods that receive an unspecified number of arguments.
  - Parameter type followed by an ellipsis (`...`) indicates that the method receives a variable number of arguments of that particular type.
  - The ellipsis can occur only once at the end of a parameter list.

Variable-Length Argument Lists - Example

```
// Variable-Length Argument Lists - Example
public static double average(double... numbers) {
   double total = 0.0;
   for(var num : numbers) {
      total += num;
   }
   return total / numbers.length;
}

public static void main(String[] args) {
   double avg = average(4, 6, 2);
   System.out.println(avg);
}
```

Banking System Example



Bookstore System example