Data Structures

FINAL PROJECT REPORT

Genshin Impact

Artifact Rater

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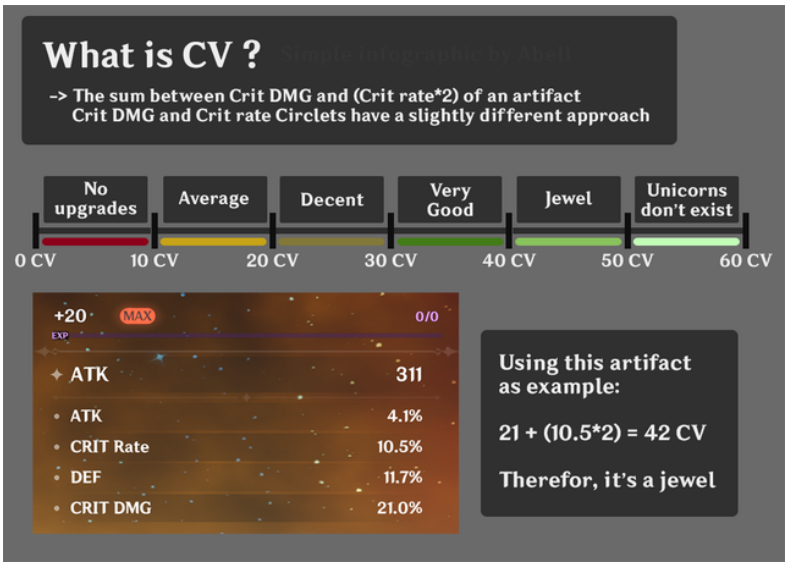
Computer Science Program

Binus University International

Problem Description:



Genshin Impact is currently one of the most popular games in the world with approximately 9 million users being active daily out of the 60 million registered users. We are aware that there are many aspects that new players struggle with such as game mechanics however that can be solved over time by playing more often. One thing that we as experienced players observed is that many players, whether they are new or not to the game struggle to decide on what makes an artifact "worth keeping". Artifacts essentially act as armor for your characters as it improves the stats and thus will assist them to deal more damage and survive longer. Even our friends would ask us whenever they had the opportunity about which artifact to level up and whether they should throw it away or not. Due to lack of knowledge, sometimes they decide to level artifacts that are deemed as "worthless" to keep as the artifacts either possess 0-low crit value. Then they would complain "Why is my character not dealing any damage?". We want to find a way how to help our friends and the community with this problem as many had to spend more time and even money unnecessarily just to get stronger. Leveling up artifacts is based on a Random Number Generated system and although the solution will not improve the rates of the game, it will assist players Genshin Impact in managing the artifacts they have.

So **"How can we let Genshin players decide on which artifacts to keep and throw?"**

Proposed Alternative Data Structures:

- **Binary Search Tree:**

  The first data structure we thought of would be the BST or the Binary Search Tree. This data structure allows us to have a comparable key to each node, where each key in any node is larger than the keys in all nodes in the left subtree and smaller than the keys in all nodes of the right subtree. The reason why a binary search tree would be great for this program is that binary search trees allow for fast insertion and deletion when balanced. BST is also really efficient, and the code is simple compared to other data structures. This data structure is great for our program as our program involves lots of insertions, deletions, and indexing of each object, however, a BST comes with the drawback of being slower when accessing an element compared to an array.

- **Linked List (doubly):**

  The second data structure we thought would suit to solve the problem is a doubly-linked list. It allows convenient access from a list node to the next node and other nodes ahead. This is through storing two pointers where one is the node following it and the other pointer to the node preceding it. Our artifact rater requires a data structure that would allow the user to store the data of their artifacts and allow them to add in between, before, or after a certain artifact. We also need a data structure that gives the flexibility to update the artifacts' stats in case they decided to level it up and decides to use our program to re-evaluate the artifacts again. Another important operation is to allow the user to delete or remove an artifact from the list as our main objective is to have the users decide which artifacts to throw away based on our ratings.

Theoretical analysis of Binary Search Tree and how it affects our program.

A binary search tree typically is a special binary tree with left subtrees containing only the keys which are lesser than the key of the node, meanwhile, the right subtree contains only the keys which are greater than the key of the node. The other left and right subtree also need to follow these binary search tree rules. The four basic operations of a BST are Searching, Insertion, Deletion, and Traversals.

Searching in a BST is done by comparing key values and determining whether they are equal to a root key, if so then the search would be successful, if lesser than the root key then search the key in the left subtree and if the key is greater than root key then search in the right subtree until finding the key value which is equal to a root key. If this process fails, the element would be determined not present in the BST. Given that the tree is balanced, it has a worst-case complexity of O(logN)

Insertion in a BST also involves the comparison of the key values. If the key value is lesser than or equal to the root key then go to the left subtree, find an empty space following the search algorithm and insert the data if the key is greater than the root key then go to the right subtree, find an empty space following the search algorithm and insert the data. Has a worst-case complexity of O(N).

