Abstract Data Types

Java Collections Framework

NIFR 2023

Agenda

ADT’s & Java Collections Framework

- Data Structures: A Primer
- Array & ArrayList
- ADT’s: Set, List, Map
- Generics
- Java Collections Framework: Comparable

What are **a**bstract **d**ata **t**ypes?

In todays context:
Data types ≈ Data Structures

Data type Data Structure

```
ArrayList<String> names = new ArrayList<String>();
```

```
String name = "George"
```

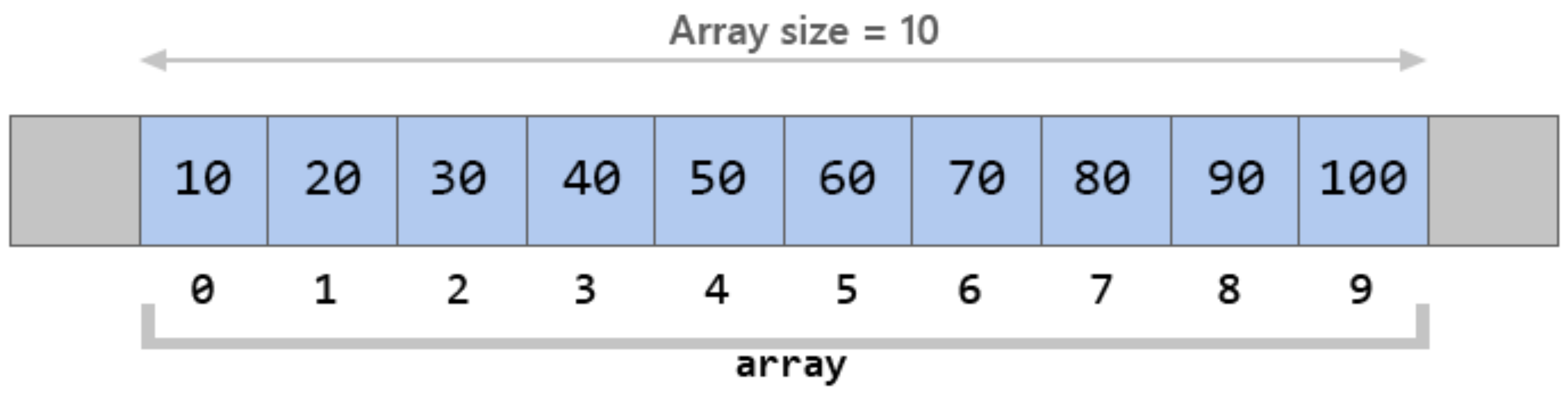
Data type

```
int age = 2;
```

Data type

An Array

```java
int[] ints = new int[10];
```



Fixed size

Variable

```
int[] ints;
```

Vs.

Instantiated array sized 10

```
int[] ints = new int[10];
```

Vs.

Initialised array with int values 1-10

```
int[] ints = {1,2,3,4,5,6,7,8,9,10};
```

Warmup exercise Arrays

Write a static method that takes an integer array as parameter

The method returns the average of the array

(Optional)
The method returns both the sum and average as an array of integers

Abstract Data Types

Data Structures

- ArrayList
- HashMap
- HashSet

Data + Data structure

What are the downsides of an array

An **Abstract Data Type** (ADT) is the specification of a group of operations that make sense for a given data type. They define an interface for working with variables holding data of a given type—hiding all details of how data is stored and operated in memory.

The List

When storing a bunch of items, you sometimes need more flexibility. For instance, you could want to freely reorder the items; or to access, insert and remove items at any position. In these cases, the **List** is handy. Commonly defined operations in a List ADT include:

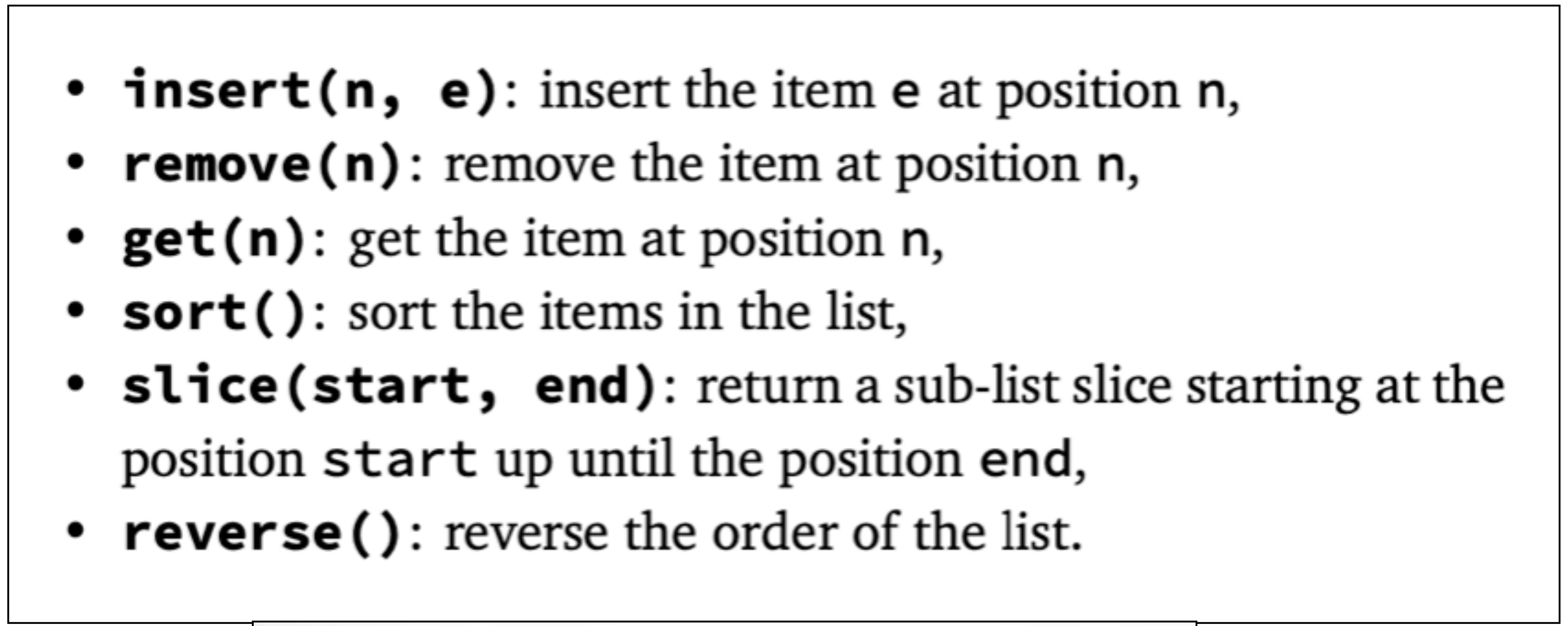
- **`insert(n, e)`**: insert the item `e` at position `n`,
- **`remove(n)`**: remove the item at position `n`,
- **`get(n)`**: get the item at position `n`,
- **`sort()`**: sort the items in the list,
- **`slice(start, end)`**: return a sub-list slice starting at the position `start` up until the position `end`,
- **`reverse()`**: reverse the order of the list.

To Do List
1.
2.
3.
4.
5.
1
2019

The List type exists in:

Same abstract operations

- Java as an ArrayList
- Javascript as an Array
- Python as a List
- C# as ArrayList
- Kotlin as ArrayList
- The List goes on…



