Searching Technique

BINARY SEARCH

UPPER BOUND

LOWER BOUND

PROBLEMS

TRICKS

In the end, it's YOU vs YOU. Be the best today, to defeat your yesterday!!

What is Binary Search

is a searching Technique which is mainly used to find target element in 'sorted Search Space' (start ⟷ end)

1 2 3 4 5 6 7

7 6 5 4 3 2 1

$mid = \frac{(s+e)}{2}$

1	2	4	6	8	9	11	14	18
0	1	2	3	4	5	6	7	8

N = 9

target = 12

a[mid] target

a = b → got the target

a < b → move Right (s = m+1)

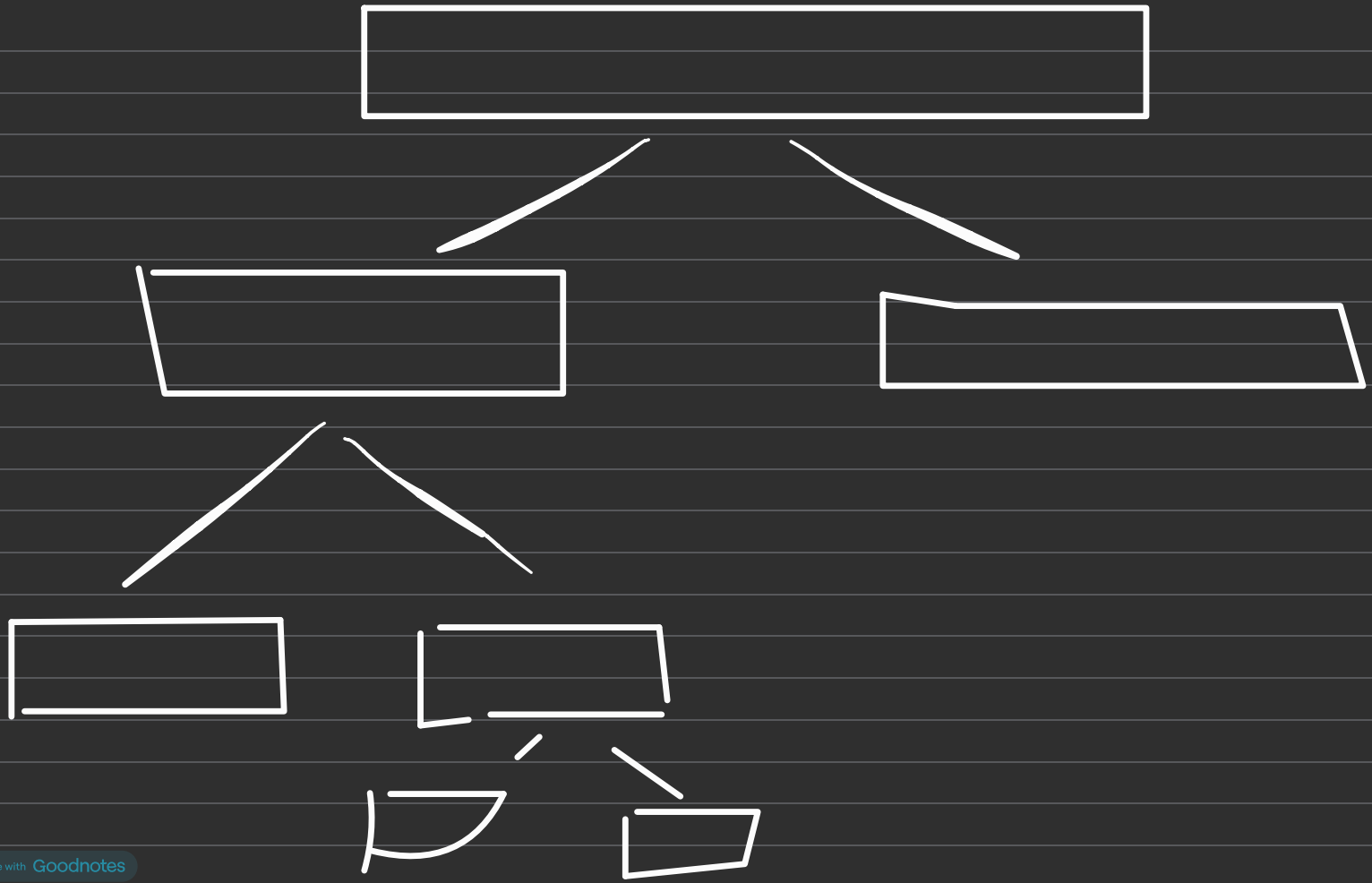
a > b → move left (e = m-1)

