

CAB301 Algorithms and Complexity - Semester 1 2020

# Development of a Software Application for a Community Library to Manage its Movie DVDs

Written in  $\text{\LaTeX}$



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# 1 Top 10 most frequently borrowed movie algorithm

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## Return top 10 Movies( $\mathcal{B}[m(\text{root})]$ )

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```
//Uses a generic BinarySearchTree class I created
//This class is iterable using in-order traversal
//Uses a MoviePair class to store name of movie and number of borrows
//MoviePair comparable such that MoviePair objects with more borrows are seen as
//being less than those with less borrows
//Input: A Binary Search Tree of Movies
//Output: An array of MoviePair associated with the top ten Movies
1:  $\mathcal{T}[mp] \leftarrow \emptyset$  //Initialized BST of MoviePair with root null
2:  $A[0..9] \leftarrow \emptyset$  //Initializes empty array of 10 items
3: for each  $m \in \mathcal{B}$  do //For each Movie in the BST of Movies
4:    $mp \leftarrow m[m.name, m.borrows]$ 
5:    $\mathcal{T}[mp].addNode(mp)$ 
6:  $i \leftarrow 0$ 
7: for each  $mp \in \mathcal{T}[mp]$  do
8:   if  $i = 10$  then
9:     break
10:   $A[i] \leftarrow mp$ 
11:   $i \leftarrow i + 1$ 
12: return  $A[0..9]$ 
```

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## 2 Analysis of the Top 10 Algorithm

In examining the first for loop the either operation  $mp \leftarrow m[m.name, m.borrows]$  or  $\mathcal{T}[mp].addNode(mp)$  could be consider the basic operations. These basic operations are in a for loop which iterates over each node in the input Binary Search Tree. Since the number of movies in the BST equates to the input size  $n$  then the time complexity of the first for loop could be consider  $c(n) = n$ . Now since the second for loop contains a break within it that breaks after 10 iterations. Its complexity can therefore be considered a constant and does not need to be considered. Thus leaving the efficiency as  $c(n) = n$  and the asymptotic efficiency class as  $c(n) = \Theta(n)$ . It has to be noted however, despite this all being said, the addNode function itself would not have be of constant time complexity. In fact the time complexity of addNode would at worst case of about  $c(n) = \mathcal{O}(n)$ . This is because  $n$  would relate closely to the general hight of tree. In general the taller the tree the more nodes need to be traversed before a valid spot can be found to add a new node. Since potentially in the worst case each consecutively added node could be for example smaller then every previous one. This situation would result in every node being needed to be traversed every add and thus result in the time complexity of  $n$ . Due to this, the entire algorithm which iterates over addNode a worst case of  $n$  a total of  $n$  number of times therefore has a time complexity of  $c(n) = n^2$  in the worst case.

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### 3 Demonstration of the Community Library Movie Management Software

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

Please make a selection (0-2, or 0 to return to main menu): 1
Enter username: staff
Enter Password: today12
Invalid Credentials

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

Please make a selection (0-2, or 0 to return to main menu): 1
Enter username: staff
Enter Password: today123

=====Staff Menu=====
1. Add a new movie DVD
2. Remove a movie DVD
3. Register a new member
4. Find a registered member's phone number
0. Return to main menu
=====

Please make a selection (0-4, or 0 to return to main menu):
```

Figure 1: Logging in as a staff member

As can be seen when logging in with invalid credentials the access is refused. When logging in with the valid staff credentials the user is returned the staff menu

```
=====Staff Menu=====
1. Add a new movie DVD
2. Remove a movie DVD
3. Register a new member
4. Find a registered member's phone number
0. Return to main menu
=====

Please make a selection (0-4, or 0 to return to main menu): 1
Enter the movie title: Avatar
Enter the starring actors(s): Actor1, Actor 2
Enter the director(s): Director 1, Director 2

Select the genre:
1. Drama
2. Adventure
3. Family
4. Action
5. Sci-Fi
6. Comedy
7. Animation
8. Thriller
9. Other
Make selection(1-9): 3

Select the classification:
1. General (G)
2. Parental Guidance (PG)
3. Mature (M15+)
4. Mature Accompanied (MA15+)
Make Selection(1-4): 2
Enter the duration (minutes): 150
Enter the release date (year): 2010
Enter the number of copies available: 5

Avatar has been added.
```

