Queensland University of Technology
CAB301 Algorithms and Complexity

Community Library

Java Software Application

Assignment 1

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1.0 Top 10 Most Frequently Borrowed Movie DVDs Algorithm

In order to implement an algorithm to display the top 10 most frequently borrowed movie DVDs, the program uses the decrease and conquer algorithm, Insertion Sort (Appendix A). To do so, the method divides the array, orderableArray, into two sections: a sorted section and an unsorted section. From there, each element is removed from the unsorted section and inserted to the sorted section at a position such that after insertion, the sorted section remains sorted. The numerical value used to perform this method is the Times Borrowed property of the Movie class. The pseudo code of this algorithm is demonstrated below:

```
Algorithm InsertionSort (Array[0...n - 1])
        For i ← 1 to n ← 1 do
                v ← Array[i]
                j ← i - 1
                While j ≥ 0 and Array[j] < v do
                        Array[j+1] ← Array[j]
                        j ← j - 1
                Array[j+1] ← v
```

In order to perform the above pseudo code, the Movie objects are extracted from the Binary Search Tree. To do so, each node in the Binary Search Tree is pushed into an array of Movie objects using the method depicted below:

```
private void TransformToArray(Node root) {
    if (root == null) {
        return;
    } else {
        TransformToArray(root.left);
        topTenListingArray[index++] = root.movie;
        TransformToArray(root.right);
    }
}
```

TransformToArray method Line 188 in Movie Collection class (MovieCollection.java)

From there, another function takes the output of the Insertion Sort method and takes the first ten elements to display as a list to the user in the console.

```
public void GetTopTen(Node root) {
    index = 0;
    int numberOfMoviesCurrently = BSTCountRecursive(root);
    topTenListingArray = new Movie[numberOfMoviesCurrently];
    System.out.println("========== Top Ten Most Borrowed DVDs ==========\n");
    TransformToArray(root);
    InsertionSort(topTenListingArray);
    for (int i = 0; i < 10; i++) {
        if (topTenListingArray[i] != null) System.out.println(topTenListingArray[i].getMovieTitle()
                + ", Borrowed:" + topTenListingArray[i].getTimesBorrowed());
    }
    System.out.println("\n");
}
```

GetTopTen method Line 177 in Movie Collection class (MovieCollection.java)

2.0 Analysis of Time Complexity

Too fully grasp the time complexity of using an Insertion Sort algorithm to identify the top 10 most frequently borrowed DVDs depends on the nature of the input (Levitin, 2012)). Specifically, the implementation in this program may require a significantly large number of inputs if the user so desires. On initial build, however, the algorithm will only handle a small number of movies to sort. The best case scenario is an input in which the array is already sorted and will result in a linear running time (O(*n*)). The time complexity of best case scenarios is exhibited below (Tang, 2020):

Figure 2.1 Insertion Sort Best Case

$$C_{best}(n) = \sum_{i=1}^{n-1} 1 = n - 1 \in \Theta(n).$$

However this is unlikely to be the case as the DVDs are added randomly and in a non-alphabetical nature. Conversely, the worst case scenario is an input in which an array is in reverse order, whereby each element is smaller than that of the element before it, giving it a quadratic running time ((O(n^2)). The time complexity of worst case scenarios is exhibited below (Tang, 2020):

Figure 2.2 Insertion Sort Worst Case

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

As previously mentioned, the DVDs are added randomly and therefore, it is unlikely for this scenario to occur. Thus, due to the relatively small length of the array input and it's random nature, the Insertion Sort algorithm will exhibit an average case efficiency. This is due to the notion that randomly ordered arrays make on average half as many comparisons to decreasing arrays as previously discussed as worst case scenarios (Levitin, 2012)). The time complexity of this algorithm is exhibited below (Tang, 2020):

Figure 2.3 Insertion Sort Average Case

$$C_{avg}(n) \approx \frac{n^2}{4} \in \Theta(n^2).$$

3.0 Functional Testing Results

Figure 3.1 Table of Functional Testing Results

Functionality	Screenshot	Result
Main Menu		

Staff Login Functionality:
User selects menu option '1' to login as a staff member. Console prompts the user to enter username and password (Figure 1.0).
 	
