

# CAB301 A3 Technical Report

**DEVELOPMENT OF A SOFTWARE APPLICATION FOR A COMMUNITY  
LIBRARY TO MANAGE ITS MOVIE DVDS**

ASSESSMENT 3 GROUP 95

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## Introduction

In this project we are building a software system for a community library to manage its collection of movie DVDs. The community library offers DVDs of motion pictures to its members. A movie's information includes its title, genre, categorization, available copies and running time in minutes. For example, a movie genre might be Action, Comedy, History, Drama, or Western. A movie is designated as either General (G), Parental Guidance (PG), Mature (M), or Mature Accompanied (MA15+). The local library could have many copies of the same DVD. The software system should save information about every movie in the local library.

To borrow DVDs from the community library, the user must register with the library. When an individual is registered with the community library by a staff member, the user's first name, last name and phone number should be entered into the software system. In addition, the software system should also maintain information on the movie DVDs presently being borrowed by each registered member.

When a registered member checks out a DVD movie from the library, the movie should be added to the member's borrowing record. Alternatively, when the member returns the DVD to the library, the movie should be removed from the member's borrowing record. A registered user may save up to five movies at once. However, none of them is permitted to have more than one DVD version of the same movie in their hands at any given time.

Staff members can add a new movie to the collection or additional DVDs to a movie that exists in the system. As well as removing DVDs from a movie in the collection, if all the DVDs are removed for a particular movie, then that movie is removed from the system. Staff members can also add or remove a user from the system, look up a member's phone number and display all members borrowing a particular movie.

This report will illustrate an effective algorithm for solving a computational problem arising from this software development and will analyze the method's time efficiency using empirical algorithm analysis approaches. Furthermore, we demonstrate the pseudocode and empirical analysis for the top 3 most borrowed movies by members in decreasing order. The report will also include a comprehensive software test plan with test results providing complete coverage of the system.

## Design and Analysis of Algorithms

### Top 3 Movies Method

#### **ALGORITHM** *Top3Movies* ( )

// Find the 3 largest elements in the local array 'A' of type IMovie by number of borrowings.  
// A remains sorted in ascending order by movie title. 'n' is the length of array A. 'temp' is of type IMovie. 'first' 'second' & 'third' are of type IMovie. 'opCounter' is the count of basic operations.  
// global 'movieCollection' is of type MovieCollection. 'collectionTemp' is of type MovieCollection.  
// Input: A local array A [0...n - 1] of type IMovie, initialized through movieCollection  
// Output: returns the top 3 movies of array A to the console

```
opCount ← 0
collectionTemp ← movieCollection
A ← collectionTemp
if A ≠ null
    temp ← 0
    first ← temp
    second ← temp
    third ← temp
    for i ← 0 to n-1 do
        if A[i] > first
            opCount ← opCount + 1
            third ← second
            second ← first
            first ← A[i]
        else if A[i] > second
            opCount ← opCount + 1
            third ← second
            second ← A[i]
        else if A[i] > third
            opCount ← opCount + 1
            third ← A[i]
```

--- Input size (n)

--- Basic operation

--- Basic operation

--- Basic operation

For testing purposes this algorithm was changed to accept parameter A [0...n - 1] of type IMovie and return the integer opCount.

## Empirical Analysis

Empirical examination of an algorithm is accomplished by executing a program on a sample of inputs and examining the data (the fundamental operation's count or physical run time). This often includes creating randomly generated numbers. The application to any algorithm is the fundamental strength of this technique; the dependency of results on the specific computer and instance sample is its main flaw.

The first option is to incorporate a counter (or several counters) into the program executing the algorithm to count the number of times the algorithm's fundamental operation is performed. The second option is to time the implementation of the algorithm in question. The primary benefit of varying the input size in accordance with a pattern is that its influence is simpler to analyze. For instance, if the size of a sample is doubled, one may calculate the ratio  $count(2n)/count(n)$  or  $time(2n)/time(n)$  to see if the ratios display a typical behavior. The empirical data gathered from an experiment must be documented and analyzed before being presented. The data is displayed numerically in Figure 1 and visual representation corresponding to the data are shown as scatter plots in Figure 2 and Figure 3. Results from both techniques are displayed, as each approach has advantages and disadvantages and showing results of only either the operation count or run time may be misleading.

n	opCount	runTime
1000	19	0.0024191
2000	21	0.0019963
3000	23	0.001979
4000	24	0.0022741
5000	25	0.003502
6000	24	0.0032835
7000	25	0.0029345
8000	28	0.0023767
9000	27	0.0030134
10000	26	0.004596
11000	27	0.0037159
12000	25	0.0020247
13000	28	0.001942
14000	26	0.0021549
15000	26	0.0021056
16000	31	0.0022647
17000	27	0.0023439
18000	29	0.0023533
19000	28	0.0022356
20000	27	0.0023407

