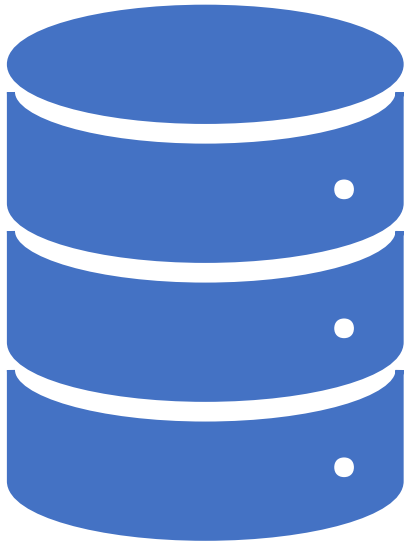
Hashing, Hash Function and Hash Table

What is Hashing



- Hashing is a technique that is used to uniquely identify a specific object from a group of similar objects.
- Examples of how hashing is used in our lives:
  - In universities, each student is assigned a unique roll number that can be used to retrieve information about them.
  - In libraries, each book is assigned a unique number that can be used to determine information about the book
- **Hashing** is the solution that can be used in almost all such situations and performs extremely well compared to above data structures like Array, Linked List, BST in practice

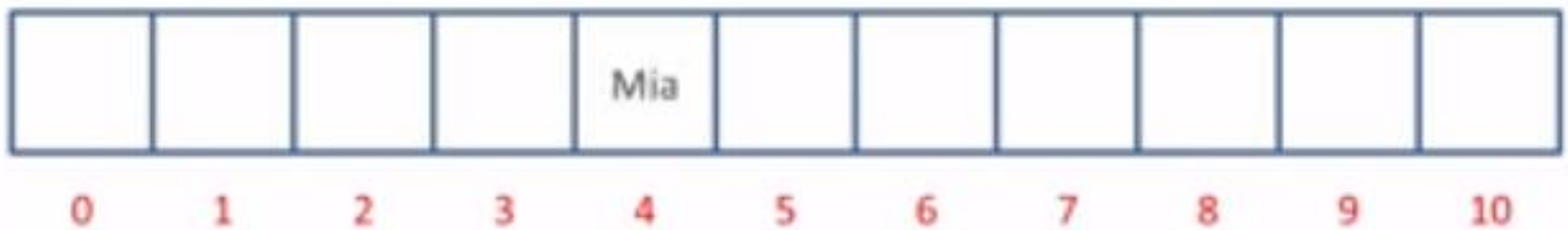
What is Hashing (Cond…)

- With hashing we get O(1) search time on average and O(n) in worst case.
- The idea is to use ***hash function*** that converts a given input number or any other key to a smaller number and uses the small number as index in a table called ***hash table***.
- Hash Function
  - Hash function maps a big number or string to a small integer that can be used as index in hash table
- Hash Table
  - An array that stores pointers to records corresponding to a given input number


