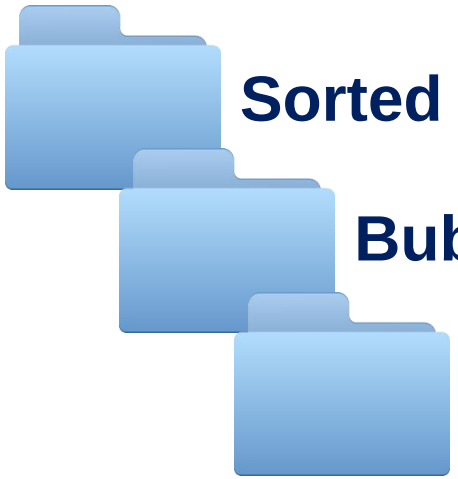
Algorithm Implementation: Sorting in Python

Lesson Objectives

At the end of this lesson, you should be able to:

- Use sorted function in Python
- Explain the importance of coding sort algorithms in Python
- Code bubble sort in Python
- Code merge sort in Python
- Read and understand other sorting algorithms written in Python
- Apply your knowledge and understanding of sorting algorithms to your problem solving in Python

Topic Outline



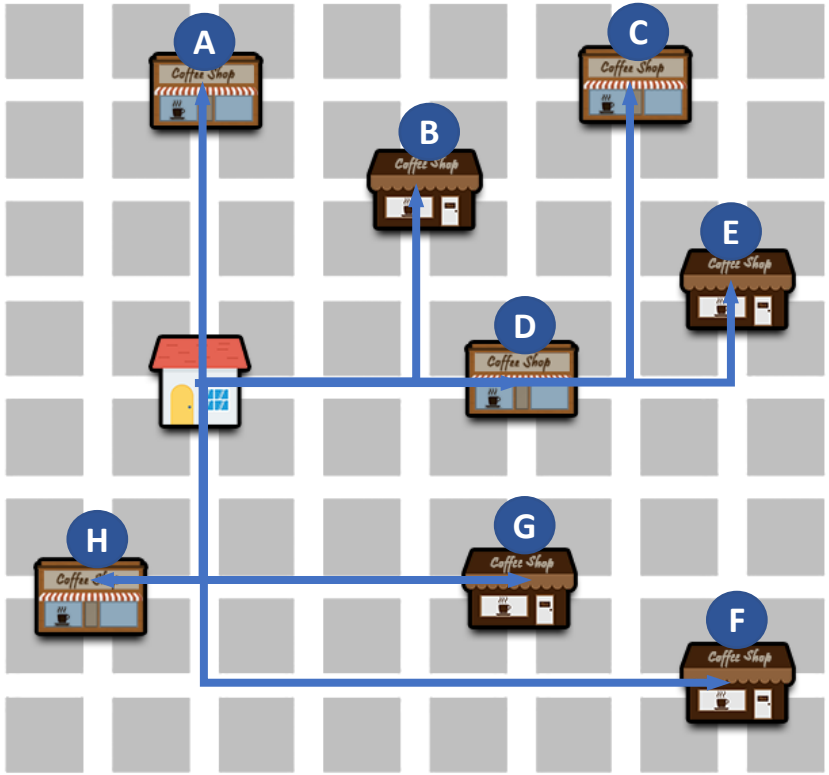
Sorted Function in Python

Bubble Sort

Merge Sort

Recall: Application of Looping

Find the Distance to N Locations

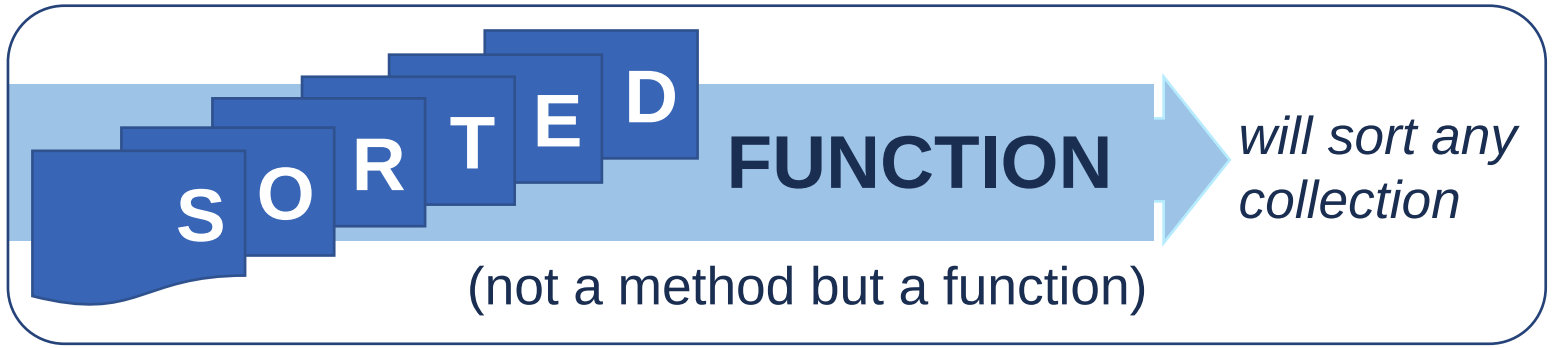


Coffeeshop	Distance
Coffeeshop A	3
Coffeeshop B	4
Coffeeshop C	7
Coffeeshop D	3
Coffeeshop E	6
Coffeeshop F	8
Coffeeshop G	5
Coffeeshop H	3

Sort by distance

Coffeeshop	Distance
Coffeeshop A	3
Coffeeshop D	3
Coffeeshop H	3
Coffeeshop B	4
Coffeeshop G	5
Coffeeshop E	6
Coffeeshop C	7
Coffeeshop F	8

Sorted Function



Separates the collection into individual elements

- Sorts those elements

Returns the elements in a sorted list

- Returns a new sorted list without changing the original list

Sort by Distance

