#Data Structure Notes

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Notes by Ipwebdevelopers

* Hashing

- Hashing is the Process of mapping large amount of data item to smaller table with the help of hashing function.
- Hashing is also known as Hashing Algorithm.
- Hashing is a technique or process of mapping keys, values into the hash table by using a hash function.

hash function A fixed process converts a key to a hash key is known as hash function.

- This function takes a key and maps it to a value of a certain lenegth which is called a Hash value.

Hash Table Hash table is a data structure used to store key - value pairs.

- It is a collection of items stored to make it easy to find them later.
- It contains value based on the key

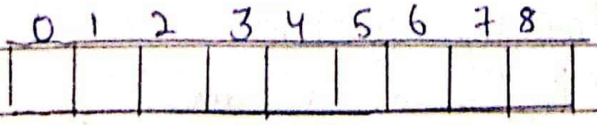

Fig hash table

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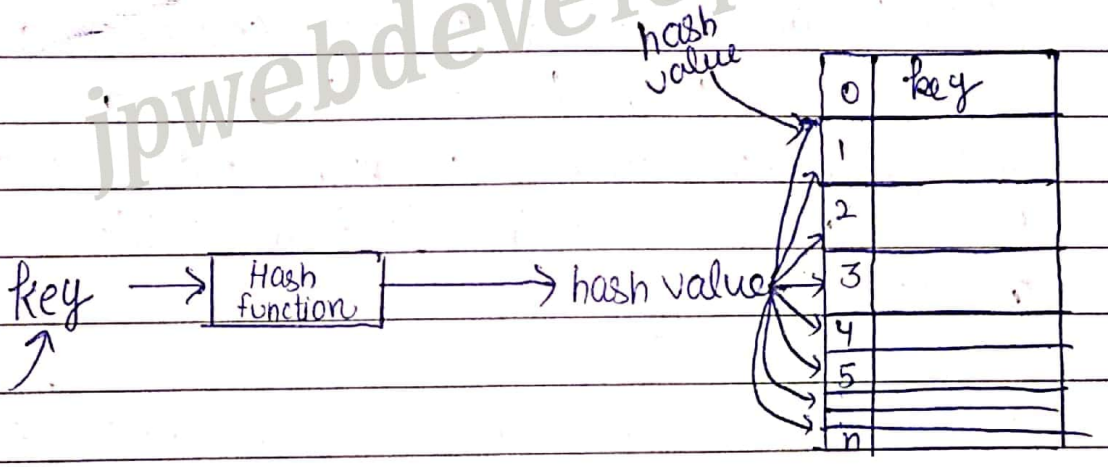
* Hash function :--

- Hash function is a function which is applied on a key by which it produces an integer, which can be used as an address of hash Table.

- The integer returned by the hash function is called hash key.

index = hash (key)



Types of Hash function :-

There are the three ways of calculating the hash function :-

- Division Method
- folding Method
- Mid square Method

1. Division Method :-

- One common method of determining a hash key is the division method of hashing.

formula :- key value % m

m is the size of table

- It takes an item and divides it by the table size and returns the remainder as its hash value.

for example :- {26, 70, 18, 31, 54, 93}

Data Item	k%m	Hash value
26	26%10=6	6
70	70%10=0	0
18	18%10=8	8
31	31%10=1	1
54	54%10=4	4
93	93%10=3	3

Hash Table

0	70
1	31
2	
3	93
4	54
5	
6	26
7	
8	18
9	

2. Folding Method :- In this, the key is divided into separate parts and by using some simple operations these parts are

Combined to produce a hash key.

(I st° method) Divicle the key k into 2 parts and adding parts the following hash Tables

H (3205) = 32 + 05 = 37
H (2345) = 23 + 45 = 68

(II) Method

Here we dealing with a hash Table with index from 00 to 99 i.e. two digit hash table So we divicle k numbers of two digits

k	2103
$k_1 k_2 k_3$	21, 03
H(k) $=(k_1+k_2+k_3)$	H(2103) 21+03 = 24

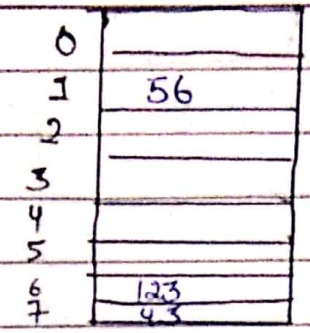
Example (II)

Consider a record of 1246512 So it will chivided into parts 124+655+12 After divicling the parts combine these parts by adding it

H(key) = 124 + 655 + 12
= 791

H(123) = [1+2+3 = 6]
H(.43) = [4+3 = 7]

H[56] = [5+6 = 11]



③ Mid Square Method :-

- The mid square method is a very good hashing method.
- In this method, first key is squared and then mid part of the result is taken as the index.
- for example :- if we want to place a record of 3101 and size of table is 1000.

