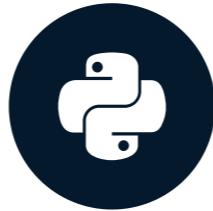


Bubble sort

DATA STRUCTURES AND ALGORITHMS IN PYTHON

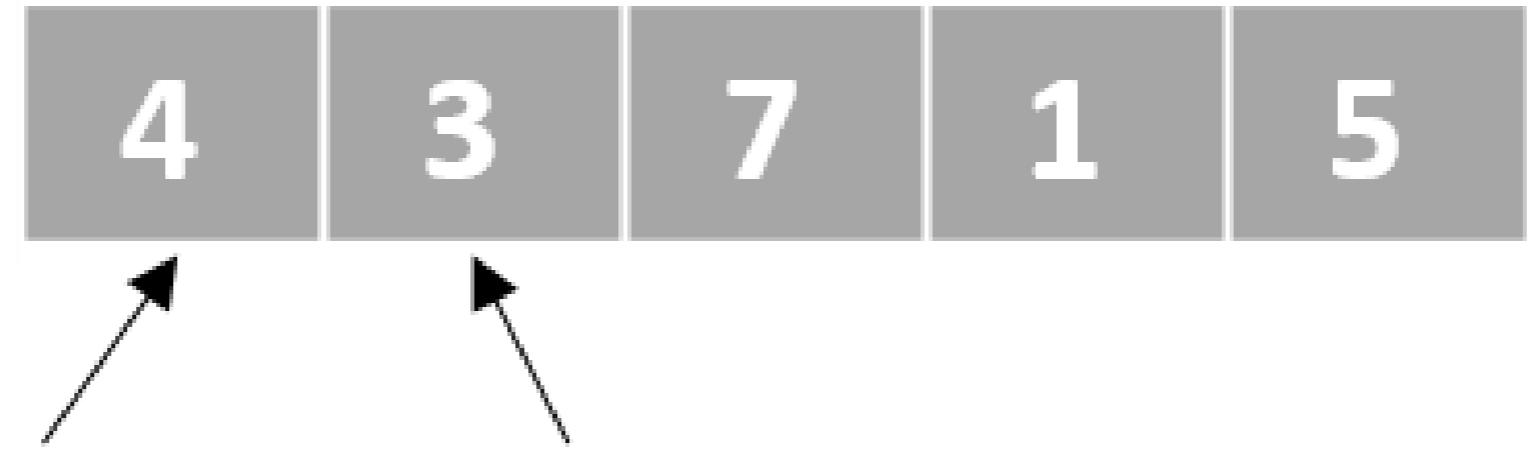


Miriam Antona
Software engineer

Sorting algorithms

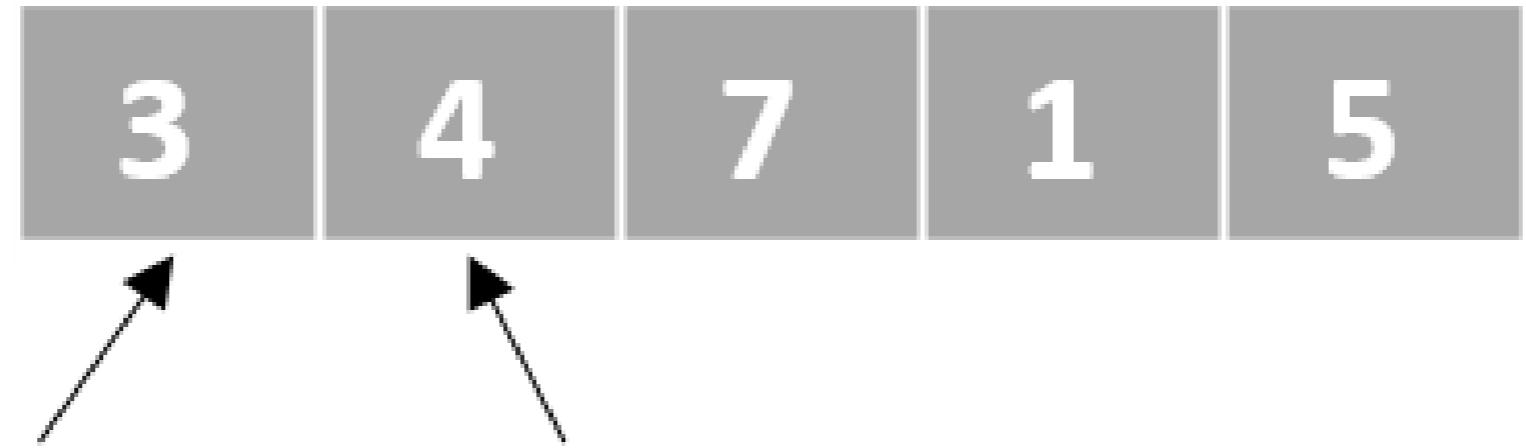
- Deeply studied
- Solve how to **sort** an **unsorted collection** in **ascending/descending** order
- Can **reduce complexity** of problems
- Some sorting algorithms:
 - bubble sort
 - selection sort
 - insertion sort
 - merge sort
 - quicksort

Bubble sort



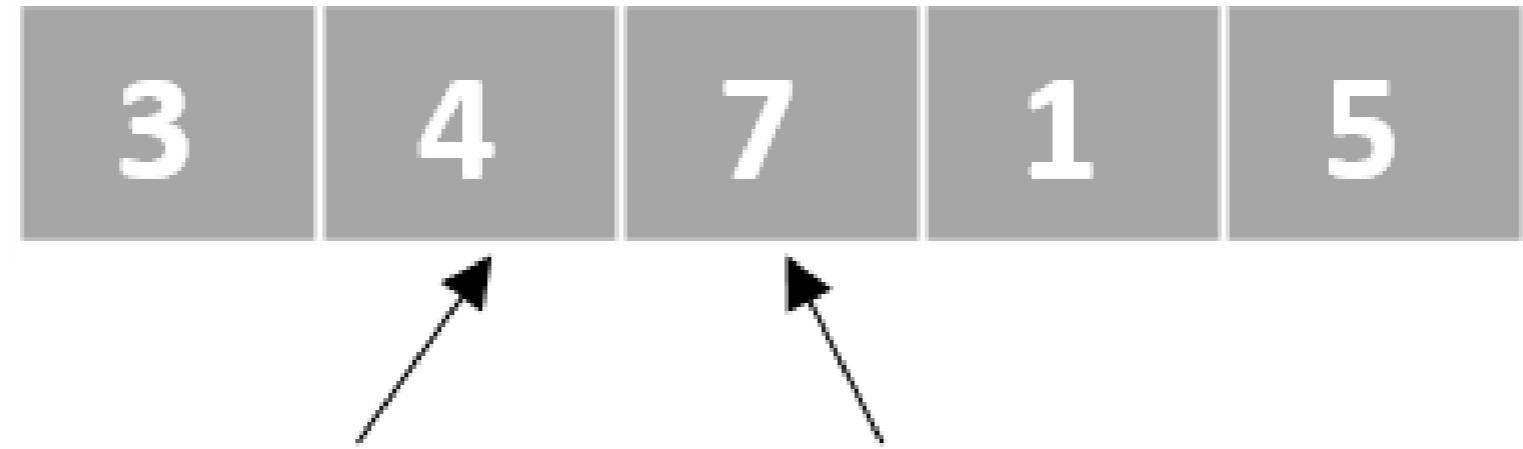
- First value greater than the second value

Bubble sort



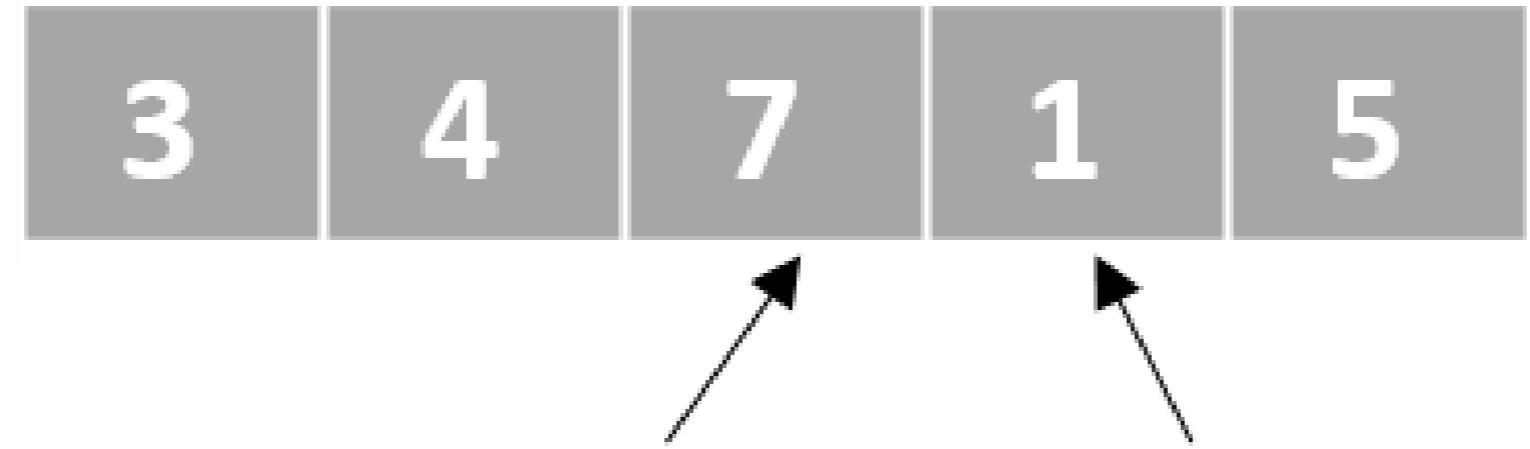
- First value greater than the second value
 - Swap them
- Second value greater than the first value
 - Nothing

Bubble sort



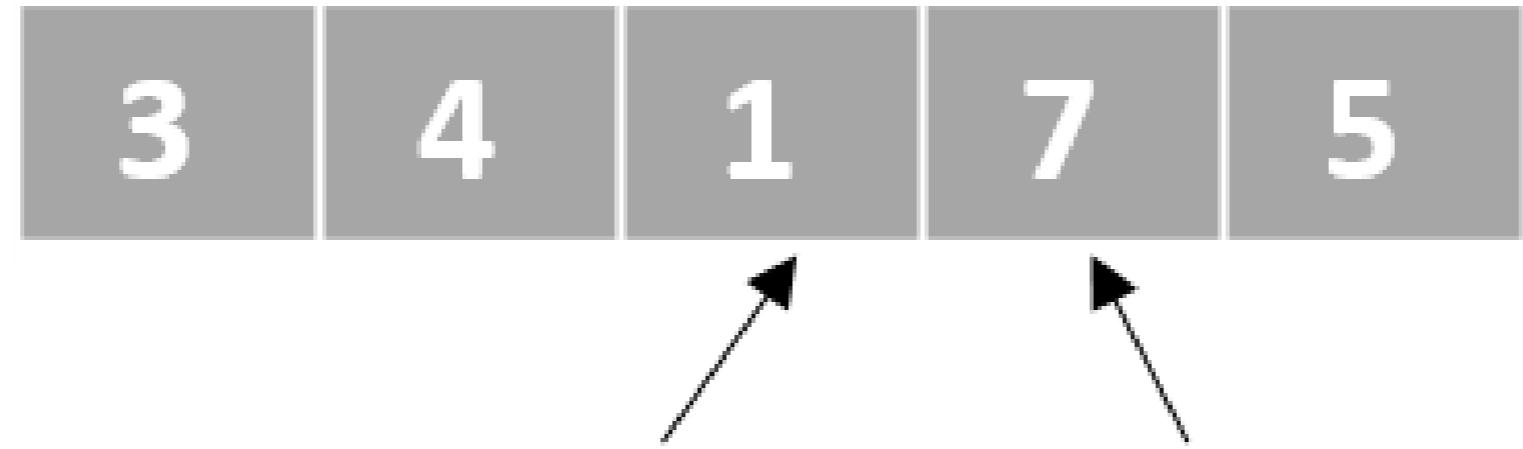
- First value greater than the second value
 - Swap them
- Second value greater than the first value
 - Nothing

Bubble sort



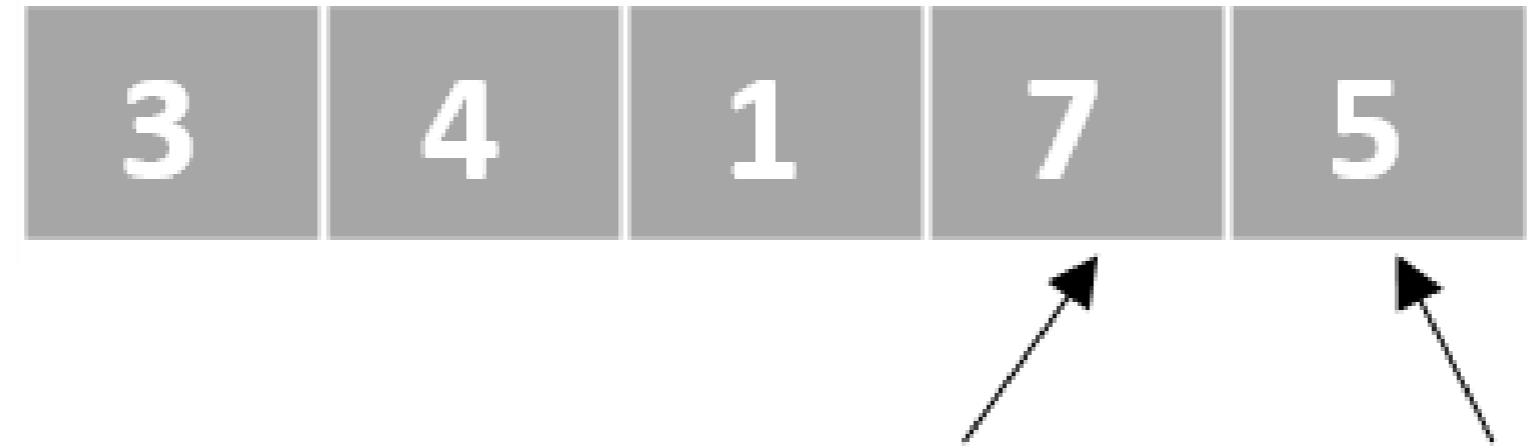
- First value greater than the second value
 - Swap them
- Second value greater than the first value
 - Nothing

Bubble sort



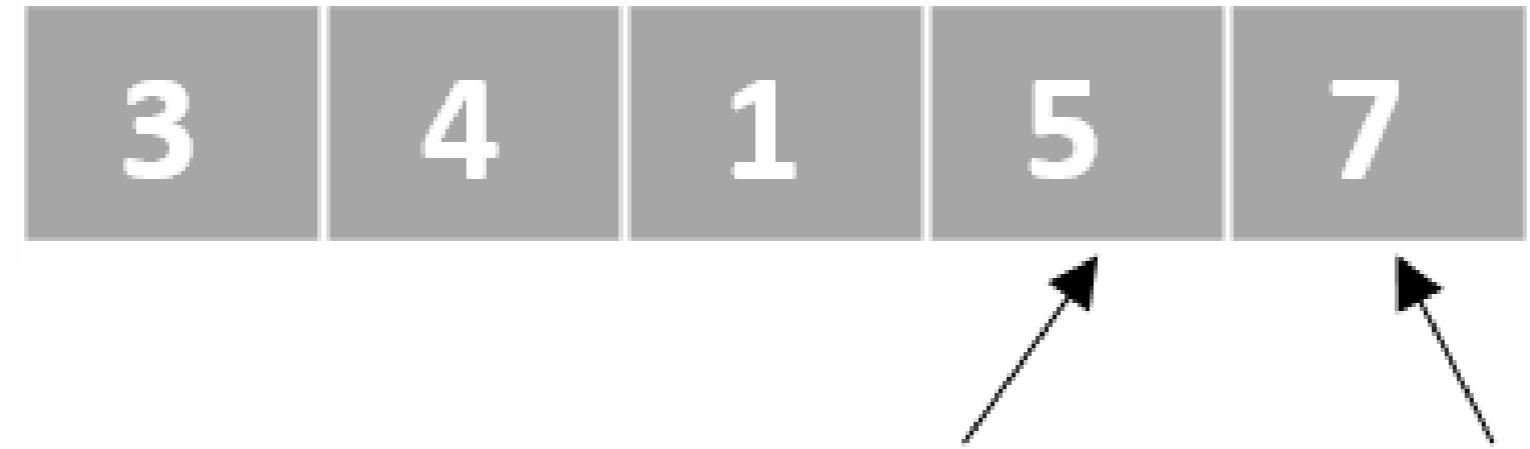
- First value greater than the second value
 - Swap them
- Second value greater than the first value
 - Nothing

Bubble sort



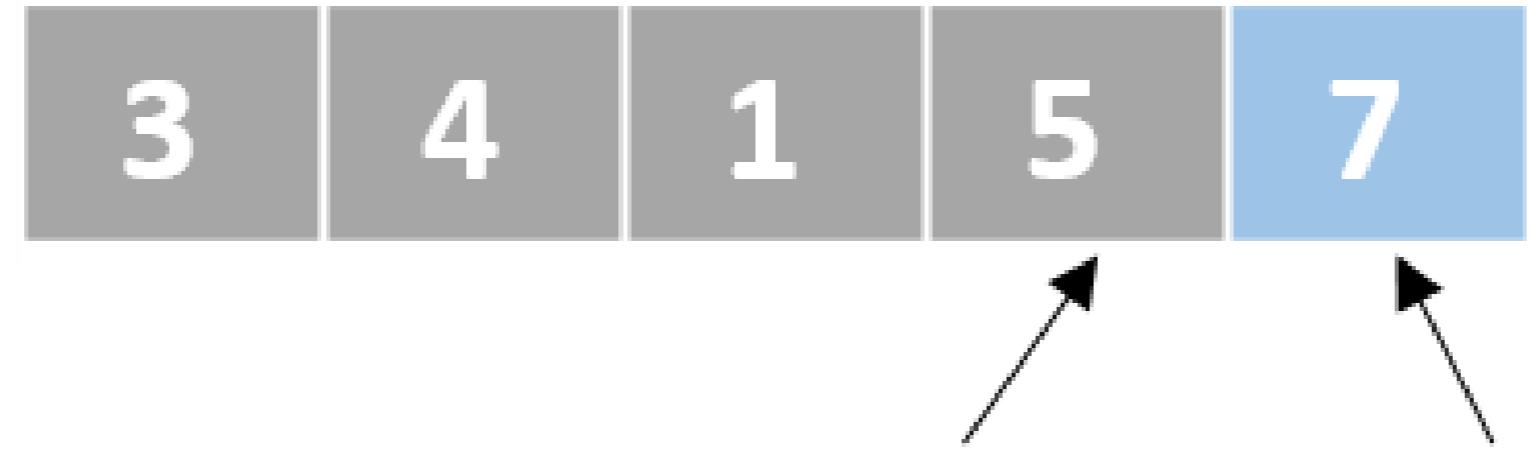
- First value greater than the second value
 - Swap them
- Second value greater than the first value
 - Nothing