Python provides a module named operator that contains the useful itemgetter for sorting values other than the first and allows sorting on multiple values.

```
from operator import itemgetter
restaurant_info = [['Kentucky', 15, 6, 'Fried chicken'],
                   ['Macdonald', 12, 5,'Burger'],
                   ['Subway', 13, 7, 'Sandwiches']]

# filed 1 (index 0): name of restaurant
# field 2 (index 1): distance of restaurant
# field 3 (index 2): average price per person of the restaurant
# field 4 (index 3): signature dish of the restaurant

sort_info = sorted (restaurant_info, key = itemgetter(1))
print('sort by distance', sort_info)
```

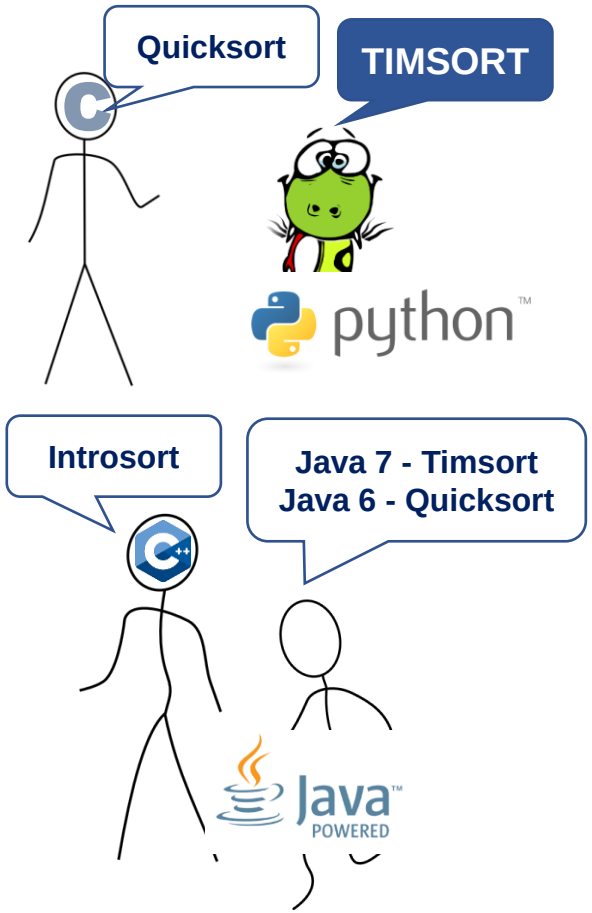
Sort by Any Field

```
from operator import itemgetter
restaurant_info = [['Kentucky', 15, 6, 'Fried chicken'],
                   ['Macdonald', 12, 5,'Burger'],
                   ['Subway', 13, 7, 'Sandwiches']]

# filed 1 (index 0): name of restaurant
# field 2 (index 1): distance of restaurant
# field 3 (index 2): average price per person of the restaurant
# field 4 (index 3): signature dish of the restaurant
sort_field = ['name','distance','price','food']

for i in range (len(sort_field)):
    sort_info = sorted (restaurant_info, key = itemgetter(i))
    print('sort by', sort_field[i], sort_info)
```

