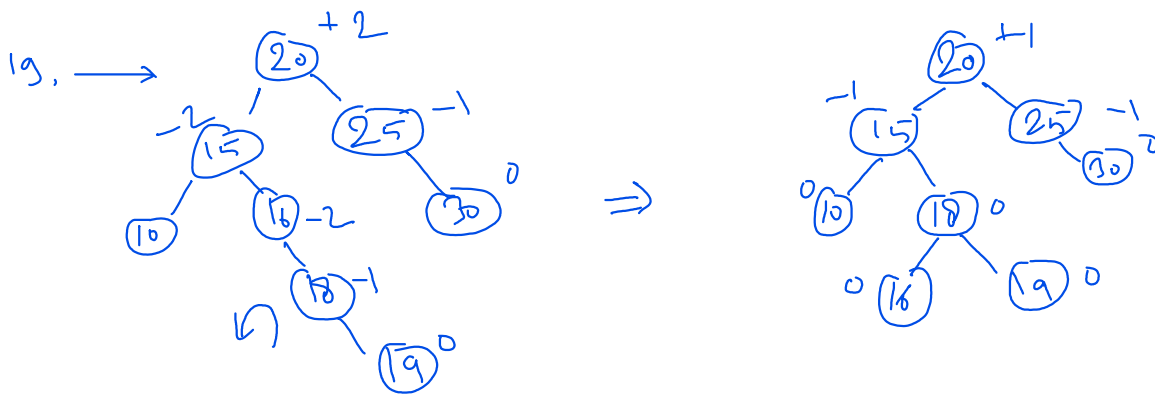




Hashing

— Hashing is a concept of search element in $O(1)$ time

Ex — 4322, 1334, 1471, 9679, 1989, 6171, 6173, 4199

$$h(x) = x \bmod 10$$

Solution — $4322 \bmod 10 = 2$

$$1334 \bmod 10 = 4$$

$$1471 \bmod 10 = 1$$

$$9679 \bmod 10 = 9$$

$$1989 \bmod 10 = 9$$

$$6171 \bmod 10 = 1$$

$$6173 \bmod 10 = 3$$

$$4199 \bmod 10 = 9$$

collision

Q 2 — Linear Probing.

