



Bansilal Ramnath Agarwal Charitable Trust's  
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Technology

**Department of  
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**Semester:** V

**Academic Year:** 2023-2024

**Subject Name & Code:** Design and Analysis of Algorithm: ADUA31202

**Title of Assignment:** Write a program to perform binary search on an unsorted random list of at least 5000 elements. The key element should be user input. Use the Divide & Conquer method to implement this program.

**Date of Performance:** 04-08-2023

**Date of Submission:** 11-08-2023

## **ASSIGNMENT NO. 1**

## **Theory:**

Binary search is a fast search algorithm with run-time complexity of  $O(\log n)$ . This search algorithm works on the principle of divide and conquer. For this algorithm to work properly, the data collection should be in the sorted form.

Binary search looks for a particular item by comparing the middle most item of the collection. If a match occurs, then the index of item is returned. If the middle item is greater than the item, then the item is searched in the sub-array to the left of the middle item. Otherwise, the item is searched for in the sub-array to the right of the middle item. This process continues the sub-array as well until the size of the subarray reduces to zero.

## **How Binary search works?**

### **1) Divide and Conquer Principle:**

Binary search is based on the "divide and conquer" approach, which means it breaks down a larger problem into smaller subproblems until a solution is found. In the case of binary search, the algorithm repeatedly divides the search space in half, eliminating half of the remaining elements at each step, thus significantly reducing the number of elements to search through.

### **2) Preconditions:**

1. The collection of data must be sorted in ascending (or descending) order. This is crucial because binary search relies on comparing elements to decide whether to search the left or right half.
2. The data structure should allow for efficient random access to elements, such as arrays or lists with indexed access.

### **3) Searching Process:**

#### **a. Initialization:**

1. Initially, you have the entire sorted collection as your search space.
2. You maintain two pointers: one pointing to the start of the current search space and the other pointing to the end.

#### **b. Comparison and Subdivision:**

1. Calculate the middle index of the current search space:  $(\text{start} + \text{end}) / 2$ .
2. Compare the element at the middle index to the target element you're searching for.
3. If the middle element matches the target, you've found it and can return the index.
4. If the middle element is greater than the target, this means the target must be in the left half, so you update the 'end' pointer to be the middle index minus one.
5. If the middle element is less than the target, the target must be in the right half, so you update the 'start' pointer to be the middle index plus one.

#### **c. Iteration or Termination:**

1. The process is repeated until the search space is reduced to zero (start becomes greater than end), indicating that the target element is not present in the collection.
2. If the target is found, its index is returned. If not, the algorithm terminates with a signal that the target is not in the collection.

**Time Complexity:**

The key reason for binary search's efficiency is its logarithmic runtime complexity, which is  $O(\log n)$ . With each iteration, the search space is effectively halved, leading to rapid convergence even with large datasets. This is in stark contrast to linear search ( $O(n)$ ), where each step eliminates only one element from consideration.

DAA Assignment no 1\* Problem statement : →

Write a program to perform binary search on an unsorted random array of atleast 5000 element. The key element should be user input. Use divide & conquer method to implement program.

\* Objective : →

- 1) To learn about divide & conquer method.
- 2) To learn about binary search algorithm.
- 3) Analyze the binary search algorithm.
- 4) Perform binary search algorithm using divide & conquer method.

\* Algorithm : →

- 1) Calculate the mid element  

$$\text{mid} = (\text{low} + \text{high}) / 2$$
- 2) Compare the mid element with key element.
  - i) If  $\text{key} = \text{mid}$ , return mid.
  - ii) if  $\text{key} > \text{mid}$  element, set  $\text{low} = \text{mid} + 1$  & go back to step 1.
  - iii) if  $\text{key} < \text{mid}$  element, set  $\text{high} = \text{mid} - 1$  & go back to step 1.
- 3) Return -1 indicating that the key element is not present inside array.

\* Pseudocode : →

```
static int binsearch(int arr[], int key) {
    int first = 0;
    int last = arr.length - 1;
    while (first <= last) {
        int mid = (first + last) / 2;
```

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```

if (key == arr[mid]): return mid
else if (key > arr[mid]): first = mid + 1
else: last = mid - 1
}
return -1
}

```

\* Example:

Consider array  $arr[] = \{2, 5, 8, 12, 16, 23, 38, 56, 72, 91\}$  &  $key = 23$

i)  $mid = \frac{0+9}{2} = 4$

$arr[mid] = 16$

$key > arr[mid] \Rightarrow low = mid + 1 = 5$

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

$arr[mid] = 56 > key$

$\therefore high = mid - 1 = 6$

iii)  $mid = \frac{5+6}{2} = 5$

$arr[mid] = 23 = key \Rightarrow \text{return mid}$

$\therefore$  key found at 5<sup>th</sup> index

Conclusion

Conclusion: We studied & implemented Binary search using divide & conquer method.

## OUTPUT:

```
#include<iostream>
using namespace std;
int main()
{
    int i, num, first, last, middle;
    int x, y, size, temp;
    int sz;

    cout<<"Enter the size of array::";
    cin>>sz;
    int randArray[sz];
    int arr[5000];
    for(int i=0;i<sz;i++)
        randArray[i]= 1 + rand()%5000; //Generate number between 0
to 5999

    cout<<"The generated array : ";
    for(int i=0;i<sz;i++)
        cout<<randArray[i]<<" ";

    for(int x=0;x<sz;x++)
        arr[x]=randArray[x];

    //Ascending order
    for (x = 0; x < sz; x++){
        for (y = x; y < sz; y++){
            if (arr[x] > arr[y+1]){
                temp = arr[x];
                arr[x] = arr[y+1];
                arr[y+1] = temp;
            }
        }
    }

