

**CS – 499 Capstone: Milestone Three**

**Enhancement Two: Data Structures & Algorithms**

Milton Francisco

Southern New Hampshire University

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**Briefly describe the artifact. What is it? When was it created?**

This artifact's purpose was to read and store data from a CSV file into a data structure. Additionally, the data was required to be sorted and was originally held in a vector. The data consisted of various college courses, including the course number, course title, and any associated prerequisites. This artifact was created as a final project for CS300: Data Structures & Algorithms, completed in the spring of 2024.

**Justify the inclusion of the artifact in your ePortfolio. Why did you select this item?**

**What specific components of the artifact showcase your skills and abilities in software development? How was the artifact improved?**

I selected this item to learn about more advanced data structures that were only lightly mentioned during previous courses. Additionally, this artifact most aligned with the desired course requirements. This artifact demonstrates multiple skills as the code has been refactored from C++ to Python, the major data structure has been changed, and the flow of the program has shifted, while still maintaining most of the original requirements. The original requirements stated that the data shall be sorted, any prerequisites listed shall have a corresponding course, and the data structure shall be a Vector, HashMap, or Binary Search Tree (BST).

In my original project, I liked the idea of using a BST, but I quickly realized that if the dataset is already sorted this results in an unbalanced tree. Since the implementations were restricted to the three structures listed above, I argued for the vector. For this enhancement, the requirements were less restrictive, and I realized I could implement an AVL tree to overcome the inefficiencies of a BST.

The artifact has improved in one way by shifting the language from C++ to Python. This allows operations to occur more easily and is shown with built-in functions like set comprehension and dictionary iteration. Additionally, the inclusion of the csv library allows the verification and loading of a file to occur in a simpler manner. The final improvement is

in the time complexity of the new data structure. Previously, the time complexity for the vector required  $O(n)$  time to search and  $O(n \log n)$  time to sort. With the new AVL tree, this time complexity has been reduced to  $O(\log n)$  for searches, and removes the sorting requirement, as the data is stored sorted. This does have an overhead when a rebalance is required in some scenarios, but the worst-case scenario matches the previous vector implementation. As with everything in computer science, there are trade-offs, this enhancement uses slightly higher space to achieve better time complexity, but this is mitigated by the improved file verification aspect. Finally, the overall purpose of the program is to search for college courses and these enhancements further that purpose.

**Did you meet the course outcomes you planned to meet with this enhancement in Module One? Do you have any updates to your outcome-coverage plans?**

The course outcomes I planned were fulfilled with this enhancement. My goal was to demonstrate proficiency in the following outcomes:

The 3<sup>rd</sup> outcome, *(Design and evaluate computing solutions that solve a given problem using algorithmic principles and computer science practices and standards appropriate to its solution, while managing the trade-offs involved in design choices (data structures and algorithms))*, is shown by evaluating the trade-offs between time and space complexity, along with implementing a more efficient solution that can be scaled more effectively than the original.

The 4<sup>th</sup> outcome, *(Demonstrate an ability to use well-founded and innovative techniques, skills, and tools in computing practices for the purpose of implementing computer solutions that deliver value and accomplish industry-specific goals (software engineering/design/database))*, is shown by understanding and successfully implementing an AVL tree during a code refactoring from C++ to Python.

Finally, the 2<sup>nd</sup> outcome, *(Design, develop, and deliver professional-quality oral, written, and visual communications that are coherent, technically sound, and*

*appropriately adapted to specific audiences and contexts*), is furthered with this enhancement narrative. These narratives demonstrate my ability to present and highlight my enhancements, as well as the reasons for my decisions.

**Reflect on the process of enhancing and modifying the artifact. What did you learn as you were creating it and improving it? What challenges did you face?**

I learned a ton about AVL trees and trees in general. During previous courses, I wished I had more time to dive in and fully understand what was happening. During this enhancement, I was able to fully understand what is happening in each section and I looked at it like a logic puzzle, which I love. Additionally, I learned more about the rich features of Python, like the built-in functions I previously mentioned. These functions, coupled with default class functions were a great refresher and helped improve my proficiency in this language. I have not developed many programs in Python during course work, and I could not fully utilize the features it contains during other courses. Finally, this was a great opportunity to review Big-O notation and review time and space complexity in preparation for job interviews.