Figure 2: Staff creating a new movie

The user can then select 1 in order to add a new movie. They are then presented with a series of prompts in order to select the movie attributes. These include the movie title, list of directors, a list of actors, the genre, classification, duration, release date and available copies

```

5. Sci-Fi
6. Comedy
7. Animation
8. Thriller
9. Other
Make selection(1-9): 3

Select the classification:
1. General (G)
2. Parental Guidance (PG)
3. Mature (M15+)
4. Mature Accompanied (MA15+)
Make Selection(1-4): 2
Enter the duration (minutes): 150
Enter the release date (year): 2010
Enter the number of copies available: 5

Avatar has been added.

=====Staff Menu=====
1. Add a new movie DVD
2. Remove a movie DVD
3. Register a new member
4. Find a registered member's phone number
0. Return to main menu
=====

Please make a selection (0-4, or 0 to return to main menu): 1
Enter the movie title: Avatar
Enter the number of copies you would like to add: 5
There are now 10 copies of Avatar

=====Staff Menu=====
1. Add a new movie DVD
2. Remove a movie DVD
3. Register a new member
4. Find a registered member's phone number
0. Return to main menu
=====

Please make a selection (0-4, or 0 to return to main menu):

```

Figure 3: Adding copies to the movie

If the user re-enters the number 1 once returned back to the staff menu and then enters an existing movie. As can be seen they can add additional copies of the movie.

```

Enter the movie title: Avatar
Enter the number of copies you would like to add: 5
There are now 10 copies of Avatar

=====Staff Menu=====
1. Add a new movie DVD
2. Remove a movie DVD
3. Register a new member
4. Find a registered member's phone number
0. Return to main menu
=====

Please make a selection (0-4, or 0 to return to main menu): 3
Enter member's first name: John
Enter member's last name: Smith
Enter member's address: 1 James st
Enter member's phone number: 0123456789
Enter member's password(4 digits): 1234
Successfully added John Smith
=====Staff Menu=====
1. Add a new movie DVD
2. Remove a movie DVD
3. Register a new member
4. Find a registered member's phone number
0. Return to main menu
=====

Please make a selection (0-4, or 0 to return to main menu): 4
Please enter member's first name: John
Please enter member's last name: Smith
John Smith's number is 123456789

=====Staff Menu=====
1. Add a new movie DVD
2. Remove a movie DVD
3. Register a new member
4. Find a registered member's phone number
0. Return to main menu
=====

Please make a selection (0-4, or 0 to return to main menu): |

```

Figure 4: Creating a New User and Searching for their number

From the staff menu the user can also add a user by entering 3. They are then prompted to enter the following details about the user: first name, last name, address, number, and a four digit password. As seen above once the user is created their number can also be retrieved.

```

Please enter member's last name: Smith
John Smith's number is 123456789

=====Staff Menu=====
1. Add a new movie DVD
2. Remove a movie DVD
3. Register a new member
4. Find a registered member's phone number
0. Return to main menu
=====

Please make a selection (0-4, or 0 to return to main menu): 3
Enter member's first name: John
Enter member's last name: Smith
John Smith has already registered.

=====Staff Menu=====
1. Add a new movie DVD
2. Remove a movie DVD
3. Register a new member
4. Find a registered member's phone number
0. Return to main menu
=====

Please make a selection (0-4, or 0 to return to main menu): 1
Enter the movie title: BeeMovie
Enter the staring actors(s): MoreActors
Enter the director(s): aDirector

Select the genre:
1. Drama
2. Adventure
3. Family
4. Action
5. Sci-Fi
6. Comedy
7. Animation
8. Thriller
9. Other
Make selection(1-9): 4

```

Figure 5: Registering a user a second time

As can be seen, a user of the same name cannot be added to the system twice. After which two a couple more movie where create for demonstration

```

=====

Please make a selection (0-4, or 0 to return to main menu): 0

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

Please make a selection (0-2, or 0 to return to main menu): 2
username: LastnameFirstname
Enter username: SmithJohn
Enter Password: 1244
Invalid Credentials

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

Please make a selection (0-2, or 0 to return to main menu): 2
username: LastnameFirstname
Enter username: SmithJohn
Enter Password: 1234

=====Member Menu=====
1. Display all movies
2. Borrow a movie DVD
3. Return a movie DVD
4. List current borrowed movie DVDs
5. Display top 10 most popular movies
0. Return to main menu
=====

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

```

Figure 6: Logging in as a member

Using 0 to return to the main menu a user can then log in with as an existing staff menu provided the correct password is provided.



