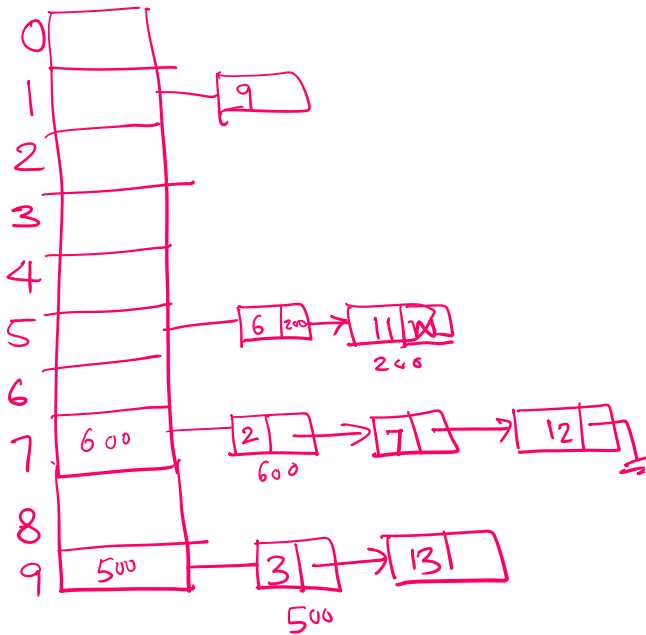


Open hashing / separate Chaining

keys:- 3 2 9 6 11 13 7 12 size = 10

$$h(k) = 2k + 3$$



- $h(3) = 9$
- $h(2) = 7$
- $h(9) = 1$
- $h(6) = 5$
- $h(11) = 5$
- $h(13) = 9$
- $h(7) = 7$
- $h(12) = 7$