Deletion in a BST uses a search algorithm to find the node. Then, find the number of children nodes to be deleted. If the node to be deleted is a leaf node, then delete it. If the node to be deleted has one child node then delete the node and place the child of the node at the position of the deleted node. If the node to be deleted has two children, find the inorder successor or inorder predecessor of the node according to the nearest value to the node that will be deleted. Replace the node with the in-order successor or predecessor. Has a worst-case complexity of O(N).

Traversal in a BST There are 4 ways to traverse a binary search tree.
Level Order Traversal: Traversing each node level by level in order of its appearance.
Pre-order Traversal: Traversing in the order of root and then left subtree and then right subtree.

Inorder Traversal: Traversing in the order of left subtree and then root and then right subtree.
Post Traversal: Traversing the nodes in the order of the left subtree and then the right subtree and then the root.

Application of Binary Search trees: Indexing, Searching, Implementation of other various data structures, implement dictionaries.

Advantages of Binary Search Tree: A binary search tree is fast in insertion and deletions when it is balanced which helps with our program as it utilizes these insertion and deletion operations a lot to add and remove multiple artifacts, and a binary search tree allows for fast and efficient executions.

Disadvantages of Binary Search Tree: The main disadvantage is that we should make sure that the implement is a balanced tree, otherwise it may cause problems by making non-logarithmic searches and degenerate into a linear search on an array, which ruins the point of having the binary search tree. Another disadvantage that actually hurts our program is the fact that accessing an element in the binary search tree is slightly slower than accessing an element in an array. A BST can also be an imbalance or degenerated which can cause an increase in complexity

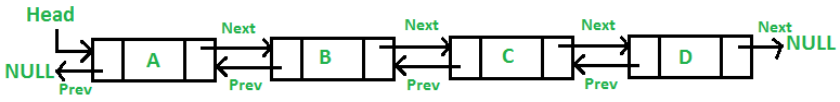
Theoretical analysis of Doubly Linked List and how it affects our program

A doubly linked list is considered a linear data structure and is a variation of a linked list where it makes navigation possible in both ways (forward and backward) easily. Each node apart from storing its data contains two fields called links where the first link points to the prev node while the second link points to the next node. The first and last node of the list has its prev and next link pointed to null to mark the start and end of a list.

- Link: can store a data called an element
- Prev: Each link contains a link to the previous link called prev
- Next: Each link contains a link to the next link called next
- LinkedList: has the connection link to the first link called first and the last link called last.

Basic Operations:

- **Insertion:** It is used to add new elements to the list which can be added at the beginning of the linked list, end of the linked list or after a given node. The time complexity for best and worse case for the insertion of an element is O(1).
- **Deletion:** This is used to remove an element from the list where the node to be deleted can be the head node, tail node, or any nodes in between. The time complexity for best and worse case for deletion of an element is O(1).
- **Traversal:** This is used to access each element in the list. It is traversed when the contents of the linked list are printed out. It can traverse forwards and backward, meaning it can be accessed in both directions. The time complexity for traversal however is O(n) as the worst case.



Application of Doubly Linked list:

- Used in navigation systems traversing back and forward is required
- Used by browsers (visit webpages) with the back and forward button
- Applications for undo and redo
- Game deck of cards

Advantages of Doubly Linked List:

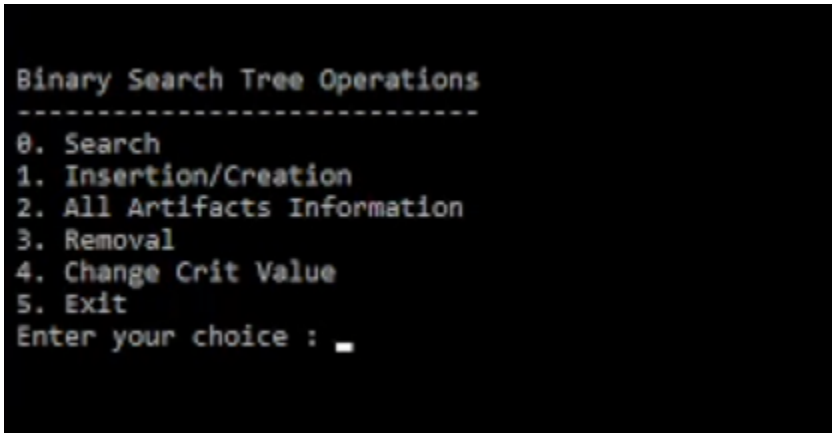
The doubly linked list has a bidirectional traversal which is not possible in a singly linked list. It is also easy to do the deletion operation compared to the singly linked list since all it takes is the pointer to be deleted. It also makes memory reallocation simple and lastly, reversing the linked list is also easy. It is more efficient compared to a singly linked list.

