CIS 121—Data Structures and Algorithms with Java - Fall 2015

Introduction Lab — Monday, August 31/Tuesday, September 1

Learning Goals

During this lab, you will:

- approach problems with consideration for runtime complexity
- apply sorting as a tool for solving some real problems
- consider tradeoffs between different solutions to problems
- get a feel for the sort of problem solving that this course will focus on

Problem 0: General Approaches

When faced with these sorts of algorithmic problems, there are some general considerations to take:

- Is there a known algorithm that solves this problem, or a related problem?
- Which kinds of data structures fit the operations we need to do?
- Do we have bounds on our input or on our runtime requirement?
- Does the problem give us additional information that might help us do better?
- Ignoring efficiency considerations, what is the very first working solution you can come up with?

Problem 1: Unique Character Strings

Given a string of length n, determine whether it contains all unique characters – or, whether any characters are used more than once.

Food for Thought:

- If you do it as fast as possible, how much extra space is needed?
- If you do it with no extra space, how quickly can you do it?
- What if you aren't worried about destroying the input string?

Problem 2: Anagram Strings

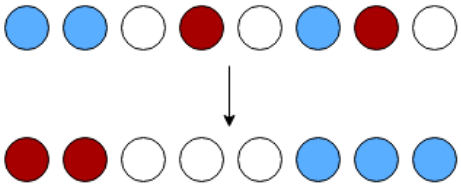
Given two strings, determine whether they are anagrams of each other.

Example:
`TOMMARVOLORIDDLE` $\longleftrightarrow$ `IAMLORDVOLDEMORT`
The above are anagrams of each other!
(Sorry if we spoiled book 2 of Harry Potter for you...)

- If you do it as fast possible, how much extra space is needed?
- If you do it with no extra space, how quickly can you do it?
- What if you aren't worried about destroying the input strings?

Problem 3: Dutch National Flag Problem

Given n balls of three colors – say red, white, and blue – arranged randomly in a line, sort them as quickly as possible into contiguous groups of red, white, and blue, with the groups in that order.



- How fast can generic sorts do this?
- What additional information do we have, beyond what generic sorts assume?
- Can we sort it in-place in $O(n)$ time?

Problem 4: Row/Column-sorted Matrix Membership

Given an m by n matrix of integers, where each row and each column of the matrix is sorted, determine whether an integer k exists somewhere in the matrix.

- How could we do this if we didn't know the rows and columns were sorted?
- How does knowing the rows and columns are sorted let us do this faster?
- What is our optimal runtime?