An error message will alert the user if the login details are incorrect. If so, the user will be redirected back to main menu selection to allow user full mobility if the staff login details are unknown (Figure 1.1).
 	
If login details are correct, the user is moved to the Staff Menu (Figure 1.0).
	Figure 1.0 Username and password input
	`Welcome to the community library!`
	`======== Menu Selection ========`
	`1. Staff Menu`
	`2. Member Menu`
	`0. Exit`
	`==============================`
	
	`Please make a selection (1-2, or 0 to exit):`
	`1`
	`========== Please enter login details ==========`
	
	`Enter staff username:`
	
	`staff`
	`Enter staff password:`
	
	`today123`
	`========== Staff Menu ==========`
	`1. Add a new movie DVD`
	`2. Remove a movie DVD`
	`3. Register a new Member`
	`4. Find a registered phone number using Member's full name`
	`0. Log out & return to main menu`
	`==============================`
	
	`Please make a selection (1-4, or 0 to return to the main menu):`
		PASS

Edge cases:
● Using symbols, special characters, or numerical digits does not cause a runtime error (Figure 1.1).
● Incorrect login credentials redirects the user back to main menu selection to allow full user mobility.
	Figure 1.1 Symbols, special characters, and numerical inputs
	`Welcome to the community library!`
	`======== Menu Selection ========`
	`1. Staff Menu`
	`2. Member Menu`
	`0. Exit`
	`==============================`
	
	`Please make a selection (1-2, or 0 to exit):`
	`1`
	`========== Please enter login details ==========`
	
	`Enter staff username:`
	
	`123 _+$%`
	`Enter staff password:`
	
	`44))--:p`
	`Staff login incorrect! Please use username: staff, password: today123`
		PASS