Disadvantages of Doubly Linked List:

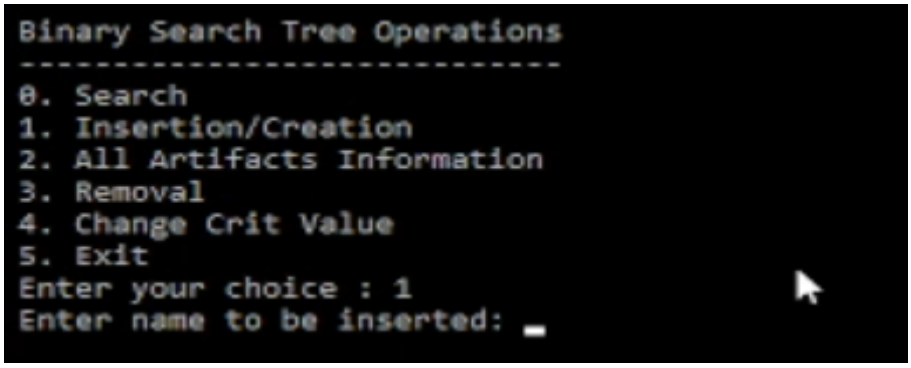
It uses more memory in comparison to a singly-linked list or an array implementation. It also doesn't allow direct access since the elements in the memory are stored randomly making the elements have to be accessed sequentially.

Program manual BST + Results!

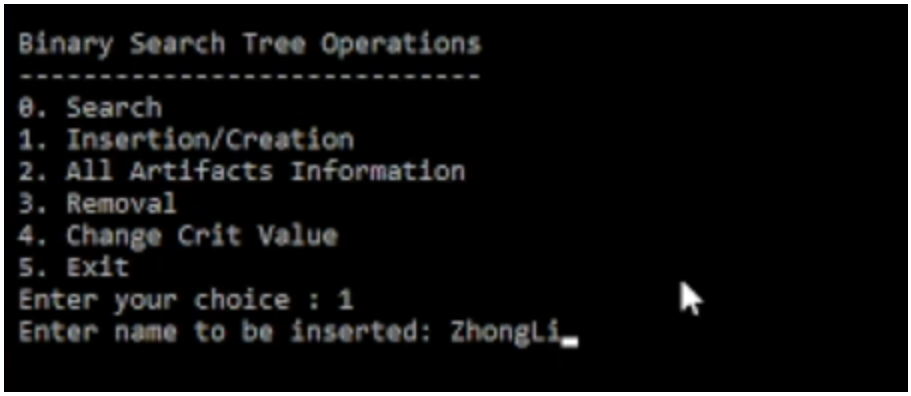
Main menu



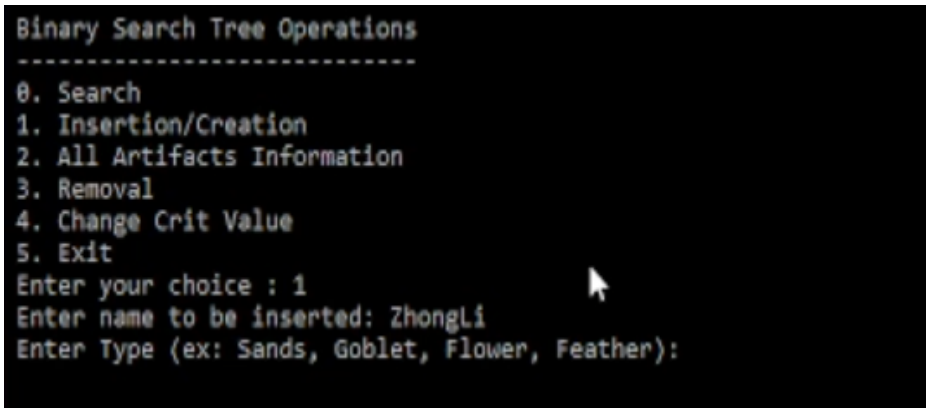
1. **Choice 1 will then prompt you with multiple information insertions starting with the name of the artifact.**



