Revision

Course on Data Structure

Pankaj Sharma • Lesson 33 • Aug 15, 2024

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CS & IT Engineering

Data Structure

Hashing

Lecture Number- 33

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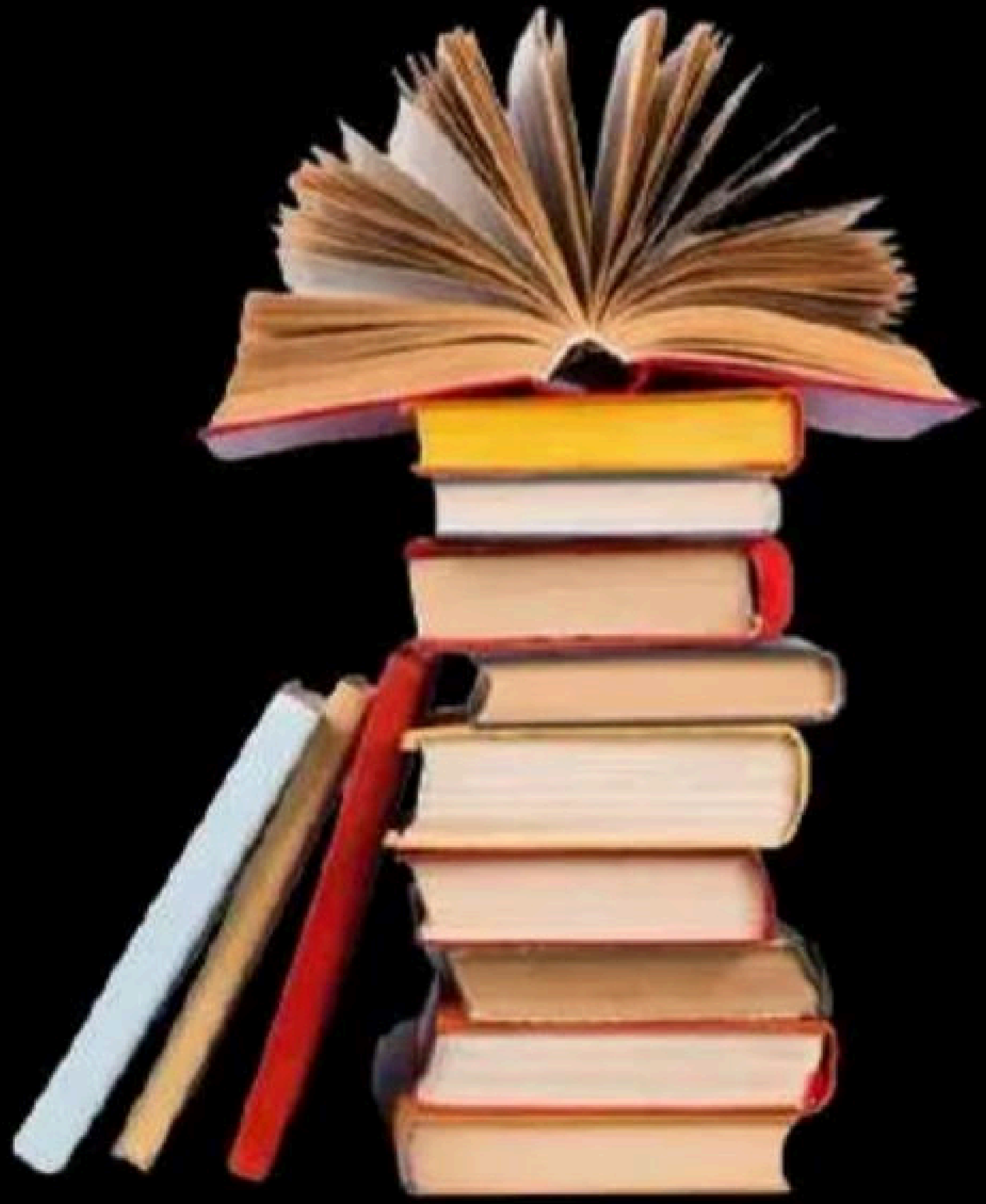
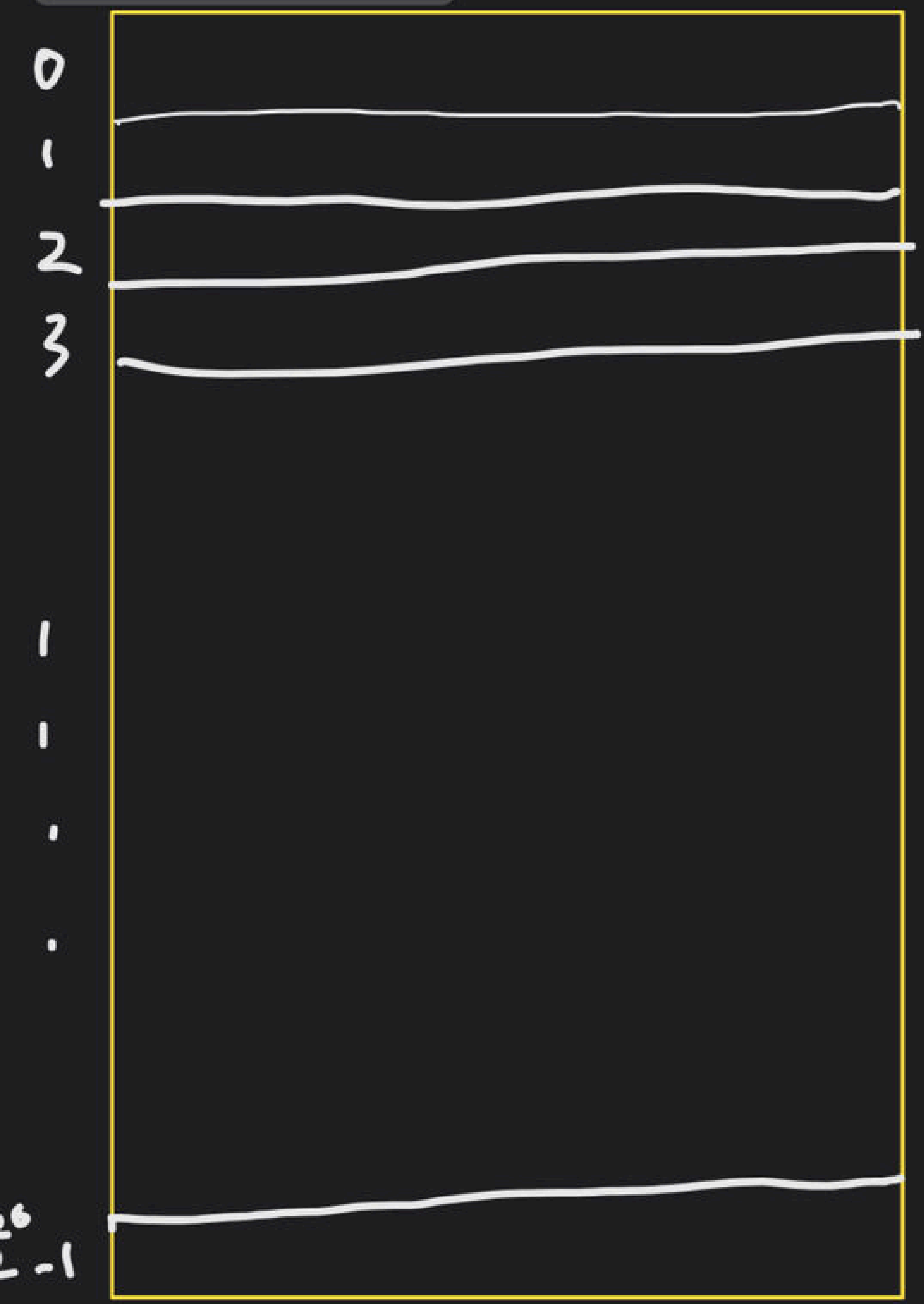
Topics

