

CAB303

Assignment 1

Technical Report

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Introduction

The application created is a software system engineered for a not-for-profit tool library. It is the solution to manage the information about their tools and members of the library. The solution uses c# and Visual Studio 2019 to help users traverse the library. It also assists in many actions required for a functional tool library system, such as creating an account and borrowing and returning tools. Although interfaces were provided, not all were implemented with design challenges forcing them to be change. For instance, public void add(Member aMember) in ToolLibrarySystem had to be changed to public bool add(Member aMember, int option) to facilitate for user login verification and contact number searching. Public bool search(Member aMember) in MemberCollection also had to be change to public Member search(Member aMember) to facilitate login verification and contact number searching. Furthermore difficulty implementing public Member[] toArray() in MemberColllection resulted in no implementation for that method. Along with these changes extras getters were added and other slight variations were implemented.

Design and Analysis of Algorithms

The algorithm chosen to solve the problem of finding the top three most borrowed tools was a Heap Sort algorithm. Although the Heap Sort method usually works with binary trees, it can easily be used with arrays which is beneficial to the task as the data structure we are sorting is an array. This algorithm was chosen over others such as the Quick Sort and Merge Sort because of its superior suitability and efficiency. The Heap Sort has a worst case efficiency of $O(n \log n)$ which is less than the Quick Sort's worst case efficiency of $O(n^2)$ and does not need temporary space unlike the Merge Sort algorithm. Furthermore, the Heap Sort algorithm does not have to sort the entire input, unlike Merge Sort. For this problem, only the top three most borrowed items need to be found, and the Heap Sort can be stopped prematurely, only running to sorting and returning the top three values, while Merge Sort which must sort the entire input. The stability of the algorithm was not considered as it has little relevance to the project. With these factors considered, the decision was made to use the Heap Sort algorithm as it is most suitable for solution for the problem at hand.

The Heap Sort algorithm has two parts to it: Heap Bottom Up and the Maximum Key Deletion. The algorithm works by firstly turning the input into a heap via the Heap Bottom Up method and then removing the largest value in the heap to a list and replacing it with the last value in the array via the maximum key deletion method, then repeating the process until all components are sorted.

Pseudocode

ALGORITHM HeapBottomUp($H[0..n-1]$)

```
for i <-  $\lfloor n/2 \rfloor$  down to 1 do
    k <- i; v <-  $H[k]$ 
    heap <- false
    while not heap and  $2*k \leq n$  do
        j <-  $2*k$ 
        if  $j < n$ 
            if  $H[j] < H[j+1]$  j <- j+1
```

```

        if  $v \geq H[j]$ 
            heap <- true
        else  $H[k] \leftarrow H[j]; k \leftarrow j$ 
     $H[k] \leftarrow v$ 

```

Pseudocode for Maximum Key Deletion

ALGORITHM Maximumkeydeletion($A[0 \dots n-1]$)

```

    for i <- 0 to n-1
        A = HeapBottomUp(A)
        SortedList[i] = A[0]
        A[0] = A[A.Length-1]
        A.remove last value and make array one smaller
    Return SortedList

```

Complexity Analysis – Mathematical

The Maximum Key Deletions basic operation is the for loop that runs for the amount for the size of the array n to sort all elements of that array. Although the maximum key deletion algorithm usually runs its for loop n times, the number of elements in the array, in this scenario it only has to run basic operation three times as it only needs to return the three most borrowed tools. Three loops with four steps in the loop results in 12 total steps in the algorithm. Thus the big O notation for a usual maximum key deletion algorithm is $O(n)$ but for this scenario it is $O(1)$.

On the other hand, the Heap Bottom Up algorithm has a for loop that runs $n/2$ times down to one and within that for loop there is a while loop which does the basic operation, array element comparisons and swaps. The while loop runs for $\log n$ times in the worst-case scenario as the while loop travels the level of the binary tree, or array, and the largest number of levels of a binary tree is $\log n$ where n is the number of nodes. For example, a binary tree with 8 nodes in it has 3 levels, and $\log(8)$ equals 3 thus the largest number of levels the while loop must travel is $\log(n)$. Multiplying these complexities together as the while loop exists inside the for loop result in the complexity of the heap bottom up being $O(n \log n)$.

