Bubble sort

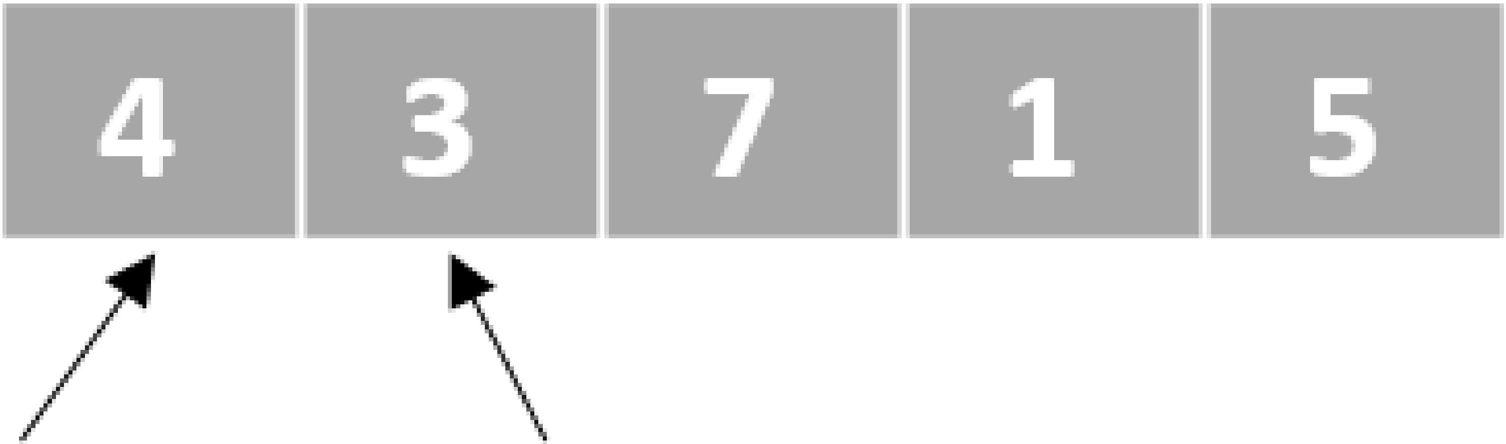
DATA STRUCTURES AND ALGORITHMS IN PYTHON

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

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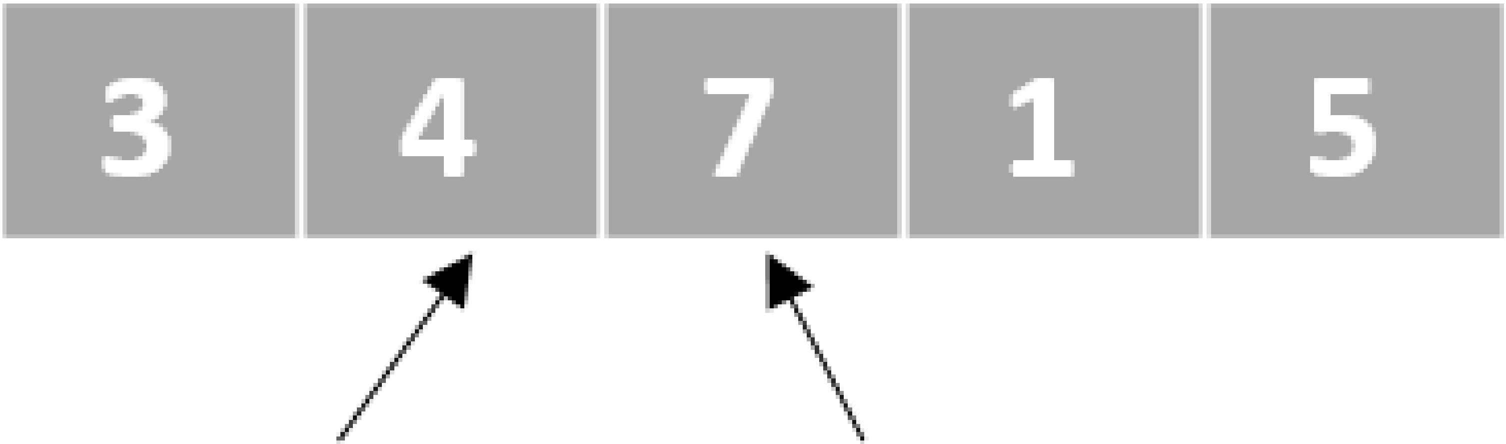

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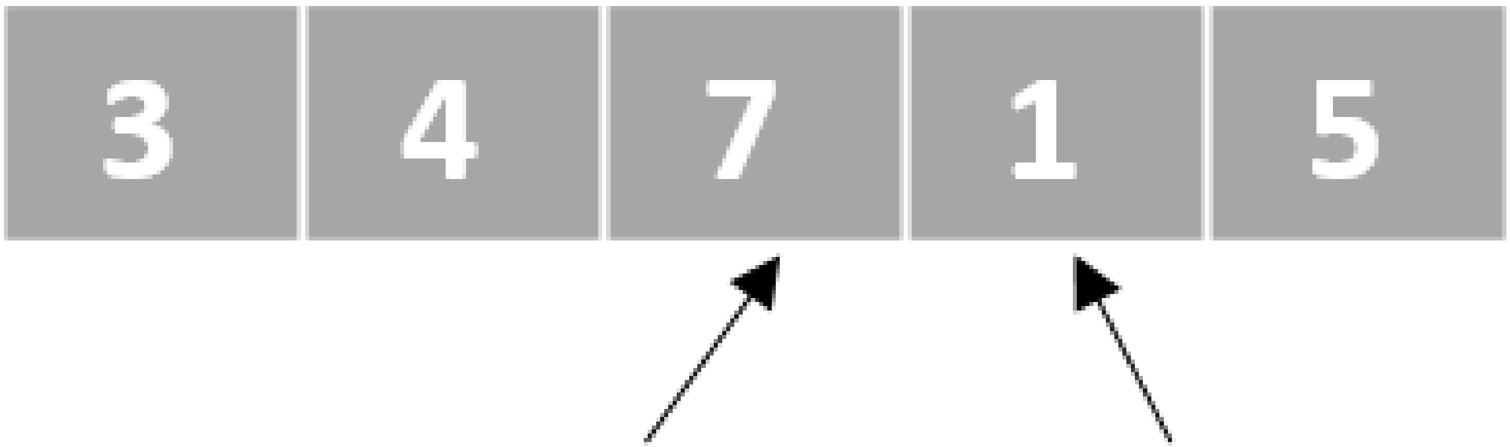

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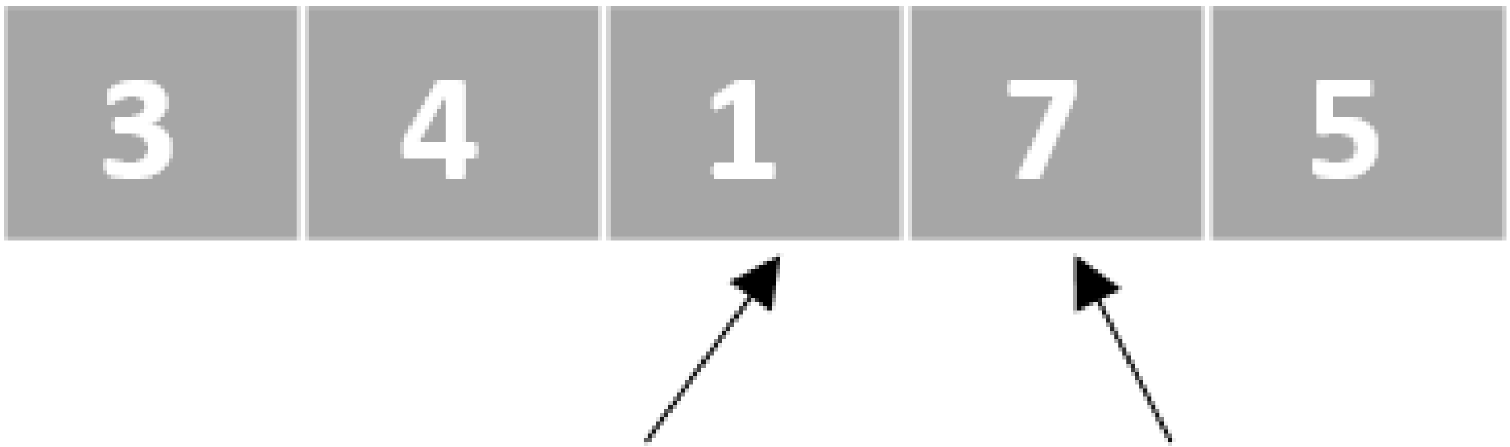

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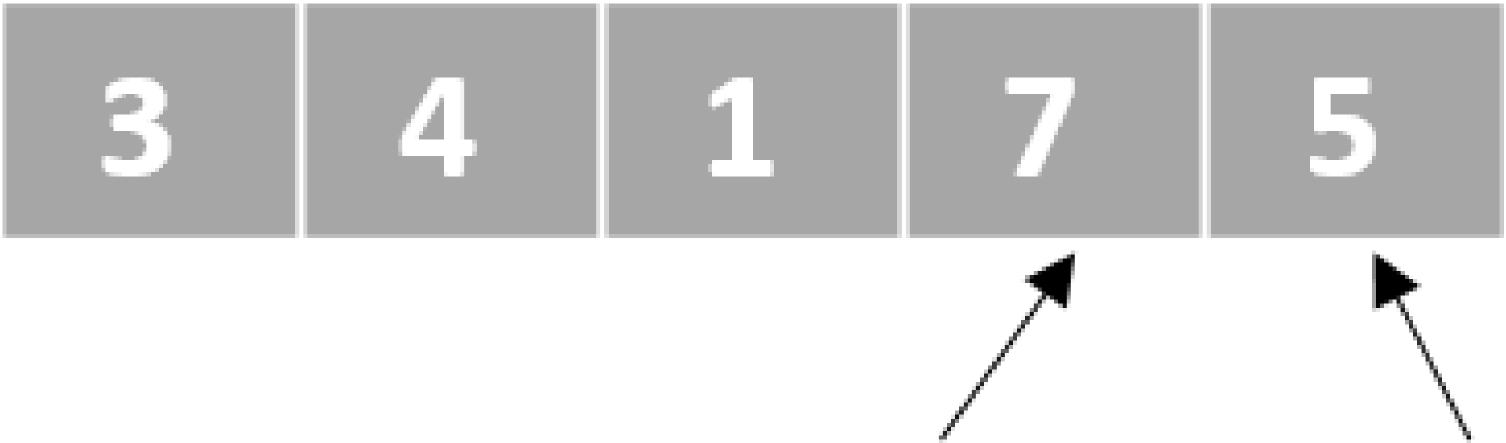

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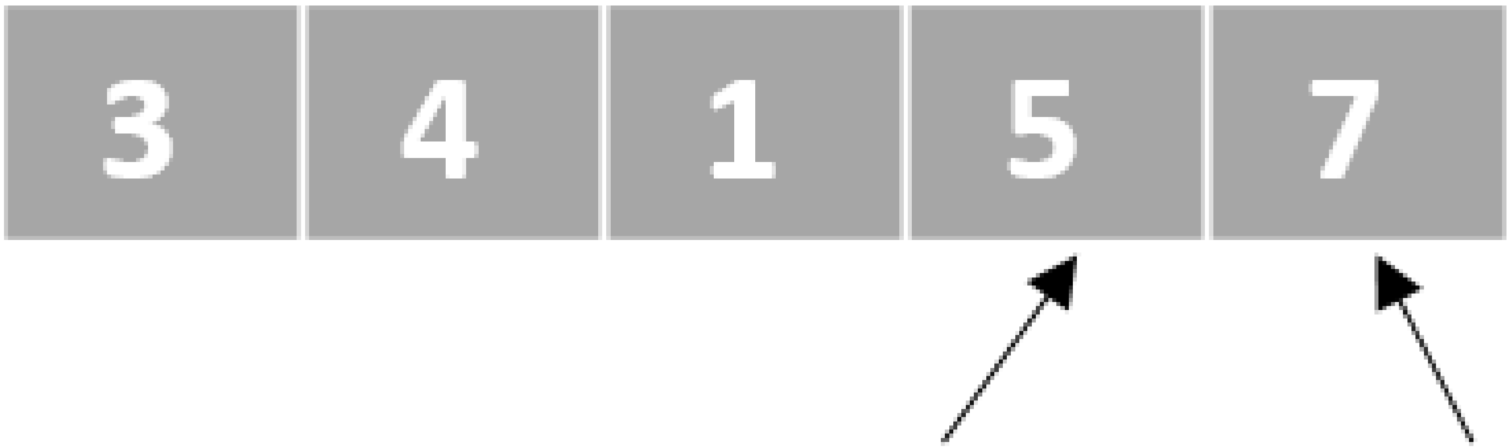

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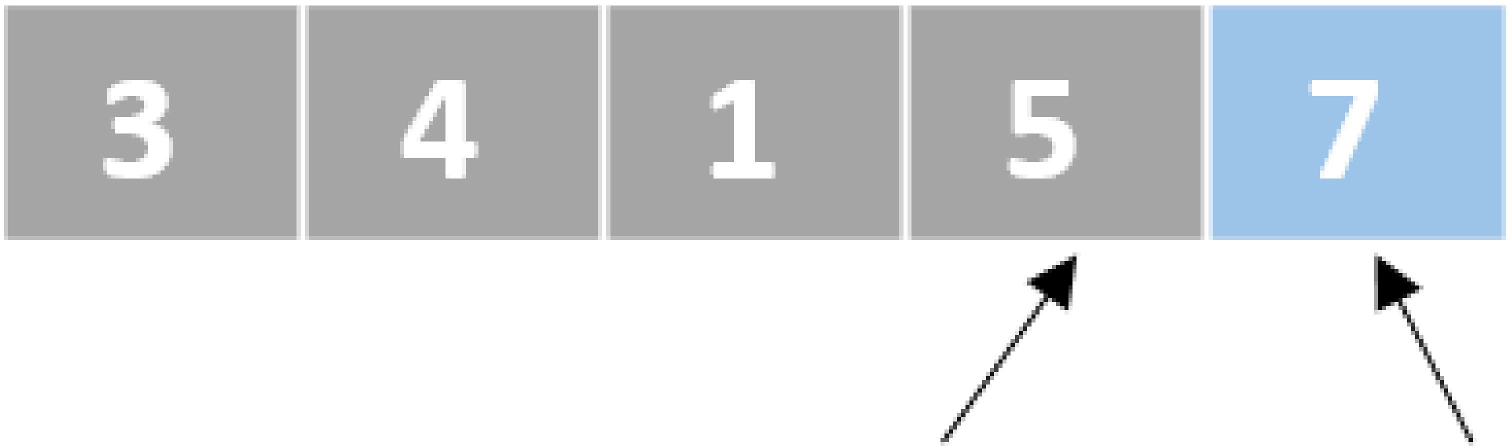

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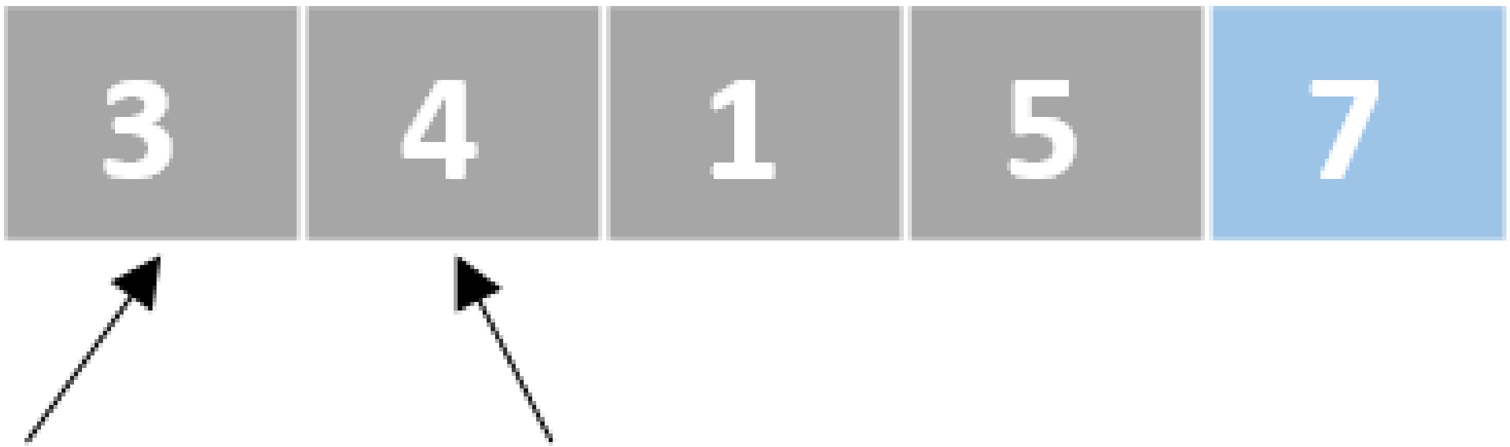

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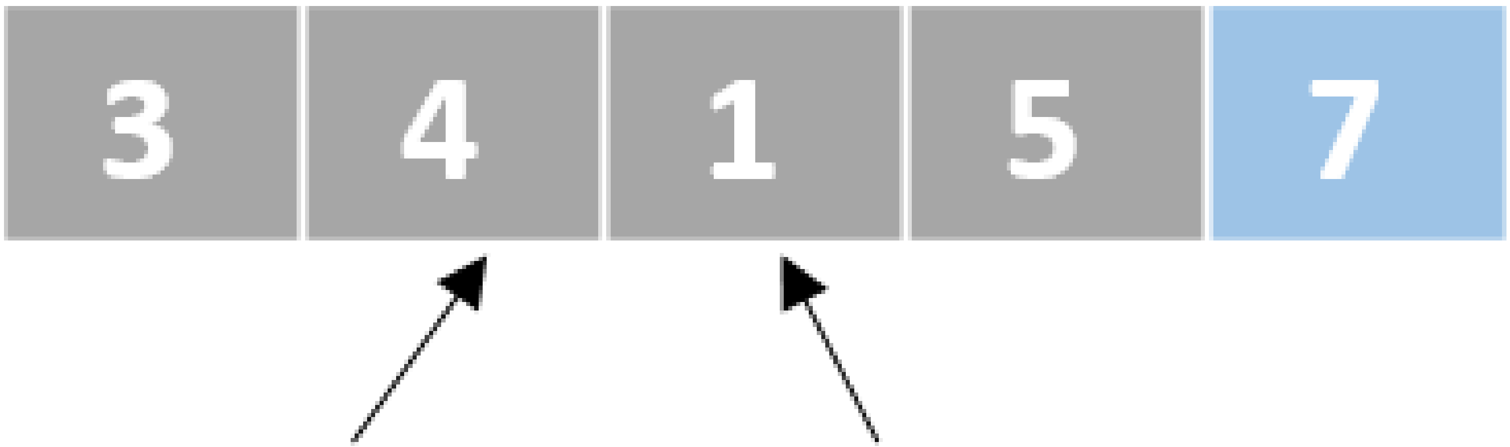

