ii) Binary Search

→ Very important algorithm, asked mostly in faang Companies.

→ Try to Share your learnings on Social.

#dsawithkunal
@ commclassroom
@ kunalstut

→ Now we learn optimised way to Search.

→ we are talking about right now, the number of comparisons being made in worst case.

→ Just imagine array is Sorted in ascending or descending order, then binary Search comes into action for Searching.

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Start mid End

[2, 4, 6, 9, 11, 12, 14, 20, 36, 48]

(i) find the middle element i.e $\left(\frac{Start + End}{2}\right)$

(ii) ~~target > middle~~ ⇒ Search in the right i.e Start = mid + 1

else

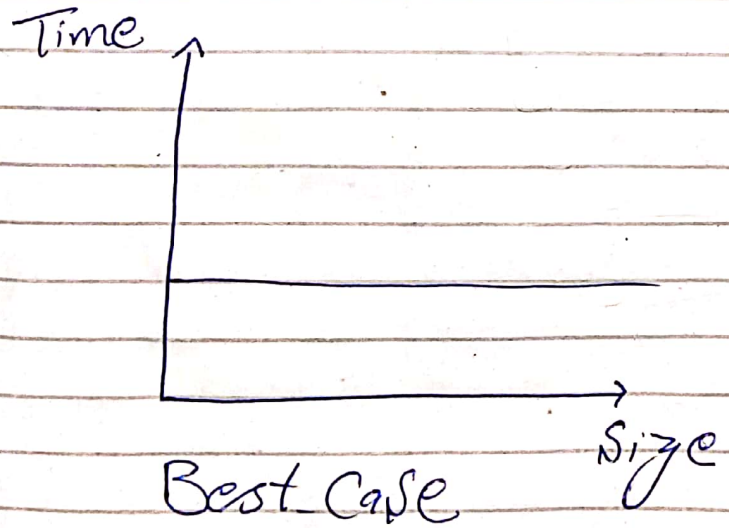
Search in the left i.e end = mid - 1

(3) if middle_element == target_element

Note O(1) Best_Case

→ When the first middle value equal to what you are searching, that is the best_case of binary search.

→ It doesn't matter our array contains 1 lakh element, 10 element and whatever amount of elements contains.



Best_Case

O(1)

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Why Binary Search?

How this formular derived? All explanation in notes on github of binary Search.

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

K is basically last level of array when using binary Search.

$$\Rightarrow \boxed{N = 2^K}$$

→ I need to find the total number of levels

$$\Rightarrow \log(N) = \log(2^K)$$

$$\Rightarrow \log N = K \log 2$$

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

$$\Rightarrow \boxed{K = \log_2 N}$$

How much total No of comparison in worst case?

Ans: $O(\log(N))$

↳ Size of Array

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Search in 1,000,000 array elements

Linear Search	Binary Search
1 million comparisons	log (1 million) = 20

→ Difference like Earth and Sky, Day and Night.

Code

// better way to find mid

* $m = \frac{(s+e)}{2}$; If s and e are very large values then this may exceeds the int range.

→ better way

* $m = s + \frac{(e-s)}{2}$;

$\Rightarrow \frac{s + (e-s)}{2}$

$\Rightarrow \frac{2s + e - s}{2}$

$\Rightarrow \frac{s+e}{2}$

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Order Agnostic Binary Search

if we don't know our array is sorted in increasing or decreasing order, then we apply this Algorithm.

```
boolean increasingOrder = false;
    if (arr[0] < arr[arr.length-1]) {
        increasingOrder = True;
    }
```

⇒ remember above technique

Haha

- Good developer copy code
- Great developer paste code

Binary Search Interview Questions

1

MicroSoft_Amazon ⇒ Interviews little easy

Google_Facebook ⇒ Require Some more effort because they have higher packages.

i) Ceiling of a Number

arr=[2, 3, 5, 9, 14, 16, 18], target=14

ceiling: smallest element in array greater than or = target

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arr = [2, 3, 5, 9, 14, 16, 18], target = 14

```
int s = 0, e = arr.length - 1;
int mid; int = ceil;
while (s <= e) {
    mid = s + ((e-s)/2);

    if (arr[mid] > target) {
        s = mid + 1;
    } else if (arr[mid] < target) {
        e = mid - 1;
    } else {
        return target;
    }
}
return arr[s];
```

while loop condition

⇒ $s^{start} \le$ end ⇒ when while loop breaks
start = end + 1;

⇒ next big Number, when no answer found = start

ii) Floor of a number

floor = greatest number equal or smaller to target

// Same thing before, Just return arr[end] instead -1.