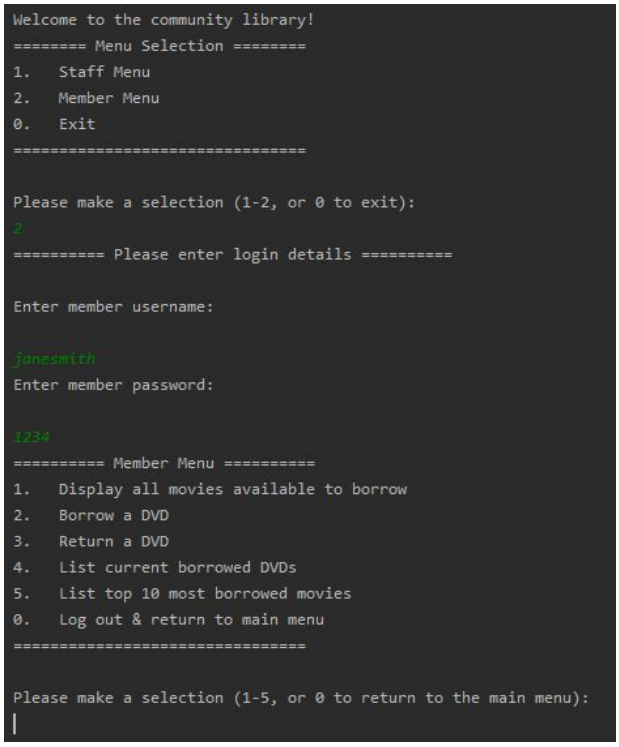
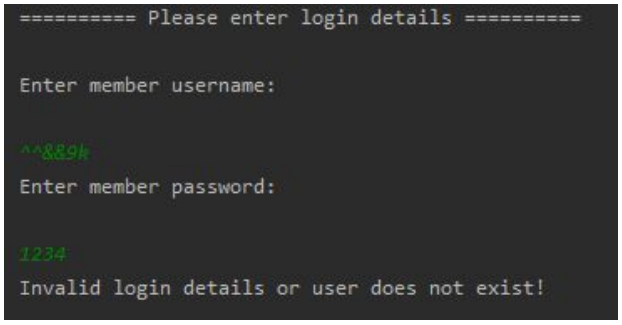
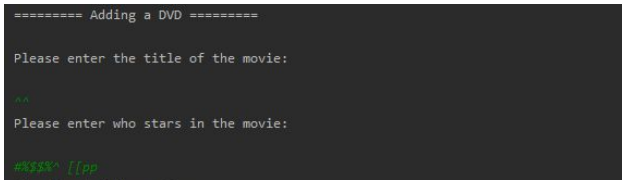
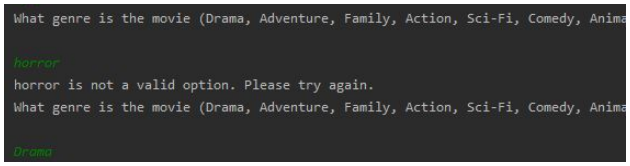
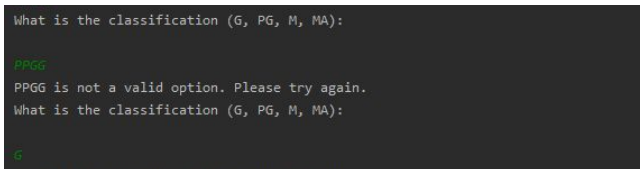
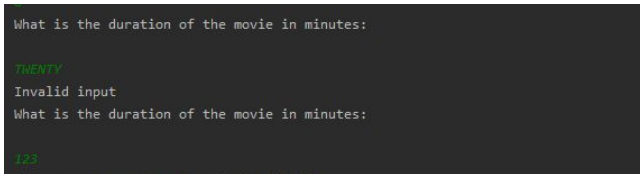
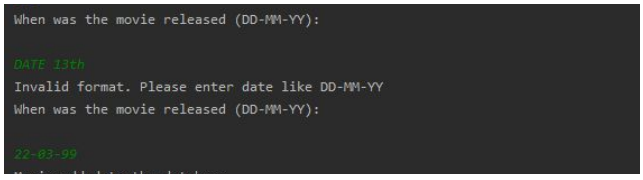
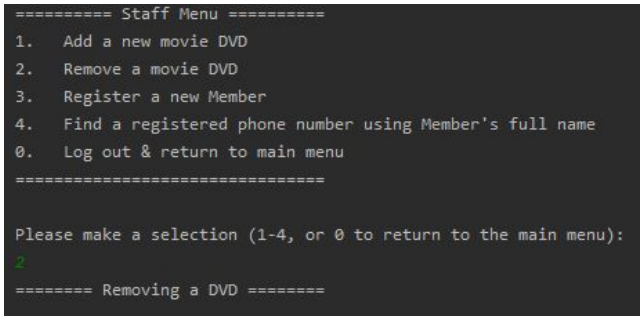
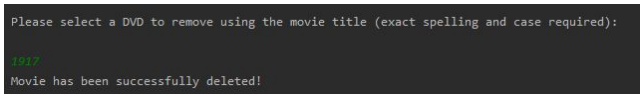
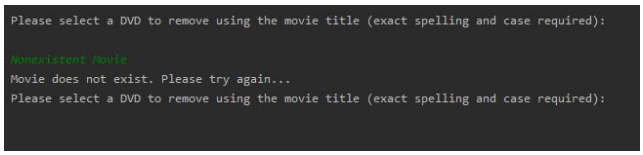
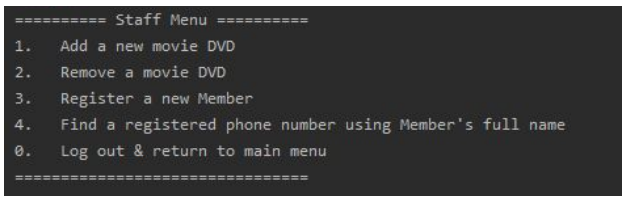
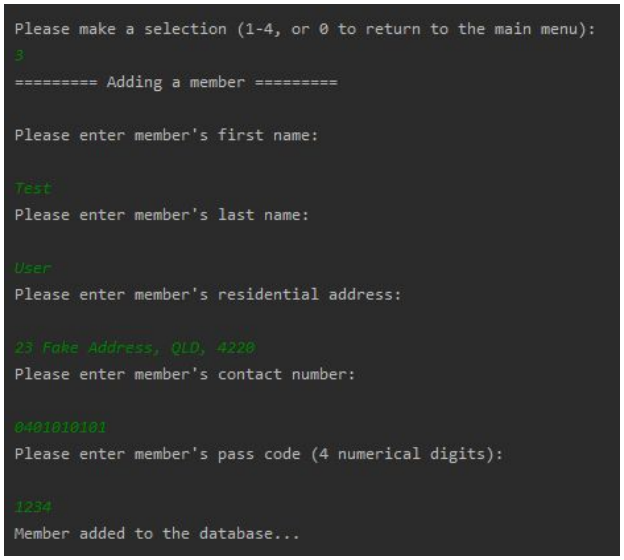
Member Login Functionality: User selects menu option '2' to login as a member. Console prompts the user to enter username and password (Figure 2.0). An error message will alert the user if the login details are incorrect or the user does not exist. If so, the user will be redirected back to main menu selection to allow user full mobility if the member login details are unknown. If login details are correct, the user is moved to the Member Menu.	Figure 2.0 Username & password input 	PASS
Edge Cases: ● Using symbols, special characters, or numerical digits does not cause a runtime error (Figure 2.1). ● Incorrect login credentials prompts an error message and redirects the user back to main menu selection to allow full user mobility (figure 2.2). ● If the user enters a password that is not a valid four digit numerical password, an error message alerts the user and the user is prompted to re-enter the password (Figure 2.3).	Figure 2.1 Symbols, special characters, and numerical inputs  Figure 2.2 Invalid login details 	