Figure 1- numerical data

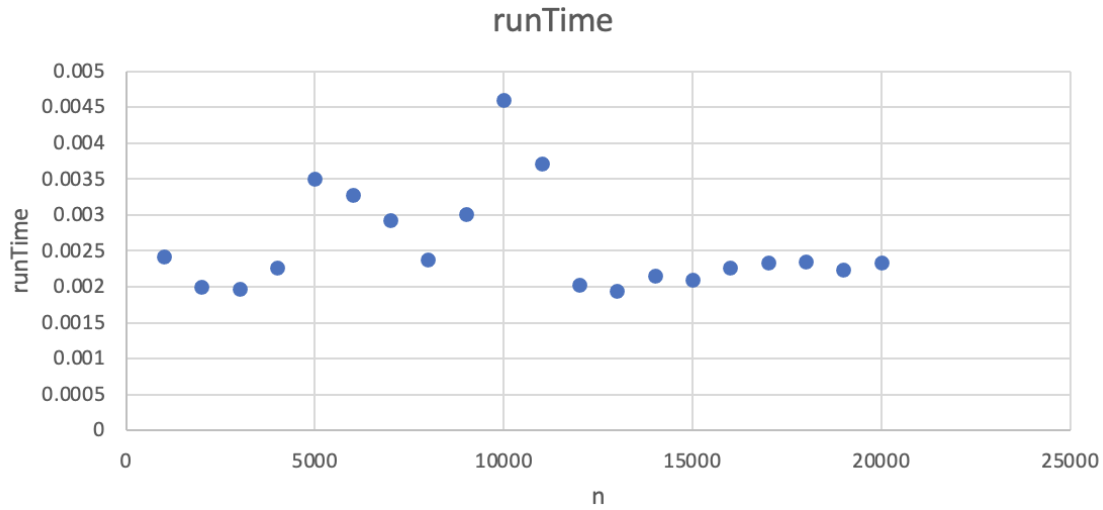


Figure 2- Run time Scatter Plot

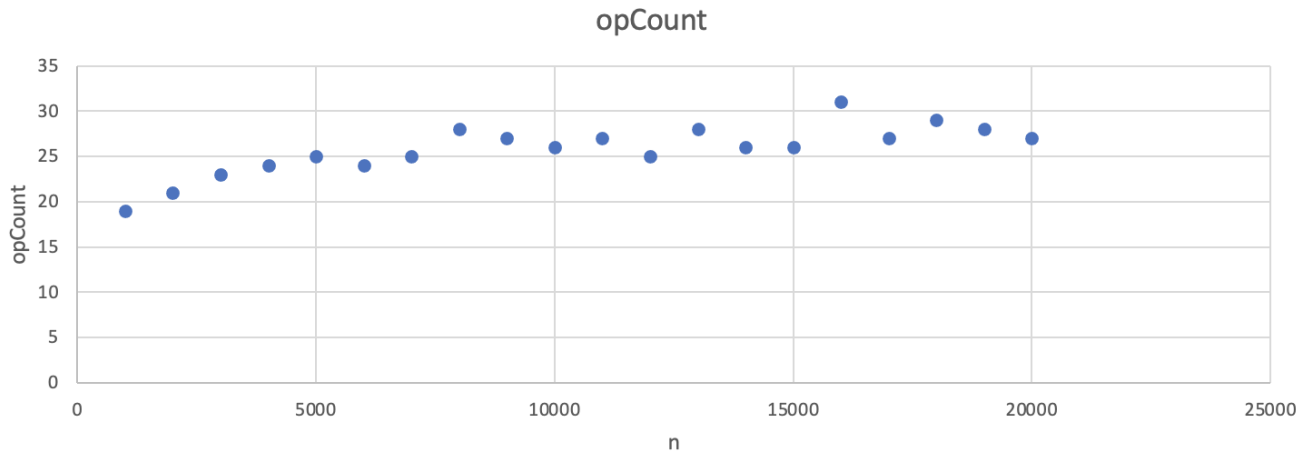


Figure 3- Operation Count scatter plot

Consider the efficiency function to be  $t(n) = cg(n)$ , where  $c$  is a constant and  $g(n)$  is a simple function. Using the given experimental data, we first determine the ratio between  $t(2n)$  and  $t(n)$ . For example,  $t(20000)/t(10000) = 0.509292863$  and  $count(20000)/count(10000) = 1.03846153$ . Therefore, the efficiency function  $t(n)$  and  $count(n)$  belong to  $O(n)$ .

Run time:

$$\frac{t(20000)}{t(10000)} = \frac{0.002341}{0.004596} = 0.509292863$$

$$\frac{t(10000)}{t(5000)} = \frac{0.004596}{0.00350195} = 1.312411656$$

$$\frac{t(8000)}{t(4000)} = \frac{0.0018421}{0.00168727} = 1.045098763$$

Count:

$$\frac{Count(20000)}{count(10000)} = \frac{27}{26} = 1.03846153$$

$$\frac{count(10000)}{count(5000)} = \frac{26}{25} = 1.04$$

$$\frac{count(8000)}{count(4000)} = \frac{28}{24} = 1.16$$

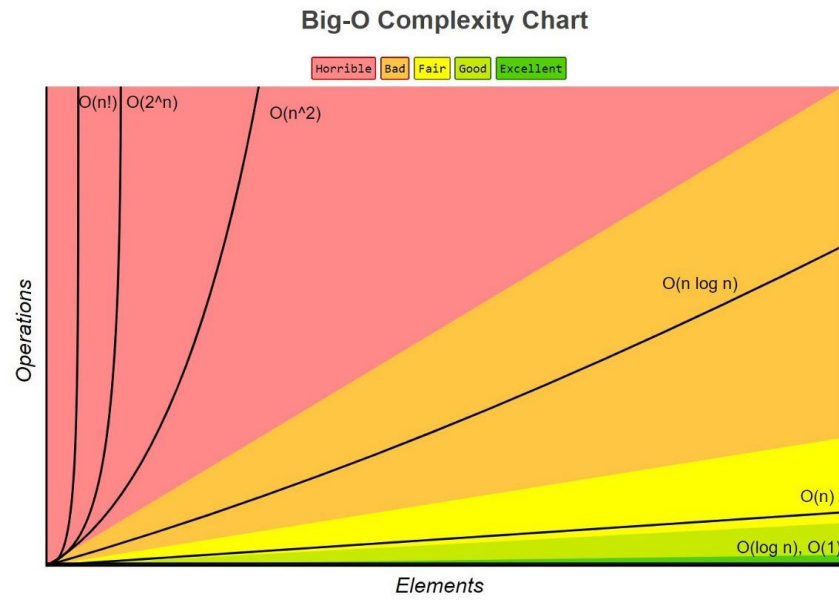


Figure 4- Big O Complexity Chart (Prado, 2019)

By looking at Figure 4, we can see that:

$$O(1) < O(\log n) < O(n) < O(n \log n)$$

It can be determined that, by comparing the experimental findings shown in the figures above, we can determine that the algorithm's efficiency class is  **$O(n)$**  and that its average case would be  **$O(\log n)$** .

