

I ILLINOIS

Hash Table

Learning Objectives

1. Understand how collisions are handled with closed hashing
2. Understand how insert, remove, and find are implemented for dictionaries with closed hashing



Hash Tables

```
Dictionary<KeyType, ValueType> d;  
d[k] = v;
```

Insert, Find, Remove

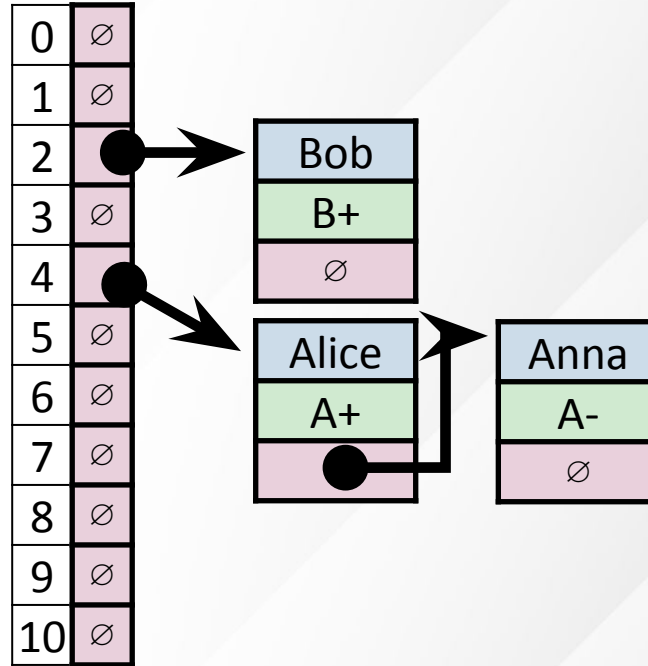
A **Hash Table** consists of three things:

1. A hash function
2. A data storage structure
3. A method of addressing *hash collisions*



Open Hashing (Separate Chaining)

Key	Value	Hash
Bob	B+	2
Anna	A-	4
Alice	A+	4
Betty	B	2
Brett	A-	2
Greg	A	0
Sue	B	7
Ali	B+	4
Laura	A	7
Lily	B+	7



Collision Handling: Probe-based Hashing

$S = \{ 1, 8, 15 \}$

$h(k) = k \% 7$

$|S| = n$

$|\text{Array}| = m$

0	
1	
2	
3	
4	
5	
6	



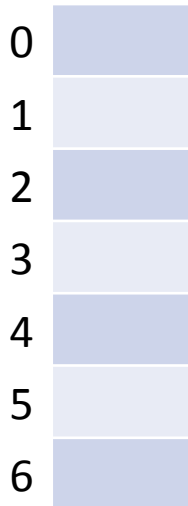
Collision Handling: Probe-based Hashing

$S = \{ 16, 8, 4, 13, 29, 11, 22 \}$

$|S| = n$

$h(k) = k \% 7$

$|\text{Array}| = m$



$h(k, i) = (k + i) \% 7$

Try $h(k) = (k + 0) \% 7$, if full...

Try $h(k) = (k + 1) \% 7$, if full...

Try $h(k) = (k + 2) \% 7$, if full...

Try ...



Collision Handling: Probe-based Hashing

$S = \{ 16, 8, 4, 13, 29, 11, 22 \}$

$|S| = n$

$h(k) = k \% 7$

$|\text{Array}| = m$

0	22
1	8
2	16
3	29
4	4
5	11
6	13

_find(29)



Collision Handling: Probe-based Hashing

$S = \{ 16, 8, 4, 13, 29, 11, 22 \}$

$|S| = n$

$h(k) = k \% 7$

$|\text{Array}| = m$

0	22
1	8
2	16
3	29
4	4
5	11
6	13

`_remove(16)`

`_find(29)`



A Problem w/ Linear Probing

Primary clustering:

0	
1	1_1
2	1_2
3	3_1
4	1_3
5	3_2
6	
7	
8	
9	

Description:

Remedy:



Another Consideration

0	22
1	8
2	16
3	29
4	4
5	11
6	13

0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