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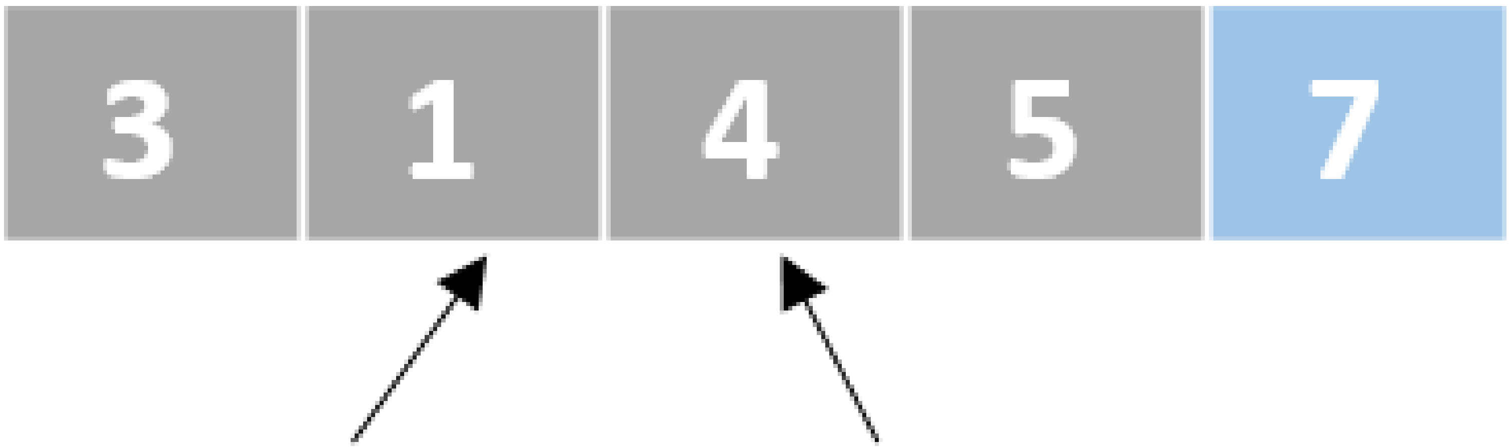

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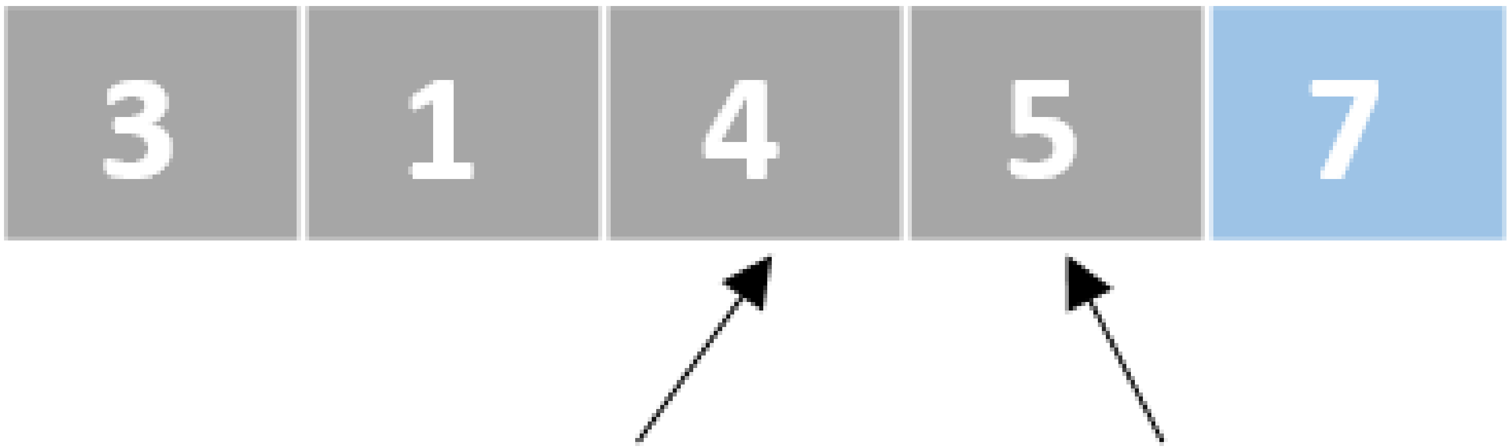

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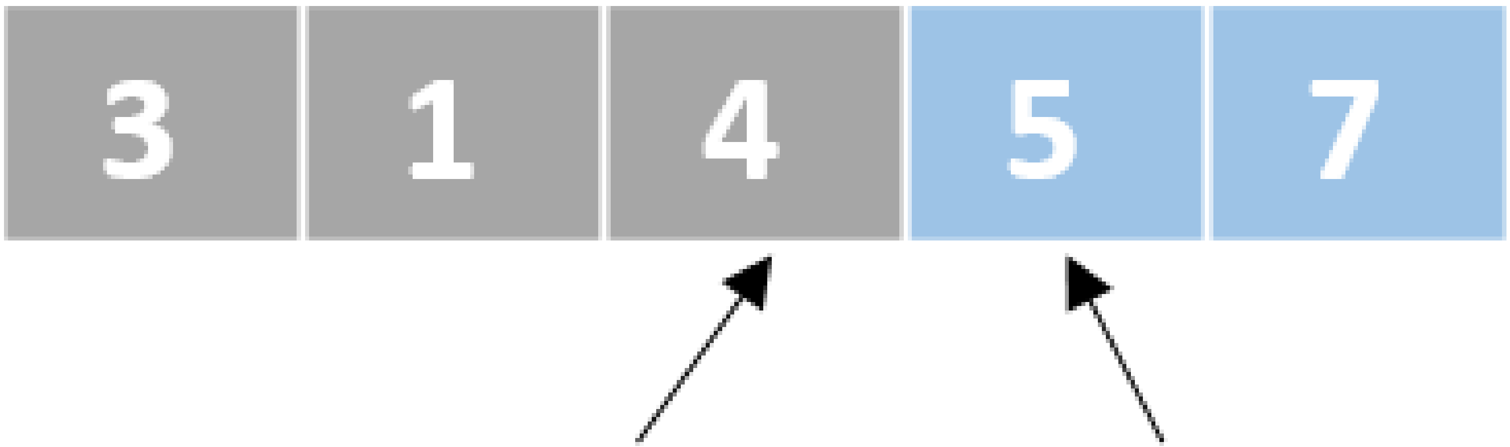

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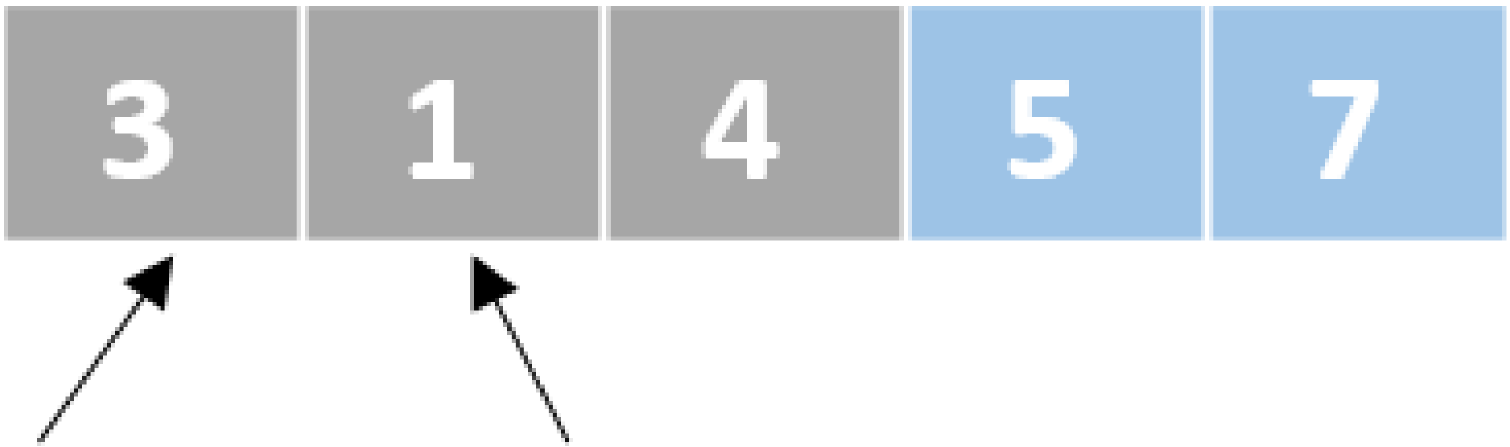

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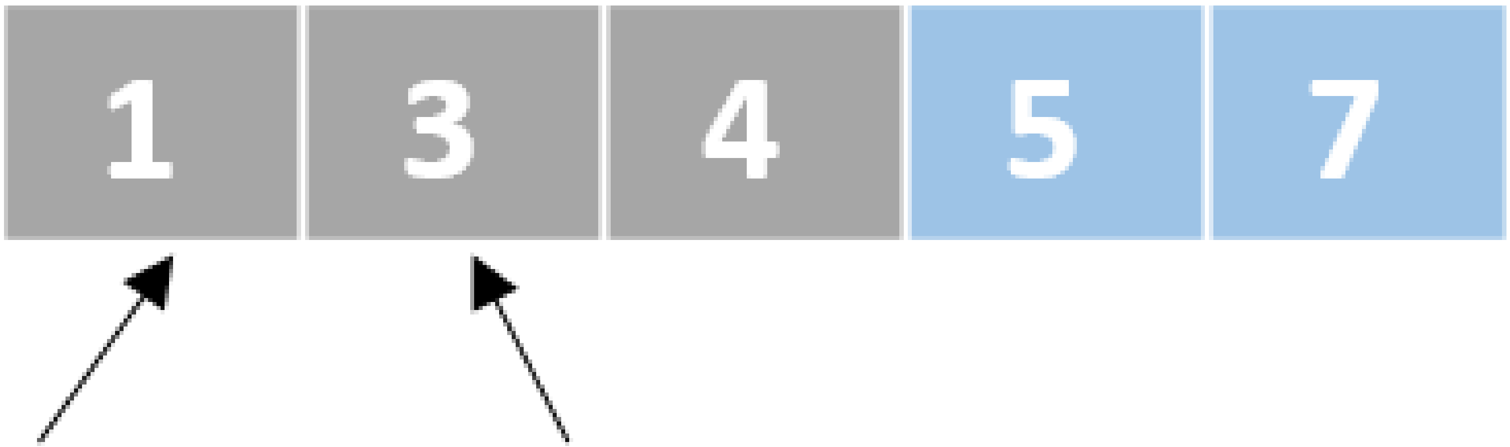

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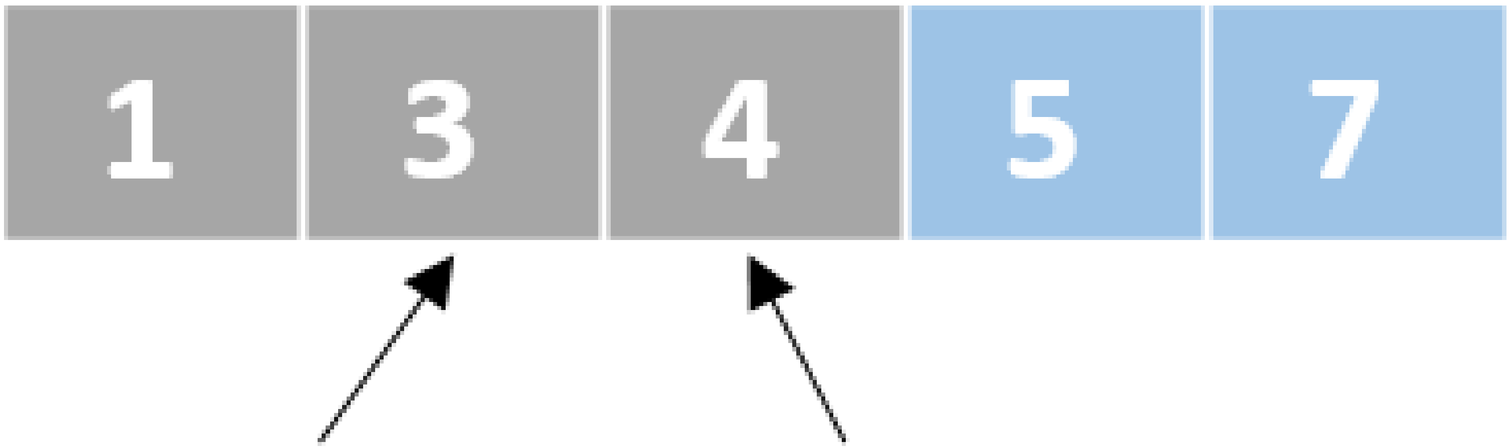

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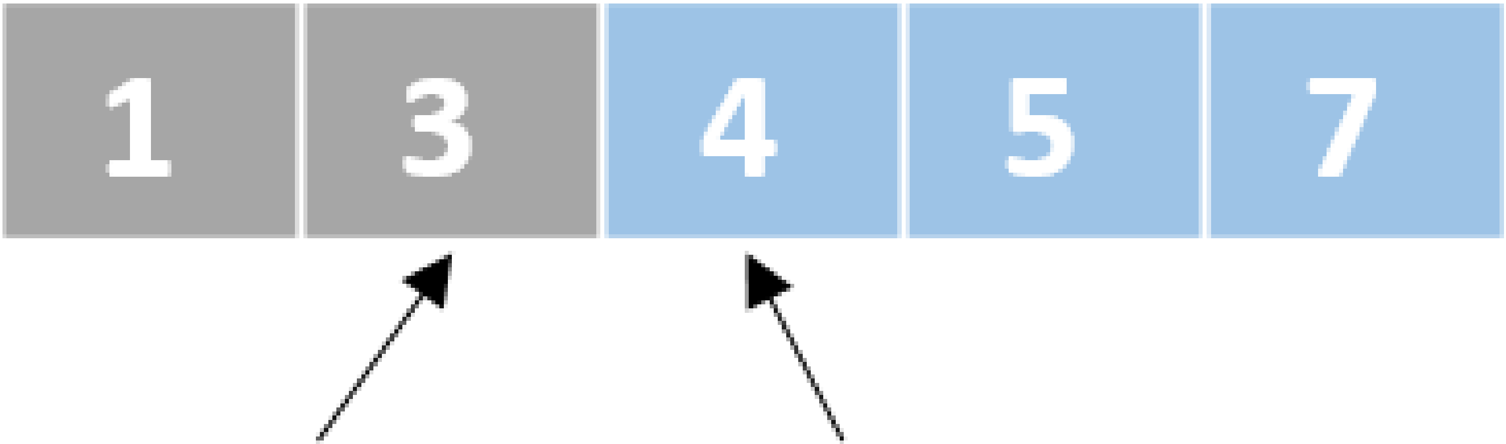

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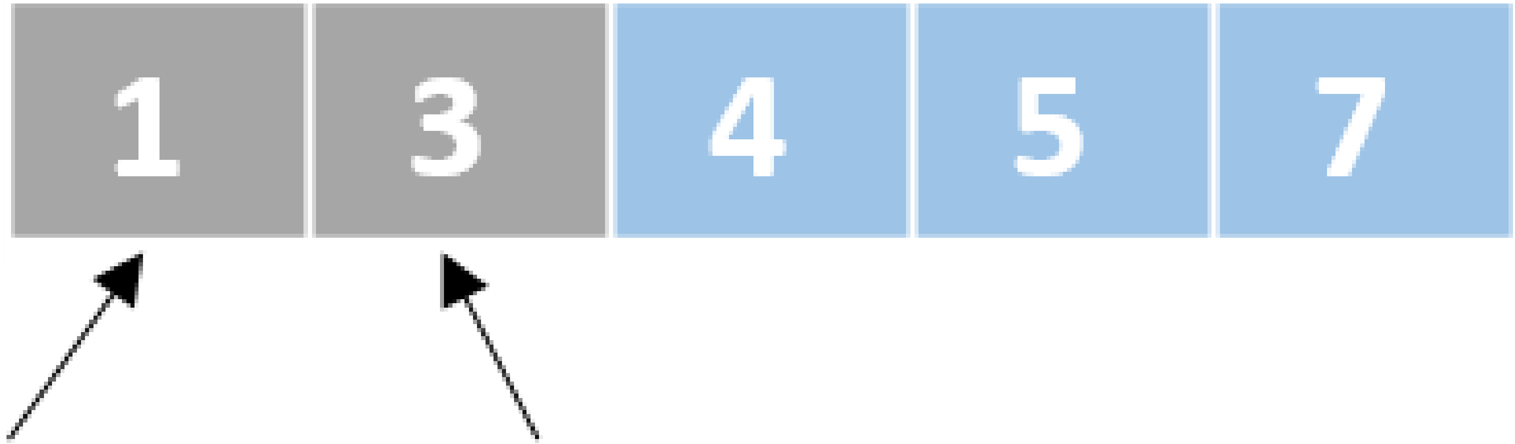

