Spring 2023 COP 4516 Individual Final Contest Summary (by Arup Guha)

The first part of the summary will be a problem by problem analysis of how teams did in the contest and some observations about the problems. The second part will be an analysis of the teams and how they did. Here is the first, by problem:

Problem A: Anya's Bracelets
Solved by: 50 out of 52 students
First Solve: 3 minutes (Kieran Toner)

This was definitely the easiest problem in the set. It probably helped a bit that it also happened to be the first one in printed set. Simply simulating the process of pressing a button is fast enough, because with exponential growth, Anya will never have to press the button more than 29 times.

Problem B: Confused Village
Solved by: 23 out of 52 students
First Solve: 23 minutes (Umran Jameel)

In the judges estimation, this was the third easiest problem in the set and it turned out that way in the end, though in the beginning of contest, more students solved this problem than Longest Upwards. This problem was testing the use of built in data structures, specifically an ordered map. (In Python, a heapq can be used while keeping track of each villager's health in parallel.) The reason a map is useful is because the structure should be ordered by health, but then given a villager's health, we need access to their index (order in input). Since no two villagers will ever have the same health at the same time, we guarantee that the keys in the map are unique. Judging by the solve times, it seems that several students in the class are very comfortable with the built in data structures and these students fairly quickly solved this problem correctly. After the first hour though, far fewer correct submissions were made in the second hour, and each student who got this problem in the second or third hour needed multiple submissions. Some of the incorrect submissions were $O(n^2)$ algorithms that exceeded the time limit.

Problem C: Lior's Dictionary
Solved by: 2 out of 52 students
First Solve: 133 minutes (Quinn Barber)

This was the hardest problem in the set, but perhaps not by much as there was only one fewer solve on this problem than Uber Driver. The initial judge's solution uses a Trie to store Lior's Dictionary and then a recursive function to solve each query. This was the solution submitted by both Quinn and Garrett. However, since only deletions are allowed from the query word, a greedy algorithm can be used to match a query word with a dictionary word: Go left to right with pointers (indexes) into both strings. If the two letters match, update both pointers. If the two letters don't match, that means you have a forced deletion from the query string, add one to the number of deletions and advance that pointer. If you can sweep through both words with 5 or fewer deletions, then that dictionary word should be counted.

Problem D: Uber Driver
Solved by: 3 out of 52 students
First Solve: 69 minutes (Quinn Barber)

All students who solved this problem correctly needed more than 1 submission. It seems that one of the common errors students made on this problem is not using long (Java)/long long (C++). Since each edge can have a weight of upto 10^9, and a single shortest path could be as many as 199 edges, it's possible that an answer to a query could be close to 9 x 199 x 10^9 (because we make a maximum of 9 "trips" and each trip could take us through close to 199 edges.) Even if students are using longs, if students use a large sentinel value to indicate no path between vertices, this sentinel value has to be larger than the number above. (In one judge solution it was 10^{15}.) It seems that quite a few students did correctly identify that Floyd-Warshall's was the intended algorithm to use, since the shortest distance between any pair of points needed to be accessed many times. Alternatively, running Dijkstra's once from every vertex to pre-compute these answers would have been fine. Running Dijkstra's for every query would get a time limit exceeded verdict, since there are so many queries and each query could have up to 9 shortest distance calculations.

Problem E: Longest Upwards

Solved by: 29 out of 52 sudents
First Solve: 25 minutes (Josh Balila)

This problem, as previously mentioned, was the second easiest, in the judge's estimation. At first, Confused Villagers had more solved, but as time wore on, more students were solving this one as their second problem. Quite a few students needed more than one submission to solve it. A straight brute force times out, but realizing that no substring can be greater than length 26 allows a brute force solution to work. (Loop through each length of substring from 26 down to 1. For each length, k, try each of the n – k + 1 possible substrings. If anyone is an upwards, store it and simply get the alphabetically first one and break out after at least one string of a particular length is found.) Alternatively, it can be noticed that any string can be subdivided into separate upwards, so one loop through the data will also suffice.

Contest Summary

The contest started out quickly, with many students realizing that Anya's Bracelets was the easiest problem. In fact, 18 students solve this problem within the first 10 minutes of the contest. In fact, no correct submissions would come in for a different problem until 20 minutes after the first correct submission on Bracelets when Umran Jameel submitted a correct solution to Confused Village. This was followed very quickly by a correct submission on Longest Upwards, by Josh Balila. Once those two problems were exposed, in fairly quick succession, several students started getting correct submissions to both of those problem. At the 47 minute mark, Quinn Barber became the first person with three correct solutions to the problems, solving Longest Upwards. He had submitted his correct solution to Confused Village 12 minutes earlier. He was soon followed by Garrett Spears and Josh Balila who got their third problem at the 51 minute and 55 minute marks, respectively.

At the one hour mark, 3 students had 3 questions, and another 9 students had 2 questions and another 36 students had 1 question. Just a few minutes after the one hour mark, at 1:09, Quinn Barber solved Uber, to be the first student to get to four problems. It is very likely the set will get solved, and solved quite early. As the second hour progressed, more students moved from 1 to 2 problems and around the midway point at the 1:26, on his fourth submission for Uber, Garrett spears got to 4 questions, and at the 1:50 mark, Josh Balila solved Uber as well, on his fourth submission.

At the end of the two hour mark, 3 students had four problems, with Lior's Dictionary left to solve. Another eight students had gotten to three problems, 16 students had solved 2 problems and nearly all of the remaining students had solved 1 problem. Of the students with 1 or 2 problems, a majority of the incorrect submissions had been made on both Confused Villagers and Longest Upwards.

At the 2:13 mark, Quinn Barber solved Lior's Dictionary, sealing the win. Amazingly enough, only one minute later, Garrett Spears also solved Lior's Dictionary, claiming second place. He was 71 penalty points behind Quinn, most of which could be attributed to his three incorrect submissions on Uber.

Another milestone was reached at the 2:27 mark as at that point in time, every student had solved at least one problem! With about 30 minutes left in the contest, 2 students had solved the set, only 1 student was a t four problems, 12 students were at three problems, 16 students were at 2 problems and 21 students were at 1 problem. As predicted by the judges, it's likely the contest will end with at least one student solving exactly 1, 2, 3, 4 and 5 problems, showing that the set did a good job of differentiating the students. As sort of a neat note, the student who made the first correct submission at 2:27 mark got her second correct problem at the 2:39 mark as the number of students with 2 correct submissions increased to 19. At the 2:54 mark another student solved their second problem to push the number of students with 2 correct submissions to 20. And with less than one minute left, Weiyuan Wu correctly solved Longest Upwards to be the last correct submission of the contest, pushing the number of students with 2 correct submission to 21.