Development of a Software Application for a Tool Library

Project Report

N10496262 – Don Misura Minduwara Kaluarachchi

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Introduction

This report is a description of the algorithms used and their analysis while implementing a tool library system. The report also contains a software test plan that was used to test the functionality of the tool library.

The tool library consisted of 5 interfaces which were used to implement their own classes, this along with the main method made up the skeleton classes for the program.

Due to the development environment being macOS there were initial difficulties in getting the interfaces to implement the classes as displayed on tutorial 7. This was eventually overcome. The constraints of not being able to modify the interface nor being able to add any external public classes made the project more time consuming. The project was done according to the specifications required. Minimal to no changes were done to the provided interfaces.

Design and Analysis of algorithm

In this unit 3 basic sorting algorithms were introduced these are Insertion sort, Selection sort, Bubble sort. Along with 3 advanced sorting algorithms such as Merge sort, Quick sort, Heap sort.

The basic idea of these sorting algorithms is that they are comparison based and arrange items in a given order. For this project the insertion sort, bubble sort or selection sort were considered. Selection sort was a possible choice as the time complexity could be taken from T(n^2) to T(3n). Discussion with other peers on slack and during class bubble sort was brought up as a plausible choice as well as it is a simple sorting algorithm and if best case scenario was considered it had a O(N).

Finally, the choice was made to use the insertion sort. Insertion sort has less swaps than the bubble sort, it is a stable sort and is faster than some of the other O(n^2) sort algorithms and could be easily computed.

1. Pseudocode

```
InsertionSort (Arr, N) // Arr is an array of size N.
{
    For ( I:= 2 to N ) // N elements => (N-1) pass
    {
    // Pass 1 is trivially sorted, hence not considered
    // Subarray { Arr[1], Arr[2], ..., Arr[I-I] } is already sorted

        insert_at = I; // Find suitable position insert_at, for Arr[I]
        // Move subarray Arr [ insert_at: I-1 ] to one position right

        item = Arr[I]; J=I-1;
        While ( J ? 1 && item < Arr[J] )
        {
                Arr[J+1] = Arr[J]; // Move to right
                // insert_at = J;
                J--;
            }
            insert_at = J+1; // Insert at proper position
            Arr[insert_at] = item; // Arr[J+1] = item;
        }
    }
}
```

Given above is the pseudocode for the insertion sort taken from an external source cited in appendix A.

2. Complexity Analysis – mathematical

The algorithms efficiency can be analysed. This is provided in the lecture slides and a snippet of it is attached below.

By analysing the algorithm's efficiency, with respect to the length n of the array and the number of comparisons '$A[j] > v$' performed, we found:

$$C_{worst}(n) = \sum_{i=1}^{n-1} \sum_{j=0}^{i-1} 1 = \sum_{i=1}^{n-1} i = \frac{(n-1)n}{2} \in O(n^2)$$

3. Empirical Analysis – time/basic analysis

An empirical analysis can be done by running a stopwatch with random data and calculating the time it takes for the sort to be finalised.

4. Big O Calculation and Justification

The insertion sort had a,
Best Case: sorted array as input, O(N).
While the worst case was: reversly sorted and was O(N^2).
On average sort it had: $O(N^2)$.

Software Test plans and Results

This portion of the report includes screenshot of test cases of the functionality as required by the criteria and specifications sheets. The software test plan is broken down into sections as seen by the menus and listed in order of the functionality given in the specifications document.

Tool Library Main Menu

Screenshot provided is of the main menu when the console application is run. The user is prompted to type in the input.
If zero is pressed the environment is exited and the program will be terminated.

```
Welcome to the Tool Library
==========Main Menu==========
1. Staff Login
2. Member Login
0. Exit
=============================

Please make a selection (1-2, or 0 to exit)
```

Staff Login

If the selection made by the user is correct and in this case is "1" it will bring up the menu for the staff to login with the given credentials as shown below. The staff account will go back to the main menu if credentials incorrect and ask to re-enter login details.

```
Please make a selection (1-2, or 0 to exit)
1
Enter staff login username
staff
Enter staff login password
today123
```

