Hashing

Hashing is a technique or process of mapping keys, values into the hash table by using hash function.

Complexity is O(1).

Types of Hashing

(i) Division method

$$H(key) = key \bmod M$$

'key' $M = 10$

e.g.

$$H(4) = 4 \% 10 = 4$$

(ii) mid - square method

$M = 10 \rightarrow$ 1 digit

Key = 123

Syntax: $(key)^2 = (123)^2 = 427919$

∴ 123 is placed at 7th position.

(iii) folding method

$m = 100 \rightarrow$ 2 Digit

key = 123456

$$\begin{array}{r} 12 \\ +34 \\ \hline 46 \\ +56 \\ \hline 102 \\ \hookrightarrow +1 \\ \hline 03 \end{array}$$

Collision Detection technique

- open Hashing (closed addressing)
  - (i) chaining method
- closed Hashing (open addressing)
  - (i) linear probing
  - (ii) quadratic probing
  - (iii) Double Hashing

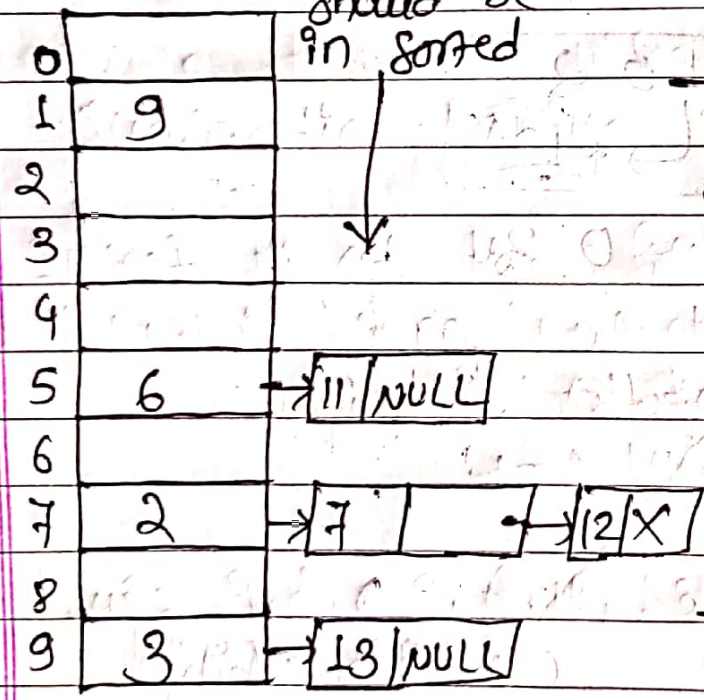
Chaining method

Keys = 3, 2, 9, 6, 11, 13, 7, 12

$h(K) = 2K + 3$ $\quad m = 10$

Use Division method & closed addressing to store these values.

$m = 10$



Keys	location
3	$[2\times3+3] \% 10 = 9$
2	$[2\times2+3] \% 10 = 7$
9	$[2\times9+3] \% 10 = 1$
6	$[2\times6+3] \% 10 = 5$
11	$[2\times11+3] \% 10 = 5$
13	$[2\times13+3] \% 10 = 9$
7	$[2\times7+3] \% 10 = 7$
12	$[2\times12+3] \% 10 = 7$

Linear probing (linear Hash shifting)

Q) Keys = 3, 2, 9, 6, 11, 13, 7, 12

$h(K) = 2K+3$

$m = 10$

use division method & open addressing to store these values.

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

key	locations (L)	probs
3	$[2\times3+3]\%10 = 9$	1
2	$[2\times2+3]\%10 = 7$	1
9	$[2\times9+3]\%10 = 1$	1
6	$[2\times6+3]\%10 = 5$	1
11	$[2\times11+3]\%10 = (5)$	2
13	$[2\times13+3]\%10 = (9)$	2
7	$[2\times7+3]\%10 = (7)$	2
12	$[2\times12+3]\%10 = (7)$	6

order of element

⇒ 13, 9, 12, —, —, 6, 11, 2, 7, 3

Linear probing :- Insert K_i at the first free locations from $(L+i)\%m$

where $i \rightarrow$ to $m-1$.