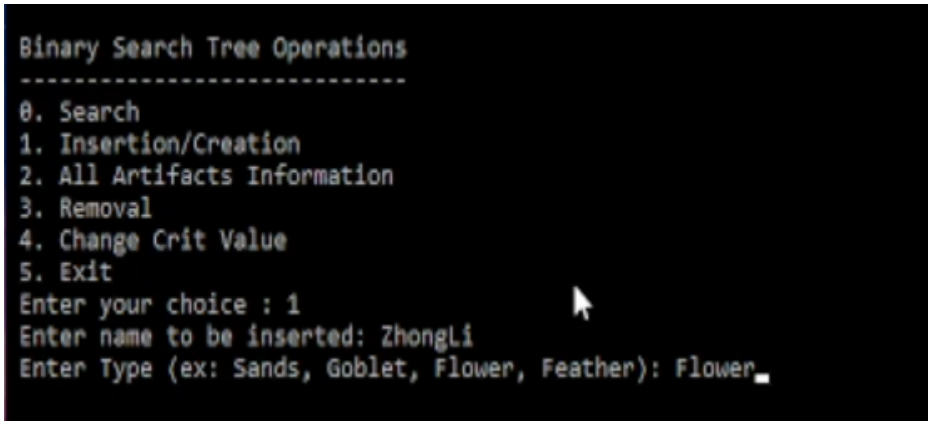
Enter a name for the artifact



After enter the artifact time, you will have to enter an artifact type

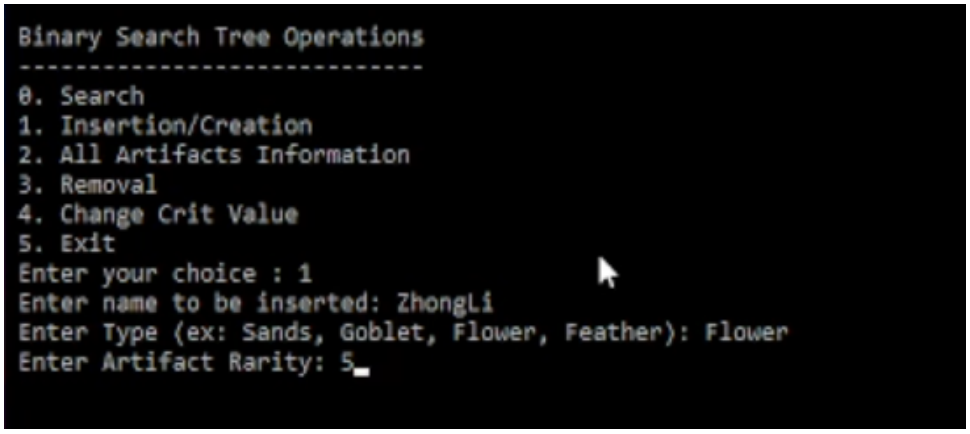


Enter the artifact type

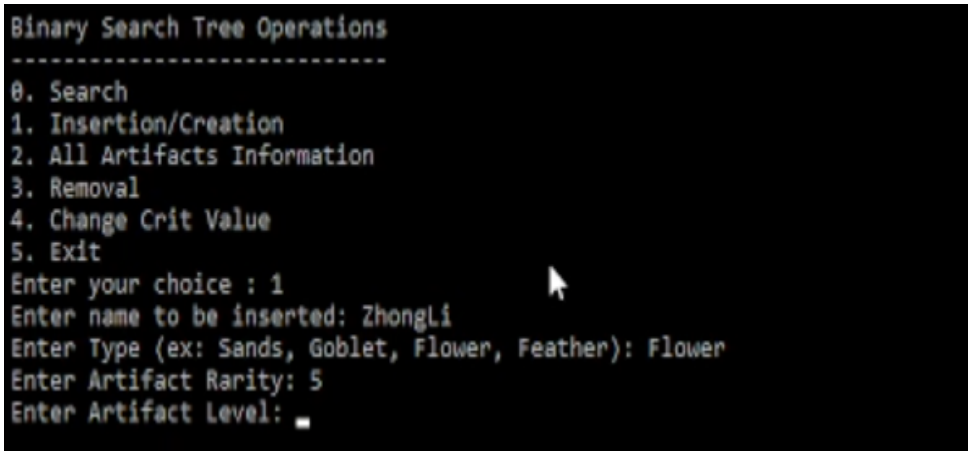


