Linear Probing

The keys are: 89, 18, 49, 58, 69

Table size = 10

$hash_i(x)=(x + i) \bmod 10$. Try $hash_0(x)$, $hash_1(x)$,…

0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

Linear Probing

The keys are: 89, 18, 49, 58, 69

Table size = 10

$hash_i(x)=(x + i) \bmod 10$. Try $hash_0(x)$, $hash_1(x)$,…

0	
1	
2	
3	
4	
5	
6	
7	
8	
9	89

$h_0(89) = 89 \bmod 10 = 9$

Linear Probing

The keys are: 89, 18, 49, 58, 69

Table size = 10

$hash_i(x)=(x + i) \bmod 10$. Try $hash_0(x)$, $hash_1(x)$,…

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

$h_0(18) = 18 \bmod 10 = 8$

Linear Probing

The keys are: 89, 18, 49, 58, 69

Table size = 10

$hash_i(x)=(x + i) \bmod 10$. Try $hash_0(x)$, $hash_1(x)$,…

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

$h_0(49) = 49 \bmod 10 = 9$ (occupied)

$h_1(49) = (49+1) \bmod 10 = 0$

Linear Probing

The keys are: 89, 18, 49, 58, 69

Table size = 10

$hash_i(x)=(x + i) \bmod 10$. Try $hash_0(x)$, $hash_1(x)$,…

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

$h_0(58) = 58 \bmod 10 = 8$ (occupied)

$h_1(58) = (58+1) \bmod 10 = 9$ (occupied)

$h_2(58) = (58+2) \bmod 10 = 0$ (occupied)

$h_3(58) = (58+3) \bmod 10 = 1$

Linear Probing

The keys are: 89, 18, 49, 58, 69

Table size = 10

$hash_i(x)=(x + i) \bmod 10$. Try $hash_0(x)$, $hash_1(x)$,…

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

$h_0(69) = 69 \bmod 10 = 9$ (occupied)

$h_1(69) = (69+1) \bmod 10 = 0$ (occupied)

$h_2(69) = (69+2) \bmod 10 = 1$ (occupied)

$h_3(69) = (69+3) \bmod 10 = 2$

Quadratic Probing

The keys are: 89, 18, 49, 58, 69

Table size = 10

$hash_i(x)=(x + i^2) \bmod 10$. Try $hash_0(x)$, $hash_1(x)$,…

0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

Quadratic Probing

The keys are: 89, 18, 49, 58, 69

Table size = 10

$hash_i(x)=(x + i^2) \bmod 10$. Try $hash_0(x)$, $hash_1(x)$,…

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

$h_0(89) = 89 \bmod 10 = 9$

$h_0(18) = 18 \bmod 10 = 8$

Quadratic Probing

The keys are: 89, 18, 49, 58, 69

Table size = 10

$hash_i(x)=(x + i^2) \bmod 10$. Try $hash_0(x)$, $hash_1(x)$,…

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

$h_0(49) = 49 \bmod 10 = 9$ (occupied)

$h_1(49) = (49+1) \bmod 10 = 0$

Quadratic Probing

The keys are: 89, 18, 49, 58, 69

Table size = 10

$hash_i(x)=(x + i^2) \bmod 10$. Try $hash_0(x)$, $hash_1(x)$,…

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

$h_0(58) = 58 \bmod 10 = 8$ (occupied)

$h_1(58) = (58+1) \bmod 10 = 9$ (occupied)

$h_2(58) = (58+4) \bmod 10 = 2$

Quadratic Probing

The keys are: 89, 18, 49, 58, 69

Table size = 10

$hash_i(x)=(x + i^2) \bmod 10$. Try $hash_0(x)$, $hash_1(x)$,…

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

$h_0(69) = 69 \bmod 10 = 9$ (occupied)

$h_1(69) = (69+1) \bmod 10 = 0$ (occupied)

$h_2(69) = (69+4) \bmod 10 = 3$

Double Hashing

Define two hash function: hash(x) and step(x)

$hash_i(x)=(hash(x)+ i*step(x)) \bmod 10$.