$L \rightarrow$ location.

for 12

(7+0) %.10 = 7 [i=0]
(7+1) %.10 = 8 [i=1]
(7+2) %.10 = 9 [i=2]
(7+3) %.10 = 0 [i=3]
(7+4) %.10 = 1 [i=4]
(7+5) %.10 = 2 [i=5]

Quadratic probing

Insert Ki at the first free location from
(u + i^2) % m where,
i = 0 to (m-1)
u → location

Keys = 3, 2, 9, 6, 11, 13, 7, 12
h(K) = 2K+3 m=10

use division method & open addressing with quadratic probing to store these values

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

Key	locations (4)	probs
3	[2×3+3] %. 10 = 9	1
2	[2×2+3] %. 10 = 7	1
9	[2×9+3] %. 10 = 1	1
6	[2×6+3] %. 10 = 5	1
11	[2×11+3] %. 10 = (6)	2
13	[2×13+3] %. 10 = (9)	2
7	[2×7+3] %. 10 = (7)	2
12	[2×12+3] %. 10 = (7)	5

for 11 $(5+0^2)$ %. 10 = 5 [for i=0]
$(5+1^2)$ %. 10 = 6 [i=1]

for 12 $(7+0^2)$ %. 10 = 7 (i=0)
$(7+1^2)$ %. 10 = 8 (i=1)
$(7+2^2)$ %. 10 = 1 (i=2)
$(7+3^2)$ %. 10 = 6 (i=3)
$(7+4^2)$ %. 10 = 3 (i=4)

order ⇒ 13, 9, —, 12, —, 6, 11, 2, 7, 3.

Double Hashing

Q Keys = 3, 2, 9, 6, 11, 13, 7, 12
$h_1(K) = 2K + 3$ $\boxed{m = 10}$ use division method & double hashing technique to insert these elements where $h_2(K) = 3K + 1$

Double Hashing :- Insert Ki at the first free place from $(u + v * i) \% m$

$i = 0$ to $(m-1)$
$u \rightarrow$ location of h_1.
$v \rightarrow [h_2(K) \% m]$ location of h_2.

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

Key	location (u)	v	probe
3	9	–	1
2	7	–	1
9	1	–	1
6	5	–	1
11	(5)	$(3\times11+1)\%10=9$	3
13	(9)	$(3\times13+1)\%10=0$	–
7	(7)	$(3\times7+1)\%10=2$	–
12	(7)	$(3\times12+1)\%10=7$	2

for 11 $(u+v*i)\%m$

$= (5+4*0)\%10 = 5$ [i=0]

$(5+4*1)\%10 = 9$ [i=1]

$(5+4*2)\%10 = 3$ [i=2]

for 13

$(u+v*i)\%m$

$= (9+0*0)\%10$ [i=0]

$= 9$

$= (9+0*1)\%10$ [i=1]

$= 9$

So, we can't insert 13 in the Hash table.

for 7

$(u+v*i)\%m$

$= (7+2*0)\%10 = 7$ [i=0]

$(7+2*1)\%10 = 9$ [i=1]

$(7+2*2)\%10 = 1$ [i=2]

$(7+2*3)\%10 = 3$ [i=3]

$(7+2*4)\%10 = 5$ [i=4]

$(7+2*5)\%10 = 7$ [i=5]

$(7+2*6)\%10 = 9$ [i=6]

$(7+2*7)\%10 = 1$ [i=7]

$(7+2*8)\%10 = 3$ [i=8]

$(7+2*9)\%10 = 5 \quad [i=9]$

So, we can't insert 7.

for 12

$(4+0*i)\%m$

$= (7+7*0)\%10 \quad [i=0]$

$= 7$

$= (7+7*1)\%10 = 4 \quad [i=1]$

order ⇒

$-, 9, -, 11, 12, 6, -, 2, -, 3$