Bubble sort



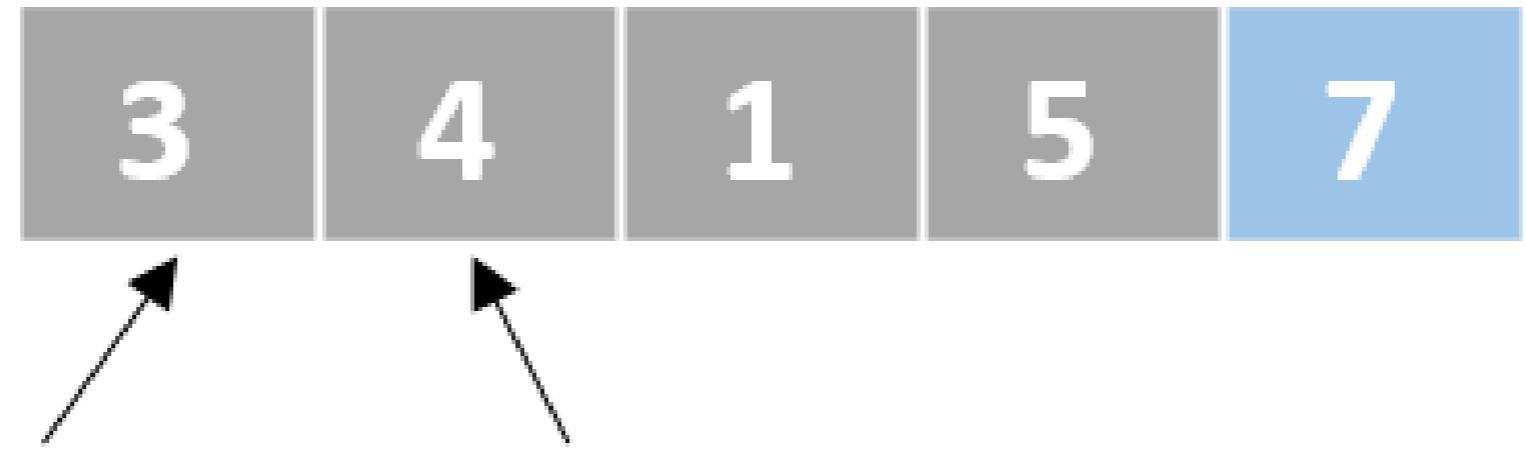
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 - Nothing

Bubble sort



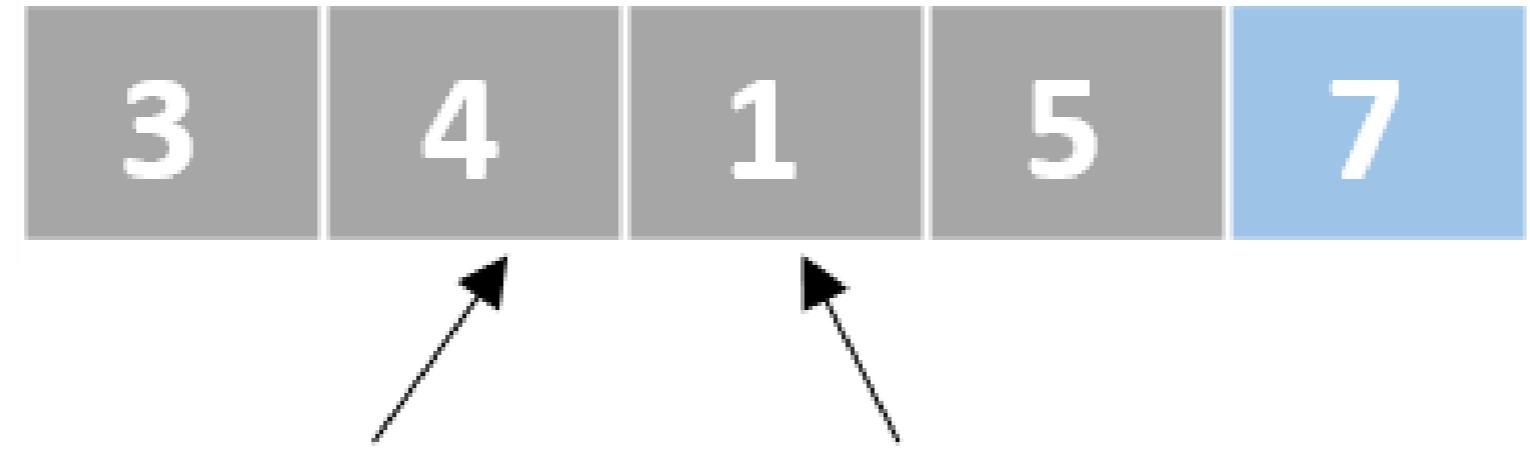
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Bubble sort



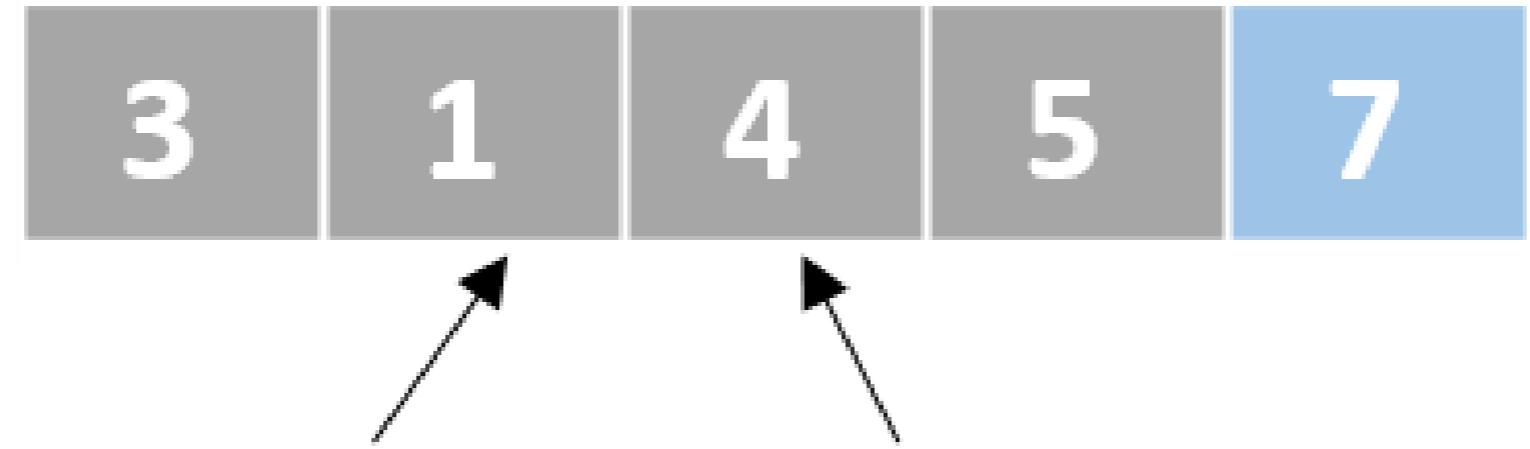
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Bubble sort



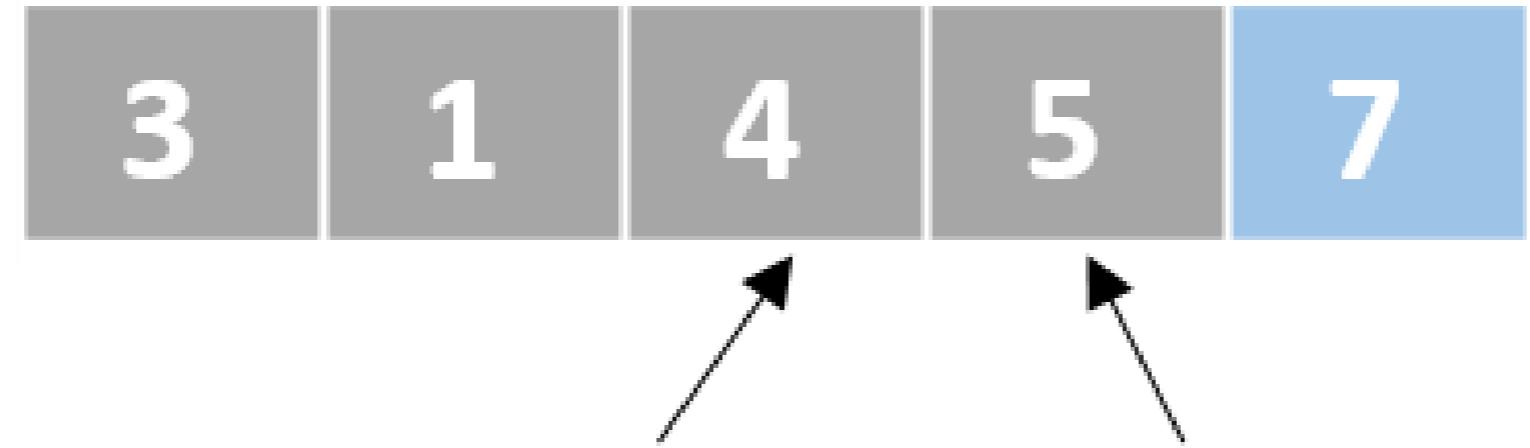
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Bubble sort



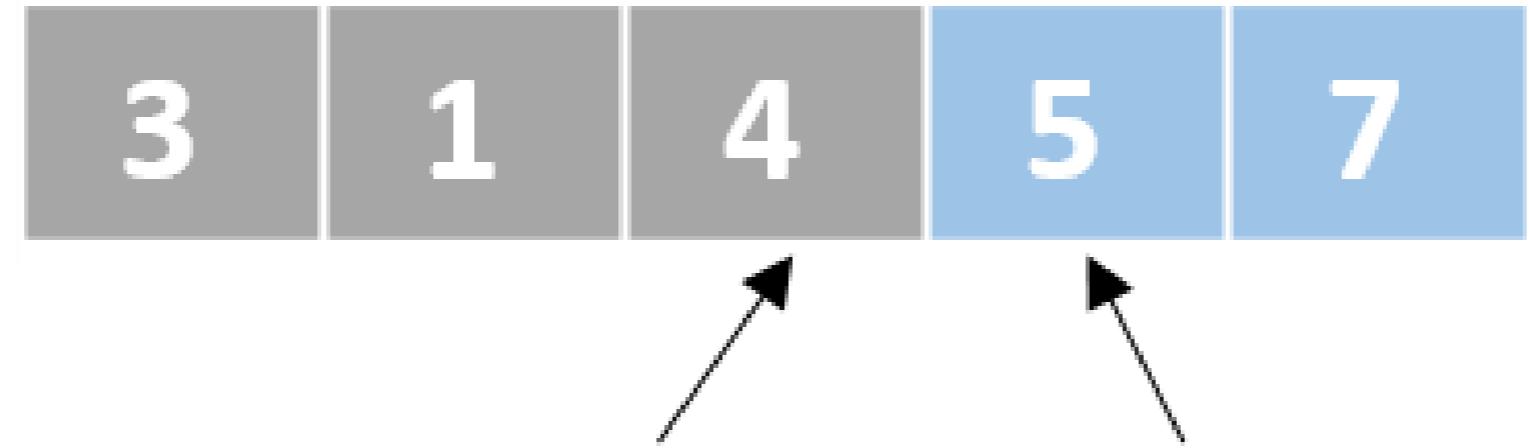
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Bubble sort



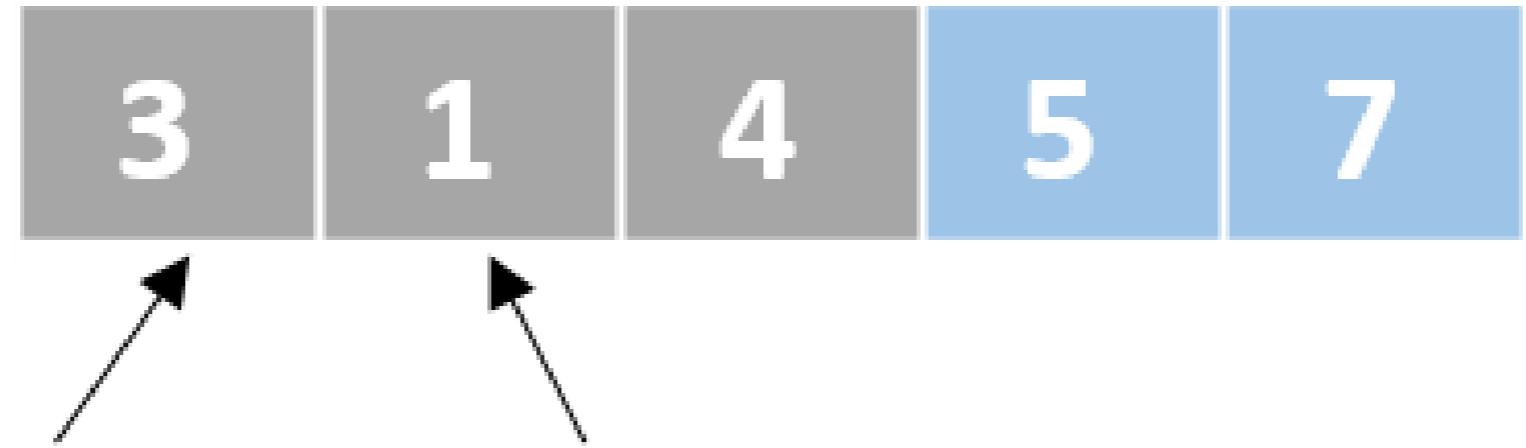
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 - Swap them
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 - Nothing

Bubble sort



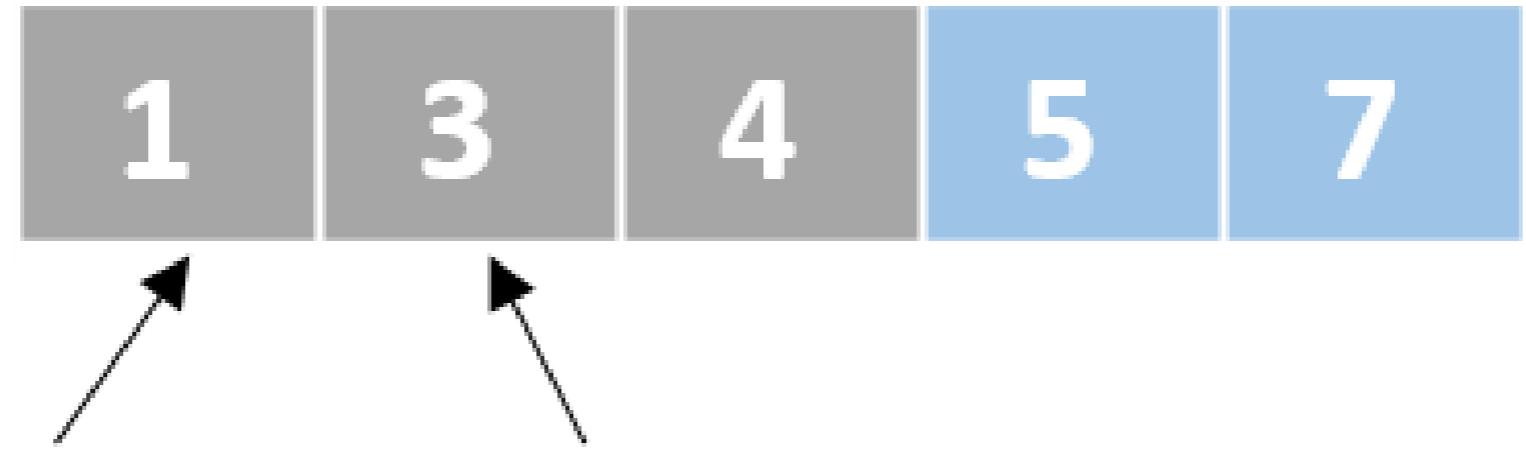
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 - Nothing

Bubble sort



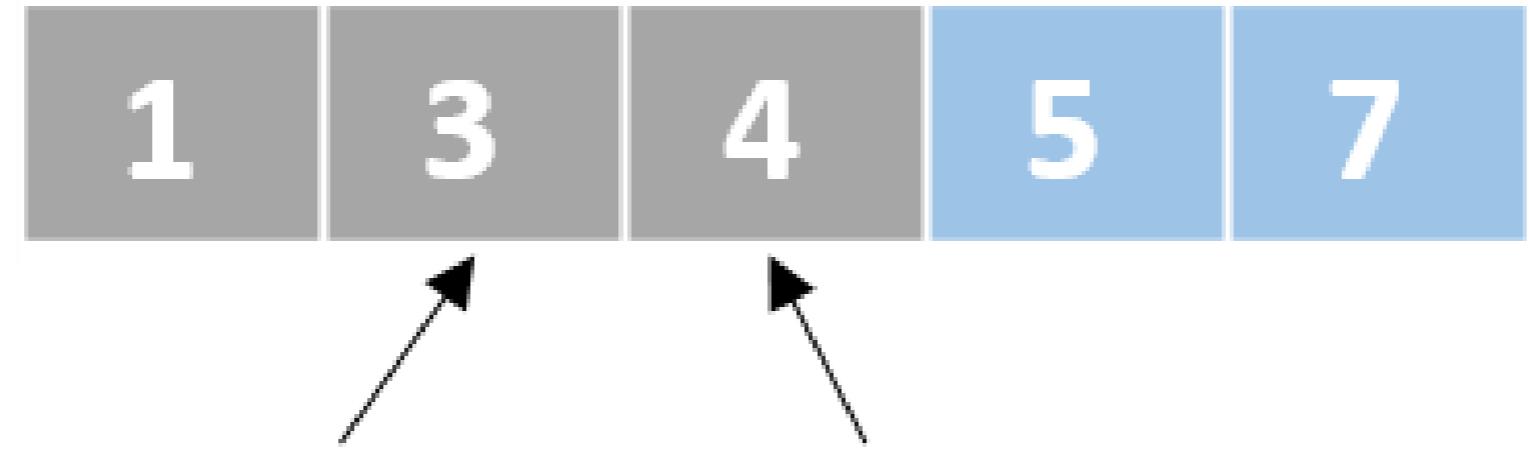
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 - Nothing

Bubble sort



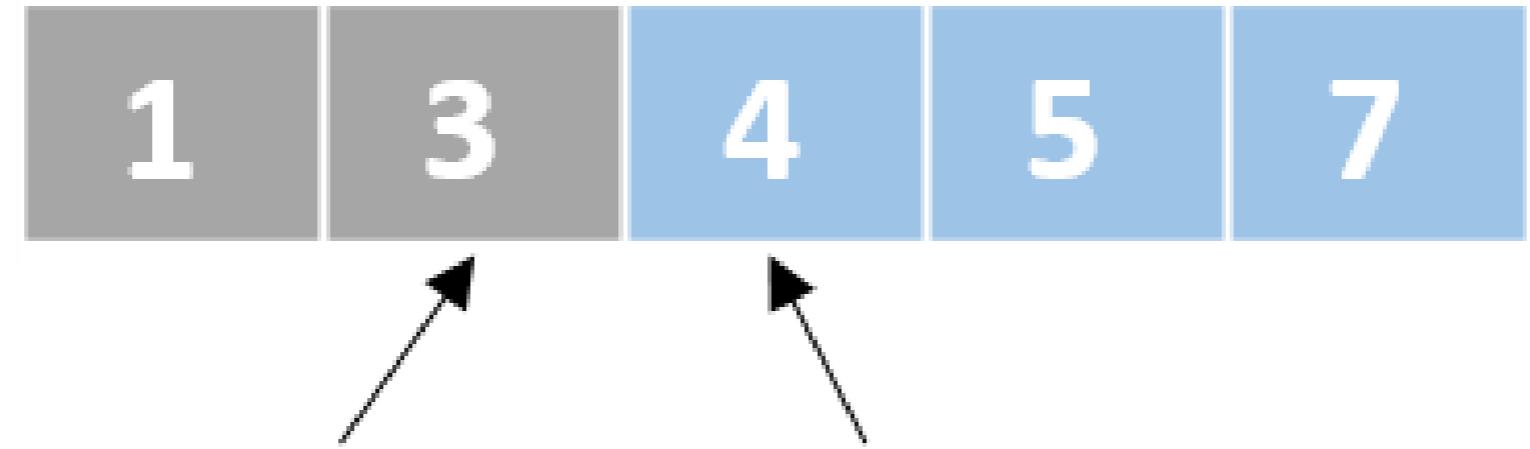
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 - Nothing