Staff Menu Functionality

Once the staff has logged in using their credentials, they will be brought to the staff menu shown below. Staff can then proceed to do any of the actions in the menu. Screenshots will be provided for each of these actions below.

```
Welcome to the Tool Library
===============Staff Menu===============
1. Add a new tool
2. Add new pieces of an existing tool
3. Remove some pieces of a tool
4. Register a new member
5. Remove a member
6. Find the contact number of a member
0. Return to main menu
=============================

Please make a selection (1-6, or 0 to return to main menu)
```

1. Add a new tool

This can be used to add a new tool depending on the tool type and category the user selects. In this case gardening tool and line trimmer is selected and a tool with the name below is added.

```
==========Add New Tool==========
1. Gardening Tool
2. Flooring tools
3. Fencing tools
4. Measuring tools
5. Cleaning tools
6. Painting tools
7. Electronic tools
8. Electricity tools
9. Automotive tools
0. Return to staff menu
================================

Please make a selection (1-9, or 0 to return to staff menu):

================================================================================
   Tool Name               Quantity           Available Quantity  No. of Borrowings
================================================================================
1. Gardening_Line_Trimmer1  1                  1                   0
```

2. Add new pieces of an existing tool

This is to add more pieces to an existing tool. For example, we can increase the quantity of the Gardening_Line_Trimmer1.

```
Please make a selection (or 0 to return to staff menu):
1

Enter the quantity:
2

================================================================================
   Tool Name               Quantity           Available Quantity  No. of Borrowings
================================================================================
1. Gardening_Line_Trimmer1  3                  3                   0
```

3. Remove some pieces of a tool

Here the added pieces of the tool can be removed. The final number of tools remaining can be seen.

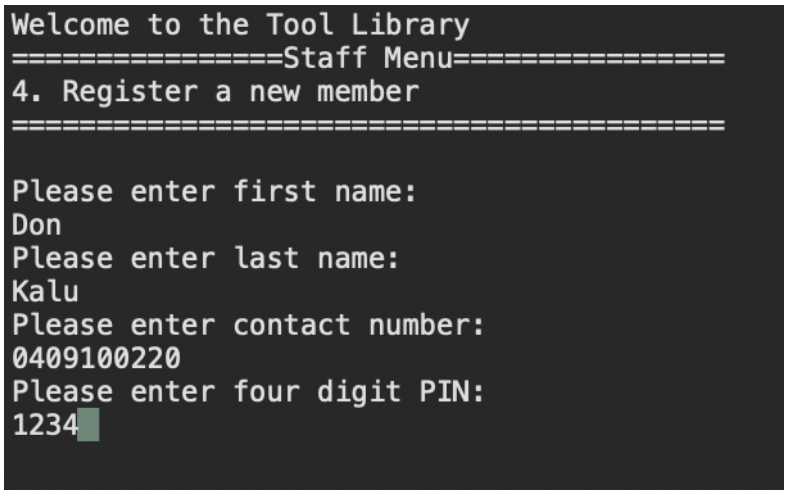
```
================================================================================
   Tool Name               Quantity           Available Quantity  No. of Borrowings
================================================================================
1. Gardening_Line_Trimmer1  3                  3                   0
Please make a selection (or 0 to return to staff menu):
1

Enter the quantity:
1

================================================================================
   Tool Name               Quantity           Available Quantity  No. of Borrowings
================================================================================
1. Gardening_Line_Trimmer1  2                  2                   0
```

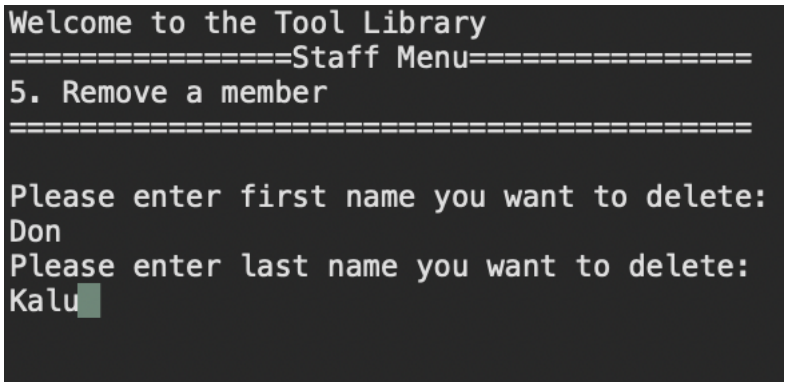
4. Register a new member

This is a staff functionality that can be used to add new members. Staff can add the details of the member and register them onto the system. These will be used later on in the member login. The username is generated as a concatenated string of first and last name.