What Algorithm does Python's Sorted() Use?

TIMSORT Hybrid sorting algorithm used by Python

- Derived from merge sort and insertion sort and designed to perform well on many kinds of real-world data
- Invented by Tim Peters in 2002 for use in the Python programming language
- Finds subsets of the data that are already ordered, and uses the subsets to sort the data more efficiently. This is done by merging an identified subset, called a run, with existing runs until certain criteria are fulfilled
- Timsort has been Python's standard sorting algorithm since version 2.3
- Now, also used to sort arrays in Java SE 7 and on the Android platform



Importance of Basic Algorithm Coding

Why is there a need to learn how to code basic sort algorithm?

Bubble Sort Algorithm

Step 1: Get the length of the sequence

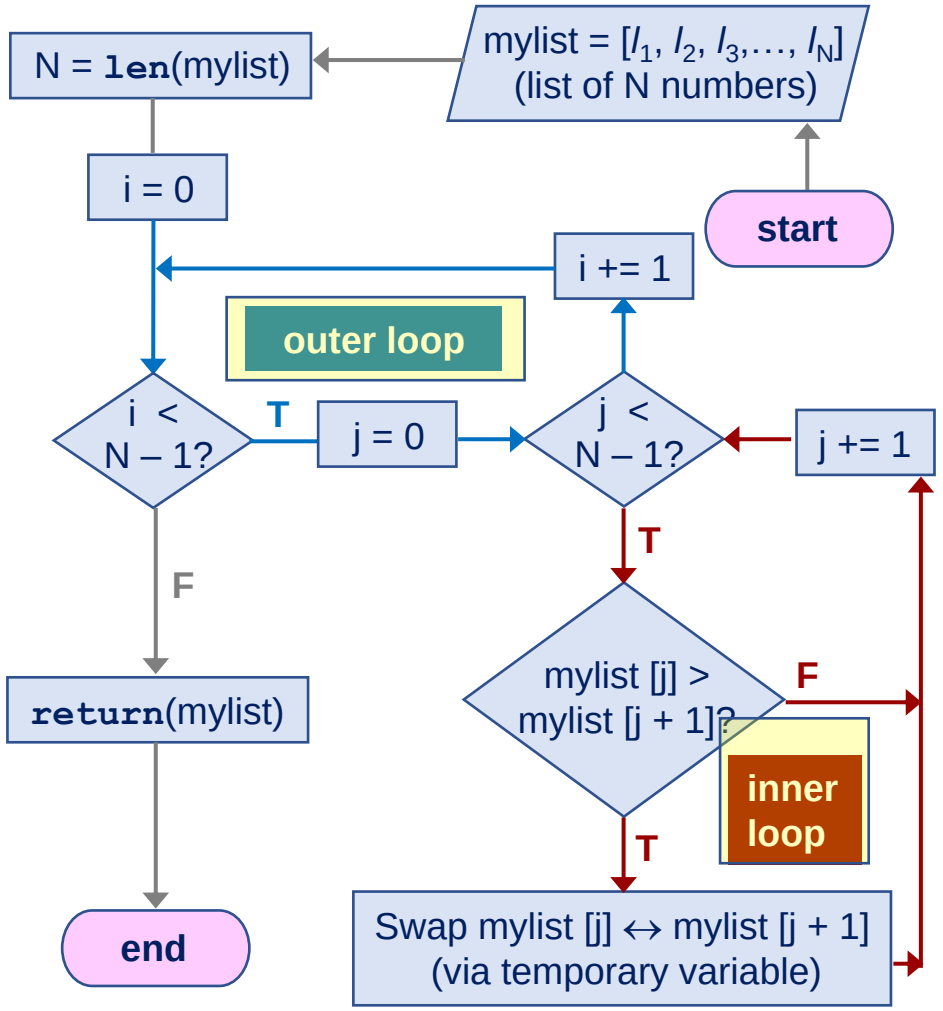
Step 2: Take the first element and compare it with the immediate neighbor to the right: $a_i > a_{i+1}$