## Software Test Plan & Results

**\*For all testing performed below, all invalid inputs include empty strings and newlines.**

### Staff functionality

Staff menu screen:

```
=====Staff Menu=====
1. Add new DVDs of a new movie to the system
2. Remove DVDs of a movie from the system
3. Register a new Member with the system
4. Remove a registered member from the system
5. Display a member's contact phone number, given the member's name
6. Display all members who are currently renting a particular movie
0. Return to the main menu

Enter your choice ==> (1/2/3/4/5/6/0)
```

### Staff login

Test case	Input/s	Expected result	Example screenshot
Valid username & valid password	staff today123	Successful login.  Proceeds to staff menu screen.	<pre>=====Staff Login===== Please Enter Username: staff Please Enter Password: today123  Staff login verified.  Press any key to continue...</pre> <pre>=====Staff Menu===== 1. Add new DVDs of a new movie to the system 2. Remove DVDs of a movie from the system 3. Register a new Member with the system 4. Remove a registered member from the system 5. Display a member's contact phone number, given the member's name 6. Display all members who are currently renting a particular movie 0. Return to the main menu  Enter your choice ==&gt; (1/2/3/4/5/6/0)</pre>
Invalid username & valid password	Staff today123	Error message displayed.  Returned to main menu.	<pre>=====Staff Login===== Please Enter Username: Staff Please Enter Password: today123  Incorrect Username or Password. Press any key to continue...</pre>



			<pre> ===== Welcome to the Community Library Movie DVD Management System =====  =====Main Menu===== 1. Staff Login 2. Member Login 0. Exit  Enter your choice ==&gt; (1/2/0) </pre>
Valid username & invalid password	staff today	Error message displayed.  Returned to main menu.	<pre> =====Staff Login===== Please Enter Username: staff Please Enter Password: today  Incorrect Username or Password. Press any key to continue...  ===== Welcome to the Community Library Movie DVD Management System =====  =====Main Menu===== 1. Staff Login 2. Member Login 0. Exit  Enter your choice ==&gt; (1/2/0) </pre>
Invalid username & Invalid password	hello there	Error message displayed.  Returned to main menu.	<pre> =====Staff Login===== Please Enter Username: hello Please Enter Password: there  Incorrect Username or Password. Press any key to continue...  ===== Welcome to the Community Library Movie DVD Management System =====  =====Main Menu===== 1. Staff Login 2. Member Login 0. Exit  Enter your choice ==&gt; (1/2/0) </pre>

Empty String & Empty String	" " " "	Error message displayed.  Returned to main menu.	<pre> =====Staff Login===== Please Enter Username:  Please Enter Password:  Incorrect Username or Password. Press any key to continue...  ===== Welcome to the Community Library Movie DVD Management System =====  =====Main Menu===== 1. Staff Login 2. Member Login 0. Exit  Enter your choice ==&gt; (1/2/0)   </pre>
Newline & Newline	\line break \line break	Error message displayed.  Returned to main menu.	<pre> =====Staff Login===== Please Enter Username:  Please Enter Password:  Incorrect Username or Password. Press any key to continue...  ===== Welcome to the Community Library Movie DVD Management System =====  =====Main Menu===== 1. Staff Login 2. Member Login 0. Exit  Enter your choice ==&gt; (1/2/0)   </pre>

Add new DVDs of a new movie to the system

Note: accepts a space " " for a title

Test Case	Input	Expected result	Example Screenshot
Invalid title input	\line break	Error message displayed. Title prompt re-sent.	<pre> ===== Add DVDs to a Movie or new Movie to this Collection ===== Title:  Invalid Input, Try again. Press 0 to exit. Title: </pre>
Valid title input – exists in collection	die hard	Proceeds to prompt to enter no. of DVD copies to be added	<pre> ===== Add DVDs to a Movie or new Movie to this Collection ===== Title: die hard  Movie Found in this Collection:  Title: Die Hard Genre: Action Classification: G Duration: 65 Available Copies: 0 Total Copies: 4  Please enter amount of DVDs to add for this movie: </pre>
Valid DVD prompt input	5	5 Copies added to movie.  Returned to staff menu.	<pre> Please enter amount of DVDs to add for this movie: 5  Adding 5 copies of DVDs to Die Hard - Total Copies 18  Press any key to return to the staff menu. </pre>
Invalid DVD prompt input	test	Error message, DVD prompt sent again or return to staff menu.	<pre> Please enter amount of DVDs to add for this movie: test  Invalid Input, must be greater than 0 and numeric. Press 0 to exit. Please enter amount of DVDs to add for this movie: </pre>
Invalid DVD prompt input	0	Error message, DVD prompt sent again or return to staff menu.	<pre> Please enter amount of DVDs to add for this movie: 0  Invalid Input, must be greater than 0 and numeric. Press 0 to exit. Please enter amount of DVDs to add for this movie: </pre>
Empty string/Newline	" "\line break	Error message, DVD prompt sent again or return to staff menu.	<pre> Please enter amount of DVDs to add for this movie:  Invalid Input, must be greater than 0 and numeric. Press 0 to exit. Please enter amount of DVDs to add for this movie: </pre>

Valid title input- doesn't exist in collection	Taken	Proceeds to genre prompt.	<pre> ===== Add DVDs to a Movie or new Movie to this Collection ===== Title: Taken  Movie 'Taken' is not found in this Collection. Please enter the new details of 'Taken'  Allowed Genre: Action (1), Comedy (2), History (3), Drama (4) or Western (5). Genre: </pre>
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### Valid title – Movie doesn't exist in collection