0
1
2
3
4
5
6
7
8
9
10

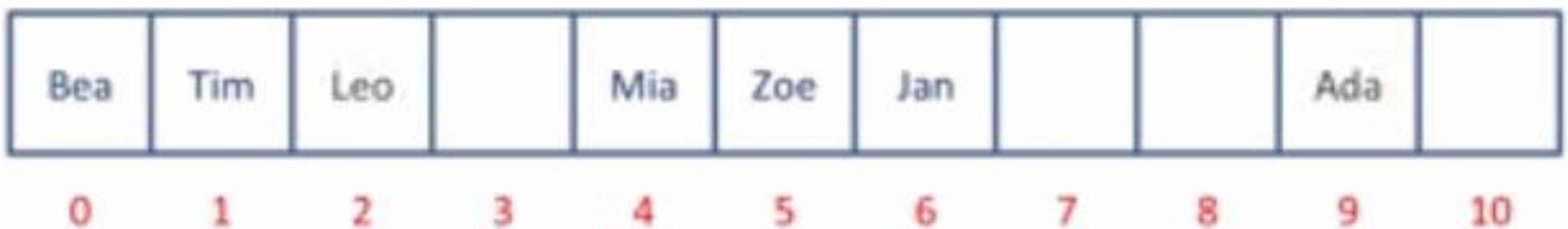
Mia		M	77	i	105	a	97		279		4

Mia	M	77	i	105	a	97	279	4



Mia	M	77	i	105	a	97	279	4
Tim	T	84	i	105	m	109	298	1

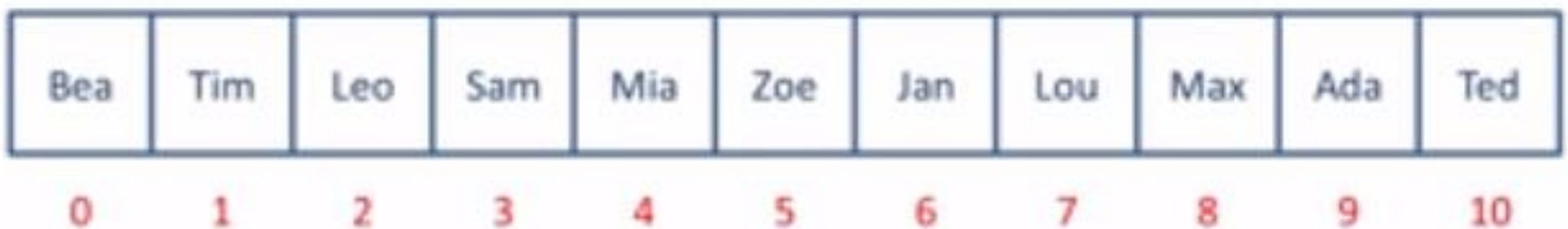
Mia	M	77	i	105	a	97	279	4
Tim	T	84	i	105	m	109	298	1
Bea	B	66	e	101	a	97	264	0
Zoe	Z	90	o	111	e	101	302	5
Jan	J	74	a	97	n	110	281	6
Ada	A	65	d	100	a	97	262	9
Leo	L	76	e	101	o	111	288	2



Mia	M	77	i	105	a	97	279	4
Tim	T	84	i	105	m	109	298	1
Bea	B	66	e	101	a	97	264	0
Zoe	Z	90	o	111	e	101	302	5
Jan	J	74	a	97	n	110	281	6
Ada	A	65	d	100	a	97	262	9
Leo	L	76	e	101	o	111	288	2
Sam	S	83	a	97	m	109	289	3
Lou	L	76	o	111	u	117	304	7
Max	M	77	a	97	x	120	294	8
Ted	T	84	e	101	d	100	285	10