After entering the artifact you will have to enter the artifact rarity

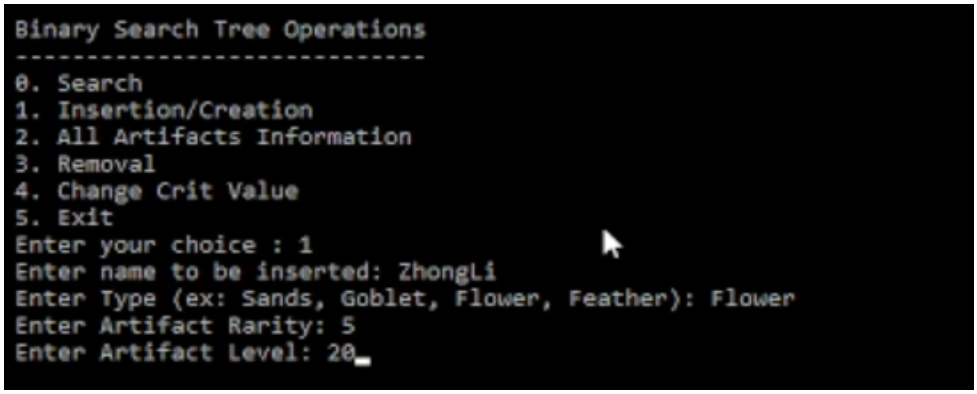
Enter Artifact rarity



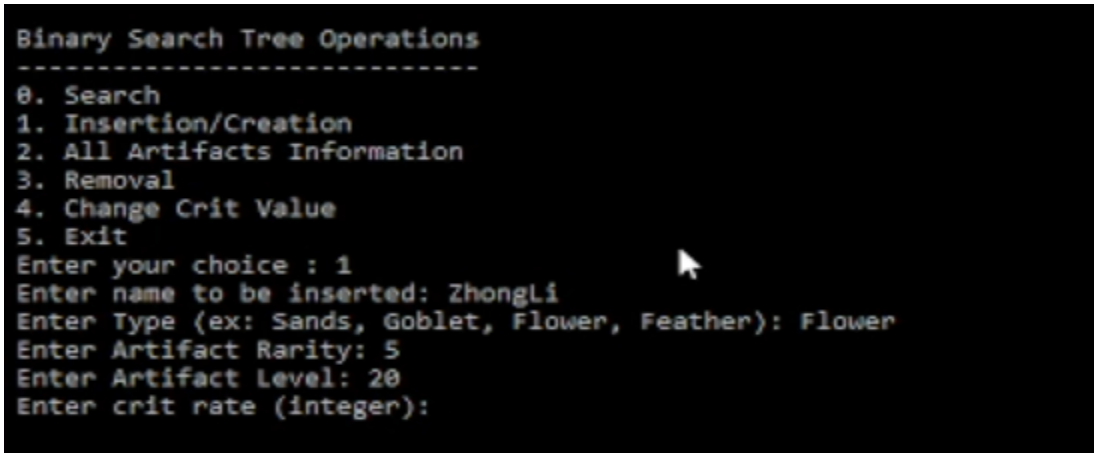
After entering the artifact rarity, you have to enter the artifact level.



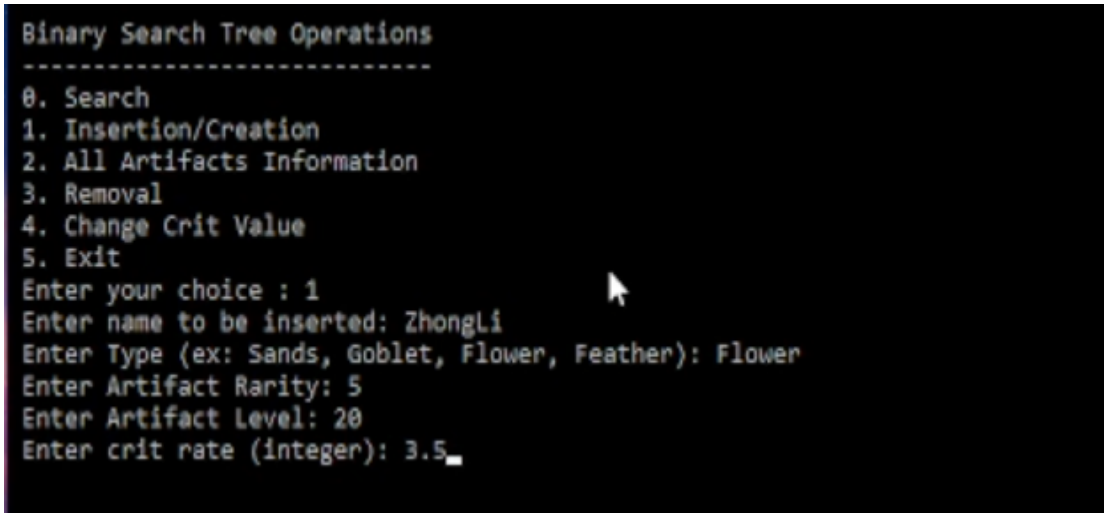
Enter the artifact level.