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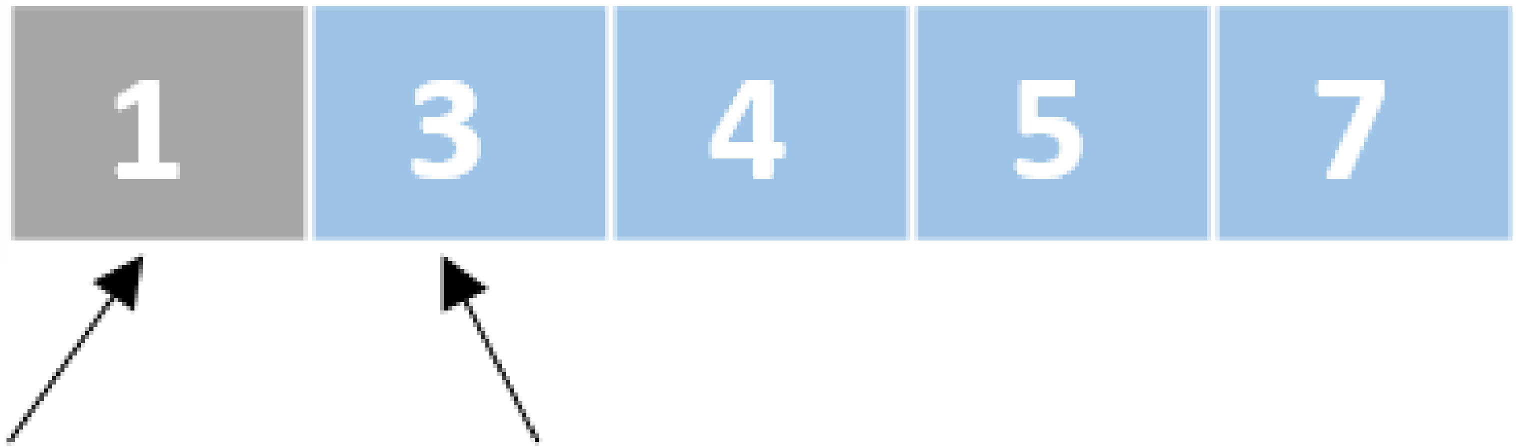

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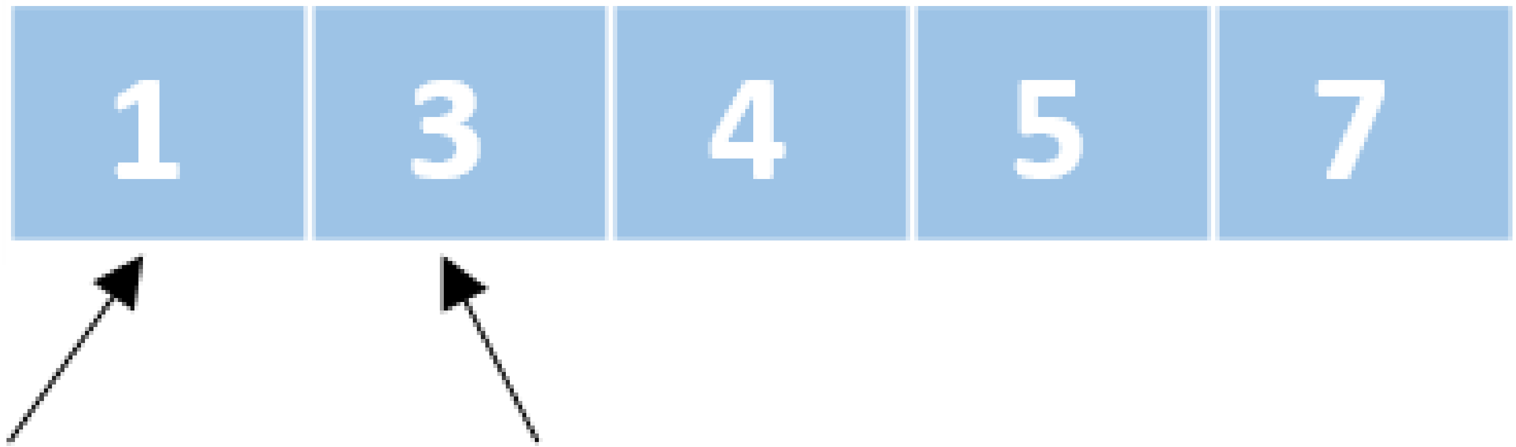

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Bubble sort - implementation

```python
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
```

```python
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!

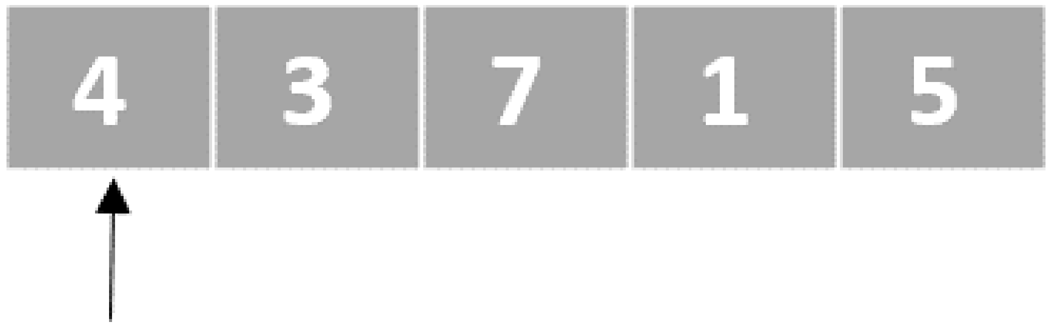
DATA STRUCTURES AND ALGORITHMS IN PYTHON

Selection Sort and Insertion Sort

DATA STRUCTURES AND ALGORITHMS IN PYTHON

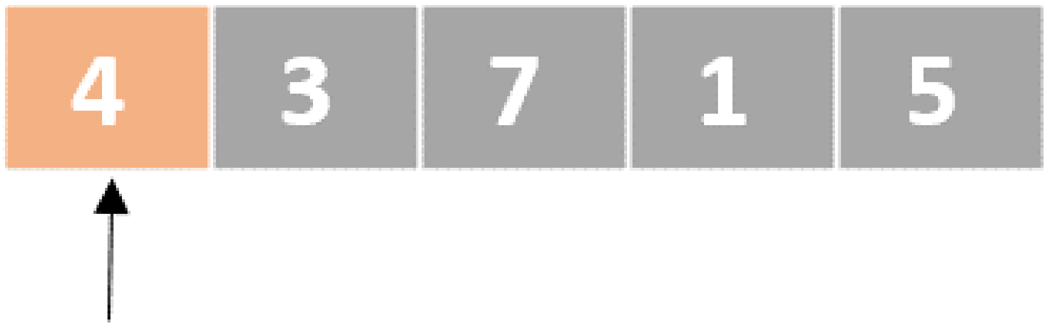
Miriam Antona
Software engineer

Selection sort



- Determine the lowest value

Selection sort



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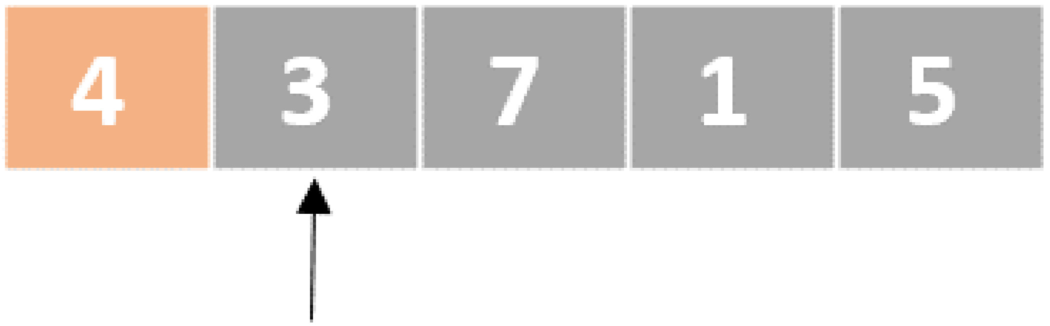

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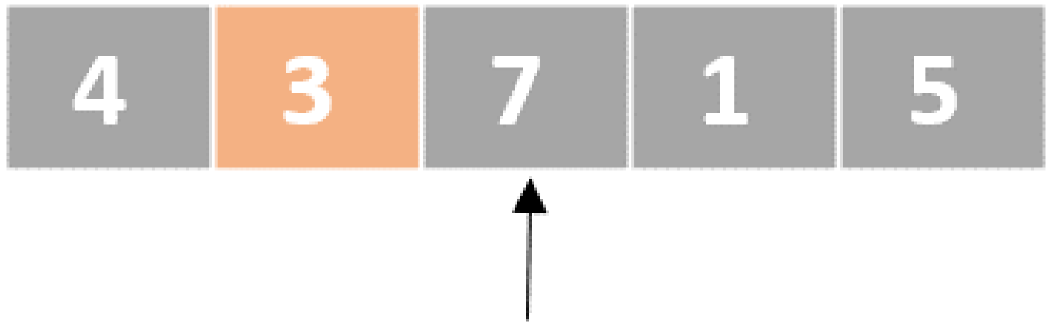

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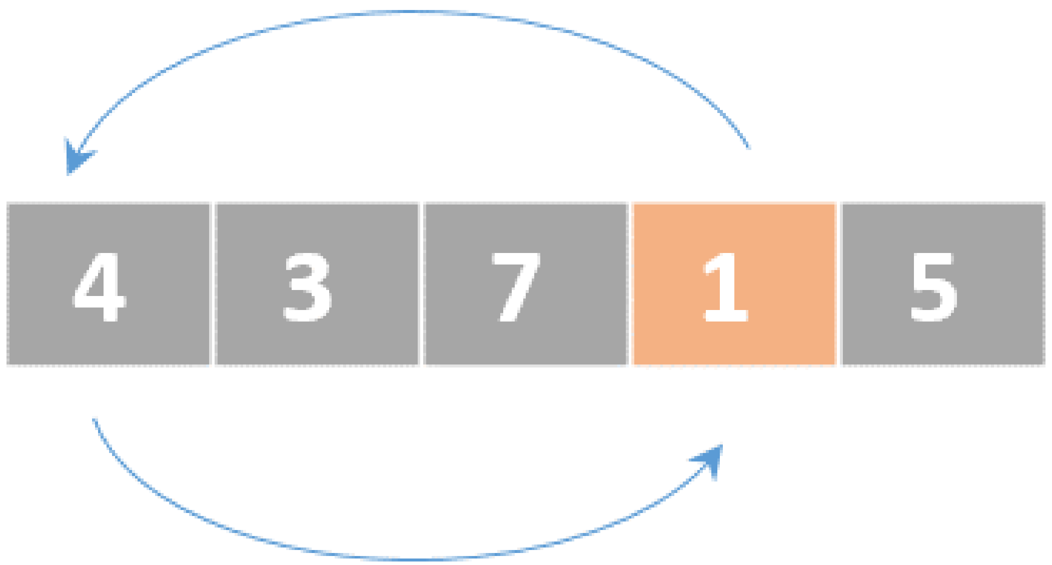

- Determine the lowest value
- Swap the lowest value with the first unordered element

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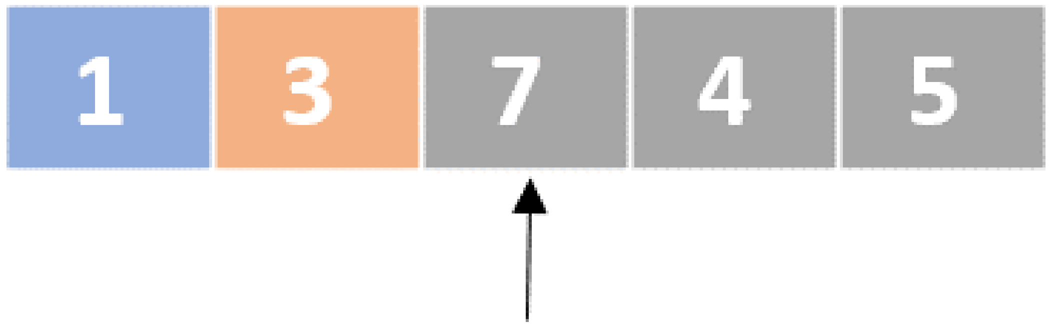

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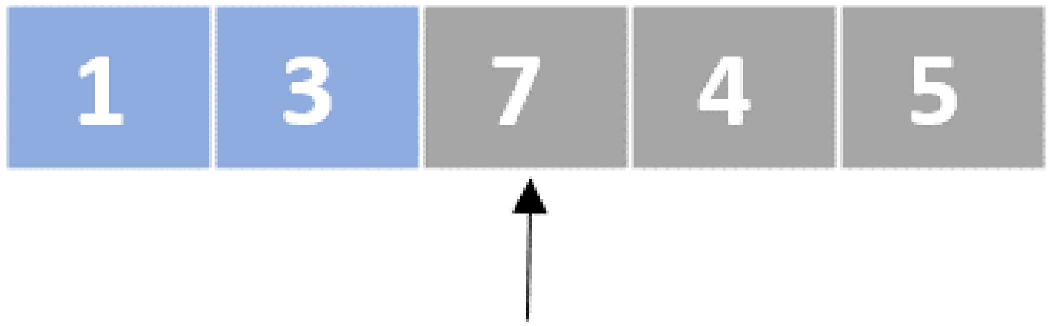

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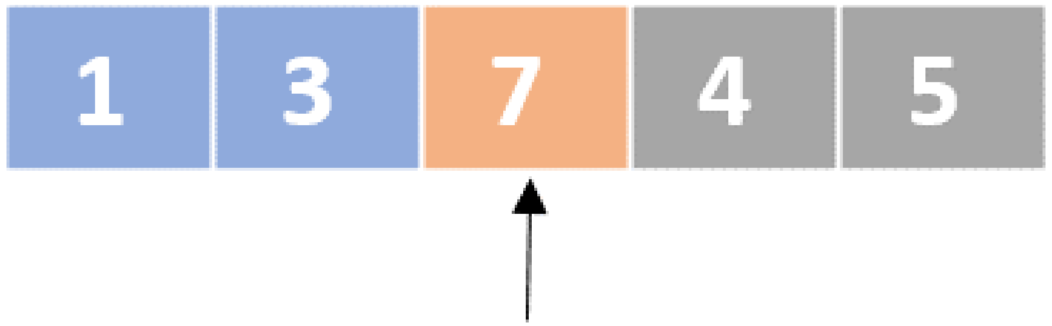

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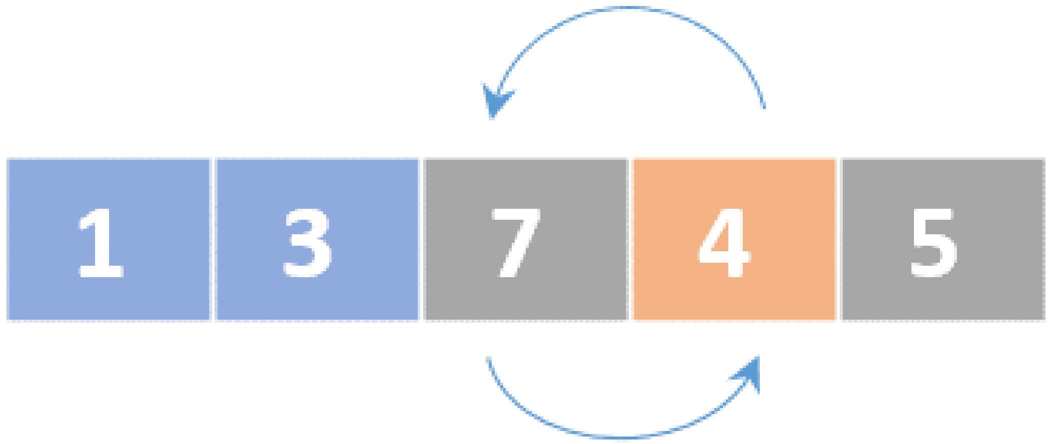

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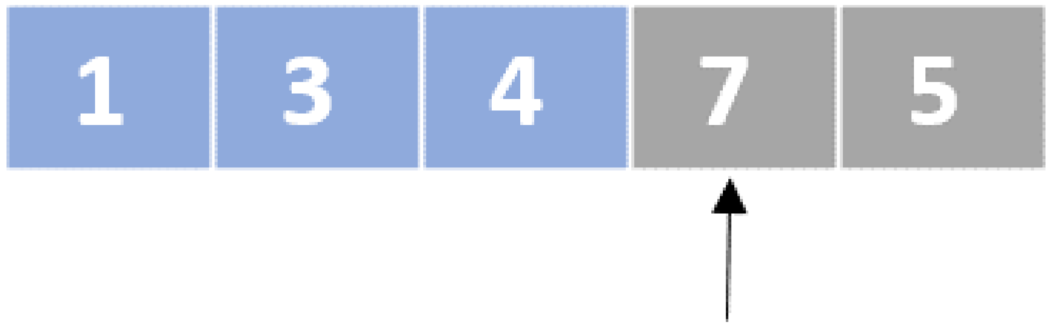

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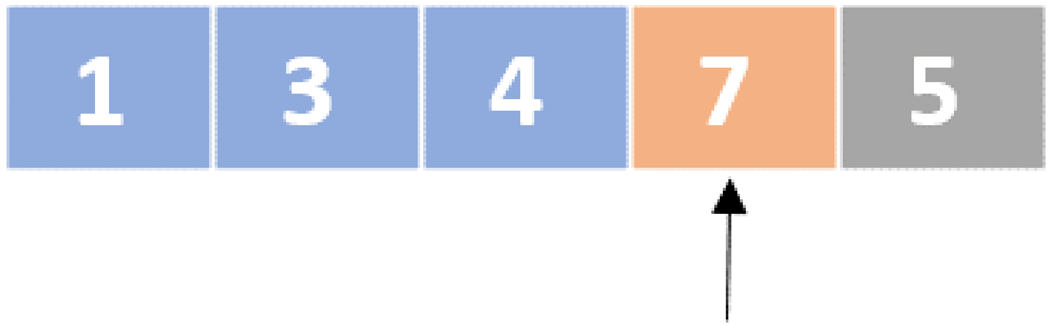

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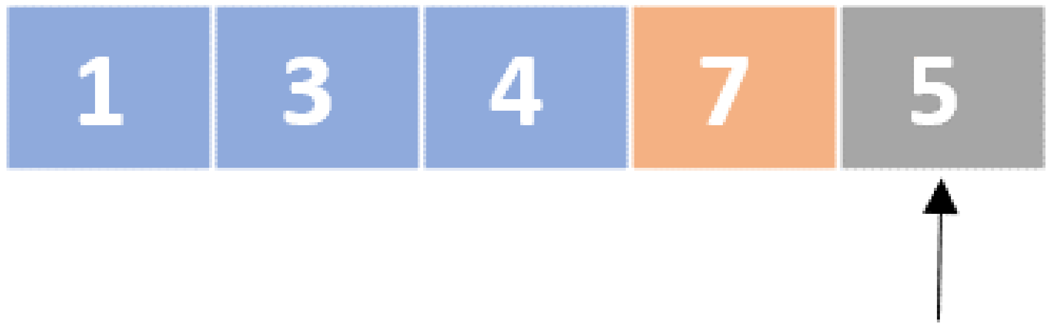

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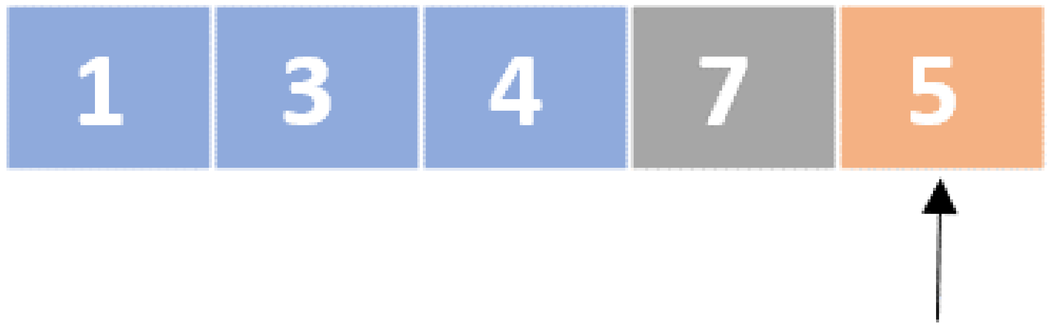

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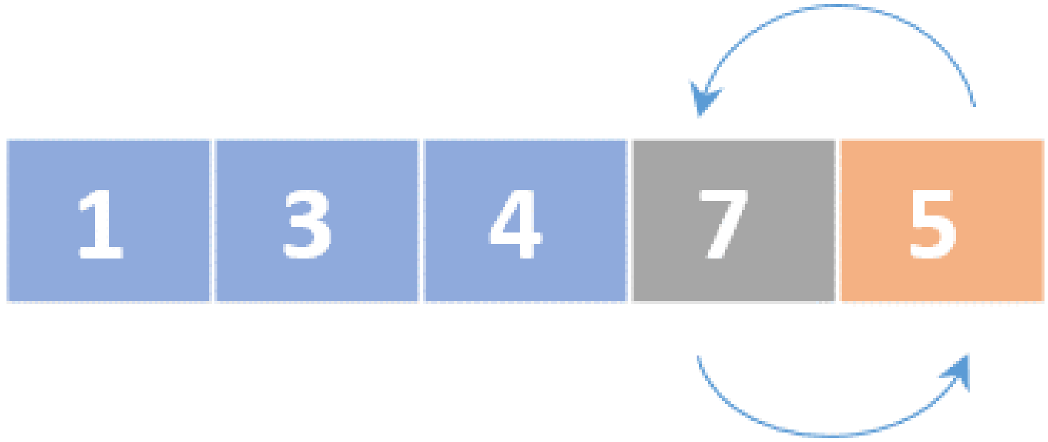

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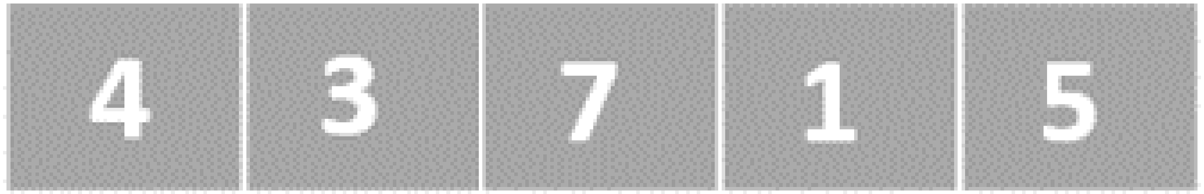
Selection sort - implementation