---

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

```
Title: Avatar
Starring: Actor1, Actor 2
Director(s): Director 1, Direcotor 2
Genre: Family
Classification: Parental Guidance (PG)
Release Date: 2010
Duration: 150 minutes
Copies Available: 10
Times Rented: 0
```

```
Title: BeeMovie
Starring: MoreAcotrs
Director(s): aDirector
Genre: Action
Classification: Parental Guidance (PG)
Release Date: 2010
Duration: 200 minutes
Copies Available: 5
Times Rented: 0
```

```
Title: Cast Away
Starring: one Actor, two Actor
Director(s): director
Genre: Thriller
Classification: Mature Accompanied (MA15+)
Release Date: 2009
Duration: 200 minutes
Copies Available: 1
Times Rented: 0
```

```
Title: Godzila
Starring: actor
Director(s): director
Genre: Sci-Fi
Classification: Mature (M15+)
Release Date: 2008
```

Figure 7: Displaying Movies Alphabetically

From the member menu a user can display movies by entering the number 1. As can be seen each movie is displayed with all its information and in alphabetical order.

```
Duration: 60 minutes
Copies Available: 0
Times Rented: 0

=====Member Menu=====
1. Display all movies
2. Borrow a movie DVD
3. Return a movie DVD
4. List current borrowed movie DVDs
5. Display top 10 most popular movies
0. Return to main menu
=====

Please make a selection (0-5, or 0 to return to main menu): 2
Please enter the movie you wish to borrow: Cast Away
You have borrowed the movie Cast Away

=====Member Menu=====
1. Display all movies
2. Borrow a movie DVD
3. Return a movie DVD
4. List current borrowed movie DVDs
5. Display top 10 most popular movies
0. Return to main menu
=====

Please make a selection (0-5, or 0 to return to main menu): 3
Enter the movie you wish to return: Godzilla
Invalid movie name

=====Member Menu=====
1. Display all movies
2. Borrow a movie DVD
3. Return a movie DVD
4. List current borrowed movie DVDs
5. Display top 10 most popular movies
0. Return to main menu
=====

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

Figure 8: Borrowing a movie

Once back at the staff menu that the user is returned, they can select 2 and enter the name of the movie they wish to borrow. Notice if the movie is a movie that has no copies available, such as Godzilla. The user is unable to borrow it.

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

Title: Avatar
Starring: Actor1, Actor 2
Director(s): Director 1, Direcotor 2
Genre: Family
Classification: Parental Guidance (PG)
Release Date: 2010
Duration: 150 minutes
Copies Available: 10
Times Rented: 0

Title: BeeMovie
Starring: MoreAcotrs
Director(s): aDirector
Genre: Action
Classification: Parental Guidance (PG)
Release Date: 2010
Duration: 200 minutes
Copies Available: 5
Times Rented: 0

Title: Cast Away
Starring: one Actor, two Actor
Director(s): director
Genre: Thriller
Classification: Mature Accompanied (MA15+)
Release Date: 2009
Duration: 200 minutes
Copies Available: 0
Times Rented: 1

Title: Godzilla
Starring: actor
Director(s): director
Genre: Sci-Fi
Classification: Mature (M15+)
Release Date: 2008
```

Figure 9: Times rented incremented and copies available is decremented

Now notice that since Cast Away has now been borrowed their are now no longer any copies available. Also since it was rented its now been recorded that its been rented once.

```

=====

Please make a selection (0-5, or 0 to return to main menu): 4
You have borrowed the following movies:
Cast Away

=====Member Menu=====
1. Display all movies
2. Borrow a movie DVD
3. Return a movie DVD
4. List current borrowed movie DVDs
5. Display top 10 most popular movies
0. Return to main menu
=====

Please make a selection (0-5, or 0 to return to main menu): 3
Enter the movie you wish to return: Cast Away
You returned the movie Cast Away

=====Member Menu=====
1. Display all movies
2. Borrow a movie DVD
3. Return a movie DVD
4. List current borrowed movie DVDs
5. Display top 10 most popular movies
0. Return to main menu
=====

Please make a selection (0-5, or 0 to return to main menu): 4
You have no borrowed movies

=====Member Menu=====
1. Display all movies
2. Borrow a movie DVD
3. Return a movie DVD
4. List current borrowed movie DVDs
5. Display top 10 most popular movies
0. Return to main menu
=====

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

```

Figure 10: Listing borrowed movies

From the member menu it can be seen above that by entering 4 the member can view their borrowed movies. Notice that it lists the movie Cast Away then after returning the movie using 3 and entering the name again. It now states that they have no borrowed movies.