Closed Hashing

① Linear Probing

$$l(k) = h(k) \text{ mod size}$$

$$l'(k) = (l(k) + i) \cdot \text{size}$$

0	13
1	9
2	12
3	
4	
5	6
6	11
7	2
8	7
9	3

$$l(11) = (2k+3) \cdot \text{size} \quad l(3) = 9$$

$$= (2 \times 11 + 3) \cdot 10 \quad l(2) = 7$$

$$= \underline{\underline{5}} \quad l(9) = 1$$

$$l'(11) = (l(11) + i) \cdot \text{size} \quad l(6) = 5$$

$$= (5 + 1) \cdot 10 \quad l(11) = 5$$

$$= \underline{\underline{6}} \quad l(13) = 9 \checkmark$$

$$l(13) = 9$$

$$l(7) = 7 \checkmark$$

$$l(12) = 7$$

$$l(13) = 9$$

$$l(7) = 1$$

$$l(12) = 7$$

$$l'(13) = (l(13) + i) \cdot \text{size} \quad i = 1 \dots \text{size}$$

$$= (9 + 1) \cdot \text{size} = 0$$

$l(2) = 7$ Vary i from 1 to 5 and insert in 2

Quadratic Probing $l(k) = (l(k) + i^2) \cdot \text{size}$ $l(3) = 9$

$$l(11) = 5 \quad (i = 1, 2 \dots \text{size} - 1) \quad l(2) = 7$$

$$l'(11) = (5 + 1^2) \cdot 10 = 6 \quad l(9) = 1$$

$$l(13) = 9$$

$$l(6) = 5$$

$$l'(11) = (9 + 1^2) \cdot 10 = 0$$

$$l(11) = 5$$

$$l(13) = 9 \checkmark$$

$$l(7) = 7$$

$$l'(7) = (7 + 1^2) \cdot 10 = 8$$

$$l(7) = 7 \checkmark$$

$$l(12) = 7$$

$$l(12) = 7$$

$$l'(12) = (7 + 1^2) \cdot 10 = 8$$

$$l'(12) = (7 + 2^2) \cdot 10 = 1$$

$$= (7 + 3^2) \cdot 10 = 6$$

$$l'(12) = (7 + 4^2) \cdot 10 = 3$$

$$l(22) = (2 \cdot 22 + 1) \cdot 10 = 5$$

$$l'(22) = (5 + 1^2) \cdot 10 = 6$$

$$= (5 + 2^2) \cdot 10 = 9$$

$$(5 + 2^2) \cdot 10 = 4$$

0	13
1	9
2	
3	12
4	22
5	6
6	11
7	2
8	7
9	3

$$= (5 + 2^2) \cdot 10 = 4$$

Demo eg: 2

Keys: - 42, 16, 91, 33, 18, 27, 36, 62

$$h(k) = k \quad \text{Size} = 10$$

0	36
1	91
2	42
3	33
4	
5	
6	16
7	27
8	18
9	

$$l'(36) = (l(36) + i^2) \cdot 10$$

$$= (6 + 1^2) \cdot 10 = 7$$

$$= (6 + 2^2) \cdot 10 = 0$$

$$l'(62) = (2 + 1^2) \cdot 10 = 3$$

$$= (2 + 2^2) \cdot 10 = 6$$

$$= (2 + 3^2) \cdot 10 = 1$$

$$= (2 + 4^2) \cdot 10 = 8$$

$$= (2 + 5^2) \cdot 10 = 7$$

$$l(42) = h(k) \cdot 10 = 42 \cdot 10 = 2$$

$$l(16) = 6$$

$$l(91) = 1$$

$$l(33) = 3$$

$$l(18) = 8$$

$$l(27) = 7$$

$$l(36) = 6$$

$$l(62) = 2$$

Double Hashing

Eg: -1 Keys: - 20, 34, 45, 70, 56 Size = 11

$$h_1(k) = k \quad h_2(k) = 8 - (k \bmod 8)$$

0	
1	34
2	
3	56
4	45
5	
6	70
7	
8	
9	20
10	

$$l'(45) = (l_1(45) + i \cdot l_2(45)) \cdot 11 \quad l(20) = h_1(k) \cdot 11 = 20 \cdot 11 = 9$$

$$= (1 + 1 \cdot 3) \cdot 11$$

$$= \underline{4}$$

$$l'(70) = (4 + 1 \cdot 2) \cdot 11$$

$$= \underline{6}$$

$$l_1(34) = 34 \cdot 11 = 1$$

$$l_1(45) = 1$$

$$l_2(45) = 8 - (45 \cdot 8) = 3$$

$$l_1(70) = 70 \cdot 11 = 4$$

$$l_2(70) = 8 - (70 \cdot 8)$$

$$\begin{aligned}
 &= 6 \\
 &= 9 \\
 &= (1 + 2 \cdot 8) \cdot 11 \\
 &= 6 \\
 &= (1 + 3 \cdot 8) \cdot 11 \\
 &= 3
 \end{aligned}$$

$$\begin{aligned}
 l_2(70) &= 8 - (70 \cdot 8) \\
 &= 2 \\
 l_1(56) &= 56 \cdot 11 = 1 \\
 l_2(56) &= 8 - 56 \cdot 8 \\
 &= 8
 \end{aligned}$$

Eg 2:- 3, 2, 9, 6, 11, 13, 7, 12 size = 10

$$h_1(k) = 2k + 3, \quad h_2(k) = 3k + 1$$

0	
1	9
2	
3	11
4	
5	6
6	
7	2
8	
9	3

$$\begin{aligned}
 l^1(11) &= (5 + 1 \cdot 4) \cdot 10 = 9 \\
 &= (5 + 2 \cdot 4) \cdot 10 = 3 \\
 l^1(13) &= (9 + 1 \cdot 0) \cdot 10 \\
 &= 9
 \end{aligned}$$

$$\begin{aligned}
 l_1(3) &= (2 \cdot 3 + 3) \cdot 10 = 9 \\
 l_1(2) &= (2 \cdot 2 + 3) \cdot 10 = 7 \\
 l_1(9) &= (2 \cdot 9 + 3) \cdot 10 = 1 \\
 l_1(6) &= (2 \cdot 6 + 3) \cdot 10 = 5 \\
 l_1(11) &= (2 \cdot 11 + 3) \cdot 10 = 5
 \end{aligned}$$

13 can't be inserted

|||y insert 7 & 12

$$\begin{aligned}
 l_2(11) &= (3 \cdot 11 + 1) \cdot 10 = 4 \\
 l_1(13) &= (2 \cdot 13 + 3) \cdot 10 = 9 \\
 l_2(13) &= (3 \cdot 13 + 1) \cdot 10 \\
 &= 8
 \end{aligned}$$