12, 18, 13, 2, 3, 23, 5, 15

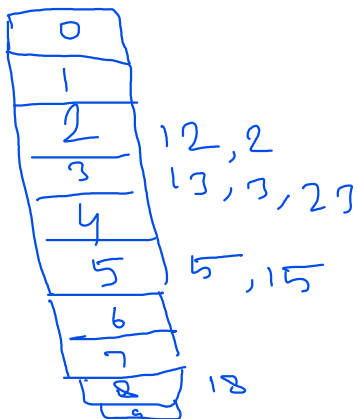
$$h(x) = x \bmod 10$$

$$12 \bmod 10 = 2$$

$$18 \bmod 10 = 8$$

$$15 \bmod 10 = 5$$

in this collision occur



0	
1	
2	12
3	13
4	2
5	3
6	23
7	5
8	18
9	15

— This is correct Linear probing

Quadratic Probing - Open addressing scheme
functions —

$$h'(x) = x \bmod m$$

$$h(x, i) = (h'(x) + i^2) \bmod m$$

$$i = 0, 1, 2, \dots, m-1$$

Ex —

50, 700, 76, 85, 92, 73, 101

Key mod 7

$$50 \bmod 7 = 1$$

$$700 \bmod 7 = 0$$

$$76 \bmod 7 = 6$$

$$85 \bmod 7 = 1$$

$$h'(x) = (1+1) \bmod 7 = 2$$

$$92 \bmod 7 = 1$$

empty block = 3 so put 92 at 3

73 mod 7 = 3 collision empty block $\Rightarrow$ 4

101 mod 7 = 3 " " $\Rightarrow$ 5

0	700
✓ 1	50
✓ 2	85
3	92
4	73
5	101
6	76

Chaining 89, 18, 49, 58, 9

$$h(x) = x \bmod 10$$

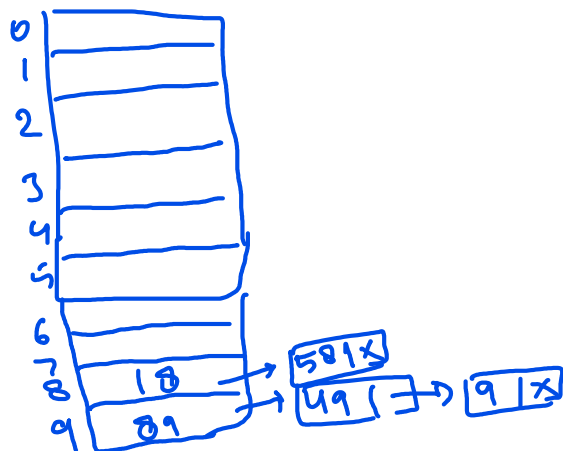
$$h(89) = 89 \bmod 10 = 9$$

$$h(18) = 18 \bmod 10 = 8$$

$$h(49) = 49 \bmod 10 = 9$$

$$h(58) = 58 \bmod 10 = 8$$

$$h(9) = 9 \bmod 10 = 9$$



Linear Probe —

$$h(x+i) = (h(x) + i) \bmod 10$$

$$h(89, 0) = (9 + 0) \bmod 10 = 9 \checkmark$$

$$h(18, 0) = (8 + 0) \bmod 10 = 8 \checkmark$$

$$h(49, 0) = (9 + 0) \bmod 10 = 9 \times$$

$$h(49, 1) = (9 + 1) \bmod 10 = 0 \checkmark$$

$$h(58, 0) = (8 + 0) \bmod 10 = 8 \times$$

$$h(58, 1) = (8 + 1) \bmod 10 = 9 \times$$

$$h(58, 2) = (8 + 2) \bmod 10 = 0 \times$$

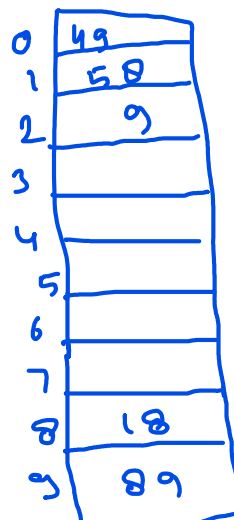
$$h(58, 3) = (8 + 3) \bmod 10 = 1 \checkmark$$

$$h(9, 0) = (9 + 0) \bmod 10 = 9 \times$$

$$h(9, 1) = (9 + 1) \bmod 10 = 0 \times$$

$$h(9, 2) = (9 + 2) \bmod 10 = 1 \times$$

$$h(9, 3) = (9 + 3) \bmod 10 = 2 \checkmark$$



Quadratic Probing

$$h_i(x) = (h(x) + i^2) \bmod 10$$

$$h_0(89) = (9 + 0^2) \bmod 10 = 9$$

$$h_0(18) = (8 + 0^2) \bmod 10 = 8$$

$$h_0(49) = (9 + 0^2) \bmod 10 = 9 \times$$

$$h_1(49) = (9 + 1^2) \bmod 10 = 0 \checkmark$$

$$h_0(58) = (8 + 0^2) \bmod 10 = 8 \times$$

$$h_1(58) = (8 + 1^2) \bmod 10 = 9 \times$$

$$h_2(58) = (8 + 2^2) \bmod 10 = 2 \checkmark \checkmark$$

$$h_0(9) = (9 + 0^2) \bmod 10 = 9 \times$$

$$h_1(9) = (9 + 1^2) \bmod 10 = 0 \times$$

$$h_2(9) = (9 + 2^2) \bmod 10 = 3 \checkmark \checkmark$$

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