Empirical Analysis

Empirical analysis of the algorithm was done by running the algorithm with arrays of varying sizes and comparing the key comparison count between them by adding a counter in the while loop of heap bottom up. Each array was tested 20 times and the results are what follows.

```

C:\Users\louis\OneDrive\Documents\LOUIS\UN
Size = 100; Average Count = 3014.35
Size = 200; Average Count = 11235.75
Size = 300; Average Count = 24514.85
Size = 400; Average Count = 42856.5
Size = 500; Average Count = 66219.6
Size = 600; Average Count = 94626.2
Size = 700; Average Count = 128058.5
Size = 800; Average Count = 166502.45
Size = 900; Average Count = 209965.85
Size = 1000; Average Count = 258434.05

```

Letting $t(n)$ be the efficiency function, $t(200)/t(100) \approx 3.7$ which is less than 4, which is the ratio you would expect from a $O(n^2)$ algorithm, and greater than 2, the ratio you would expect from a $O(n)$ algorithm. Thus, the big O notation that would satisfies this ratio is $n \log n$ as it is in between n^2 and n .

Summary of Big O calculation

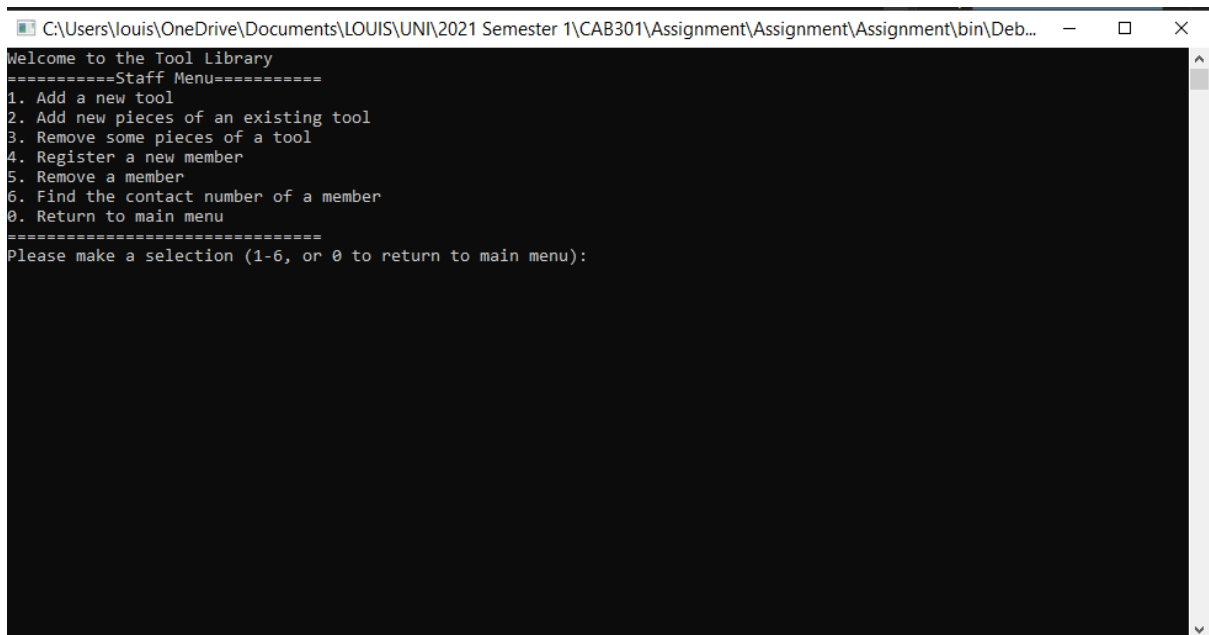
In summary, through mathematical and empirical analysis it is found that the Big O calculation for this heap sort algorithm is $O(n \log n)$.

Software test plan

Test	Expected Result	Result	Appendix
Log into staff menu with correct details	Open Staff Menu	Pass	Appendix 1
Log into staff menu with incorrect details	Do not open staff menu and tell user the username/password is incorrect	Pass	Appendix 2
Log into member menu with correct details	Open Member Menu	Pass	Appendix 3
Log into member menu with incorrect details	Do not open member menu and notify user	Pass	Appendix 4
Add a new tool	Add new tool	Pass	Appendix 5
Add new pieces of an existing tool	Update quantity of tool	Pass	Appendix 6
Remove some pieces of a tool	Update quantity of tool	Pass	Appendix 7
Remove a member	Successfully remove member	Pass	Appendix 8
Find the contact number of a member	Return contact number of the member	Pass	Appendix 9