- **insert(n, e)**: insert the item e at position n,
- **remove(n)**: remove the item at position n,
- **get(n)**: get the item at position n,
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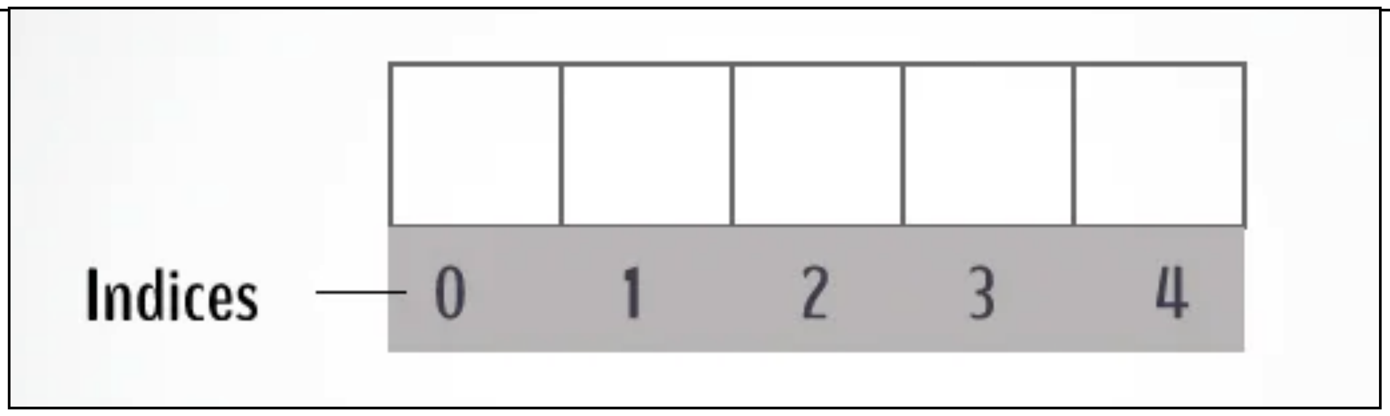
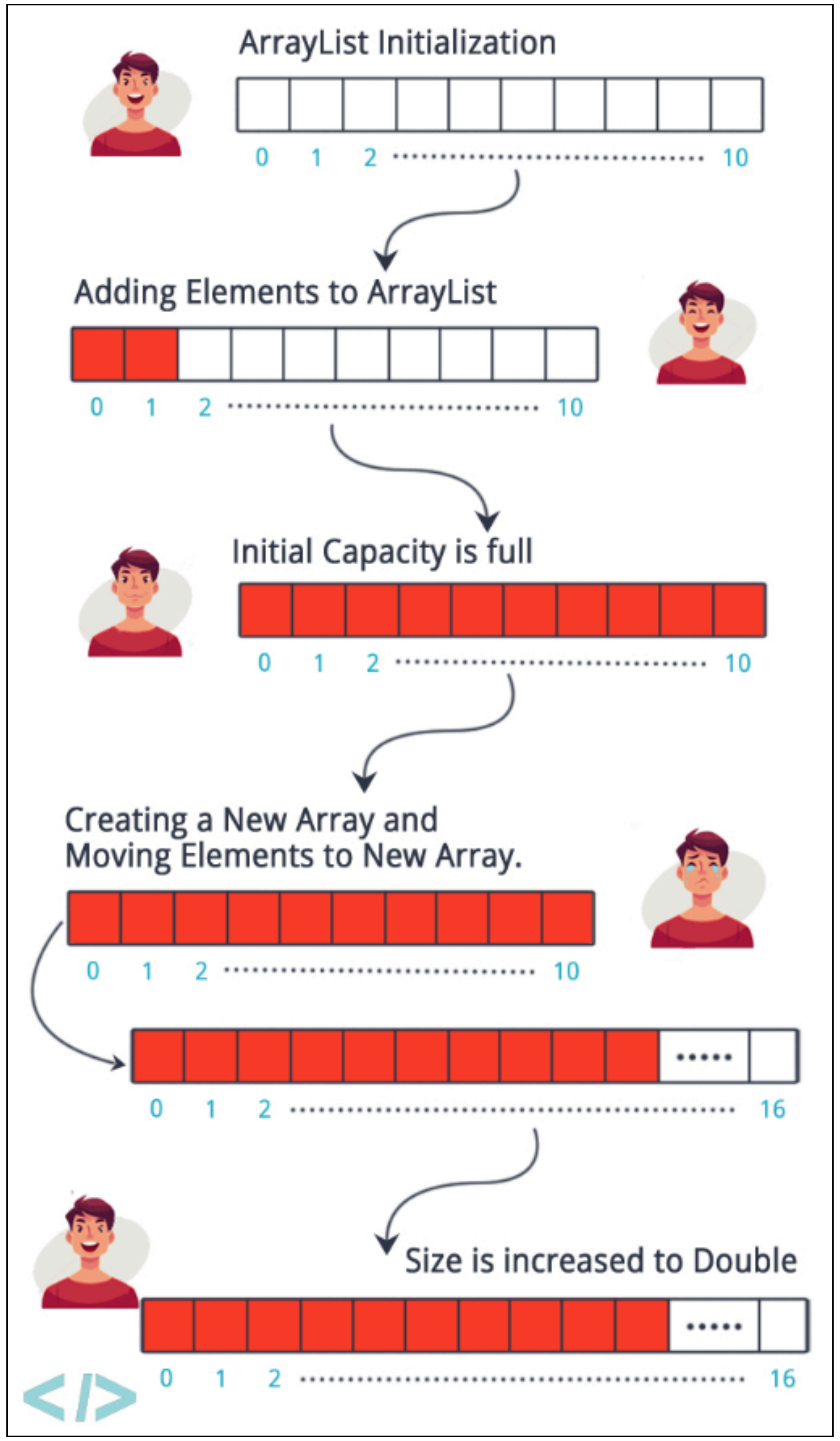


ArrayList

ImplementationADT

```
private void add(E e, Object[] elementData, int s) {
    if (s == elementData.length)
        elementData = grow();
    elementData[s] = e;
    size = s + 1;
}
```

From ArrayList



ArrayList Initialization
0 1 2 10
Adding Elements to ArrayList
0 1 2 10
Initial Capacity is full
0 1 2 10
Creating a New Array and Moving Elements to New Array.
0 1 2 10
0 1 2 16
Size is increased to Double
0 1 2 16

Example ArrayList

Fundamental Questions

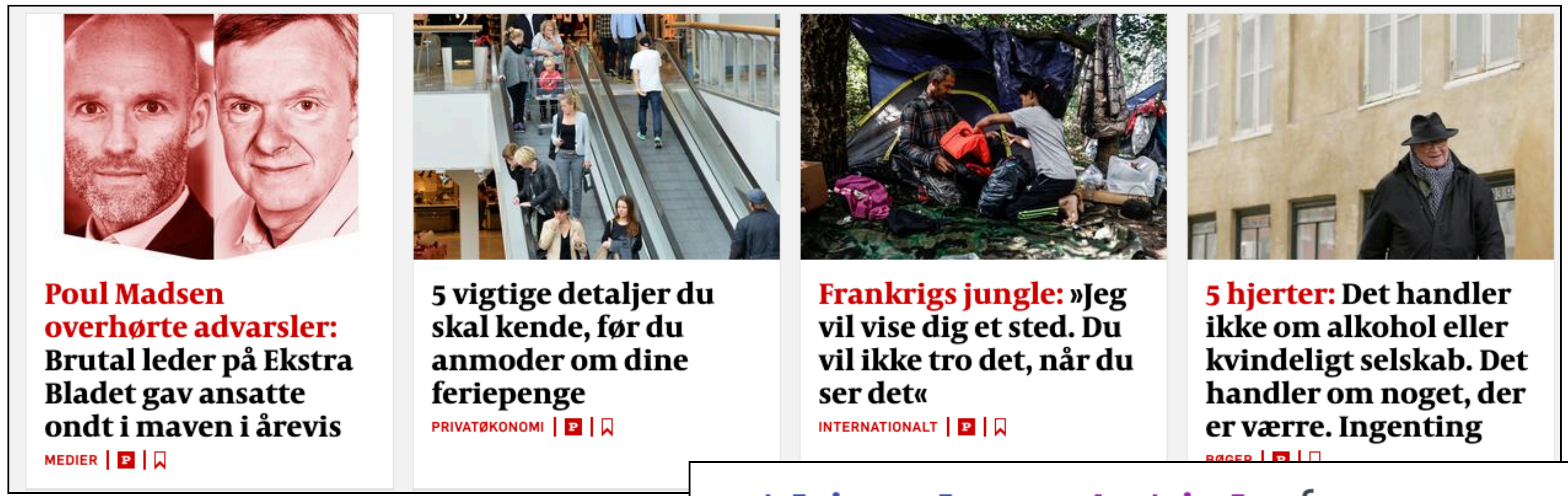
Dealing with ADT’s / Data Structures

- What:
  - What does my data look like “naturally”?
  - What structure can represent my data
- Why:
  - Which data structure should I use?
- How:
  - Do I insert data? Remove data? Manipulate data?