    //Output
    cout <<"\n\nElements sorted in the ascending order are : ";
    for (x = 1; x <= sz; x++){
        cout << arr[x]<<" ";
    }

    cout<<"\n\nEnter Element to be Search: ";
    cin>>num;
    first = 0;
    last = sz-1;
```

```

middle = (first+last)/2;
while(first <= last)
{
    if(arr[middle]<num)
        first = middle+1;
    else if(arr[middle]==num)
    {
        cout<<"\nThe number, "<<num<<" found at Position
"<<middle;
        break;
    }
    else
        last = middle-1;
    middle = (first+last)/2;
}
if(first>last)
    cout<<"\nThe number, "<<num<<" is not found in given Array";
cout<<endl;
return 0;
}

```

Output

Enter the size of array::5000

The generated array : 4384 887 2778 1916 2794 3336 387 493 1650 1422 2363 28 3691 60 2764 3927 541 3427 4173 737 212 369 2568 1430 783 1531 2863 124 4068 3136 3930 4803 4023 3059 3070 3168 1394 3457 12 3043 1230 2374 4422 4920 3785 3538 199 4325 3316 4371 1414 3527 1092 3981 4957 1874 1863 4171 1997 2282 2306 926 2085 1328 337 1506 847 1730 1314 858 1125 3896 4583 546 3815 3368 435 385 4044 3751 1088 1809 2277 2179 789 3585 404 2652 2755 2400 4933 61 4677 3369 2740 13 1227 3587 3095 2540 796 571 1435 379 2468 1602 98 2903 3318 493 1653 757 2302 281 4287 4442 3866 4690 3445 1620 3441 4730 3032 9118 3098 772 4482 676 710 3528 4568 2857 4498 2354 4587 1966 307 4684 1220 3625 1529 2672 733 3830 4504 20 3271 3369 4709 1716 1341 3150 2797 724 2619 2246 2847 3452 2922 3556 2380 2489 2765 3229 4842 2351 194 1501 2035 2765 125 4915 1988 857 3744 1492 2228 3366 4860 1937 1433 2552 1438 4229 3276 408 1475 1122 3859 4396 1030 1238 3236 3794 819 4429 1144 1012 929 4530 3777 2405 4444 764 4614 4539 3607 1841 2905 4819 129 689 2370 2918 4918 3007 2235 2741 1322 2185 2321 506 3255 1571 515 508 3095 3110

Output

64 3282 3427 4318 1736 3629

Elements sorted in the ascending order are : 1 1 2 3 4 5 6 8 9 9 11 12 12 13 13 13 13 14 15 15 16 18 18 19 19 20 20 22 22 24 27 28 28 28 29 30 31 31 33 33 34 35 36 38 39 39 39 40 43 43 47 48 49 50 50 50 51 53 54 54 55 56 56 57 57 58 58 58 59 60 61 63 63 64 64 67 67 70 70 71 72 73 74 75 76 77 78 78 80 82 82 83 83 84 85 85 86 88 91 91 91 94 95 97 97 97 98 98 99 100 101 101 105 106 108 108 108 108 109 109 110 110 113 114 115 115 116 116 116 116 117 117 118 119 121 123 123 124 124 125 125 127 128 128 128 129 129 129 130 132 132 136 137 140 140 140 141 141 143 144 147 148 148 149 150 151 151 152 152 153 154 154 155 155 155 155 156 158 160 160 160 161 161 162 163 164 165 165 166 167 169 169 169 170 171 172 172 173 173 177 177 178 178 178 180 182 183 184 186 187 187 187 187 188 190 191 192 192 193 193 194 194 195 197 197 197 198 199 200 203 208 208 208 208 211 211 212 213 213 214 216 216 217 217 218 219 221 221 223 224 224 227 227 228 230 230 232 236 236 237 237 238 238 239 239 240 243 245 245 247 248 248 251 251 251 254 254 255 255 256 256 259 259 260 260 260 261 261 261 261 263 263 264 266

Output

4803 4803 4803 4806 4806 4808 4810 4811 4812 4812 4813 4813 4814 4814 4815 4815 4816 4816 4819 4819 4819 4820 4820 4820 4822 4823 4826 4827 4827 4827 4829 4830 4830 4831 4832 4832 4832 4833 4834 4834 4834 4836 4836 4838 4840 4841 4842 4845 4848 4848 4849 4849 4850 4851 4852 4853 4854 4854 4855 4857 4856 4860 4860 4862 4862 4863 4863 4864 4866 4873 4873 4874 4875 4878 4878 4877 4878 4878 4879 4883 4883 4884 4884 4885 4885 4886 4888 4888 4889 4890 4893 4894 4894 4896 4897 4897 4900 4902 4902 4903 4903 4905 4905 4905 4907 4909 4909 4910 4912 4912 4913 4914 4915 4916 4917 4918 4918 4919 4919 4920 4920 4928 4931 4932 4933 4933 4934 4935 4938 4938 4939 4940 4940 4943 4945 4945 4945 4946 4946 4946 4947 4947 4947 4948 4950 4950 4950 4950 4951 4952 4955 4956 4957 4957 4957 4959 4959 4959 4961 4963 4964 4967 4968 4968 4968 4970 4970 4970 4970 4971 4973 4973 4973 4975 4977 4977 4977 4977 4978 4978 4982 4983 4983 4985 4986 4987 4987 4987 4988 4988 4993 4995 4996 4997 4997 5000 5000

Enter Element to be Search: 155

The number, 155 found at Position 174