Return to Main Menu	Open Main Menu screen	Pass	Appendix 10
Display all the tools of a tool type	Display all tools of a given tool type	Pass	Appendix 11
Borrow a tool	Successfully borrow a tool	Pass	Appendix 12
Return a tool	Successfully return tool	Pass	Appendix 13
List all the tools that user is currently renting	List all tools that user is renting	Pass	Appendix 14
Display top three most frequently rented tools	Display top 3 most borrowed tools	Pass	Appendix 15
Try to borrow an item while borrowing 3 items	Refuse user access to borrow an item	Pass	Appendix 16

Appendix



```

C:\Users\louis\OneDrive\Documents\LOUIS\UNI\2021 Semester 1\CAB301\Assignment\Assignment\Assignment\bin\Deb...
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):

```

Appendix 1: Log into staff menu with correct details

```
C:\Users\louis\OneDrive\Documents\LOUIS\UNI\2021 Semester 1\CAB301\Assignment\Assignment\Assignment\bin\Deb...
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): 1

Please enter username and password

Username: Bruh
Password: Bruh

Incorrect Username or Password

Press any key to continue:
```

Appendix 2: Log into staff menu with incorrect details

```
C:\Users\louis\OneDrive\Documents\LOUIS\UNI\2021 Semester 1\CAB301\Assignment\Assignment\Assignment\bin\Deb...
Welcome to the Tool Library
=====Member Menu=====
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
=====
Please make a selection (1-5, or 0 to return to main menu):
```

Appendix 3: Log into member menu

```
C:\Users\louis\OneDrive\Documents\LOUIS\UNI\2021 Semester 1\CAB301\Assignment\Assignment\Assignment\bin\Deb...
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): 2

Please enter first name, last name and password
First name: A
Last name: B
Password: 1111

Cannot Find Member With Those Details

Press any key to continue:
```

Appendix 4: Log into member menu with incorrect details

```
C:\Users\louis\OneDrive\Documents\LOUIS\UNI\2021 Semester 1\CAB301\Assignment\Assignment\Assignment\bin\Deb...
Tool Library System - Add New Tool To Library
=====
Enter the name of the new Tool: Hammer

Select the Category

1. Gardening Tools
2. Flooring Tools
3. Fencing Tools
4. Measuring Tools
5. Cleaning Tools
6. Painting Tools
7. Electronic Tools
8. Electricity Tools
9. Automotive Tools

Select option from menu: 1

Select the Tool Type

1. Line Trimmers
2. Lawn Mowers
3. Hand Tools
4. Wheelbarrows
5. Garden Power Tools

Select option from menu: 1

Successfully added tool Hammer

Press any key to continue
```

Appendix 5: Add a new tool


```
C:\Users\louis\OneDrive\Documents\LOUIS\UNI\2021 Semester 1\CAB301\Assignment\Assignment\Assignment\bin\Deb...
Tool Library System - Add Tools To Library
=====
Select the Category
1. Gardening Tools
2. Flooring Tools
3. Fencing Tools
4. Measuring Tools
5. Cleaning Tools
6. Painting Tools
7. Electronic Tools
8. Electricity Tools
9. Automotive Tools

Select option from menu: 1

Select the Tool Type
1. Scrapers
2. Floor Lasers
3. Floor Leveling Tools
4. Floor Leveling Materials
5. Floor Hand Tools
6. Tiling Tools

Select option from menu: 1

      Name    Quantity
1.    Tool1    1
2.    Tool2    1
3.    Hammer  1

Which Tool would you like to update: 3

How much are you adding: 5

Updated the quantity of Hammer in the library to 6

Press any key to continue
```

Appendix 6: Update quantity of a tool

```
C:\Users\louis\OneDrive\Documents\LOUIS\UNI\2021 Semester 1\CAB301\Assignment\Assignment\Assignment\bin\Deb...
Tool Library System - Remove Tools from Library
=====
Select the Category
1. Gardening Tools
2. Flooring Tools
3. Fencing Tools
4. Measuring Tools
5. Cleaning Tools
6. Painting Tools
7. Electronic Tools
8. Electricity Tools
9. Automotive Tools

Select option from menu: 1

Select the Tool Type
1. Scrapers
2. Floor Lasers
3. Floor Leveling Tools
4. Floor Leveling Materials
5. Floor Hand Tools
6. Tiling Tools

Select option from menu: 1

      Name    Quantity
1.    Tool1    1
2.    Tool2    1
3.    Hammer  6

Which Tool would you like to update: 3

How much are you removing: 4

Updated the quantity of Hammer in the library to 2
Press any key to continue:
```