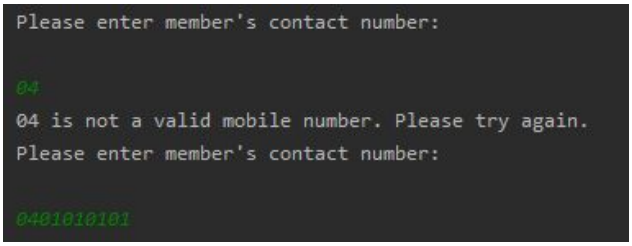
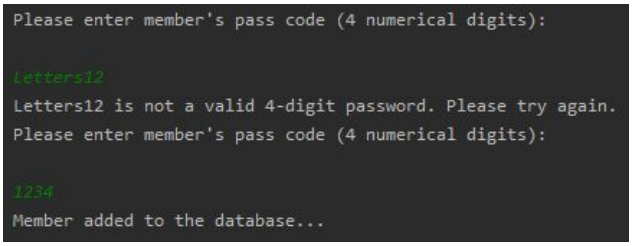
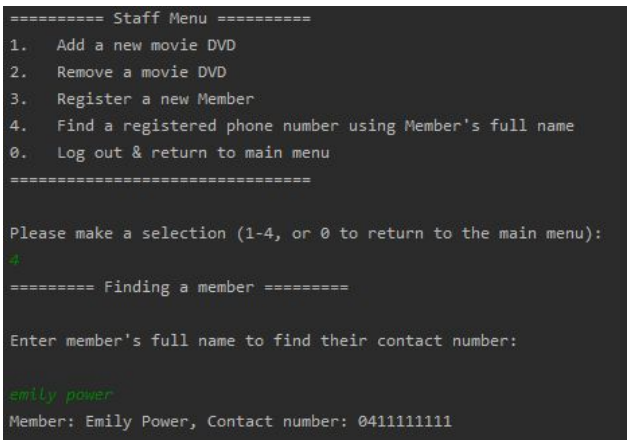
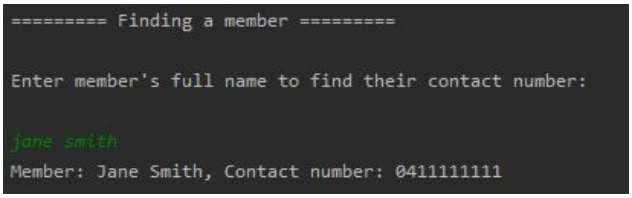
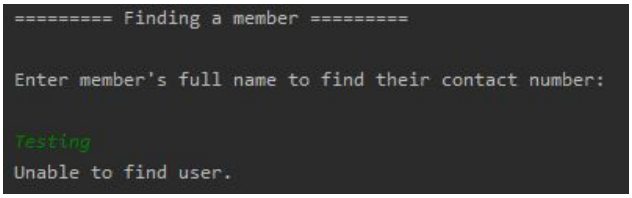
	Figure 2.3 Invalid 4-digit password
	`========== Please enter login details ==========`
	
	`Enter member username:`
	
	`test`
	`Enter member password:`
	
	`wrong`
	`wrong is not a valid 4-digit password. Please try again.`
	`Enter member password:`	

Staff Menu		

Add DVD Functionality:
User selects menu option '1' to add a new DVD as a staff member. Console prompts the user to enter the movie title, starring actors, the director, the genre, the classification, the duration, and the release date (Figure 3.0).
 	