So :- 3101 * 3101 = 9616201

i.e. h(3101) = 162 (middle 3 digit)

K	4147	3750	2103
K^2	17197609	14062500	4422609
h(K)	97	62	22

Removing digits from Square of key values

~~***97~~~~6~~~~0~~~~9~~*

~~**06~~~~2~~~~5~~~~0~~~~0~~

~~**22~~ ~~6~~ ~~0~~ ~~9~~

hash address	keys
0	
1	
..	
..	
...	
22	2103
.. .	
...	
62	3750
..	
..	
..	
97	4147
..	
99	

Chash Table with Mid Sq Divisio

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Collision :-

- A collision occurs when a hashing algorithm produces an address for a key and that address is already occupied.

- When the two different values have the same value, then the problem occurs between the two values, known as a collision.

Example :- → k(101) = 101 mod 10 = 1

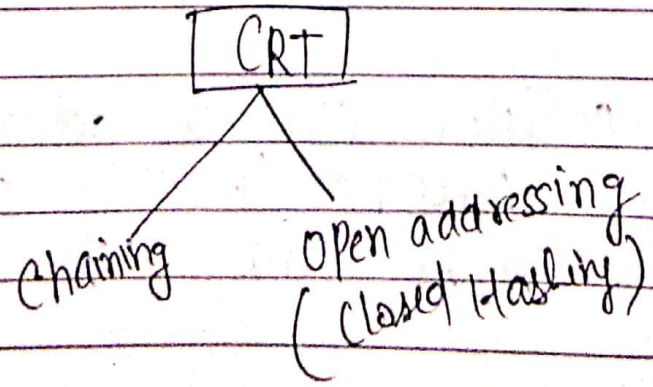
k2(141) = 141 mod 10 = 1 ← Collision occured.

Collision Resolution Technique (CRT) :-

The following are the collision techniques :-

(i) Open Addressing

(ii) Separate Chaining



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(i) Open Addressing :-

- In open addressing method, when a key is colliding with another key, the collision is resolved by finding a nearest empty space by probing the cells.
- Home Area address are searched for an open or unoccupied element where nao data can be placed.

Types of Open Addressing :-

1. Linear Probing
2. Quadratic Probing
3. Double Hashing

1. Linear Probing :-

- It is kind of Open Addressing.
- It is very easy and simple method to resolve or to handle the collision.
- In this collision can be solved by placing the second record linearly down, whenever the empty place is found.

- The Position in which a key can be stored is found by sequentially searching all positions starting starting from the position calculated by hash function until an empty cell is found. This type of probing is called Linear Probing.

Example:-

0	NULL
1	71
2	NULL
3	NULL
4	64
5	NULL
6	56
7	36
8	NULL
9	NULL

Keys = 56, 64, 36, 71

In this diagram we can see that 56 and 36 need to be placed at same bucket but by Linear probing technique the records linearly placed elsewhere if place is empty, it can be seen 36 is placed at index 7.

(2) Quadratic Probing:-

Quadratic Probing is an open addressing technique that uses quadratic polynomial for searching until a empty slot is found.

Hash function =

$$H(key) = (H(key) + i^2) \cdot 1 \cdot m$$

↑ table size

Example :- 89, 18, 49, 58, 69

m = 10

1. Hash(89) = 89 % 10 = 9
2. Hash (18) = 18 % 10 = 8
3. Hash (49) = 49 % 10 = 9 → Collision occurs for first time i = 1

$h1(49) = (9 + 1^2) \% 10 = 10 \% 10 = 0$

4. Hash (58) = 58 % 10 = 8 → Collision occurs for first time i = 1

$h1(58) = (8 + 1^2) \% 10 = 9$ → Collision occurs for second time i = 2

$h2(58) = (8 + 2^2) \% 10 = 2$

5. Hash (69) = 69 % 10 = 9 → Collision occurs for first time i = 1

$h1(69) = (9 + 1^2) \% 10 = 9$ → Collision occurs for first time i = 2

$h2(69) = (9 + 2^2) \% 10 = 3$

0	49
1	
2	58
3	69
4	
5	
6	
7	
8	18
9	89

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(3) Double Hashing :-

- Double Hashing is an open addressing technique which is used to avoid the collisions
- It is a collision resolution technique which uses two hash function to handle collision.

Advantages of double hashing :-

- The technique does not yield any clusters.
- It can is the best form of probing because it can find next free slot in hash table more quickly then linear probing.

Example

$h_1(k) = k \bmod m$ (first hash fun).

$h_2(k) = 8 - (k \bmod 8)$ (Second hash fun.)

Example - Suppose, we have a hash table of size 11. We want to insert keys 20, 30, 45, 70, 56 in the hash table.

$h_1(k) = k \bmod 11$ (first hash function)
$h_2(k) = 8 - (k \bmod 8)$ (Second hash fun.)

