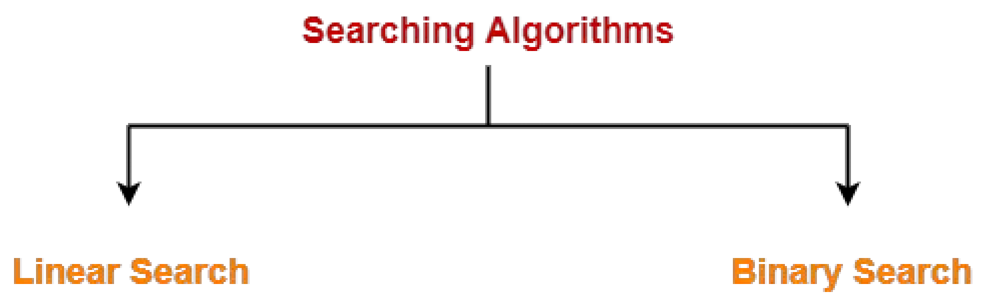
Searching-

- Searching is a process of finding a particular element among several given elements.
- The search is successful if the required element is found.
- Otherwise, the search is unsuccessful.

Searching Algorithms

Searching Algorithms are a family of algorithms used for the purpose of searching.

The searching of an element in the given array may be carried out in the following two ways-



1. Linear Search
2. Binary Search

Linear Search

- Linear Search is the simplest searching algorithm.
- It traverses the array sequentially to locate the required element.
- It searches for an element by comparing it with each element of the array one by one.
- So, it is also called as **Sequential Search**.

Linear Search Algorithm is applied when-

- No information is given about the array.
- The given array is unsorted or the elements are unordered.
- The list of data items is smaller.

Linear Search Algorithm-

Consider-

- There is a linear array ‘a’ of size ‘n’.
- Linear search algorithm is being used to search an element ‘item’ in this linear array.
- If search ends in success, it sets loc to the index of the element otherwise it sets loc to -1.

Then, Linear Search Algorithm is as follows-

Linear_Search (a , n , item , loc)

```
Begin
for i = 0 to (n - 1) by 1 do
if (a[i] = item) then
set loc = i
Exit
endif
endfor
set loc = -1
End
```

Time Complexity Analysis-

Linear Search time complexity analysis is done below-

Best case-

In the best possible case,

- The element being searched may be found at the first position.
- In this case, the search terminates in success with just one comparison.
- Thus in best case, linear search algorithm takes O(1) operations.

Worst Case-

In the worst possible case,

- The element being searched may be present at the last position or not present in the array at all.
- In the former case, the search terminates in success with n comparisons.
- In the later case, the search terminates in failure with n comparisons.
- Thus in worst case, linear search algorithm takes O(n) operations.

Thus, we have-

Time Complexity of Linear Search Algorithm is O(n).

Here, n is the number of elements in the linear array.

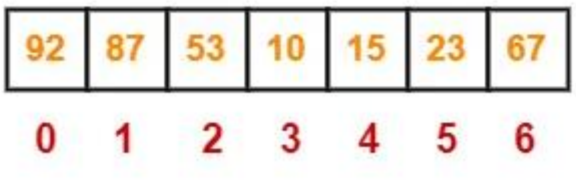
Linear Search Efficiency-

- Linear Search is less efficient when compared with other algorithms like Binary Search & Hash tables.
- The other algorithms allow significantly faster searching.

Linear Search Example-

Consider-

- We are given the following linear array.
- Element 15 has to be searched in it using Linear Search Algorithm.



LInear Search Example

Now,

- Linear Search algorithm compares element 15 with all the elements of the array one by one.
- It continues searching until either the element 15 is found or all the elements are searched.

Linear Search Algorithm works in the following steps-

Step-01:

- It compares element 15 with the 1st element 92.
- Since 15 ≠ 92, so required element is not found.
- So, it moves to the next element.

Step-02:

- It compares element 15 with the 2nd element 87.
- Since 15 ≠ 87, so required element is not found.
- So, it moves to the next element.

Step-03:

- It compares element 15 with the 3rd element 53.
- Since 15 ≠ 53, so required element is not found.
- So, it moves to the next element.

Step-04:

- It compares element 15 with the 4th element 10.
- Since 15 ≠ 10, so required element is not found.
- So, it moves to the next element.

Step-05:

- It compares element 15 with the 5th element 15.

- Since 15 = 15, so required element is found.
- Now, it stops the comparison and returns index 4 at which element 15 is present.

Binary Search

- Binary Search is one of the fastest searching algorithms.
- It is used for finding the location of an element in a linear array.
- It works on the principle of divide and conquer technique.