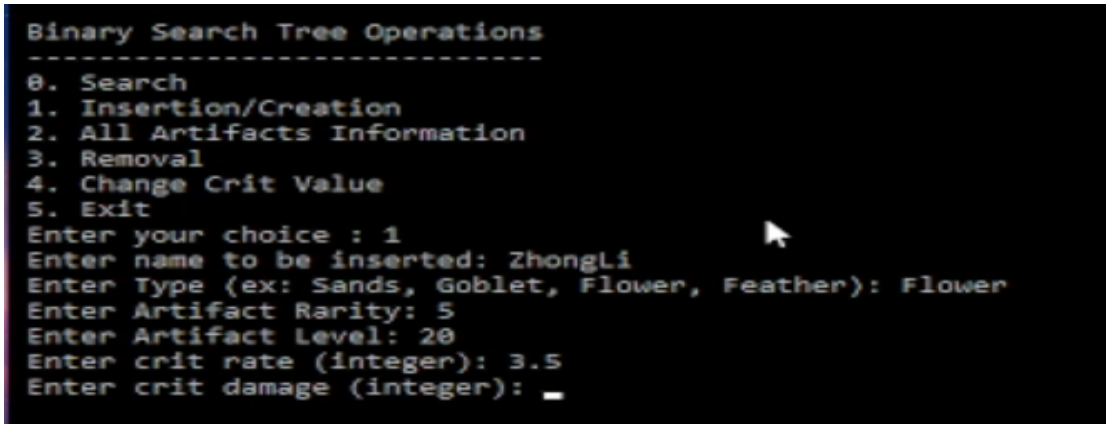
After entering the artifact level you have to enter the crit rate now in integers and doubles.



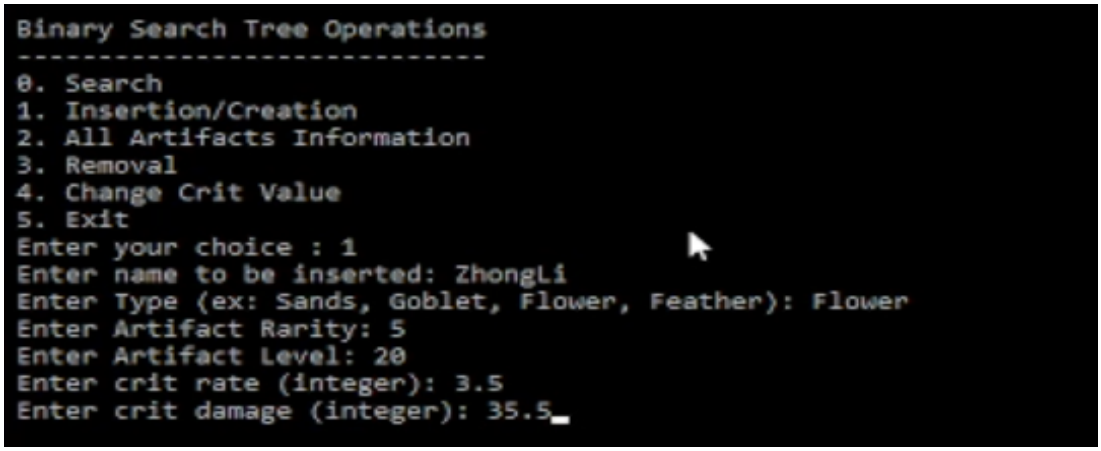
Enter A crit rate in either integer or double.



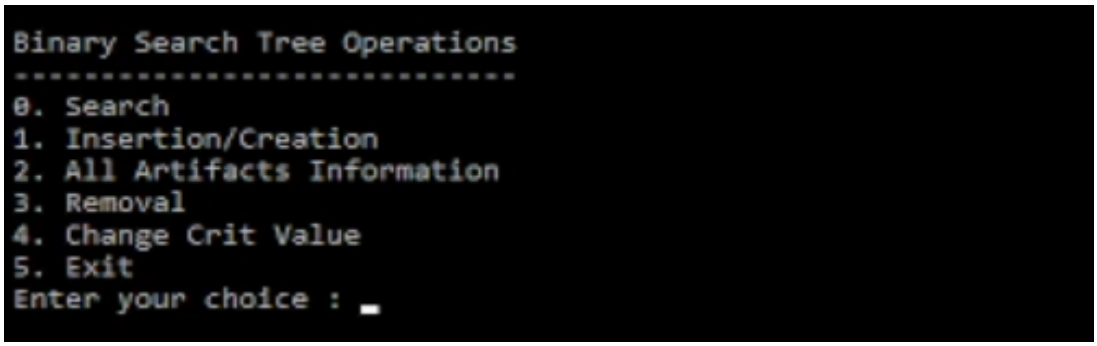
After the crit rate you have to enter the crit damage value of the artifact substats



Enter the crit damage



Back to the main menu



2. **After choosing option 2 the program will show the artifact you have stored in the binary search tree.**

```
Binary Search Tree Operations
----------------------------
0. Search
1. Insertion/Creation
2. All Artifacts Information
3. Removal
4. Change Crit Value
5. Exit
Enter your choice : 2

                                    Artifact  Information
-------------------------------------------------------------------------------------------
 LEVEL          RARITY          NAME            CRITVALUE               TYPE            RATING
 20             5               ZhongLi         42                      Flower          Jewel
```

