CS & IT ENGINEERING

Data Structure

Chapter- 07

Chapter- Hashing

Lec-02

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TOPICS TO BE COVERED

Hashing-II

Quadratic Probing

Quad. Probing is free from primary clustering

$h(k) = k \bmod m \Rightarrow$ this leads to a collission

$h(k) = k \bmod m = L_1$] Collission

$$\boxed{H(k,i) = (h(k) + i^2) \bmod m}$$

$\boxed{i=1}$ $H(k,1) = (h(k) + 1^2) = L_1 + 1^2$] collission

$\boxed{i=2}$ $H(k,2) = (h(k) + 2^2) = L_1 + 4$] collission

$\boxed{i=3}$ $H(k,3) = (h(k) + 3^2) = L_1 + 9$

Quadratic Probing

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

$m = 11$

$h(24) = 24 \bmod 11 = 2$

$h(17) = 17 \bmod 11 = 6$

$h(32) = 32 \bmod 11 = 10$

$h(2) = 2 \bmod 11 = 2$ × Collission

$i = 1$

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

$h(13) = 13 \bmod 11 = 2$ collission

$\boxed{i = 1}$

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

$\boxed{i = 2}$

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

$\boxed{i = 3}$

$H(13,3) = (h(13) + 3^2) \bmod 11 = 0$ ✓

$h(50) = 50 \bmod 11 = 6$ ×

$H(50,1) = (h(50) + 1^2) \bmod 11 = 7$

$h(30) = 30 \bmod 11 = 8$

$h(61) = 61 \bmod 11 = 6$ ×

$H(61,1) = (h(61) + 1^2) \bmod 11 = 7$ ×

$H(61,2) = (h(61) + 2^2) \bmod 11 = 10$ ×

$H(61,3) = (h(61) + 3^2) \bmod 11 = 4$ ✓

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

Secondary Clustering Problem

$$h(24) = 24 \bmod 11 = 2$$
$$h(2) = 2 \bmod 11 = 2$$
$$h(13) = 13 \bmod 11 = 2$$

$\boxed{i=1}$

$$H(24,1) = (h(24)+1) \bmod 11 = 3$$
$$H(2,1) = (h(2)+1) \bmod 11 = 3$$
$$H(13,1) = (h(13)+1) \bmod 11 = 3$$

$\boxed{i=2}$

$$H(24,2) = (h(24)+2^2) \bmod 11 = 6$$
$$H(2,2) = (h(2)+2^2) \bmod 11 = 6$$
$$H(13,2) = (h(13)+2^2) \bmod 11 = 6$$

$\boxed{i=3}$

$$H(24,3) = (h(24)+3^2) \bmod 11 = 0$$
$$H(2,3) = (h(2)+3^2) \bmod 11 = 0$$
$$H(13,3) = (h(13)+3^2) \bmod 11 = 0$$

$i=4$

$$H(24,4) = (h(24)+4^2) \bmod 11 = 7$$
$$H(2,4) = (h(2)+4^2) \bmod 11 = 7$$
$$H(13,4) = (h(13)+4^2) \bmod 11 = 7$$