Appendix 7: remove quantity of a tool

```
C:\Users\louis\OneDrive\Documents\LOUIS\UNI\2021 Semester 1\CAB301\Assignment\Assignment\Assignment\bin\Deb...
Tool Library System - Remove Member
=====
Please Enter the members first name: A
Please Enter the members last name: A
Please Enter the members contact number: 0490447607
Please Enter the members pin: 0000
Successfully removed member A A

Press any key to continue:
```

Appendix 8: Remove a member

```
C:\Users\louis\OneDrive\Documents\LOUIS\UNI\2021 Semester 1\CAB301\Assignment\Assignment\Assignment\bin\Deb...
Tool Library System - Search Member
=====
Please Enter the members first name: A
Please Enter the members last name: A

Contact Number for A A is 0490447607

Press any key to continue:
```

Appendix 9: Search contact number of a member

```
C:\Users\louis\OneDrive\Documents\LOUIS\UNI\2021 Semester 1\CAB301\Assignment\Assignment\Assignment\bin\Deb...
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):
```

Appendix 10: Return to main menu

```
C:\Users\louis\OneDrive\Documents\LOUIS\UNI\2021 Semester 1\CAB301\Assignment\Assignment\Assignment\bin\Deb...
Tool Library System - Display Tools
=====
Select the Category
1. Gardening Tools
2. Flooring Tools
3. Fencing Tools
4. Measuring Tools
5. Cleaning Tools
6. Painting Tools
7. Electronic Tools
8. Electricity Tools
9. Automotive Tools
Select option from menu: 1

Select the Tool Type
1. Scrapers
2. Floor Lasers
3. Floor Leveling Tools
4. Floor Leveling Materials
5. Floor Hand Tools
6. Tiling Tools
Select option from menu: 1

      Name    Quantity    Available Quantity
1.    Tool1     1           1
2.    Tool2     1           1
3.    Hammer  1           1

Please enter any key to continue
```

Appendix 11: Display tools of a given type

```
C:\Users\louis\OneDrive\Documents\LOUIS\UNI\2021 Semester 1\CAB301\Assignment\Assignment\Assignment\bin\Deb...
Tool Library System - Borrow Tool
=====
Select the Category
1. Gardening Tools
2. Flooring Tools
3. Fencing Tools
4. Measuring Tools
5. Cleaning Tools
6. Painting Tools
7. Electronic Tools
8. Electricity Tools
9. Automotive Tools

Select option from menu: 1
1. Line Trimmers
2. Lawn Mowers
3. Hand Tools
4. Wheelbarrows
5. Garden Power Tools

Select option from menu: 1

      Name    Quantity    Available Quantity
1.    Tool1     1           1
2.    Tool2     1           1
3.    Hammer  1           1

Please select the tool you want to borrow: 3

A has succesfully borrowed Hammer

Press any key to continue:
```

Appendix 12: Borrow a tool

```
C:\Users\louis\OneDrive\Documents\LOUIS\UNI\2021 Semester 1\CAB301\Assignment\Assignment\Assignment\bin\Deb...
Tool Library System - Return Tool
=====
1. Hammer
Please select from the following options: 1

Successfully returned Hammer

Please enter any key to continue:
```

Appendix 13: Return a tool

```
C:\Users\louis\OneDrive\Documents\LOUIS\UNI\2021 Semester 1\CAB301\Assignment\Assignment\Assignment\bin\Deb...
Tool Library System - Display Tools Borrowed
=====
1. Hammer

Please enter any key to continue:
```

Appendix 14: Display borrowed tools

```
C:\Users\louis\OneDrive\Documents\LOUIS\UNI\2021 Semester 1\CAB301\Assignment\Assignment\Assignment\bin\Deb...
Displaying top three most borrowed tools
=====
      Name      Amount Borrowed
      Tool1      1
      Tool2      1
      Hammer     1
Press any key to continue:
```

Appendix 15: Display 3 most borrowed tools

```
C:\Users\louis\OneDrive\Documents\LOUIS\UNI\2021 Semester 1\CAB301\Assignment\Assignment\Assignment\bin\Deb...
Tool Library System - Borrow Tool
=====
You cannot borrow more than 3 items at a time, please return item before borrowing
Press any key to continue:
```

Appendix 16: Try to borrow a tool while already borrowing 3 other tools