Advanced Topics: Searching and Sorting

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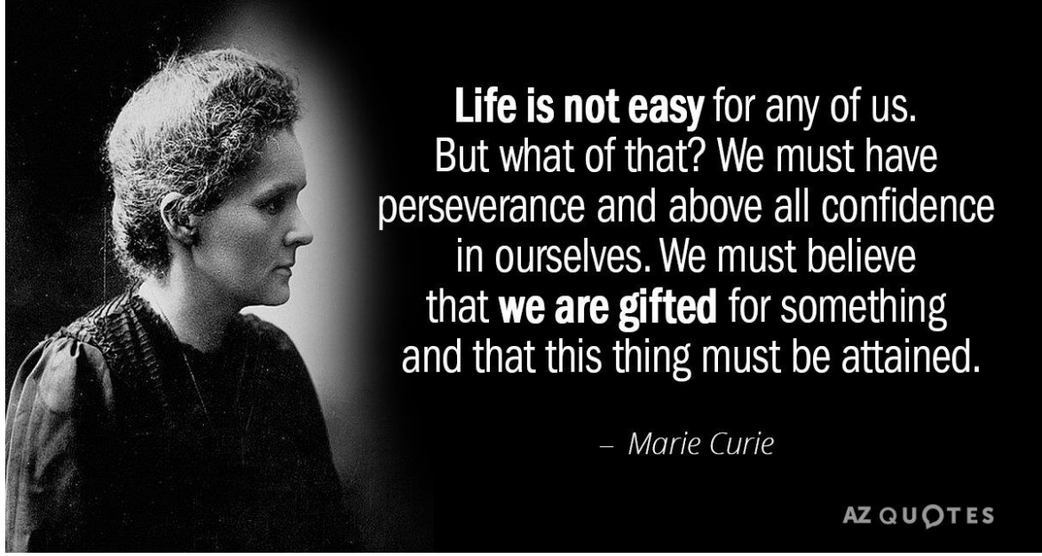
Announcements



TODO Reminders:

Readings are due **before** lecture

- Reading 25 (zybooks) – you should have already done that ☺
- Lab 16
- Reading 26 (zyBooks) you should have already done that ☺
- Lab 17
- RPA 12

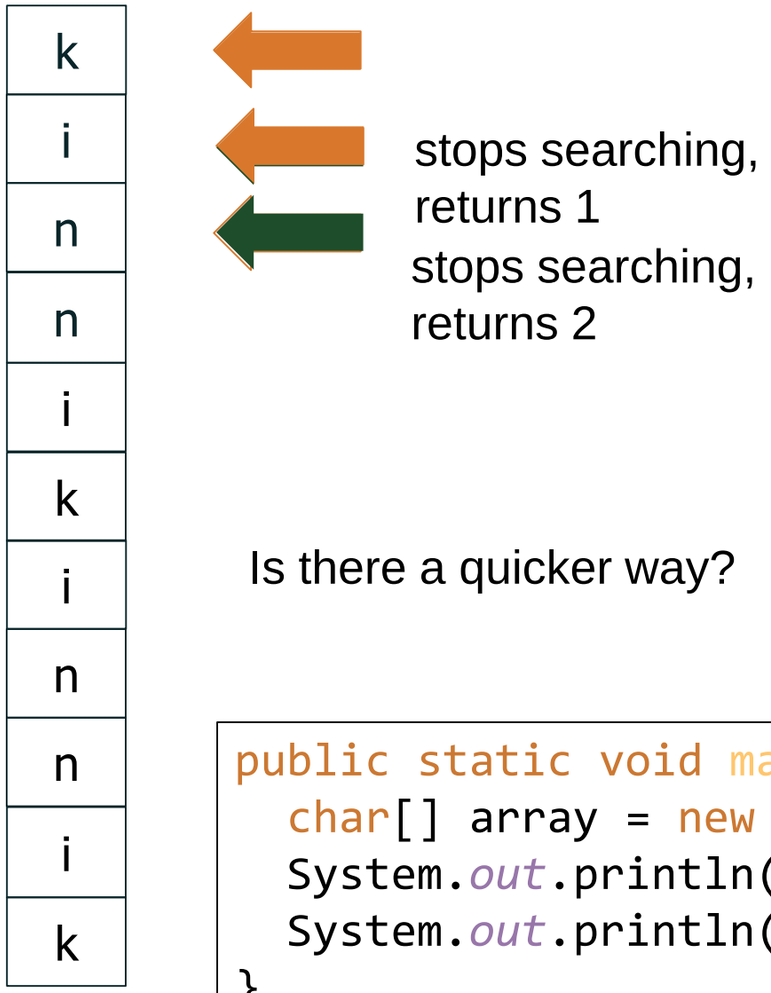
Keep practicing your RPAs in a spaced and mixed manner ☺

Help Desk

Day	Time : Room
Monday	12 PM - 2 PM : CSB 120
Tuesday	6 PM - 8 PM : Teams
Wednesday	3 PM - 5 PM : CSB 120
Thursday	6 PM - 8 PM : Teams
Friday	3 PM - 5 PM : CSB 120
Saturday	12 PM - 4 PM : Teams
Sunday	12 PM - 4 PM : Teams

Additional Reading: https://www.geeksforgeeks.org/linear-search/

Linear Search



stops searching, returns 1

stops searching, returns 2

Is there a quicker way?