Binary Search Algorithm can be applied only on Sorted arrays.

So, the elements must be arranged in-

- Either ascending order if the elements are numbers.
- Or dictionary order if the elements are strings.

To apply binary search on an unsorted array,

- First, sort the array using some sorting technique.
- Then, use binary search algorithm.

Binary Search Algorithm-

Consider-

- There is a linear array ‘a’ of size ‘n’.
- Binary search algorithm is being used to search an element ‘item’ in this linear array.
- If search ends in success, it sets loc to the index of the element otherwise it sets loc to -1.
- Variables beg and end keeps track of the index of the first and last element of the array or sub array in which the element is being searched at that instant.
- Variable mid keeps track of the index of the middle element of that array or sub array in which the element is being searched at that instant.

Then, Binary Search Algorithm is as follows-

```
Begin
Set beg = 0
Set end = n-1
Set mid = (beg + end) / 2
while ( (beg <= end) and (a[mid] ≠ item) ) do
    if (item < a[mid]) then
        Set end = mid - 1
    else
        Set beg = mid + 1
    endif
    Set mid = (beg + end) / 2
endwhile
if (beg > end) then
    Set loc = -1
else
    Set loc = mid
endif
End
```

Explanation

Binary Search Algorithm searches an element by comparing it with the middle most element of the array.

Then, following three cases are possible-

Case-01

If the element being searched is found to be the middle most element, its index is returned.

Case-02

If the element being searched is found to be greater than the middle most element,

then its search is further continued in the right sub array of the middle most element.

Case-03

- If the element being searched is found to be smaller than the middle most element, then its search is further continued in the left sub array of the middle most element.
- This iteration keeps on repeating on the sub arrays until the desired element is found
- or size of the sub array reduces to zero.

Time Complexity Analysis-

Binary Search time complexity analysis is done below-

- In each iteration or in each recursive call, the search gets reduced to half of the array.
- So for n elements in the array, there are $\log_2 n$ iterations or recursive calls.

Thus, we have-

Time Complexity of Binary Search Algorithm is $O(\log_2 n)$.

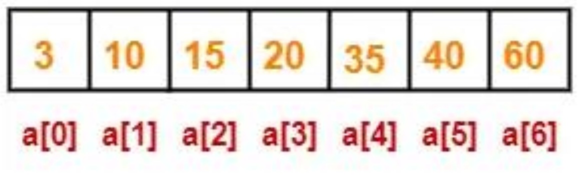
Here, n is the number of elements in the sorted linear array.

This time complexity of binary search remains unchanged irrespective of the element position even if it is not present in the array.

Binary Search Example-

Consider-

- We are given the following sorted linear array.
- Element 15 has to be searched in it using Binary Search Algorithm.



Binary Search Example

Binary Search Algorithm works in the following steps-

Step-01:

- To begin with, we take beg=0 and end=6.
- We compute location of the middle element as-

mid

= (beg + end) / 2

= (0 + 6) / 2

= 3

- Here, a[mid] = a[3] = 20 ≠ 15 and beg < end.
- So, we start next iteration.

Step-02:

- Since a[mid] = 20 > 15, so we take end = mid – 1 = 3 – 1 = 2 whereas beg remains unchanged.
- We compute location of the middle element as-

mid

= (beg + end) / 2

= (0 + 2) / 2

= 1

- Here, a[mid] = a[1] = 10 ≠ 15 and beg < end.
- So, we start next iteration.

Step-03:

- Since a[mid] = 10 < 15, so we take beg = mid + 1 = 1 + 1 = 2 whereas end remains unchanged.
- We compute location of the middle element as-

mid

= (beg + end) / 2

= (2 + 2) / 2

= 2

- Here, a[mid] = a[2] = 15 which matches to the element being searched.
- So, our search terminates in success and index 2 is returned.

Binary Search Algorithm Advantages-

The advantages of binary search algorithm are-

- It eliminates half of the list from further searching by using the result of each comparison.
- It indicates whether the element being searched is before or after the current position in the list.
- This information is used to narrow the search.
- For large lists of data, it works significantly better than linear search.

Binary Search Algorithm Disadvantages-

The disadvantages of binary search algorithm are-

- It employs recursive approach which requires more stack space.
- Programming binary search algorithm is error prone and difficult.
- The interaction of binary search with memory hierarchy i.e. caching is poor.

(because of its random access nature)

Important Note-

For in-memory searching, if the interval to be searched is small,

- Linear search may exhibit better performance than binary search.
- This is because it exhibits better locality of reference.