to be covered



1. Hashing-I

$n = 2^{20}$



$\# comp = O(n) = 2^{20}$

$\rightarrow$ BST

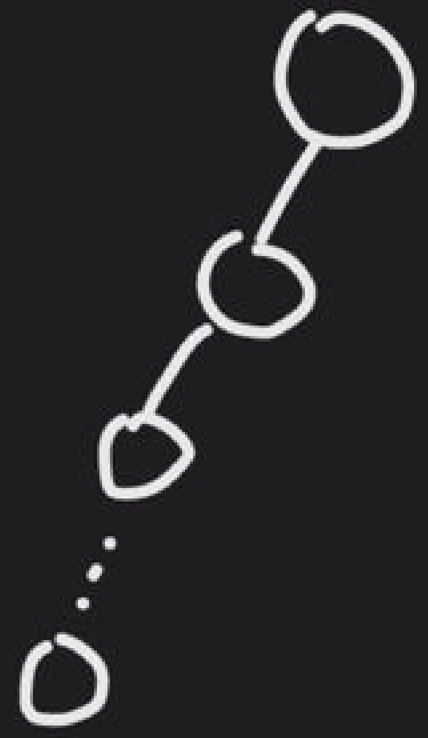
case1 | case 2

$\# comp = O(h)$

Skewed $= O(n) = 2^{20}$

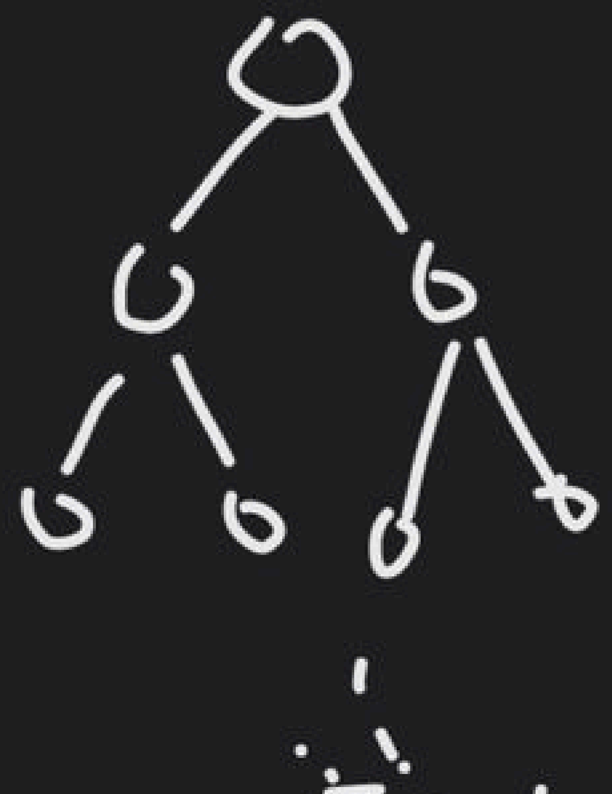
CBT/FBT $= O(\log_2 n)$

$\Rightarrow$ 20 comp.