Bubble sort



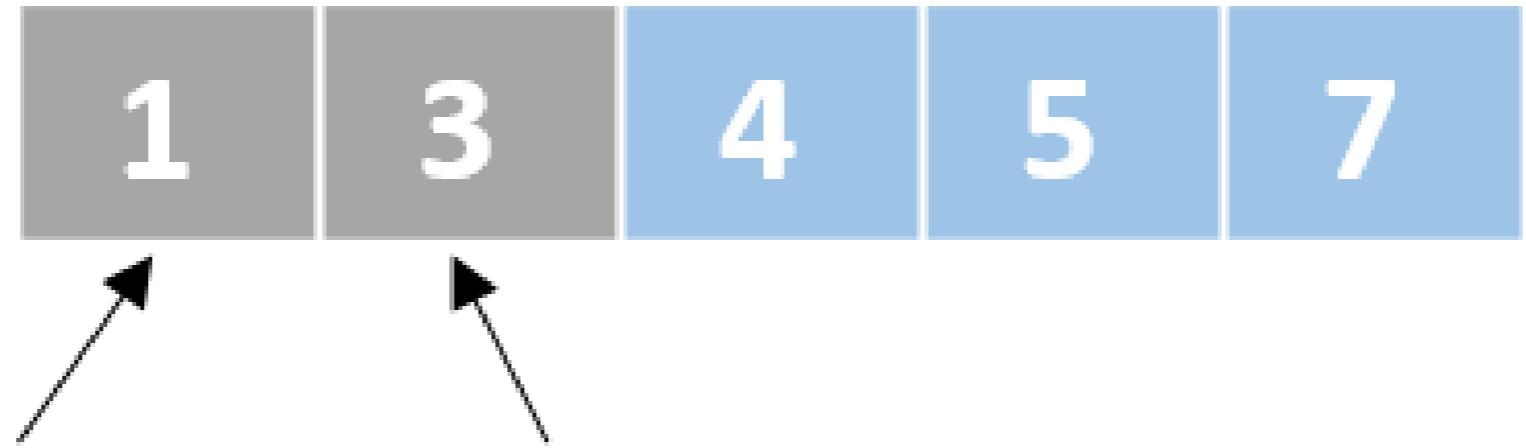
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Bubble sort



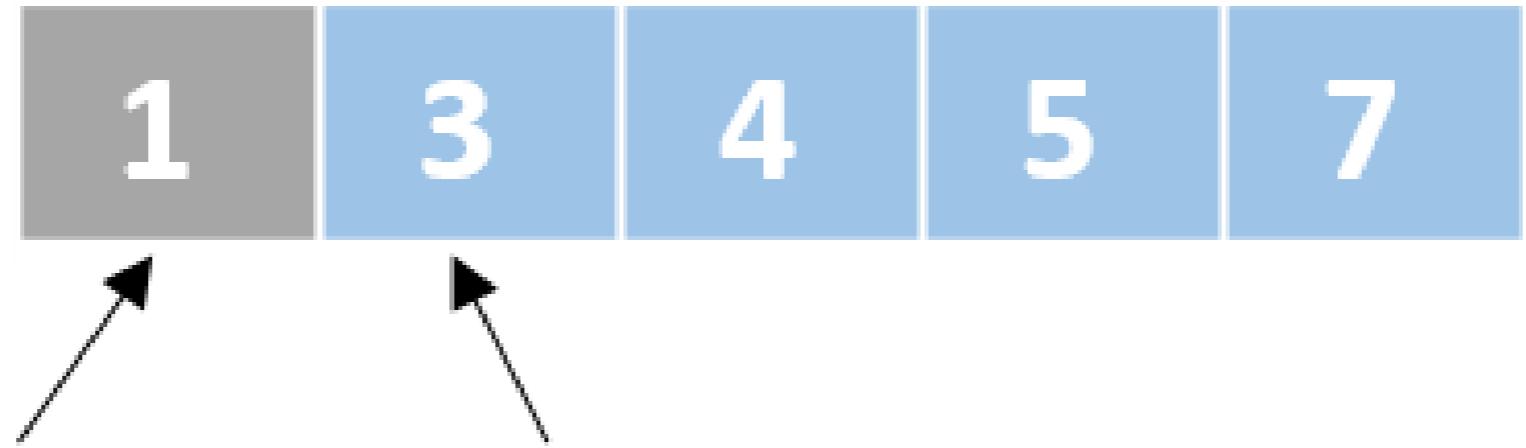
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 - Nothing

Bubble sort



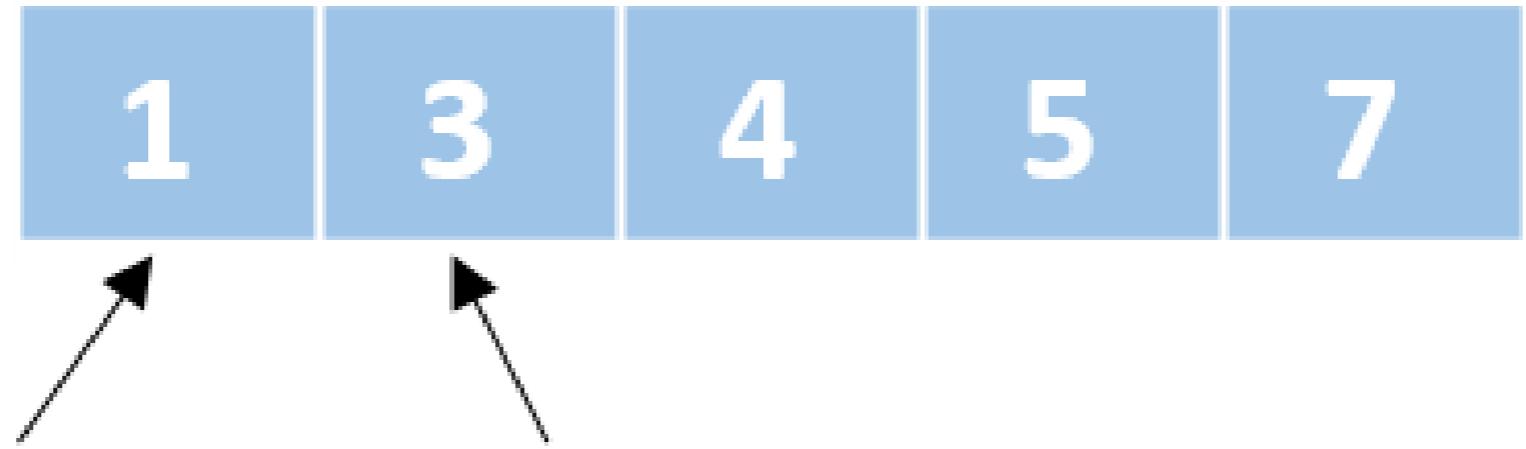
- First value greater than the second value
 - Swap them
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 - Nothing

Bubble sort



- First value greater than the second value
 - Swap them
- Second value greater than the first value
 - Nothing

Bubble sort



- First value greater than the second value
 - Swap them
- Second value greater than the first value
 - Nothing

Bubble sort - implementation

```
def bubble_sort(my_list):
    list_length = len(my_list)
    for i in range(list_length-1):
        for j in range(list_length-1-i):
            if my_list[j] > my_list[j+1]:
                my_list[j] , my_list[j+1] = my_list[j+1] , my_list[j]
    return my_list
```

```
print(bubble_sort([4,3,7,1,5]))
```

```
[1, 3, 4, 5, 7]
```

Bubble sort - implementation

```
def bubble_sort(my_list):
    list_length = len(my_list)
    is_sorted = False
    while not is_sorted:
        is_sorted = True
        for i in range(list_length-1):
            if my_list[i] > my_list[i+1]:
                my_list[i] , my_list[i+1] = my_list[i+1] , my_list[i]
                is_sorted = False
        list_length -= 1
    return my_list
```

Bubble sort - complexity

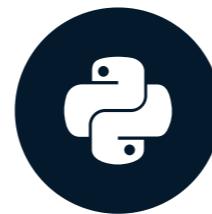
- Worst case: $O(n^2)$
- Best case - not improved version: $\Omega(n^2)$
- Best case - improved version: $\Omega(n)$
- Average case: $\Theta(n^2)$
- Doesn't perform well with highly unsorted large lists
- Performs well:
 - large sorted/almost sorted lists
 - small lists

Let's practice!

DATA STRUCTURES AND ALGORITHMS IN PYTHON

Selection Sort and Insertion Sort

DATA STRUCTURES AND ALGORITHMS IN PYTHON



Miriam Antona
Software engineer

Selection sort



- Determine the lowest value

Selection sort



- Determine the lowest value

Selection sort



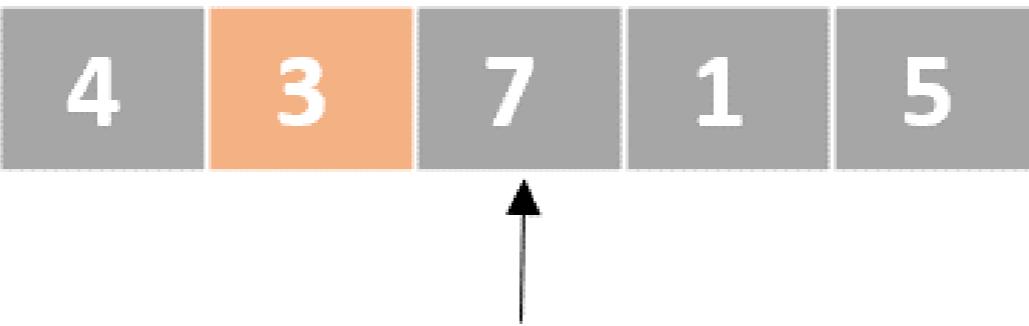
- Determine the lowest value

Selection sort



- Determine the lowest value

Selection sort



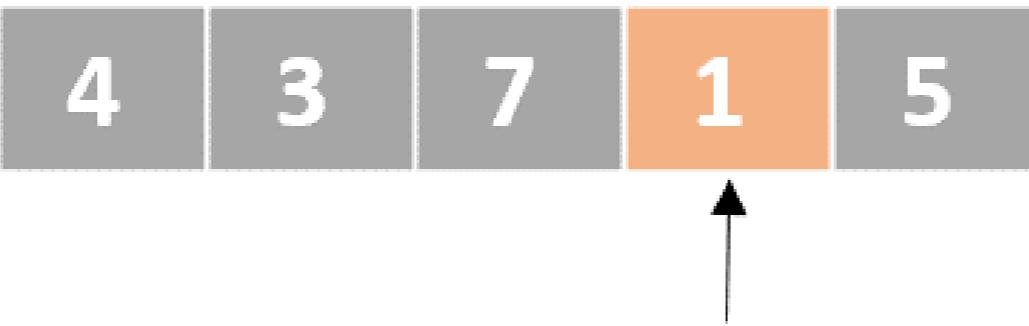
- Determine the lowest value

Selection sort



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Selection sort



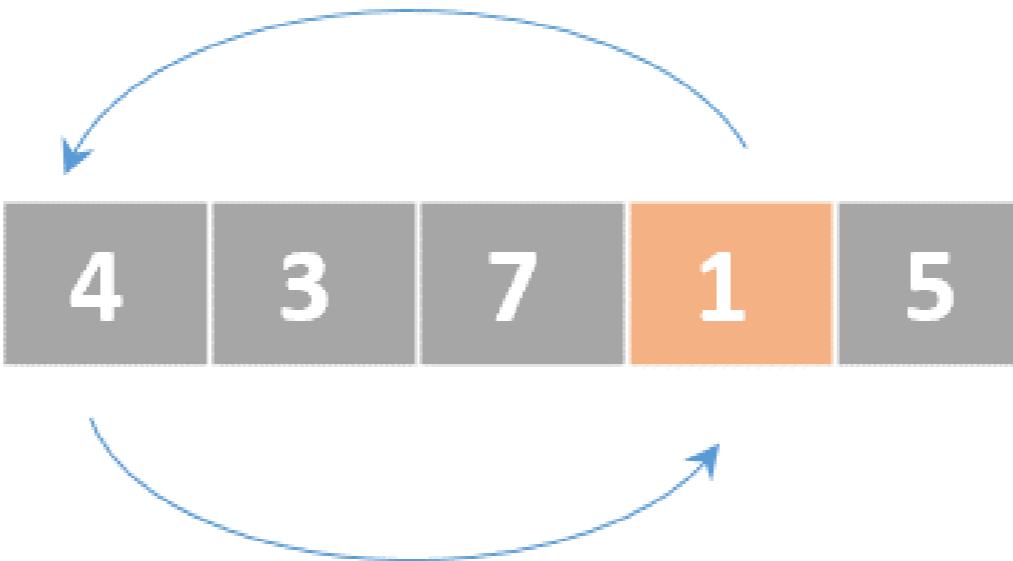
- Determine the lowest value

Selection sort



- Determine the lowest value

Selection sort



- Determine the lowest value
- Swap the lowest value with the first unordered element

Selection sort



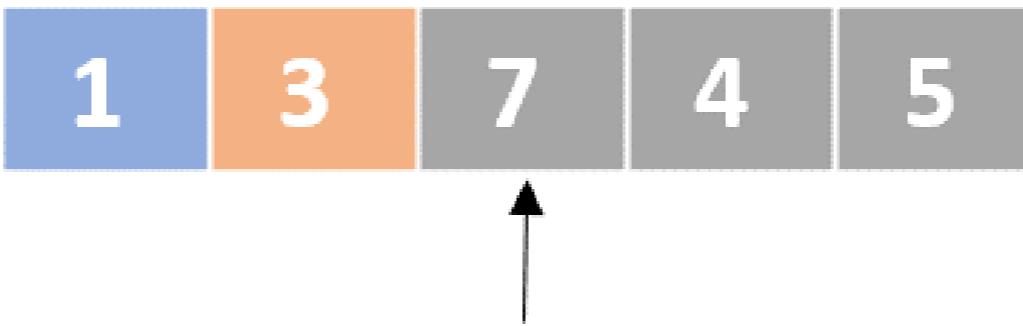
- Determine the lowest value
- Swap the lowest value with the first unordered element

Selection sort



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- Swap the lowest value with the first unordered element

Selection sort



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Selection sort



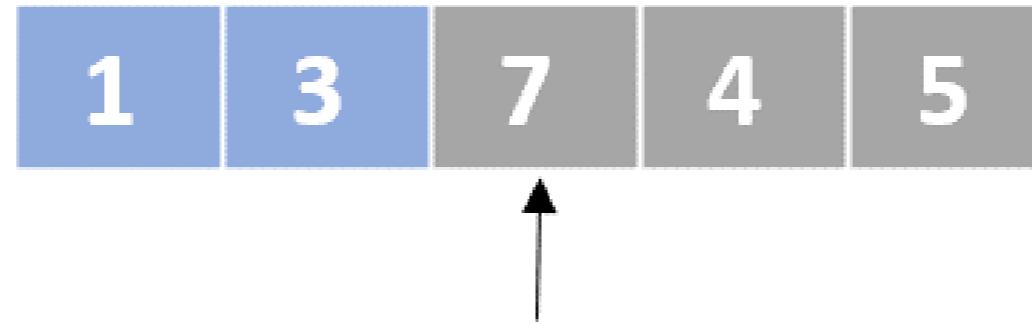
- Determine the lowest value
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Selection sort



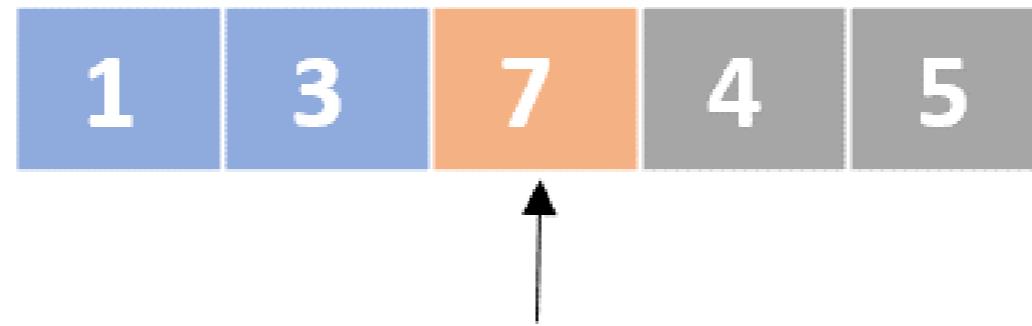
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Selection sort



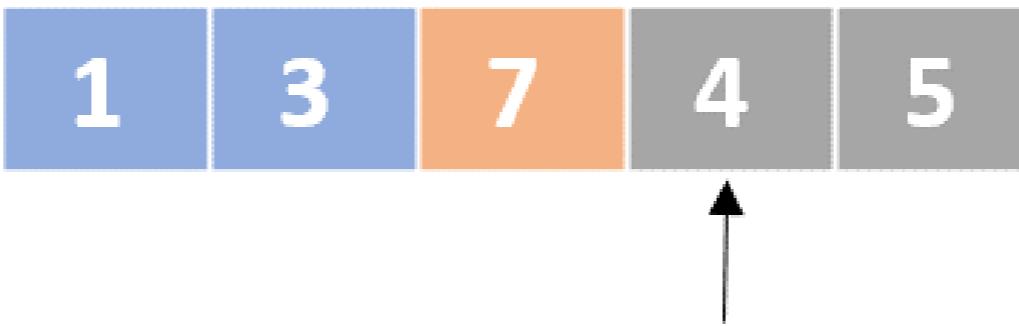
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Selection sort