Movies are added to the binary search tree alphabetically (Figure 3.1).
	Figure 3.0 Movie information input
	`========== Staff Menu ==========`
	`1. Add a new movie DVD`
	`2. Remove a movie DVD`
	`3. Register a new Member`
	`4. Find a registered phone number using Member's full name`
	`0. Log out & return to main menu`
	`================================`
	
	`Please make a selection (1-4, or 0 to return to the main menu):`
	`1`
	`========= Adding a DVD =========`
	
	`Please enter the title of the movie:`
	
	`Testing a Movie Title`
	`Please enter who stars in the movie:`
	
	`Some Fake Actor, Another Fake Actor`
	`Who directed the movie:`
	
	`A Fake Director`
	`What genre is the movie (Drama, Adventure, Family, Action, Sci-Fi, Comedy, Anim`
	
	`Action`
	`What is the classification (G, PG, M, MA):`
	
	`M`
	`What is the duration of the movie in minutes:`
	
	`129`
	`When was the movie released (DD-MM-YY):`
	
	`03-04-12`
	`Movie added to the database...`
	
	Figure 3.1 Alphabetical insertion (Appendix B)
	`Movie added to the database...`
	`Movies currently in the database...`
	`Movie Titled: 1917, Starring: Dean-Charles Chapman, Directed by: Sam Mendes, Duration of: 144 minutes, Genre: Drama, Classification: MA, Released: 16-01-20, Times borrowed: 0, Copies: 1`
	`Movie Titled: 2001 Space Odyssey, Starring: Keir Dullea, Directed by: Stanley Kubrick, Duration of: 149 minutes, Genre: Sci-Fi, Classification: M, Released: 02-05-68, Times borrowed: 0, Copies: 1`
	`Movie Titled: Alien, Starring: Sigourney Weaver, Directed by: Ridley Scott, Duration of: 177 minutes, Genre: Sci-Fi, Classification: MA, Released: 6-12-79, Times borrowed: 0, Copies: 1`
	`Movie Titled: Annihilation, Starring: Natalie Portman, Directed by: Alex Garland, Duration of: 120 minutes, Genre: Sci-Fi, Classification: M, Released: 13-02-18, Times borrowed: 0, Copies: 1`
	`Movie Titled: Blade Runner, Starring: Harrison Ford, Directed by: Ridley Scott, Duration of: 157 minutes, Genre: Action, Classification: MA, Released: 16-12-82, Times borrowed: 0, Copies: 1`
	`Movie Titled: Donnie Darko, Starring: Jake Gyllenhaal, Directed by: Richard Kelly, Duration of: 113 minutes, Genre: Drama, Classification: M, Released: 17-10-02, Times borrowed: 0, Copies: 1`
	`Movie Titled: Forrest Gump, Starring: Tom Hanks, Directed by: Robert Zemeckis, Duration of: 142 minutes, Genre: Drama, Classification: M, Released: 17-11-94, Times borrowed: 0, Copies: 1`
	`Movie Titled: Interstellar, Starring: Matthew McConaughey, Directed by: Christopher Nolan, Duration of: 154 minutes, Genre: Sci-Fi, Classification: M, Released: 09-07-14, Times borrowed: 0, Copies: 1`
	`Movie Titled: Joker, Starring: Joaquin Phoenix, Directed by: Todd Phillips, Duration of: 102 minutes, Genre: Thriller, Classification: MA, Released: 03-10-19, Times borrowed: 0, Copies: 1`
	`Movie Titled: Marriage Story, Starring: Adam Driver, Directed by: Noah Baumbach, Duration of: 147 minutes, Genre: Drama, Classification: M, Released: 06-12-19, Times borrowed: 0, Copies: 1`
	`Movie Titled: Parasite, Starring: Kang-ho Song, Directed by: Bong Joon Ho, Duration of: 132 minutes, Genre: Thriller, Classification: MA, Released: 30-05-19, Times borrowed: 0, Copies: 1`
		PASS