During this enhancement, the largest challenge I faced was fully understanding the rotations that occur when the tree is out of balance. To aid this, I used a physical whiteboard to track the positions of the nodes during rotations. This allowed me to have a breakthrough in understanding when I realized that for the slightly more complex cases, like Right-Left and Left-Right, it essentially changes the case to a simpler Right-Right or Left-Left case, before performing the additional rotation. This helped my understanding, as the Right-Right and Left-Left case were intuitive to me upon the first encounter. Other aspects included perusing official documentation to identify the various capabilities that are allowed in Python, but this was more time spent researching than a challenge. Finally, the last challenge I faced was in the file verification function. It felt inefficient in the initial artifact, so improving this to use a dictionary and a set for missing prerequisites improved the programs readability and efficiency.

## Enhancement Pictures

### Display All Courses:

```
PS C:\Users\mjfra\Documents\My Stuff\School Stuff\Classes\CS-499 Capstone\Week 4\Enhancement 2> python course_planner.py
*****
* Advising Assistance Program *
*****

Please enter the file name that contains the course data (or type 'exit' to exit): courses.csv
Loading courses...

Welcome to the course planner.

Main Menu:
  1. Print Course List
  2. Find Specific Course Details
  9. Exit

What would you like to do? 1

Course List:
AI520 - Introduction to Artificial Intelligence
AI521 - Neural Networks
ARTS101 - Fundamentals of Art
ARTS290 - Introduction to Painting
ARTS291 - Digital Art
BIOL130 - Introduction to Biology
BIOL230 - Cell Biology
BIOL640 - Advanced Genetics
BIOT410 - Biotechnology Fundamentals
BIOT411 - Genetic Engineering
BUSN101 - Introduction to Business
BUSN330 - Principles of Marketing
BUSN331 - Organizational Behavior
BUSN332 - Financial Accounting
BUSN333 - Managerial Accounting
CHEM110 - General Chemistry I
CHEM220 - Organic Chemistry
CHEM221 - General Chemistry II
CHEM670 - Physical Chemistry
COMP280 - Software Testing
COMP281 - User Interface Design
COMP282 - Machine Learning
COMP283 - Data Visualization
```

## Find Course:

```
PS C:\Users\mjfra\Documents\My Stuff\School Stuff\Classes\CS-499 Capstone\Week 4\Enhancement 2> python course_planner.py
*****
* Advising Assistance Program *
*****

Please enter the file name that contains the course data (or type 'exit' to exit): courses.csv
Loading courses...

Welcome to the course planner.

Main Menu:
  1. Print Course List
  2. Find Specific Course Details
  9. Exit

What would you like to do? 2
What course do you want to know about? csci108

Course Details:
CSCI108 - Networks and Communications
Prerequisites: CSCI107

Press Enter to continue...|
```

**Hidden Option to View Tree Structure:** (This method helped me ensure the tree populated correctly)

```
PS C:\Users\mjfra\Documents\My Stuff\School Stuff\Classes\CS-499 Capstone\Week 4\Enhancement 2> python course_planner.py
*****
* Advising Assistance Program *
*****

Please enter the file name that contains the course data (or type 'exit' to exit): courses.csv
Loading courses...

Welcome to the course planner.

Main Menu:
  1. Print Course List
  2. Find Specific Course Details
  9. Exit

What would you like to do? 3

                                THERM352 (H=1)
                                SUST600 (H=2)
                                STAT401 (H=1)
                                STAT400 (H=3)
                                SOFT591 (H=1)
                                SOFT590 (H=4)
                                SOCL391 (H=1)
                                SOCL390 (H=2)
                                SOCL101 (H=1)
                                ROBO622 (H=3)
                                ROBO421 (H=1)
                                ROBO420 (H=2)
                                PSYC381 (H=1)
                                PSYC380 (H=5)
                                PSYC260 (H=1)
                                PSYC101 (H=2)
                                POLI370 (H=1)
                                PHYS650 (H=3)
                                PHYS211 (H=1)
                                PHYS210 (H=2)
                                PHIL311 (H=1)
                                PHIL310 (H=4)
                                PHIL101 (H=1)
                                NURS371 (H=2)
                                NURS370 (H=1)
```

Ensure file is formatted correctly:

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS COMMENTS python3.13 + v [ ] [ ] ... ^ X

PS C:\Users\mjfra\Documents\My Stuff\School Stuff\Classes\CS-499 Capstone\Week 4\Enhancement 2> python course\_planner.py

\*\*\*\*\*

\* Advising Assistance Program \*

\*\*\*\*\*

Please enter the file name that contains the course data (or type 'exit' to exit): prereq\_fail.csv

Loading courses...

Missing prerequisite(s): CSCI199, MATH200

Improper file format: Some prerequisites do not have a corresponding course in the file.

Please try again or type 'exit' to quit.

Please enter the file name that contains the course data (or type 'exit' to exit):