Here is what happens when you create a second artifact

```
Binary Search Tree Operations
----------------------------
0. Search
1. Insertion/Creation
2. All Artifacts Information
3. Removal
4. Change Crit Value
5. Exit
Enter your choice : 1
Enter name to be inserted: HuTao
Enter Type (ex: Sands, Goblet, Flower, Feather): Feather
Enter Artifact Rarity: 5
Enter Artifact Level: 20
Enter crit rate (integer): 3.5
Enter crit damage (integer): 7.8
```

Printing it out looks like this:

```
Binary Search Tree Operations
----------------------------
0. Search
1. Insertion/Creation
2. All Artifacts Information
3. Removal
4. Change Crit Value
5. Exit
Enter your choice : 2

                                    Artifact  Information
-------------------------------------------------------------------------------------------
 LEVEL          RARITY          NAME            CRITVALUE               TYPE            RATING
 20             5               HuTao           14                      Feather         Average
 20             5               ZhongLi         42                      Flower          Jewel
```

3. **Option zero lets you search based on the name of the Artifact**

```
 Binary Search Tree Operations
 ----------------------------
 0. Search
 1. Insertion/Creation
 2. All Artifacts Information
 3. Removal
 4. Change Crit Value
 5. Exit
 Enter your choice : 0
 Enter the name of the Artifact to search for:
ZhongLi
The Crit value for ZhongLi is 42
```

4. Deleting an element using the artifact name

```
 Binary Search Tree Operations
 ----------------------------
 0. Search
 1. Insertion/Creation
 2. All Artifacts Information
 3. Removal
 4. Change Crit Value
 5. Exit
 Enter your choice : 3
 Enter data to be deleted : HuTao
```

Resulting print out

```
Binary Search Tree Operations
----------------------------
0. Search
1. Insertion/Creation
2. All Artifacts Information
3. Removal
4. Change Crit Value
5. Exit
Enter your choice : 2

                                Artifact  Information
-------------------------------------------------------------------------------------------
 LEVEL          RARITY          NAME            CRITVALUE               TYPE            RATING
 20             5               ZhongLi         42                      Flower          Jewel
```

5. Option 4 lets you change the crit value for a stats upgrade.

```
Binary Search Tree Operations
-----------------------------
0. Search
1. Insertion/Creation
2. All Artifacts Information
3. Removal
4. Change Crit Value
5. Exit
Enter your choice : 4
Enter the name of the Artifact of which the crit value you wish to change:
ZhongLi

Enter the new Crit Value:
50

Crit value changed successfully.
```

This will show after printing it out

```
Binary Search Tree Operations
-----------------------------
0. Search
1. Insertion/Creation
2. All Artifacts Information
3. Removal
4. Change Crit Value
5. Exit
Enter your choice : 2

                                    Artifact  Information
-------------------------------------------------------------------------------------------
 LEVEL          RARITY          NAME            CRITVALUE               TYPE            RATING
 20             5               ZhongLi         50                      Flower          Jewel
```

6. **Type 5 to exit.**

```
Binary Search Tree Operations
-----------------------------
0. Search
1. Insertion/Creation
2. All Artifacts Information
3. Removal
4. Change Crit Value
5. Exit
Enter your choice : 5
```

Program manual Doubly Linked List + Results!

Step 1: Run the program and view the options

```
What operation do you want to perform? Select Option number. Enter 0 to exit.
1. append Artifact
2. prepend Artifact
3. insert Artifact After
4. delete Artifact By Name
5. update Artifact By Name
6. print Artifact List
7. Clear Screen
```

Step 2: Enter 1 to add an artifact to the list. Proceed to enter all required data.

```
1
This is the Append Artifact Operation
Enter a new artifact name:
Emblem
what is the artifact type? (ex: sands, hat, goblet, flower, feather)
sands
Enter a new artifact's crit rate:
2.8
Enter a new artifact's crit damage:
7.8
Enter a new artifact's level:
20
Enter a new artifact's rarity:
5
```

```
Artifact Appended as Head Artifact

What operation do you want to perform? Select Option number. Enter 0 to exit.
1. append Artifact
2. prepend Artifact
3. insert Artifact After
4. delete Artifact By Name
5. update Artifact By Name
6. print Artifact List
7. Clear Screen
```

Step 3: Enter 2 to prepend/add an artifact at the start of the list. Proceed to enter all required data.

```
Enter the new artifact name:
shimenawa
what is the artifact type? (ex: sands, hat, goblet, flower, feather)
goblet
Enter the new artifact's crit rate:
5.8
Enter the new artifact's crit damage:
27.3
Enter the new artifact's level:
20
Enter the new artifact's rarity:
5
Artifact Prepended
```

Step 4: Enter 3 to insert an artifact after another artifact (insertion in between). Proceed to enter all required data.

```
3
Insert Artifact After Operation
Enter artifact name of existing Artifact after which you want to Insert this New Artifact:
shimenawa
Enter the name of the new artifact you want to insert:
maidens
what is the artifact type? (ex: sands, hat, goblet, flower, feather)
flower
Enter the new artifact's crit rate:
15.5
Enter the new artifact's crit damage:
12.4
Enter the new artifact's level:
20
Enter the new artifact's rarity:
```