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	Keys	Hash function	Index	Description
1.	20	$h_1(20) = 20 \bmod 11$	9	No collision occurs.
2.	34	$h_1(34) = 34 \bmod 11$	1	No collision occurs.
3	45	$h_1(45) = 45 \bmod 11$	1	Collision occur because index 1 is already occupied by 34.
		$h_2(45) = 8 - (45 \bmod 8)$ $= 3$		Now we will use the second hash function to calculate the index for the key 45.
		$4(45, 1) = (1 + 3) \bmod 11$ (↑ first collision occurs)	4	
4.	70	$h_1(70) = 70 \bmod 11$	4.	Collision occurs because index 4 is already occupied. Now we use the second hash function
		$h_2(70) = 8 - (70 \bmod 8) = 2$ $h(70, 1) = (4 + 1 * 2) \bmod 11$	6	$i = 1$, because first collision occurs

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5-	56	$h_1(56) = 56 \bmod 11$	56	Collision occurs because index 1 is already occupied. Now we use the second hash function
		$h_2(56) = 8 - (56 \bmod 8)$ $= 8$	9	Again collision occur.
		$h(56,1) = (1 + 1*8) \bmod 11$		The index 9 is already occupied. (value of i is incremented by 1)
		$h(56,2) = (1 + 2*8) \bmod 11$	6	(Again collision occurs)
		$h(56,3) = (1 + 3*8) \bmod 11$ value of i is incremented	3	So, now we will store 56 at index 3.

Hash Table :-

0	
1	34
2	
3	56
4	45
5	
6	70
7	
8	
9	20
10	
11	

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(2) Chaining :-

→ also known as separate chaining.

→ In this, a linked list is created from the slot in which collision has occured, after which the new key is inserted into the linked list.

→ This linked list of slots look like a chain, so it is called separate chaining

Example:- let us consider a simple hash function "key mod 7" and keys are 50, 700, 76, 85, 92, 73, 101.

0	
1	
2	
3	
4	
5	
6	

initial empty Table

0	
1	50
2	
3	
4	
5	
6	

Insert 50

0	700
1	50
2	
3	
4	
5	
6	76

insert 700 and 76

0	700
1	50 → 85
2	
3	
4	
5	
6	76

Insert 85 collision occurs, add to chain

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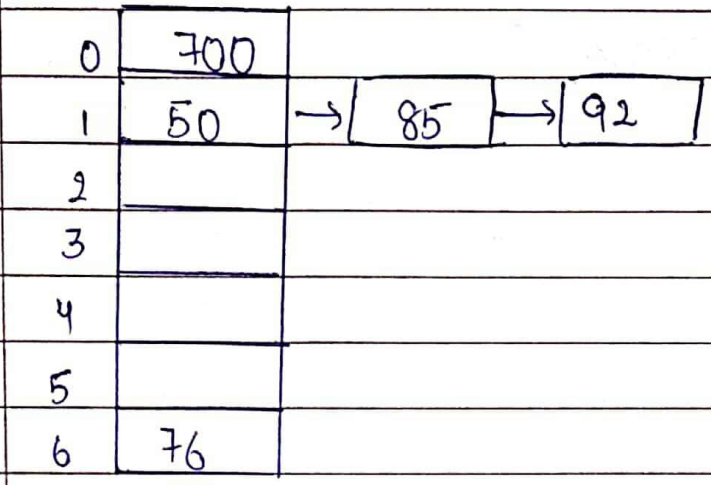
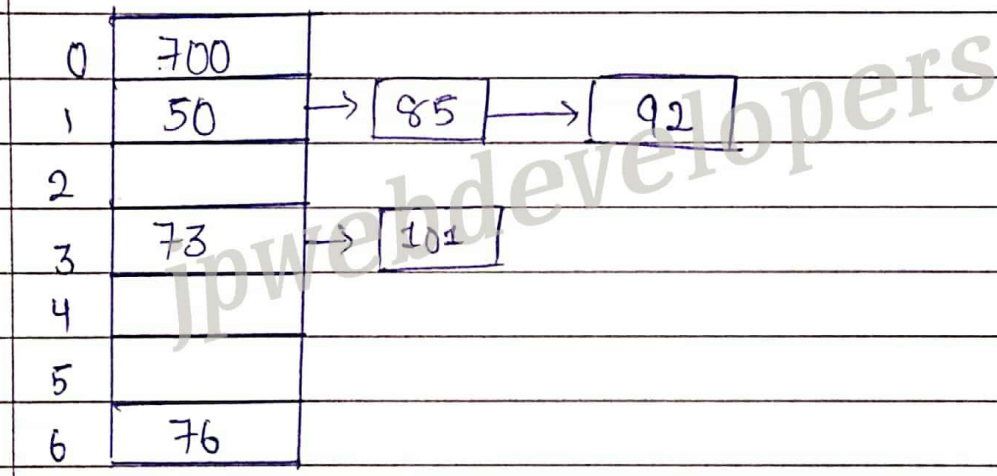


insert [92] Collision occur, add to chain.



insert 73 and 101

Advantages:-

→ Simple to implement
→ Hash Table never fills up, we can always add more elements to the chain.

Disadvantages:- → If the chain becomes long then search can become worst.
→ Wastage of Space.