Binary Search

In this tutorial, you will learn how Binary Search sort works. Also, you will find working examples of Binary Search in C, C++, Java and Python.

Binary Search is a searching algorithm for finding an element's position in a sorted array.

In this approach, the element is always searched in the middle of a portion of an array.

> Binary search can be implemented only on a sorted list of items. If the elements are not sorted already, we need to sort them first.

Binary Search Working

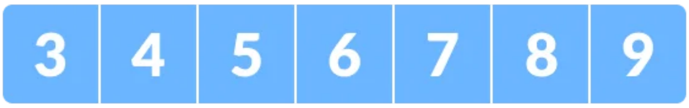
Binary Search Algorithm can be implemented in two ways which are discussed below.

1. Iterative Method
2. Recursive Method

The recursive method follows the divide and conquer approach.

The general steps for both methods are discussed below.

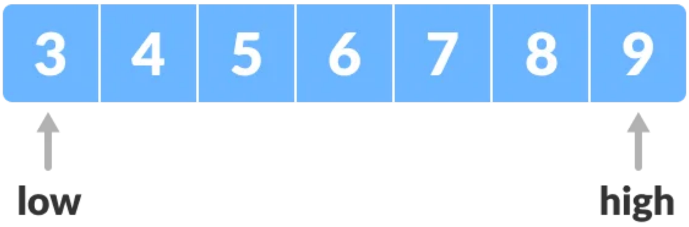
1. The array in which searching is to be performed is:



Initial array

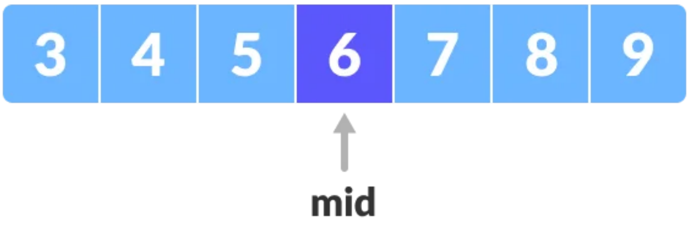
Let `x = 4` be the element to be searched.

2. Set two pointers low and high at the lowest and the highest positions respectively.



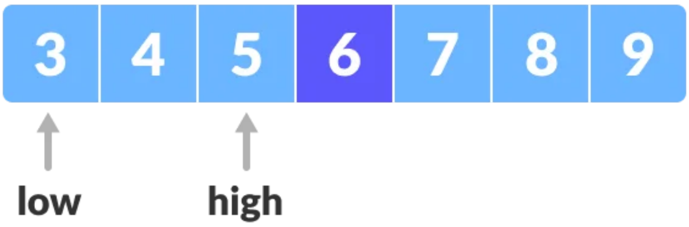
Setting pointers

3. Find the middle element `mid` of the array ie. `arr[(low + high)/2] = 6`.



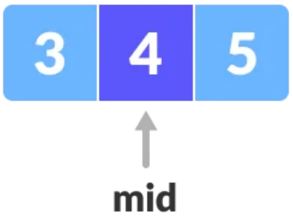
Mid element

4. If x == mid, then return mid.Else, compare the element to be searched with m.
5. If `x > mid`, compare `x` with the middle element of the elements on the right side of `mid`. This is done by setting `low` to `low = mid + 1`.
6. Else, compare `x` with the middle element of the elements on the left side of `mid`. This is done by setting `high` to `high = mid - 1`.



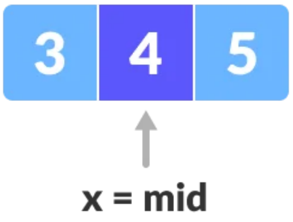
Finding mid element

7. Repeat steps 3 to 6 until low meets high.



Mid element

8. `x = 4` is found.



Found

Binary Search Algorithm

Iteration Method

```
do until the pointers low and high meet each other.
    mid = (low + high)/2
    if (x == arr[mid])
        return mid
    else if (x > arr[mid]) // x is on the right side
        low = mid + 1
    else                       // x is on the left side
        high = mid - 1
```

Recursive Method

```
binarySearch(arr, x, low, high)
    if low > high
        return False
    else
        mid = (low + high) / 2
        if x == arr[mid]
            return mid
        else if x > arr[mid]        // x is on the right side
            return binarySearch(arr, x, mid + 1, high)
        else                               // x is on the left side
            return binarySearch(arr, x, low, mid - 1)
```

Python, Java, C/C++ Examples (Iterative Method)

Python Java C C++

```c
// Binary Search in C

#include <stdio.h>

int binarySearch(int array[], int x, int low, int high) {
  // Repeat until the pointers low and high meet each other
  while (low <= high) {
    int mid = low + (high - low) / 2;

    if (array[mid] == x)
      return mid;

    if (array[mid] < x)
      low = mid + 1;

    else
      high = mid - 1;
  }

  return -1;
}

int main(void) {
  int array[] = {3, 4, 5, 6, 7, 8, 9};
  int n = sizeof(array) / sizeof(array[0]);
  int x = 4;
  int result = binarySearch(array, x, 0, n - 1);
  if (result == -1)
```

Python, Java, C/C++ Examples (Recursive Method)

Python Java C C++

```
# Binary Search in python


def binarySearch(array, x, low, high):

    if high >= low:

        mid = low + (high - low)//2

        # If found at mid, then return it
        if array[mid] == x:
            return mid

        # Search the left half
        elif array[mid] > x:
            return binarySearch(array, x, low, mid-1)

        # Search the right half
        else:
            return binarySearch(array, x, mid + 1, high)

    else:
        return -1


array = [3, 4, 5, 6, 7, 8, 9]
x = 4
```

Binary Search Complexity

Time Complexities

- **Best case complexity**: `O(1)`
- **Average case complexity**: `O(log n)`
- **Worst case complexity**: `O(log n)`

Space Complexity

The space complexity of the binary search is `O(1)`.

Binary Search Applications

- In libraries of Java, .Net, C++ STL
- While debugging, the binary search is used to pinpoint the place where the error happens.