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Selection sort



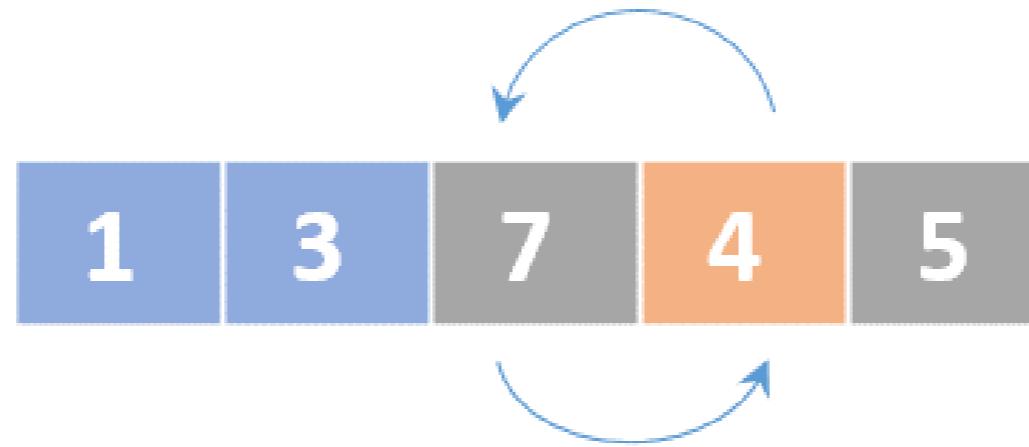
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Selection sort



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Selection sort



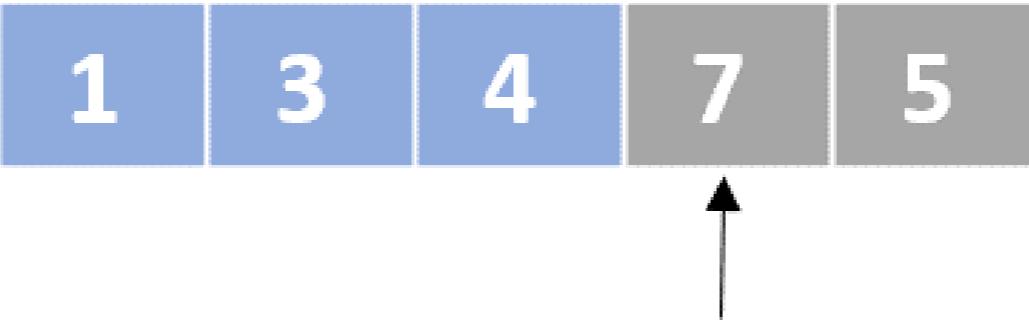
- Determine the lowest value
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Selection sort



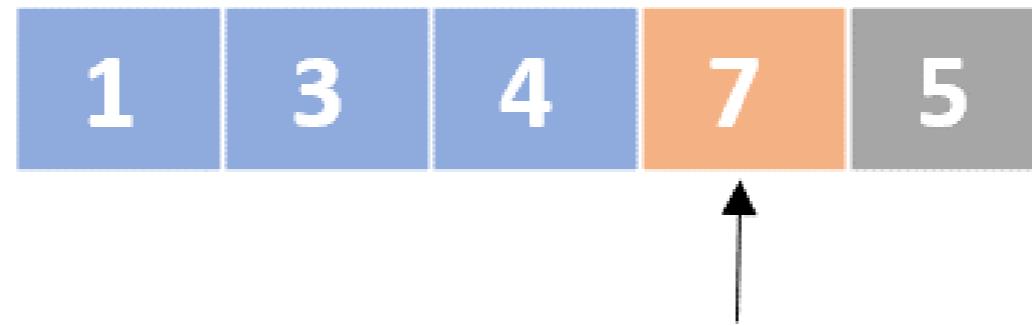
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Selection sort



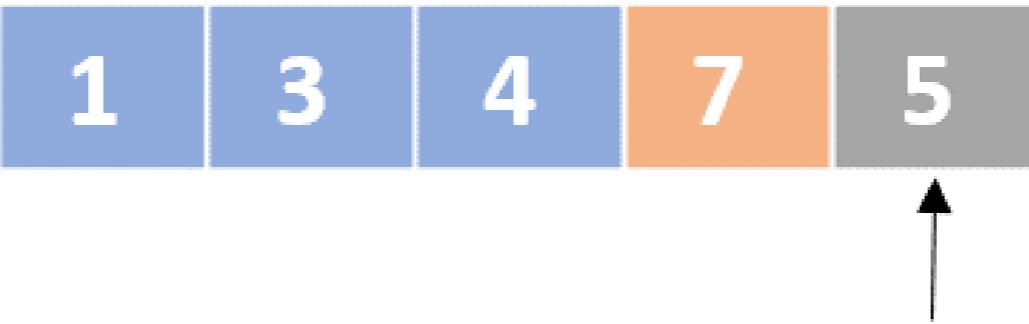
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Selection sort



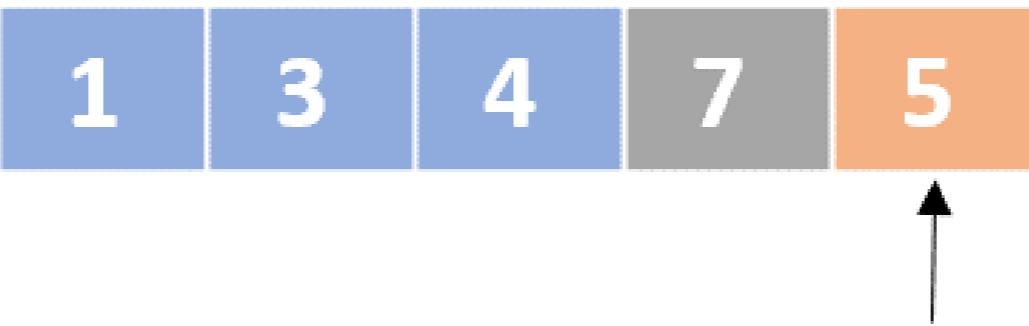
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Selection sort



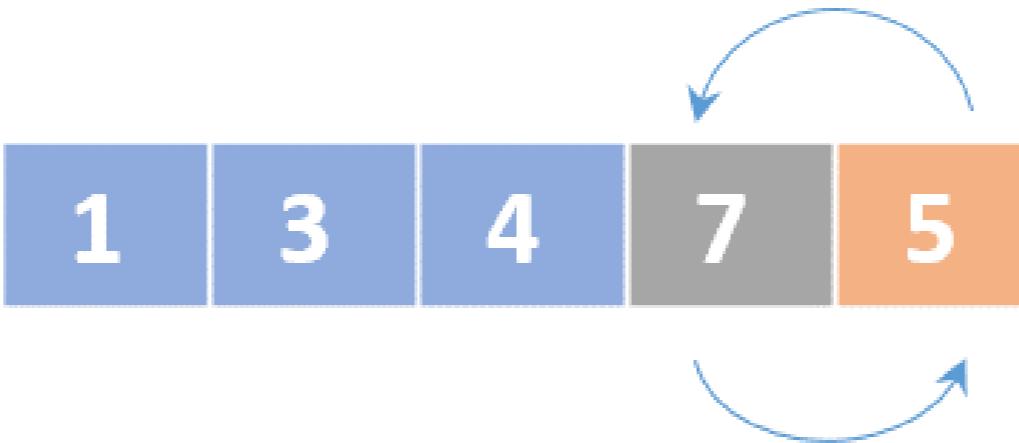
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Selection sort



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Selection sort



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Selection sort



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Selection sort



- Determine the lowest value
- Swap the lowest value with the first unordered element

Selection sort



- Determine the lowest value
- Swap the lowest value with the first unordered element

Selection sort - implementation

```
def selection_sort(my_list):
    list_length = len(my_list)
    for i in range(list_length - 1):
        lowest = my_list[i]
        index = i
        for j in range(i + 1, list_length):
            if my_list[j] < lowest:
                index = j
                lowest = my_list[j]
        my_list[i] , my_list[index] = my_list[index] , my_list[i]
    return my_list
```

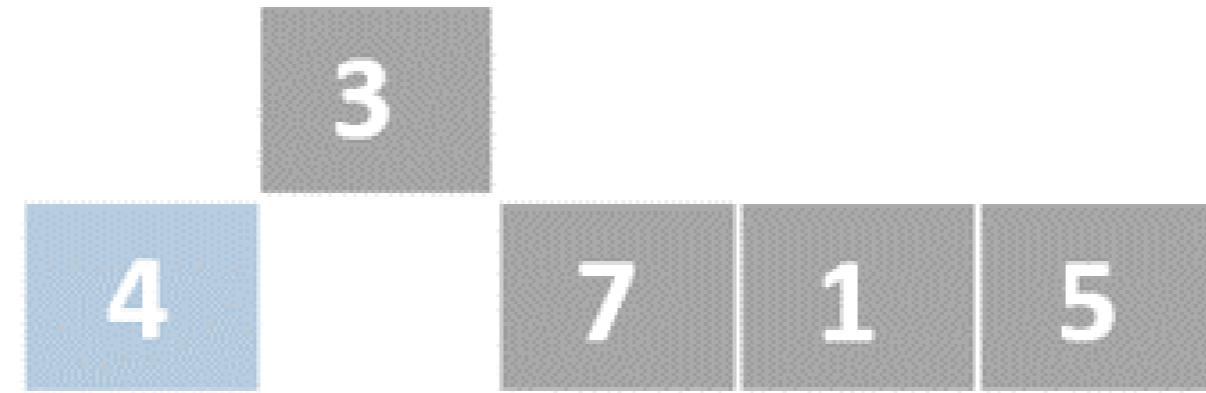
Selection sort - complexity

- Worst case: $O(n^2)$
- Average case: $\Theta(n^2)$
- Best case: $\Omega(n^2)$

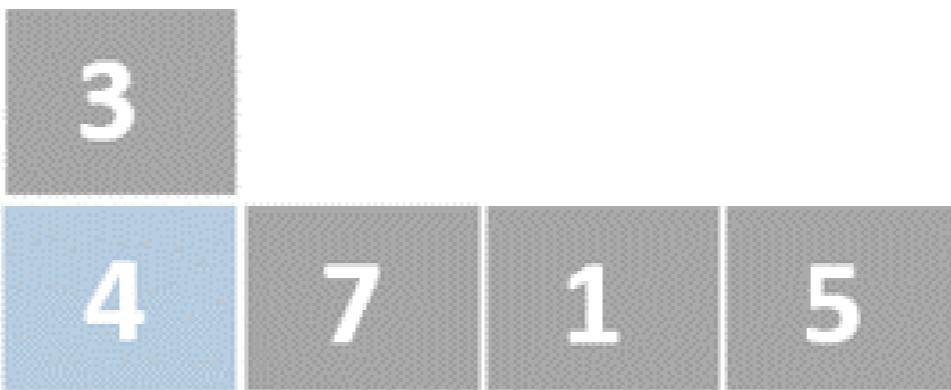
Insertion sort



Insertion sort



Insertion sort



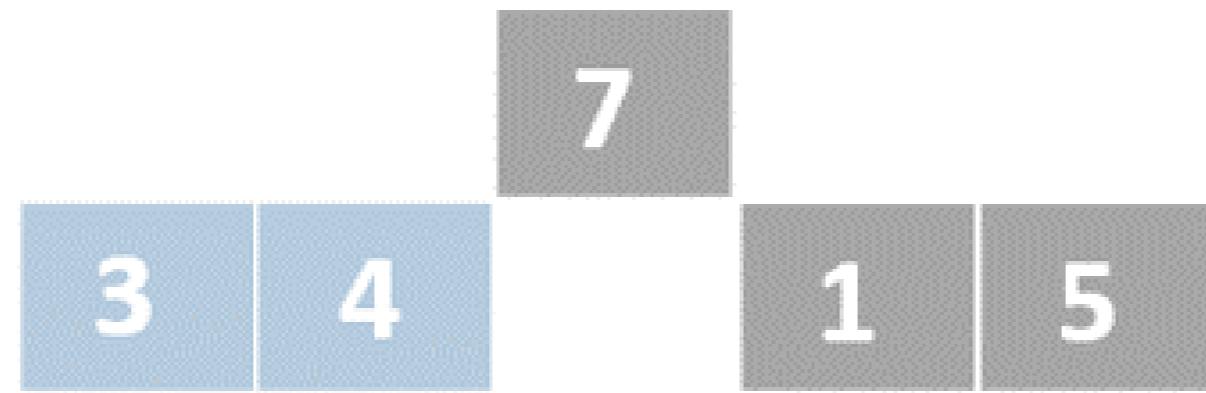
Insertion sort



Insertion sort



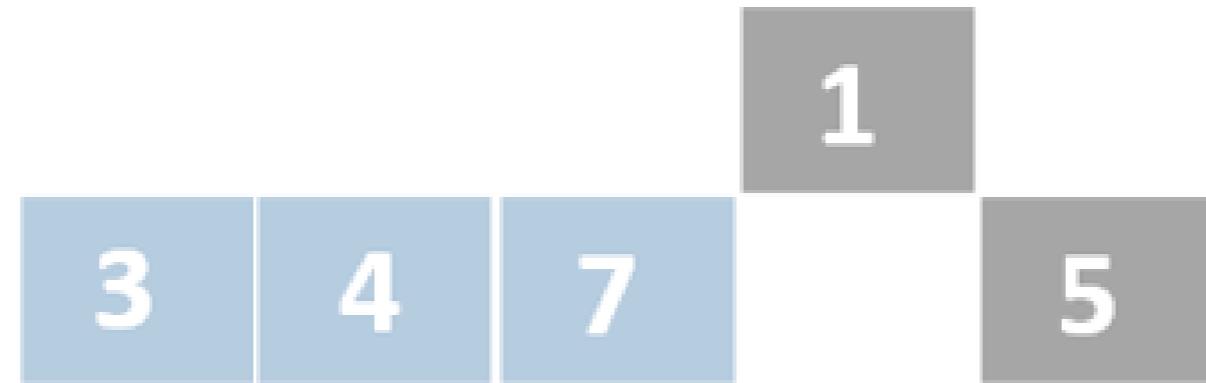
Insertion sort



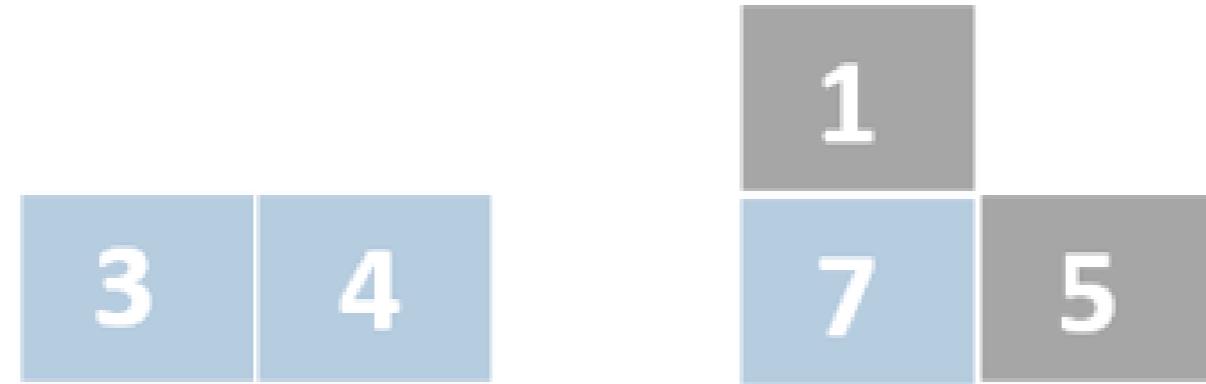
Insertion sort



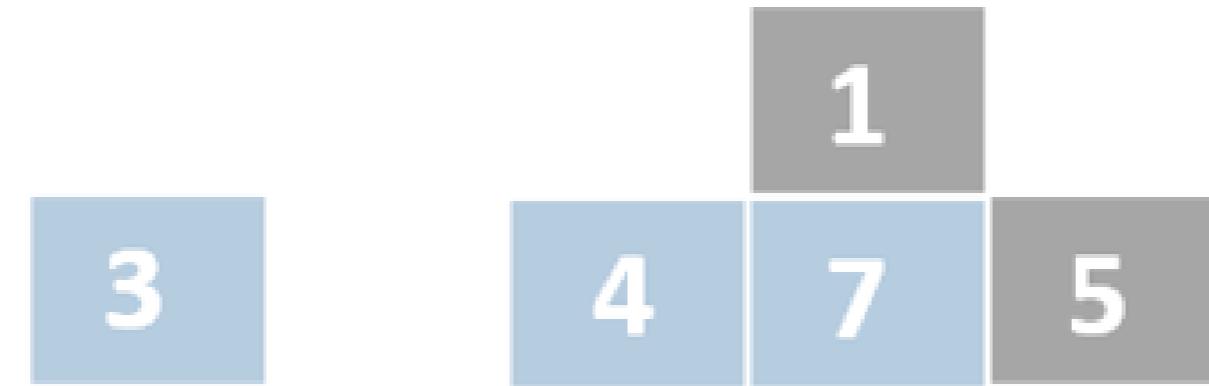
Insertion sort



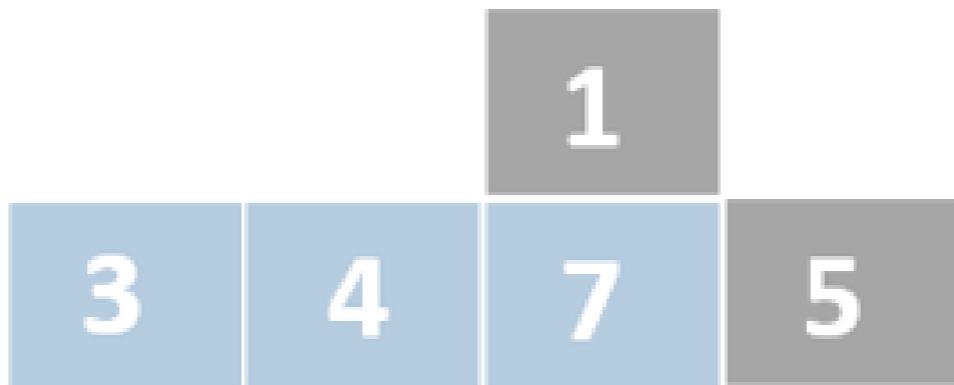
Insertion sort



Insertion sort



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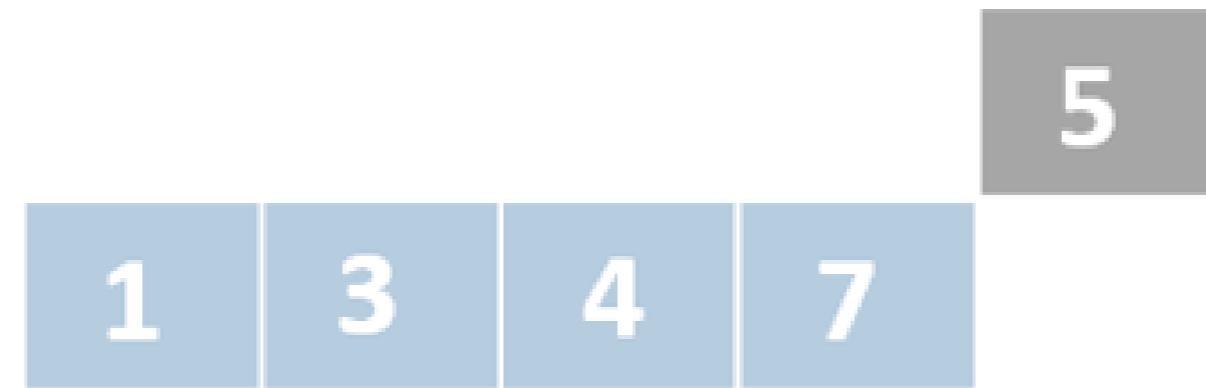
Insertion sort



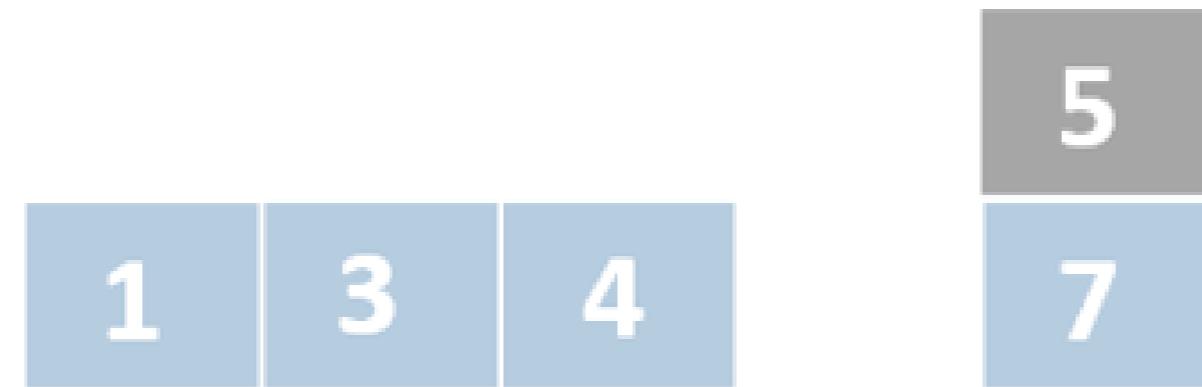
Insertion sort



Insertion sort



Insertion sort



Insertion sort



Insertion sort - implementation

```
def insertion_sort(my_list):
    for i in range(1, len(my_list)):
        number_to_order = my_list[i]
        j = i - 1
        while j >= 0 and number_to_order < my_list[j]:
            my_list[j + 1] = my_list[j]
            j -= 1
        my_list[j + 1] = number_to_order
    return my_list
```

Insertion sort - complexity

- Worst case: $O(n^2)$
- Average case: $\Theta(n^2)$
- Best case: $\Omega(n)$

Let's practice!