Skewed tree

$h = O(n)$



FBT|CBT

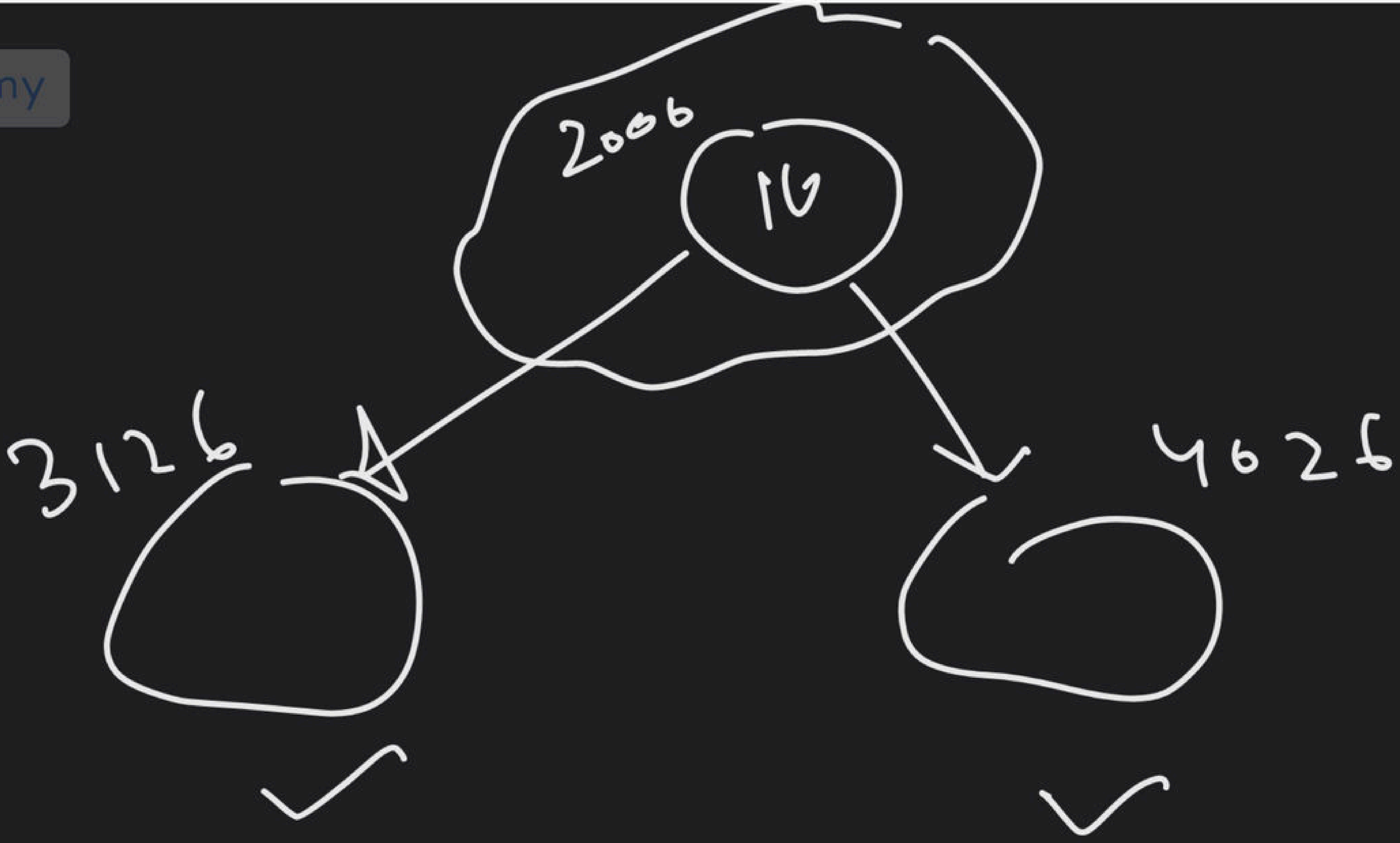
$h = O(\log_2 n)$

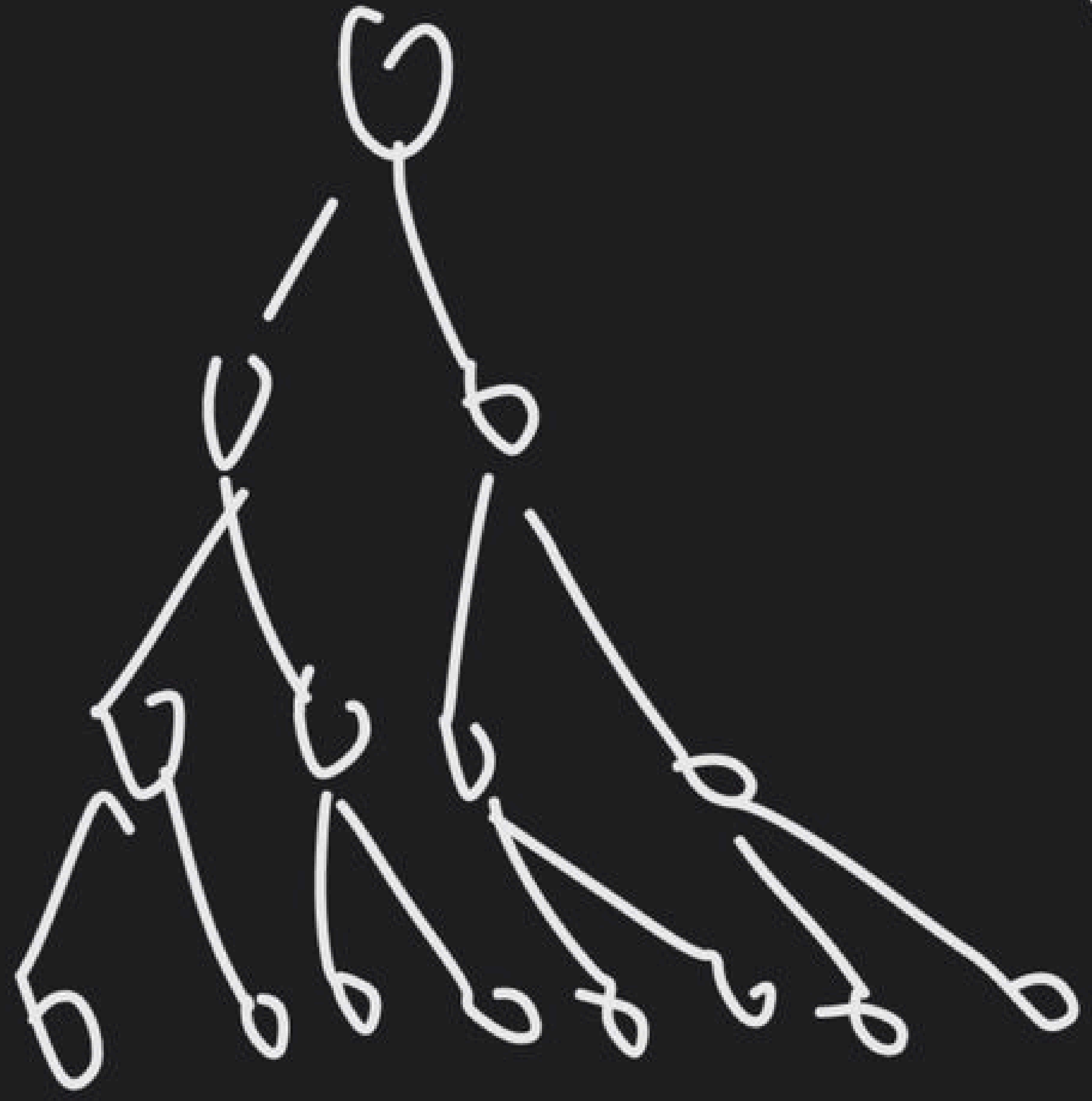
height balanced BST

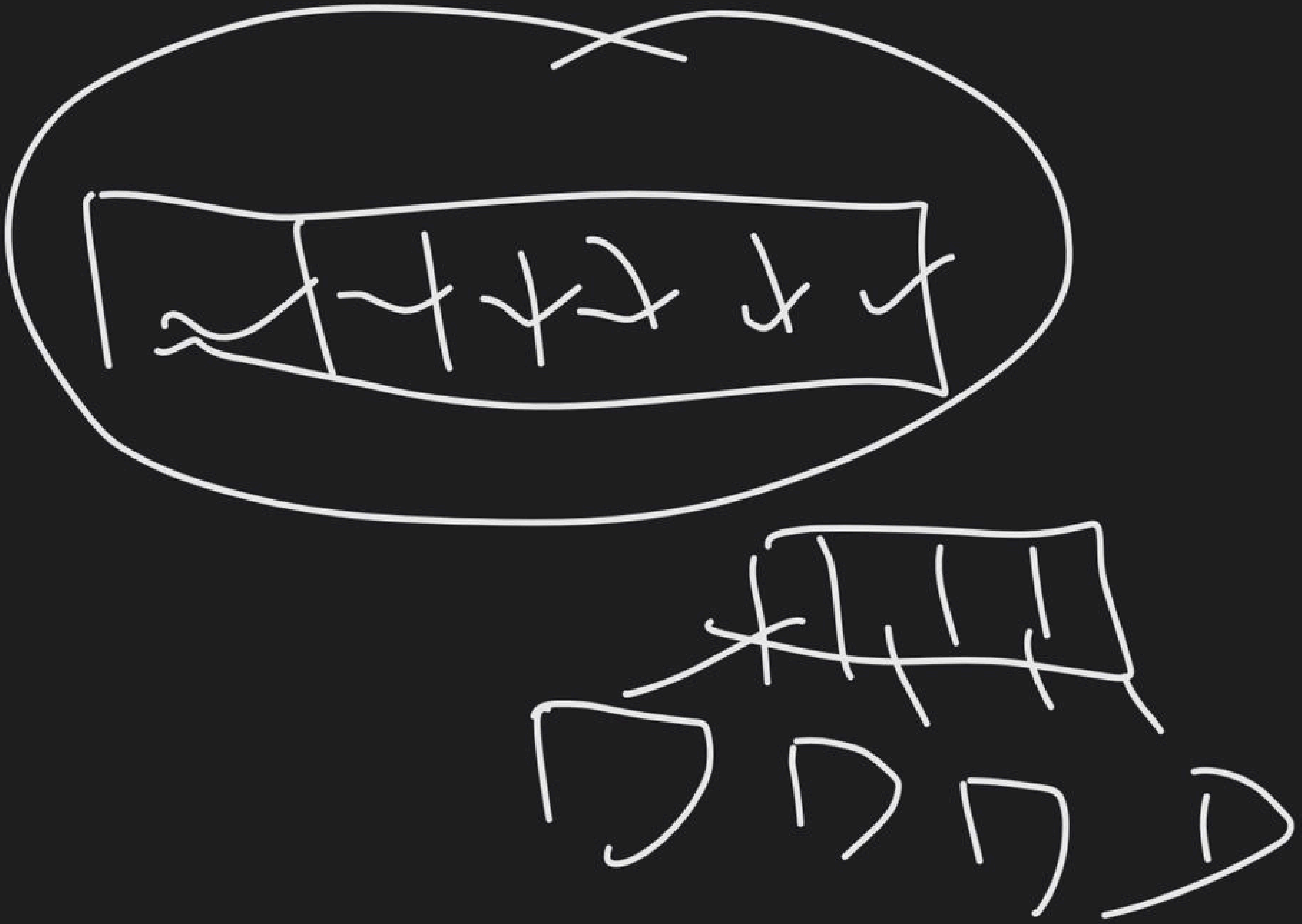
AVL Tree

$h = O(\log_2 n) \Rightarrow 20$ comp.

m-way search tree


2006
1G
3126
4026





B-Tree/B+ Tree

order: 8

$O(\log_m n)$

$\rightarrow \log_8 2^{20}$

$\Rightarrow \simeq 7$ comp.

what u want ?