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

Title: Avatar
Starring: Actor1, Actor 2
Director(s): Director 1, Direcotor 2
Genre: Family
Classification: Parental Guidance (PG)
Release Date: 2010
Duration: 150 minutes
Copies Available: 10
Times Rented: 0

Title: BeeMovie
Starring: MoreAcotrs
Director(s): aDirector
Genre: Action
Classification: Parental Guidance (PG)
Release Date: 2010
Duration: 200 minutes
Copies Available: 5
Times Rented: 0

Title: Cast Away
Starring: one Actor, two Actor
Director(s): director
Genre: Thriller
Classification: Mature Accompanied (MA15+)
Release Date: 2009
Duration: 200 minutes
Copies Available: 1
Times Rented: 1

Title: Godzilla
Starring: actor
Director(s): director
Genre: Sci-Fi
Classification: Mature (M15+)
Release Date: 2008
```

Figure 11: Copies incremented again once movie returned

Notice now that the movie Cast Away now has copies available since its been returned

---

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

```
Welcome to the Community Library
```

```
=====Main Menu=====
```

- 1. Staff Login
- 2. Member Login
- 0. Exit

```
=====
```

```
Please make a selection (0-2, or 0 to return to main menu): 1
```

```
Enter username: staff
```

```
Enter Password: today123
```

```
=====Staff Menu=====
```

- 1. Add a new movie DVD
- 2. Remove a movie DVD
- 3. Register a new member
- 4. Find a registered member's phone number
- 0. Return to main menu

```
=====
```

```
Please make a selection (0-4, or 0 to return to main menu): 2
```

```
Enter the name of the movie you wish to delete: Godzilla
```

```
The movie Godzilla was deleted.
```

```
=====Staff Menu=====
```

- 1. Add a new movie DVD
- 2. Remove a movie DVD
- 3. Register a new member
- 4. Find a registered member's phone number
- 0. Return to main menu

```
=====
```

```
Please make a selection (0-4, or 0 to return to main menu): 0
```

```
Welcome to the Community Library
```

```
=====Main Menu=====
```

- 1. Staff Login
- 2. Member Login
- 0. Exit

Figure 12: Deleting Movie

As seen above, entering zero returns the user to the main menu. Now a staff member logs in and by selecting 2 they are able to remove a movie. In this case its Godzilla

```
4. List current borrowed movie DVDs
5. Display top 10 most popular movies
0. Return to main menu
=====

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

Title: Avatar
Starring: Actor1, Actor 2
Director(s): Director 1, Direcoter 2
Genre: Family
Classification: Parental Guidance (PG)
Release Date: 2010
Duration: 150 minutes
Copies Available: 10
Times Rented: 0

Title: BeeMovie
Starring: MoreAcotrs
Director(s): aDirector
Genre: Action
Classification: Parental Guidance (PG)
Release Date: 2010
Duration: 200 minutes
Copies Available: 5
Times Rented: 0

Title: Cast Away
Starring: one Actor, two Actor
Director(s): director
Genre: Thriller
Classification: Mature Accompanied (MA15+)
Release Date: 2009
Duration: 200 minutes
Copies Available: 1
Times Rented: 1

=====Member Menu=====
```

Figure 13: Movie deleted

Now returning to the main menu, then logging in as a member again and displaying movies. It can be seen that the movie Godzilla is gone

---

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

Please make a selection (0-2, or 0 to return to main menu): 0
Exiting...
Process finished with exit code 0
```

Figure 14: Exiting

Now returning to the main menu again. It can be seen that by selecting 0, the program displays that its exiting before closing.



```
=====

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

Title: Movie1
Starring: Actor
Director(s): Director
Genre: Adventure
Classification: Mature Accompanied (MA15+)
Release Date: 2012
Duration: 50 minutes
Copies Available: 1
Times Rented: 1

Title: Movie10
Starring: Actor, Actor 2
Director(s): Director, Director 3
Genre: Adventure
Classification: Mature Accompanied (MA15+)
Release Date: 2012
Duration: 50 minutes
Copies Available: 5
Times Rented: 10

Title: Movie11
Starring: Actor, Actor 2
Director(s): Director, Director 3
Genre: Adventure
Classification: Mature Accompanied (MA15+)
Release Date: 2015
Duration: 70 minutes
Copies Available: 15
Times Rented: 5

Title: Movie2
Starring: Actor, Actor 2
Director(s): Director, Director 3
Genre: Adventure
Classification: Mature Accompanied (MA15+)
```

Figure 15: Restarting the program with the following hard coded movies  
The program was restarted and some movie where added as can be seen above