Example valid input: Taken, Action, M, 80, 10

Taken, 1, 1, 80, 10

Before movie added:

Current collection of movies:

```

Title: Die Hard, Genre: Action, Classification: G, Duration: 65, Available Copies: 0, Total Copies: 4
Title: Revenge of the Sith, Genre: Action, Classification: G, Duration: 65, Available Copies: 1, Total Copies: 3
Title: Willy Wonker, Genre: Action, Classification: G, Duration: 65, Available Copies: 3, Total Copies: 3

```

After movie added:

Current collection of movies:

```

Title: Die Hard, Genre: Action, Classification: G, Duration: 65, Available Copies: 0, Total Copies: 4
Title: Revenge of the Sith, Genre: Action, Classification: G, Duration: 65, Available Copies: 1, Total Copies: 3
Title: Taken, Genre: Action, Classification: M, Duration: 80, Available Copies: 10, Total Copies: 10
Title: Willy Wonker, Genre: Action, Classification: G, Duration: 65, Available Copies: 3, Total Copies: 3

```

Test Case	Input	Expected output	Example Screenshot
Valid Genre - number	1	Classification prompt sent	<pre> Allowed Genre: Action (1), Comedy (2), History (3), Drama (4) or Western (5). Genre: 1  Allowed Classification: G (1), PG (2), M (3) or M15Plus (4). Classification: </pre>
Valid genre – text	Action		<pre> Allowed Genre: Action (1), Comedy (2), History (3), Drama (4) or Western (5). Genre: Action  Allowed Classification: G (1), PG (2), M (3) or M15Plus (4). Classification: </pre>
Invalid Genre input - number	8	Error message displayed, genre prompt re-sent	<pre> Allowed Genre: Action (1), Comedy (2), History (3), Drama (4) or Western (5). Genre: 8  Invalid Input, Try again. Press 0 to exit. Allowed Genre: Action (1), Comedy (2), History (3), Drama (4) or Western (5). Genre: </pre>
Invalid Genre input - text	Horror	Error message displayed, genre prompt re-sent	<pre> Allowed Genre: Action (1), Comedy (2), History (3), Drama (4) or Western (5). Genre: Horror  Invalid Input, Try again. Press 0 to exit. Allowed Genre: Action (1), Comedy (2), History (3), Drama (4) or Western (5). Genre: </pre>
Invalid Genre input Empty string/newline	"/line break	Error message displayed, genre prompt re-sent	<pre> Allowed Genre: Action (1), Comedy (2), History (3), Drama (4) or Western (5). Genre:  Invalid Input, Try again. Press 0 to exit. Allowed Genre: Action (1), Comedy (2), History (3), Drama (4) or Western (5). Genre: </pre>

Valid classification - number	3	Duration prompt sent	Allowed Classification: G (1), PG (2), M (3) or M15Plus (4). Classification: 3  Duration:
Valid classification input - text	M		Allowed Classification: G (1), PG (2), M (3) or M15Plus (4). Classification: M  Duration:
Invalid classification input - text	good	Error message displayed; classification prompt re-sent	Allowed Classification: G (1), PG (2), M (3) or M15Plus (4). Classification: good  Invalid Input, Try again. Press 0 to exit. Allowed Classification: G (1), PG (2), M (3) or M15Plus (4) Classification:
Invalid classification input - number	5		Allowed Classification: G (1), PG (2), M (3) or M15Plus (4). Classification: 5  Invalid Input, Try again. Press 0 to exit. Allowed Classification: G (1), PG (2), M (3) or M15Plus (4) Classification:
Invalid classification input Empty string/newli ne	“ ” /Line break		Allowed Classification: G (1), PG (2), M (3) or M15Plus (4). Classification:  Invalid Input, Try again. Press 0 to exit. Allowed Classification: G (1), PG (2), M (3) or M15Plus (4) Classification:
Valid Duration input	80	Total copies prompt sent	Duration: 80  Total Copies:
Invalid duration input	test	Error message displayed; duration prompt re-sent	Duration: test Duration must be greater than 0 and Numeric.  Invalid Input, Try again. Press 0 to exit. Duration:
Invalid duration input Empty string/newli ne	“ ” /Line break		Duration:  Duration must be greater than 0 and Numeric.  Invalid Input, Try again. Press 0 to exit. Duration:
Valid total copies input	10	Confirmation screen displayed	Total Copies: 10  Press any key to continue...

			<pre> =====Confirm Movie Details=====  Title: Taken Genre: Action Classification: M Duration: 80 Available Copies: 10  To add this movie, press 'Y' or Press or press 'N' to exit </pre>
Invalid total copies input	test	Error message displayed; total copies prompt re- sent	<pre> Total Copies: test Total Copies must be greater than 0 and Numeric.  Invalid Input, Try again. Press 0 to exit. Total Copies: </pre>
Invalid total copies input Empty string/newli ne	"/Line break		<pre> Total Copies must be greater than 0 and Numeric.  Invalid Input, Try again. Press 0 to exit. Total Copies: </pre>

Remove DVDs of a movie from the system

Example screen on entry:

```

=====Remove DVDs from a Movie in the Collection=====

Current collection of movies:

Title: Die Hard, Genre: Action, Classification: G, Duration: 65, Available Copies: 0, Total Copies: 4
Title: Revenge of the Sith, Genre: Action, Classification: G, Duration: 65, Available Copies: 1, Total Copies: 3
Title: Willy Wonker, Genre: Action, Classification: G, Duration: 65, Available Copies: 3, Total Copies: 3

=====

Please enter a movie title: _