Bea	Tim	Leo	Sam	Mia	Zoe	Jan	Lou	Max	Ada	Ted
0	1	2	3	4	5	6	7	8	9	10

Index number = *sum ASCII codes* Mod *size of array*

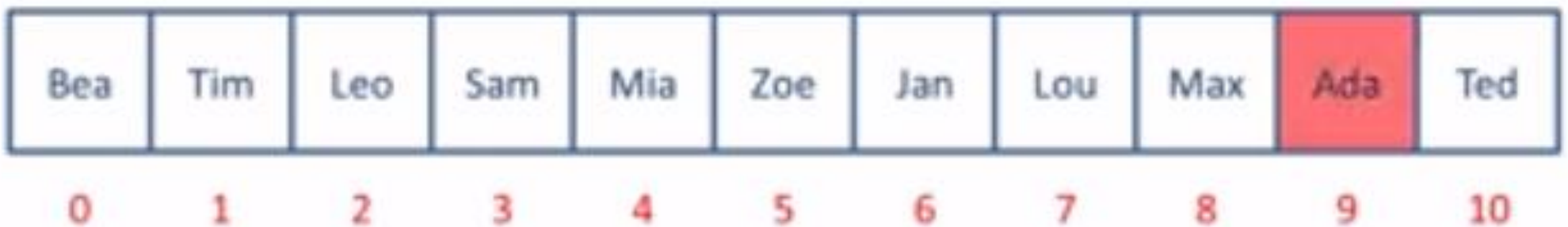


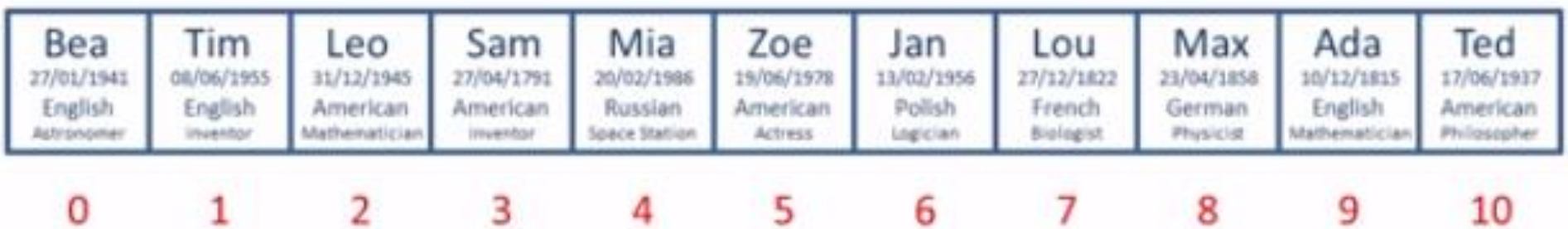
Find Ada

Ada = (65 + 100 + 97) = 262

262 Mod 11 = 9

myData = Array(9)




Bea
27/01/1941
English
Astronomer
Tim
08/06/1955
English
Inventor
Leo
31/12/1945
American
Mathematician
Sam
27/04/1791
American
Inventor
Mia
20/02/1986
Russian
Space Station
Zoe
19/06/1978
American
Actress
Jan
13/02/1956
Polish
Logician
Lou
27/12/1822
French
Biologist
Max
23/04/1858
German
Physicist
Ada
10/12/1815
English
Mathematician
Ted
17/06/1937
American
Philosopher
0
1
2
3
4
5
6
7
8
9
10

Hashing Algorithm

- Calculation applied to a key to transform it into an address
- For numeric keys, divide the key by the number of available addresses, *n*, and take the remainder

address = *key* Mod *n*

- For alphanumeric keys, divide the sum of ASCII codes in a key by the number of available addresses, *n*, and take the remainder
- Folding method divides key into equal parts then adds the parts together
  - The telephone number 01452 8345654, becomes 01 + 45 + 28 + 34 + 56 + 54 = 218
  - Depending on size of table, may then divide by some constant and take remainder

Understand Collision

Mia	M	77	i	105	a	97	279	4
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Bea	B	66	e	101	a	97	264	0
Zoe	Z	90	o	111	e	101	302	5

Understand Collision

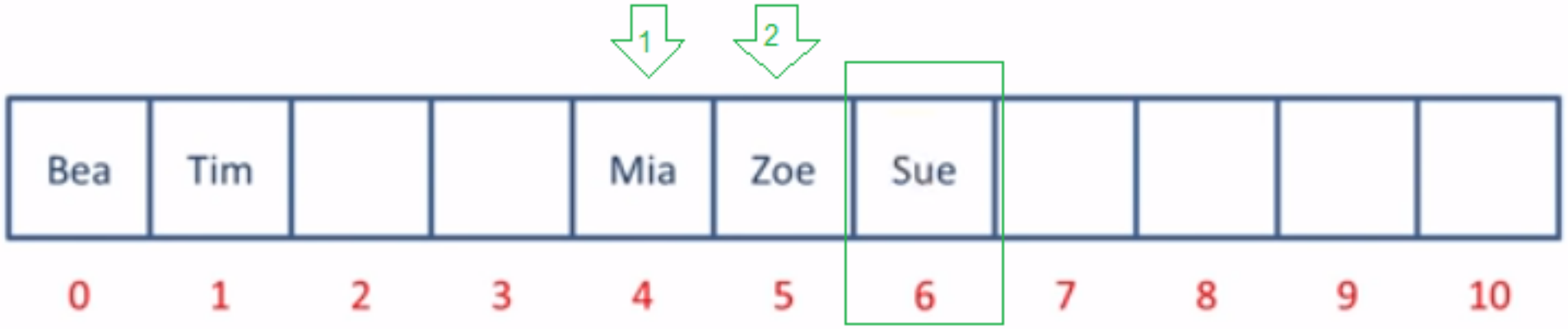
Mia	M	77	i	105	a	97	279	4
Tim	T	84	i	105	m	109	298	1
Bea	B	66	e	101	a	97	264	0
Zoe	Z	90	o	111	e	101	302	5
Sue	S	83	u	117	e	101	301	4