$i=5$

$$H(24,5) = (h(24)+5^2) \bmod 11 = 5$$
$$H(2,5) = 5$$
$$H(13,5) = 5$$

$\boxed{i=6}$

$$H(24,6) = (h(24)+6^2) \bmod 11 = 5$$
$$H(2,6) = 5$$
$$H(13,6) = 5$$

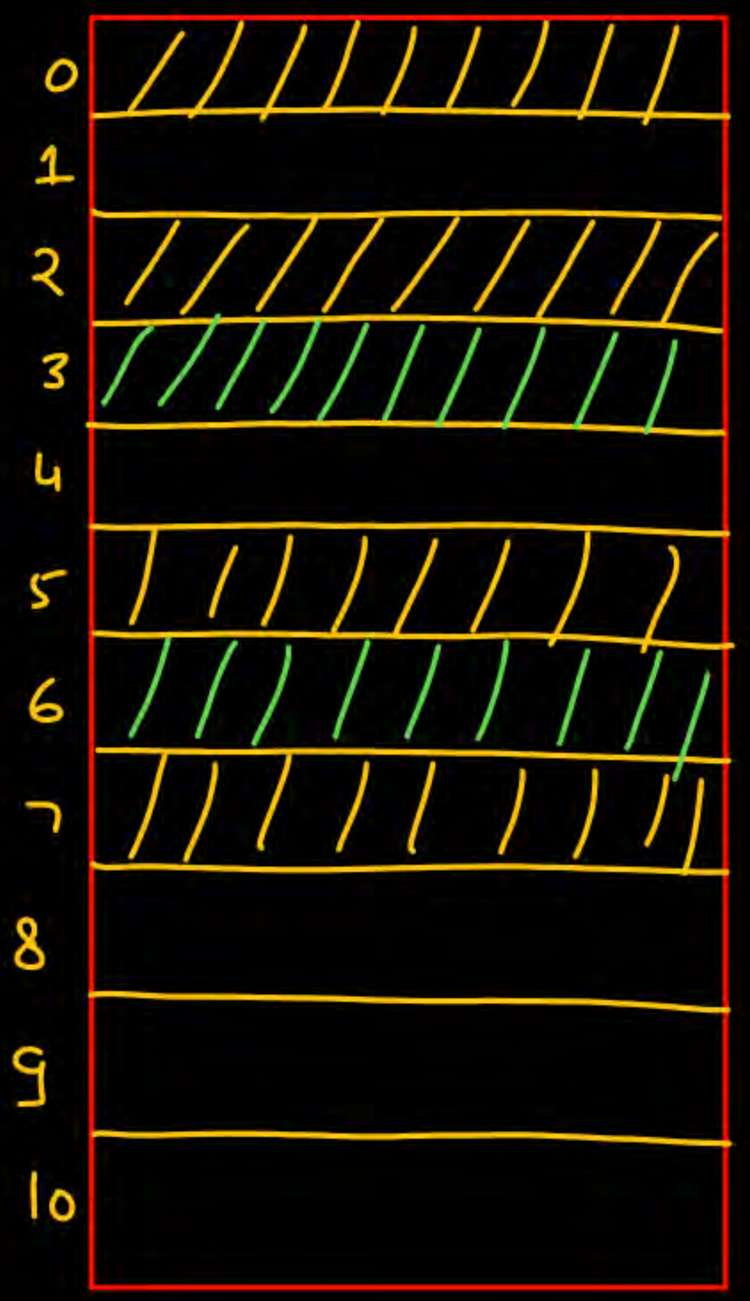
2, 3, 6, 0, 7, 5, 5, 7, 0, 6

$\boxed{i=7}$

$$H(24,7) = (h(24)+7^2) \bmod 11 = 7$$
$$H(2,7) = 7$$
$$H(13,7) = 7$$

$\boxed{i=8}$

$$H(24,8) = H(2,8) = H(13,8) = (2+8^2) \bmod 11 = 0$$



$i=9$

$$H(24,9) = (h(24)+9^2) \bmod 11 = 6$$
$$H(2,9) = 6$$
$$H(13,9) = 6$$

2, 3, 6, 0, 7, 5, 5, 7, 0 6

$\boxed{Key = 24}$

2, 3, 6, 0, 7, 5, 5, 7, 0, 6, 3, 2,

2, 3, 6, 0, 7, 5

Keys that are hashed to same location follow the same resolution path bcz of which we are not able to utilize the table size Efficiently.