$O(1)$

$n \rightarrow \log_2 n \rightarrow \log_n n \Rightarrow O(1)$

want

Hashing

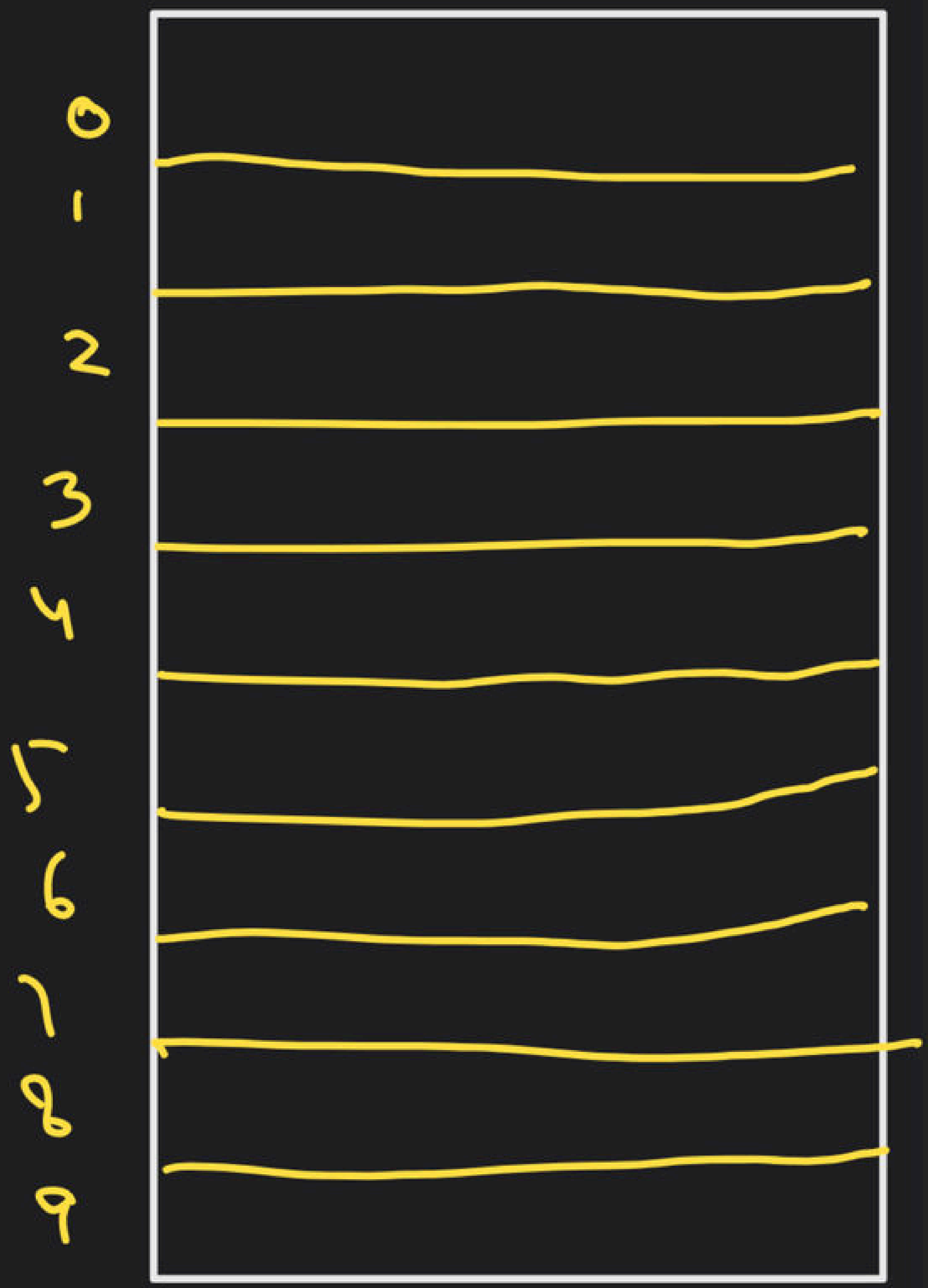
Keys: 12, 18, 15, 14, 13, 29, 31, 57

$m = 10$

Key → Hash function → location/memory address $\{0, 1, 2, \ldots 9\}$

Key → Hash func. → $\{0, 1, \ldots 9\}$

$$\boxed{h(K) = K \bmod 10}$$



Hashing

Keys: 12, 18, 15, 14, 13, 29, 31, 57

$m = 10$

$h(k) = k \bmod 10$

$h(12) = 12 \bmod 10 = 2$

$h(18) = 8$

$h(15) =$

Insertion: $O(1)$

Search: $O(1)$

0	
1	31
2	12
3	13
4	14
5	15
6	
7	57
8	18
9	29

Keys: 12, 23, 42, 83, 54, 31, 82

$h(K) = K \bmod 10$

$h(12) = 2$

$h(23) = 3$

$h(42) = 2$

$h(K_1) \rightarrow L_1$

$h(K_2) \rightarrow L_1$

Collission

0	
1	
2	12
3	23
4	
5	
6	
7	
8	
9	

Collision

Collission Resolution Tech.