Collision Handling

- Irrespective of how good a hash function is, collisions are bound to occur.
- Therefore, to maintain the performance of a hash table, it is important to manage collisions through various collision resolution techniques.
  - Open addressing
    - Linear Probing
    - Quadratic Probing
    - Double Hashing
  - Closed addressing

Open Addressing (Linear)

Mia	M	77	i	105	a	97	279	4
Tim	T	84	i	105	m	109	298	1
Bea	B	66	e	101	a	97	264	0
Zoe	Z	90	o	111	e	101	302	5
Sue	S	83	u	117	e	101	301	4



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Tim	T	84	i	105	m	109	298	1
Bea	B	66	e	101	a	97	264	0
Zoe	Z	90	o	111	e	101	302	5
Sue	S	83	u	117	e	101	301	4
Len	L	76	e	101	n	110	287	1

Mia	M	77	i	105	a	97	279	4
Tim	T	84	i	105	m	109	298	1
Bea	B	66	e	101	a	97	264	0
Zoe	Z	90	o	111	e	101	302	5
Sue	S	83	u	117	e	101	301	4
Len	L	76	e	101	n	110	287	1
Moe	M	77	o	111	e	101	289	3
Lou	L	76	o	111	u	117	304	7
Rae	R	82	a	97	e	101	280	5
Max	M	77	a	97	x	120	294	8
Tod	T	84	o	111	d	100	295	9

Bea	Tim	Len	Moe	Mia	Zoe	Sue	Lou	Rae	Max	Tod
0	1	2	3	4	5	6	7	8	9	10

Find Rae

Rae = (82 + 97 + 101) = 280

280 Mod 11 = 5

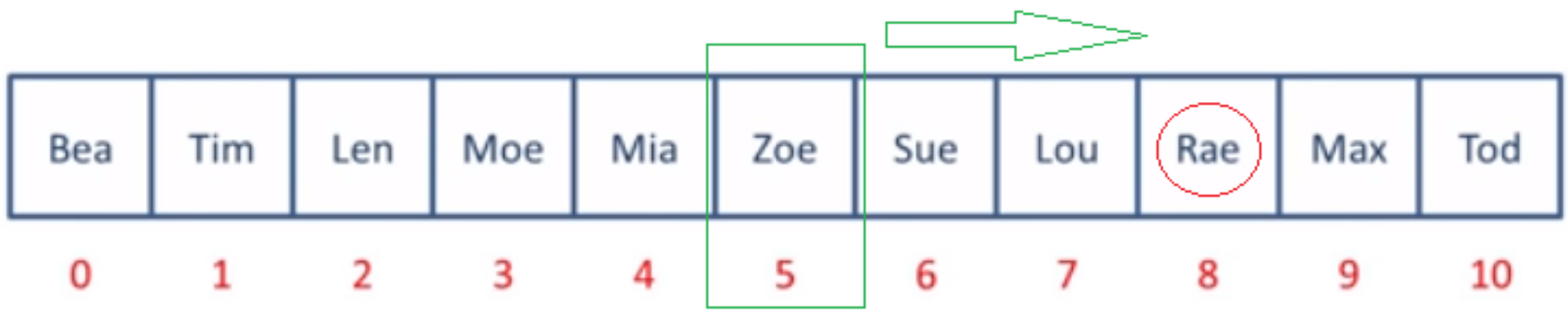
myData = Array(5)