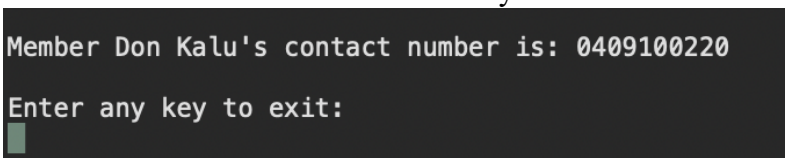
5. Remove a member

This is a staff functionality that can be used to remove members from the tool library system by typing in their first and last name.



6. Find the contact number of a member

This is the last of the staff functionality. The staff member can type in the



0. Return to main menu

This is the last option of the switch case that takes the staff to the main menu

Member Login

The second option from the main menu is the member login. This can be accessed once a member has been added onto the system by a staff member. Once the member has been added they can login from the main menu using their credentials as shown below.

```
Please make a selection (1-2, or 0 to exit)
2
Please enter your username
DonKalu
Please enter your PIN
1234
```

Member Menu Functionality

Once a member has successfully logged in, they can choose to do any of the five functionalities shown below.

```
Welcome to the Tool Library
===============Member Menu================
1. Display all the tools of a tool type
2. Borrow a tool
3. Return a tool
4. List all the tools I am renting
5. Display top three (3) most frequenlty rented tools
0. Return to main menu
==============================

Please make a selection (1-5, or 0 to return to main menu)
```

1. Display all the tools of a tool type

The first option is to display all the tool categories and tool types in the tool library system. AS shown below depending on the selection of the user the subcategories can be seen. In this screenshot the user input was the gardening tools.

```
Please make a selection (1-5, or 0 to return to main menu): 1

Select a category:
        1. Gardening Tools
        2. Flooring Tools
        3. Fencing Tools
        4. Measuring Tools
        5. Cleaning Tools
        6. Painting Tools
        7. Electronic Tools
        8. Elecricity Tools
        9. Automotive Tools
Enter the number corresponding to the category:

Select a sub-category:
        1. Line Trimmers
        2. Lawn Mowers
        3. Hand Tools
        4. Wheelbarrows
        5. Garden Power Tools
Enter the number corresponding to the category: 1
```

If a tool has been added already it can be seen in here. If we recall from the staff functionality, we added the “Gardening_Line_Trimmer1” this can be seen below in the display tool functionality.

```
        1. Name: Gardening_Line_Trimmer1, Available Quantity: 3

Welcome to the Tool Library
```

2. Borrow a tool

This functionality is for a member to borrow a tool from the tool library that has already been registered.

As shown below you can navigate to the necessary tool and select what you want to borrow

```
Select a category:
        1. Gardening Tools
        2. Flooring Tools
        3. Fencing Tools
        4. Measuring Tools
        5. Cleaning Tools
        6. Painting Tools
        7. Electronic Tools
        8. Elecricity Tools
        9. Automotive Tools
```

Once navigated they can see the tools available to be borrowed and can select it.

```
        1. Name: Gardening_Line_Trimmer1, Available Quantity: 3

Enter the name of the tool you wish to borrow: Gardening_Line_Trimmer1
You have borrowed a 'Gardening_Line_Trimmer1'.
```

3. Return a tool

This functionality in a sense is the opposite of the borrow functionality in that it removes the tool from the member and adds it back onto the library system. As shown below the current tools borrowed by the member can be removed by typing its name which will cause the tool to return.

```
You have returned Name: Gardening_Line_Trimmer1, Available Quantity: 3.

Welcome to the Tool Library
==========Member Menu==========
1. Display all the tools of a tool type
2. Borrow a tool
3. Return a tool
4. List all the tools that I am renting
5. Display top three (3) most frequently rented tools
0. Return to main menu
==============================

 Current borrowed tools for Don:
        1. Fencing_HandTools1
        2. FlooringTools_Scrapers1
 Enter the number associated with the tool to return: 1

 You have returned Name: Fencing_HandTools1, Available Quantity: 4.
```