1.) Linear Probing

2.) Quadratic Probing

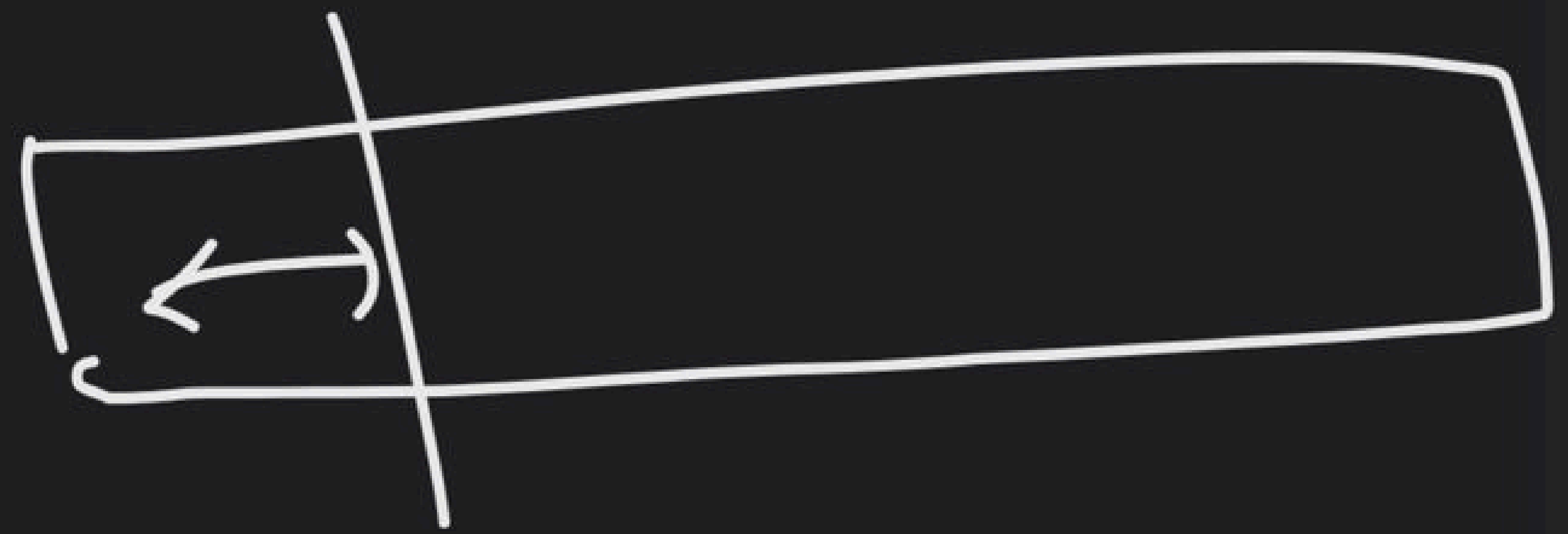
3) Double Hashing

4) Chaining

Good hash function

(i) Easy to compute

(ii) Uniformly distribution



Hash function

$H(K) = K \bmod m$ $\quad$ m: Table size

$(0, 1, 2, \ldots m-1)$

$H(K) = K \bmod m + 1$

$(1, 2, \ldots m)$

Linear Probing

let $h(k) = k \bmod m$ is the hash function

↳ results in a collision for key k_1

$h(k_1)$

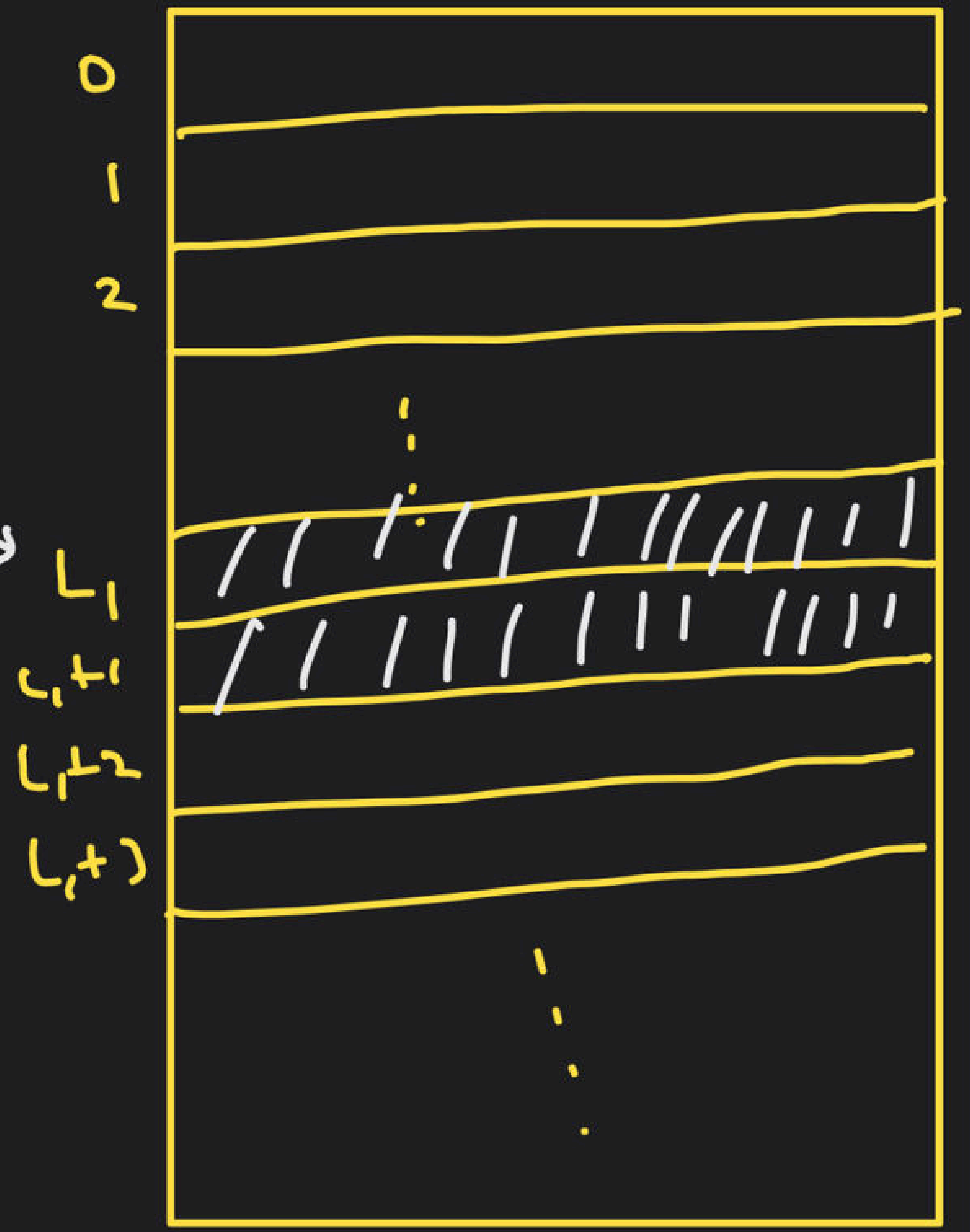
$h(k_1) = L_1$

CR Function → collision No. for a key

$$H(k, i) = (h(k) + i) \bmod m$$

$$H(k_1, 1) = (h(k_1) + 1) \bmod m$$

$$= L_1 + 1$$

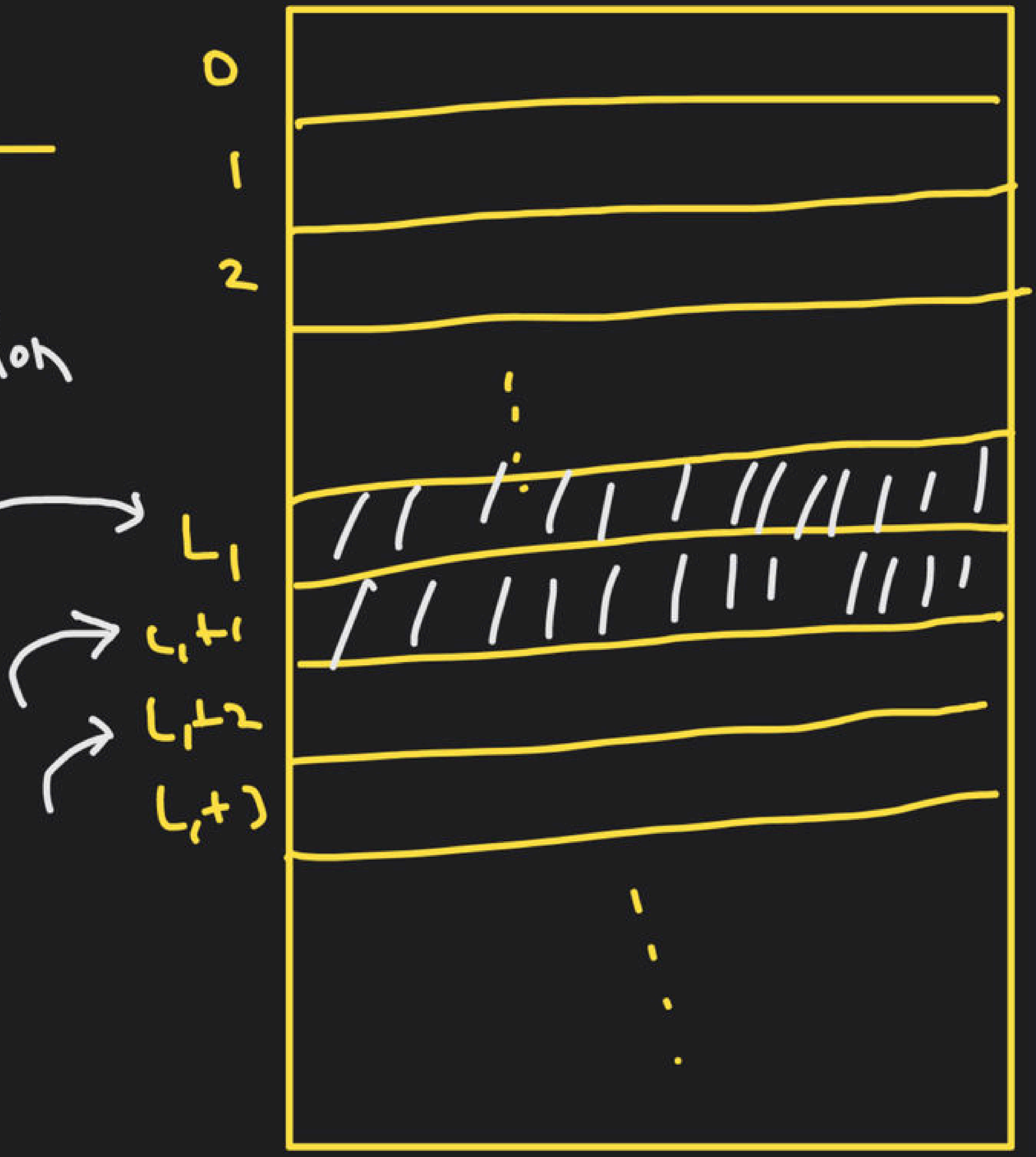


Linear Probing

let $h(k) = k \bmod m$ is the hash function

↳ results in a collision for key k_1

$h(k_1)$



$h(k_1) = L_1$

$i = 2$

$$H(k_1, 2) = (h(k_1) + 2) \bmod m$$

$$= L_1 + 2$$

$m = 10$, $0, 1, 2, 3, 4, 5, 6, 7, 8, 9$

let $h(k_1) = 4 \rightarrow$ Collission occurs

$H(k,1) = (h(k_1) + 1) = 4 + 1 = 5$

$i=2$ $H(k,2) = (h(k_1) + 2) = 4 + 2 = 6$

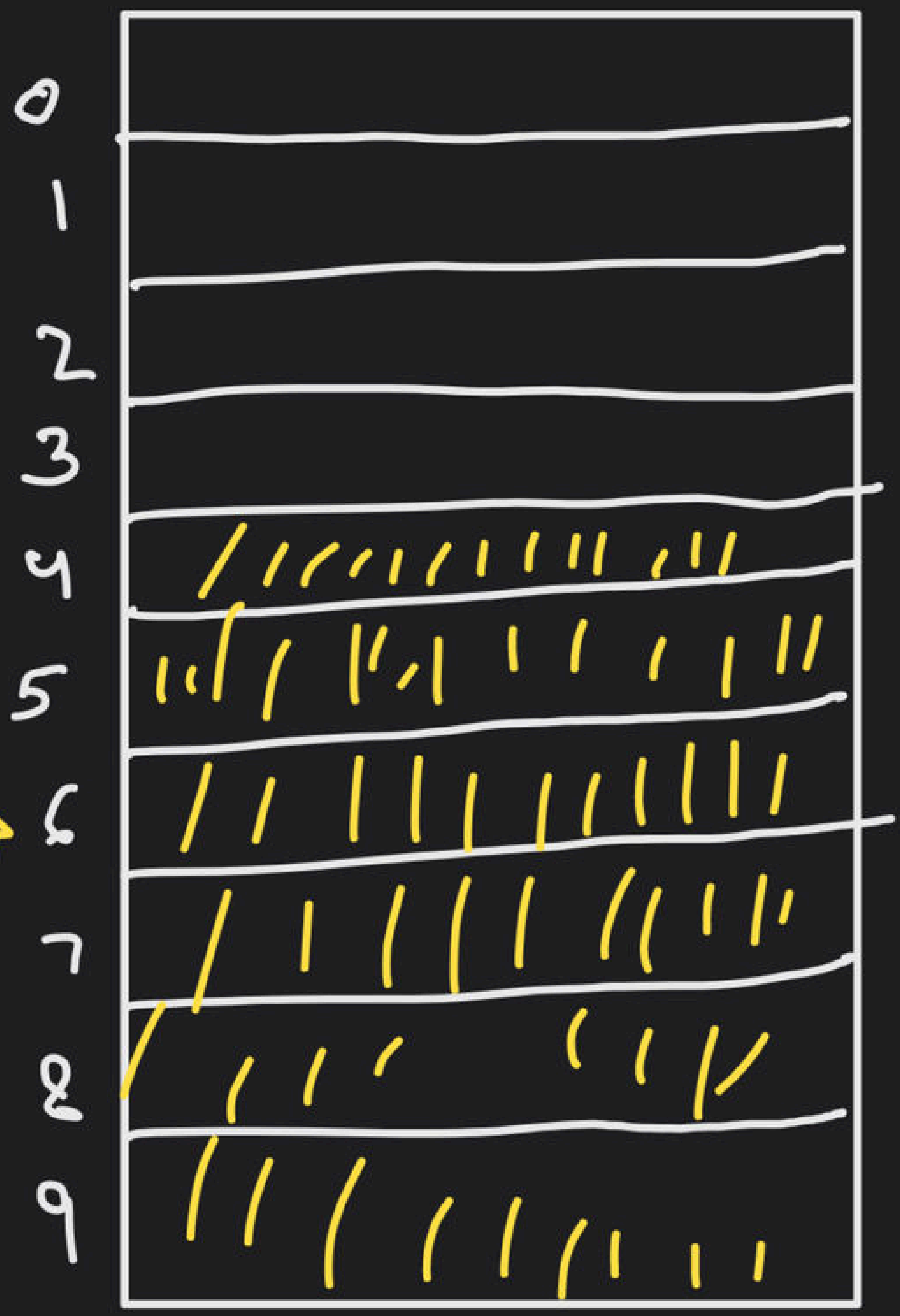
$i=3$ $H(k,3) = (h(k_1) + 3) = 4 + 3 = 7$