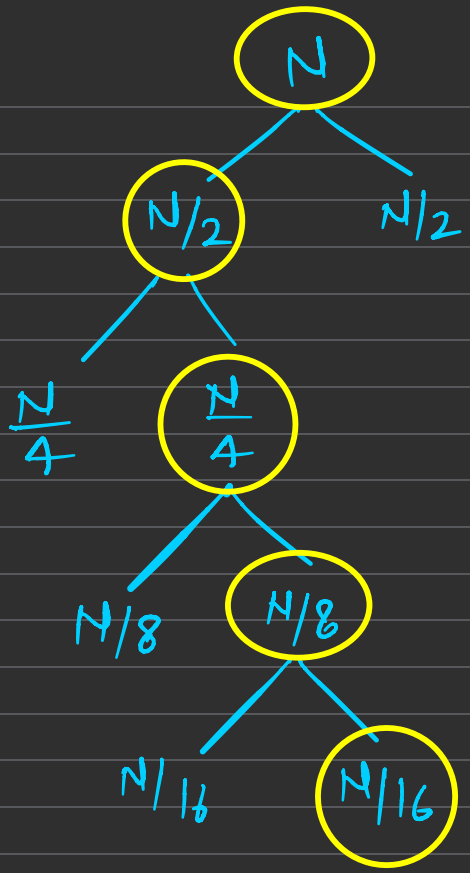
s = 0
e = 8
mid = 4

s = 5
e = 8
mid = 6

s = 7
e = 8
mid = 7

```
int binarySearch ( int a[], int target, int N)
{
    int start = 0 , end = N-1
    while ( start ≤ end )
    {
        mid = ( start + end ) / 2
        if (a[mid] == target)
            return mid
        else if ( a[mid] < target)
            start = mid + 1
        else
            end = mid - 1
    }
    return -1
}
```





$N = N/2^0$

$\frac{N}{2} = N/2^1$

$\frac{N}{4} = N/2^2$

$\frac{N}{8} = N/2^3$

$\frac{N}{16} = N/2^4$

$\frac{N}{2^K} = 1$

$N = 2^K$

$\log N = \log 2^K$

$\log N = K \log 2$

$\frac{\log N}{\log 2} = K$

$K = \log_2 N$

Lower Bound

N = 5

1	2	4	6	7	
0	1	2	3	4	N(5)

LB (2) = 1

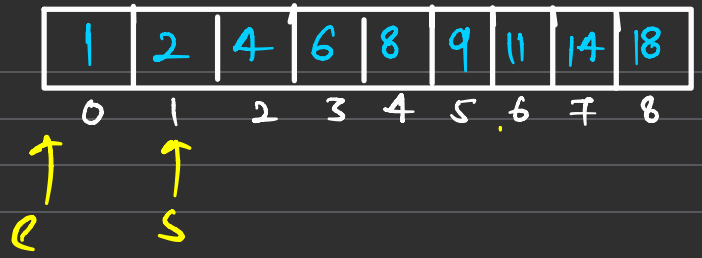
LB (3) = 2

LB (10) = N

} index

ans = 1

LB



N = 9

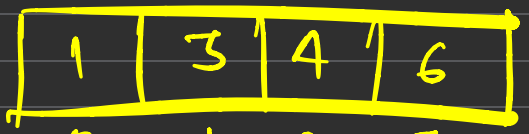
target = 2

s = 0
e = 8
mid = 4

s = 0
e = 3
mid = 1

s = 0
e = 0
m = 0

```
if (a[mid] ≥ target)
} index = mid
  end = mid - 1
}else
  start = mid + 1
```



int index = ?