```

Test Case	Input	Expected result	Example Screenshot
Empty movie collection	NIL	Error message displayed.  Returned to staff menu.	<pre> =====Remove DVDs from a Movie in the Collection=====  Current collection of movies:  No movies exist in the movie collection.  Press any key to return to the staff menu. </pre>
Invalid title input	test	Error message displayed, title prompt re-sent	<pre> =====  Please enter a movie title: test  Please enter a valid movie title (Press 0 to Exit): </pre>
Invalid title input Empty string/newline	"/line break		<pre> Please enter a movie title:  Please enter a valid movie title (Press 0 to Exit): </pre>
Valid title input –copies available	willy wonker	DVD prompt sent.	<pre> =====  Please enter a movie title: willy wonker  Enter number of DVDs to be removed: _ </pre>
Valid title input –no copies available	die hard	Error message displayed.  Returned to staff menu.	<pre> =====  Please enter a movie title: die hard  Error - There is no available copies to remove. There are 4 total copies remaining for 'Die Hard', with 4 currently on borrow.  Press any key to return to the staff menu. </pre>
Valid DVD prompt input	2	Specified DVD copies successfully removed.  Returned to staff menu.	<pre> =====  2 DVD copies removed from Movie 'Willy Wonker'.  There are 1 total copies remaining for 'Willy Wonker', with 0 currently on borrow.  =====  Press any key to return to the staff menu. </pre>

Invalid DVD prompt input	8, test	Error message displayed; DVD prompt re-sent	<pre> Enter number of DVDs to be removed: 8 Please enter a number between 1 and 3 (Press 0 to Exit): test Please enter a number between 1 and 3 (Press 0 to Exit): </pre>
Invalid DVD prompt input Empty string	“ ” /Line break		<pre> Enter number of DVDs to be removed: Please enter a number between 1 and 3 (Press 0 to Exit): </pre>
Remove all copies of a movie	willy wonker , 3	Warning sent; confirmation prompt sent. Movie deleted from collection.  Returned to staff menu.	<pre> ===== Please enter a movie title: willy wonker Enter number of DVDs to be removed: 3  Warning! - Removing the last copy of a DVD from a movie will remove the movie from the collection. Press 'Y' continue or Press or press 'N' to exit y  =====  3 DVD copies removed from Movie 'Willy Wonker'.  There are 0 total copies remaining for 'Willy Wonker', with 0 currently on borrow.  Movie 'Willy Wonker' has been removed from the system as there are no copies left.  ===== Press any key to return to the staff menu. </pre>

#### Register a new Member with the system

Test Case	Input	Expected result	Example Screenshot
Invalid first name input	23	First name prompt re-sent	<pre> =====Register a Member===== First Name: 23 Please enter a valid First Name (press 0 to exit): </pre>
Invalid Empty string	“ ”		<pre> First Name: Please enter a valid First Name (press 0 to exit): </pre>
Valid first name input	Ryan	Last name prompt sent	<pre> First Name: Ryan Last Name: </pre>
Invalid last name input	100	Last name prompt re-sent	<pre> Last Name: 100 Please enter a valid Last Name (press 0 to exit): </pre>
Invalid Empty string	“ ”		<pre> Last Name: Please enter a valid Last Name (press 0 to exit): </pre>
Valid last name input	Reynolds	Contact number prompt sent	<pre> Last Name: Reynolds Contact Number: </pre>



Invalid contact number input	040422211	Contact number prompt re-sent	Contact Number:040422211 Please enter a valid contact number (press 0 to exit):
Valid contact number input	0404444111	PIN prompt sent	Contact Number:0404444111 PIN:
Invalid PIN input	0123467, test	PIN prompt re-sent	PIN: 01234567 Please enter a valid pin (press 0 to exit): test Please enter a valid pin (press 0 to exit):
Valid PIN input	4444	Continue to confirmation screen, member successfully added.  Returned to staff menu.	PIN: 4444 Press any key to continue...  =====Confirm Add Member ===== First Name: Ryan Last Name: Reynolds Ph: 0404222111 Pin: 4444  To add this member, press 'Y' or Press or press 'N' to exit y  Ryan Reynolds succesfully registered. Press any key to continue...
Add member that already exists	James Wyatt	Display error.  Return to staff menu.	=====Confirm Add Member ===== First Name: James Last Name: Wyatt Ph: 0422977674 Pin: 1414  To add this member, press 'Y' or Press or press 'N' to exit y  Error - James Wyatt Member already existis. Press any key to continue...

Remove a registered member from the system

Example screen on entry:

```

===== Delete a Registered Member =====

Members found in collection (Last name, First name):

Alpha, John
Kelly, John
Last, Harry
Lee, Crystal
Smith, Peter
Wyatt, James
Zebra, Chris

=====

Please enter a valid member from the collection:
First Name:

```

Test Case	Input	Expected result	Example Screenshot
Empty member collection	NIL	Error message displayed.  Returned to staff menu.	<pre> ===== Delete a Registered Member =====  Error - No members in the Member Collection  Press any key to continue... </pre>
Invalid user input	hello there	Error message displayed, prompt re-sent	<pre> =====  Please enter a valid member from the collection: First Name: hello Last Name: there  Please enter a valid member from the collection (press 0 to quit): First Name: </pre>
Invalid Empty string	“ “ “ “		<pre> Please enter a valid member from the collection: First Name: Last Name:  Please enter a valid member from the collection (press 0 to quit): First Name: </pre>
Valid user input – no movies on borrow	John Alpha	Confirmation screen sent, user successfully deleted.  Returned to staff menu.	<pre> Please enter a valid member from the collection (press 0 to quit): First Name: John Last Name: Alpha  Press any key to continue...  =====Confirm Delete Member =====  John Alpha Ph:0423444441 Pin:4837  To DELETE this member, press 'Y' or Press or press 'N' to exit y  John Alpha succesfully deleted.  Press any key to continue... </pre>
Valid user input – has movies on borrow	John Kelly	Error message displayed- user cannot be deleted.  Returned to staff menu.	<pre> =====  Please enter a valid member from the collection: First Name: John Last Name: Kelly  Error - Cannot remove 'John Kelly' as they have DVDs on borrow. Number of DVDs on borrow: 1  Press any key to return to the staff menu. </pre>

Display a member's contact phone number, given the member's name

Notes: User refers to the first name and last name inputs (case sensitive). Must both be correct to be considered a valid input.