Step 5: Enter 6 to print the artifact list.

```
6

YOUR ARTIFACTS LIST :
<><><><><><><><><><><><><><><><><><><><>
Artifact name: shimenawa
Type: goblet
Crit value: 38.9
Level: 20
Rarity: 5
<><><><><><><><><><><><><><><><><><><><>
Artifact name: maidens
Type: flower
Crit value: 43.4
Level: 20
Rarity: 5
<><><><><><><><><><><><><><><><><><><><>
Artifact name: Emblem
Type: sands
Crit value: 13.4
Level: 20
Rarity: 5
<><><><><><><><><><><><><><><><><><><><>
What operation do you want to perform? Select Option number. Enter 0 to exit.
```

Step 6: Enter 5 to update the artifact's crit rate, crit damage, and level.

```
5
Update Artifact By artifact name Operation
Enter the artifact name that you want to update the stats for:
Emblem
Enter the updated crit rate:
8.2
Enter the updated crit damage:
7.8
Enter the updated level:
20
The Artifact's crit value and level has been Updated Successfully
```

Step 7: Enter 6 to print out the list again and check if the artifact got updated. As can be seen, the crit value has changed.

```
YOUR ARTIFACTS LIST :
<><><><><><><><><><><><><><><><><><><><>
Artifact name: shimenawa
Type: goblet
Crit value: 38.9
Level: 20
Rarity: 5
<><><><><><><><><><><><><><><><><><><><>
Artifact name: maidens
Type: flower
Crit value: 43.4
Level: 20
Rarity: 5
<><><><><><><><><><><><><><><><><><><><>
Artifact name: Emblem
Type: sands
Crit value: 24.2
Level: 20
Rarity: 5
<><><><><><><><><><><><><><><><><><><><>
```

Step 8: Enter 4 to do the deletion. I decided to delete the first artifact in the list which happens to be Shimenawa.

```
4
Delete Artifact By artifact name Operation -
Enter the name of an Artifact to be deleted:
shimenawa
Artifact UNLINKED with artifactnames value : shimenawa
```

Step 9: Enter 6 to print the list again to see if the deletion works.

```
6

YOUR ARTIFACTS LIST :
<><><><><><><><><><><><><><><><><><><><>
Artifact name: maidens
Type: flower
Crit value: 43.4
Level: 20
Rarity: 5
<><><><><><><><><><><><><><><><><><><><>
Artifact name: Emblem
Type: sands
Crit value: 24.2
Level: 20
Rarity: 5
<><><><><><><><><><><><><><><><><><><><>
```

(Optional step): press 7 anytime to clear the screen if it's too much.

```
What operation do you want to perform? Select Option number. Enter 0 to exit.
1. append Artifact
2. prepend Artifact
3. insert Artifact After
4. delete Artifact By Name
5. update Artifact By Name
6. print Artifact List
7. Clear Screen
```

Step 10: Enter 0 to exit the program!

```
What operation do you want to perform? Select Option number. Enter 0 to exit.
1. append Artifact
2. prepend Artifact
3. insert Artifact After
4. delete Artifact By Name
5. update Artifact By Name
6. print Artifact List
7. Clear Screen
0
PS C:\Users\tiffa\Documents\BINUS\CS\Data Structures\Assignments>
```

Teamwork & Contribution:

Nicholas:

- Created the BST program
- Theoretical analysis of Binary Search Tree and how it affects our program
- Recorded Video
- Demo Video voiceover
- Documentation on BST Manual
- Proposed Alternative Data Structure (Binary search Tree) Documentation

Tiffany

- Created the Doubly Linked List program
- Theoretical analysis of Doubly Linked List and how it affects our program
- Documentation on Doubly Linked List Manual
- Demo video voiceover
- Problem Description Documentation
- Proposed Alternative Data Structure (Doubly Linked List) Documentation

File Links:

GitHub: https://github.com/Pandalmation/DS-Final-Project

Video Demo: (we already recorded, just that video is 8 minutes long)

Resources:

https://www.geeksforgeeks.org/applications-advantages-and-disadvantages-of-binary-search-tree/

https://www.geeksforgeeks.org/advantages-disadvantages-and-uses-of-doubly-linked-list/

https://www.daniweb.com/programming/software-development/threads/327525/binary-search-tree-file-reading

https://www.geeksforgeeks.org/complexity-different-operations-binary-tree-binary-search-tree-avl-tree/#:~:text=In%20general%2C%20time%20complexity%20is%20O(h).,complexity%20is%20O(h).

https://www.studytonight.com/data-structures/doubly-linked-list