Boys

- Liam
- Noah
- Oliver
- Elijah
- William
- James
- Benjamin
- Lucas
- Henry
- Alexander

Top 10 popular baby names: List of strings



Poul Madsen overhørte advarsler: Brutal leder på Ekstra Bladet gav ansatte ondt i maven i årevis
MEDIER

5 vigtige detaljer du skal kende, før du anmoder om dine feriepenge
PRIVATØKONOMI

Frankrigs jungle: »Jeg vil vise dig et sted. Du vil ikke tro det, når du ser det«
INTERNATIONALT

5 hjerter: Det handler ikke om alkohol eller kvindeligt selskab. Det handler om noget, der er værre. Ingenting
BØGER

List of articles

```java
public class Article{
    private String headline;
    private String author;
    private String category;
    private boolean isOnFrontPage;
}
```

```java
ArrayList<Article> names = new ArrayList<Article>();
```

```java
ArrayList<String> names = new ArrayList<String>()
```

Abstract Data Types

Data Structures

- ArrayList
- HashMap
- HashSet

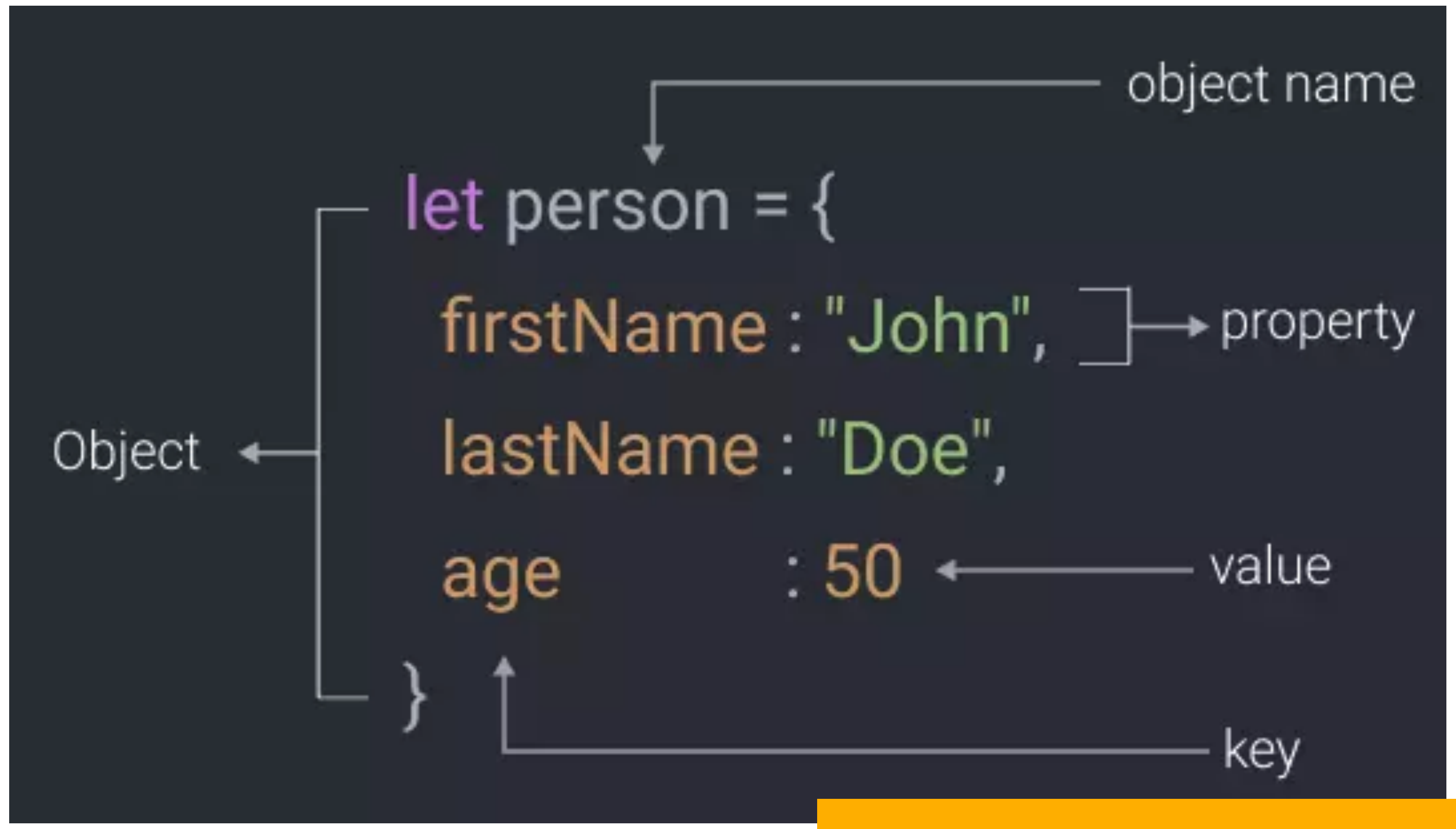
Implementation Abstract Type

Data + Data structure

What is hashing

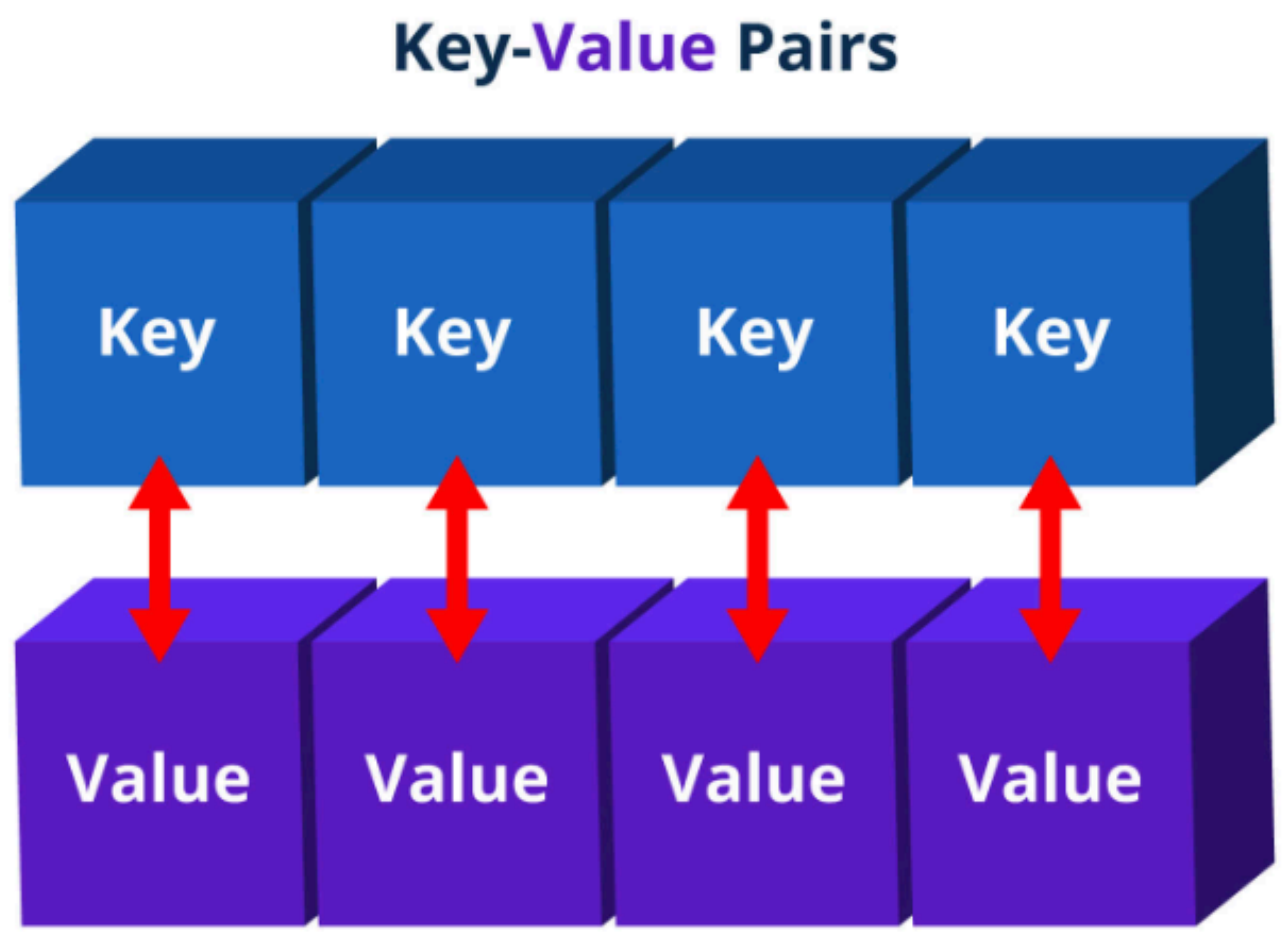
Abstract Data Types

Map Type



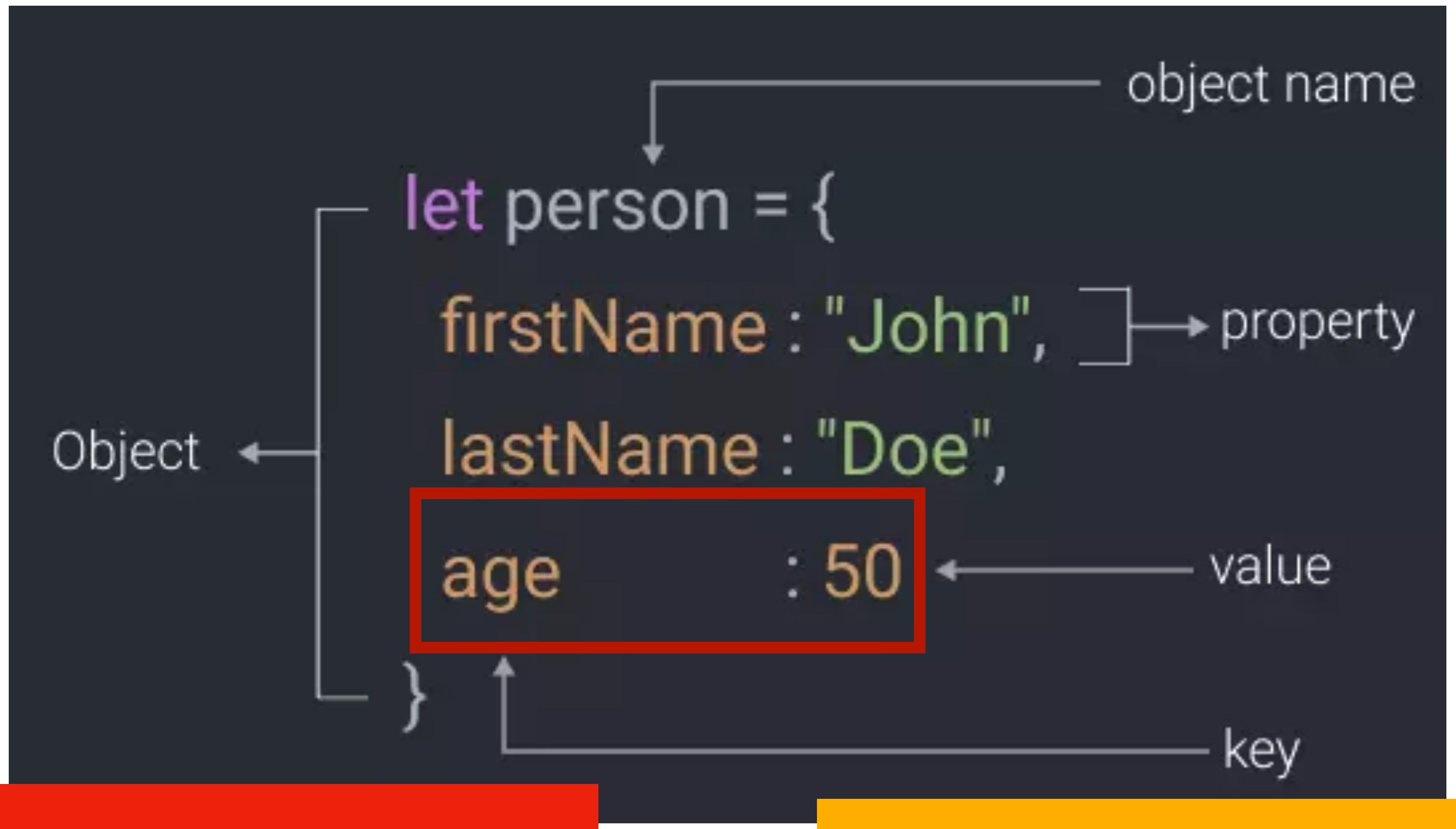
```
let person = {
  firstName : "John",
  lastName : "Doe",
  age       : 50
}
```

Javascript object-like



Abstract Data Types

Map Type



```
let person = {
  firstName : "John",
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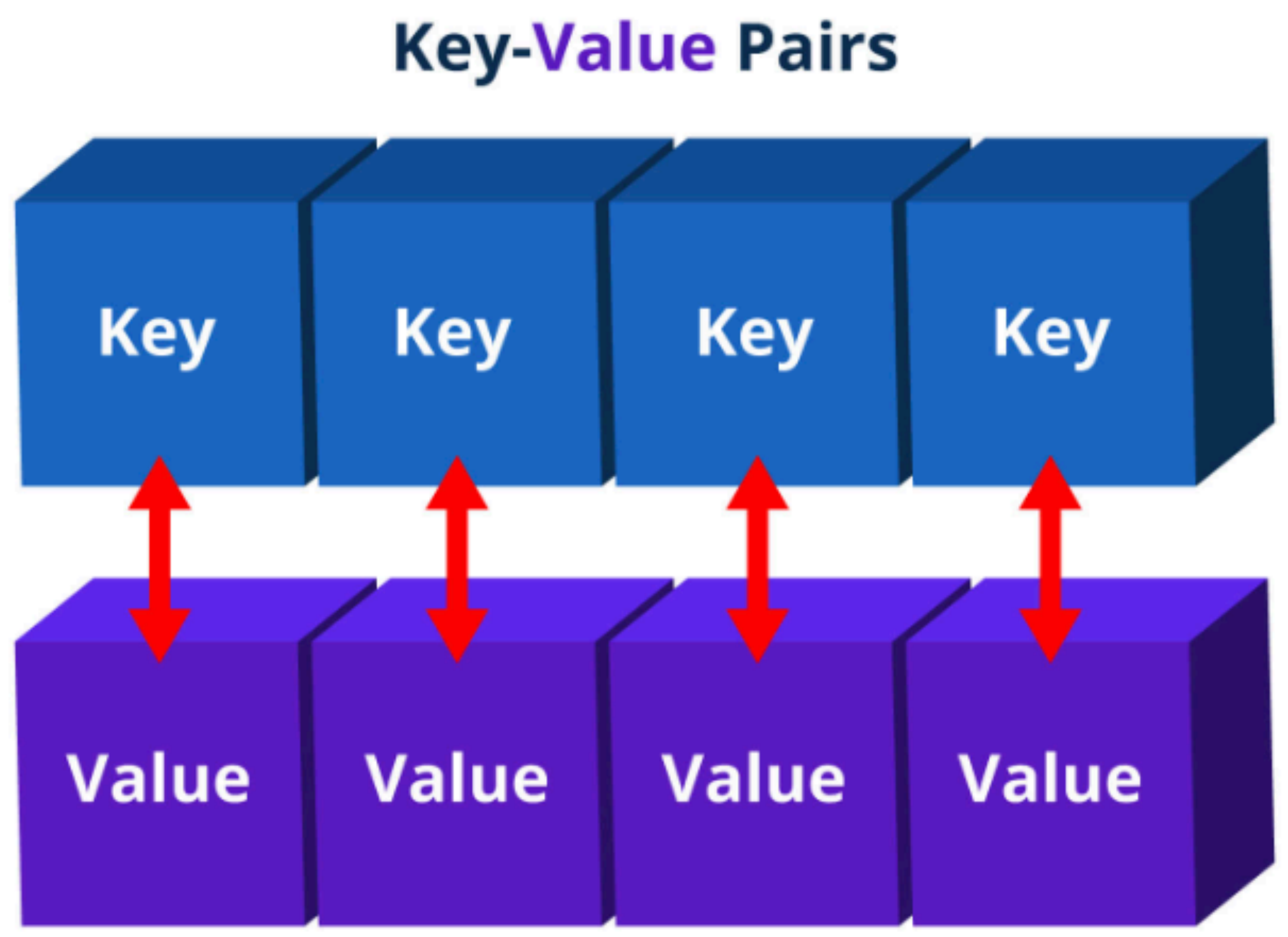
  age       : 50
}
```

Has to be same type (in java)

Javascript object-like



HashMap

ImplementationADT

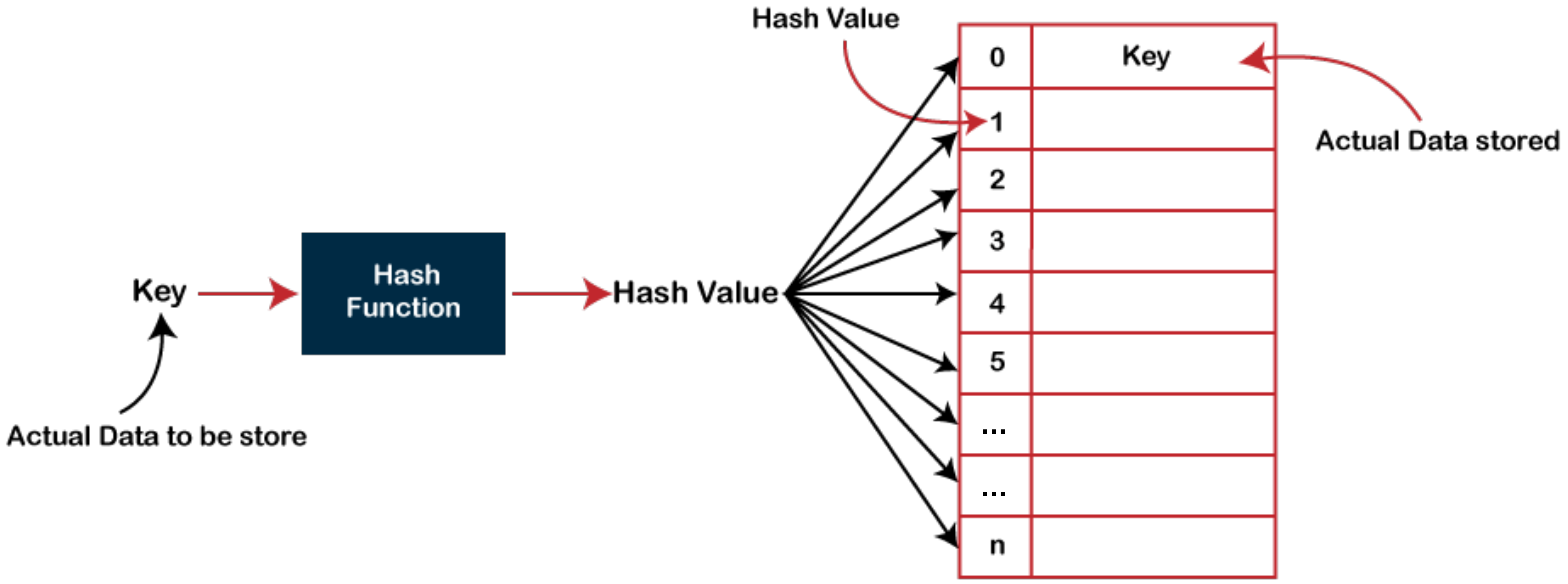
- **set(key, value)**: add a key-value mapping,
- **delete(key)**: remove key and its associated value,
- **get(key)**: retrieve the value that was associated to key.

