Module 1-8

Collections: Maps and Sets

Objectives

- Students should be able to effectively use objects of the following collection classes:
    - Map
    - Set/HashSet
- Students should be aware of performance/optimization considerations of various data structures
- Students should be able to describe "Big O" (Big Omicron) notation and common examples for the basic Big O categories

Maps: Introduction

Maps are used to store key value pairs.

- Examples of key value pairs: dictionary entries (word -> definition), a phone book (name -> phone number), a list of employees (employee number -> employee name)
- We will focus on a type of **unordered** map called a HashMap.

Maps

- Indexed collection
  - Allows values to be located using user-defined keys
  - Snack machine
    - Key “a5” gets you a bag of Fritos

Maps: Declaring

Maps follow the following declaration pattern.

```
import java.util.HashMap;
import java.util.Map;

public class MyClass {

        public static void main(String args[]) {

        Map <Integer, String> myMap = new HashMap<>();
        }
}
```

Note the we will need these 2 imports for a hash map.

We are creating a type of Map called a HashMap

We have specified that the key will be an integer and the value will be the String

Note the "**new**" keyword which **instantiates** the map.

Maps: put method

The put method adds an item to the map. The data types must match the declaration.

```
Map <Integer, String> myMap = new HashMap<>();
myMap.put(1, "Rick");
myMap.put(2, "Beth");
myMap.put(3, "Jerry");
myMap.put(4, "Summer");
myMap.put(5, "Mortimer");
```

The put method call requires two parameters:

- The key
  - In this example it is of data type Integer
- The value
  - In this example it is of data type String
- On the highlighted line, we inserted an entry with a key of 1 and a value of Rick.

Maps: containsKey method

The containsKey method returns a boolean indicating if the key exists.

```
Map <String, String> reservations = new HashMap<>();

reservations.put("HY234-9234", "Rick");
reservations.put("HY234-4235", "Beth");
reservations.put("HY234-3234", "Jerry");

System.out.println(reservations.containsKey("HY234-4235"));
// True
System.out.println(reservations.containsKey("AAAI-4235"));
// False
System.out.println(reservations.containsKey("Jerry"));
// False
```

- The containsKey method requires one parameter, the key you are searching for.
- containsKey returns a boolean

Note that in the last example returns false because it's not a key, it's a value

Maps: containsValue method

The containsValue method returns a boolean indicating if the value is in the Map.

```
Map <String, String> reservations = new HashMap<>();

reservations.put("HY234-9234", "Rick");
reservations.put("HY234-4235", "Beth");
reservations.put("HY234-3234", "Jerry");

System.out.println(reservations.containsValue(“Rick"));
// True
System.out.println(reservations.containsValue(“Betsy"));
// False
System.out.println(reservations.containsValue(“AA234-1111"));
// False
```

- The containsValue method requires one parameter, the value you are searching for.
- containsValue returns a boolean

Note that in the last example returns false because it’s not a value, it’s a key

Maps: get method

The get method returns the value associated with a key.

```
Map <String, String> reservations = new HashMap<>();

reservations.put("HY234-9234", "Rick");
reservations.put("HY234-4235", "Beth");
reservations.put("HY234-3234", "Jerry");

String name = reservations.get("HY234-9234");
System.out.println(name); // Prints Rick

String anotherName = reservations.get(“AAl93-2345”);
System.out.println(name); // Prints null
```

- The get method requires one parameter, the key you are searching for.
- It will return the value associated with the key.
- If keys do not match the parameter provided, it returns a null.

Maps: remove method

The remove method removes an item from the map, given a key value.

```
Map <String, String> reservations = new HashMap<>();

reservations.put("HY234-9234", "Rick");
reservations.put("HY234-4235", "Beth");
reservations.put("HY234-3234", "Jerry");

System.out.println(reservations.get("HY234-3234"));
// Prints Jerry
reservations.remove("HY234-3234");
System.out.println(reservations.get("HY234-3234"));
 // Prints null
```

- The remove method requires one parameter, the key you are searching for.

Maps: size method

The size method lists the size of the map in terms of key value pairs present.

```
Map <String, String> reservations = new HashMap<>();

reservations.put("HY234-9234", "Rick");
reservations.put("HY234-4235", "Beth");
reservations.put("HY234-3234", "Jerry");

System.out.println(reservations.size(); // Prints 3
reservations.remove("HY234-3234");
System.out.println(reservations.size(); // Prints 2
```

- The size method requires no parameters.
- It will return an integer, the number of key value pairs present.

Maps: looping through the pairings

The keySet() method returns a Set of all keys in the Map.

```
Map <String, String> reservations = new HashMap<>();

reservations.put("HY234-9234", "Rick");
reservations.put("HY234-4235", "Beth");
reservations.put("HY234-3234", "Jerry");

Set<String> keys  = reservations.keySet();

for (String reservationNumber: keys) {
      System.out.println(reservationNumber + " is for " +
          reservations.get(reservationNumber);
}
```

- Keys will contain a set of all the keys in the reservations HashMap
- We can use a forEach loop to iterate through to print out the values

Maps: Some Additional Rules

Maps are used to store key value pairs.