- You have already done it!
- Searches an array
  - If item exits – return location
  - else return -1

```
public static int linearSearch(char key, char[] array) {
    for(int i = 0; i < array.length; i++) {
        if(key == array[i])  return i;
    }
    return -1;
}
```

```
public static void main(String[] args) {
  char[] array = new char[]{'k', 'i','n','n', 'i', 'k', 'i', 'n', 'n', 'i', 'k'};
  System.out.println(linearSearch('i',array));
  System.out.println(linearSearch('n',array));
}
```

Additional reading: https://www.geeksforgeeks.org/binary-search/

Binary Search

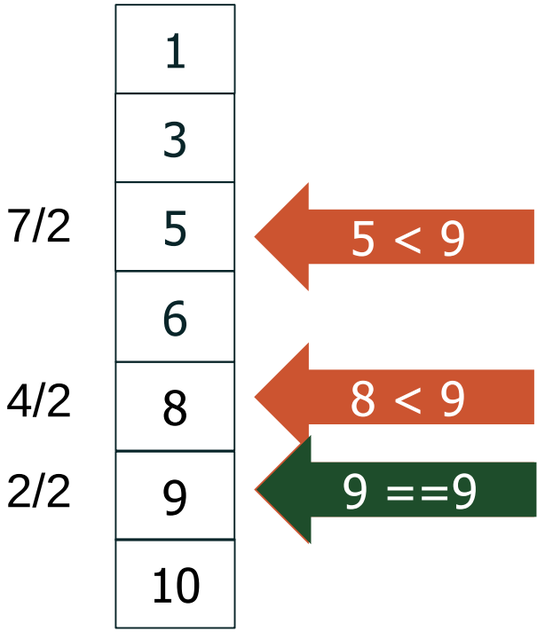
- Similar to guess number game
- I will choose a number between 0 and 100, with 0 and 100 included
- Now you try to guess, what is the number that I am thinking ☺
- What strategy you should use?

- Guess the middle number
- If it is the middle – you found!
- If the number is less than the middle – divide again in the middle but just for the first half part (0-49)
- If the number is greater than the middle – divide again in the middle but just for the second half part (51-100)
- Repeat the process until you find the number!

Additional reading: https://www.geeksforgeeks.org/binary-search/

Binary Search

- if the elements are **in order / sorted**
- why go in order?
  - start in the middle!
  - example: looking for 9



Very Fast – if Sorted!

We can quickly search by 'dividing' the array into two parts each time

We ask ourselves, is the key 'larger' or ‘smaller’ each time, until we find it!

Additional reading: https://www.geeksforgeeks.org/binary-search/

Binary Search

- Lets implement a recursive binary search!
- Our method will receive an ordered array of ints, a number that we are looking for, index for the beginning of the search, index for the end of the search
  - Method should return the index where that element is in our array
  - Or -1 if the number is not in our array
- We will need to adapt our strategy and transform it into a program ☺!

- Guess the middle number
- If it is the middle – you found!
- If the number is less than the middle – divide again in the middle but just for the first half part (0-49)
- If the number is greater than the middle – divide again in the middle but just for the second half part (51-100)
- Repeat the process until you find the number!

Additional Reading: https://www.geeksforgeeks.org/bubble-sort/

Bubble Sort (Sorting by Exchange)

Kenneth Inverson

- "Bubbles" up the largest numbers
- Takes the first number
  - if the next is less, swap it so the larger moves up
  - if the next is more, shift to that number, and continue
- Pass 1
  - the largest number ends up at the end
- Pass 2
  - the second largest number ends up at the end
- and so on

```
Look at 3   [3, 2, 1, 5, 8]
            [2, 3, 1, 5, 8]
            [2, 1, 3, 5, 8]
            [2, 1, 3, 5, 8]
            [2, 1, 3, 5, 8]
Start again [2, 1, 3, 5, 8]
            [1, 2, 3, 5, 8]
```

Should never use Bubble Sort

Additional Reading: https://www.geeksforgeeks.org/bubble-sort/

Bubble Sort (Sorting by Exchange)

Kenneth Inverson

- https://visualgo.net/en/sorting
- Now let's implement the Bubble Sort!

Additional Reading: https://www.geeksforgeeks.org/selection-sort/

Selection Sort

- Searches array for **lowest** value
- Moves that to the start index
  - repeats
  - incrementing index

https://visualgo.net/en/sorting

Let's implement the selection sort!

```
[3, 2, 1, 5, 8]
[1, 2, 3, 5, 8]
```

Then checks 2-8

Example 2:

```
[3, 5, 1, 9, 8]
[1, 5, 3, 9, 8]
[1, 3, 5, 9, 8]
[1, 3, 5, 8, 9]
[1, 3, 5, 8, 9]
```

The Big-O

- Both selection and bubble sort
  - 10 elements, it can look at all 10 ten times!
  - N elements N times
    - We call this - $O(n^2)$
- Linear Search
  - we only look at <u>each</u> element once
    - we call this O(n)
- Binary Search
  - we only look at reducing halves of elements
    - we call this O(log n)
- You will learn this more later in 165, 220 and 270
  - Why? Knowing the most efficient algorithm for different situations matter
  - CS 320 really dives into how to speed up programs by knowing algorithms

Practice - Attendance

- Given the following list write each ‘step’ (array) of the bubble sort

```
[3, 2, 5, 1, 8]
```

Practice - Attendance

- Given the following list write each ‘step’ (array) of the bubble sort

```
[3, 2, 5, 1, 8]
```

```
[2, 3, 5, 1, 8]
[2, 3, 1, 5, 8]
[2, 1, 3, 5, 8]
[1, 2, 3, 5, 8]
```