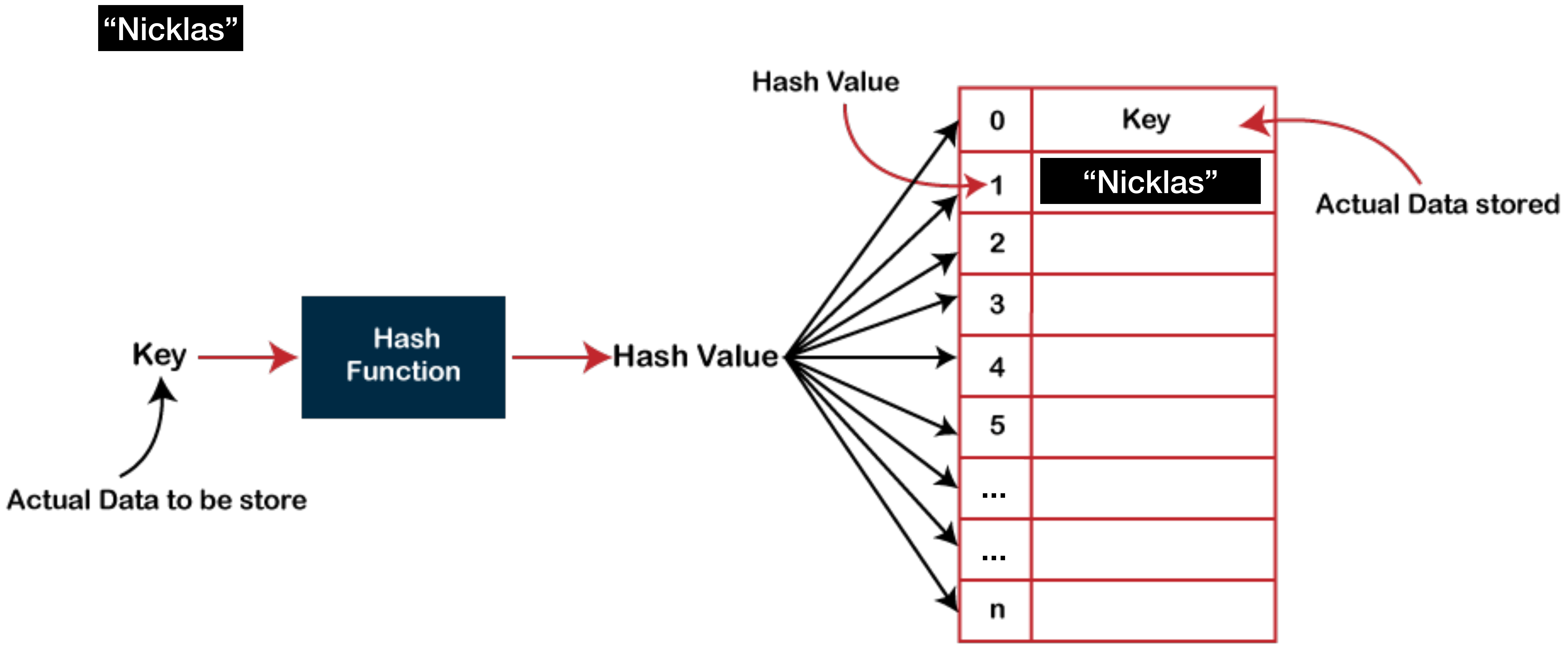
```
//Data looks like this:
//Nicklas , 20436262
//Jakob , 88009872
HashMap<String,Integer> phonebook = new HashMap<~>();

phonebook.get("Nicklas");
//Returns 20436262
```

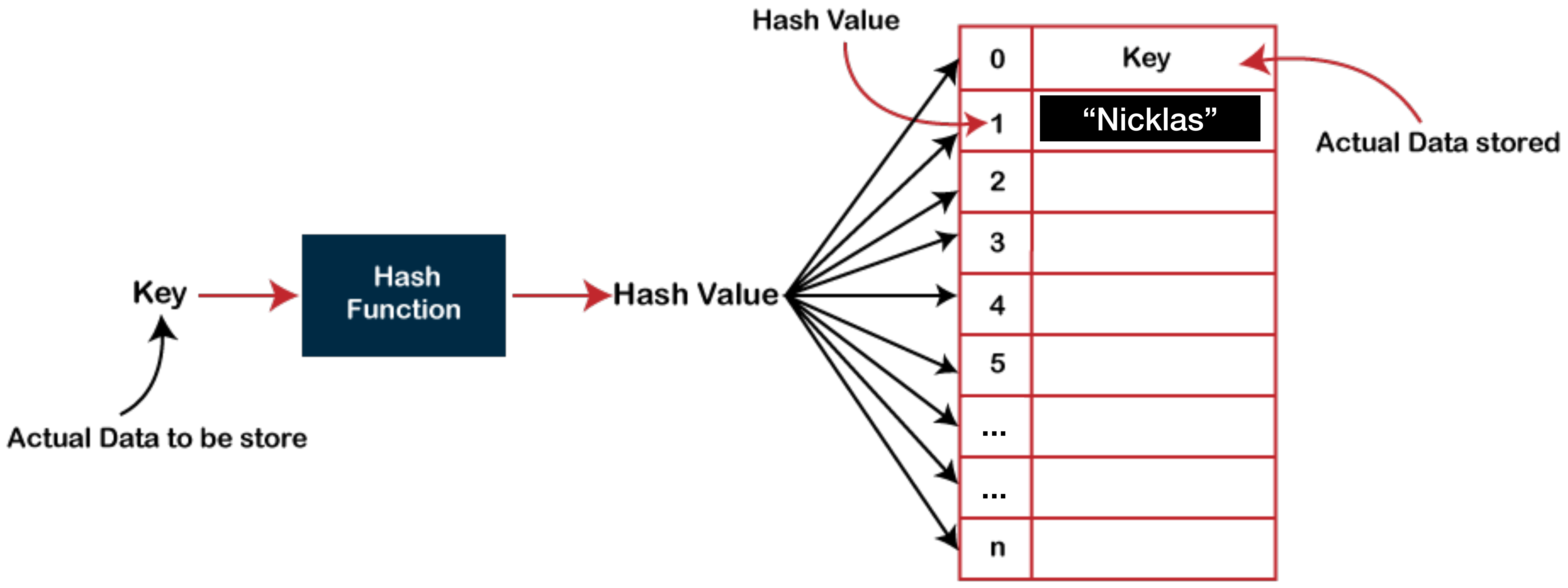
Key	**Value**
Nicklas	20436262
Karsten	20202020
Evander	29392291
…	…
N	N

“Nicklas”

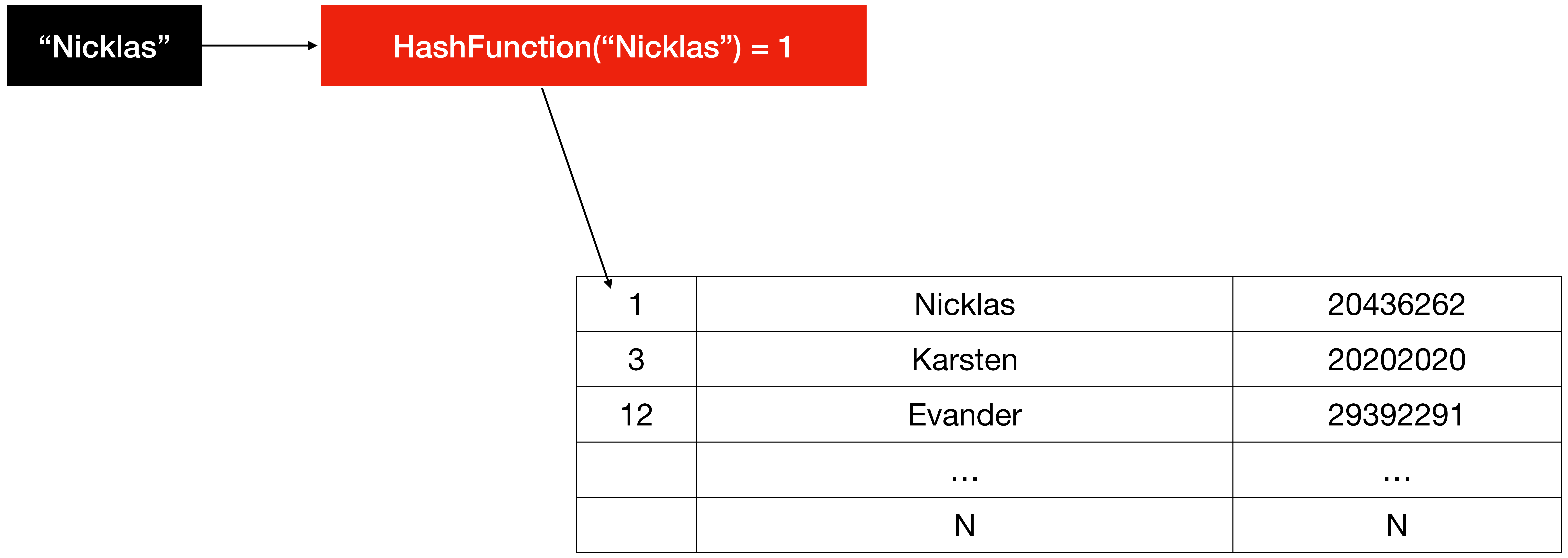

Hash Value
0
Key
1
2
3
4
5
...
...
n
Actual Data stored
Key
Hash Function
Hash Value
Actual Data to be store


"Nicklas"
Hash Value
0
Key
1
"Nicklas"
Actual Data stored
2
3
Key
Hash Function
Hash Value
4
5
...
...
n
Actual Data to be store

Hash Value	Key	Value
1	Nicklas	20436262
3	Karsten	20202020
12	Evander	29392291
	…	…
	N	N



```
phonebook.get("Nicklas")
```



1	Nicklas	20436262
3	Karsten	20202020
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	…	…
	N	N

HashMap

ImplementationADT

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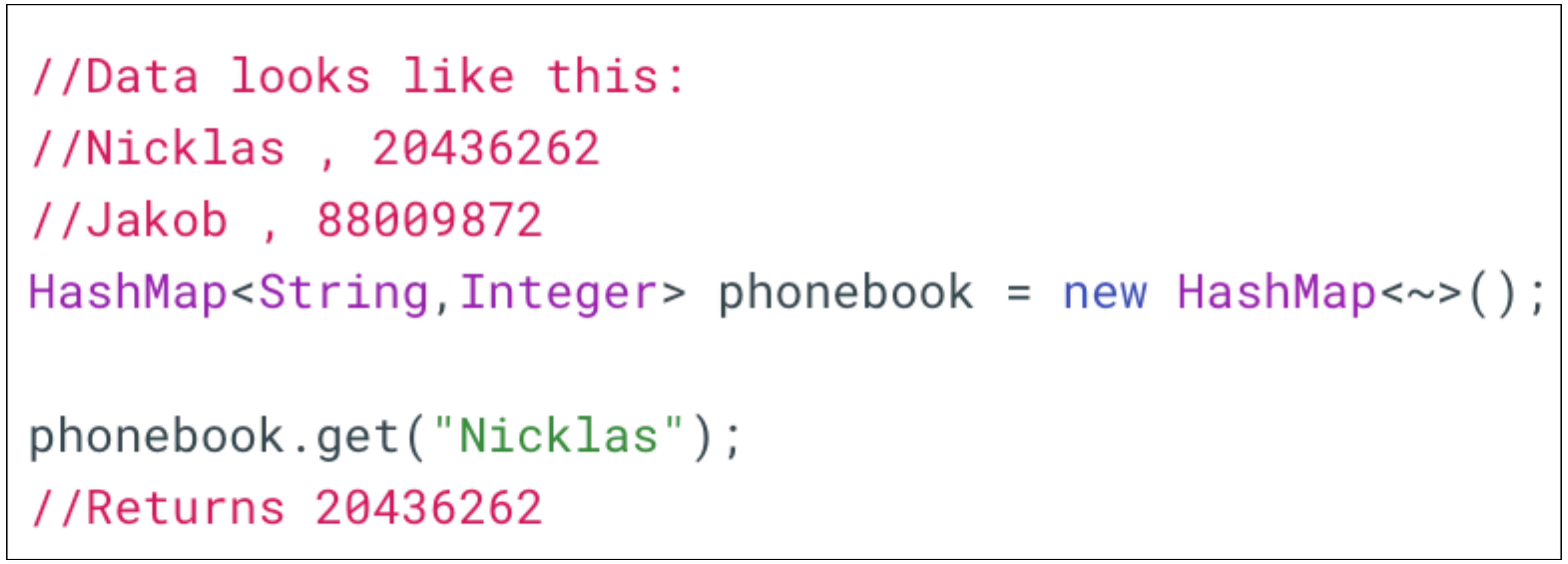

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HashMap<String,Integer> phonebook = new HashMap<~>();

phonebook.get("Nicklas");
//Returns 20436262
```

The Set

The **Set** represents unordered groups of *unique* items, like mathematical sets described in Appendix III. They're used when the order of items you need to store is meaningless, or if you must ensure no items in the group occurs more than once. The common Set operations are:

- **`add(e)`**: add an item to the set or produce an error if the item is already in the set,
- **`list()`**: list the items in the set,
- **`delete(e)`**: remove an item from the set.

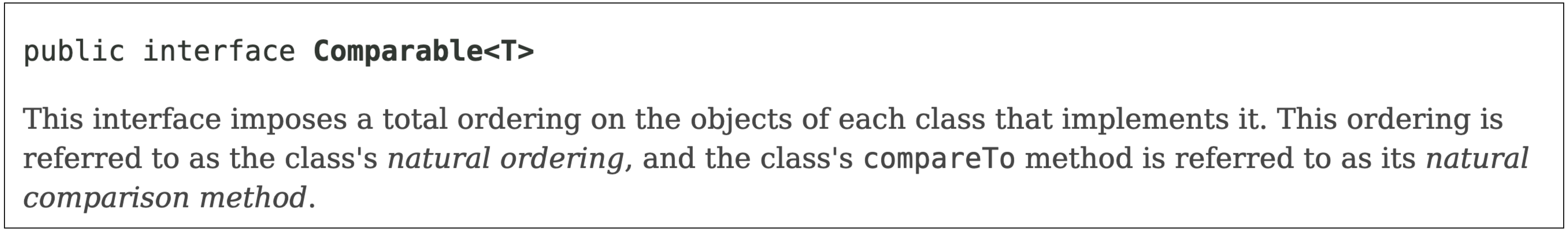
How Reading a file in Java
Exercises: Text-analysis
(Pair programming)

If you start coding right away - you're probably doing it wrong

Comparable Interface

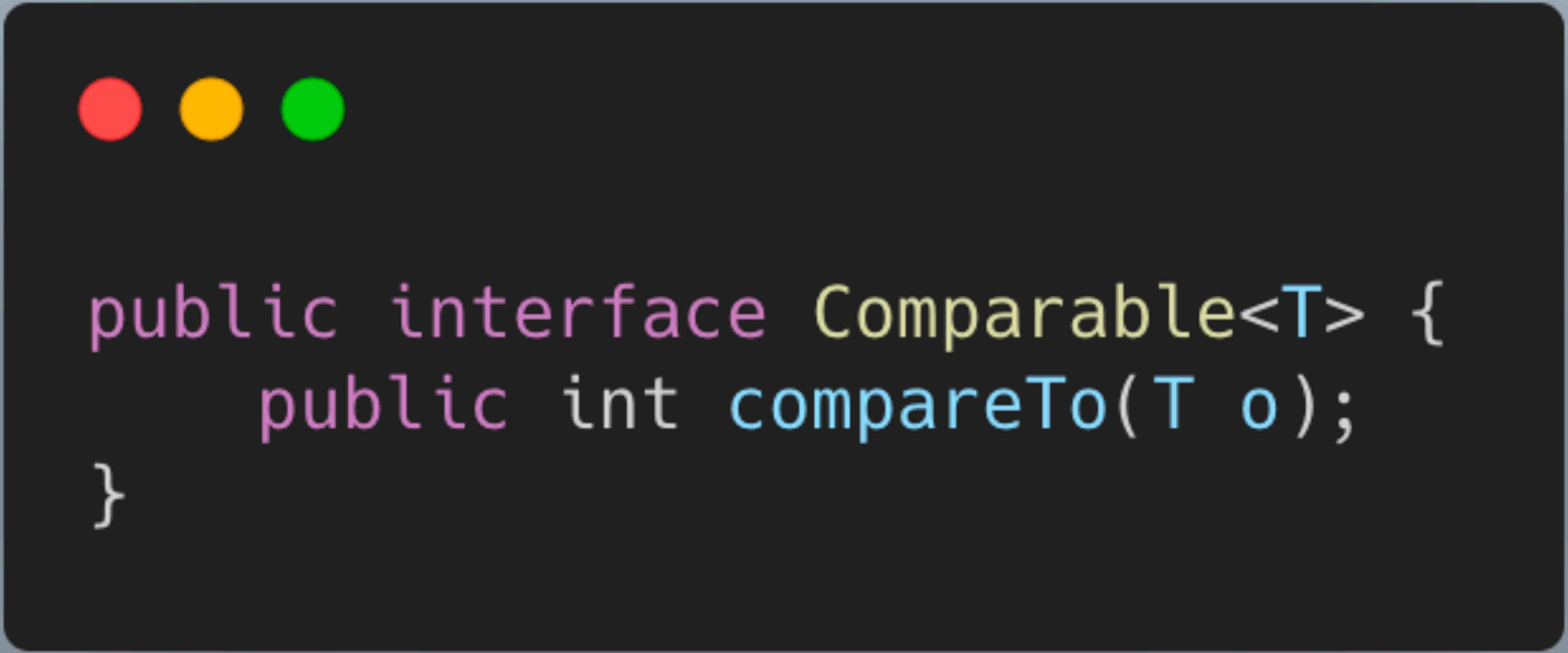
Comparable interface

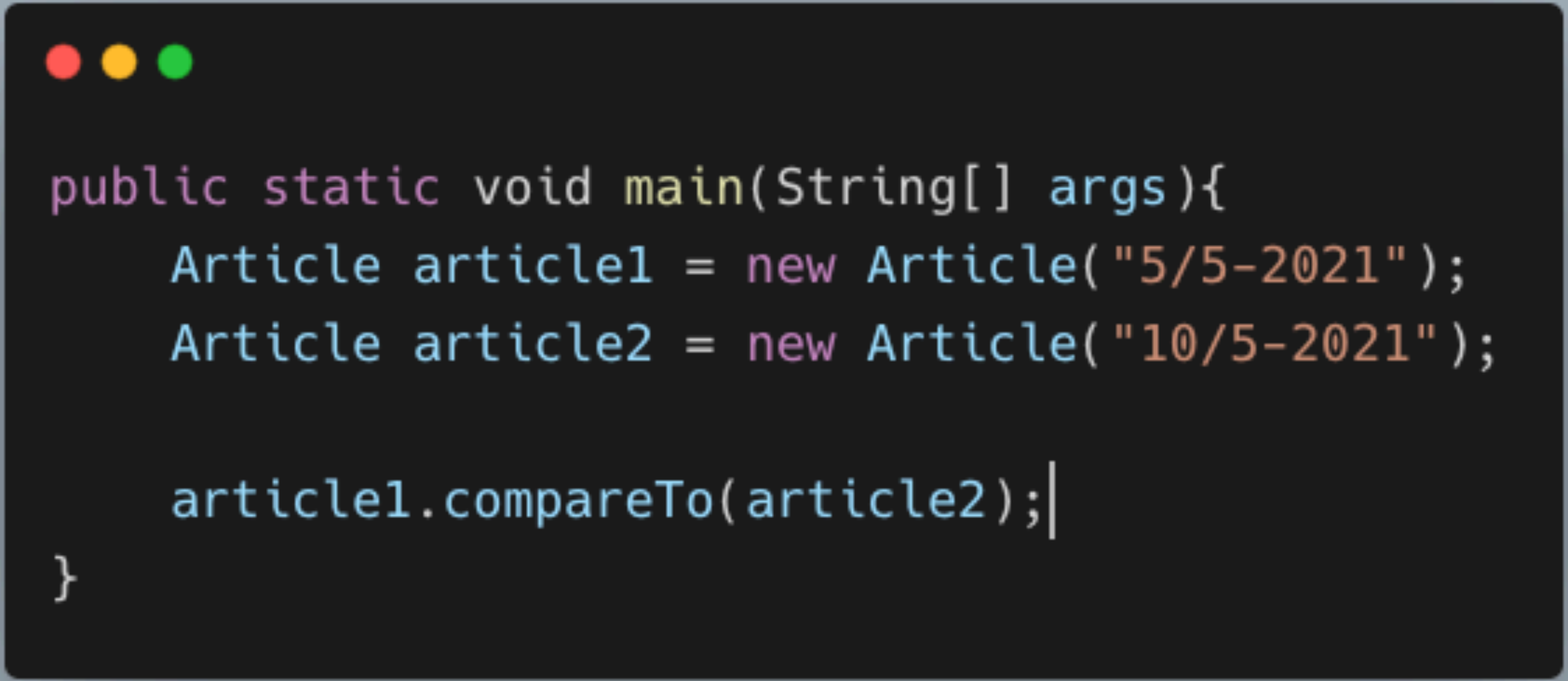
Concept



```
public interface **Comparable<T>**
```

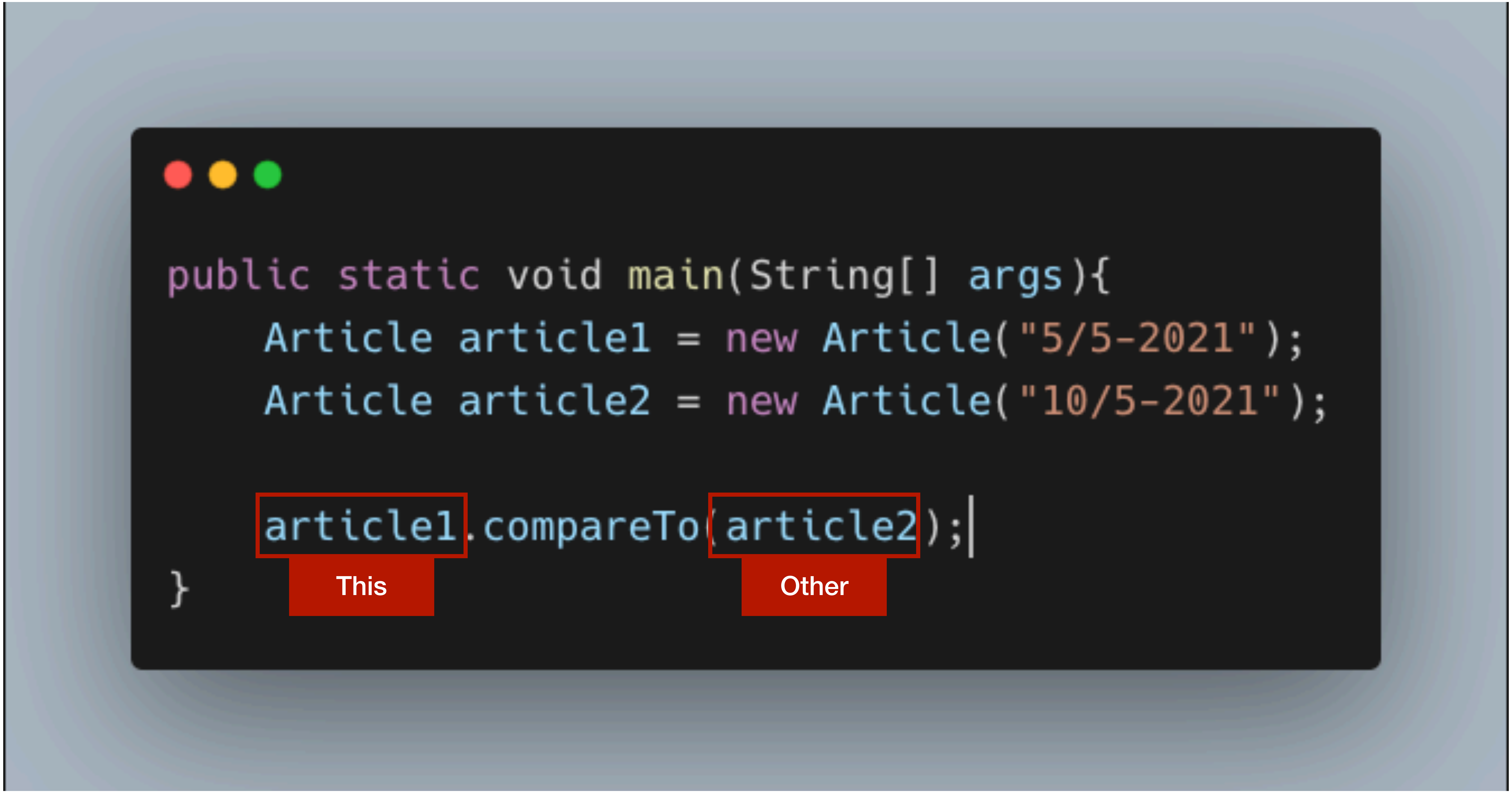
This interface imposes a total ordering on the objects of each class that implements it. This ordering is referred to as the class's *natural ordering*, and the class's `compareTo` method is referred to as its *natural comparison method*.


```
public interface Comparable<T> {
    public int compareTo(T o);
}
```



```java
public static void main(String[] args){
    Article article1 = new Article("5/5-2021");
    Article article2 = new Article("10/5-2021");

    article1.compareTo(article2);
}
```



```
public static void main(String[] args){
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    article1.compareTo(article2);
}
```
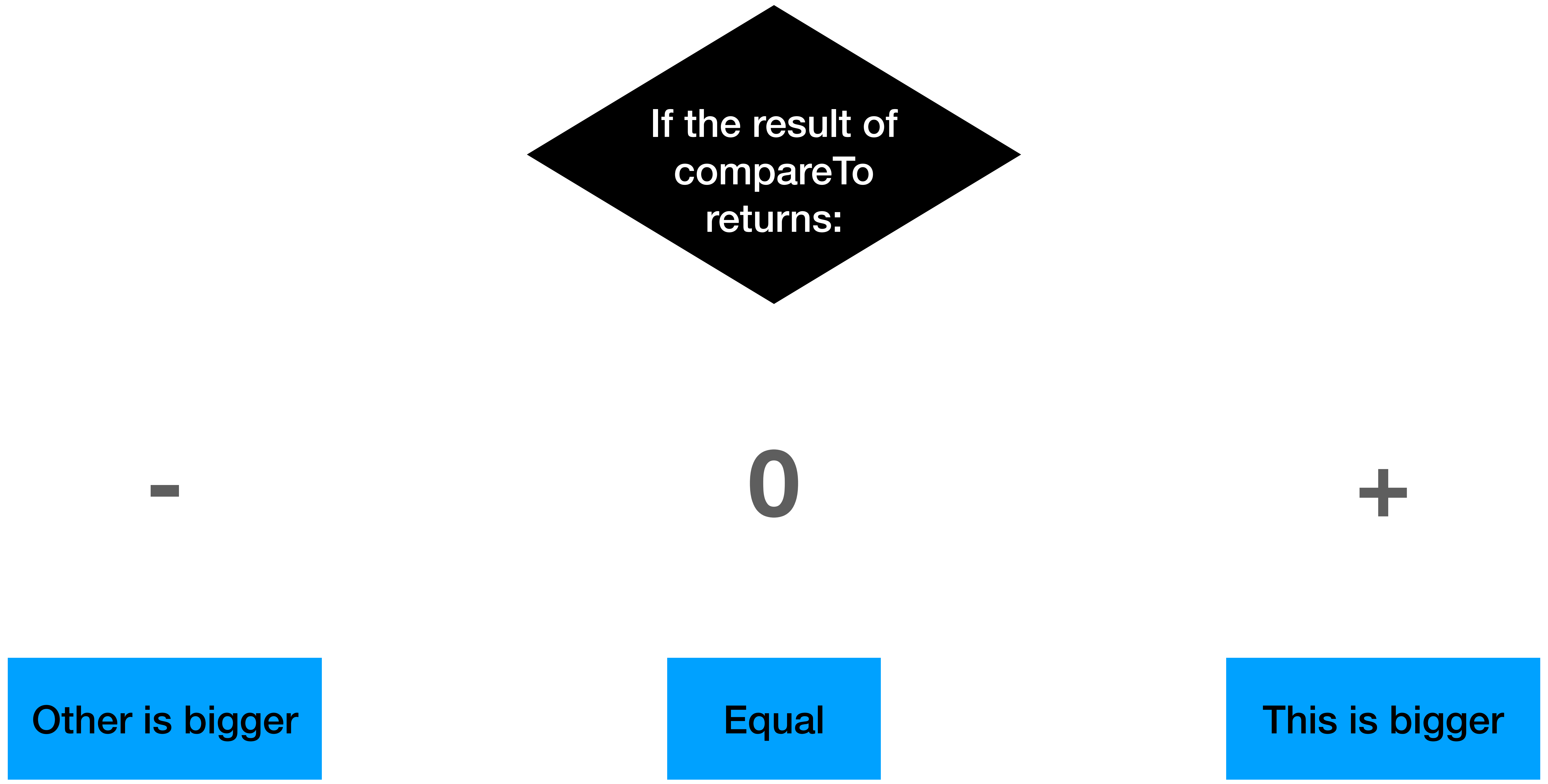
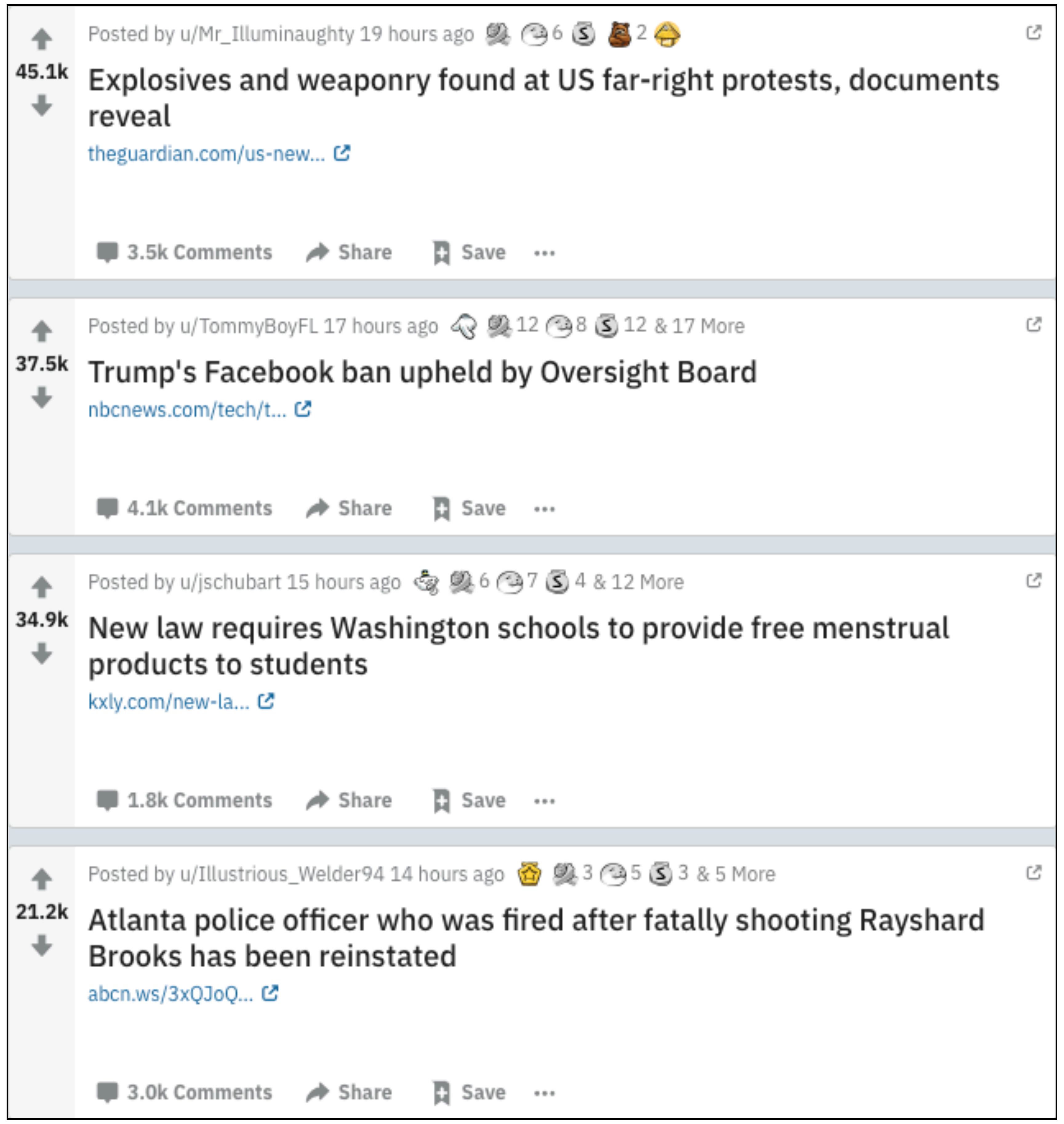


If the result of compareTo returns:
-
0
+
Other is bigger
Equal
This is bigger

“A non programming analogy for an interface is a professional certification. It’s possible for a person to become certified as a teacher, nurse, accountant, or doctor. To do this, the person must demonstrate certain abilities required of members of those professions”

Reges, Stepp, Building Java Programs - Chapter 9 P. 653

Comparable example: RedditPost



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Exercises: Comparable