- Do not use primitive types with Maps, use the Wrapper classes instead.
- Make sure there are no duplicate keys. If a key value pair is entered with a key that already exists, it will overwrite the existing one!

Let’s Code!

- KeySet returns a set of keys
- EntrySet returns an set of map entries (key, value pairs)

Sets: Introduction

A set is also a collection of data.

- It differs from other collections we've seen so far in that no duplicate elements are allowed.
- It is also **unordered**.

Sets: Declaring

The following pattern is used in declaring a set.

```
import java.util.HashSet;
import java.util.Set;

public class MyClass {

        public static void main(String args[]) {

        Set<Integer> primeNumbersLessThan10 = new HashSet<>();
        }
}
```

Note the we will need these 2 imports for a hash map.

We are creating a type of Set called a HashSet

We have specified that the set will contain only integers.

Note the “**new**” keyword which **instantiates** the set.

Sets: add method

The add method creates a new element in the set.

```
Set<Integer> primeNumbersLessThan10 = new HashSet<>();
primeNumbersLessThan10.add(2);
                primeNumbersLessThan10.add(3);
primeNumbersLessThan10.add(5);
```

Only one parameter is required, the data that is being added.

In this example I have specified that this is a set of Integers, so the integers 2, 3, and 5 are being added.

Sets: contains method

The contains method returns a boolean specifying if an element is part of the set.

```
Set<Integer> primeNumbersLessThan10 = new HashSet<>();
primeNumbersLessThan10.add(2);
                primeNumbersLessThan10.add(3);
primeNumbersLessThan10.add(5);

System.out.println(primeNumberLessThan10.contains(5));
// true
System.out.println(primeNumberLessThan10.contains(4));
// false
```

Only one parameter is required, the data that we want to search for.

Sets: remove method

The contains method returns a boolean specifying if an element is part of the set.

```
Set<Integer> primeNumbersLessThan10 = new HashSet<>();
primeNumbersLessThan10.add(2);
                primeNumbersLessThan10.add(3);
primeNumbersLessThan10.add(5);

primeNumbersLessThan10.remove(5);
```

Only one parameter is required, the data that we want to remove.

Sets: size method

Last but not least, sets also have a size method.

```
Set<Integer> primeNumbersLessThan10 = new HashSet<>();
primeNumbersLessThan10.add(2);
                primeNumbersLessThan10.add(3);
primeNumbersLessThan10.add(5);

System.out.println(primeNumbersLessThan10.size());
// 3
```

- No parameters are required.
- An integer is returned.

Let’s Code!

Arrays vs Lists vs Maps vs Sets

- Use **Arrays** when … you know the maximum number of elements, and you know you will primarily be working with primitive data types.
- Use **Lists** when … you want something that works like an array, but you don't know the maximum number of elements.
- Use **Maps** when … you have key value pairs.
- Use **Sets** when … you know your data does not contain repeating elements.

If you know you will be dealing with non primitive data types like **POJO's** (Plain Old Java Objects) you may want to avoid arrays and instead use lists, maps, or sets.

Algorithmic Complexity

- Many different solutions to solve problem
- Sometimes need an efficient solution
  - Scalability – works well for large data set (what we will focus on)
  - Memory needed
- Correctness has to do with whether method solved problem
- Efficiency has to do with how method is defined
- Measure algorithm speed in terms of number of operations performed relative to input size.
- Want to know the worse possible amount of time it could take
  - Big O notation – Big Omicron – Worst case
  - Discussed in terms of input size of N

Execution-time requirements

- How long will it take to run?

```
public boolean isLastElementEven(int[] array){
        return array[length – 1] % 2 == 0;
}
```

- What if array is 1 element long?
- 100? 1000?
- O (1)

Execution-time requirements

- How long will it take to run?

```
public boolean doesArrayContain10(int[] array){
        boolean hasATen = false;
        for(int I = 0; I < array.length; i++) {
            if (array[i] == 10){
                hasATen = true;
            }
        }
        return hasATen;
}
```

- O (n)
- Worst case is we search every element and cannot find a 10

Execution-time requirements

- How long will it take to run?

```
public boolean doesArrayContainDuplicates(int[] array){
        boolean hasDuplicate = false;
        for(int i = 0; i < array.length; i++) {
            for (int j = 0; i < array.length; j++){
                if (i == j) {
                        continue;
                }
                if (array[i] == array[j]){
                  hasDuplicate = true;
                }
        }
        return hasDuplicate;
}
```

- O (n^2)
- Worst case is we compare each element and there are no duplicates
- Nested loops are always O(n^2)

Real world examples of Complexity

- O(1) - determining if a number is odd or even
- O(log N) - finding a word in the dictionary (using binary search)
- O(N) - reading a book
- O(N log N) - sorting a deck of playing cards (using merge sort)
- O(N^2) - checking if you have everything on your shopping list in your trolley
- O(infinity) - tossing a coin until it lands on heads
-
- O(10^N): trying to break a password by testing every possible combination (assuming numerical password of length N)