Try hash(x), hash(x)+step(x), hash(x)+ 2step(x), …

0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

The keys are: 89, 18, 49, 58, 69

Table size = 10

hash(x) =x mod 10

step(x) = 7 - (x mod 7)

Double Hashing

The keys are: 89, 18, 49, 58, 69

hash(x) =x mod 10, step(x) = 7 - (x mod 7)

$hash_i(x)=(hash(x)+ i*step(x)) \bmod 10$.

0	
1	
2	
3	
4	
5	
6	
7	
8	
9	89

$h_0(89) = 89 \bmod 10 = 9$

Double Hashing

The keys are: 89, 18, 49, 58, 69

hash(x) =x mod 10, step(x) = 7 - (x mod 7)

$hash_i(x)=(hash(x)+ i*step(x)) \bmod 10$.

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

$h_0(18) = 18 \bmod 10 = 8$

Double Hashing

The keys are: 89, 18, 49, 58, 69

hash(x) =x mod 10, step(x) = 7 - (x mod 7)

$hash_i(x)=(hash(x)+ i*step(x)) \bmod 10$.

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

$h_0(49) = 49 \bmod 10 = 9$ (occupied)

step(49) = 7- (49 mod 7) = 7-0 = 7.

$h_1(49) = (9+7) \bmod 10 = 6$

Double Hashing

The keys are: 89, 18, 49, 58, 69

hash(x) =x mod 10, step(x) = 7 - (x mod 7)

$hash_i(x)=(hash(x)+ i*step(x)) \bmod 10$.

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

$h_0(58) = 58 \bmod 10 = 8$ (occupied)

step(58) = 7-(58 mod 7) = 7 - 2 = 5.

$h_1(58) = (8+5) \bmod 10 = 3$

Double Hashing

The keys are: 89, 18, 49, 58, 69

hash(x) =x mod 10, step(x) = 7 - (x mod 7)

$hash_i(x)$=(hash(x)+ i*step(x)) mod 10.

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

$h_0(69)$ = 69 mod 10 = 9 (occupied)

step(69) = 7-(69 mod 7) = 7 - 6 = 1.

$h_1(69)$ = (9+1) mod 10 = 0

Double Hashing

The keys are: 89, 18, 49, 58, 69, 60, 23

hash(x) =x mod 10, step(x) = 7 - (x mod 7)

$hash_i(x)$=(hash(x)+ i*step(x)) mod 10.

0	69
1	
2	60
3	58
4	
5	
6	49
7	
8	18
9	89

$h_0(60)$ = 60 mod 10 = 0 (occupied)

step(60) = 7-(60 mod 7) = 7 - 4 = 3.

$h_1(60)$ = (0+3) mod 10 = 3 (occupied)

$h_2(60)$ = (0+2*3) mod 10 = 6 (occupied)

$h_3(60)$ = (0+3*3) mod 10 = 9 (occupied)

$h_4(60)$ = (0+4*3) mod 10 = 2

Double Hashing

The keys are: 89, 18, 49, 58, 69, 60, 23

hash(x) =x mod 10, step(x) = 7 - (x mod 7)

$hash_i(x)$=(hash(x)+ i*step(x)) mod 10.

0	69
1	
2	60
3	58
4	
5	
6	49
7	
8	18
9	89

$h_0(23)$ = 23 mod 10 = 3 (occupied)

step(23) = 7-(23 mod 7) = 7 - 2 = 5.

$h_1(23)$ = (3+5) mod 10 = 8 (occupied)

$h_2(23)$ = (3+2*5) mod 10 = 3 (occupied)

$h_3(23)$ = (3+3*5) mod 10 = 8 (occupied)

$h_4(23)$ = (3+4*5) mod 10 = 3 (occupied)

Double Hashing

Table size = 10

step(x)= 5

Result: Infinite loop!!!!

Why does it happen?

Can it be avoided?