DATA STRUCTURES AND ALGORITHMS IN PYTHON

Merge sort

DATA STRUCTURES AND ALGORITHMS IN PYTHON



Miriam Antona
Software engineer

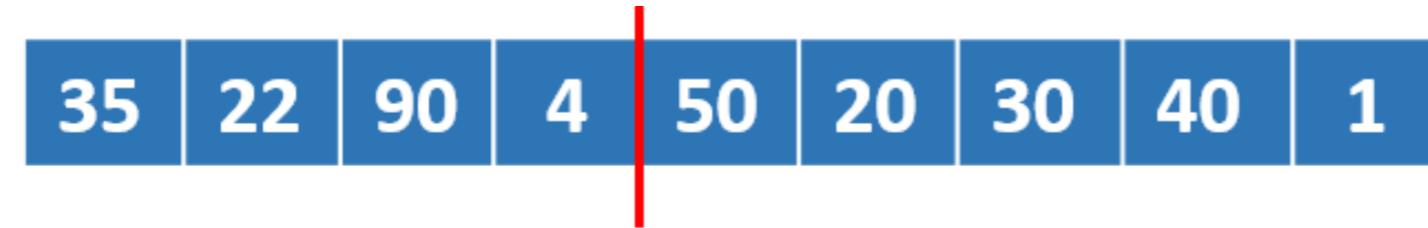
Merge sort

- Follows **divide and conquer**
 - **Divide**
 - divides the problem into smaller sub-problems
 - **Conquer**
 - sub-problems are solved recursively
 - **Combine**
 - solutions of sub-problems are combined to achieve the final solution