$i = 9$

$H(24, 9) = (h(24) + 9^2) \bmod 11 = 6$

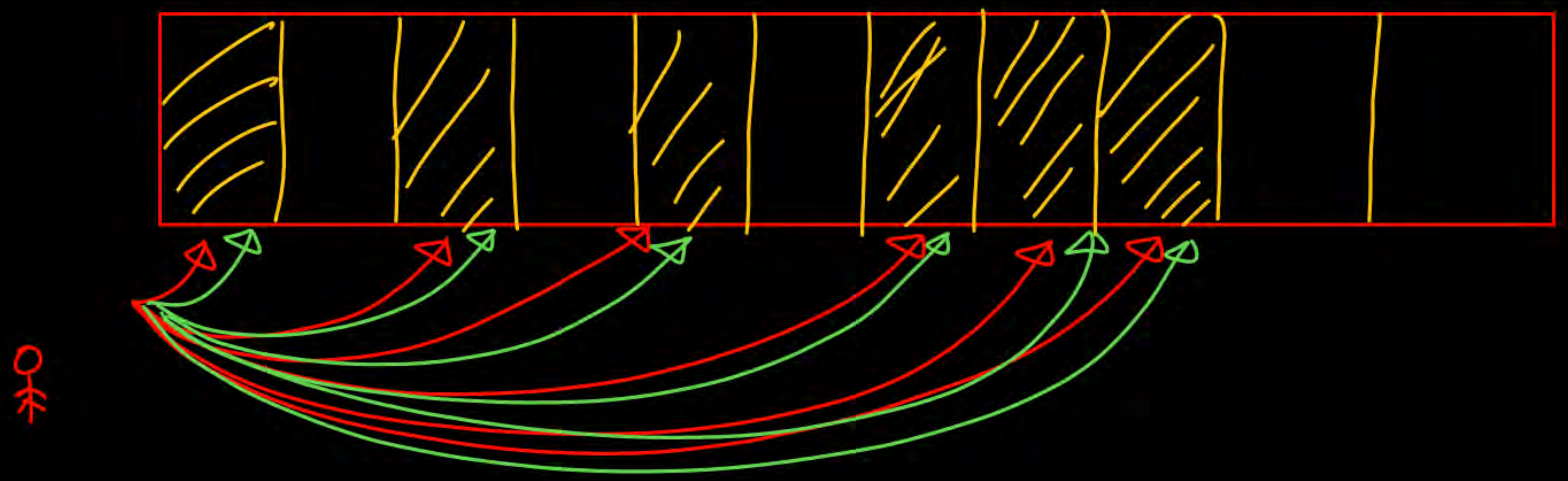
$H(2, 9) = 6$

$H(13, 9) = 6$

$m = 11$

$\left(\frac{m+1}{2}\right) \rightarrow$ occupied

Inspite of almost 50% free slots we are not able to insert a new element.



Double Hashing

Let $h(k)$ is the hash function

$h(k) = k \bmod m \implies$ Collission

$$H(k, i) = (h(k) + i) \bmod m \quad L.P$$

$$= (h(k) + i^2) \bmod m \quad Q.P$$

$$\boxed{H(k, i) = (\underbrace{h(k)}_{\text{Primary hash function}} + i\, \underbrace{h'(k)}_{\text{Secondary hash function}}) \bmod m}$$

Q what if the value generated by $h'(k)$ is 0 ?

$\Downarrow$

$\boxed{h'(k) \text{ never generate } 0}$

Double Hashing

2 6 10 7 8 9 1 5

Key : 13, 17, 21, 2, 57, 28, 30, 27

$h(x) = x \bmod 11$

$h'(x) = 7 - (x \bmod 7)$

$h(13) = 13 \bmod 11 = 2$

$h(17) = 17 \bmod 11 = 6$

$h(21) = 21 \bmod 11 = 10$

$h(2) = 2 \bmod 11 = 2$ ×

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

$h'(2) = 7 - 2 \bmod 7$

$= 7 - 2 = 5$

$H(2,1) = (2 + 1 \cdot 5) \bmod 11 = 7$

$h(57) = 57 \bmod 11 = 2$ ×

$H(57,1) = (h(57) + 1 \cdot h'(57)) \bmod 11$

$h'(57) = 7 - 57 \bmod 7$

$= 7 - 1 = 6$

$H(57,1) = (2 + 1 \cdot 6) \bmod 11 = 8$

$h(28) = 28 \bmod 11 = 6$ ×

$H(28,1) = (h(28) + 1 \cdot h'(28)) \bmod 11$

$h'(28) = 7 - 28 \bmod 7 = 7$

$H(28,1) = (6 + 1 \cdot 7) \bmod 11 = 2$ ×

$H(28,2) = (h(28) + 2 \cdot h'(28)) \bmod 11$

$= (6 + 2 \cdot 7) \bmod 11 = 9$ ✓

$h(30) = 30 \bmod 11 = 8$ ×

$H(30,1) = (h(30) + 1 \cdot h'(30)) \bmod 11$

$h'(30) = 7 - 30 \bmod 7$

$= 7 - 2 = 5$

$H(30,1) = (8 + 1 \cdot 5) \bmod 11 = 2$ ×

$H(30,2) = (8 + 2 \cdot 5) \bmod 11 = 7$ ×

$H(30,3) = (8 + 3 \cdot 5) \bmod 11 = 1$

$h(27) = 27 \bmod 11 = 5$

$h(2) = 2 \bmod 11 = 2, 7$

$h(57) = 57 \bmod 11 = 2, 8$

Problem

* Overhead $\Longrightarrow$ 2 hash function

Computation time.