```python
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



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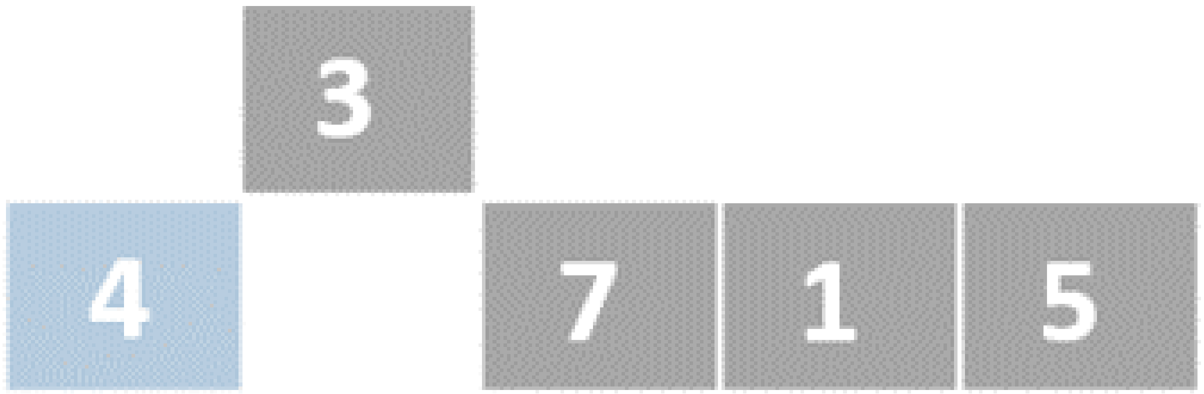

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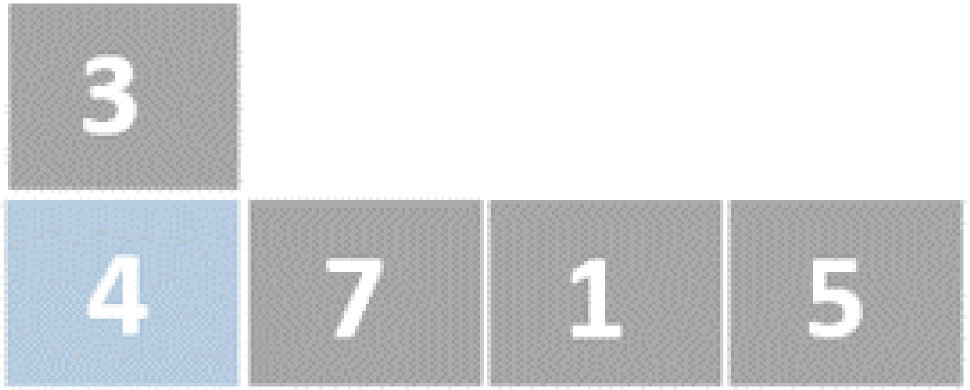

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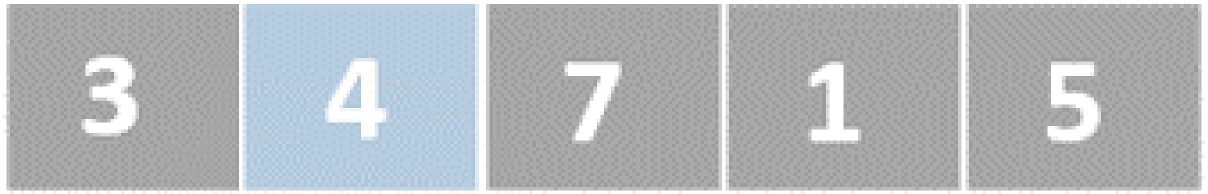

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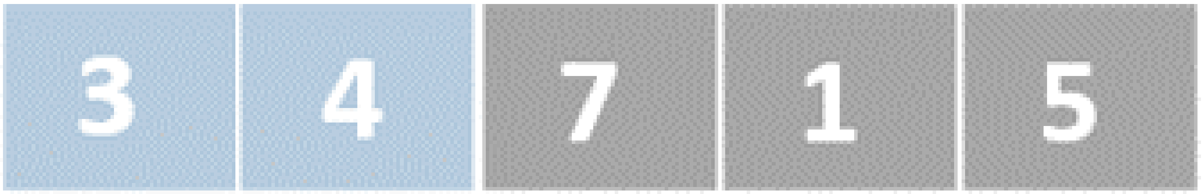

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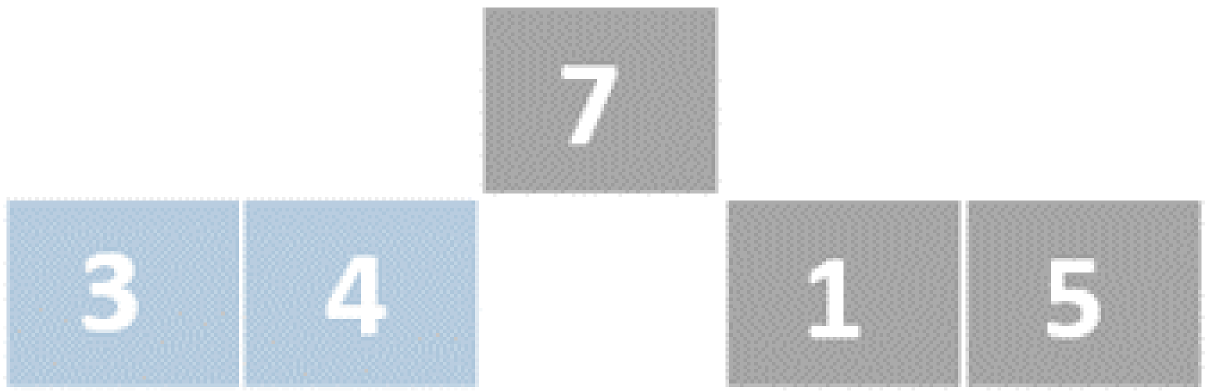

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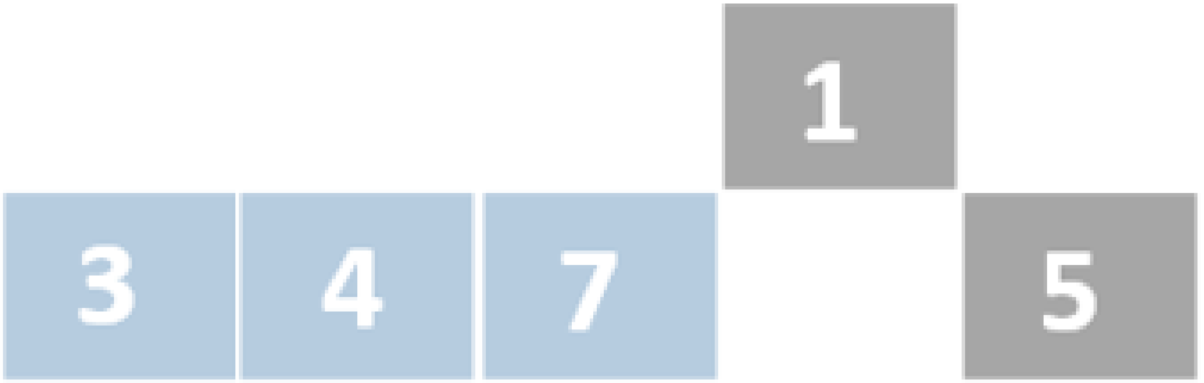

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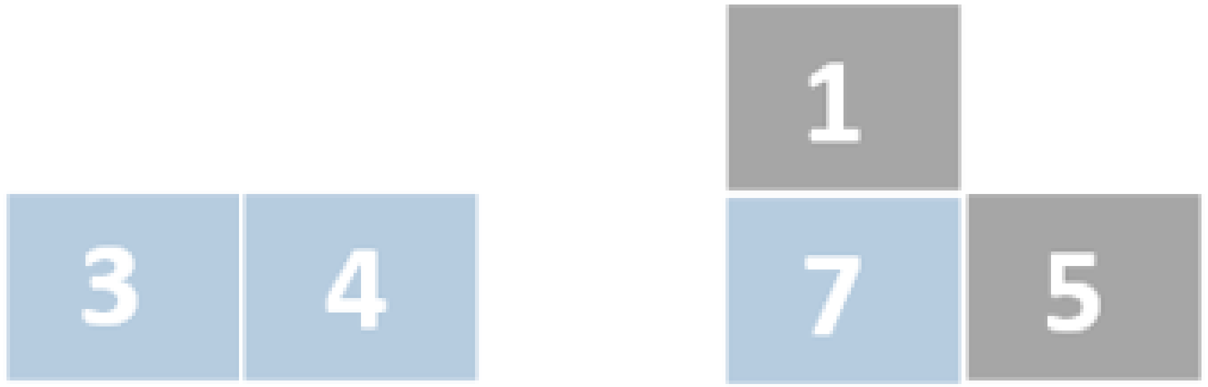

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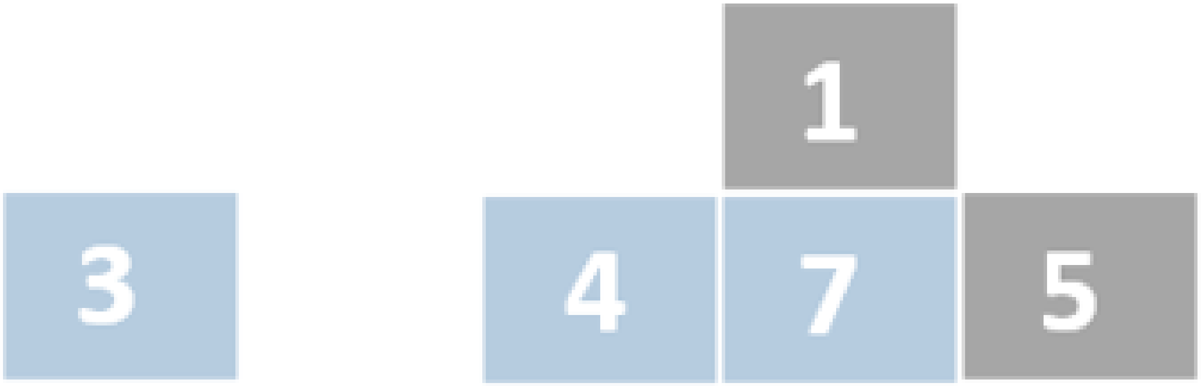

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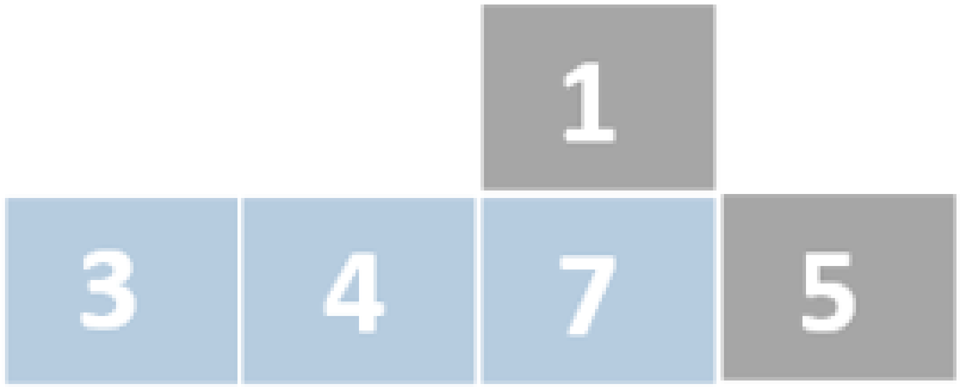

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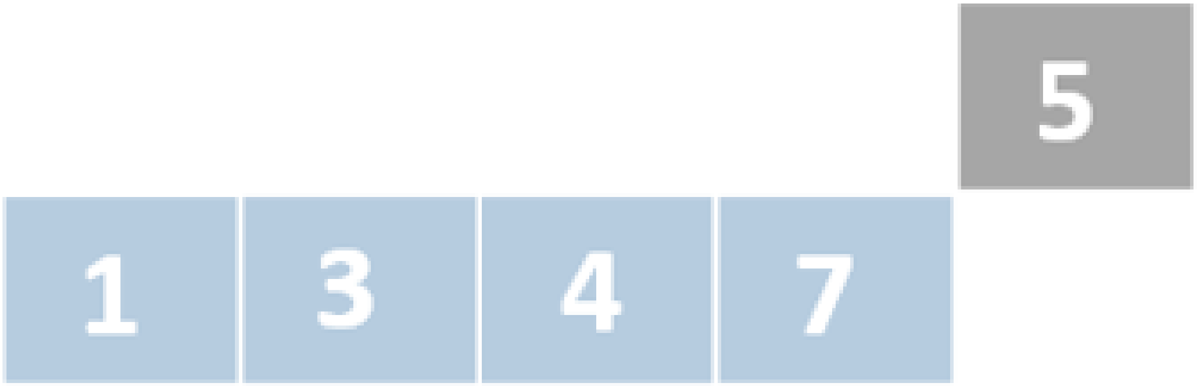

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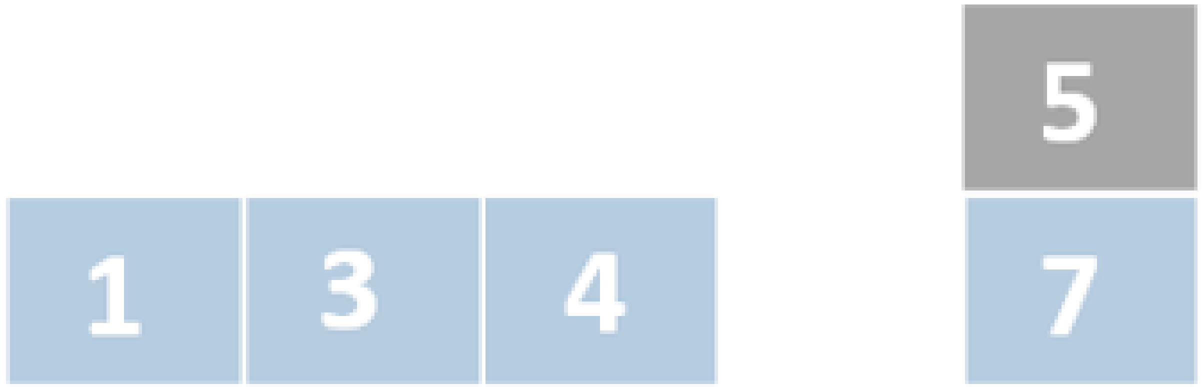