Example screen on entry:

```

===== Obtain a Member's Contact Number =====

Members found in collection (Last name, First name):

Alpha, John
Kelly, John
Last, Harry
Lee, Crystal
Smith, Peter
Wyatt, James
Zebra, Chris

=====

Please enter a valid member from the collection:
First Name: _

```

Test Case	Input	Expected result	Example Screenshot
Empty member collection	NIL	Error message displayed.  Returned to staff menu.	<pre> ===== Obtain a Member's Contact Number =====  Error - No members in the Member Collection  Press any key to continue... </pre>
Valid user input	John Alpha	Input user's contact number is displayed.  Returned to staff menu.	<pre> =====  Please enter a valid member from the collection: First Name: John Last Name: Alpha  =====  John Alpha's contact number is 0423444441.  =====  Press any key to return to the staff menu. </pre>
Invalid user input	Hello Test	Error message displayed, prompt re-sent	<pre> =====  Please enter a valid member from the collection: First Name: Hello Last Name: Test  Please enter a valid member from the collection (press 0 to quit): First Name: _ </pre>
Invalid Empty string	"" ""		<pre> Please enter a valid member from the collection: First Name: Last Name:  Please enter a valid member from the collection (press 0 to quit): First Name: </pre>

Display all members who are currently renting a particular movie:

Example screen on entry:

```

===== Display Borrowers of a Movie =====

Current collection of movies:

Title: Die Hard, Genre: Action, Classification: G, Duration: 65, Available Copies: 0, Total Copies: 4
Title: Harry Potter 1, Genre: Action, Classification: G, Duration: 65, Available Copies: 3, Total Copies: 3
Title: Lord of the Rings, Genre: Action, Classification: G, Duration: 65, Available Copies: 2, Total Copies: 3
Title: Revenge of the Sith, Genre: Action, Classification: G, Duration: 65, Available Copies: 1, Total Copies: 3
Title: The Clone Wars, Genre: Action, Classification: G, Duration: 65, Available Copies: 2, Total Copies: 3
Title: Willy Wonker, Genre: Action, Classification: G, Duration: 65, Available Copies: 2, Total Copies: 3
=====

```

Test Case	Input	Expected result	Example Screenshot
Empty movie collection	NIL	Error message displayed.  Returned to staff menu.	<pre> ===== Display Borrowers of a Movie =====  Current collection of movies:  No movies exist in the movie collection.  Press any key to return to the staff menu. </pre>
Invalid title input	testing	Error message, title prompt sent.	<pre> ===== Please enter a movie title: testing Please enter a valid movie title (press 0 to quit): _ </pre>
Invalid Empty string	“ ”		<pre> Please enter a movie title: Please enter a valid movie title (press 0 to quit): </pre>

Valid title Input			
<p>Example valid input: willy wonker</p> <p>Before member borrows out movie:</p> <pre> ===== Please enter a movie title: willy wonker =====  No one is currently borrowing out 'Willy Wonker'. ===== </pre> <p>After member <a href="#">John Kelly</a> borrows out movie:</p> <pre> ===== Please enter a movie title: willy wonker =====  List of members currently borrowing out 'Willy Wonker':  Kelly, John ===== </pre>			
Test Case	Input	Expected output	Example Screenshot

Movie has DVDs rented out to members	die hard	First name and last name of members borrowing movie die hard displayed.  Returned to staff menu.	<pre> ===== Please enter a movie title: die hard =====  List of members currently borrowing out Die Hard:  Kelly, John Last, Harry Smith, Peter Wyatt, James  =====  Press any key to return to the staff menu. </pre>
Movie has no DVDs rented out to members	willy wonker	Error message.  Returned to staff menu.	<pre> ===== Please enter a movie title: willy wonker =====  No one is currently borrowing out 'Willy Wonker'.  =====  Press any key to return to the staff menu. </pre>

## Member functionality

### Member Login

Member existing in collection:

```

34  Member member1 = new Member("John", "Kelly", "0404444544", "4837");
35  memberCollection.Add(member1);

```

Notes: User refers to the first name and last name inputs (case sensitive). Must both be correct to be considered a valid input.

Test case	Input	Expected result	Example screenshot
Valid User & valid password	John Kelly 4837	Successful login.  Proceeds to member menu screen.	<pre> =====Member Login===== Please enter first name: John Please enter last name: Kelly Please Enter PIN: 4837  Verification Successful - Now Logging In 'John Kelly'.  Press any key to continue... </pre>

			<pre> =====Member Menu===== 1. Browse all the movies 2. Display all the information about a movie, given the title of the movie 3. Borrow a movie DVD 4. Return a movie DVD 5. List current borrowing movies 6. Display the top 3 movies rented by the members 0. Return to the main menu  Enter your choice ==&gt; (1/2/3/4/5/6/0) </pre>
Invalid User & valid password	John Test 4837	Error message displayed.  Returned to main menu.	<pre> =====Member Login===== Please enter first name: John Please enter last name: Test Please Enter PIN: 4837  Error - 'John Test' does not exists in this collection.  Press any key to return to the main menu. </pre> <pre> ===== Welcome to the Community Library Movie DVD Management System =====  =====Main Menu===== 1. Staff Login 2. Member Login 0. Exit  Enter your choice ==&gt; (1/2/0) </pre>
Valid username & invalid password	John Kelly 7283	Error message displayed.  Returned to main menu.	<pre> =====Member Login===== Please enter first name: John Please enter last name: Kelly Please Enter PIN: 7283  Error - 'John Kelly' does not exists in this collection.  Press any key to return to the main menu. </pre> <pre> ===== Welcome to the Community Library Movie DVD Management System =====  =====Main Menu===== 1. Staff Login 2. Member Login 0. Exit  Enter your choice ==&gt; (1/2/0) </pre>

Invalid username & Invalid password	Hello there 0000	Error message displayed.  Returned to main menu.	<pre> =====Member Login===== Please enter first name: Hello Please enter last name: there Please Enter PIN: 0000  Error - 'Hello there' does not exists in this collection. Press any key to return to the main menu. ===== Welcome to the Community Library Movie DVD Management System =====  =====Main Menu===== 1. Staff Login 2. Member Login 0. Exit  Enter your choice ==&gt; (1/2/0) </pre>
Invalid empty string	" " " " " "		<pre> =====Member Login===== Please enter first name:  Please enter last name:  Please Enter PIN:  Error - ' ' does not exists in this collection. Press any key to return to the main menu. </pre>

Browse all the movies

No input is required from the user.