$\vdots$

$i=6$

$H(k,6) = (h(k_1) + 6) = 4 + 6 = 10$

why mod?



$h(k) = k \bmod m$

keys : 31, 26, 43, 27, 34, 46, 14, 58, 13

$m = 12$

$h(31) = 31 \bmod 12 = 7$

$h(26) = 26 \bmod 12 = 2$

$h(43) = 43 \bmod 12 = 7$ coll

$H(k,i) = (h(k)+i) \bmod 12$

$H(43,1) = (7+1) \bmod 12 = 8$

$h(27) = 27 \bmod 12 = 3$

$h(34) = 34 \bmod 12 = 10$

$h(46) = 46 \bmod 12 = 10$ coll

$H(58,2) = (h(58)+2) \bmod 12 = 0$

$h(13) = 13 \bmod 12 = 1$

$H(46,1) = (h(46)+1) \bmod 12$
$= 11 \bmod 12 = 11$

$h(14) = 14 \bmod 12 = 2$ coll

$H(14,1) = (h(14)+1) \bmod 12$
$= 3$ coll.

$H(14,2) = (h(14)+2) \bmod 12$
$= 4$

$h(58) = 58 \bmod 12 = 10$ coll

$H(58,1) = (h(58)+1) \bmod 12$
$= 11$ coll.

0	58
1	13
2	26
3	27
4	14
5	
6	
7	31
8	43
9	
10	34
11	46

$h(k) = k \bmod m$

keys : 31, 26, 43, 22, 34, 46, 14, 58, 13

31	26	43	22	34	46	14	58	13
7	2	$\cancel{7}$ 8	3	10	$\cancel{10}$ 11	$\cancel{2}$ $\cancel{3}$ 4	$\cancel{10}$ $\cancel{11}$ 0	1

$m = 12$

Primary clustering

problem

34, 46, 58, 13, 26, 27, 14

0	58
1	13
2	26
3	27
4	14
5	////// //
6	
7	31
8	43
9	
10	34
11	46

Probability that a new key will get this slot