- If true: swap and increment *i* by one
- If false: increment *i* by one

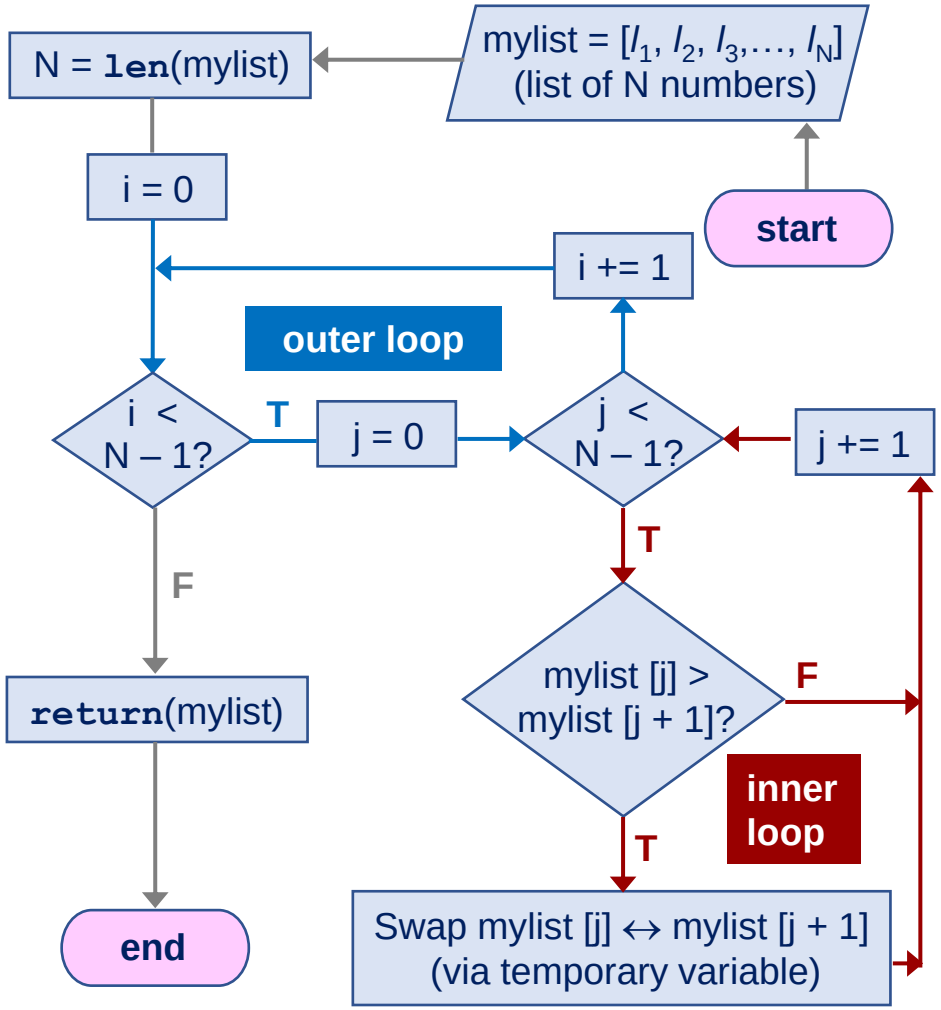
Step 3: Repeat step 2, N – 1 times

Pseudocode

```
while k < N
        for i = 0 to N - 1
                if a[i] > a[i + 1]
                then
                        swap()
        end
        k = k + 1
end
```