Test case	Expected result	Example Screenshot
Empty movie collection	Error message displayed. Returned to member menu.	<pre> =====Browsing All Movies=====  There are currently no movies available.  Press any key to return to the member menu. </pre>
1 or more movies in collection	List of all the movies in the movie collection.  Returned to member menu.	<pre> =====Browsing All Movies=====  Title: Die Hard, Genre: Action, Classification: G, Duration: 65, Available Copies: 4 Title: Revenge of the Sith, Genre: Action, Classification: G, Duration: 65, Available Copies: 3  Press any key to return to the member menu. </pre>
New movie "Total War 3" added to collection	List of all the movies in the movie collection.  Returned to member menu.	<pre> =====Browsing All Movies=====  Title: Die Hard, Genre: Action, Classification: G, Duration: 65, Available Copies: 4 Title: Revenge of the Sith, Genre: Action, Classification: G, Duration: 65, Available Copies: 3 Title: Total War 3, Genre: Action, Classification: PG, Duration: 120, Available Copies: 10  Press any key to return to the member menu. </pre>

Display all the information about a movie, given the title of the movie

Note: Title input is not case sensitive

Test Case	Input	Expected result	Example Screenshot
Empty movie collection	NIL	Error message displayed.  Returned to member menu.	<pre> =====Obtain Movie Info=====  There are currently no movies in the movie collection.  Press any key to return to the member menu. </pre>
Valid title input	die hard	Details of movie die hard displayed.  Returned to member menu.	<pre> =====Obtain Movie Info=====  Please enter a movie title: die hard  Title: Die Hard, Genre: Action, Classification: G, Duration: 65, Available Copies:  Press any key to return to the member menu. </pre>
Invalid title input	nonexistent title	Error message, title prompt re-sent.	<pre> =====Obtain Movie Info=====  Please enter a movie title: nonexistent title Please enter a valid movie title (press 0 to quit): </pre>
Invalid Empty string	“ ”		<pre> =====Obtain Movie Info=====  Please enter a movie title:  Please enter a valid movie title (press 0 to quit): </pre>

Borrow a movie DVD

Example screen on entry:

```

===== Borrow Movie =====

Movies currently borrowing:

Title: Die Hard, Genre: Action, Classification: G, Duration: 65, Available Copies: 0

Movies available for borrow:

Title: Revenge of the Sith, Genre: Action, Classification: G, Duration: 65, Available Copies: 1
Title: Willy Wonker, Genre: Action, Classification: G, Duration: 65, Available Copies: 2

=====
Please enter a movie title:

```

Error Cases			
	Input	Expected result	Example Screenshot
Empty movie collection	NIL	Error message displayed.  Returned to member menu.	<pre> ===== Borrow Movie =====  There are currently no movies in the movie collection.  Press any key to return to the member menu. </pre>



Invalid title input	nonexistent title	Error message, title prompt re-sent.	<pre> ===== Please enter a movie title: nonexistent title Please enter a valid movie title (press 0 to quit): </pre>
Invalid Empty string	" "		<pre> ===== Please enter a movie title: Please enter a valid movie title (press 0 to quit): </pre>
max limit (5) on borrow reached	Error message displayed	Error message displayed.  Returned to member menu.	<pre> ===== You have 5 DVDs already borrowed. This is the Maximum limit. Please return a DVD before borrowing another.  Press any key to return to the member menu. </pre>

Valid title input cases		
<p>Note: number of copies is checked before if member has movie on borrow</p> <p>Confirmation screen example when valid title is input.</p> <pre> ===== Confirm Borrow Movie =====  Title: Die Hard Genre: Action Classification: G Duration: 65 Available Copies: 0  To borrow this movie, press 'Y' or Press or press 'N' to exit </pre>		
	<b>Expected Result</b>	<b>Example Screenshot</b>
copies available	<p>Movie successfully borrowed.</p> <p>Returned to member menu.</p>	<pre> Willy Wonker has been successfully borrowed.  Press any key to continue... </pre> <p>(Borrow movie screen after successful borrow)</p> <pre> ===== Borrow Movie =====  Movies currently borrowing:  Title: Die Hard, Genre: Action, Classification: G, Duration: 65, Available Copies: 0 Title: Willy Wonker, Genre: Action, Classification: G, Duration: 65, Available Copies: 2  Movies available for borrow:  Title: Revenge of the Sith, Genre: Action, Classification: G, Duration: 65, Available Copies: 1 Title: Taken, Genre: Action, Classification: M, Duration: 80, Available Copies: 10 </pre>
already on borrow	Error message displayed.	<pre> Error - Member 'John Kelly' already has 'Die Hard' on borrow.  Press any key to continue... </pre>
no copies available	Returned to member menu.	<pre> There is no available copies for 'Die Hard' at the present time - Try again later.  Press any key to continue... </pre>

Return a movie DVD  
 Example screen on entry:

```

===== Return Movie =====

Movies currently borrowing:

Title: Die Hard, Genre: Action, Classification: G, Duration: 65, Available Copies: 0
Title: Willy Wonker, Genre: Action, Classification: G, Duration: 65, Available Copies: 1

=====
Please enter a movie title: _
  