8/12

$Prob(5) = 8/12$

$Prob(6) = 1/12$

$Prob(9) = 3/12$

44

CRT

Open addressing

Seberate chaining

1) Linear Probing (Primary clustering)

2) Quadratic Probing (free from Primary clustering problem

& Secondary Clustering problem

3) Double Hashing

Quadratic Probing

let $h(K) = K \bmod m$

↳ it leads to a collision

$$h(K) = K \bmod m = L_1$$

$$H(K, i) = (h(K) + i^2) \bmod m$$

$$H(K, 1) = (h(K) + 1) \bmod m = L_1 + 1$$

$$H(K, 2) = (h(K) + 2^2) \bmod m = L_1 + 4$$

Keys: 24, 17, 32, 2, 13, 50, 30, 61

$m = 11$

$h(24) = 2$

$h(17) = 6$

$h(32) = 10$

$h(2) = 2$

$H(2,1) = (h(2) + 1^2) \bmod 11$

$= 3$

$h(13) = 2$ coll.

$H(13,1) = (h(13) + 1^2) \bmod 11 = 3$

$H(13,2) = (2 + 2^2) \bmod 11 = 6$

$H(13,3) = (h(13) + 3^2) \bmod 11$

$= 0$

$h(50) = 6$

$H(50,1) = (h(50) + 1) \bmod 11 = 7$

$h(30) = 8$

$h(61) = 6$ coll.

$H(61,1) = 7$

$H(61,2) = (6 + 2^2) \bmod 11$

$= 10$

$H(61,3) = (6 + 3^2) \bmod 11$

$= 4$

0	13
1	
2	24
3	2
4	61
5	
6	17
7	50
8	30
9	
10	32

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THANK YOU!

Here's to a cracking journey ahead!