Edge Cases: ● Using symbols, special characters, or numerical digits does not cause a runtime error (Figure 3.2). ● Entering a genre that is not a listed option prompts the user to try again (cases ignored) (Figure 3.3). ● Entering a classification that is not a listed option prompts the user to try again (cases ignored) (Figure 3.4). ● Entering a duration that is not a numerical digit prompts the user to try again (Figure 3.5). ● Entering a date that does not follow the DD-MM-YY convention prompts the user to try again (Figure 3.6). ● If a movie is added with the exact same movie title as a movie that already exists, a new copy is added to the existing movie (Figure 3.7)	Figure 3.2 Symbols, special characters, and numerical inputs  Figure 3.3 Invalid genre input  Figure 3.4 Invalid classification input  Figure 3.5 Invalid duration input  Figure 3.6 Invalid date input  Figure 3.7 Adding another copy (Appendix D) 	PASS
Remove DVD Functionality: User selects menu option '2' to remove an existing DVD as a staff member. Console prompts the user to enter the movie title with exact spelling and casing (Figure 4.0). In addition to a success message, the console will display all existing movies in the database before and after removal to demonstrate	Figure 4.0 Remove movie input 	PASS

the removal has occurred successfully.	Figure 4.1 Success message 	
Edge Cases: ● Console does not allow the removal of a movie that does not exist and prompts the user to try again (Figure 4.2).	Figure 4.2 Removal of a nonexistent movie 	PASS
Registration Functionality: User selects menu option '3' to register a new member as a staff member. Console prompts the user to enter the member's first and last name, residential address, and 4-digit pass code (Figure 5.0). The username is generated by combining the member's first and last name and is shown after the member is added to the database (Figure 5.1)	Figure 5.0 Register new user input   Figure 5.1 Overview of existing members (Appendix C) 	PASS

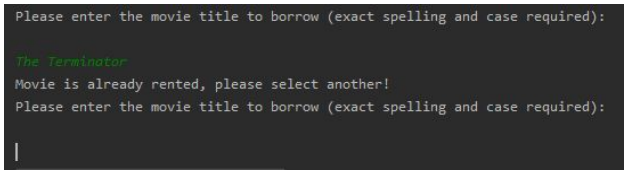
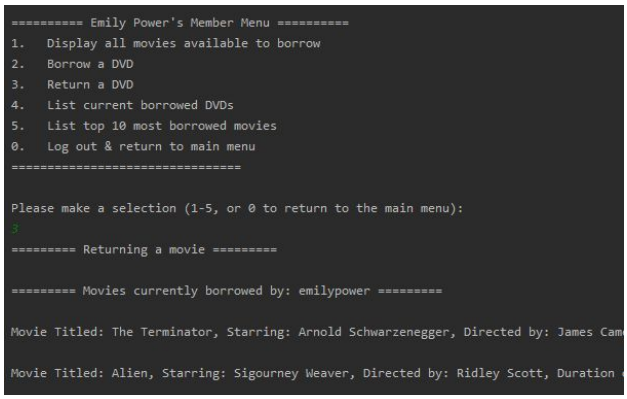
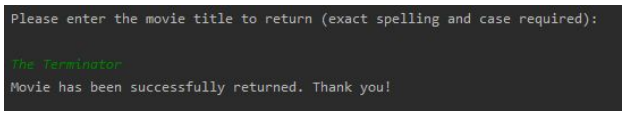
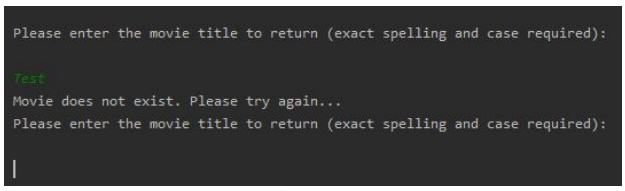
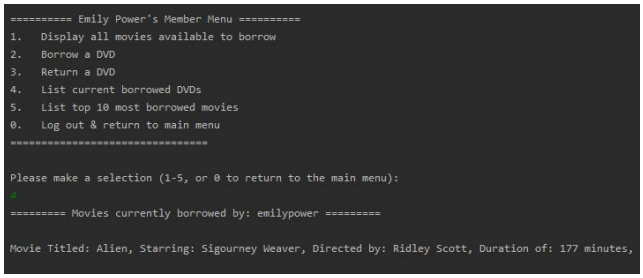
Edge Cases: ● Console does not allow a contact number that is not equal to ten numerical digits (Figure 5.2). ● Console does not allow a password that is not four numerical digits (Figure 5.3). ● Console will add a new user even if a user exists under the same name.	Figure 5.2 Invalid contact number  Figure 5.3 Invalid 4-digit password 	PASS
Find Member Functionality User selects menu option '4' to find a member's contact number using the member's full name as a staff member. Console prompts the user to enter the member's first and last name (Figure 6.0).	Figure 6.0 Find member input 	PASS
Edge Cases: ● Console is not case sensitive when searching through member's using the user's input. ● If the program cannot find the user, the user is given an error message and returned to the menu.	Figure 6.1 Case Sensitivity  Figure 6.2 Unable to find user 	PASS