```

Error Cases			
Test Case	Input	Expected result	Example Screenshot
Empty movie collection	NIL	Error message displayed.  Returned to member menu.	<pre> ===== Return Movie =====  There are currently no movies in the movie collection.  Press any key to return to the member menu.           </pre>
No movies on borrow	NIL	Error message displayed.  Returned to member menu.	<pre> ===== Return Movie =====  Movies currently borrowing:  John Kelly has no movies currently on borrow.  Press any key to continue...           </pre>
Invalid title input	test	Error message, title prompt sent.	<pre> ===== Please enter a movie title: test Please enter a valid movie title (press 0 to quit): _           </pre>
Invalid Empty string	“ ”		<pre> ===== Please enter a movie title: Please enter a valid movie title (press 0 to quit):           </pre>

Valid Title Input Cases		
Note: number of copies is checked before if member has movie on borrow Confirmation screen example when valid title is input.		
<pre> ===== Confirm Return Movie =====  Title: Die Hard Genre: Action Classification: G Duration: 65 Available Copies: 0  To return this movie, press 'Y' or Press or press 'N' to exit           </pre>		
Test Case	Expected Result	Example Screenshot
Movie on borrow	Movie successfully returned.  Returned to member menu.	<pre> Die Hard has been successfully returned.  Press any key to continue...           </pre>

Movie not on borrow	Error message displayed.  Returned to member menu.	<pre>Error - Member 'John Kelly' does not have 'Die Hard' on borrow. Press any key to continue...</pre>
---------------------	--	---

### List current borrowing movies

No input is required from the user.

Test Case	Expected Result	Example Screenshot
Empty movie collection	Error message displayed.  Returned to member menu.	<pre>===== Current Borrowing Movies ===== There are currently no movies in the movie collection. Press any key to return to the member menu.</pre>
User not borrowing any movies	Error message displayed.  Returned to member menu.	<pre>===== Current Borrowing Movies ===== John Kelly has no movies currently on borrower. Press any key to continue...</pre>
User has 1 or more movies on borrow	Movies on borrow displayed.  Returned to member menu.	<pre>===== Current Borrowing Movies ===== Title: Die Hard, Genre: Action, Classification: G, Duration: 65, Available Copies: 0 Title: Willy Wonker, Genre: Action, Classification: G, Duration: 65, Available Copies: 1 Press any key to continue...</pre>

### Display the top 3 movies rented by the members

Note: only movies that have been borrowed at least once are displayed.

Test Case	Expected Result	Example Screenshot
Empty movie collection	Error message displayed.  Returned to member menu.	<pre>===== Top 3 Borrowed Movies ===== There are currently no movies in the movie collection. Press any key to return to the member menu.</pre>
Only 1 movie has been borrowed out by members	Top movie displayed.  Returned to member menu.	<pre>===== Top 3 Borrowed Movies ===== 1 - Revenge of the Sith - Total times borrowed: 2 2 - nil 3 - nil Press any key to continue...</pre>
Collection has 2 movies borrowed out by members	Top 2 movies displayed.  Returned to member menu.	<pre>===== Top 3 Borrowed Movies ===== 1 - Revenge of the Sith - Total times borrowed: 2 2 - Back To The Future 1 - Total times borrowed: 1 3 - nil Press any key to continue...</pre>

Collection has 3 or more movies borrowed out by members	Top 3 movies displayed.  Returned to member menu.	<pre> ===== Top 3 Borrowed Movies ===== 1 - Die Hard - Total times borrowed: 4 2 - Revenge of the Sith - Total times borrowed: 2 3 - Willy Wonker - Total times borrowed: 1 Press any key to continue... </pre>
"Willy Wonker" gets borrowed 2 times.	Top 3 movies displayed.  Returned to member menu.	<pre> ===== Top 3 Borrowed Movies ===== 1 - Die Hard - Total times borrowed: 4 2 - Willy Wonker - Total times borrowed: 3 3 - Revenge of the Sith - Total times borrowed: 2 Press any key to continue... </pre>
"Willy Wonker" gets borrowed another 2 times.	Top 3 movies displayed.  Returned to member menu.	<pre> ===== Top 3 Borrowed Movies ===== 1 - Willy Wonker - Total times borrowed: 5 2 - Die Hard - Total times borrowed: 4 3 - Revenge of the Sith - Total times borrowed: 2 Press any key to continue... </pre>
"Revenge of the Sith" gets borrowed 5 times.	Top 3 movies displayed.  Returned to member menu.	<pre> ===== Top 3 Borrowed Movies ===== 1 - Revenge of the Sith - Total times borrowed: 7 2 - Willy Wonker - Total times borrowed: 5 3 - Die Hard - Total times borrowed: 4 Press any key to continue... </pre>
New movie "The Clone Wars" gets borrowed 12 times.	Top 3 movies displayed.  Returned to member menu.	<pre> ===== Top 3 Borrowed Movies ===== 1 - The Clone Wars - Total times borrowed: 12 2 - Revenge of the Sith - Total times borrowed: 7 3 - Willy Wonker - Total times borrowed: 5 Press any key to continue... </pre>
"Willy Wonker" gets borrowed another 5 times.	Top 3 movies displayed.  Returned to member menu.	<pre> ===== Top 3 Borrowed Movies ===== 1 - The Clone Wars - Total times borrowed: 12 2 - Willy Wonker - Total times borrowed: 10 3 - Revenge of the Sith - Total times borrowed: 7 Press any key to continue... </pre>

## Bibliography

Prado, K. S. (2019, March 5). *Understanding time complexity with Python examples*. Retrieved from towardsdatascience.com: <https://towardsdatascience.com/understanding-time-complexity-with-python-examples-2bda6e8158a7>