CSE373: Data Structures & Algorithms
Lecture 25: Problem Solving

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Tools at our Disposal

Over the past 8 weeks we have developed a broad knowledge of data structures and algorithms (I hope):

- Stacks and Queues
  - Various implementation (Stack/List)
- Trees
  - Balanced (AVL), BST
- Graphs
  - Directed/Undirected, Acyclic/Cyclic, Weighted
  - Dijkstra's, BFS, DFS
  - Topological Sort
- PriorityQueues
  - BinaryHeap
- Dictionaries
  - HashMap, TreeMap
- Union Find
  - Uptrees

Everything is a Trade-off

- Very rarely is there a "perfect" solution in the real world.
  - Often must prioritize things like:
    - space vs. time
    - simplicity vs. robustness

- Understanding the ins and outs of each structure allows you to make informed design decisions that balance these trade-offs.

Reinventing the Wheel

- More often than not, the problem you are trying to solve is not entirely unique
  - Usually it is possible to simplify a problem down to a few core principles
    - Important operations
    - Space/time constraints
- Once you have found an appropriate analog, allow the well-thought out design to assist you
  - Example: AVL trees handle balancing for you
  - Example: Hash tables will handle collisions for you

Don’t let the Abstract rule you!

- In this class, we have lived and died by the asymptotic runtime, however this is not always the case
  - Sometimes simple and readable code is more important
  - Sometimes you know very distinct things about your input
    - Sorting input that is almost entirely sorted
    - Dictionary of elements that have nearly identical keys

Question 1:

```
Given a value ‘x’ and an array of integers,
determine whether two of the numbers add up to ‘x’:
```

Questions you should have asked me:

1) Is the array in any particular order?
2) Should I consider the case where adding two large numbers could cause an overflow?
3) Is space a factor, in other words, can I use an additional structure(s)?
4) Is this method going to be called frequently with different/the same value of ‘x’?
5) About how many values should I expect to see in the array, or is that unspecified?
6) Will ‘x’ always be a positive value?
7) Can I assume the array won’t always be empty, what if its null?

Why these questions matter!

1) Is the array in any particular order?

If the array is already sorted, then this question becomes a lot easier, and can be done in O(n) time.

2) Should I consider the case where adding two large numbers could cause an overflow?

If the integers are very large, I should use something other than 'ints' to store my results, such as double or longs, or else I could get inconsistent results.

3) Is space a factor, in other words, can I use an additional structure(s)?

If space is not a factor, then it might be better to leave the original array alone, and instead sort the array in a separate structure. Or even use a BST representation.

Why these questions matter!

1) Is this method going to be called frequently with different/the same value of 'x'?

This is a *great* question. If the client will be calling this frequently, it might make more sense to store a copy of the sorted array to prevent needing to re-sort it every time. This could drastically speed-up frequent calls. This process is called **memoization.**

2) About how many values should I expect to see in the array, or is that unspecified?

Often times, it is safe to assume that there could be any range of values (or in our case, asymptotically very many). However, this is not always the case. Our solution to this problem may be different if we knew that there were always exactly 12 values in our array.

Question 1.5

Given an array of integers, return a new array of the same values without any duplicates

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```
create set, s
for each value, x in input_array:
    add x to s
create new array, result
for each value, x in s:
    add x to result
return result
```

Question 2:

Given an array that contains the values 1 through ‘n’ two times each, find the one number that is contained only 1 time.

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```
create map from strings->ints, map
for each value, x in input_array:
    if !map.contains(x):
        map.put(x, 0)
    map.put(x, map.get(x) + 1)

for each key in map, key:
   if map.get(key) == 1:
       return key
```

Question 3:

Given a list of integers, find the highest value obtainable by concatenating them together.

For example: given [9, 918, 917], result = 9918917

For example: given [1, 112, 113], result = 1131121

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-Convert all numbers to strings
-Sort numbers based on largest first number, break ties by moving on to next digit if its greater than the previous

Question 4:

Given a very large file of integers (more than you can store in memory), return a list of the largest 100 numbers in the file

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```
Create min-heap, h
Add first 100 values to h
while there are remaining numbers:
    x = next number
    if x > h.getMin():
        h.deleteMin()
        h.add(x)

create new list, l
while h.isEmpty():
    l.add(h.deleteMin())
return l
```

Question 5

Given an unsorted array of values, find the 2nd biggest value in the array.

(Harder alternative)

Find the k'th biggest value in the array

Question 5

Given an unsorted array of values, find the 2nd biggest value in the array.

```
sort input_array
return input_array[len - 2]
```

```
max = -infinity
2nd_max = -infinity
for each value, v in input_array:
    if v > max:
        2nd_max = max
        max = v
return 2nd_max
```

```
max-heap h = heapify(input_array)
h.removeMax()
Return h.removeMax()
```

Question 6

Given a list of strings, write a method that returns the frequency of the word with the highest frequency.

(Harder version)

Given a list of strings, write a method that returns a sorted list of words based on frequency

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Given a list of strings, write a method that returns the frequency of the word with the highest frequency.

```
max = 0
map from string->int, map
for each string, s:
    if !map.contains(s):
        map.put(s,0)
    map.put(s, map.get(s) + 1)
    if map.get(s) > max:
        max = 0
```

Question 7:

Given an array of strings that are each sorted lexicographically, determine the order of characters in the given alphabet.
For example, given the english alphabet, the ordering is: “a,b,c,d,e,f . . . x,y,x”.

Your output should be the lexicographic order of only the characters that were found in the input strings.

For example: input = [xyz, yk, zk, xm, my], then the output would be [x,m,y,z,k]