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③ 744. Find Smallest Letter Greater than target

① Exact same approach that we used for ceiling of no.

② Ignore the target = what we are looking for.

③ arr = [$\overset{0}{\text{'c'}}$, $\overset{1}{\text{'d'}}$, $\overset{2}{\text{'y'}}$, $\overset{3}{\text{'j'}}$], target = 'v'

condition violated: start = end+1

length of array = N

return s % N;

④ Find First and last position of Elements in Sorted Array

arr = [$\overset{0}{5}$, $\overset{1}{7}$, $\overset{2}{7}$, $\overset{3}{7}$, $\overset{4}{7}$, $\overset{5}{8}$, $\overset{6}{8}$, $\overset{7}{10}$]

target = 7

$\log N + \log N = 2 \log N$

constants are ignored in time complexity.

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s e
s mid e
s mid e
s mid e

int[] arr = {2, 2, 3, 4, 4, 5, 5, 6, 7, 8, 8, 7, 7}; target=4;

Q:5 Find position of an element in a sorted array of infinite numbers.

i) we don't length of array
ii) finding low and high using this ~~int~~ technique.

```
int start = 0;
int end = 1;
while(target > arr[end]) {

    int newStart = end+1;
    // end += end*2;
    end = end + (end - start + 1)*2;

}
```

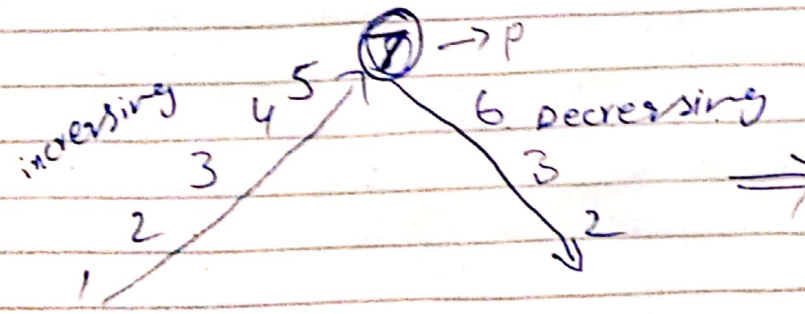
end=
newStart=

elements in previous array

elements in next array

Q:6 Peak index in a Mountain array

arr = [1, 2, 3, 5, 7, 6, 3, 2]



⟹ bitonic array

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How to be a good Software Engineer with Kelsey Hightower

→ Being a good person is also included in being a good Software engineer.

→ Communications Skills are on high.

→ There are no hard Skills or Soft Skills, there are Just Skills.

→ This changed the perpective of Kunal.

```
Start = 0 ; end = arr.length - 1
while ( Start < end ) {
  int mid = Start + (end - Start) / 2 ;
        if (arr[mid > arr[mid+1]) {
              end = mid;
        } else {
              Start = mid+1;
        }
  }
}
return Start;
```

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1995. Find in Mountain Array

→ Stay tuned, you will be faang interview ready
(Kunal Kushwaha)

→ "Cracking the coding interviews is not the difficult, hard question doe'snt means hard, You Just need to know the algorithms and the problem solving skills, and each and every skills for every data structure and algorithm, Kunal will teach you free"

"♡ you Kunal"

33. Search in Rotated Sorted Array

Two approaches

(i)

(a) finding pivot (→ max element array) in array, ⇒ from where your next No's are Ascending.

(b) Search in first half
⇒ Simple BS (0, pivot)

(c) Search in Second half, pivot+1 till end.

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Finding Pivot?

arr. [3, 4, 5, 6, 0, 1, 2]

Ans when? → when you find that mid > mid+1 element, i.e. pivot.

