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$$\text{arr} = [2, 4, 9, 10, 12, 14, 18, 19]$$

→ ascending

$$\text{arr2} = [19, 12, 6, 5, 3, 2, -8, -10]$$

→ descending order

max comparisons :  $N \Rightarrow$  No. of elements

$$\frac{0+9}{2} = 4$$

- ① find the middle element
- ②  $\text{target} > \text{mid} \Rightarrow$  search in the right  
else search in left
- ③ if middle element == target element // ans

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

Indices: 0 1 2 3 4 5 6 7 8 9

The element 11 at index 4 is circled in red and blue.

target = 36

Sensor 12

$\Sigma$   $\begin{matrix} 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\ 2, & 4, & 6, & 9, & 11, & 12, & 14, & 20, & 36, & 48 \end{matrix}$   $\epsilon$

$$\frac{5+9}{2} = (7)$$

$\Sigma$   $\begin{matrix} 12, 14 \end{matrix}$   $\begin{matrix} m \\ 20, 36, 48 \end{matrix}$   $\epsilon$

$\Sigma$   $\begin{matrix} 12, 14 \end{matrix}$   $\epsilon$

Ans = 5

if  $s > e$  : element not found.

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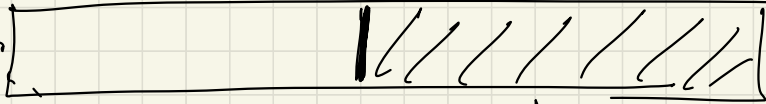
Best case

$O(1)$

# Why Binary Search?

Q: Find the max number of such comparisons in worst case.

0



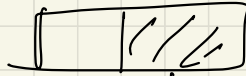
$$N = \frac{N}{2^0}$$

1

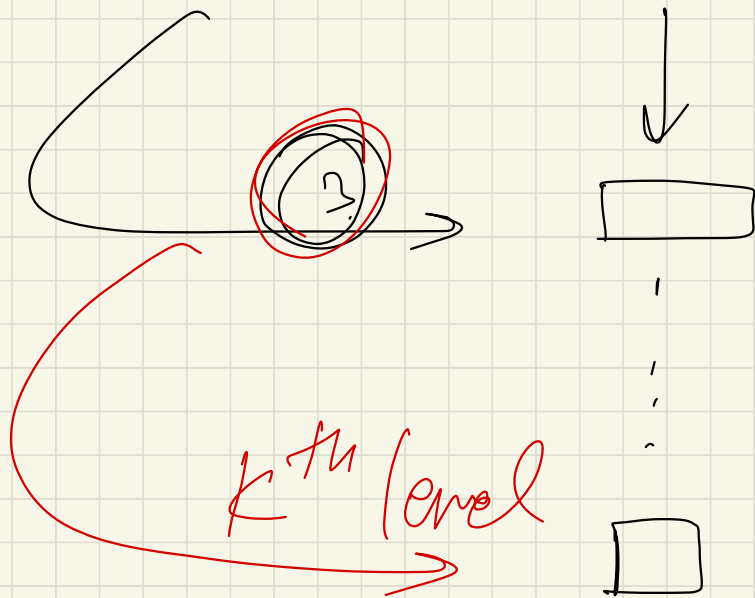


$$\frac{N}{2} = \frac{N}{2^1}$$

2



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



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

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

$$\frac{N}{2^k} = 1 \Rightarrow N = 2^k$$

$$\log(N) = \log(2^k)$$

$$\log N = k \log 2$$

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

$$k = \log_2 N$$



Total comparisons in the worst case =  $\log N$

Search in a 1, 000, 000

Linear

1 mill

Binary search

20 comparisons

$O(\log N)$

// better way to find mid

$$\star \quad m = \frac{(s + e)}{2}$$

This may exceed  
the int range

$$\star \quad m = s + \frac{(e - s)}{2}$$

$$\begin{aligned} & s + \frac{e - s}{2} \\ & \cancel{s + e} \cancel{- s} \\ & = \frac{s + e}{2} \end{aligned}$$

#dsa with Kunal

@commclassroom

@Kunalstwt

## Order agnostic Binary Search

arr = [ 90, 75, 18, 12, 6, 4, 3, 17 ]

Indices: 0, 1, 2, 3, 4, 5, 6, 7

Target: 75

target > middle  $\Rightarrow$  left

$$e = m - 1$$

target < middle  $\Rightarrow$  right

$$s = m + 1$$

arr = [3, 2, 3, 3, 3, 3, 3, 14, 20, 33]

*Handwritten annotations:*

- A red circle around the first element '3'.
- A red arrow pointing from the circled '3' to the second element '2'.
- A red arrow pointing from the '2' to the word 'Prob!' written above the array.
- A red 's' written above the last element '33'.

if  $s > j \Rightarrow$  increasing

else  $\Rightarrow$  decreasing

