**Exercise 6: Library Management System**

**Explain linear search and binary search algorithms.**

**Linear Search:**

The linear search algorithm is defined as a sequential search algorithm that starts at one end and goes through each element of a list until the desired element is found; otherwise, the search continues till the end of the data.

In Linear Search Algorithm,

* Every element is considered as a potential match for the key and checked for the same.
* If any element is found equal to the key, the search is successful and the index of that element is returned.
* If no element is found equal to the key, the search yields No match found.

**Binary Search:**

Binary search is a search algorithm used to find the position of a target value within a sorted array.

It works by repeatedly dividing the search interval in half until the target value is found or the interval is empty. The search interval is halved by comparing the target element with the middle value of the search space.

In Binary search algorithm,

* Find the middle index.
* Compare the middle element of the search space with the target.
* If the target is found at middle element, the process is terminated.
* If the target is not found at middle element, then choose the half to continue searching
  + If the target is smaller than the middle element, then the left side is used for next search.
  + If the target is larger than the middle element, then the right side is used for next search.
* This process is continued until the key is found or the total search space is exhausted.

**Compare the time complexity of linear and binary search.**

**Linear Search**

* **Best Case: O(1)** –target element might be present at the first index
* **Average Case: O(n)** – The target element is somewhere in the middle.
* **Worst Case: O(n)** – The target element is at the last index or not found.

**Binary Search**

* **Best Case: O(1)** – The target is at the middle.
* **Average Case: O(log n)** – The search space is halved each time.
* **Worst Case: O(log n)** – The target is at the beginning or the end of the search space.

**Discuss when to use each algorithm based on the data set size and order.**

**Linear Search:**

* Simple to implement, no need for the list to be sorted.
* Best for small or unsorted datasets.

**Binary Search:**

* Much faster for large datasets, provided the list is sorted.
* Ideal for large, sorted datasets where search efficiency is crucial.

The decision of selection is based on the size of the data and how the data is.

* If the data is already sorted or is maintained in a sorted order without much overhead then binary search is preferable.
* For smaller set of data, sorting might become and overhead and hence linear search can be preferred.
* For the data where sorting is not an feasible option then, linear search is used.