Time complexity

Separate Chaining

Load factor (λ)

$$\boxed{\lambda = \frac{n}{m}}$$

n → no. of keys

m → Table size

$n = 20$ keys

$m = 40$

$$\lambda = \frac{20}{40} = \frac{1}{2}$$ ✓

$n = 40$

$m = 30$

$\boxed{\lambda \leq 1}$

Linear Probing

Quad. Probing

Double Hashing

$\boxed{\lambda > 1}$

Separate chaining : Collission resolve

List

Keys: 400, 500, 635, 425, 36, 86, 126, 16

$m = 10$

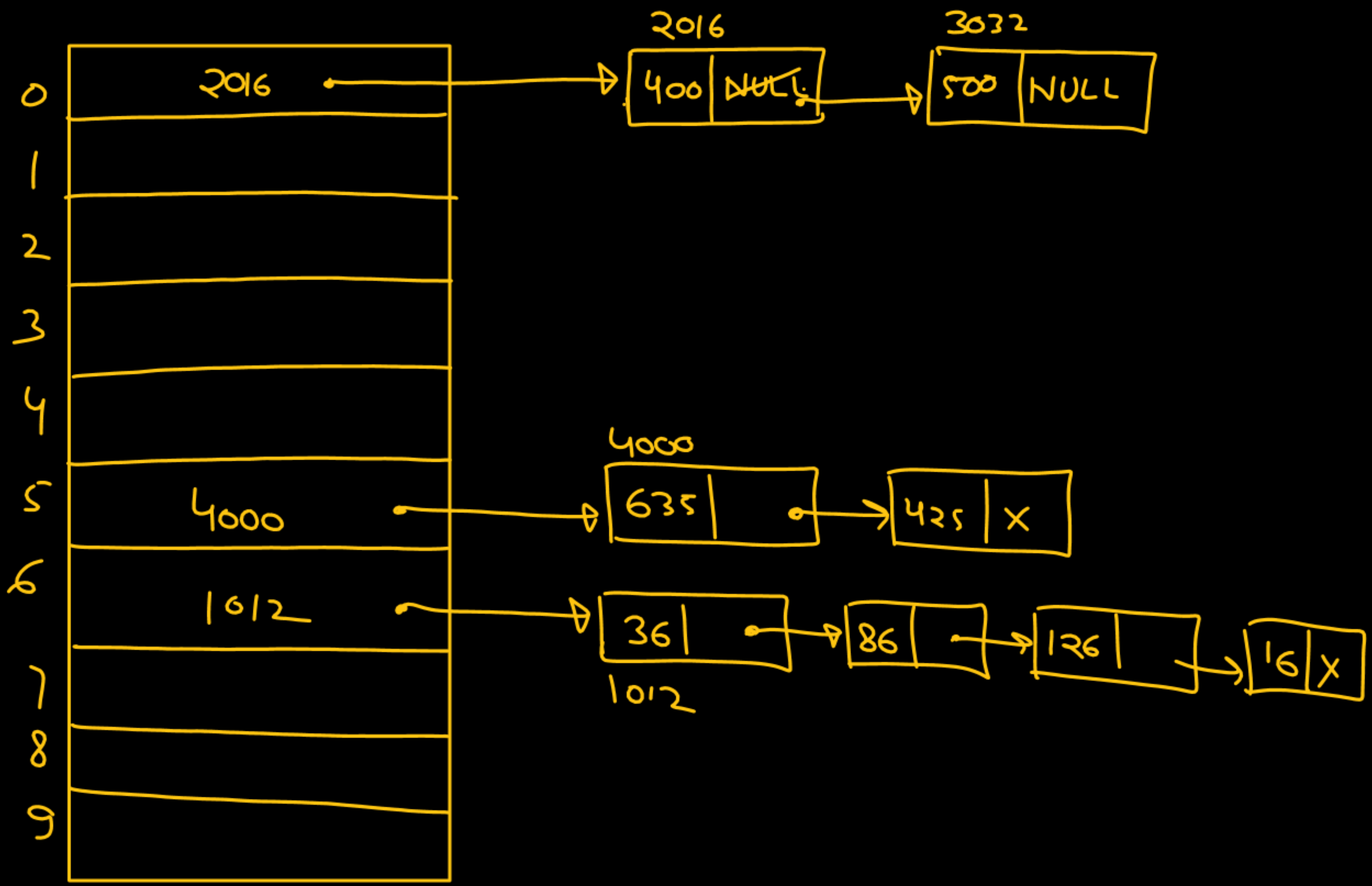
$h(400) = 400 \bmod 10 = 0$

$h(500) = 500 \bmod 10 = 0$

$h(635) = 635 \bmod 10 = 5$

$(n+m)$

Extra pointer



Linear Probing

Keys: 31, 26, 43, 27, 34, 12, 46, 14, 58

$m = 12$

delete 26

Search 14

$14 \bmod 12$

$= 2$

after deletion

⇒ Rem. Keys Re-hash

0	12
1	58
2	~~26~~
3	27
4	14
5	
6	
7	31
8	43
9	
10	34
11	46


THANK YOU GW
SOLDIERS !