1 B(10)

N=4

x=10

s=0
e=3
mid=1

s=3
e=3
mid=3

s=2
e=3
mid=2

s=4
e=3

X

3 ≥ 10

6 < 10

index = N

```
start = 0    end = N-1
index = N
while ( start ≤ end )
{
    mid = (start + end) / 2
    if ( a[mid] ≥ target )
    {
        index = mid
        end = mid - 1
    }else
        start = mid + 1
}
return Index
```

Upper Bound

N = 5

1	2	4	5	7
0	1	2	3	4

UB(2) = 2
UB(3) = 2
UB(10) = N(5)

} index

```
if (a[mid] > target)
{ index = mid
  end = mid - 1
}else
  start = mid + 1
```

35. Search Insert Position

Solved

Easy | Topics | Companies | Re-do

Given a sorted array of distinct integers and a target value, return the index if the target is found. If not, return the index where it would be if it were inserted in order.

You must write an algorithm with `O(log n)` runtime complexity.

Example 1:

```
Input: nums = [1,3,5,6], target = 5
Output: 2
```

Example 2:

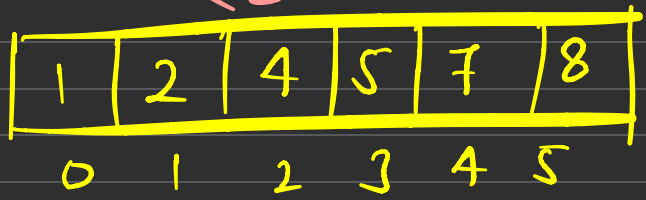
```
Input: nums = [1,3,5,6], target = 2
Output: 1
```

Example 3:

```
Input: nums = [1,3,5,6], target = 7
Output: 4
```

x=10

(3)



x = 7

(4)

x = 3

(2) index

```
for (i=0 ; i<N ; i++)
{
    if (a(i) == target)
        return i
    else if (a(i) > target)
        return i
}
return M
```

O(N)

Rich People Value Time

Poor People Value Money

Floor in a Sorted Array

Difficulty: **Easy** Accuracy: **33.75%** Submissions: **475K+** Points: **2** Average Time: **30m**

Given a sorted array **arr[]** and an integer **x**, find the index (0-based) of the largest element in arr[] that is less than or equal to x. This element is called the **floor** of x. If such an element does not exist, return -1.

Note: In case of multiple occurrences of ceil of x, return the index of the last occurrence.

Examples

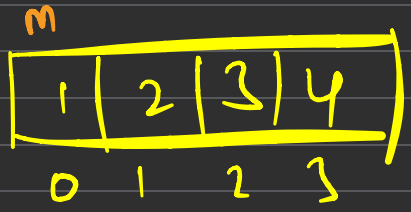
Input: arr[] = [1, 2, 8, 10, 10, 12, 19], x = 5
Output: 1
Explanation: Largest number less than or equal to 5 is 2, whose index is 1.

Input: arr[] = [1, 2, 8, 10, 10, 12, 19], x = 11
Output: 4
Explanation: Largest Number less than or equal to 11 is 10, whose indices are 3 and 4. The index of last occurrence is 4.

Input: arr[] = [1, 2, 8, 10, 10, 12, 19], x = 0
Output: -1
Explanation: No element less than or equal to 0 is found. So, output is -1.

index = -1

x = 0



s = 0 e = 3

m = 1

s = 0 e = 0

m = 0

s = 0, e = -1

```
int upperBound ( arr[], N, target)
{
    start = 0 , end = N-1
    index = -1
    while ( s <= e)
    {
        mid = (s+e)/2
        if (a[m] <= x)
        {
            index = mid
            s = m+1
        }
        else
            e = m-1
    }
    return index
}
```

34. Find First and Last Position of Element in Sorted Array

Solved

Medium | Topics | Companies | Re-do

Given an array of integers `nums` sorted in non-decreasing order, find the starting and ending position of a given `target` value.

If `target` is not found in the array, return `[-1, -1]`.

You must write an algorithm with `O(log n)` runtime complexity.