---

```
1
Title: Movie2
Starring: Actor, Actor 2
Director(s): Director, Director 3
Genre: Adventure
Classification: Mature Accompanied (MA15+)
Release Date: 2012
Duration: 50 minutes
Copies Available: 2
Times Rented: 2
```

```
Title: Movie3
Starring: Actor
Director(s): Director
Genre: Adventure
Classification: Mature Accompanied (MA15+)
Release Date: 2012
Duration: 50 minutes
Copies Available: 3
Times Rented: 3
```

```
Title: Movie4
Starring: Actor, Actor 2
Director(s): Director, Director 3
Genre: Adventure
Classification: Mature Accompanied (MA15+)
Release Date: 2012
Duration: 50 minutes
Copies Available: 4
Times Rented: 4
```

```
Title: Movie5
Starring: Actor, Actor 2
Director(s): Director, Director 3
Genre: Adventure
Classification: Mature Accompanied (MA15+)
Release Date: 2012
Duration: 50 minutes
Copies Available: 5
```

Figure 16: Restarting the program with the following hard coded moviec continued.

---

```
Title: Movie5
Starring: Actor, Actor 2
Director(s): Director, Director 3
Genre: Adventure
Classification: Mature Accompanied (MA15+)
Release Date: 2012
Duration: 50 minutes
Copies Available: 5
Times Rented: 5
```

```
Title: Movie6
Starring: Actor, Actor 2
Director(s): Director, Director 3
Genre: Adventure
Classification: Mature Accompanied (MA15+)
Release Date: 2012
Duration: 50 minutes
Copies Available: 5
Times Rented: 6
```

```
Title: Movie7
Starring: Actor, Actor 2
Director(s): Director, Director 3
Genre: Adventure
Classification: Mature Accompanied (MA15+)
Release Date: 2012
Duration: 50 minutes
Copies Available: 5
Times Rented: 7
```

```
Title: Movie8
Starring: Actor, Actor 2
Director(s): Director, Director 3
Genre: Adventure
Classification: Mature Accompanied (MA15+)
Release Date: 2012
Duration: 50 minutes
Copies Available: 5
```

Figure 17: Restarting the program with the following hard coded movie continued..

```
Copies Available: 5
Times Rented: 8

Title: Movie9
Starring: Actor, Actor 2
Director(s): Director, Director 3
Genre: Adventure
Classification: Mature Accompanied (MA15+)
Release Date: 2012
Duration: 50 minutes
Copies Available: 5
Times Rented: 9

=====Member Menu=====
1. Display all movies
2. Borrow a movie DVD
3. Return a movie DVD
4. List current borrowed movie DVDs
5. Display top 10 most popular movies
0. Return to main menu
=====

Please make a selection (0-5, or 0 to return to main menu): 5
Top 10 Most Frequently Borrowed Movies:
Movie10 borrowed 10 times.
Movie9 borrowed 9 times.
Movie8 borrowed 8 times.
Movie7 borrowed 7 times.
Movie6 borrowed 6 times.
Movie5 borrowed 5 times.
Movie11 borrowed 5 times.
Movie4 borrowed 4 times.
Movie3 borrowed 3 times.
Movie2 borrowed 2 times.

=====Member Menu=====
1. Display all movies
2. Borrow a movie DVD
3. Return a movie DVD
```

Figure 18: Displaying the top 10 movies

From the member menu the ability to display the top 10 most frequently borrowed movies. As can be seen above, it displays each movie name in order from most to least borrowed.

```
Please make a selection (0-5, or 0 to return to main menu): 4
You have borrowed the following movies:
Movie1
Movie10
Movie2
Movie3
Movie4
Movie5
Movie6
Movie7
Movie8
Movie9
```

```
=====Member Menu=====
1. Display all movies
2. Borrow a movie DVD
3. Return a movie DVD
4. List current borrowed movie DVDs
5. Display top 10 most popular movies
0. Return to main menu
=====
```

```
Please make a selection (0-5, or 0 to return to main menu): 2
Please enter the movie you wish to borrow: Movie11
Too many borrowed movies.
Movie unavailable
```

```
=====Member Menu=====
1. Display all movies
2. Borrow a movie DVD
3. Return a movie DVD
4. List current borrowed movie DVDs
5. Display top 10 most popular movies
0. Return to main menu
=====
```

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

Figure 19: Borrowing more then 10 movies

Now as can be seen above, a member that is logged in has borrowed 10 movies. Notice that when 2 is selected again and when they enter another movie it fails. The system then informs the user that they have borrowed too many movies since 10 is the limit.