































































































































































































































































































































































































































































































































































































































































































































































































































































































































































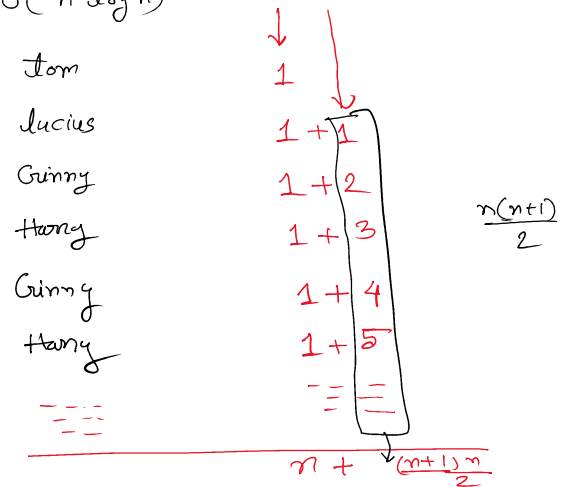
|              |   | map <String, bool> | Key              | Value      |
|--------------|---|--------------------|------------------|------------|
| tom          | → | mp["tom"] = 0      | mp["tom"] = 1    |            |
| lucius       | → | mp["lucius"] = 0   | mp["lucius"] = 1 | print      |
| gimmy        | → |                    | 0   1            | NO         |
| harry        | → |                    | 0   1            | NO         |
| <u>gimmy</u> | → | mp["gimmy"] = 1    |                  | <u>YES</u> |
| harry        | → | mp[harry] = 1      |                  | yes        |

$O(n)$

$$O(n * (n + n \log n)) \ll$$

$$O(n * n \log n)$$

$$O(n^2 \log n)$$



$$O\left(\frac{n^2}{2}\right) \approx O(n^2)$$

$$n + \frac{n^2 + n}{2} = \frac{n^2}{2} + \frac{n}{2}$$

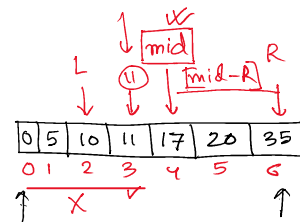
$$n=10 \quad 10 + \frac{100}{2} + \frac{10}{2} = 65$$

$$n=1000 \quad 1000 + \frac{500000}{2} + \frac{1000}{2} = 250150$$

## Binary Search

\* Searching Algorithm

find = 20



- Apple
- Ball
- Cat
- Jump
- Sheep
- Zoo

find = 20

p;

Get

















































































































































































































































































































































































































































































Lower Bound

$LB(14) = 3, LB(12) = 3, LB(26) = 11$   
 $LB(6) = 0$

|     |   |   |    |    |    |    |    |    |    |    |    |    |
|-----|---|---|----|----|----|----|----|----|----|----|----|----|
| val | → | 7 | 10 | 10 | 14 | 14 | 14 | 15 | 16 | 18 | 18 | 25 |
| pos | → | 0 | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 |

|     |   |   |    |    |    |    |    |    |    |    |    |    |
|-----|---|---|----|----|----|----|----|----|----|----|----|----|
| val | → | 7 | 10 | 10 | 14 | 14 | 14 | 15 | 16 | 18 | 18 | 25 |
| pos | → | 0 | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 |

Upper Bound

$UB(14) = 6, UB(18) = 10, UB(25) = 11$   
 $UB(9) = 1, UB(6) = 0$

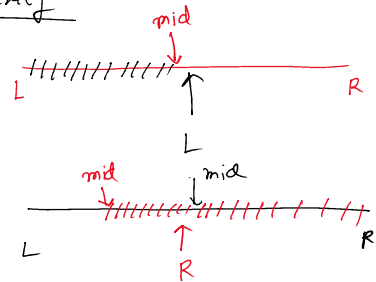
|   |   |   |   |
|---|---|---|---|
| 1 | 4 | 5 | 7 |
|---|---|---|---|

eldest < 8 → ①

8 < smallest → ②

9  
4  
6  
8  
10

Time Complexity



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

$$\Rightarrow N = 2^{K-1}$$

$$\Rightarrow \log_2(N) = K-1$$

$$\Rightarrow \textcircled{K} = \log_2(N) + 1$$

$$O(\log_2 N)$$

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

$$N/2 \rightarrow \frac{N}{2^1}$$

$$N/4 \rightarrow \frac{N}{2^2}$$

-----  
 -----  
 -----

$$1 \rightarrow \frac{N}{2^{K-1}}$$

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

⊗

$$N \rightarrow N/2^0$$

$$N/2 \rightarrow N/2^1$$

$$N/4 \rightarrow N/2^2$$

$$N/8 \rightarrow N/2^3$$

$$N/16 \rightarrow N/2^4$$

$$N/32 \rightarrow N/2^5$$

$$N/64 \rightarrow N/2^6$$

$$N/128 \rightarrow N/2^7$$

$$N/256 \rightarrow N/2^8$$

$$N/512 \rightarrow N/2^9$$

$$N/1024 \rightarrow N/2^{10}$$

$$N/2048 \rightarrow N/2^{11}$$

$$N/4096 \rightarrow N/2^{12}$$

$$N/8192 \rightarrow N/2^{13}$$

$$N/16384 \rightarrow N/2^{14}$$

$$N/32768 \rightarrow N/2^{15}$$

$$N/65536 \rightarrow N/2^{16}$$

$$N/131072 \rightarrow N/2^{17}$$

$$N/262144 \rightarrow N/2^{18}$$

$$N/524288 \rightarrow N/2^{19}$$

$$N/1048576 \rightarrow N/2^{20}$$

KK  
S  
K  
=