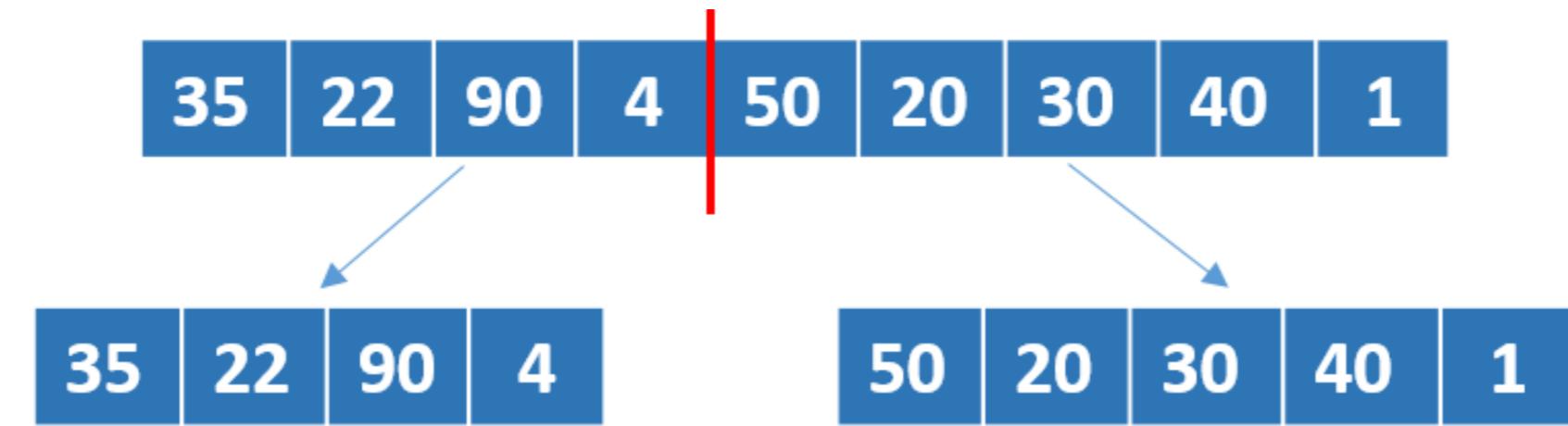
Merge sort - in action

35	22	90	4	50	20	30	40	1
----	----	----	---	----	----	----	----	---

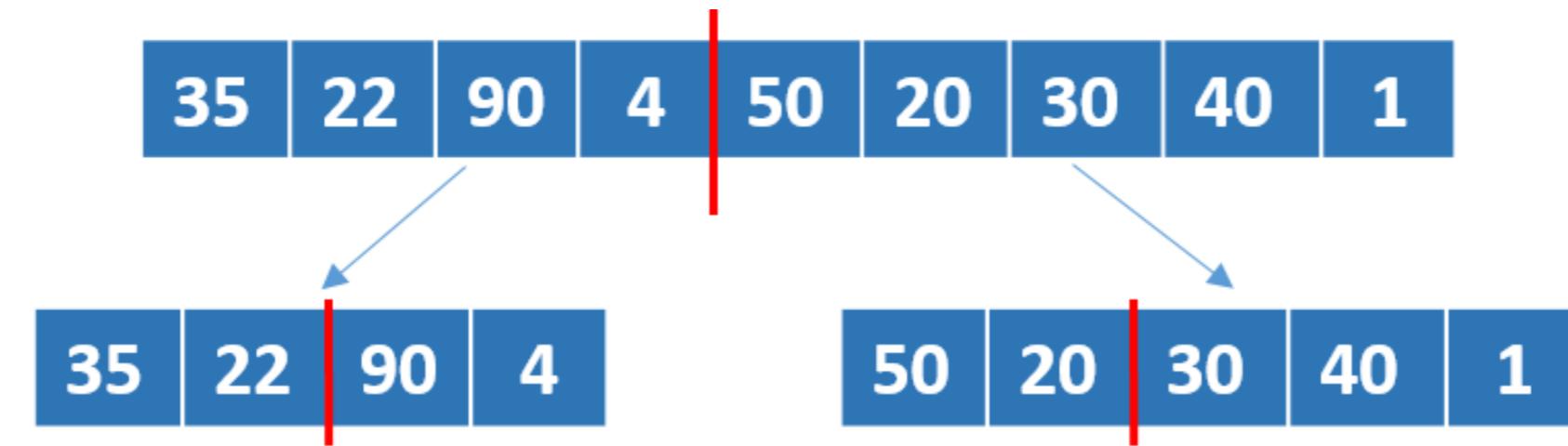
Merge sort - in action



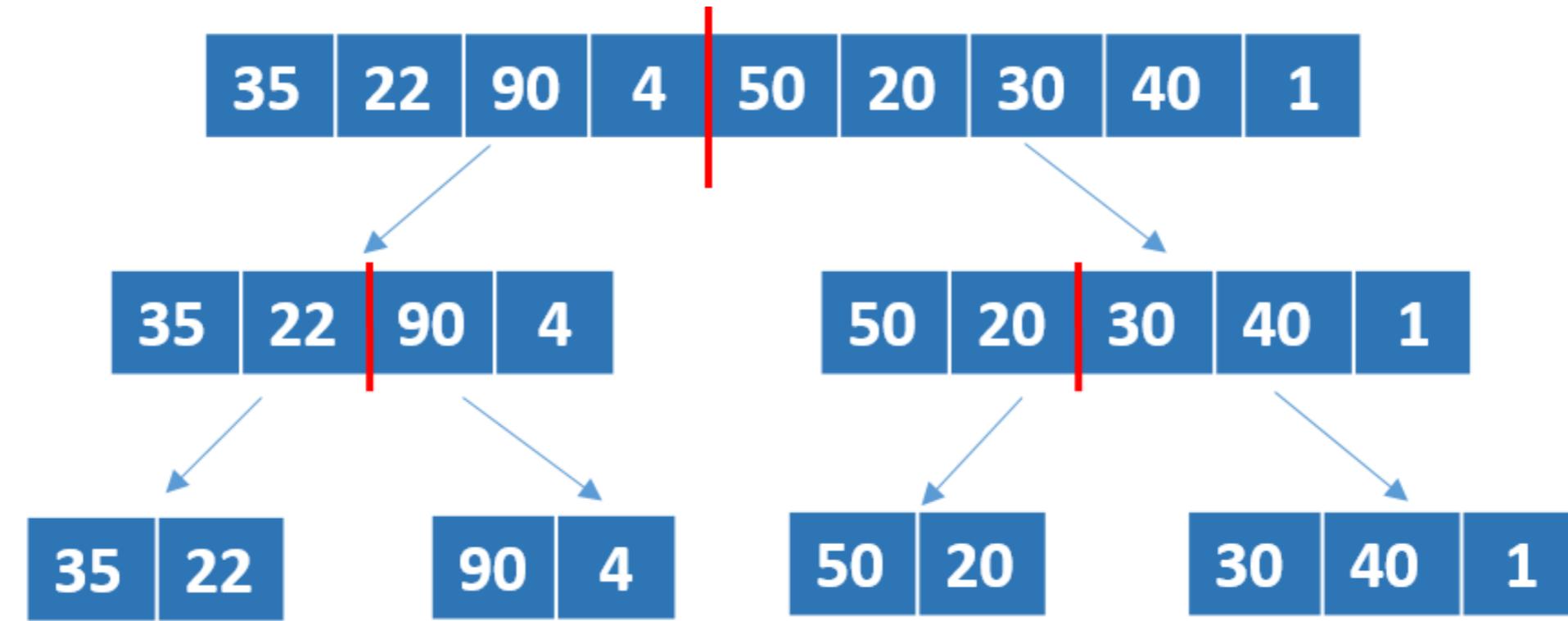
Merge sort - in action



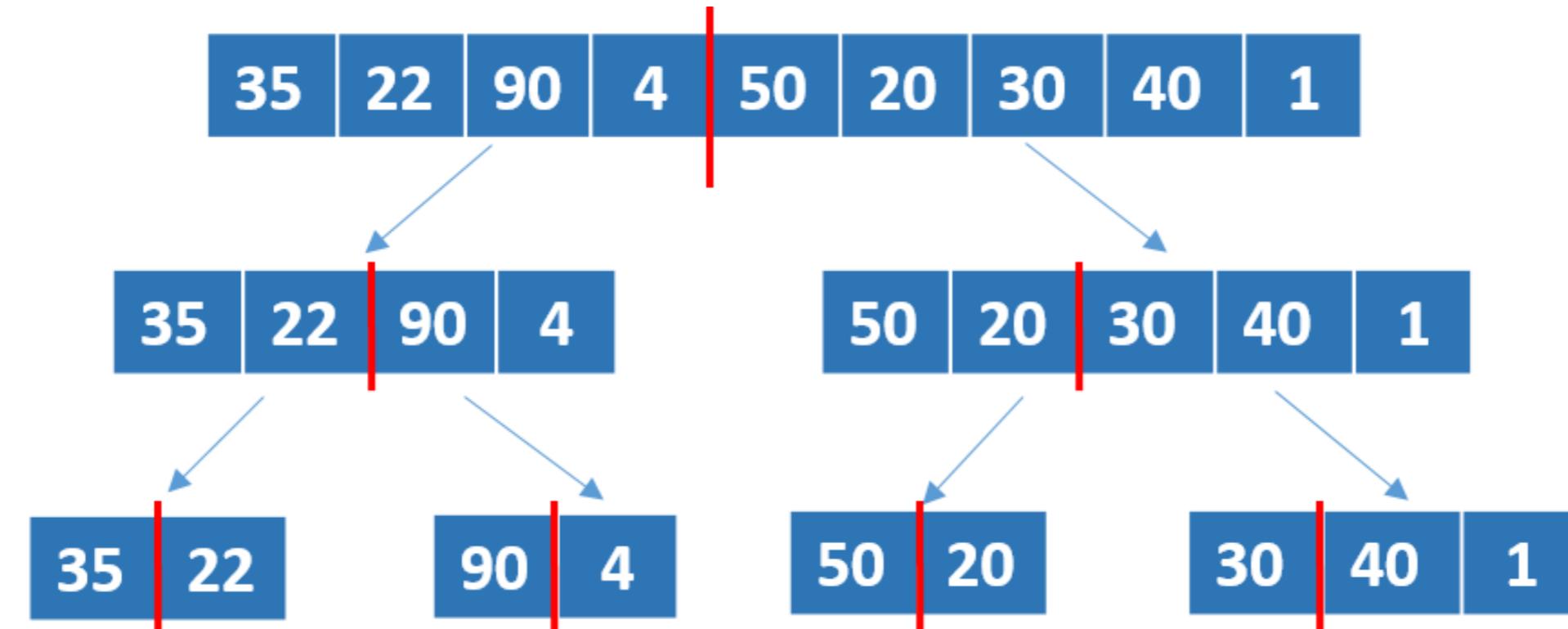
Merge sort - in action



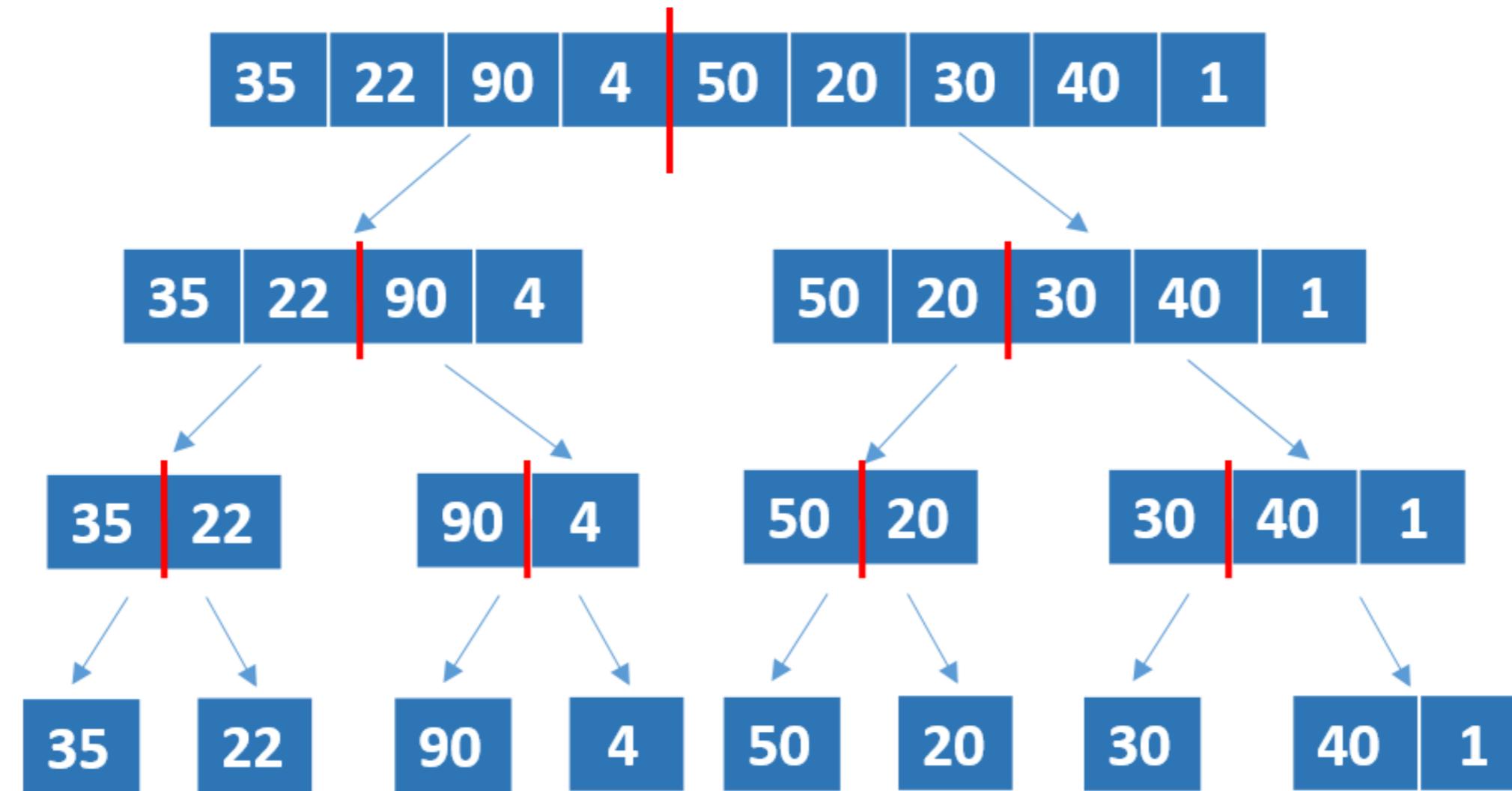
Merge sort - in action



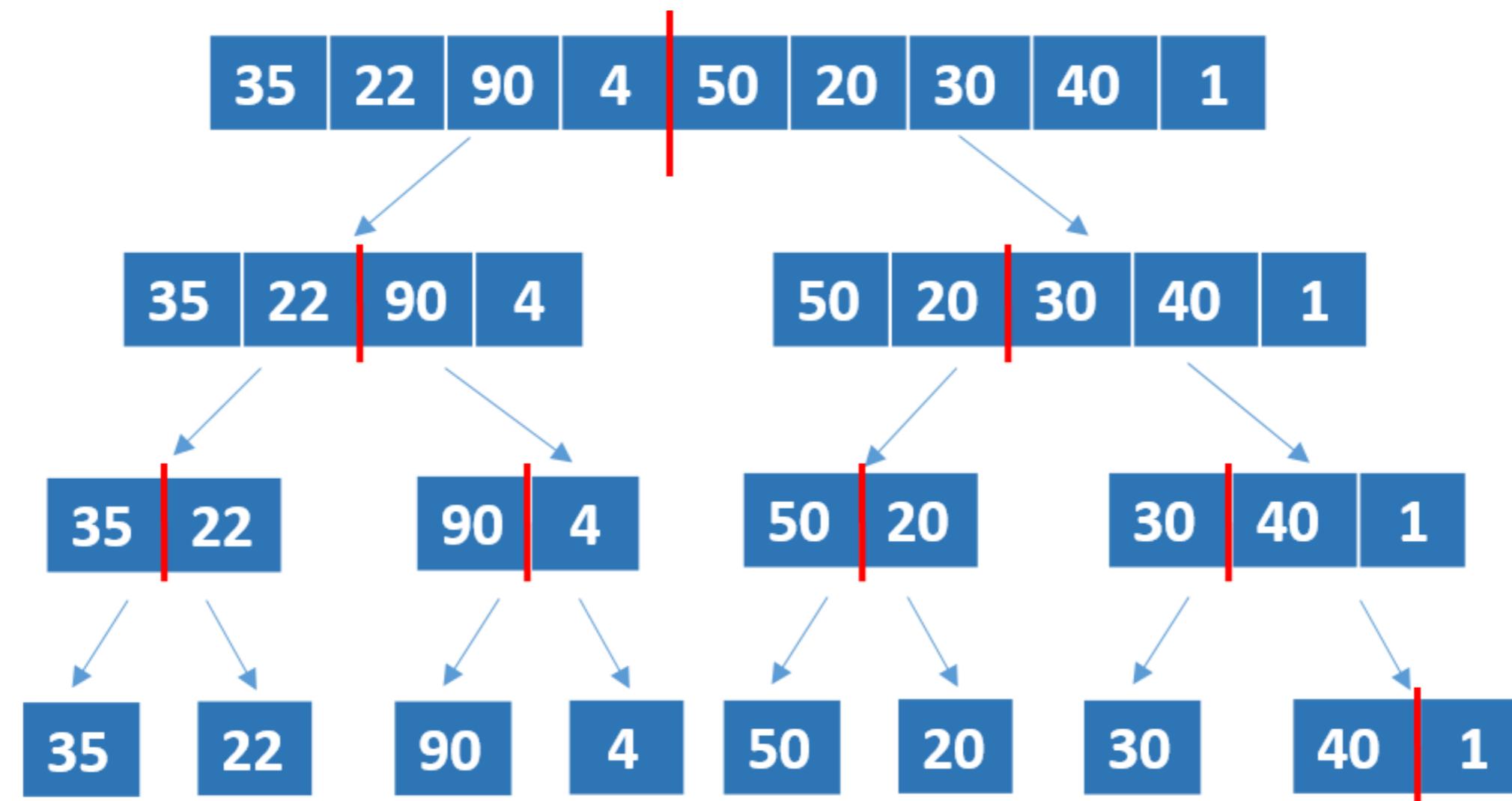
Merge sort - in action



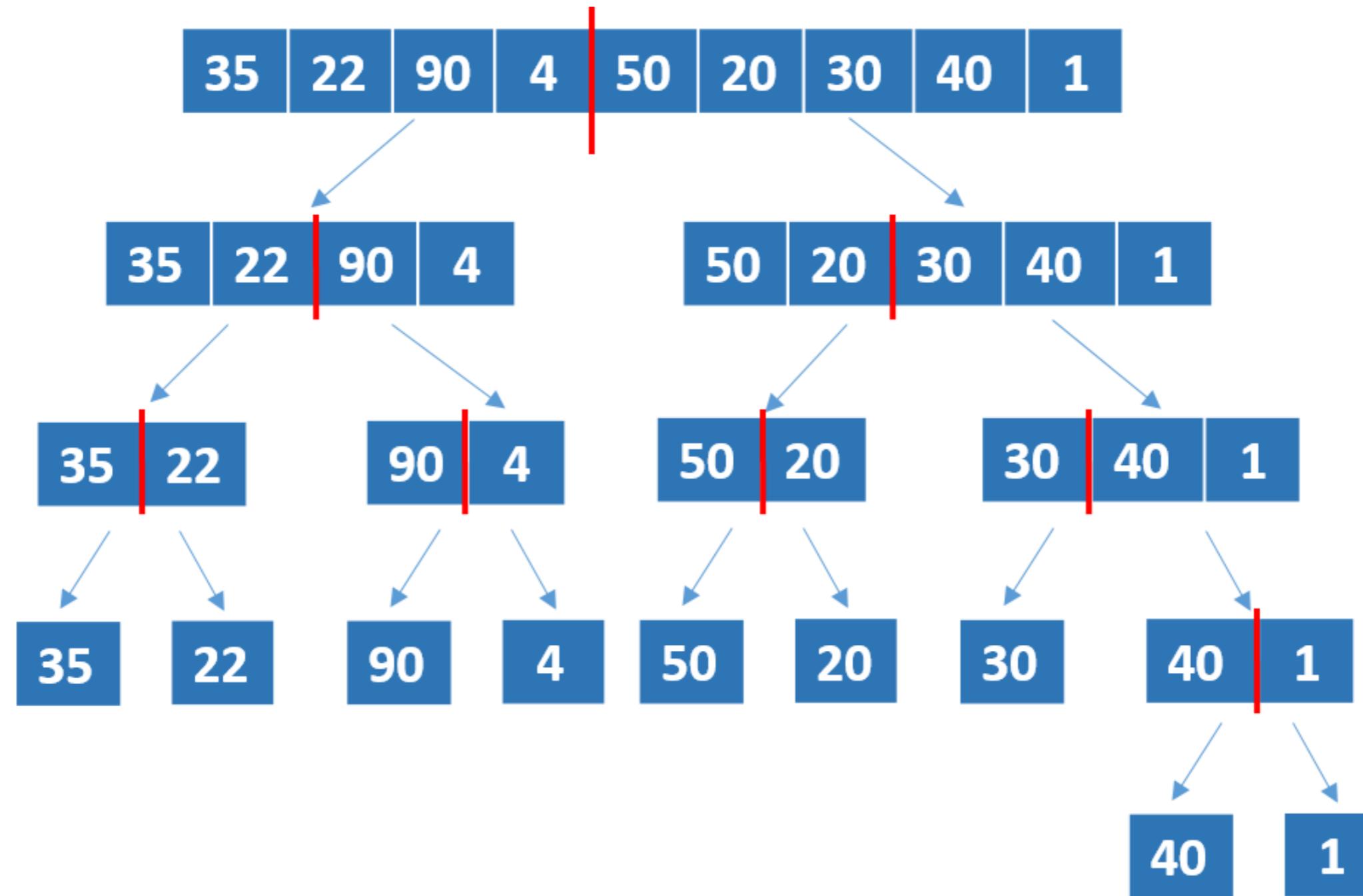
Merge sort - in action



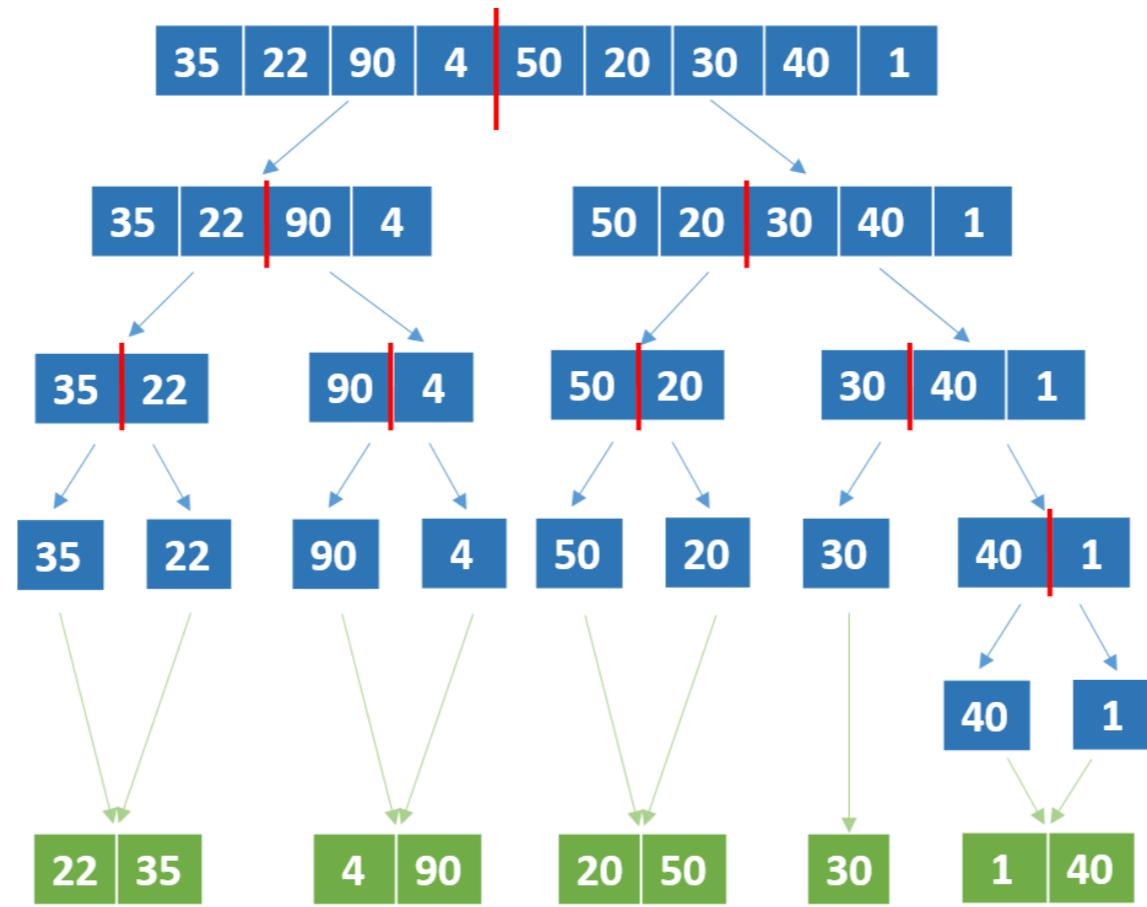
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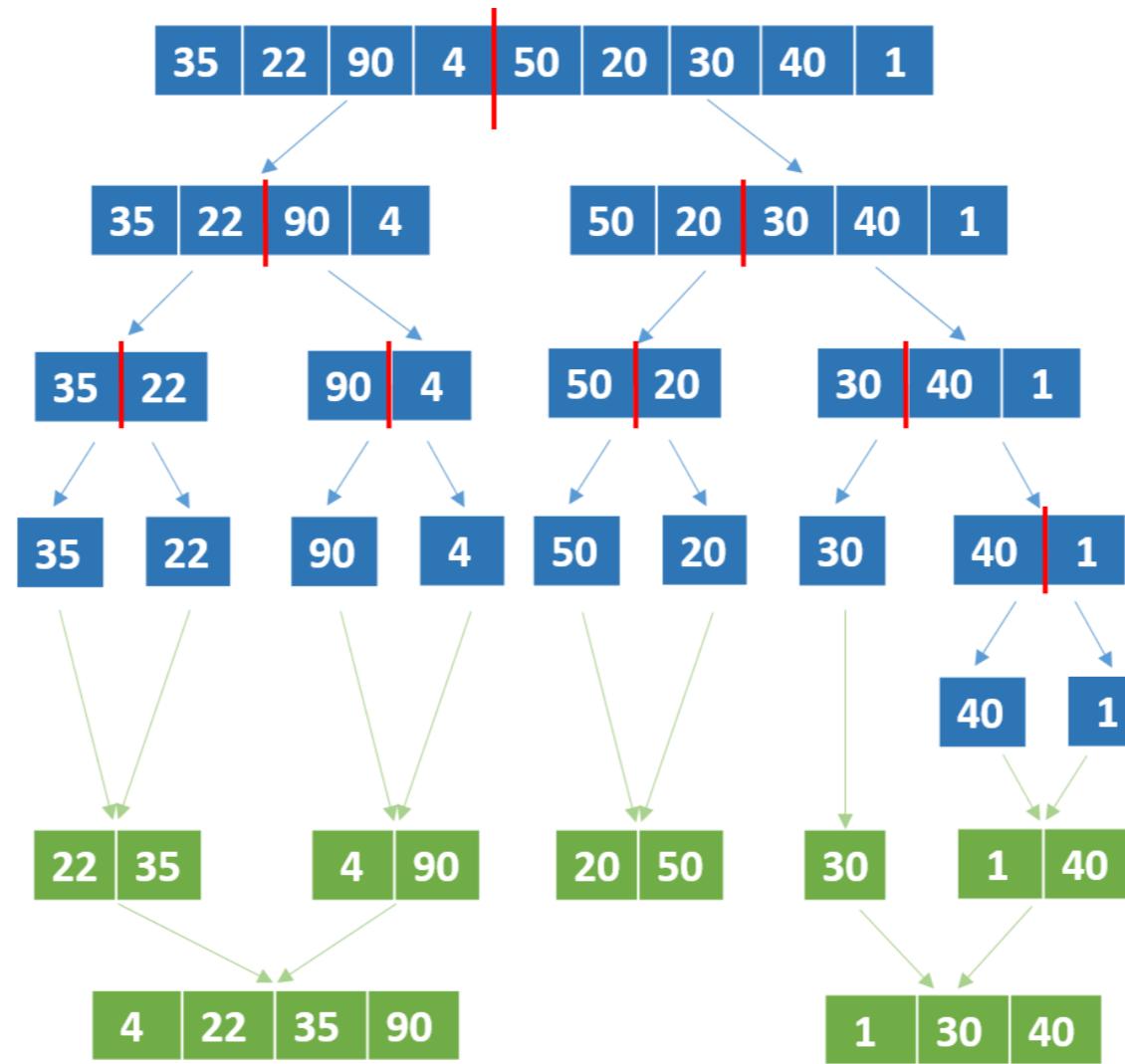
Merge sort - in action