Insertion sort

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

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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

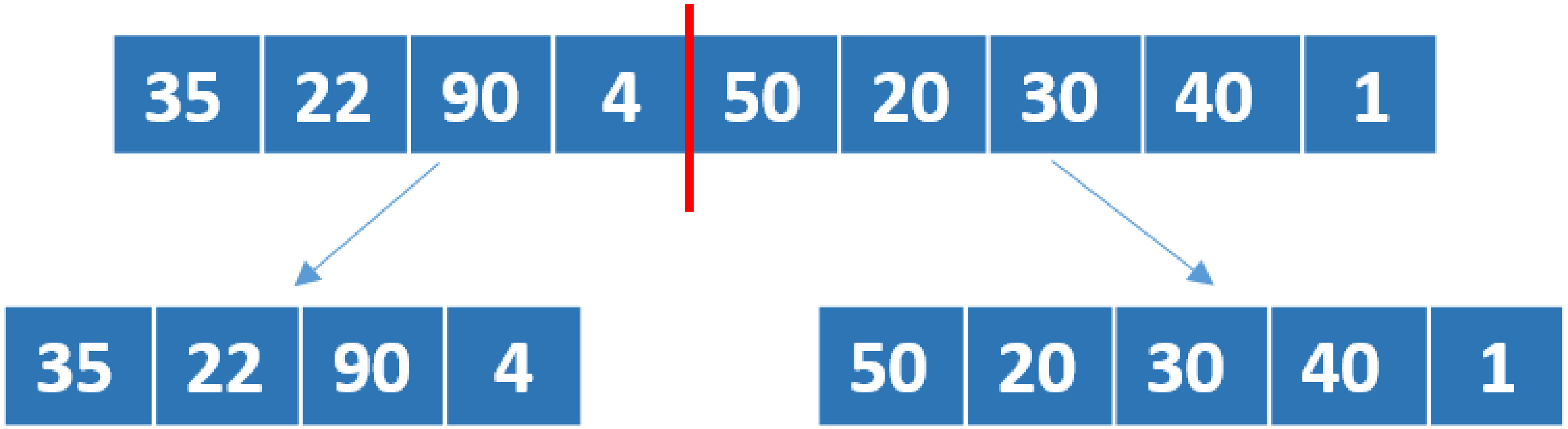
Merge sort - in action

35	22	90	4	50	20	30	40	1

Merge sort - in action

35	22	90	4	50	20	30	40	1

Merge sort - in action



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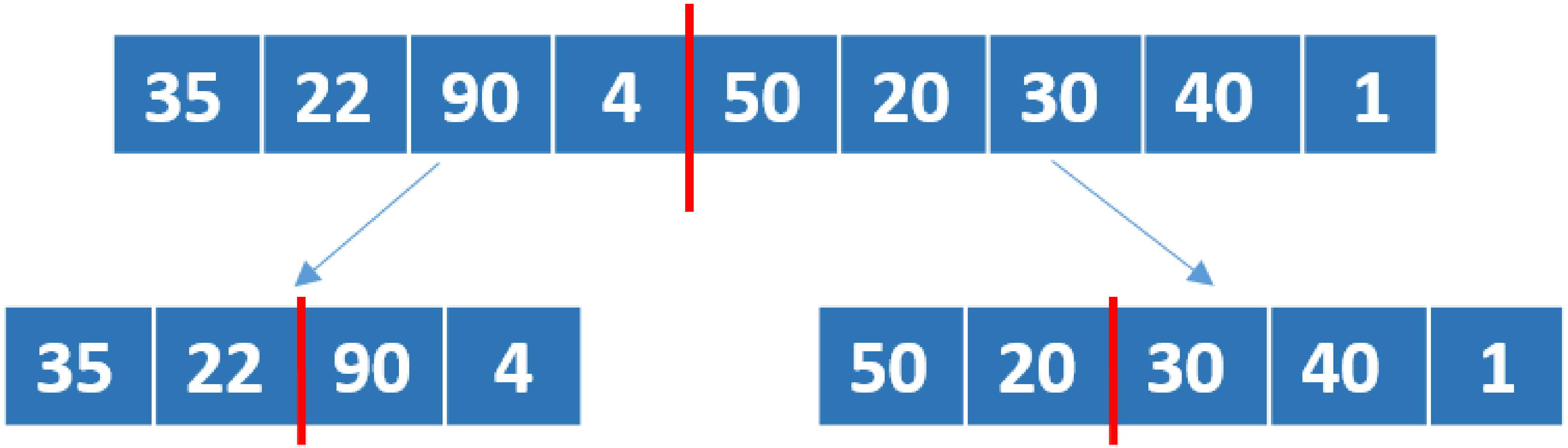

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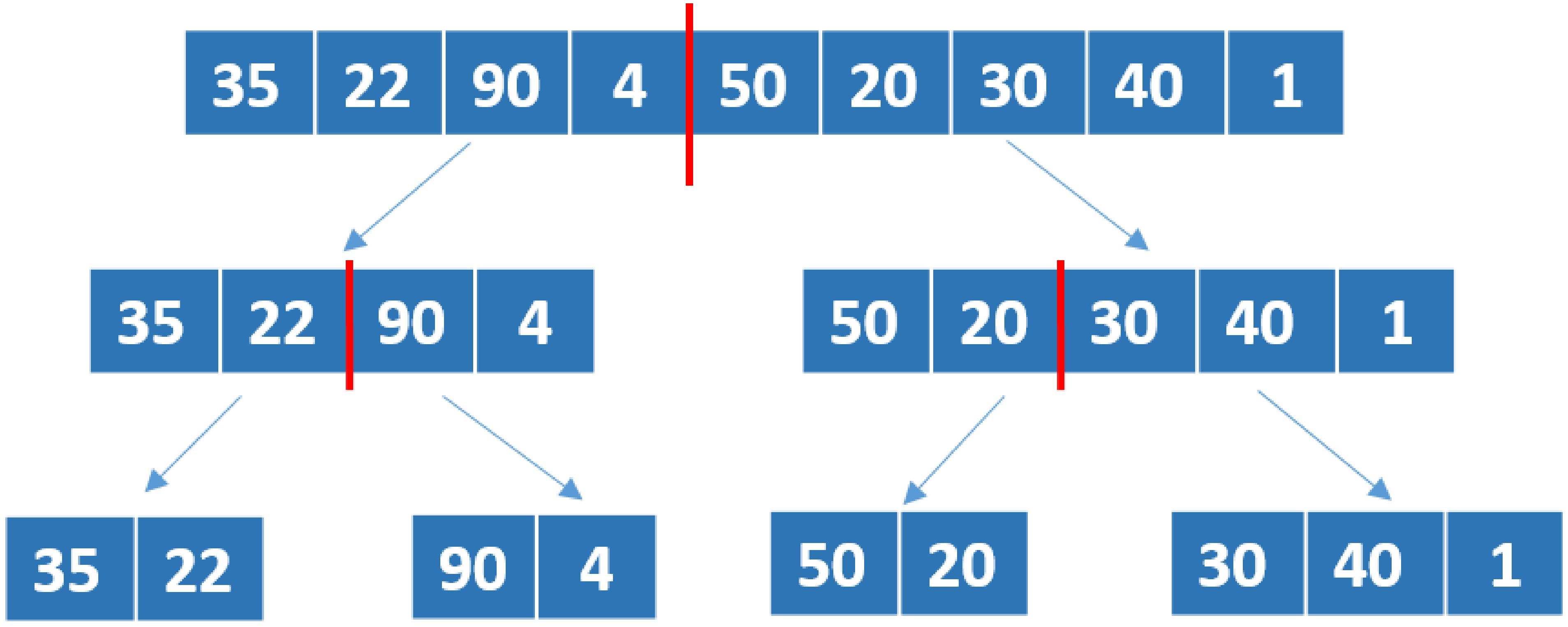

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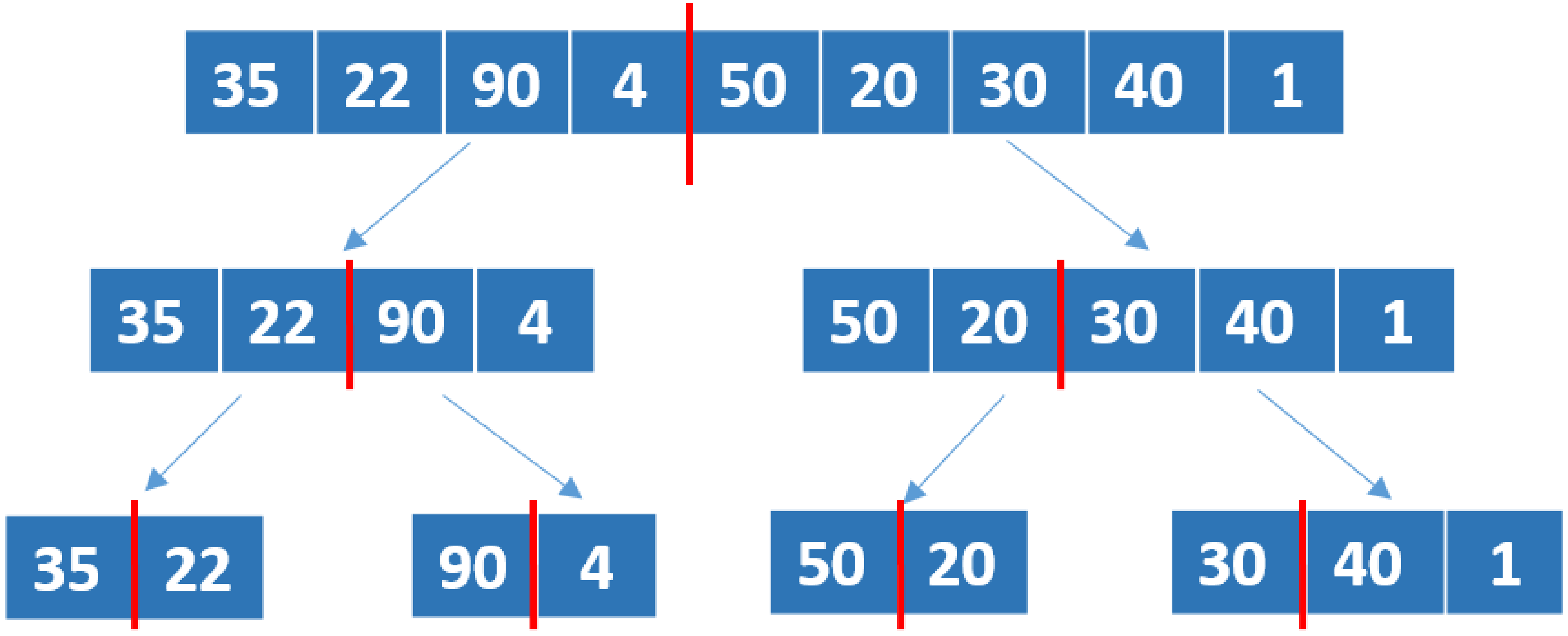

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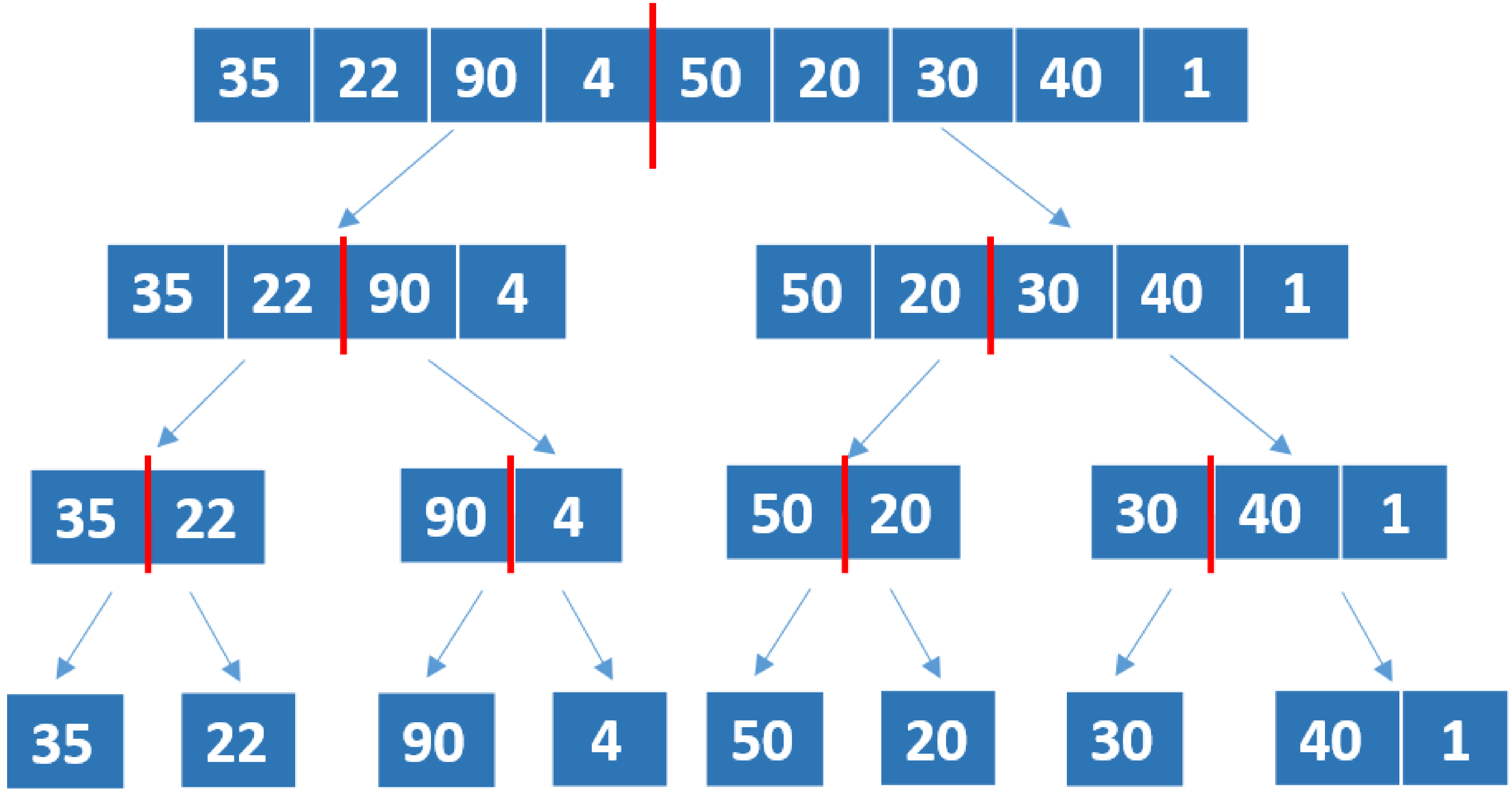

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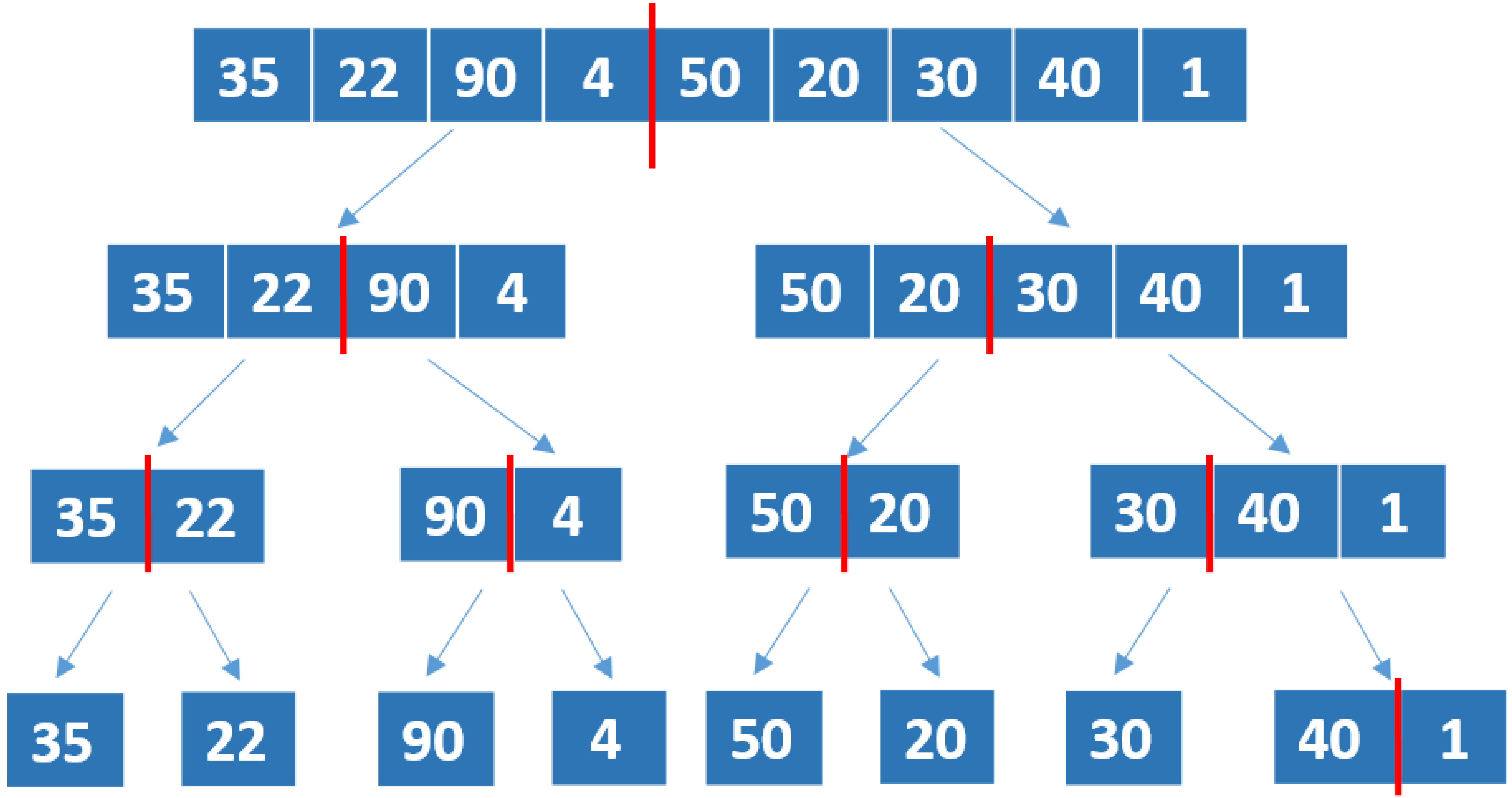

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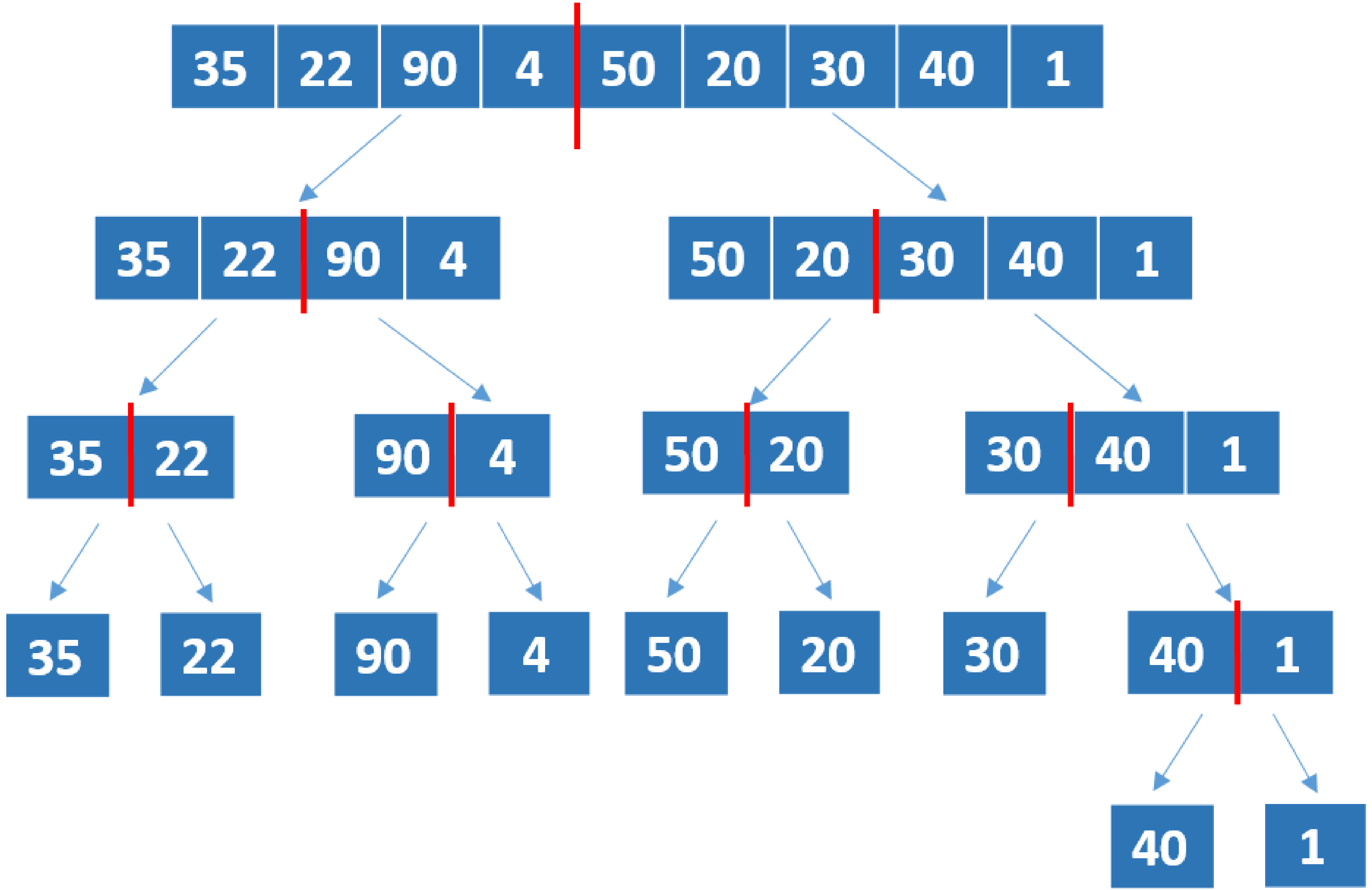
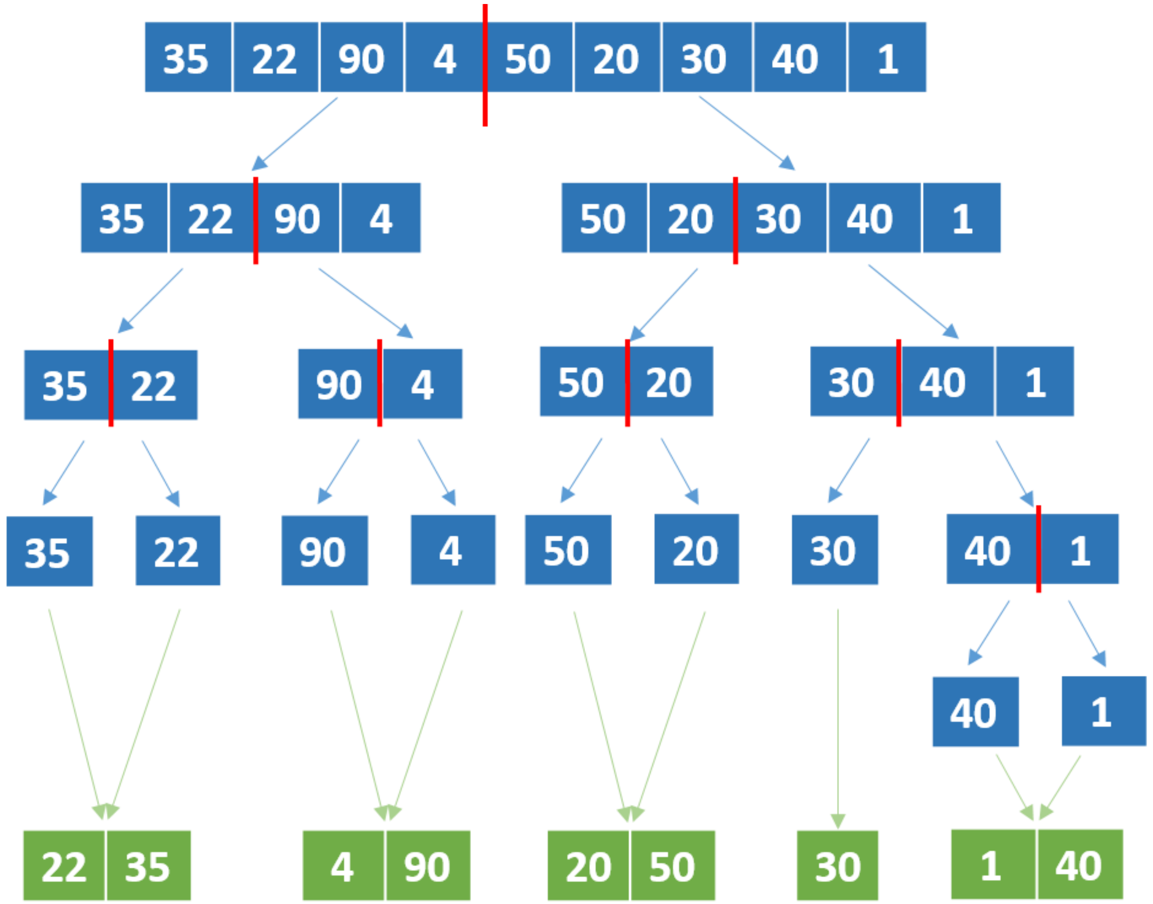
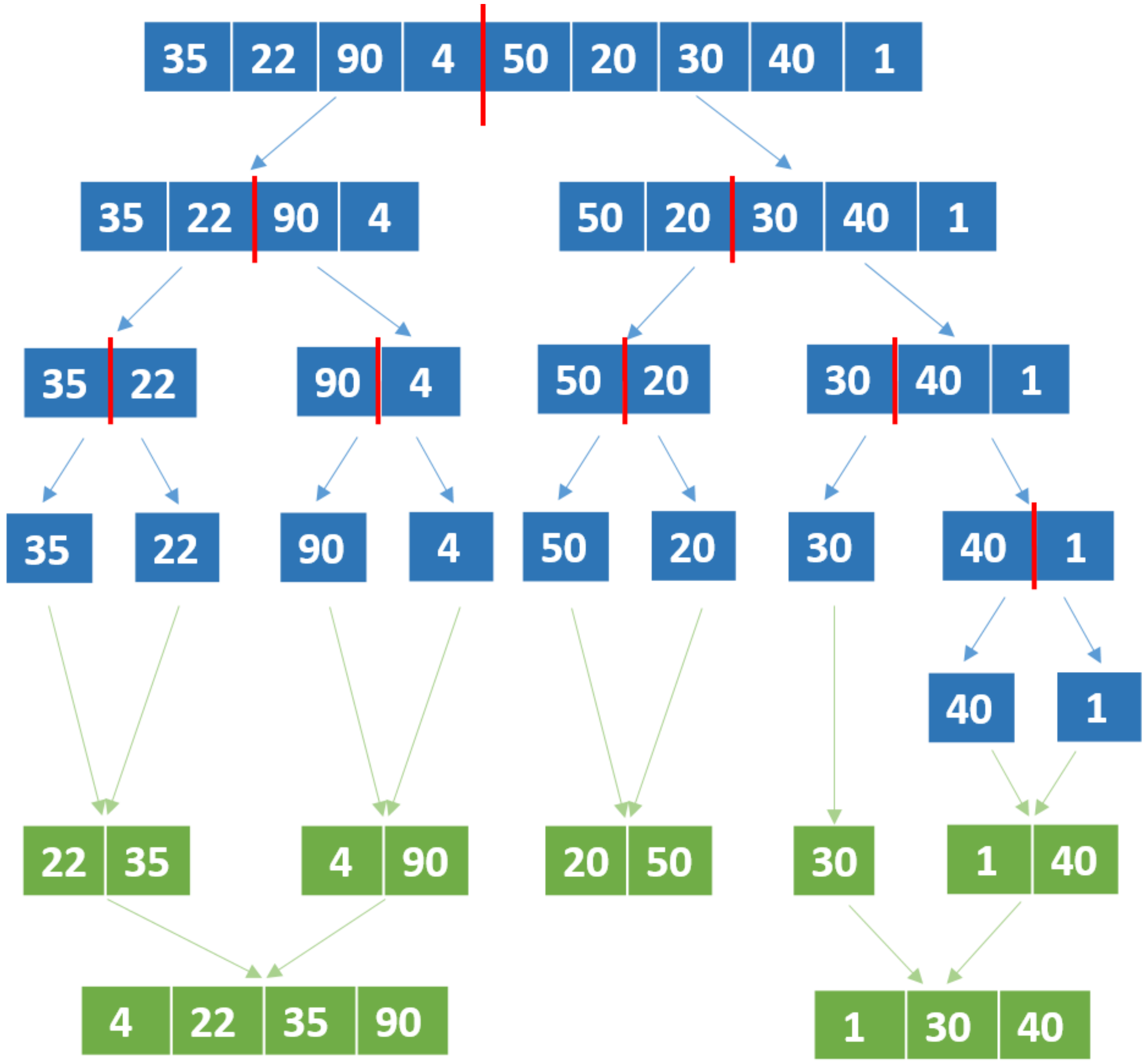


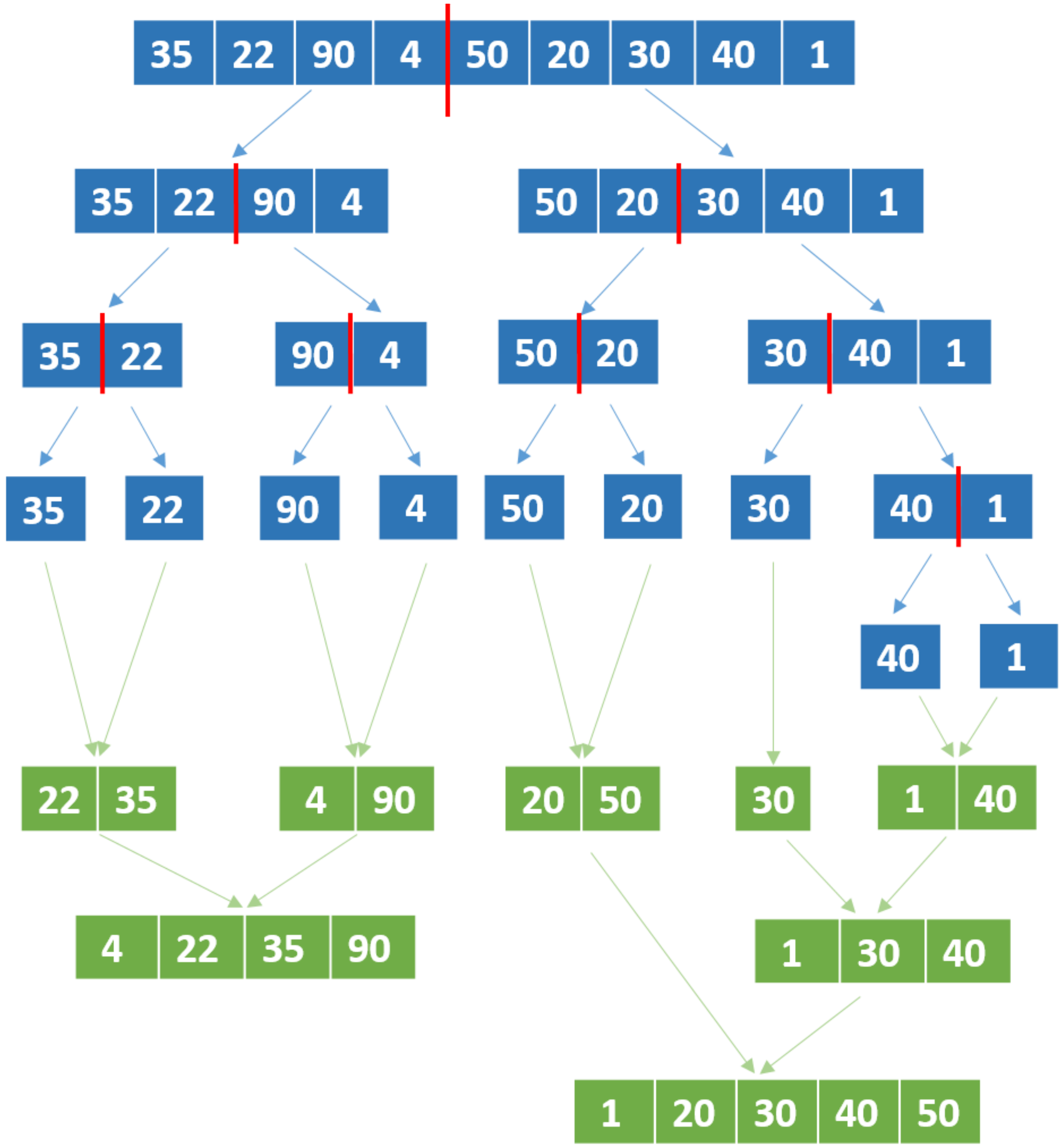
Merge sort - in action



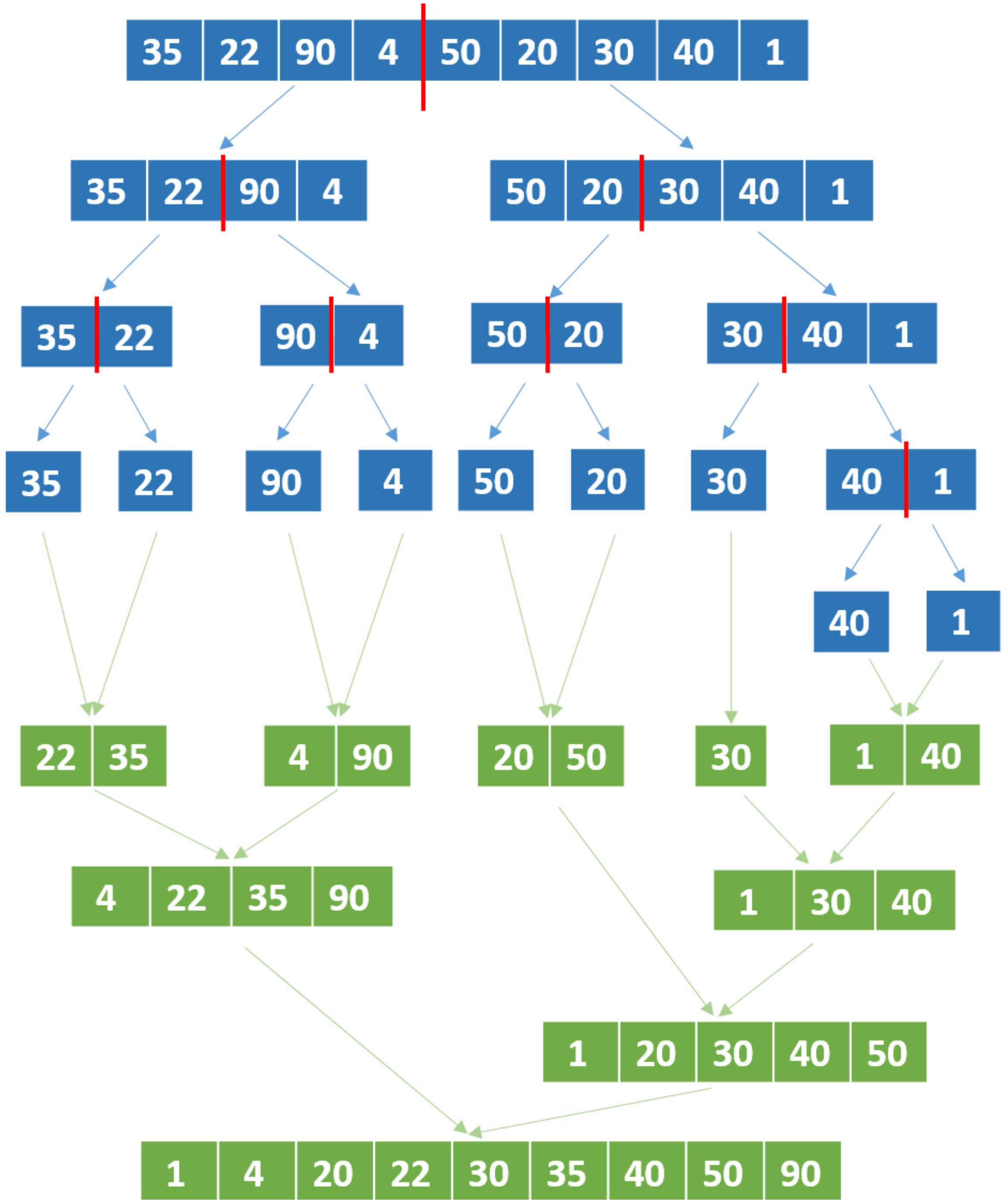
Merge sort - in action



Merge sort - in action



Merge sort - in action



Merge sort - implementation

```python
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
```

```python
    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
```

```python
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

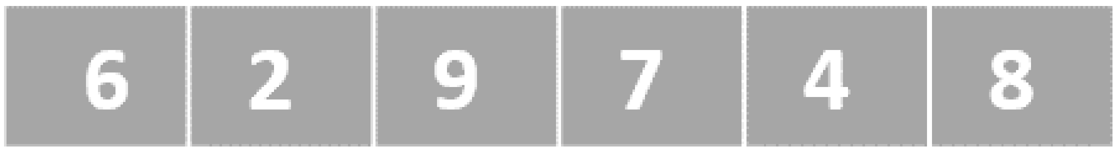
DATA STRUCTURES AND ALGORITHMS IN PYTHON

Miriam Antona
Software engineer

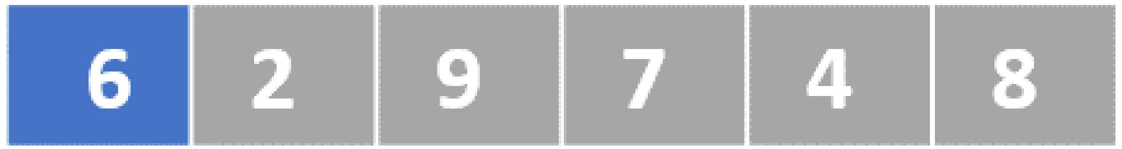
Quicksort

- 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

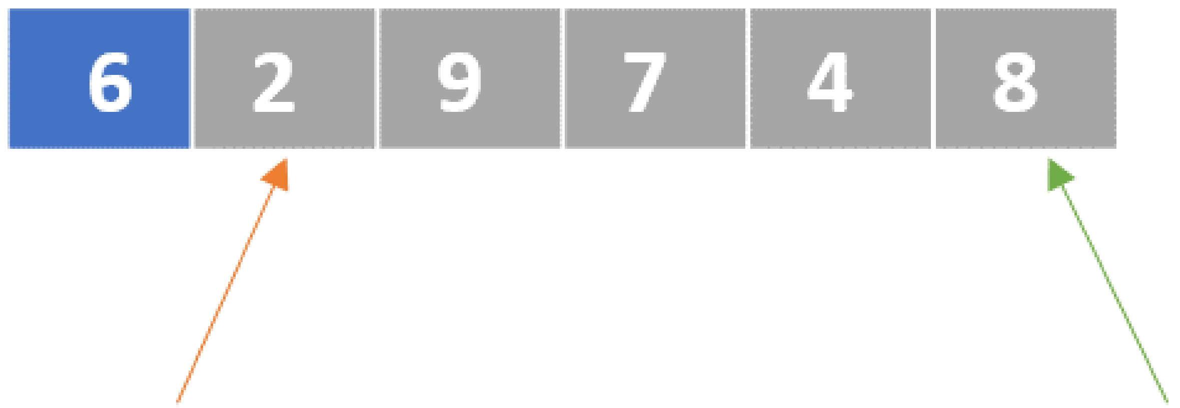


Quicksort - in action



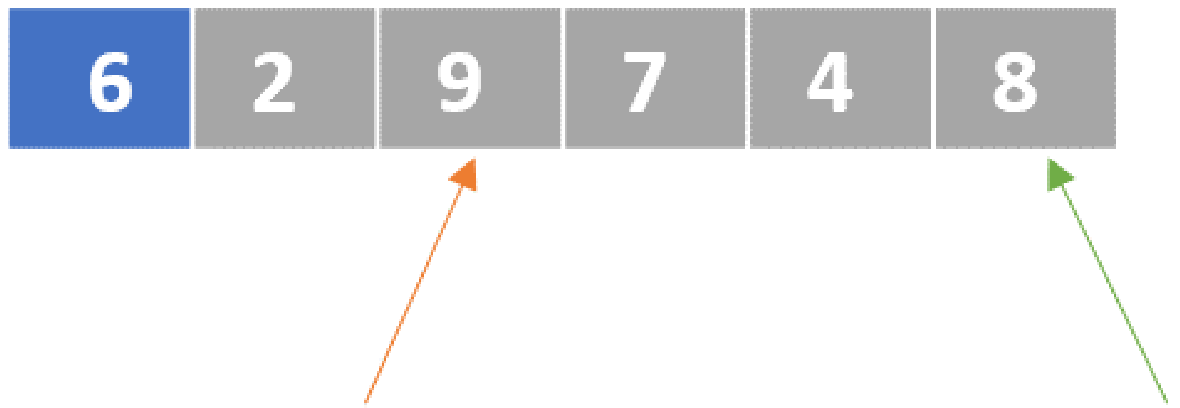
- Hoare's partition

Quicksort - in action



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

Quicksort - in action



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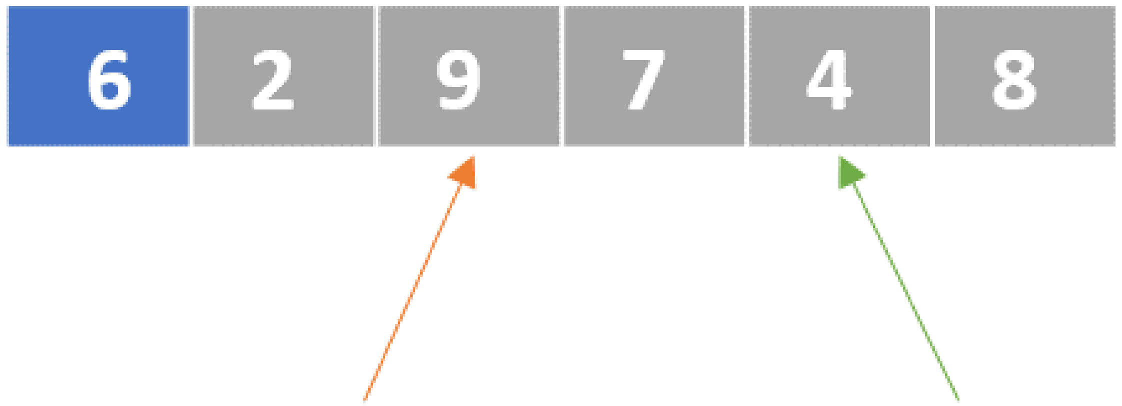
Quicksort - in action



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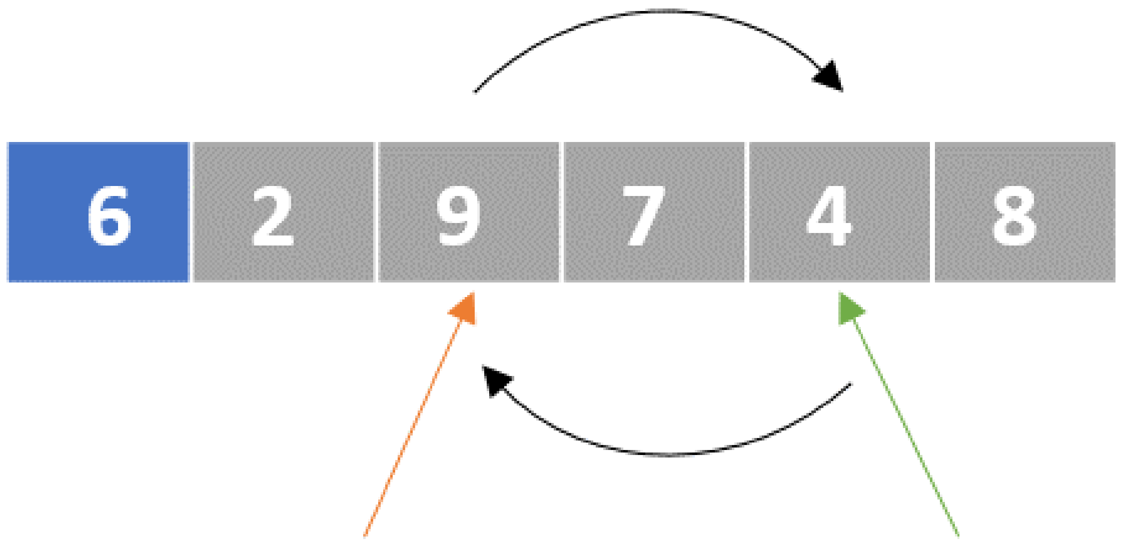

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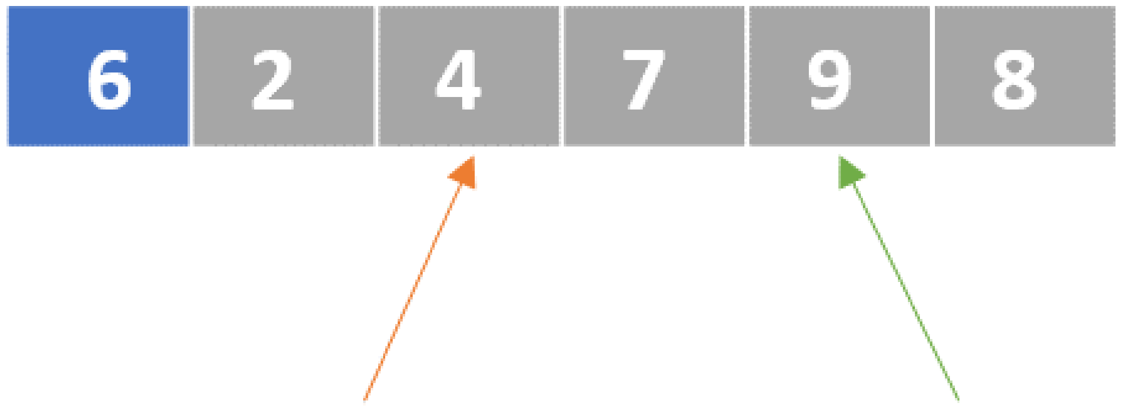

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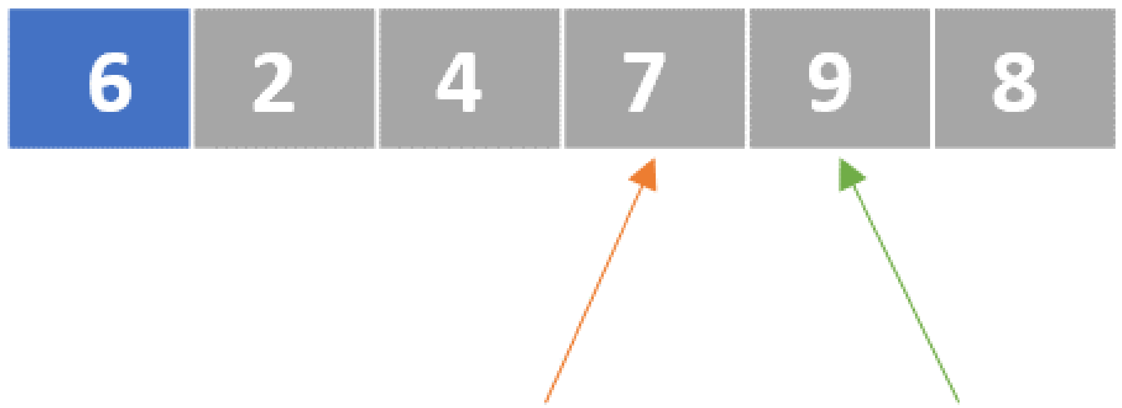

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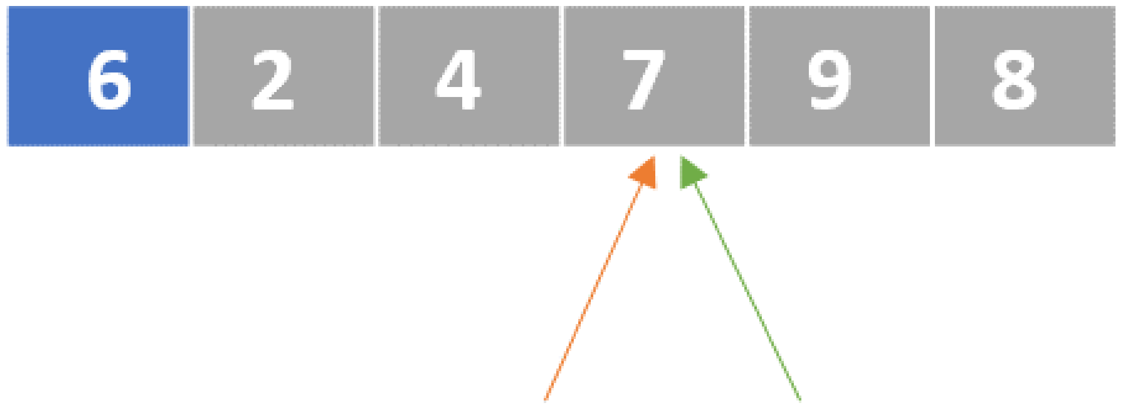

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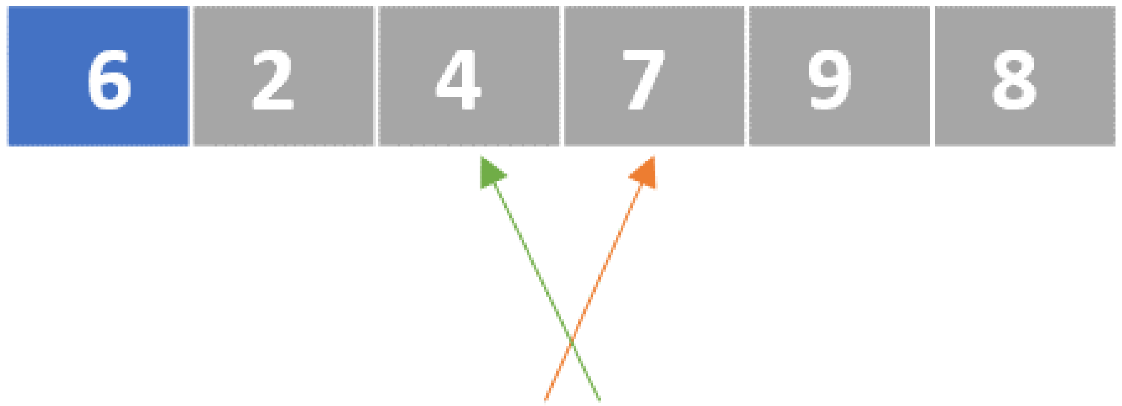

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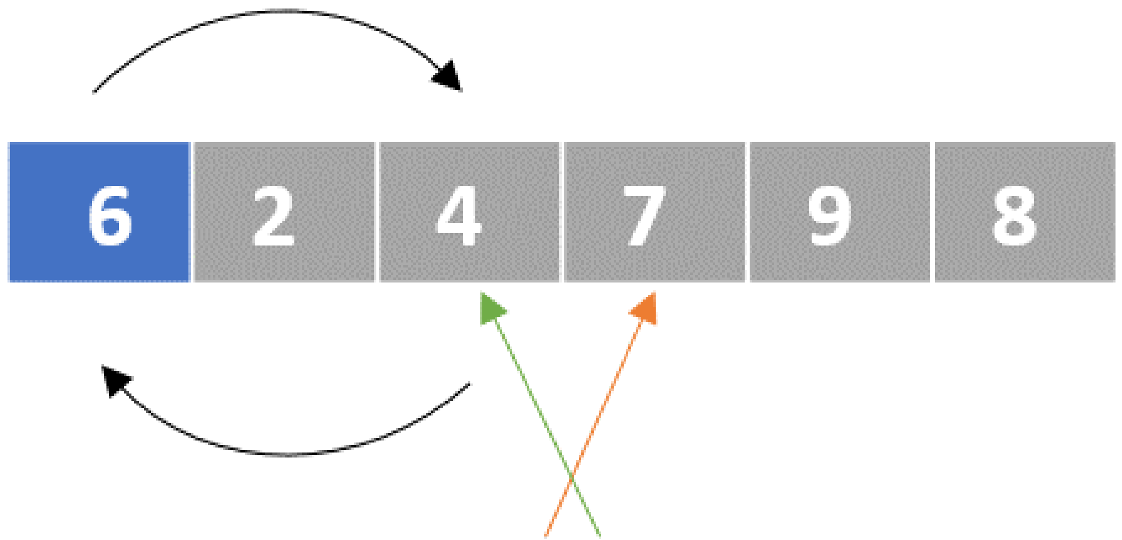

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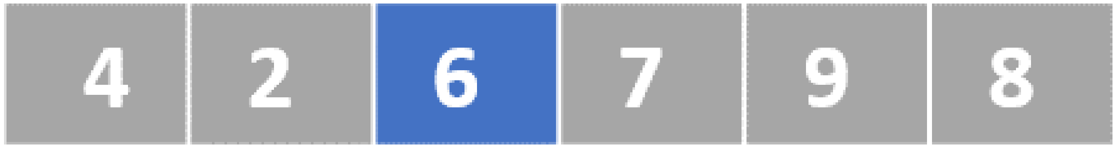

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Quicksort - in action

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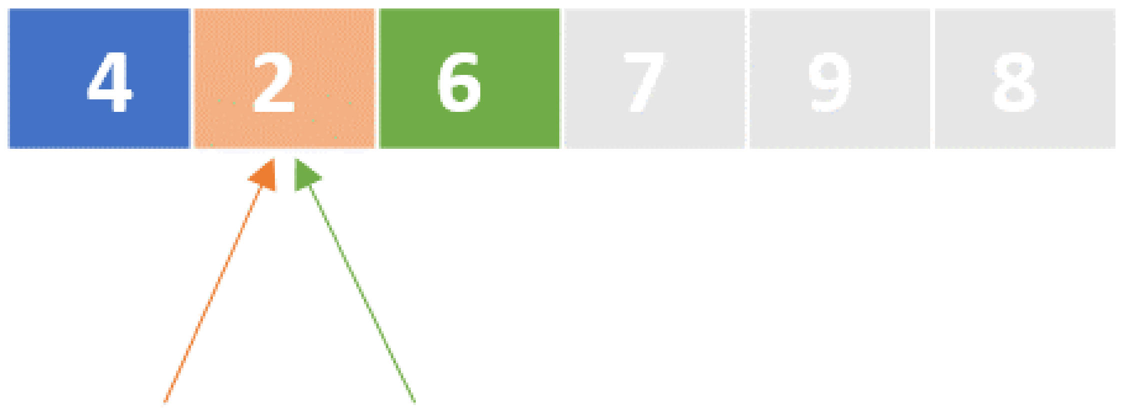

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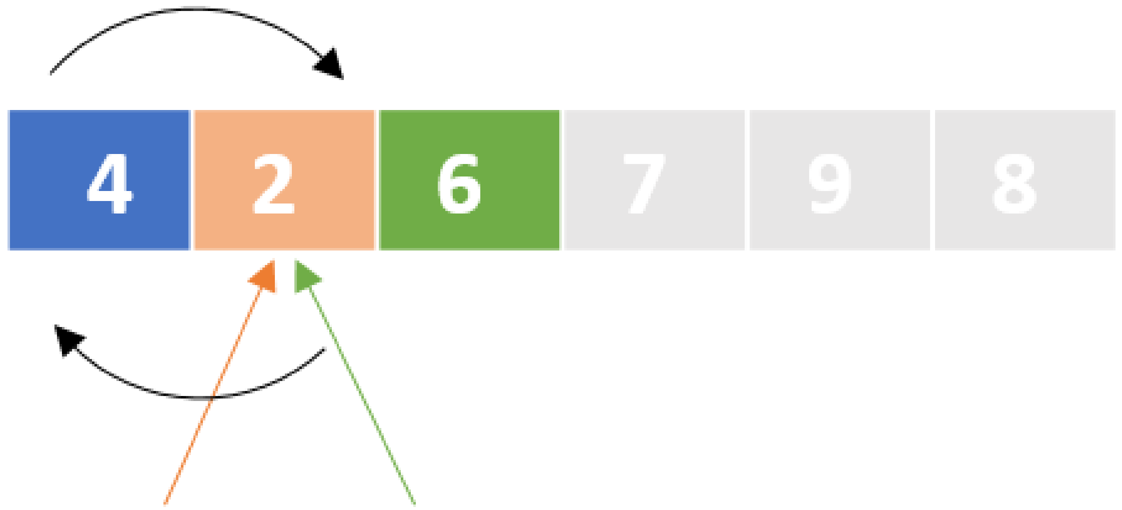

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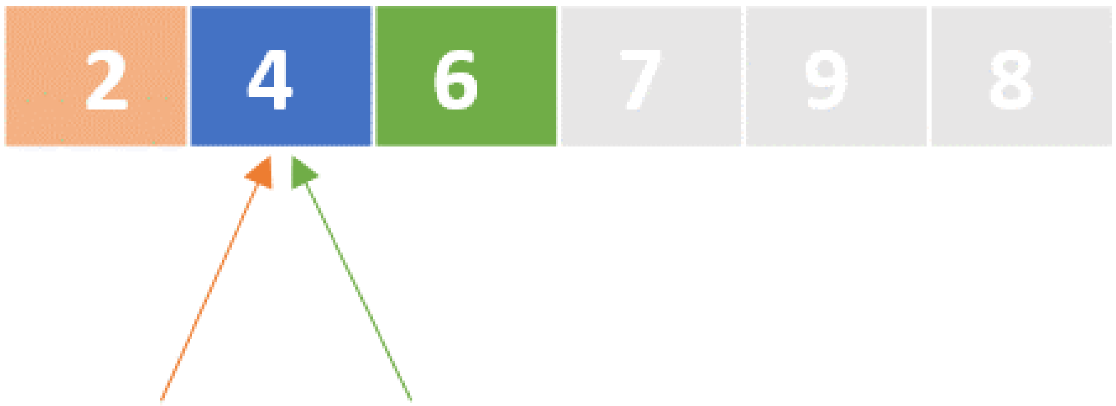

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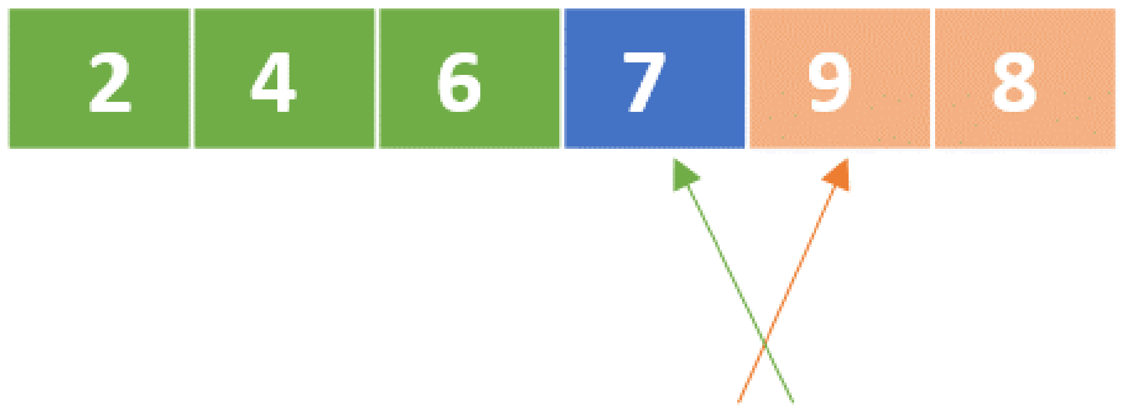

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Quicksort - in action

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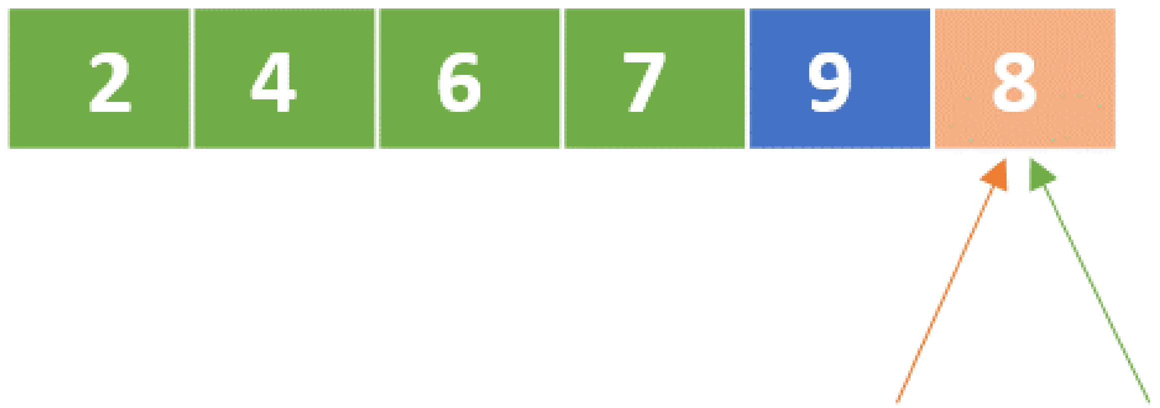

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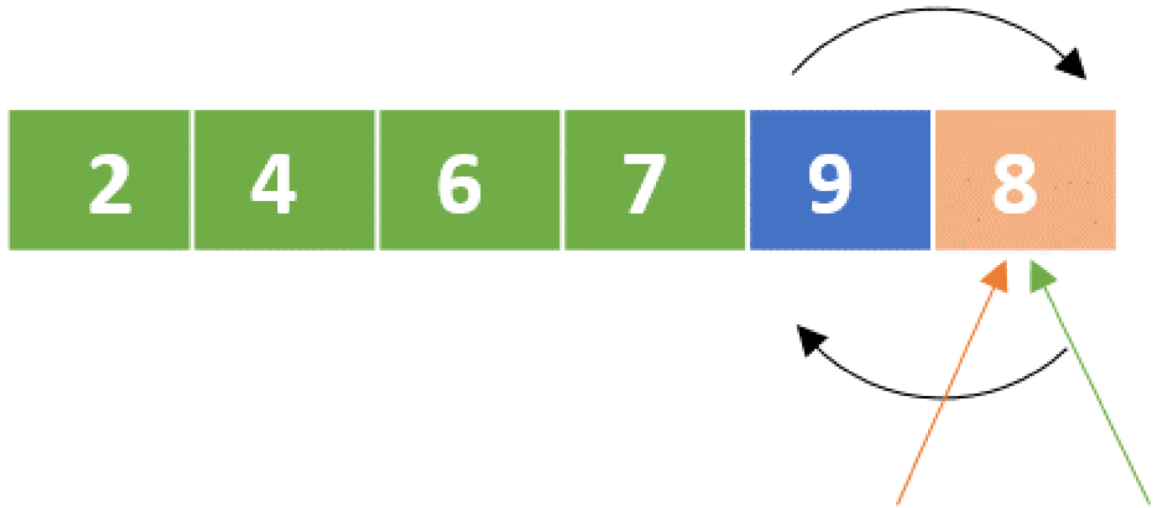

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Quicksort - in action

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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!

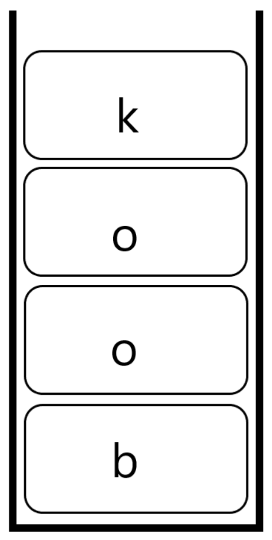
DATA STRUCTURES AND ALGORITHMS IN PYTHON

Miriam Antona
Software engineer

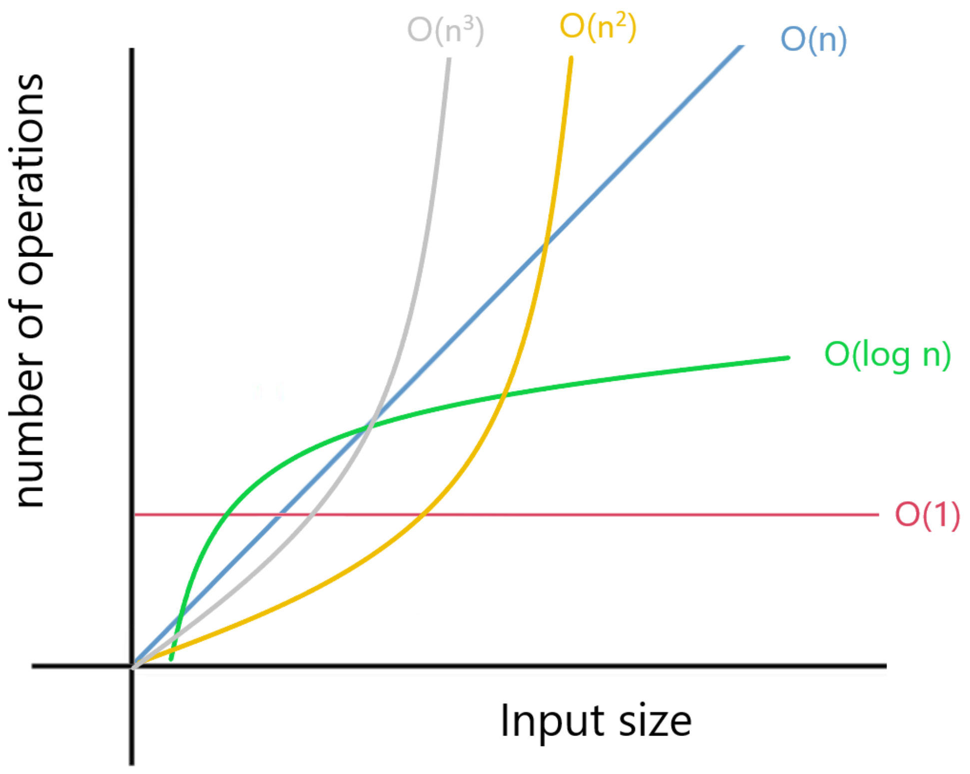
Chapter 1

- What algorithms and data structures are
- Linked lists

- Stacks

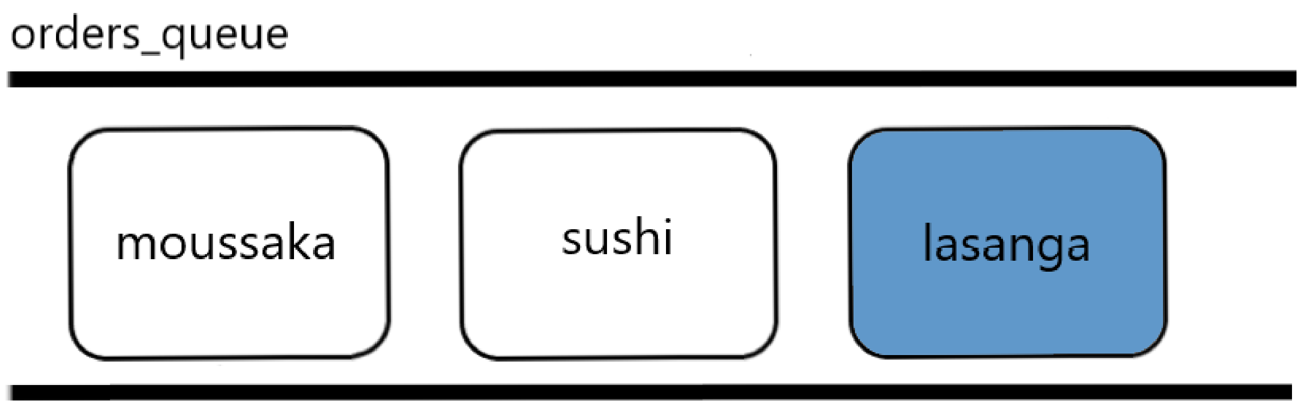


- Calculate time complexity using Big O Notation



Chapter 2

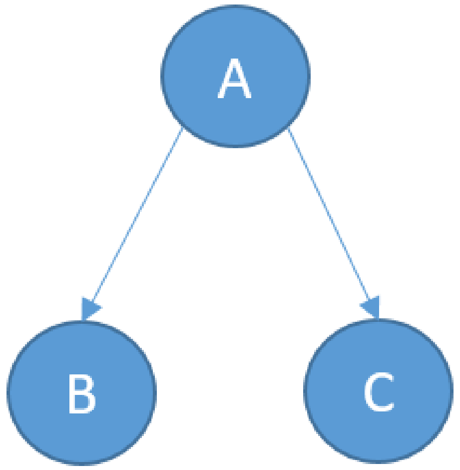
- Queues



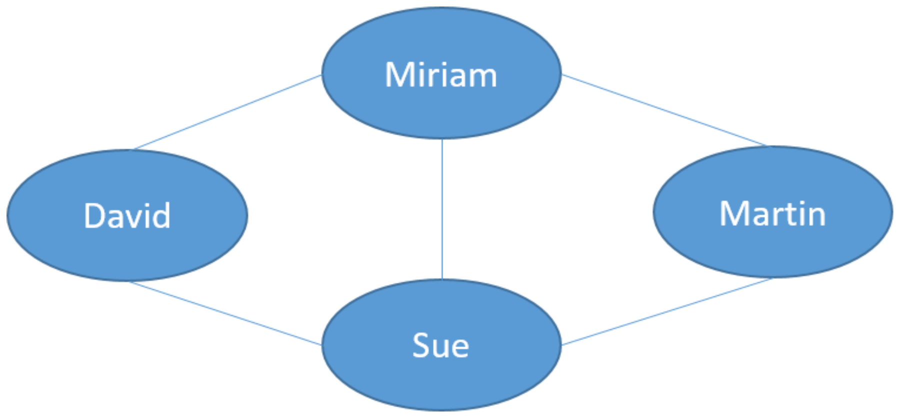
- Hash tables

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

- Trees



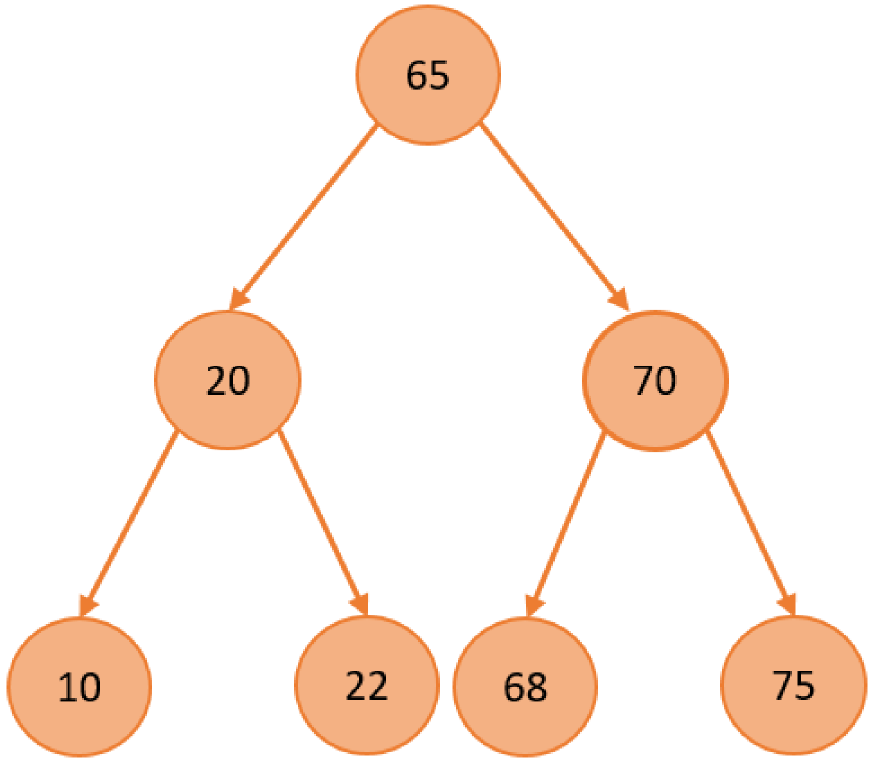
- Graphs



- 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