Case (1)

What otherways, I can get my answer.

if mid element < (mid-1) element i.e. also my ans ⇒ ans = m,

Case – (2)

Case – (3)

Start element > mid element

[4, 5, 6, 3, 2, 1, 0]

s m e

in this case, element from mid-element will be < start. There we can ignore all there elements since we are looking for peak i.e. largest element e = mid+1,

1)

2)

3)

4)

5) S.

Key things to Note!

* It is a Journey, It is a process you keep getting better at Software Engineering at coding, at DS Algo and definitely will be able to crack the interview for the dream company as well.

"Apurva Singh Software Engineer at Meta"

* We don't need competative programming for FAANG.

What Skills are needed for faang?

1) Do adequate Research about the company and Targeted Job profile

2) programming language (Java)

3) Data Structure & Algorithms

4) Core CS Subjects
   - (i) Operating Systems
   - (ii) Computer Networks
   - (iii) DataBase Management Systems

5) System Design (preferable, but not sufficient for beginner)

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⑥ practice as Many programming problem as you can.

⑦ Be prepared for Questions Based on your technical projects.

⑧ practice with Mock Interviews and Test Series.

Tips

i) prepare a professional Resume

ii) participate in Standard coding challenges.

iii) Work on required analytical and soft skills

iv) Grow your professional Network and ASK for Refferalls.

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Case # 04

S element < mid element

0	1	2	3	4
3	4	5	6	2
s		m		e

Sorted

$S = m+1$

if this way pivot, it would have been returned in case 1 & 2

That proved, that bigger number lie ahead. Hence, ignore mid & put $S = mid + 1$

Note:

Always look for cases while solving problem, cases are nothing but these are just brainstorming.

what can happen, your thinking outline.

Find the Rotation Count in Rotated Sorted array

ans = pivot + 1 ;

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What are open source contributions?

10. Split Array Largest Sum (very Imp)

arr = [7, 2, 5, 10, 8] , m = 2

Max = 24

max = 18

max = 23

ans = 18

* min partition 1
* max partion max

Note:

Always remember corner case when approaching problem.

Corner Case:

(i) if arr length is 1, what have to do.

(ii) if arr length is 0, what have to do

(iii) if arr length is N, what have to do.

(iv) if arr length in between 1 and N, what have to do.

minAns = max value in array

maxAns = Sum of all values in array.

[10, 32]

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What is potential answer while solving problem?

"Make learning fun. It's all about collaboration ~~and~~ than competitions And these indian people all they think about competition first, JE competition, then CP (competative programming) competition, and everything. If you ~~will~~ ~~get~~ think about collaboration, then you can get better opportunity then that they get using competitions."

Kunal Kushwaha.

① Binary Search in 2D Arrays

Searching in Matrices:

r = 0
c = 2

1	2	3
4	5	6
9	18	19

0, 2
1, 2
2, 2

Target 18

2

Case : 1 element == target
Case : 2 element < target
r ++
else
c --

really nice

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②

this is also very imp, must perform after exam.

Question Search in Sorted matrix

Note: Try to ~~Search~~ reduce the Search Space when you are given such big matrix.

* Take middle column & perform Binary Search on it

target=2

rStart=0
rEnd=3

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

> target

① if (element == target) {
return ans

② if (element > target (ignoring next rows)

③ if (element < target (ignoring above rows)

→ this is how we are reducing Search Space

→ In the end, two rows are remaining.

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1	2	3	4
5	6	7	8

1. Check whether the mid column you are at, contains the answer i.e (2, 6)

2. Consider the four parts
   i) Apply simple binary search on these four.

Time Complexity $= O(\log(N) + \log(M))$

After Mid exams,

Firstly, follow these instructions

i) Read Notes upto this carefully.
ii) Then practice all Questions that covered in previous BS lectures.
iii) Solve all Questions in BS Assignment.
iv) After solving BS Questions, Solve Array assignment 3 hard Questions.

v) Move on Next topic.

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Kunal Kushwaha Tips & Tricks

→ How to stay motivated while learning code?

→ Don't compare yourself with others.

→ working hard is not also that is required, But working smart that is required.

→ Code in public.

→ How to stay motivated when not getting result?
  i) Be patient and Network with people.
  ii) Inspiring from others.

→ Do not indulge in click-bid videos.

→ How Kunal learn so many things in short Time?

- Year → Month → Weeks
- PI Shaped learning
- Learning In public

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