**Binary Search :: Simulation**

**Remember Binary Search pre-requisite is sorted array. So we shall take sorted Array**

**Test Case-1:**

**Total Data: 16, So**

**Low Index=0**

**High Index=15**

**Mid= (low + high) /2 = 0 + 15 = 15/ 2 =7**

**Suppose we shall search for 3**

**Low=0 mid=7 high=15**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Data** | **1** | **3** | **5** | **13** | **14** | **15** | **21** | **22** | **25** | **32** | **44** | **51** | **66** | **95** | **99** | **110** |
| **Index** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |

Look there is 22 at mid index 7 and 3 is less than 22, so we shall search again at left side.

Now **Low Index=0**

**High Index=mid – 1=7-1=6**

**Mid= (low + high) /2 = (0+6) / 2=3**

**Low=0 mid=3 high=6**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Data** | **1** | **3** | **5** | **13** | **14** | **15** | **21** | **22** | **25** | **32** | **44** | **51** | **66** | **95** | **99** | **110** |
| **Index** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |

Look there is 13 at mid index 3 and 3 is less than 13, so we shall search again at left side.

Now **Low Index=0**

**High Index=mid – 1=3-1=2**

**Mid= (low + high) /2 = (0+2) / 2=1**

**Low=0 mid=1 high=2**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Data** | **1** | 3 | **5** | **13** | **14** | **15** | **21** | **22** | **25** | **32** | **44** | **51** | **66** | **95** | **99** | **110** |
| **Index** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |

Look there is 3 at mid index 1 and 3 equal to key 3, so we found 3

**Test Case-2:**

**Total Data: 16, So**

**Low Index=0**

**High Index=15**

**Mid= (low + high) /2 = 7**

**Suppose we shall search for 110**

**Low=0 mid=7 high=15**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Data** | **1** | **3** | **5** | **13** | **14** | **15** | **21** | **22** | **25** | **32** | **44** | **51** | **66** | **95** | **99** | **110** |
| **Index** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |

Look there is 22 at mid index 7 and **110** is greater than 22, so we shall search again at right side.

Now **Low Index=mid + 1 = 7 + 1 =8**

**High Index=15**

**Mid= (low + high) /2 = (8+15) / 2=23/2=11**

**Low=0 mid=3 high=6**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Data** | **1** | **3** | **5** | **13** | **14** | **15** | **21** | **22** | **25** | **32** | **44** | **51** | **66** | **95** | **99** | **110** |
| **Index** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |

Look there is 51 at mid index 11 and **110** is greater than 51, so we shall search again at right side.

Now **Low Index=mid + 1 = 11 + 1 =12**

**High Index=15**

**Mid= (low + high) /2 = (12+15) / 2=27/2=13**

**Low=12 mid=1 3 high=15**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Data** | **1** | 3 | **5** | **13** | **14** | **15** | **21** | **22** | **25** | **32** | **44** | **51** | **66** | **95** | **99** | **110** |
| **Index** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |

Look there is 95 at mid index 13 and **110** is greater than 95, so we shall search again at right side.

Now **Low Index=mid + 1 = 12 + 1 =13**

**High Index=15**

**Mid= (low + high) /2 = (13+15) / 2=28/2=14**

**Low=12 mid=1 3 high=15**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Data** | **1** | 3 | **5** | **13** | **14** | **15** | **21** | **22** | **25** | **32** | **44** | **51** | **66** | **95** | **99** | **110** |
| **Index** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |

Look there is 99 at mid index 14 and **110** is greater than 99, so we shall search again at right side.

Now **Low Index=mid + 1 = 14+ 1 =15**

**High Index=15**

**Mid= (low + high) /2 = (15+15) / 2=30/2=15**

**low/mid/high=15**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Data** | **1** | 3 | **5** | **13** | **14** | **15** | **21** | **22** | **25** | **32** | **44** | **51** | **66** | **95** | **99** | **110** |
| **Index** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |

Look there is **110** at mid index 15 and **110** is equal to key **110**, so we found our search key.

**Test Case-3 and Improved Binary Search:**

**Total Data: 16, So**

**Low Index=0**

**High Index=15**

**Mid= (low + high) /2 = 7**

**Suppose we shall search for such a value will not found at the array bellow: Like 200**

**Remember Binary Search pre-requisite is sorted array.**

**Look low index 0 conatins 1 and high index 15 contains 110, But 200 is greater than high index value 110. So we can decide without searhing the entire array.**

**Low=0 mid=7 high=15**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Data** | **1** | **3** | **5** | **13** | **14** | **15** | **21** | **22** | **25** | **32** | **44** | **51** | **66** | **95** | **99** | **110** |
| **Index** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |

Decision: no need to search this array.

**Test Case-4:**

**Total Data: 16, So**

**Low Index=0**

**High Index=15**

**Mid= (low + high) /2 = 0 + 15 = 15/ 2 =7**

**Suppose we shall search for 2**

**Low=0 mid=7 high=15**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Data** | **1** | **3** | **5** | **13** | **14** | **15** | **21** | **22** | **25** | **32** | **44** | **51** | **66** | **95** | **99** | **110** |
| **Index** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |

Look there is 22 at mid index 7 and 2 is less than 22, so we shall search again at left side.

Now **Low Index=0**

**High Index=mid – 1=7-1=6**

**Mid= (low + high) /2 = (0+6) / 2=3**

**Low=0 mid=3 high=6**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Data** | **1** | **3** | **5** | **13** | **14** | **15** | **21** | **22** | **25** | **32** | **44** | **51** | **66** | **95** | **99** | **110** |
| **Index** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |

Look there is 13 at mid index 3 and 2 is less than 13, so we shall search again at left side.

Now **Low Index=0**

**High Index=mid – 1=3-1=2**

**Mid= (low + high) /2 = (0+2) / 2=1**

**Low=0 mid=1 high=2**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Data** | **1** | 3 | **5** | **13** | **14** | **15** | **21** | **22** | **25** | **32** | **44** | **51** | **66** | **95** | **99** | **110** |
| **Index** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |

Look there is 3 at mid index 1 and 2 less than 3, so we shall search again.

Now **Low Index=0**

**High Index=mid – 1=1-1=0**

**Mid= (low + high) /2 = (0+0) / 2=0**

**Low/mid/high=0**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Data** | **1** | 3 | **5** | **13** | **14** | **15** | **21** | **22** | **25** | **32** | **44** | **51** | **66** | **95** | **99** | **110** |
| **Index** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |

Look there is 1 at mid index 0 and 2 is **not matched or found.**

Pseducode-1:

Procedure binary\_search

Arr ← sorted array

n ← size of array

key ← value to be searched

Set low = 0

Set high = n-1

While low <= high

IF key == arr[mid]

Return mid;

IF key < arr[mid]

Low=mid-1;

IF key > arr[mid]

Otherwise Key Not found

end while

end procedure

Pseducode-2:

Procedure binary\_search\_improved

Arr ← sorted array

n ← size of array

key ← value to be searched

Set low = 0

Set high = n-1

IF Key < arr[low] OR Key > arr[high] OR Key != arr[low] OR Key != arr[high]

Key Not Found

ELSE

WHILE low <= high

IF key == arr[mid]

Return mid;

IF key < arr[mid]

Low=mid-1;

IF key > arr[mid]

Otherwise Key Not found

end while

end procedure

Problems: