

SORTING

SORTING

- **Selection sort**
- **Exchange (Exchange) sort**
- **Insertion sort**
- **Shell sort**
- **Radix sort**

SELECTION SORT

- **LOGIC**

- **Array is considered into two parts**
 - **Unsorted and Sorted**
 - **Initially whole array is unsorted**

SELECTION SORT

- **SELECTION**

- Select the lowest element in the unsorted array

- **SWAPPING**

- Bring it to the starting position

- **COUNTER SHIFT**

- Change the counter for unsorted array

LOGIC

64

25

12

22

11

SELECTION

SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

64

25

12

22

11

SELECTION

64

SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

64

25

12

22

11

SELECTION

64

SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

64

25

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22

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SELECTION

25

SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

64

25

12

22

11

SELECTION

25

SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

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SELECTION

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SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

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SELECTION

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SWAPPING

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SELECTION SORT

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SELECTION

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SWAPPING

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SHIFT**

SELECTION SORT

LOGIC

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SELECTION

12

SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

64

25

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22

11

SELECTION

11

SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

64	25	12	22	11
----	----	----	----	----

SELECTION



SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

11	25	12	22	64
----	----	----	----	----

SELECTION



SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

11

25

12

22

64

SELECTION

SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

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25

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22

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SELECTION

25

SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC



SELECTION



SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

11	25	12	22	64
----	----	----	----	----

SELECTION

12

SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC



SELECTION



SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

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22

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SELECTION

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SWAPPING

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SELECTION SORT

LOGIC

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25

12

22

64

SELECTION

12

SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

11	25	12	22	64
----	----	----	----	----

SELECTION



SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

11	12	25	22	64
----	----	----	----	----

SELECTION



SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

11	12	25	22	64
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SELECTION

SWAPPING

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LOGIC

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SELECTION

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SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

11	12	25	22	64
----	----	----	----	----

SELECTION



SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

LOGIC

11	12	22	25	64
----	----	----	----	----

SELECTION



SWAPPING

**COUNTER
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SELECTION SORT

LOGIC

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12

22

25

64

SELECTION

SWAPPING

**COUNTER
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SELECTION SORT

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SELECTION

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SWAPPING

**COUNTER
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SELECTION SORT

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SELECTION

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SELECTION

SWAPPING

**COUNTER
SHIFT**

SELECTION SORT

EXCHANGE SORT

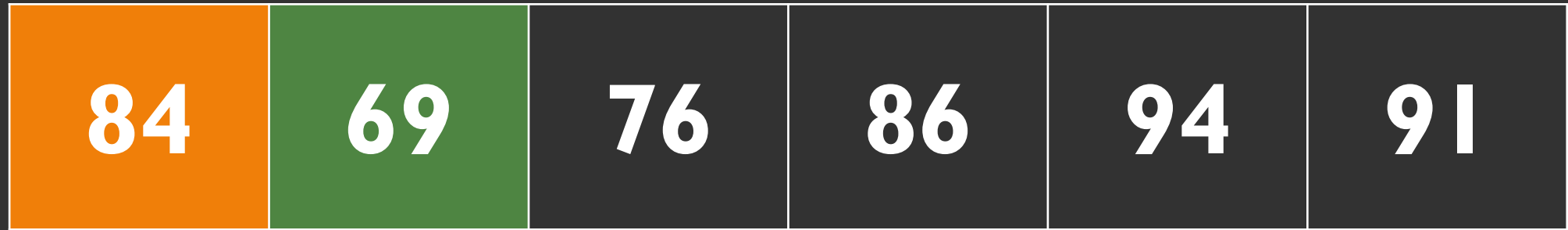
- Similar to its cousin, the **bubble sort**, in that it **compares** elements of the array and **swaps** those that are out of order.
- **Compares** the **first element** with each following element of the array, making any necessary swaps.

84	69	76	86	94	91
----	----	----	----	----	----

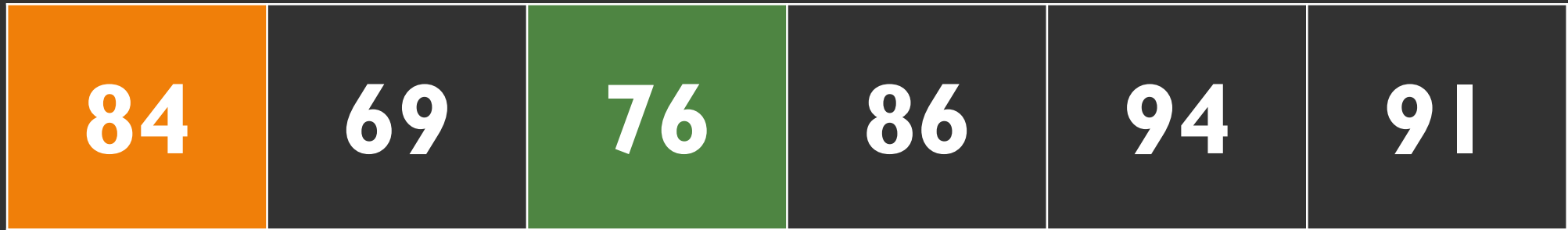
EXCHANGE SORT: DESCENDING

84	69	76	86	94	91
----	----	----	----	----	----

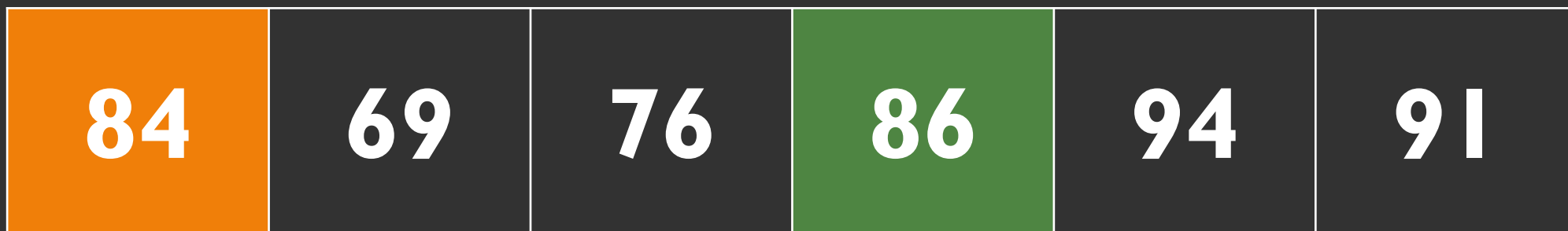
EXCHANGE SORT: DESCENDING



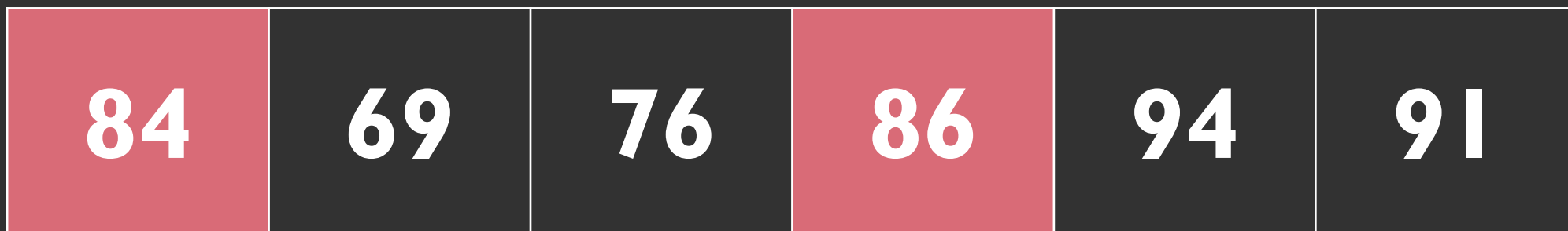
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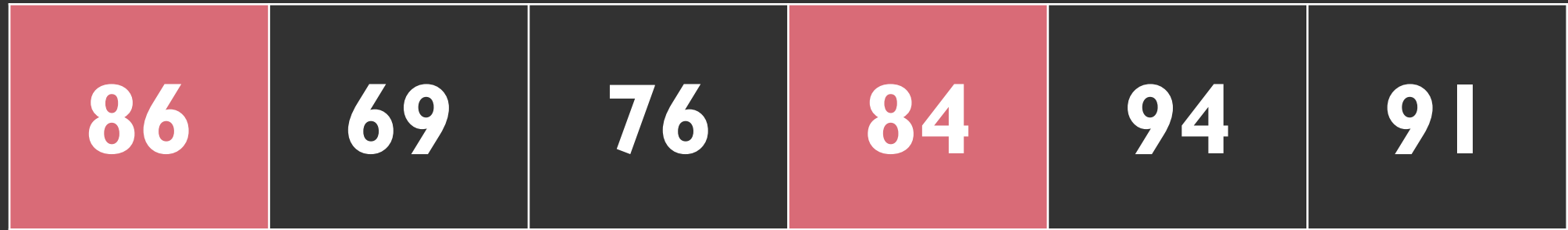
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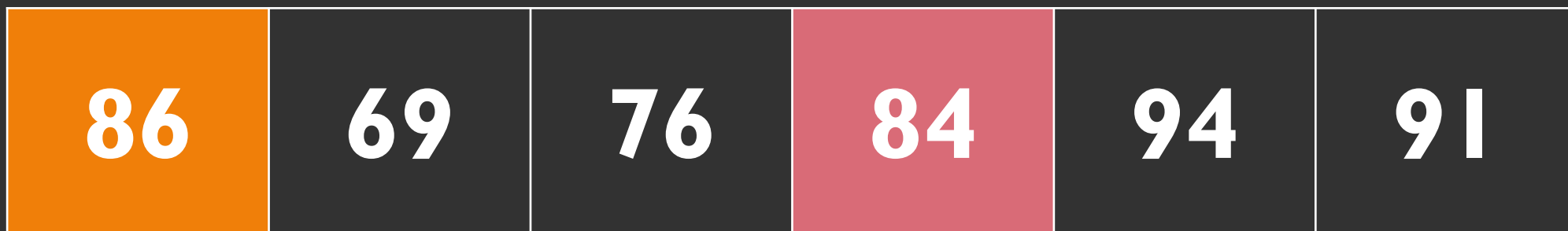
EXCHANGE SORT: DESCENDING



EXCHANGE SORT: DESCENDING



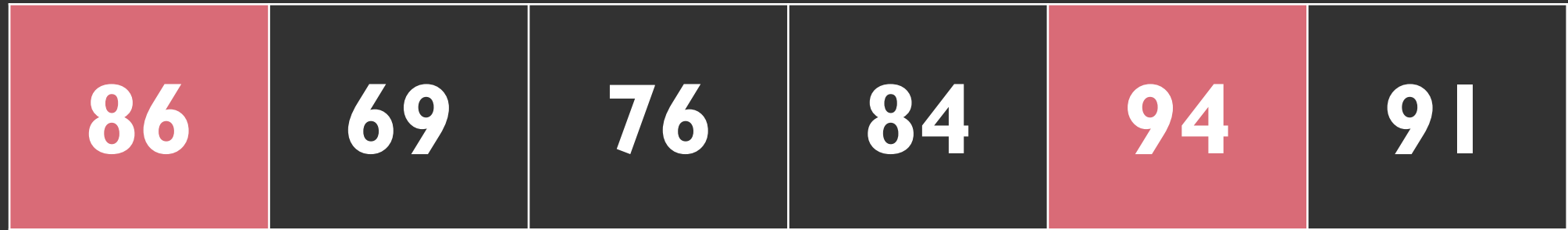
EXCHANGE SORT: DESCENDING



EXCHANGE SORT: DESCENDING



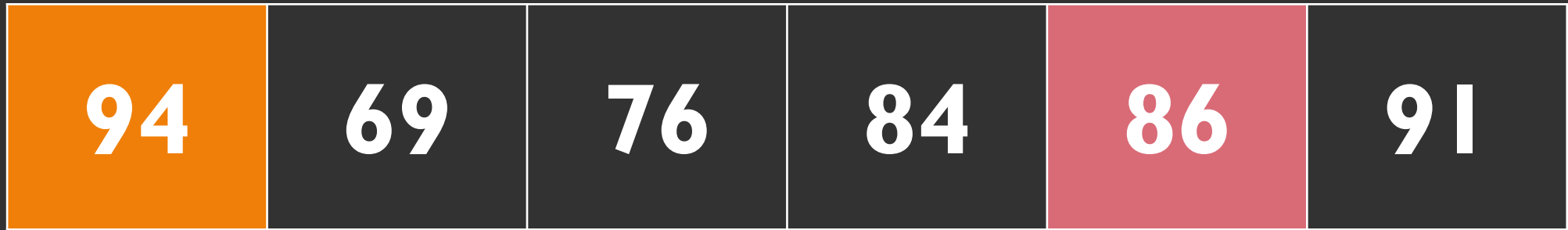
EXCHANGE SORT: DESCENDING



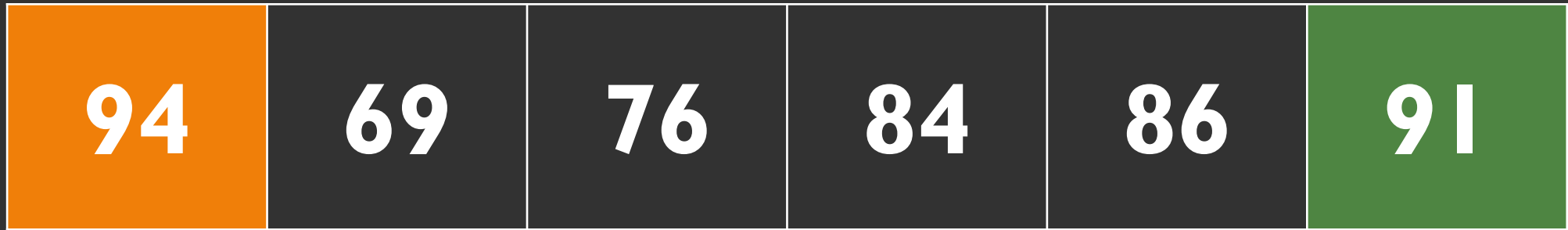
EXCHANGE SORT: DESCENDING



EXCHANGE SORT: DESCENDING



EXCHANGE SORT: DESCENDING



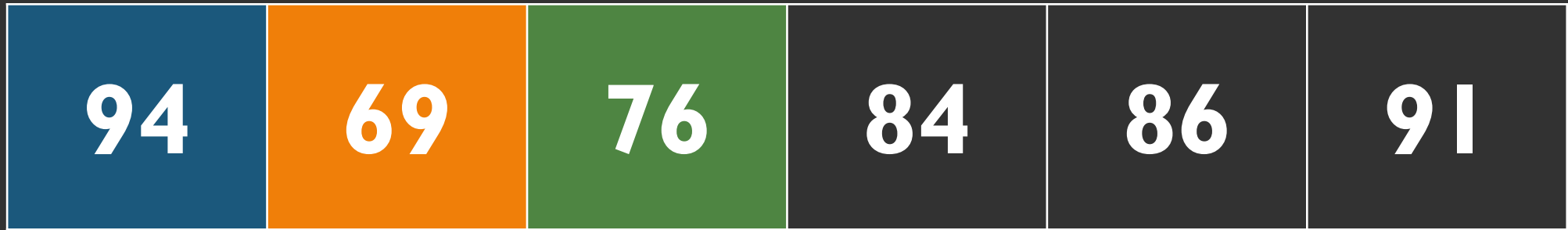
EXCHANGE SORT: DESCENDING

94	69	76	84	86	91
----	----	----	----	----	----

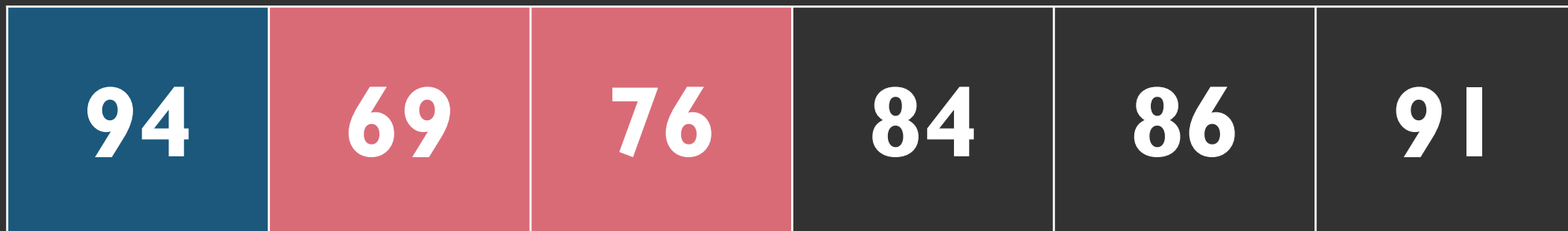
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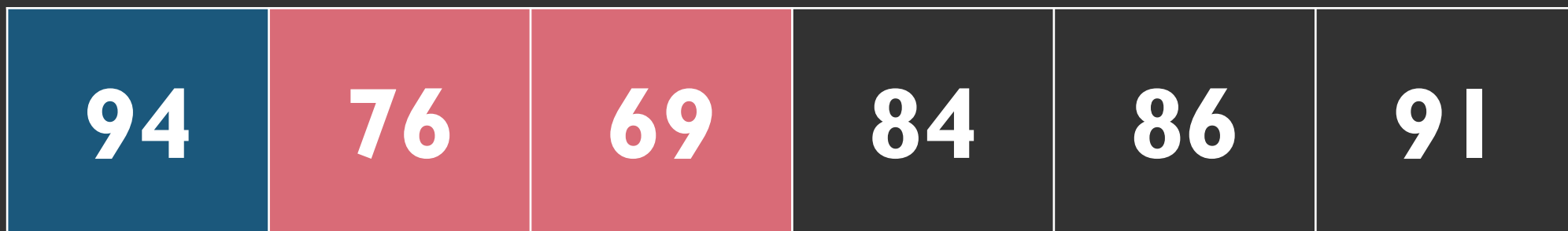
EXCHANGE SORT: DESCENDING



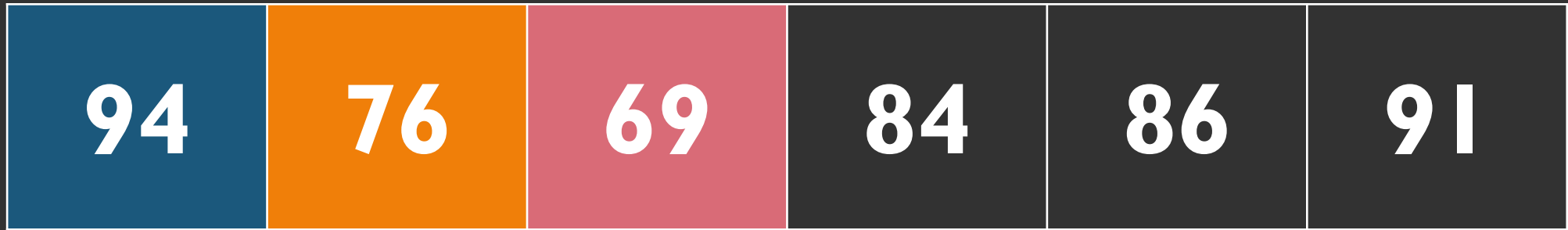
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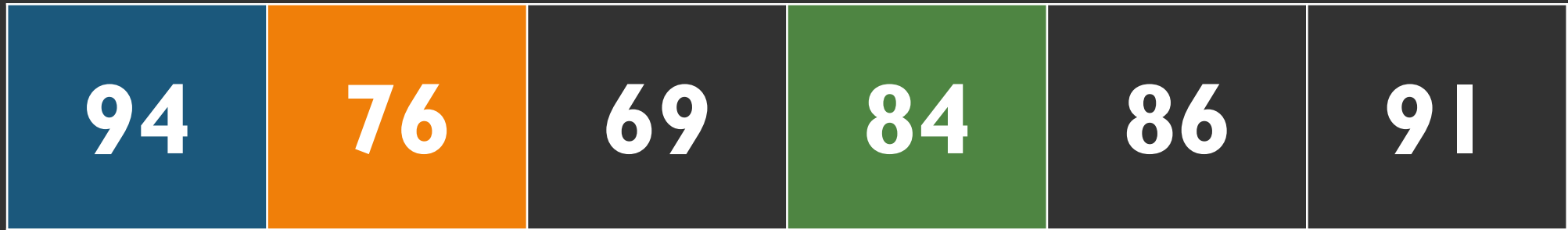
EXCHANGE SORT: DESCENDING



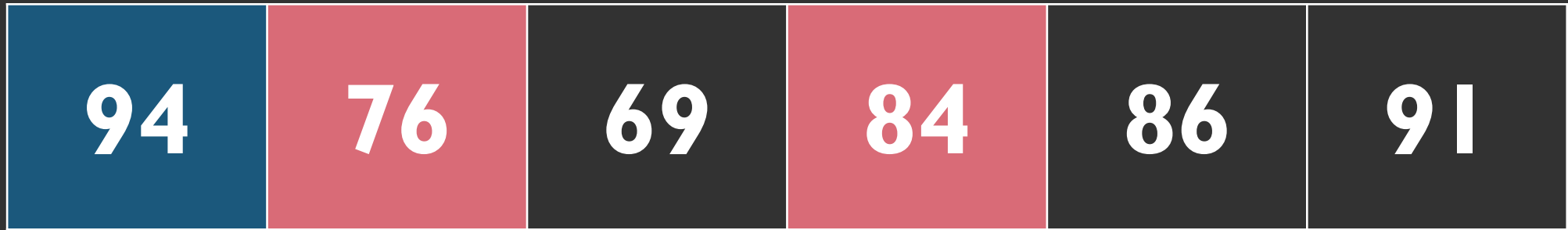
EXCHANGE SORT: DESCENDING



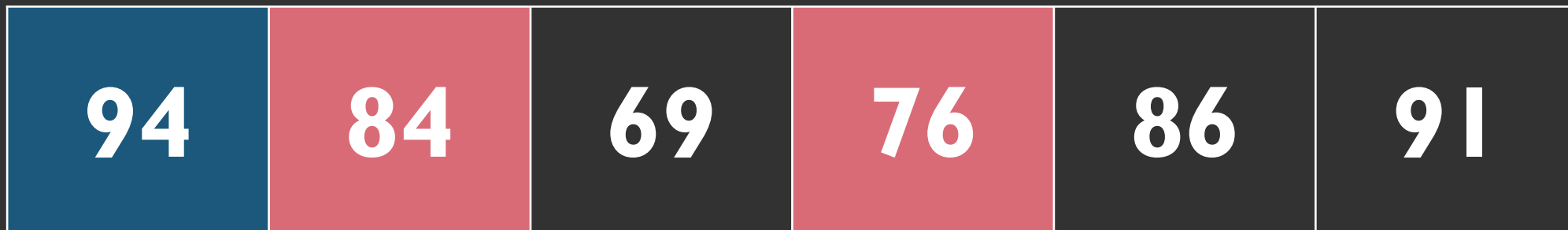
EXCHANGE SORT: DESCENDING



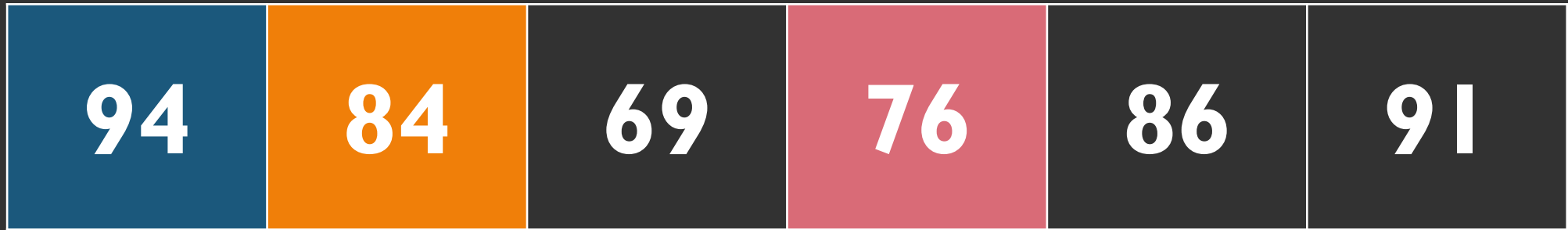
EXCHANGE SORT: DESCENDING



EXCHANGE SORT: DESCENDING



EXCHANGE SORT: DESCENDING



EXCHANGE SORT: DESCENDING



EXCHANGE SORT: DESCENDING



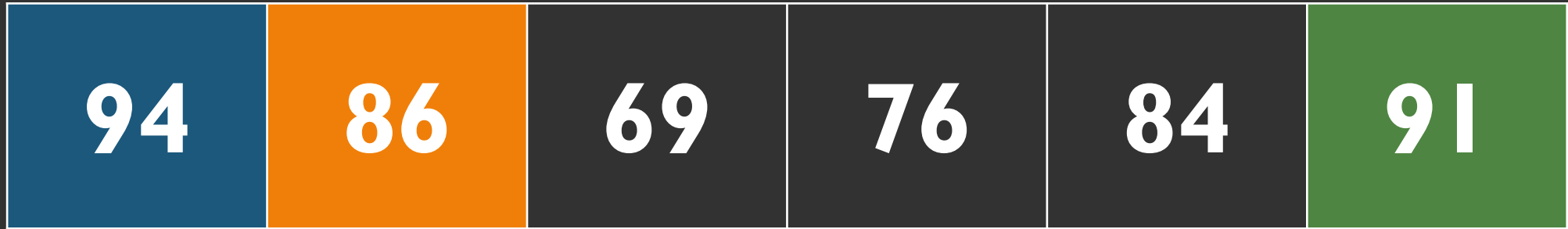
EXCHANGE SORT: DESCENDING



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EXCHANGE SORT: DESCENDING



EXCHANGE SORT: DESCENDING



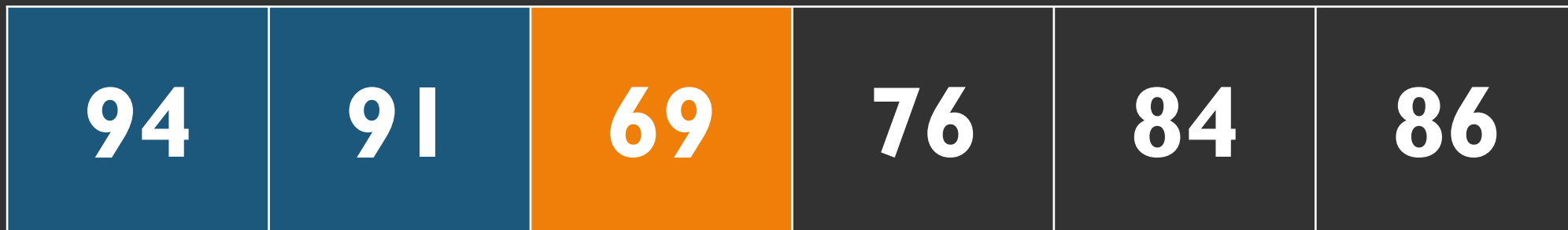
EXCHANGE SORT: DESCENDING



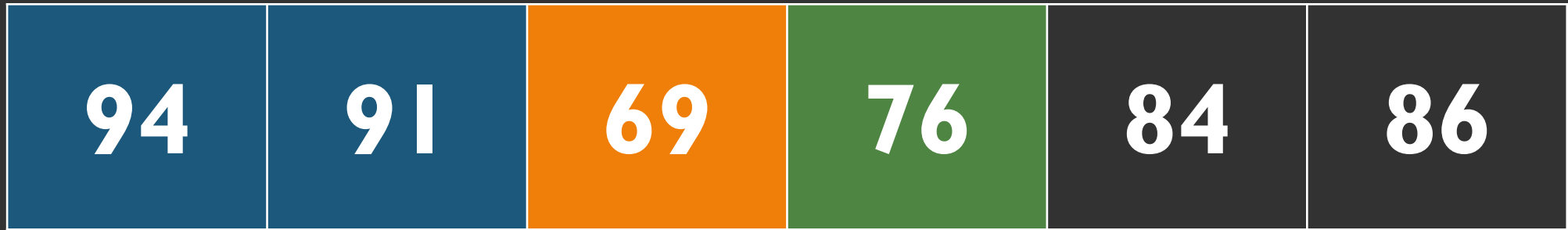
EXCHANGE SORT: DESCENDING

94	91	69	76	84	86
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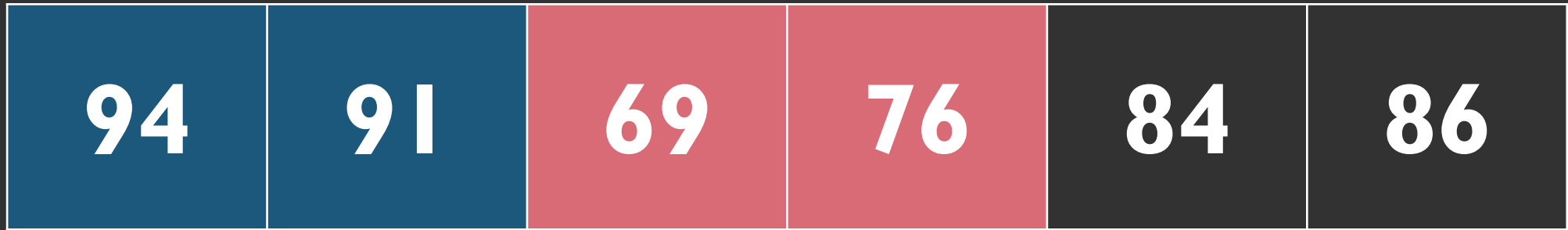
EXCHANGE SORT: DESCENDING



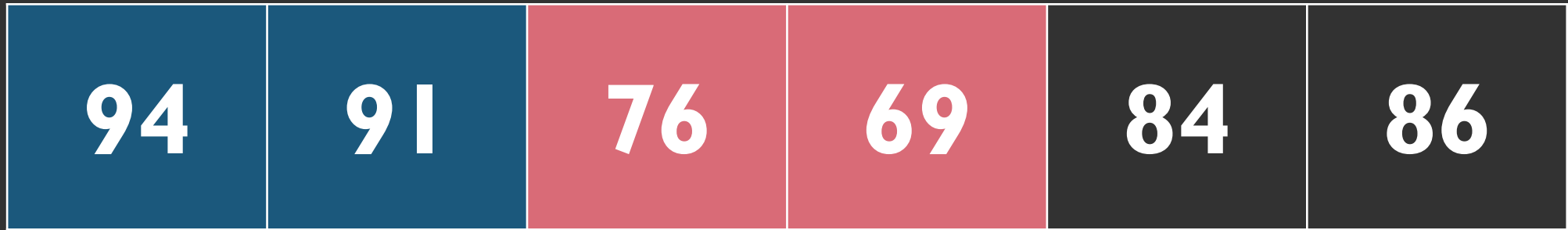
EXCHANGE SORT: DESCENDING



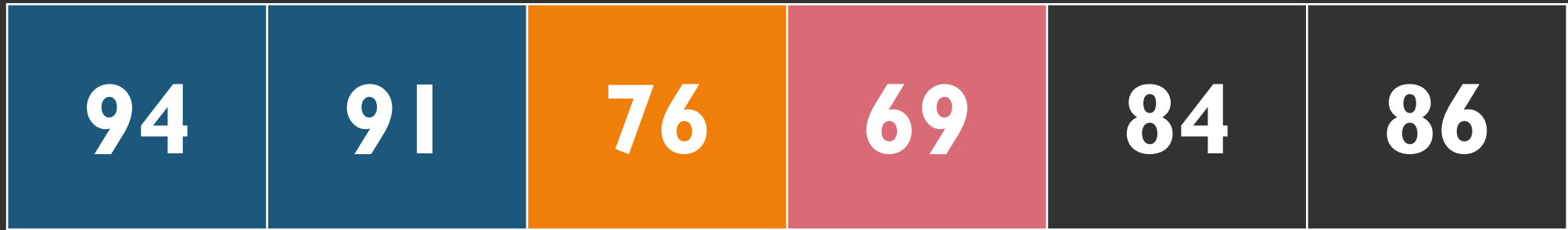
EXCHANGE SORT: DESCENDING



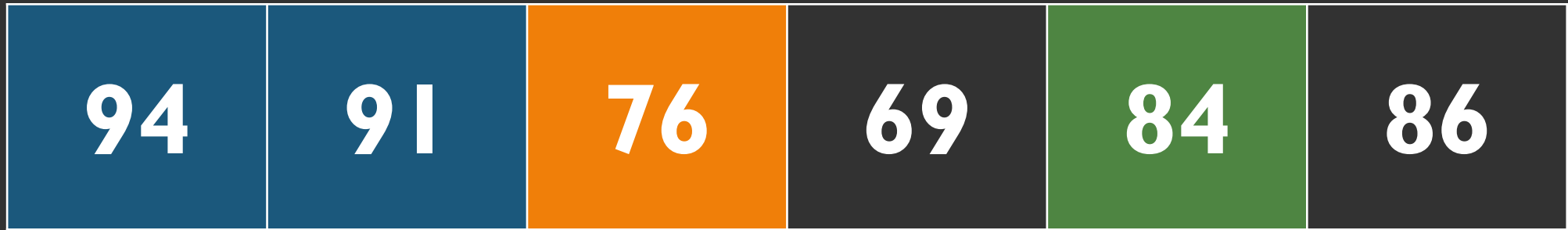
EXCHANGE SORT: DESCENDING



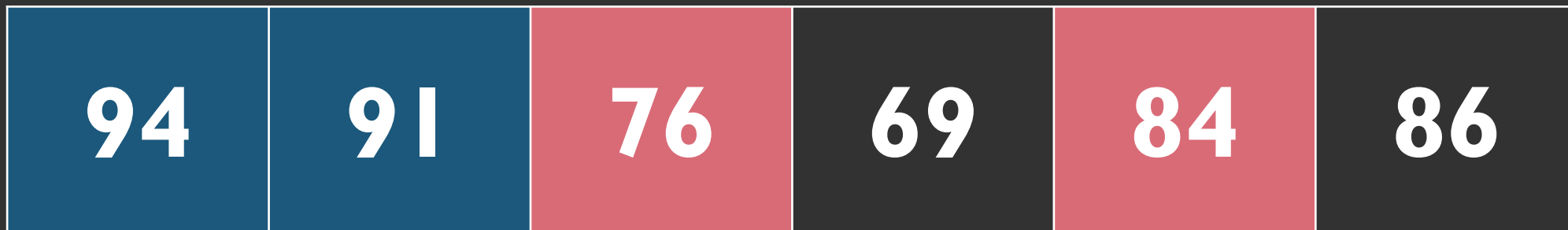
EXCHANGE SORT: DESCENDING



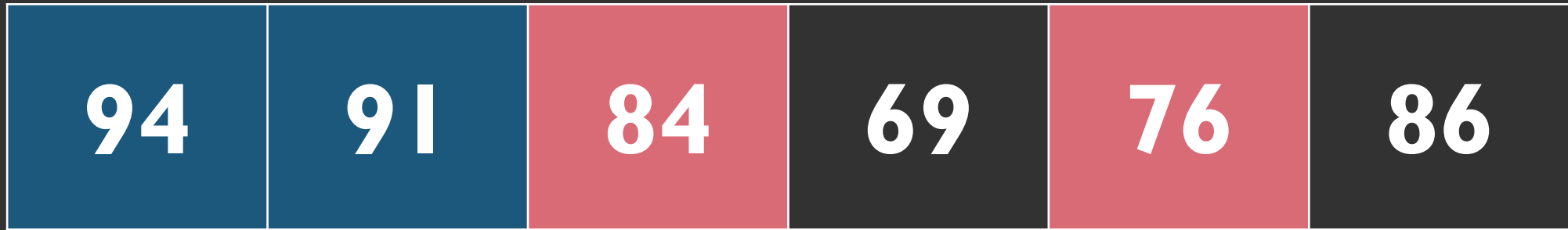
EXCHANGE SORT: DESCENDING



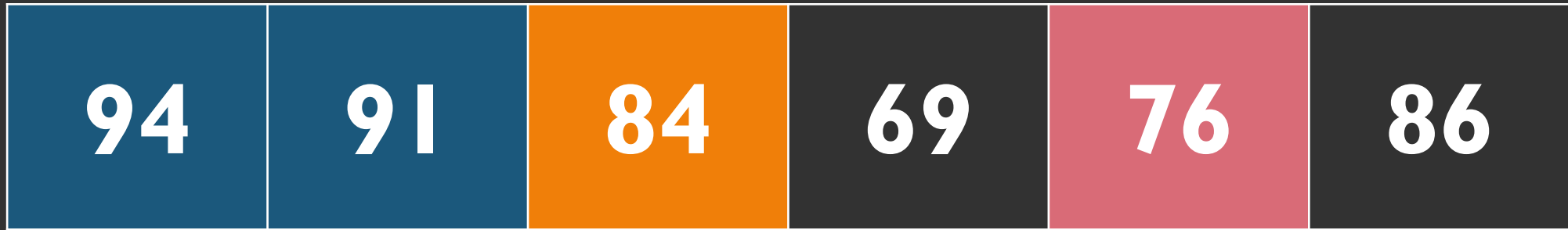
EXCHANGE SORT: DESCENDING



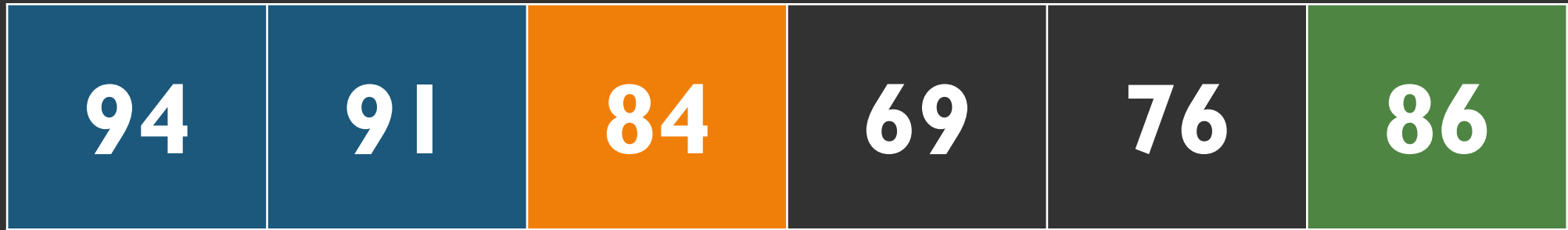
EXCHANGE SORT: DESCENDING



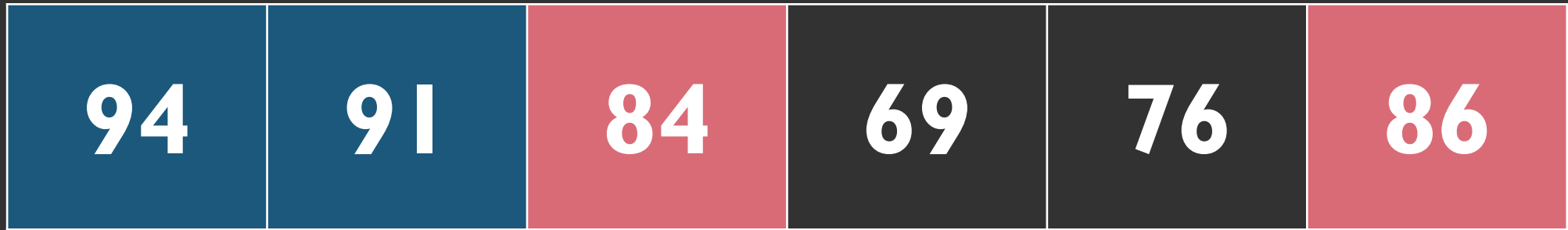
EXCHANGE SORT: DESCENDING



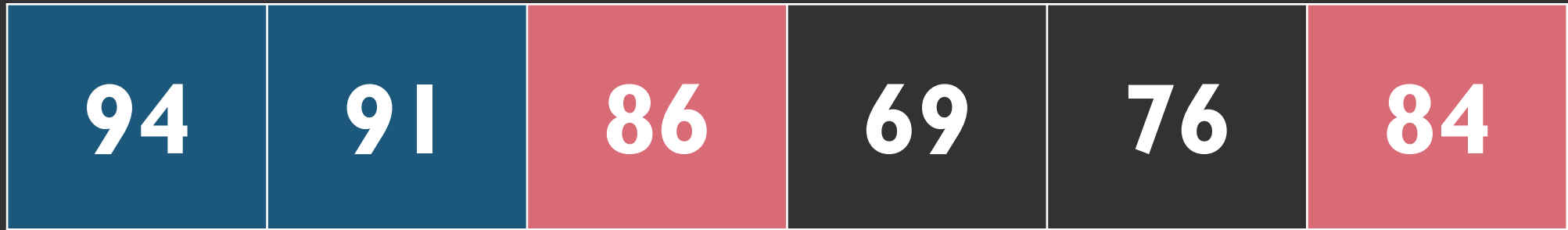
EXCHANGE SORT: DESCENDING



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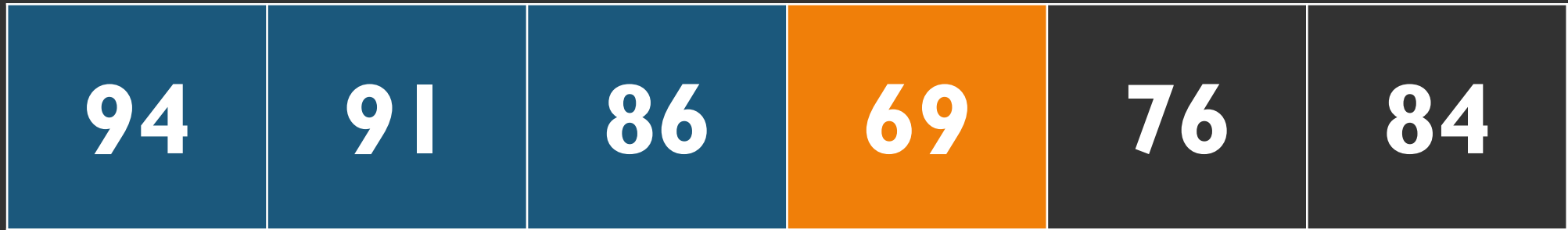
EXCHANGE SORT: DESCENDING



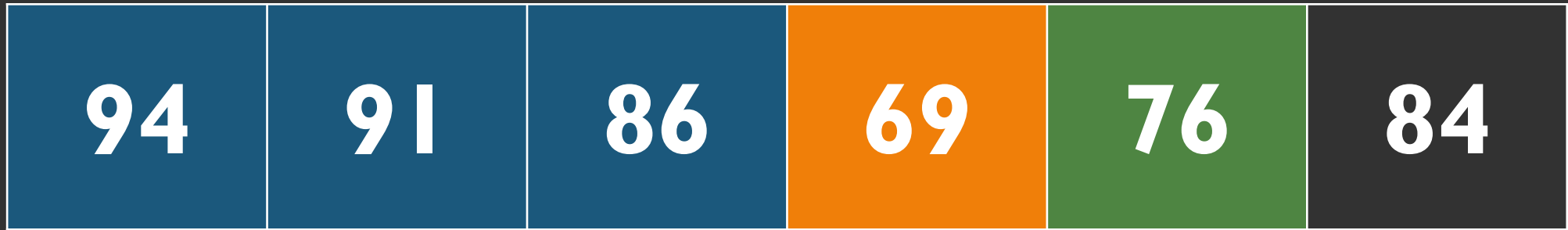
EXCHANGE SORT: DESCENDING

94	91	86	69	76	84
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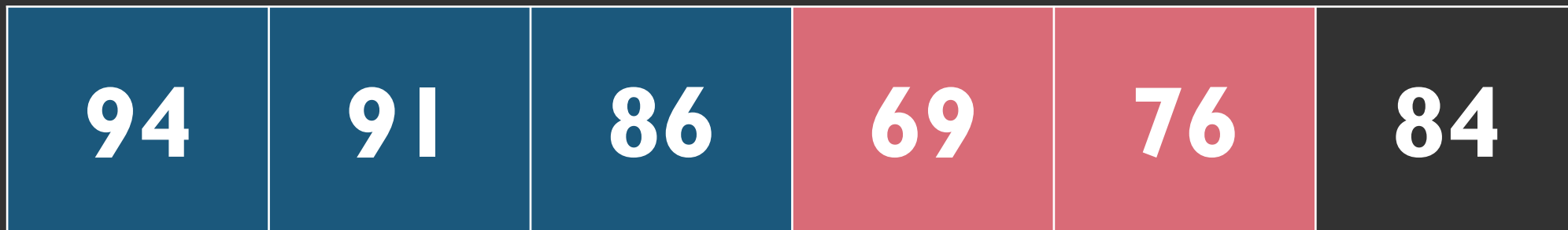
EXCHANGE SORT: DESCENDING



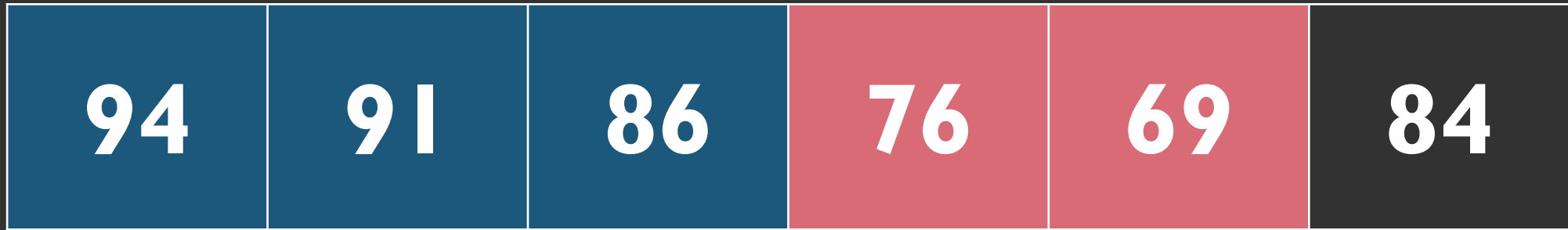
EXCHANGE SORT: DESCENDING



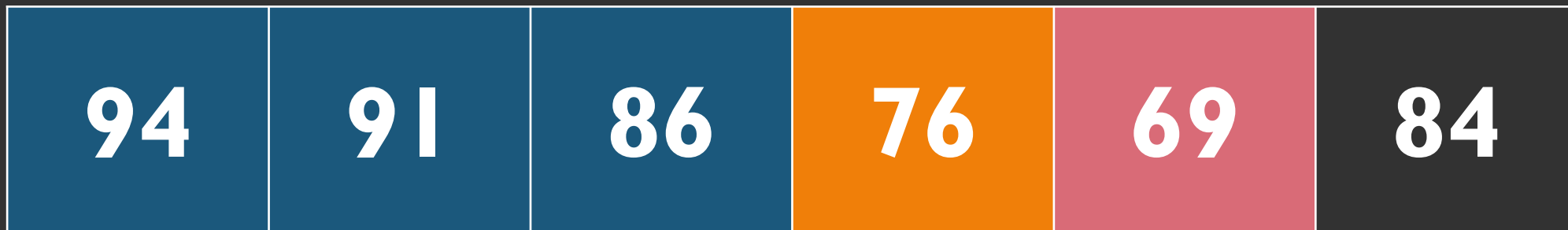
EXCHANGE SORT: DESCENDING



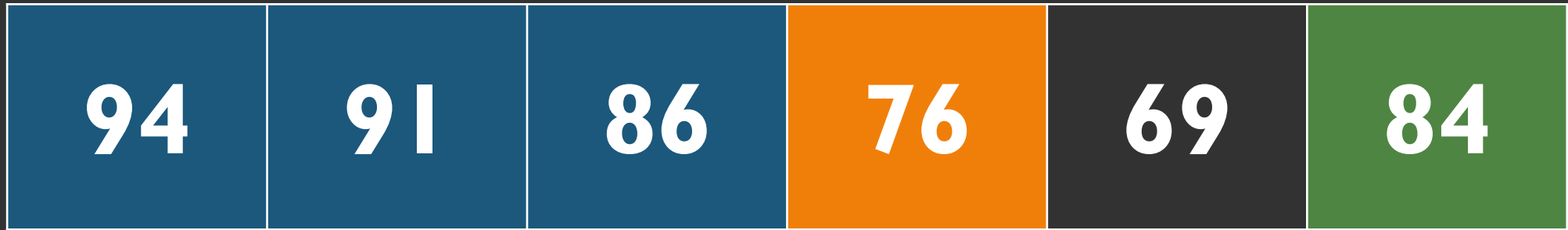
EXCHANGE SORT: DESCENDING



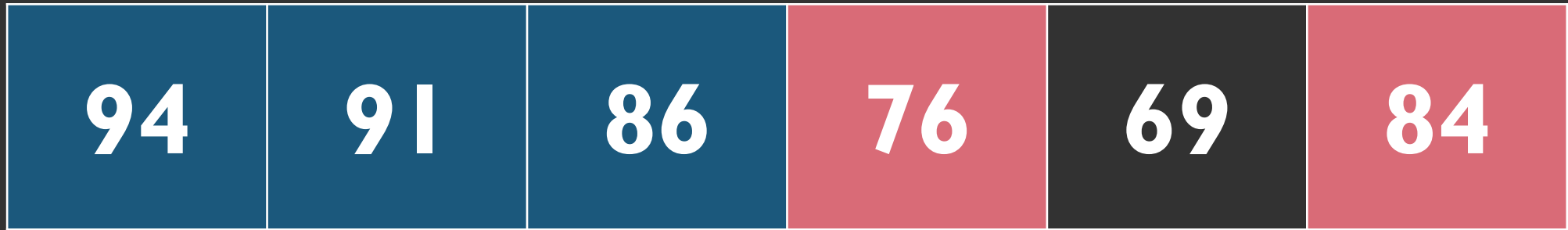
EXCHANGE SORT: DESCENDING



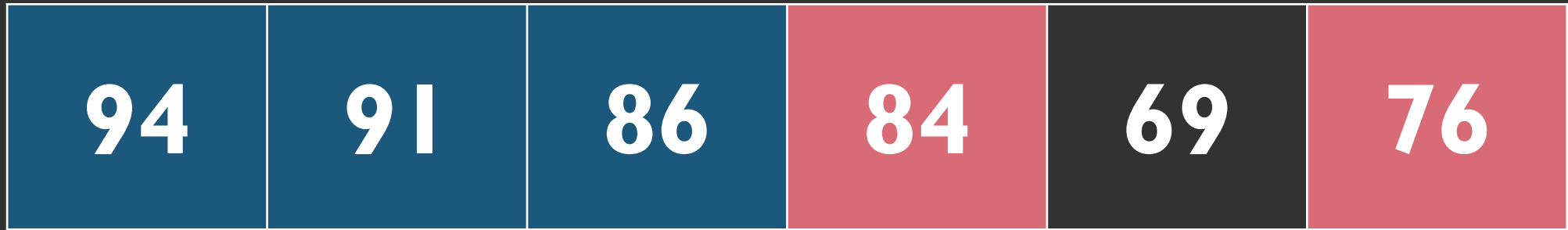
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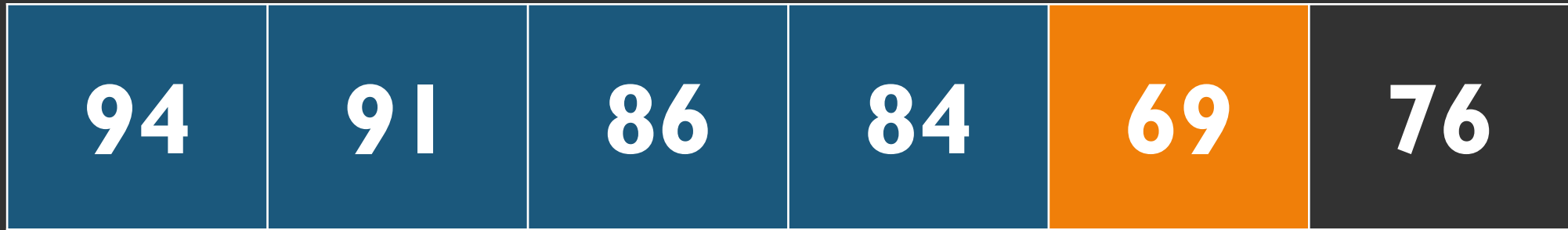
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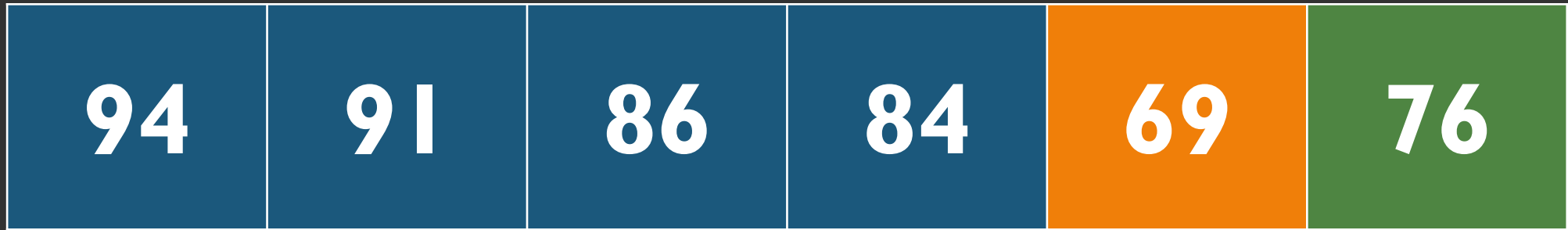
EXCHANGE SORT: DESCENDING

94	91	86	84	69	76
----	----	----	----	----	----

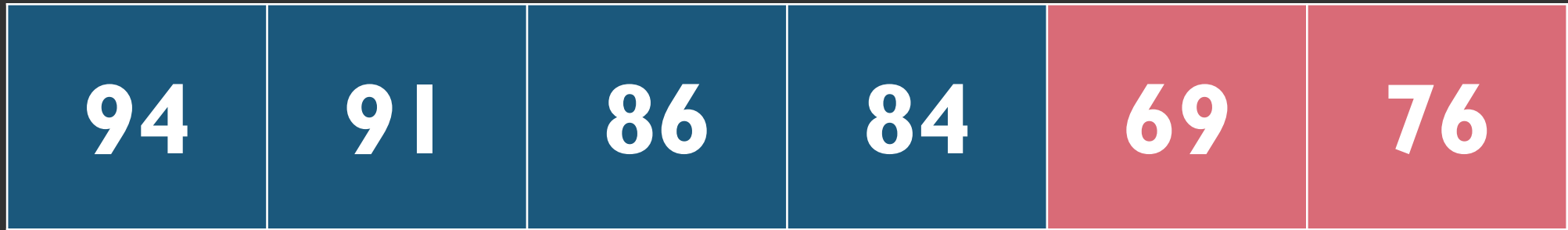
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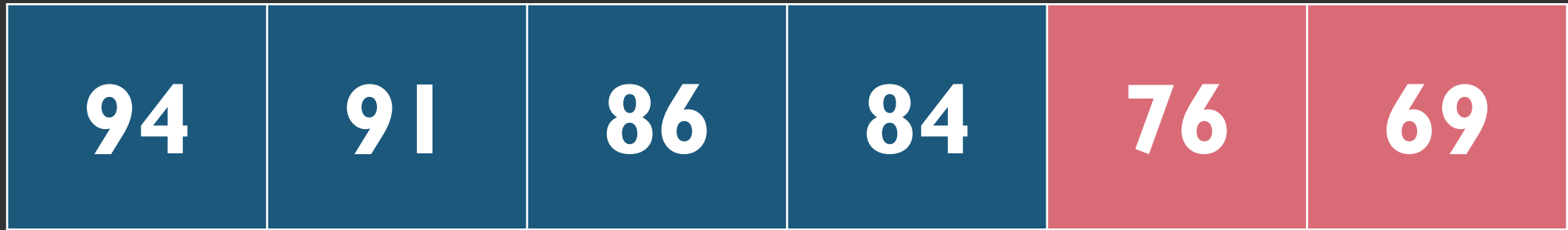
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EXCHANGE SORT: DESCENDING

94	91	86	84	76	69
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EXCHANGE SORT: DESCENDING

INSERTION SORT

- 1. Set a marker for the sorted section after the first element**
- 2. Repeat the following until sorted section is empty**
 - 1. Select the first unsorted element**
 - 2. Swap other elements to the right to create the correct position and shift the unsorted element.**
 - 3. Advance the marker to the right one element**



- 1. Select the first unsorted element**
- 2. Swap other elements to the right to create the correct position and shift the unsorted element.**
- 3. Advance the marker to the right one element**

INSERTION SORT



1. **Select the first unsorted element**
2. **Swap other elements to the right to create the correct position and shift the unsorted element.**
3. **Advance the marker to the right one element**

INSERTION SORT



1. Select the first unsorted element
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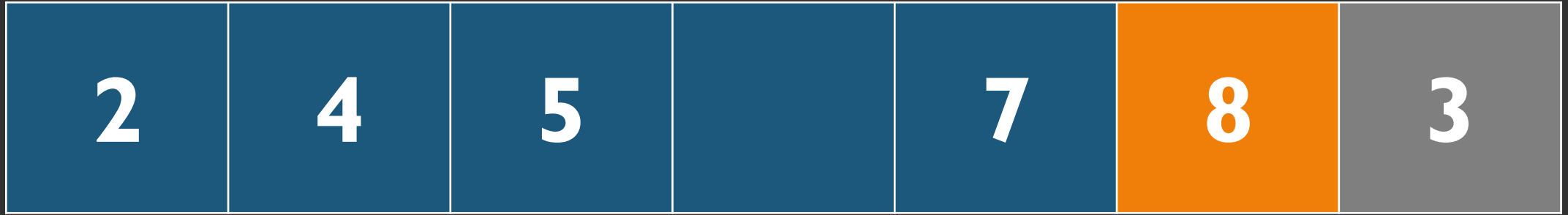
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3. Advance the marker to the right one element

INSERTION SORT



1. Select the first unsorted element
2. Swap other elements to the right to create the correct position and shift the unsorted element.
3. Advance the marker to the right one element

INSERTION SORT



1. **Select the first unsorted element**
2. **Swap other elements to the right to create the correct position and shift the unsorted element.**
3. **Advance the marker to the right one element**

INSERTION SORT



1. Select the first unsorted element
2. Swap other elements to the right to create the correct position and shift the unsorted element.
3. Advance the marker to the right one element



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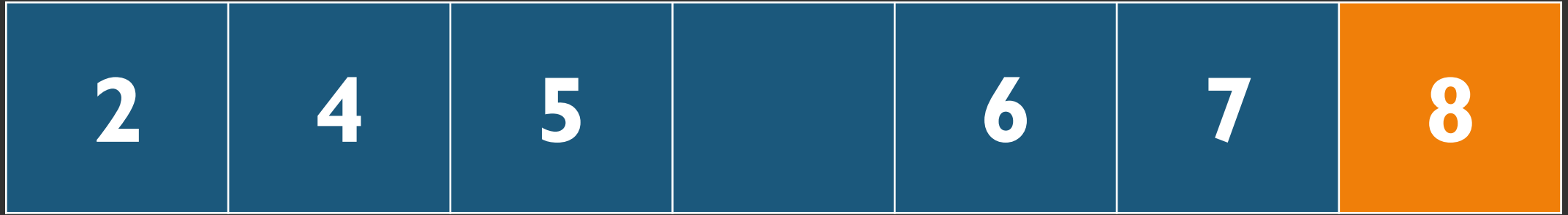
INSERTION SORT



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INSERTION SORT



1. Select the first unsorted element
2. Swap other elements to the right to create the correct position and shift the unsorted element.
3. Advance the marker to the right one element

INSERTION SORT

2	3	4	5	6	7	8
---	---	---	---	---	---	---

1. Select the first unsorted element
2. Swap other elements to the right to create the correct position and shift the unsorted element.
3. Advance the marker to the right one element

INSERTION SORT



- 1. Select the first unsorted element**
- 2. Swap other elements to the right to create the correct position and shift the unsorted element.**
- 3. Advance the marker to the right one element**

INSERTION SORT

RADIX SORT

- Only used to **sort numbers**
- Sort numbers from the **least** significant digit to **most** significant digit
- Use **counting sort** as subroutine to sort

170	45	75	90	802	24	2	66
------------	-----------	-----------	-----------	------------	-----------	----------	-----------

RADIX SORT

170	45	75	90	802	24	2	66
------------	-----------	-----------	-----------	------------	-----------	----------	-----------

First consider the ones place

RADIX SORT

170	45	75	90	802	24	2	66
-----	----	----	----	-----	----	---	----

First consider the one's place

RADIX SORT

170	90	802	2	24	45	75	66
-----	----	-----	---	----	----	----	----

Observe that 170 has come before 90...

This is because it appeared before in the original list

RADIX SORT

170	90	802	2	24	45	75	66
------------	-----------	------------	----------	-----------	-----------	-----------	-----------

Now consider the tens place

RADIX SORT

170	90	802	_2	24	45	75	66
-----	----	-----	----	----	----	----	----

Now consider the tens place

RADIX SORT

802	2	24	45	66	170	75	90
-----	---	----	----	----	-----	----	----

Now consider the hundreds place

RADIX SORT

802	_ _ 2	_ 24	_ 45	_ 66	 70	_ 75	_ 90
------------	--------------	-------------	-------------	-------------	-------------	-------------	-------------

Now consider the hundreds place

RADIX SORT

2	24	45	66	75	90	170	802
----------	-----------	-----------	-----------	-----------	-----------	------------	------------

Array is now sorted!

RADIX SORT

SHELL SORT

- mainly a variation of **Insertion Sort**
- allow exchange of **far** items
- compare elements that are distance apart rather than adjacent
- calculate “gap” for each pass, and then select the elements towards the right of gap
- reduce the gap by dividing it by 2

7	8	5	2	4	6	3
---	---	---	---	---	---	---

SHELL SORT

$n = 7$

7	8	5	2	4	6	3
---	---	---	---	---	---	---

SHELL SORT

$$k = n/2$$

$$n = 7$$

7	8	5	2	4	6	3
---	---	---	---	---	---	---

SHELL SORT

$$k = n/2$$

$$n = 7$$

7	8	5	2	4	6	3
---	---	---	---	---	---	---

$$k = 3$$

SHELL SORT

$n = 7$



$k = 3$

SHELL SORT

$n = 7$



$k = 3$

SHELL SORT

$n = 7$



$k = 3$

SHELL SORT

$n = 7$



$k = 3$

SHELL SORT

$n = 7$



$k = 3$

SHELL SORT

$n = 7$



$k = 3$

SHELL SORT

$n = 7$



$k = 3$

SHELL SORT

n = 7



k = 3

SHELL SORT

$n = 7$



$k = 3$

SHELL SORT

$n = 7$



$k = 3$

SHELL SORT

$n = 7$

2	4	5	3	8	6	7
---	---	---	---	---	---	---

$k = 3$

SHELL SORT

$$k = k/2$$

$$n = 7$$

2	4	5	3	8	6	7
---	---	---	---	---	---	---

$$k = 3$$

SHELL SORT

$$k = k/2$$

$$n = 7$$

2	4	5	3	8	6	7
---	---	---	---	---	---	---

$$k = 1$$

SHELL SORT

$$k = k/2$$

$$n = 7$$

2	4	5	3	8	6	7
---	---	---	---	---	---	---

$$k = 1$$

SHELL SORT

$$k = k/2$$

$$n = 7$$

2	4	5	3	8	6	7
---	---	---	---	---	---	---

$$k = 1$$

SHELL SORT

$k = k/2$

$n = 7$

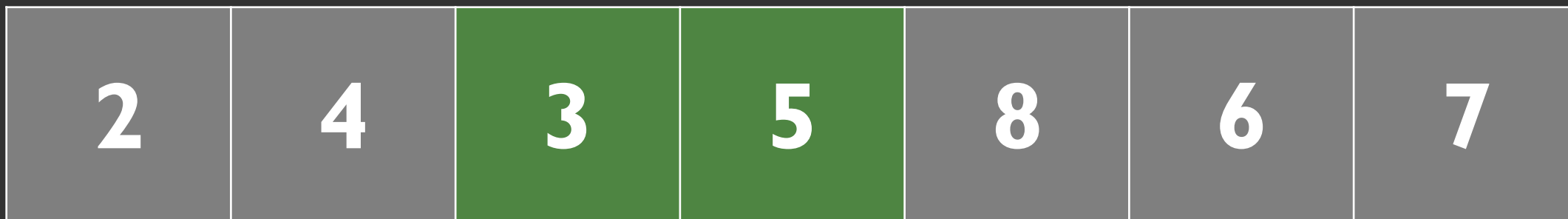
2	4	5	3	8	6	7
---	---	---	---	---	---	---

$k = 1$

SHELL SORT

$k = k/2$

$n = 7$



$k = 1$

SHELL SORT

$$k = k/2$$

$$n = 7$$

2	4	3	5	8	6	7
---	---	---	---	---	---	---

$$k = 1$$

SHELL SORT

$k = k/2$

$n = 7$



$k = 1$

SHELL SORT

$$k = k/2$$

$$n = 7$$

2	4	3	5	6	8	7
---	---	---	---	---	---	---

$$k = 1$$

SHELL SORT

$$k = k/2$$

$$n = 7$$

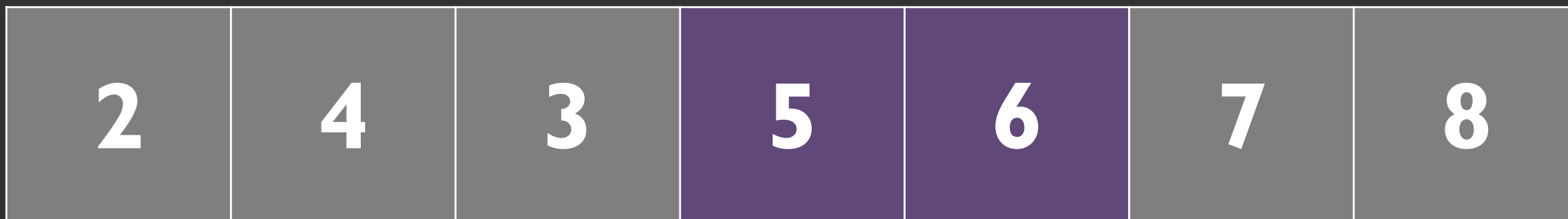
2	4	3	5	6	7	8
---	---	---	---	---	---	---

$$k = 1$$

SHELL SORT

$k = k/2$

$n = 7$



$k = 1$

SHELL SORT

$k = k/2$

$n = 7$



$k = 1$

SHELL SORT

$$k = k/2$$

$$n = 7$$

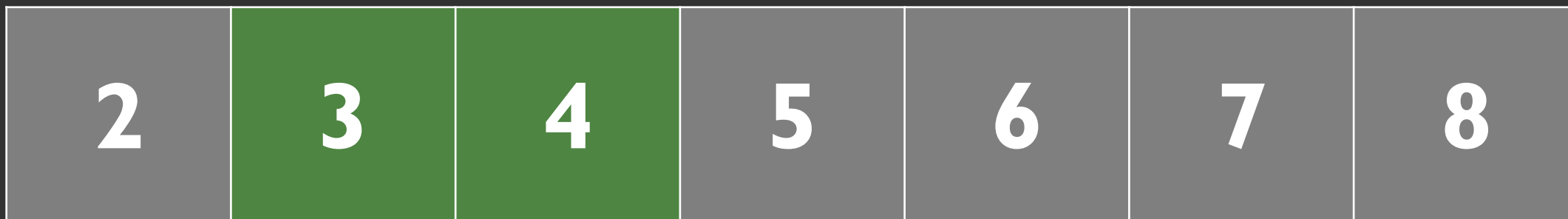
2	4	3	5	6	7	8
---	---	---	---	---	---	---

$$k = 1$$

SHELL SORT

$k = k/2$

$n = 7$



$k = 1$

SHELL SORT

$$k = k/2$$

$$n = 7$$

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SHELL SORT

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SHELL SORT

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---	---	---	---	---	---	---

$$k = 1$$

SHELL SORT

2	3	4	5	6	7	8
---	---	---	---	---	---	---

SHELL SORT

SORTING TIME COMPLEXITY

SORTING ALGORITHM	BEST CASE	AVERAGE CASE	WORST CASE
Selection Sort	$\Omega(n^2)$	$\theta(n^2)$	$O(n^2)$
Exchange (Bubble) Sort	$\Omega(n)$	$\theta(n^2)$	$O(n^2)$
Insertion Sort	$\Omega(n)$	$\theta(n^2)$	$O(n^2)$
Shell Sort	$\Omega(n \cdot \log n)$	$\theta(n \cdot \log n)$	$O(n^2)$
Radix Sort	$\Omega(nk)$	$\theta(nk)$	$O(nk)$