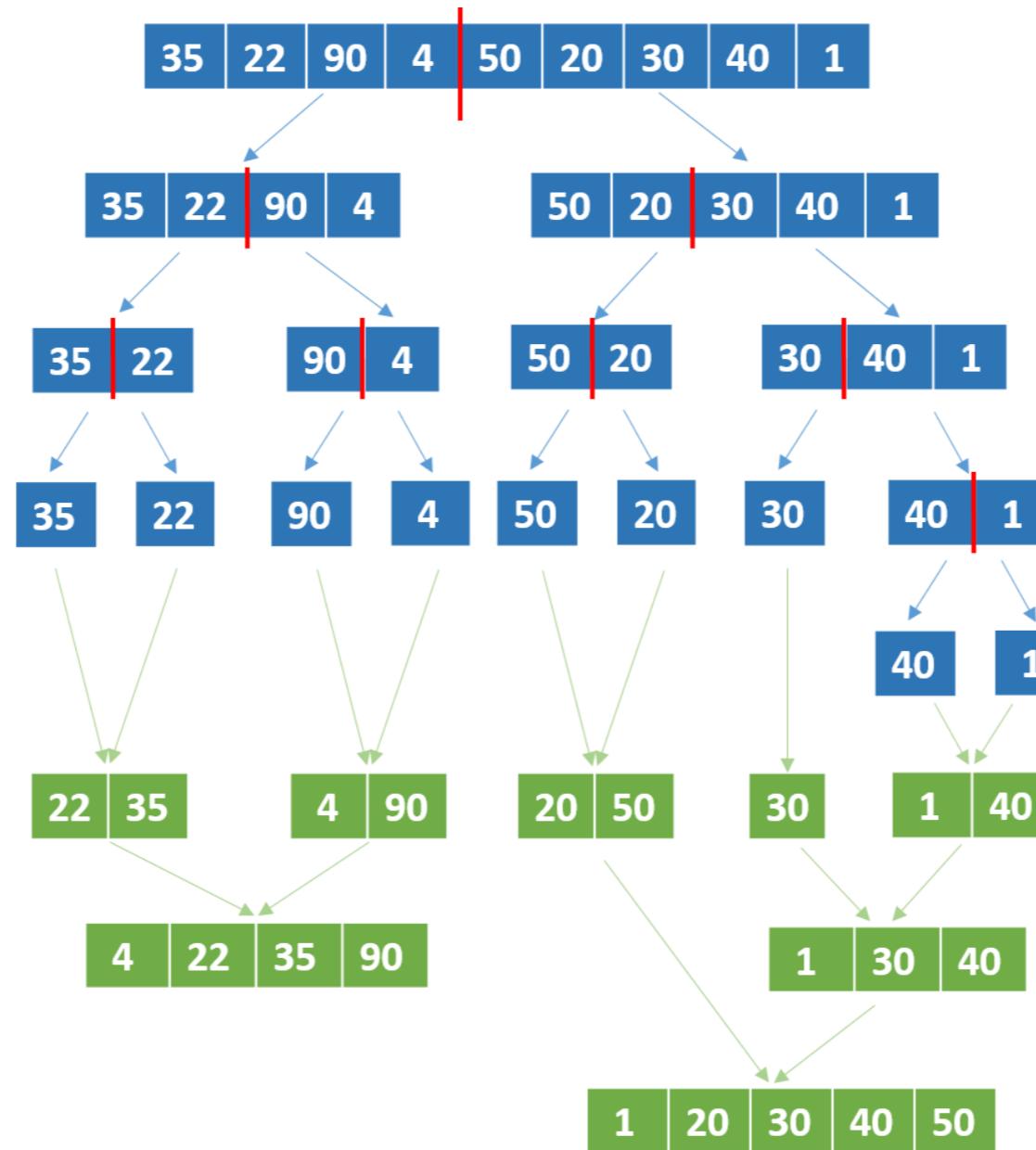
Merge sort - in action



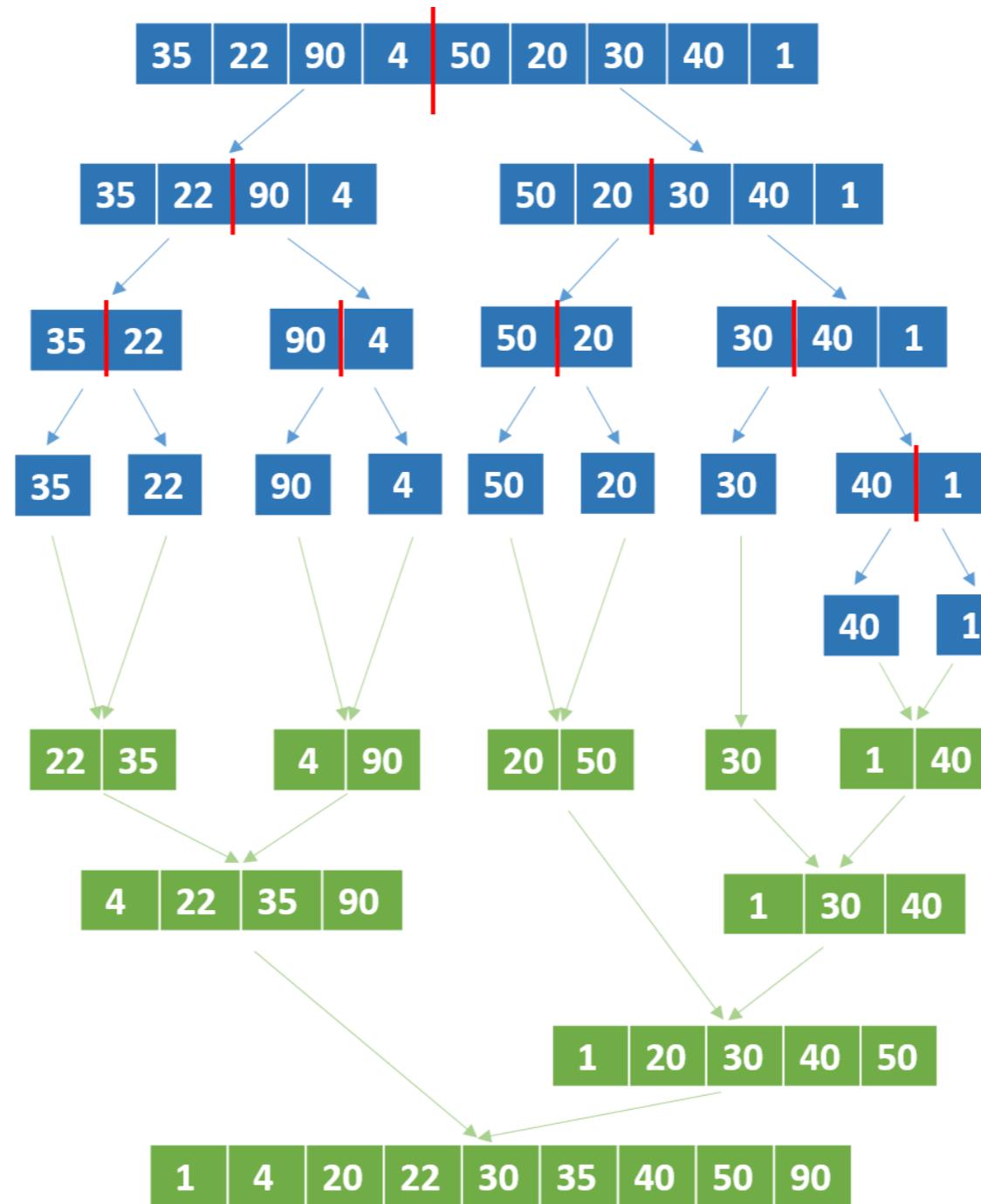
Merge sort - in action



Merge sort - in action



Merge sort - in action



Merge sort - implementation

```
def merge_sort(my_list):
    if len(my_list) > 1:
        mid = len(my_list)//2
        left_half = my_list[:mid]
        right_half = my_list[mid:]
        merge_sort(left_half)
        merge_sort(right_half)

        i = j = k = 0
        while i < len(left_half) and j < len(right_half):
            if left_half[i] < right_half[j]:
                my_list[k] = left_half[i]
                i += 1
            else:
                my_list[k] = right_half[j]
                j += 1
            k += 1
```

```
while i < len(left_half):
    my_list[k] = left_half[i]
    i += 1
    k += 1

while j < len(right_half):
    my_list[k] = right_half[j]
    j += 1
    k += 1
```

```
my_list = [35, 22, 90, 4, 50, 20, 30, 40, 1]
merge_sort(my_list)
print(my_list)
```

```
[1, 4, 20, 22, 30, 35, 40, 50, 90]
```

Merge sort - complexity

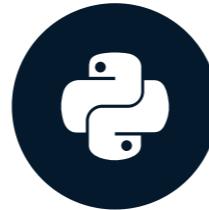
- Worst case: $O(n \log n)$
 - significant improvement over bubble sort, selection sort, and insertion sort
 - suitable for sorting large lists
- Average case: $\Theta(n \log n)$
- Best case: $\Omega(n \log n)$
 - other algorithms (e.g. bubble sort, insertion sort) have better best case complexity
- Space complexity: $O(n)$
 - worst space complexity than other algorithms with $O(1)$
- Other variants reduce this space complexity

Let's practice!

DATA STRUCTURES AND ALGORITHMS IN PYTHON

Quicksort

DATA STRUCTURES AND ALGORITHMS IN PYTHON



Miriam Antona
Software engineer

Quicksort

- Follows **divide and conquer** principle
- Implemented by many **programming languages**
- **Partition** technique
 - **Pivot**
 - items **smaller** than the pivot -> **left**
 - items **greater** than the pivot -> **right**
- Elements to the **left** will be sorted **recursively**
- Elements to the **right** will be sorted **recursively**

Quicksort - in action



Quicksort - in action



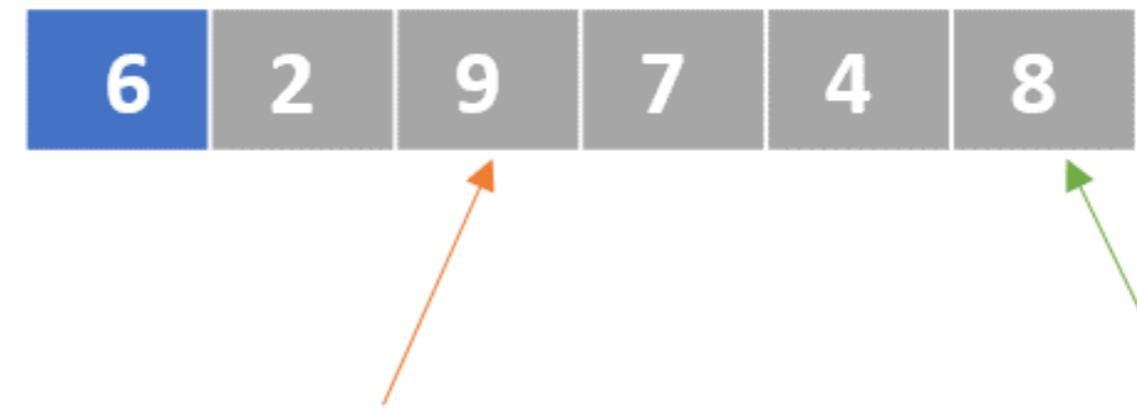
- Hoare's partition

Quicksort - in action



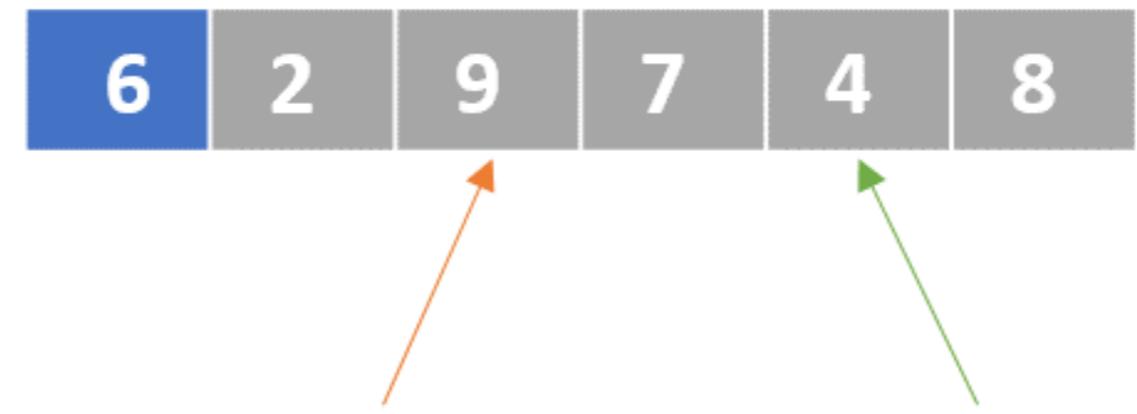
- Hoare's partition
 - Move **left** pointer until a value **greater** than pivot is found

Quicksort - in action



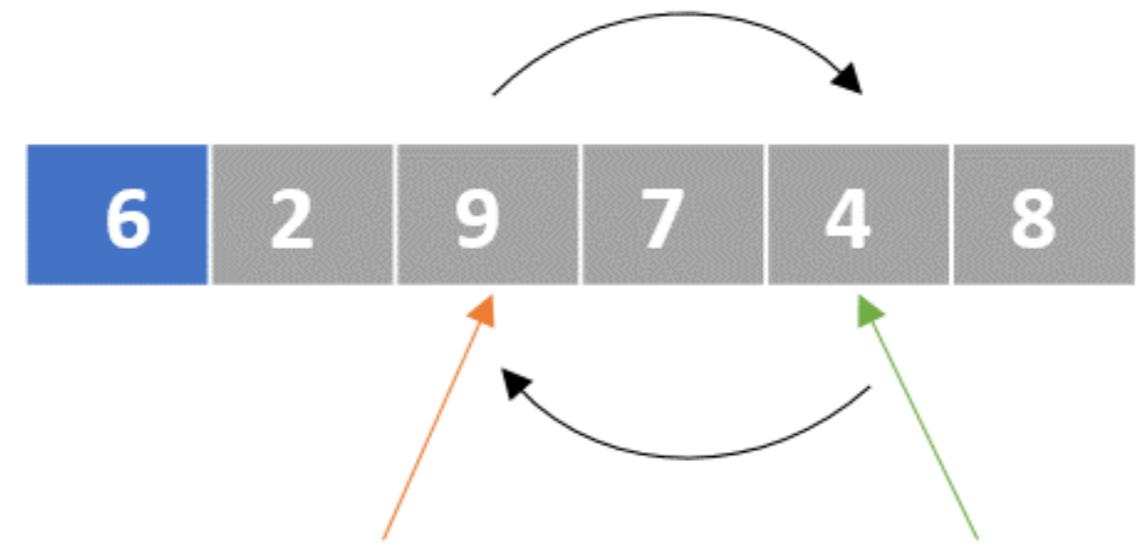
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Quicksort - in action



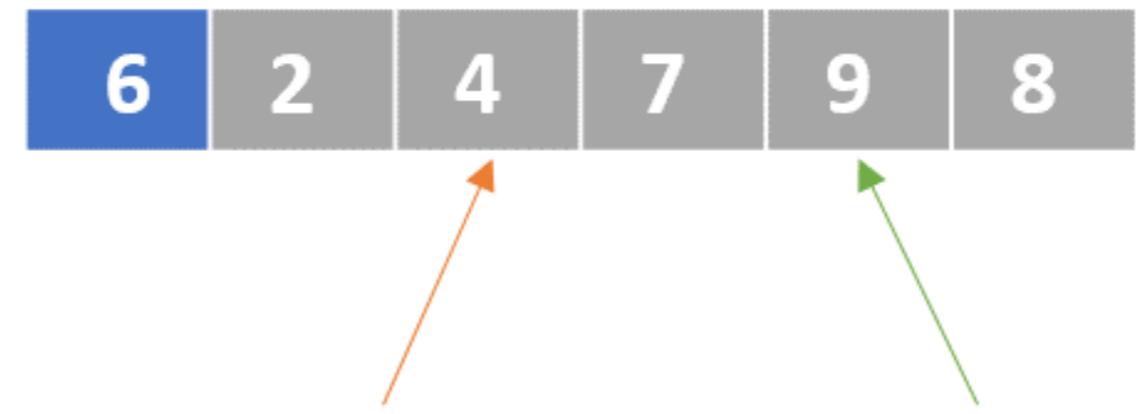
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 - Move **right** pointer until a value **lower** than pivot is found

Quicksort - in action



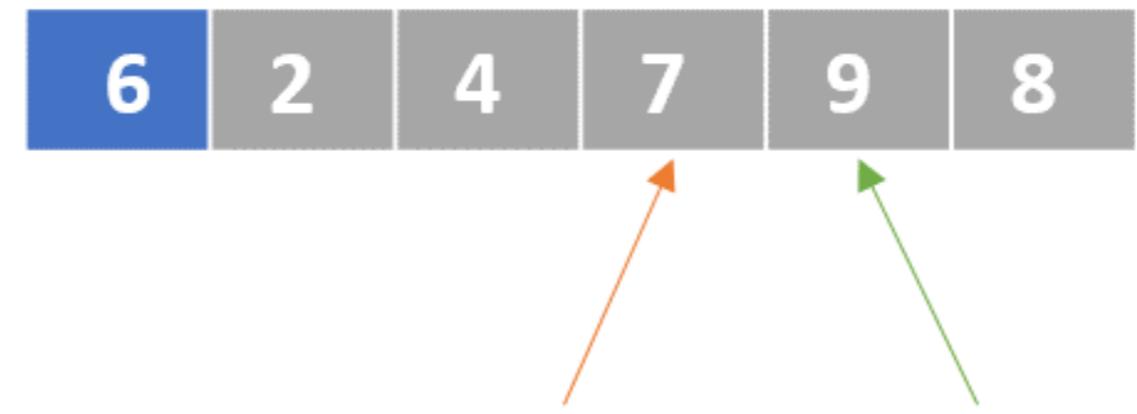
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Quicksort - in action



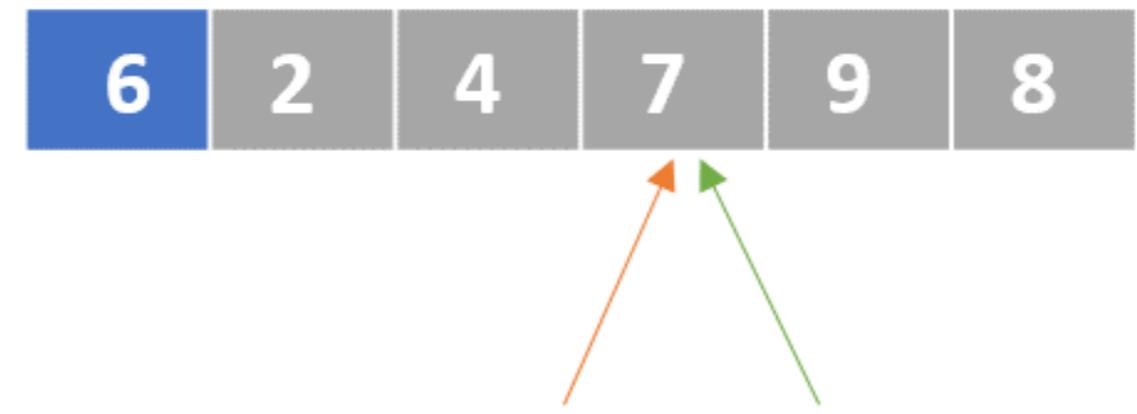
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Quicksort - in action



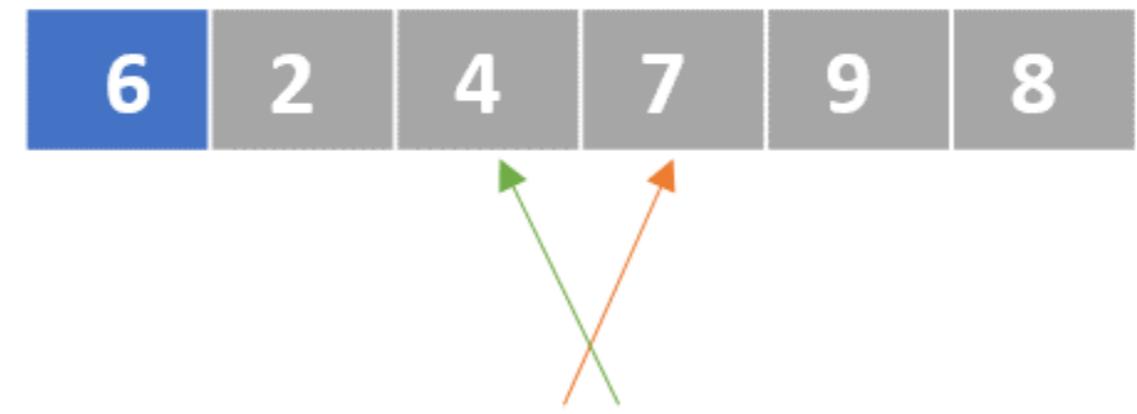
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Quicksort - in action



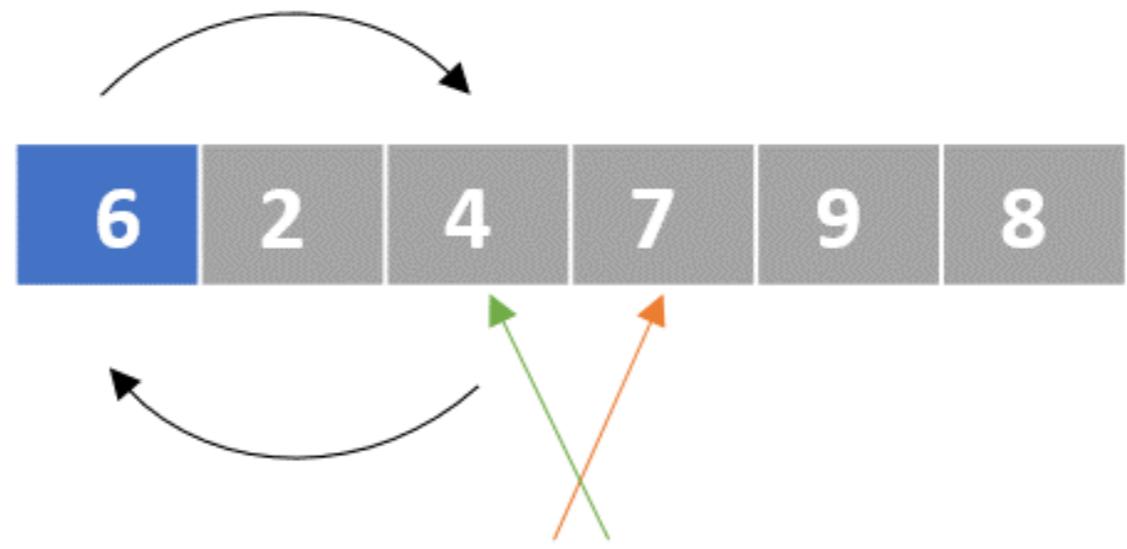
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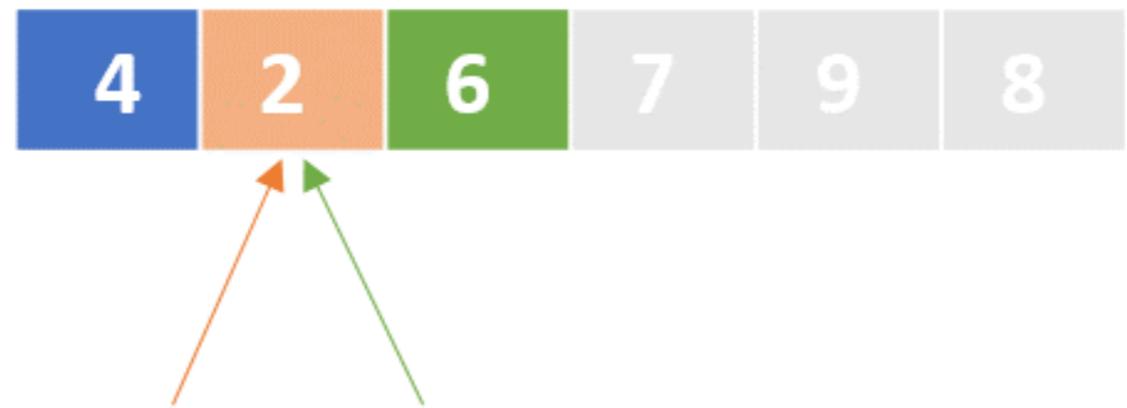
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Quicksort - in action