Find Rae

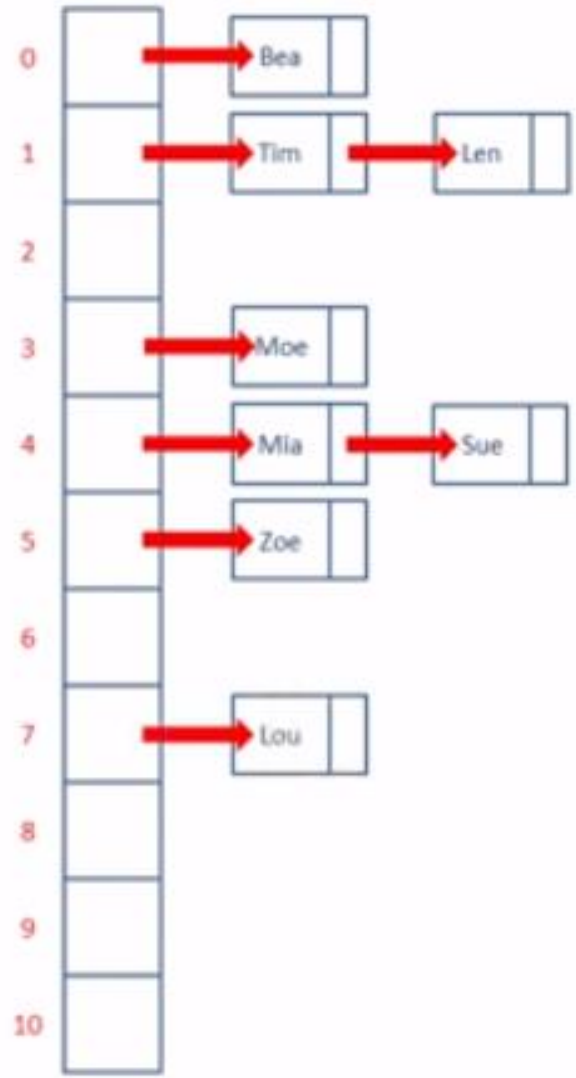
Rae = (82 + 97 + 101) = 280

280 Mod 11 = 5

myData = Array(5)



Closed Addressing (Non-Linear)



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Sue	S	83	u	117	e	101	301	4
Len	L	76	e	101	n	110	287	1
Moe	M	77	o	111	e	101	289	3
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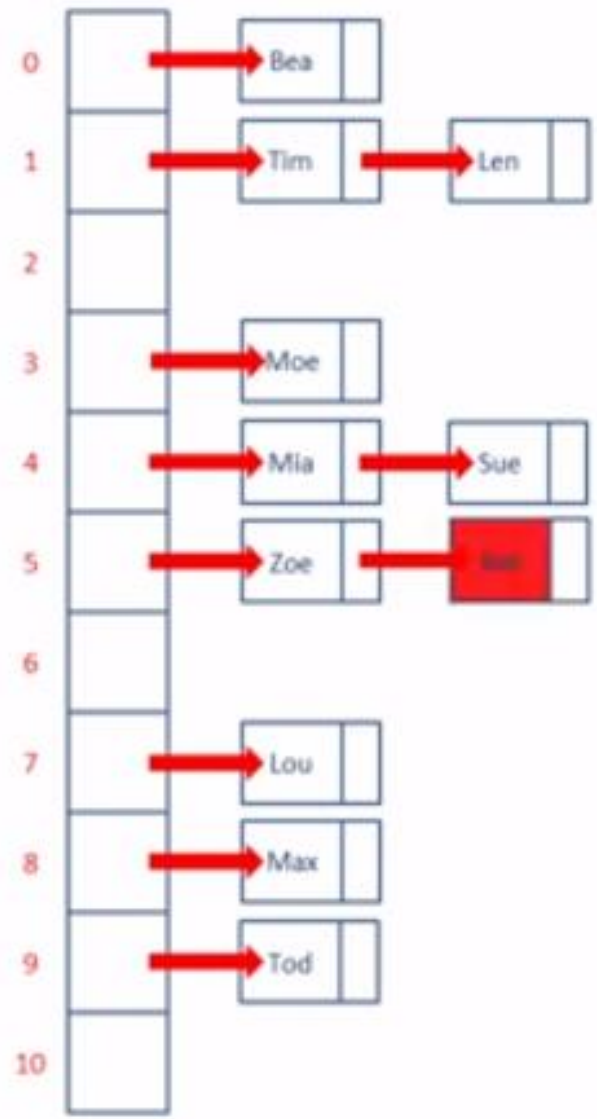

Find Rae 280 Mod 11 = 5

myData = Array(5)

Objectives of Hash Function

- Minimize collisions
- Uniform distribution of hash values
- Easy to calculate
- Resolve any collisions