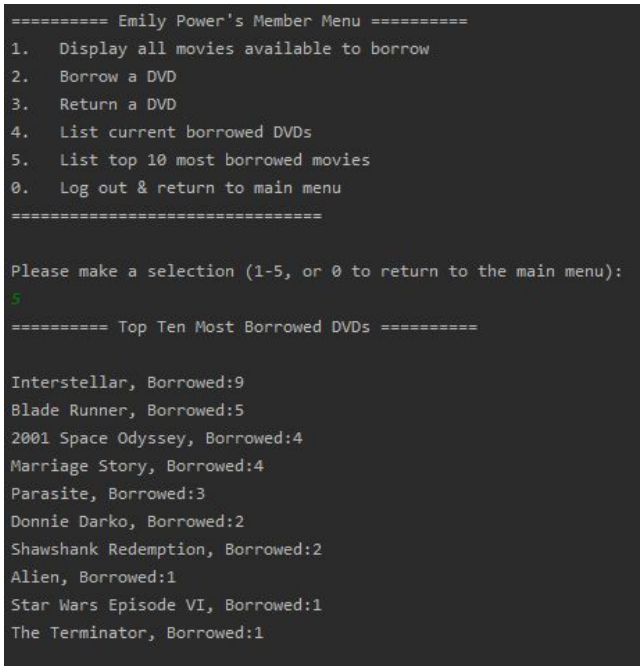
Member Menu		

Display DVD Functionality:
User selects menu option '1' to display all the information about all the DVD's in alphabetical order of the movie title, including the number of copies currently in the library (Figure 7.0).
	Figure 7.0 Display all information
	`========== Emily Power's Member Menu ==========`
	`1. Display all movies available to borrow`
	`2. Borrow a DVD`
	`3. Return a DVD`
	`4. List current borrowed DVDs`
	`5. List top 10 most borrowed movies`
	`0. Log out & return to main menu`
	`================================`
	`Please make a selection (1-5, or 0 to return to the main menu):`
	`1`
	7.1 Alphabetical order and copies (Appendix B).
	 
		PASS

DVD Borrow Functionality:
User selects menu option '2' to borrow a DVD, given the title of the DVD (Figure 8.0).
	Figure 9.0 Borrowing a DVD
	`========== Emily Power's Member Menu ==========`
	`1. Display all movies available to borrow`
	`2. Borrow a DVD`
	`3. Return a DVD`
	`4. List current borrowed DVDs`
	`5. List top 10 most borrowed movies`
	`0. Log out & return to main menu`
	`================================`
	`Please make a selection (1-5, or 0 to return to the main menu):`
	`2`
	`========= Borrowing a movie =========`
	`All movies currently in the database...`
	`Please enter the movie title to borrow (exact spelling and case required):`
	`The Terminator`
	`Movie has successfully been borrowed. Enjoy!`
	`========= Movies currently borrowed by: emilypower =========`
	`Movie Titled: The Terminator, Starring: Arnold Schwarzenegger, Directed by: J`
		PASS

