AlgoManiaX Lecture - 2

Searching - Linear and Binary, and Applications

Array

- An array is a collection of data items, all of the same type, accessed using a common name.
- A one-dimensional array is like a list;
- A two dimensional array is like a table.

Example :

1. char arr[10]; declares an array of 10 characters.
2. int arr[n]; declares an array of ‘n’ integers, where n is a variable. The value of ‘n’ should be stored prior to this operation, else it may lead to memory overflows.

Linear Search

‘Linear’ is when we go in a line i.e. we go through all the values present in the array, to check for the presence of some required element.

```
int index = -1;
for (int i=0; i<n; i++)
{
      if (a[i] == x)
      {
            index = i;
            break;
      }
}
```

How Efficient is Linear Search ?

Best Case Time Complexity = O(1)

Worst Case Time Complexity = O(n)

Advantage :

- Works with any array, irrespective of values in the array.

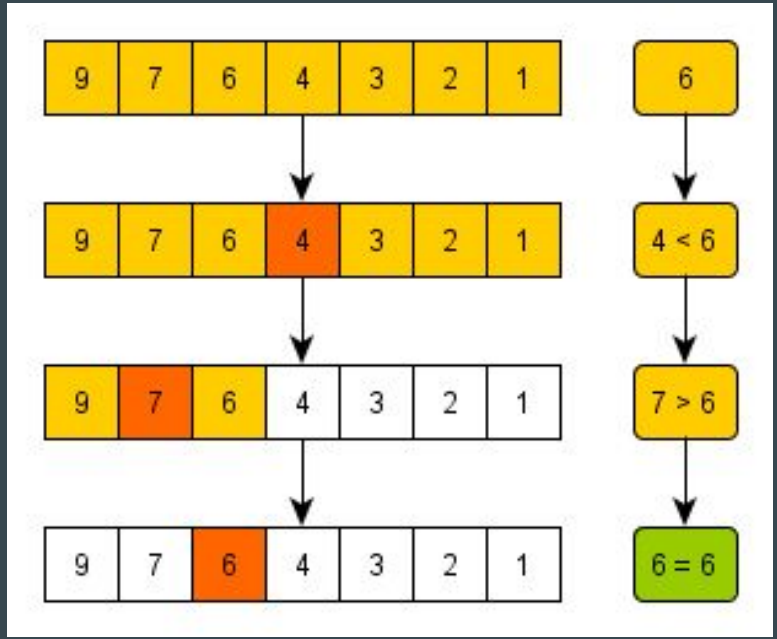
Disadvantages :

- Not very efficient
- Might give incorrect results, in case of repetitions in the array.

Binary Search - A better approach

Works only with sorted arrays.

Binary Search uses the fact that our array is sorted, and in every iteration, reduces the effective size of our search radius by half, thereby being much more efficient than Linear search.



Code - Binary Search

```
int l = 0, r = n-1, answer;
while( l <= r )
{
      int mid = (l+r)/2;
      if( a[mid] == x )
            break;
      else if( a[mid] < x )
            l = mid+1;
      else
            r = mid-1;
}
if( l>r )  // element x not found.
else       answer = mid;
```

Binary Search - Is it really that efficient ?

Best Case Time Complexity = O(1)

Worst Case Time Complexity = O(log n) : much much lesser than O(n)

Limitations :

- Works only with **MONOTONIC** functions.

Practice Questions

And Applications of Binary Search

Square Root of a Number

1. Find the integral square root of a number using Binary Search.
2. Find the precise square root of a number upto a precision of 10^(-6).

- Constraints : N <= 10^18.
- Integral Square root : sqrt(48) = 6, sqrt(10) = 3.

Upper Bound and Lower Bound

Given a non-decreasing array, find the “Upper Bound” and “Lower Bound” of a number given a input.

Example : Array - 1 2 2 3 3 3 3 4 6 6 8 10 11.

- Upper Bound of 9 = 10.
- Upper Bound of 1 = 1.
- Upper Bound of 3 = rightmost 3 (index 6)
- Lower Bound of 8 = 8.
- Lower Bound of 50 = 11.
- Lower Bound of 6 = leftmost 6 (index 8)

Aggressive Cows - SPOJ

Farmer John has built a new long barn, with N (2 <= N <= 100,000) stalls. The stalls are located along a straight line at positions x1,...,xN (0 <= xi <= 1,000,000,000).

His C (2 <= C <= N) cows don't like this barn layout and become aggressive towards each other once put into a stall. To prevent the cows from hurting each other, FJ wants to assign the cows to the stalls, such that the minimum distance between any two of them is as large as possible.

What is the largest minimum distance ?

http://www.spoj.com/problems/AGGRCOW/

Interviewers and the Queue (DSA Lab Compre 2016)

Interviews are going on in the Placement Unit of BITS Goa, and students outside are waiting outside in a queue for their chance at the interviewer.

This year, we have ‘N’ interviewers sitting in rooms from 1 to N, and every interviewer has a fixed interview time per student. There are numerous students waiting outside the rooms, in a queue numbered from 1 to infinity. Keshav is standing in the queue at position number X. Now he is curious and wants to know at what time his interview starts and which interviewer will take his interview.

At t=0, all N interviewers invite students simultaneously, and after that the queue proceeds real-time i.e. as soon as an interviewer finishes one student, he invites the next student in the queue. If multiple interviewers finish at the same time, the one with the lesser room number is given priority. Assume the interview durations of interviewers from 1 to N are sorted in increasing order.

Given the values of N, X and the N interview durations, find out the time at which Keshav’s interview starts, and the room number Keshav is invited to.

N <= 50, X <= 10^12, Each interview duration <= 10^5.

More Practice Problems

1. Discover the Monk - https://www.hackerearth.com/code-monk-searching/algorithm/discover-the-monk/

2. Ice Cream Parlour - https://www.hackerrank.com/challenges/icecream-parlor

3. Vanya and Lanterns - http://codeforces.com/problemset/problem/492/B

4. Worms - http://codeforces.com/problemset/problem/474/B