Example 1:

```
Input: nums = [5,7,7,8,8,10], target = 8
Output: [3,4]
```

Example 2:

```
Input: nums = [5,7,7,8,8,10], target = 6
Output: [-1,-1]
```

Example 3:

```
Input: nums = [], target = 0
Output: [-1,-1]
```

start = -1 , end = -1

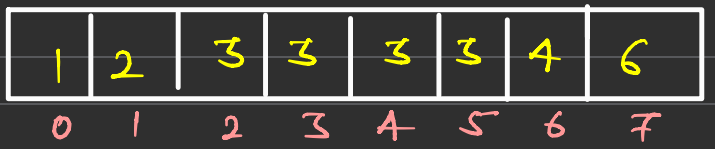
gives index of first occ.

```
for (i=0; i<N; i++)
{   if (a[i] == x)
    {   start = i
        break
    }
}
```

gives index of last occ

```
for (i=N-1; i>=0; i--)
{   if (a[i] == x)
    {   end = i
        break
    }
}
```

(2, 5)



N=8

x=3

start = -1 , end = -1

start = ~~-1~~ 2

end = ~~-1~~ 2

~~2~~

~~4~~

5

for (i=0 ; i<N ; i++) ——— O(N)

{

if (a(i) == x)

{ if (start == -1)

start = i

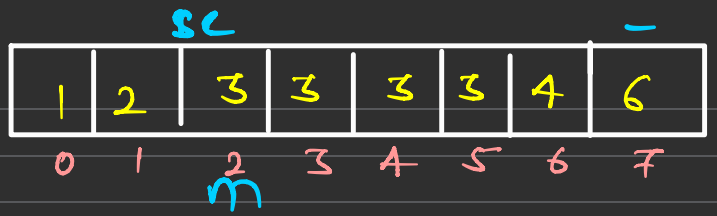
end = i

}

}

index = 3

2



N=8

x = 3

s = 0
e = 7
mid = 3

s = 0
e = 2
mid = 1

s = 2
e = 1

s = 2
e = 2

```
int binarySearch ( int a[], int target, int N)
{
    int start = 0 , end = N-1
    while ( start <= end )
    {
        mid = ( start + end ) / 2
        if (a[mid] == target)
        {
            ans = mid
            e = mid - 1
        }
        else
            s = mid + 1
    }
    return ans
}
```

N=8

x = 3

```
int binarySearch (int a[], int target, int N)
{
    int start = 0, end = N-1
    while (start ≤ end)
    {
        mid = (start + end)/2
        if (a[mid] == target)
        {
            ans = mid
            s = mid + 1
        }
        else
            e = mid - 1
    }
}
return ans
```

540. Single Element in a Sorted Array

Solved

Medium | Topics | Companies | Re-do

You are given a sorted array consisting of only integers where every element appears exactly twice, except for one element which appears exactly once.

Return *the single element that appears only once*.

Your solution must run in `O(log n)` time and `O(1)` space.

Example 1:

```
Input: nums = [1,1,2,3,3,4,4,8,8]
Output: 2
```

Example 2:

```
Input: nums = [3,3,7,7,10,11,11]
Output: 10
```

Peak element

Difficulty: **Medium** Accuracy: **38.86%** Submissions: **618K+** Points: **4**

Average Time: **30m**

You are given an array **arr[]** where no two adjacent elements are same, find the **index** of a **peak** element. An element is considered to be a **peak** if it is greater than its adjacent elements (if they exist).

If there are multiple peak elements, Return index of any one of them. The output will be **"true"** if the index returned by your function is correct; otherwise, it will be "**false**".

Note: Consider the element **before** the **first** element and the element **after** the **last** element to be **negative infinity**.

Examples :

Input: arr = [1, 2, 4, 5, 7, 8, 3]
Output: true
Explanation: arr[5] = 8 is a peak element because arr[4] < arr[5] > arr[6].

Given a **sorted** array, **arr[]** and a number **target**, you need to find the number of occurrences of **target** in **arr[]**.

Examples :

Input: arr[] = [1, 1, 2, 2, 2, 2, 3], target = 2
Output: 4
Explanation: target = 2 occurs 4 times in the given array so the output is 4.

Input: arr[] = [1, 1, 2, 2, 2, 2, 3], target = 4
Output: 0
Explanation: target = 4 is not present in the given array so the output is 0.

Input: arr[] = [8, 9, 10, 12, 12, 12], target = 12
Output: 3
Explanation: target = 12 occurs 3 times in the given array so the output is 3.