Edges Cases:
● If the program cannot find the movie, an error message is shown and the user is prompted to try again (Figure 9.1).
● If the selected movie is already rented (no available copies), the user is shown an error
	Figure 9.1 Unable to find requested DVD
	`Please enter the movie title to borrow (exact spelling and case required):`
	`Test`
	`Movie does not exist. Please try again...`
	`Please enter the movie title to borrow (exact spelling and case required):`
	Figure 9.2 Movie already rented
		PASS

message and the user is prompted to try again (Figure 9.2).		
DVD Return Functionality: User selects menu option '3' to return a DVD, given the title of the DVD (Figure 9.0).	Figure 9.0 Returning a DVD  	PASS
Edges Cases: ● If the given movie title does not exist in the user's borrowed movies account, an error message is shown and the user is prompted to try again (Figure 9.1).	Figure 9.1 Returning a DVD that does not exist 	PASS
List Currently Rented DVDs Functionality: User selects menu option '4' to view the currently rented DVDs for the logged in user (Figure 10.0).	Figure 10.0 Currently rented DVDs 	PASS

Top 10 Frequently Borrowed DVDs Functionality: User selects menu option '5' to display the top 10most frequently borrowed DVDs by the members in descending order of the frequency. The list depicts the movie title and the number of times the DVD has been borrowed by members (Figure 11.0).	Figure 11.0 Top 10 frequently borrowed 	PASS
Edge Cases: ● If there are not enough movies to satisfy "top 10" (whereby most movies have had 0 copies borrowed, the algorithm will show ten DVDs based on alphabetical order nonetheless.	Figure 11.1 Case where all movies have 0 times borrowed 	PASS

4.0 References

Levitin, A. (2012). Introduction to The Design & Analysis of Algorithms (3rd ed.) Pearson.

Tang, M. (2020, May 5). CAB301 Algorithms and Complexity: Lecture 4 [Lecture notes] https://blackboard.qut.edu.au/webapps/blackboard/content/listContent.jsp?course_id=_148986_1&content_id=_8458173_1

5.0 Appendix

Appendix A

```
private void InsertionSort(Movie[] orderableArray) {
    int n = orderableArray.length;
    for (int i = 1; i < n; i++) {
        Movie key = orderableArray[i];
        int j = i - 1;
        while (j >= 0 && orderableArray[j].getTimesBorrowed() < key.getTimesBorrowed()) {
            orderableArray[j + 1] = orderableArray[j];
            j = j - 1;
        }
        orderableArray[j + 1] = key;
    }
}
```

Insertion Sort method on Line 176 in Movie Collection class (MovieCollection.java).

Appendix B

Alphabetical sorting of movies aftering inserting into the binary search tree

Appendix C

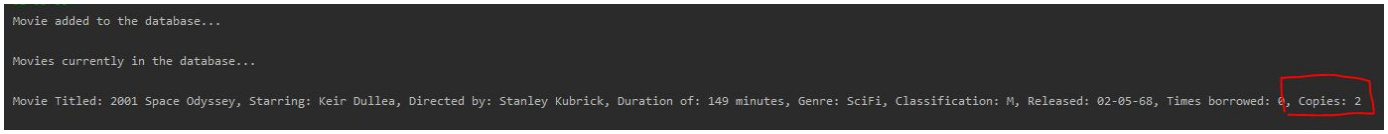
```
Member added to the database...

Members currently in the database...

Name: Jane Smith, Residential address: 44 Random Street, Contact number: 0067643665, Username: janesmith, Password: 1234
Name: John Smith, Residential address: 88 London Ave, Contact number: 0067643665, Username: johnsmith, Password: 1234
Name: Emily Power, Residential address: 66 Bell Cresent, Contact number: 0067643665, Username: emilypower, Password: 1234
Name: Audrey Niffenegger, Residential address: 123 Fake Street, Contact number: 0067643665, Username: audreyniffenegger, Password: 1234
Name: Mark Manson, Residential address: U9/99 Cornell Court, Contact number: 0067643665, Username: markmanson, Password: 1234
Name: Test User, Residential address: 23 Fake Address, QLD, 4220, Contact number: 0401010101, Username: TestUser, Password: 1234
```

Members currently stored in the database shown after registering a new user

Appendix D



Movie added to the database with exact title as an existing movie adds a new copy