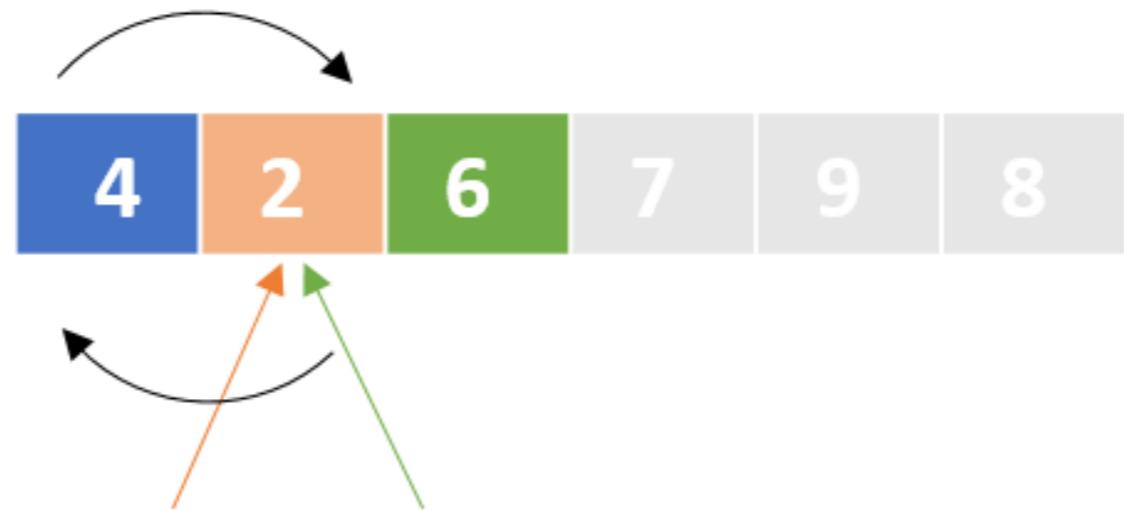
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Quicksort - in action



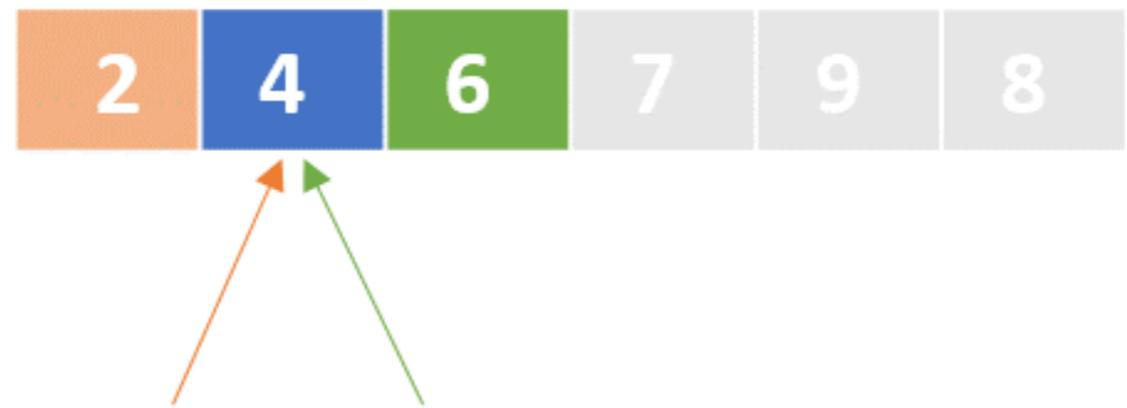
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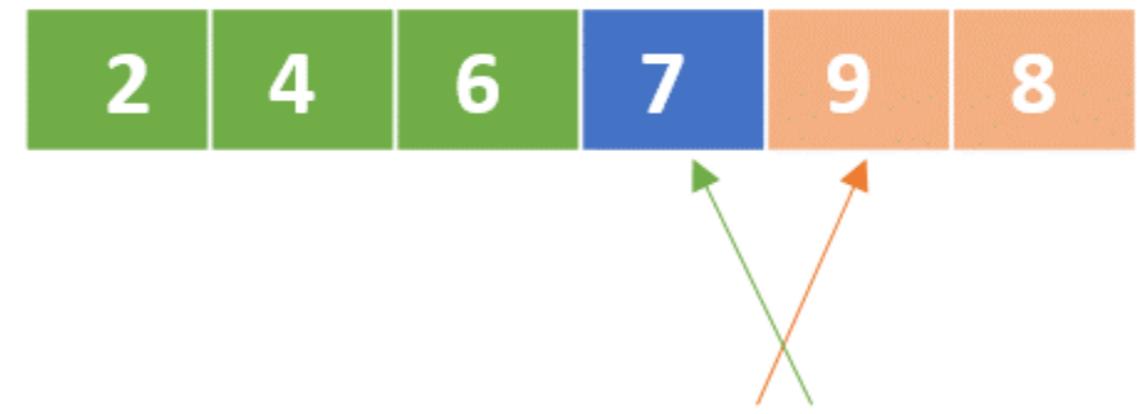
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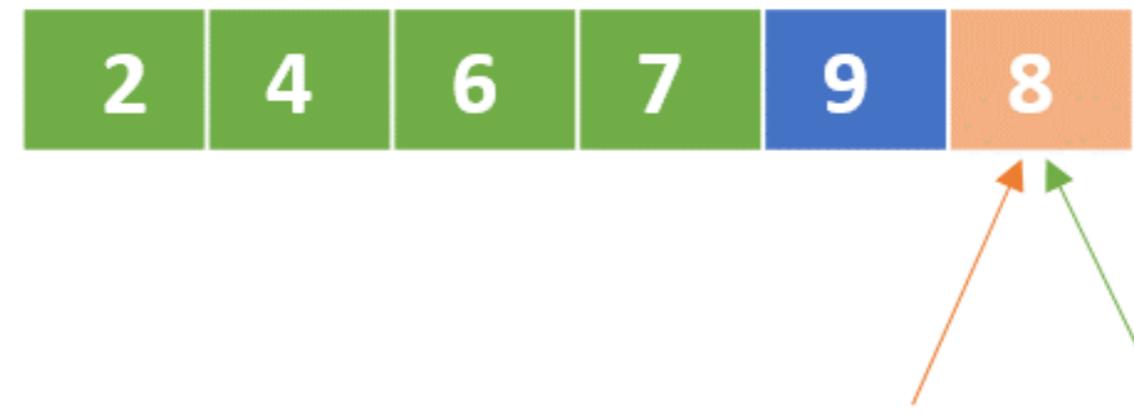
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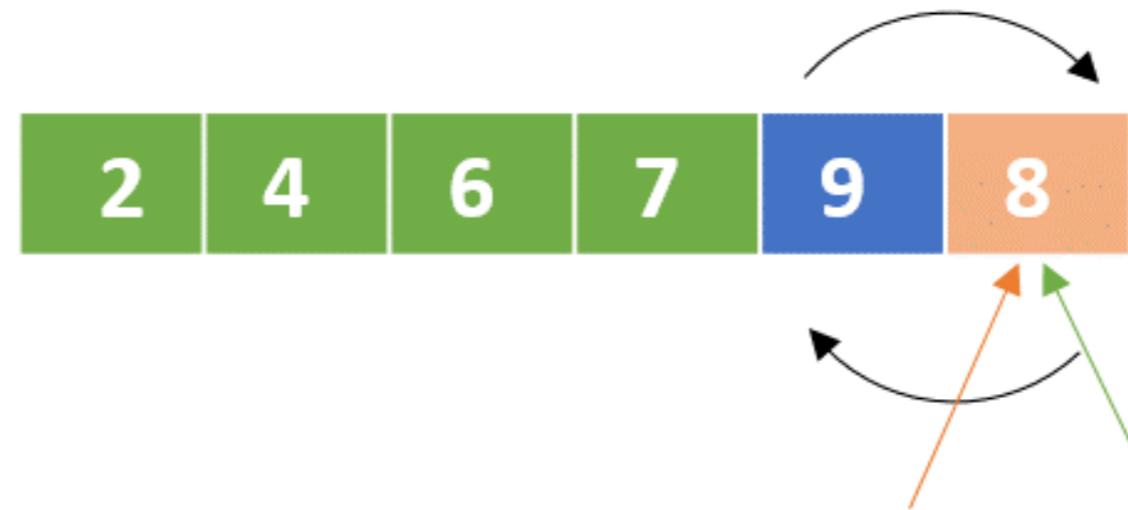
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Quicksort - in action



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Quicksort - implementation

```
def quicksort(my_list, first_index, last_index):
    if first_index < last_index:
        partition_index = partition(my_list, first_index, last_index)
        quicksort(my_list, first_index, partition_index)
        quicksort(my_list, partition_index + 1, last_index)
```

Quicksort - implementation

```
def partition(my_list, first_index, last_index):
    pivot = my_list[first_index]
    left_pointer = first_index + 1
    right_pointer = last_index
    while True:
        while my_list[left_pointer] < pivot and left_pointer < last_index:
            left_pointer += 1
        while my_list[right_pointer] > pivot and right_pointer >= first_index:
            right_pointer -= 1
        if left_pointer >= right_pointer:
            break
        my_list[left_pointer], my_list[right_pointer] = my_list[right_pointer], my_list[left_pointer]
    my_list[first_index], my_list[right_pointer] = my_list[right_pointer], my_list[first_index]
    return right_pointer
```

Quicksort - implementation

```
my_list = [6, 2, 9, 7, 4, 8]
quicksort(my_list, 0, len(my_list) - 1)
print(my_list)
```

```
[2, 4, 6, 7, 8, 9]
```

Quicksort - complexity

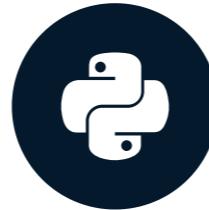
- Worst case: $O(n^2)$
- Very efficient!
 - Average case: $\Theta(n \log n)$
 - Best case: $\Omega(n \log n)$
- Space complexity: $O(n \log n)$

Let's practice!

DATA STRUCTURES AND ALGORITHMS IN PYTHON

Congratulations!

DATA STRUCTURES AND ALGORITHMS IN PYTHON



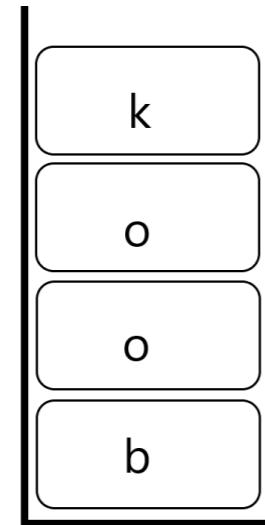
Miriam Antona
Software engineer

Chapter 1

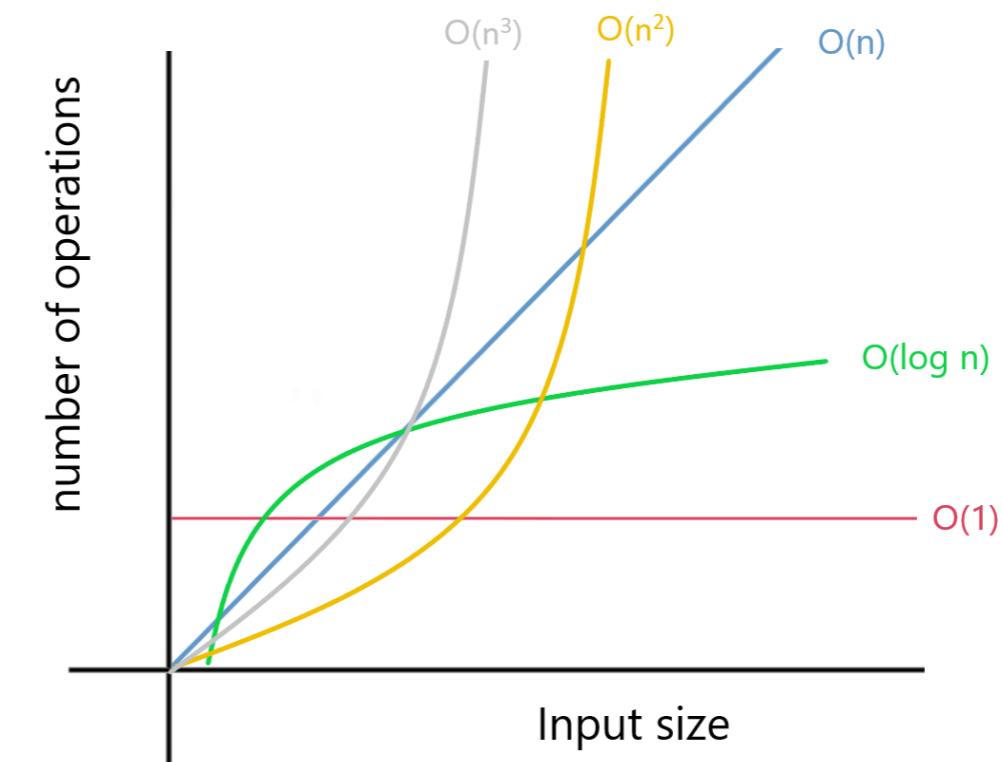
- What algorithms and data structures are
- Linked lists



- Stacks

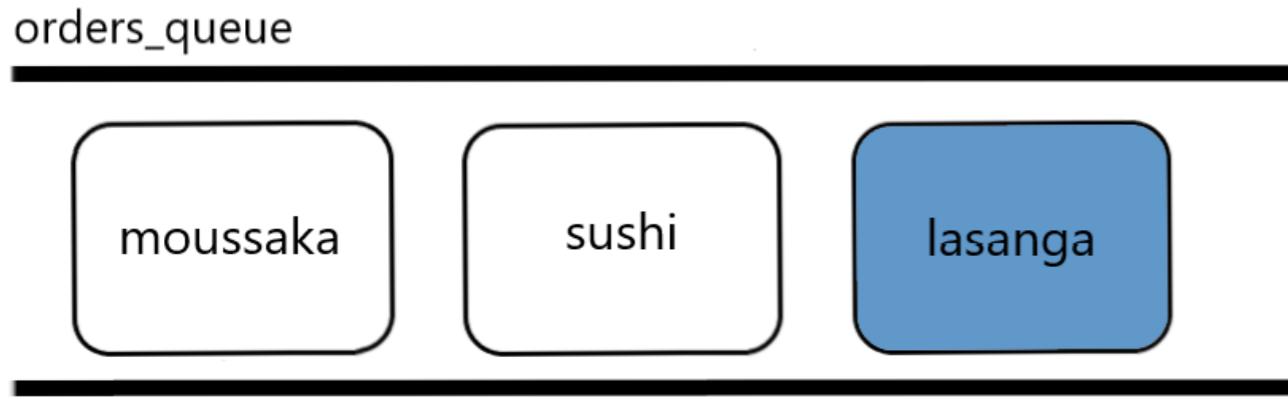


- Calculate time complexity using Big O Notation



Chapter 2

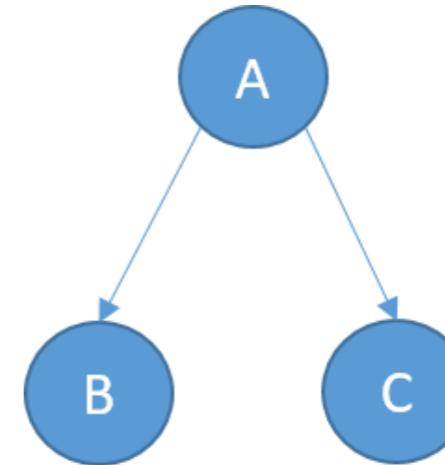
- Queues



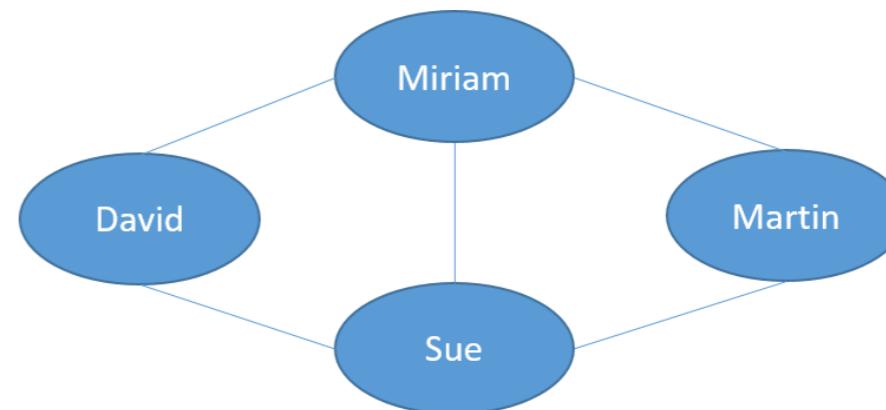
- Hash tables

```
my_menu = {  
    'lasagna': 14.75,  
    'moussaka': 21.15,  
    'sushi': 16.05  
}
```

- Trees



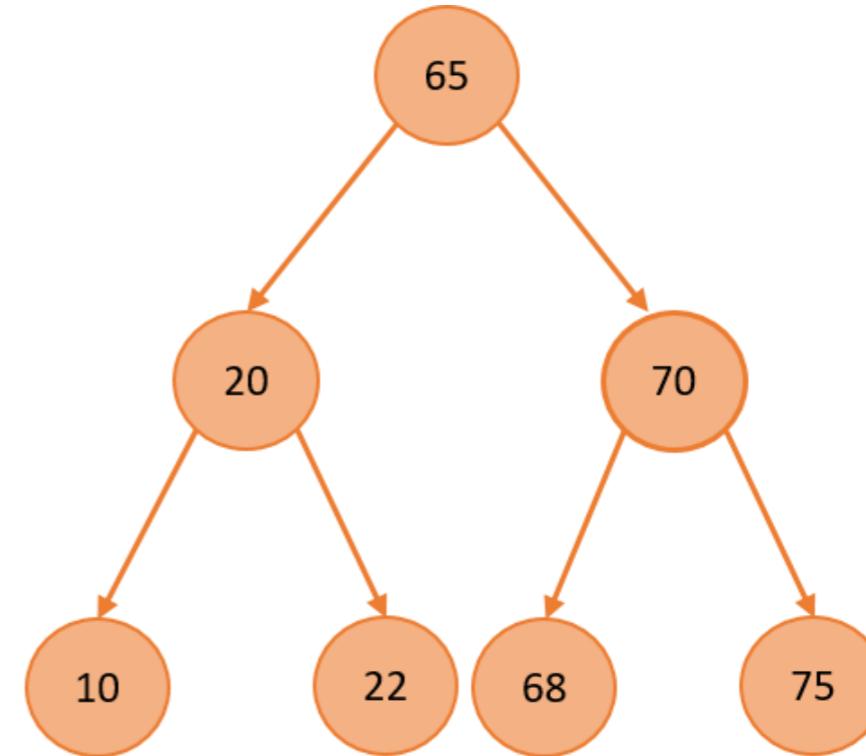
- Graphs



- Recursion

Chapter 3

- Searching algorithms:
 - Linear search
 - Binary search
 - Depth first search
 - Breadth first search
- Binary search trees



Chapter 4

- Sorting algorithms
 - Bubble sort
 - Selection sort
 - Insertion sort
 - Merge sort
 - Quicksort

Thank you!

DATA STRUCTURES AND ALGORITHMS IN PYTHON