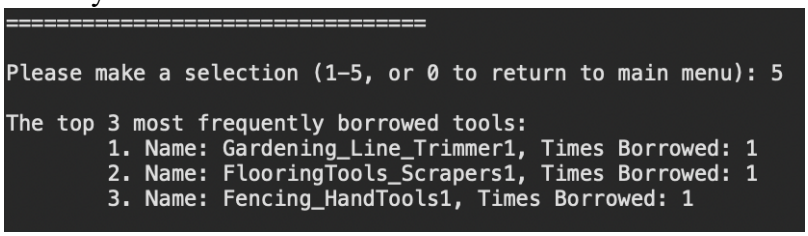
4. List all the tools I am renting

This is the functionality that displays all the tools held currently by a member.

```
Current borrowed tools for Don:
        1. Gardening_Line_Trimmer1
        2. FlooringTools_Scrapers1
```

5. Display top three (3) most frequently rented tools

This is the final functionality of the members menu. This functionality uses the algorithm analysed in the previous section of the report. This shows the 3 most frequently borrowed tools by the member.



0. Return to main menu

This is the last option for the member to go back to the main menu.

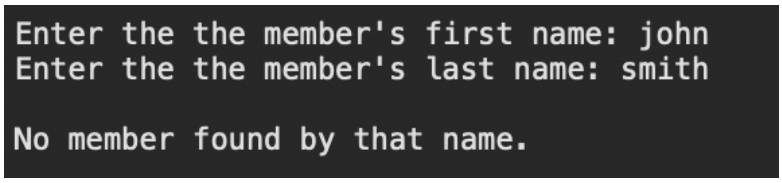
Code Review

The main classes (Tool, Tool Collection, Member, MemberCollection, ToolLibrary system and program) were such that they implemented the interfaces provided with in project.

The toolcollection uses arrays to store the collection of tool objects. The membercollection uses a binary search tree provided to store the member objects.

A private method was made inside the main program called UserInputCheck that took in the input from the staff and members and made sure if was within the range of inputs acceptable.

Other forms of error checking were also implemented to ensure the code does not break. An example of it shown below where a member tries to login or use a functionality but the is given that the credentials are invalid.



Appendix A: References

1. Photo in page 1: Science.slc.edu. 2021. *Running Time Graphs*. [online] Available at: <http://science.slc.edu/~jmarshall/courses/2002/spring/cs50/BigO/index.html> [Accessed 24 May 2021].
2. Basic Sorting Algorithms: https://blackboard.qut.edu.au/bbcswebdav/pid-9201587-dt-content-rid-37919164_1/courses/CAB301_21se1/CAB301-Lecture4.pdf
3. Advanced Sorting Algorithms: https://blackboard.qut.edu.au/bbcswebdav/pid-9218543-dt-content-rid-38163887_1/courses/CAB301_21se1/CAB301-Lecture6%282%29.pdf
4. Brilliant.org. 2021. *Insertion Sort | Brilliant Math & Science Wiki*. [online] Available at: <https://brilliant.org/wiki/insertion/> [Accessed 24 May 2021].
5. GeeksforGeeks. 2021. *Comparison among Bubble Sort, Selection Sort and Insertion Sort - GeeksforGeeks*. [online] Available at: <https://www.geeksforgeeks.org/comparison-among-bubble-sort-selection-sort-and-insertion-sort/> [Accessed 24 May 2021].
6.

Appendix B: Approved Extension Letter

Subject
EN01 10496262 Kaluarachchi, Don Misura Minduwara - CAB301 Assignment Extension (EXT) [Faculty of Science]

Response By Email (Anna) (25/05/2021 05.17 PM)

Dear Don Misura Minduwara,

Your request for an Assignment Extension has been **approved**. The details of your extension are provided below:

Unit: CAB301
Assignment Title: Assignment (Applied Project) : Development of a Software Application for aTool L
Original Submission Due Date: 24/05/2021
Revised Approved Submission Due Date: 31/05/2021

Please submit your assignment using the normal submission process as outlined in your unit's Blackboard site.

You are required to attach a copy of this email when submitting your assignment as it is confirmation of your approved extension.

If you do not submit your assignment by the extended due date your work will not be marked and you will receive a grade of 1 or 0% against the assessment item.

Book an individual session with a success coach or specialist educator (study skills, language and writing support, STEM skills) to get back on track with your studies. Find out more about other the academic support available at qut.to/academicsupport.

If you require additional information or assistance, please contact us.

Kind regards,
Anna

Student Support
Faculty of Science | Queensland University of Technology

ph 3138 2004 | email Science@qut.edu.au | CRICOS No 00213J