Suggested Code

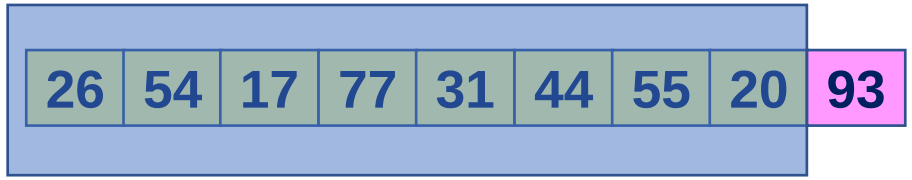



```
def bubbleSort(alist):
    for passnum in range(len(alist)-1):
        for i in range(len(alist)-1):
            if alist[i]>alist[i+1]:
                temp = alist[i]
                alist[i] = alist[i+1]
                alist[i+1] = temp

alist = [6,5,4,3]
bubbleSort(alist)
print(alist)
```

- **Is it efficient?**
- **Any possible improvement?**

Bubble Sort: Second Pass - End

- At the end of the first pass, there are n – 1 items left to sort.
- At the end of the second pass, there are n – 2 items left to sort.
- Number of items to be sorted decreases while the number of pass increases.



93 in place after the first pass

Second Pass

Improved Code of Bubble Sort

```
def bubbleSort(alist):
    for passnum in range(len(alist)-1):
        for i in range(len(alist)-passnum-1):
            if alist[i]>alist[i+1]:
                temp = alist[i]
                alist[i] = alist[i+1]
                alist[i+1] = temp

alist = [54,26,93,17,77,31,44,55,20]
bubbleSort(alist)
print(alist)
```

- The inner loop executes **n – 1** times at first, linearly dropping to just once
- On average, inner loop executes about **n/2** times for each execution of the outer loop

Any possible improvement?

Recall Since each pass places the next largest value in place, the total number of passes necessary will be n − 1.

Quick Check

What is the output of the following Python code?

```
def bubbleSort(alist):
    for passnum in range(len(alist)-1):
        for i in range(len(alist)-passnum-1):
            if alist[i]>alist[i+1]:
                temp = alist[i]
                alist[i] = alist[i+1]
                alist[i+1] = temp
        print("pass",passnum+1, ":",alist)

alist = [1,2,3,4,5,6]
bubbleSort(alist)
print(alist)
```

Quick Check: Answer

What is the output of the following Python code?

```
def bubbleSort(alist):
    for passnum in range(len(alist)-1):
        for i in range(len(alist)-passnum-1):
            if alist[i]>alist[i+1]:
                temp = alist[i]
                alist[i] = alist[i+1]
                alist[i+1] = temp
        print("pass",passnum+1, ":",alist)

alist = [1,2,3,4,5,6]
bubbleSort(alist)
print(alist)
```

Answer

```
pass 1 : [1, 2, 3, 4, 5, 6]
pass 2 : [1, 2, 3, 4, 5, 6]
pass 3 : [1, 2, 3, 4, 5, 6]
pass 4 : [1, 2, 3, 4, 5, 6]
pass 5 : [1, 2, 3, 4, 5, 6]
[1, 2, 3, 4, 5, 6]
```

Break: Early Exit to be More Efficient

```
procedure bubbleSort( list : array of items )
    loop = list.count;
    for i = 0 to loop-1 do:
      swapped = false
      for j = 0 to loop-i-1 do:
         /* compare the adjacent elements */
         if list[j] > list[j+1] then
            /* swap them */
            swap( list[j], list[j+1] )
            swapped = true
         end if
      end for
      /*if no number was swapped that means array is sorted now, break the loop.*/
      if(not swapped) then
         break
      end if
    end for
end procedure return list
```

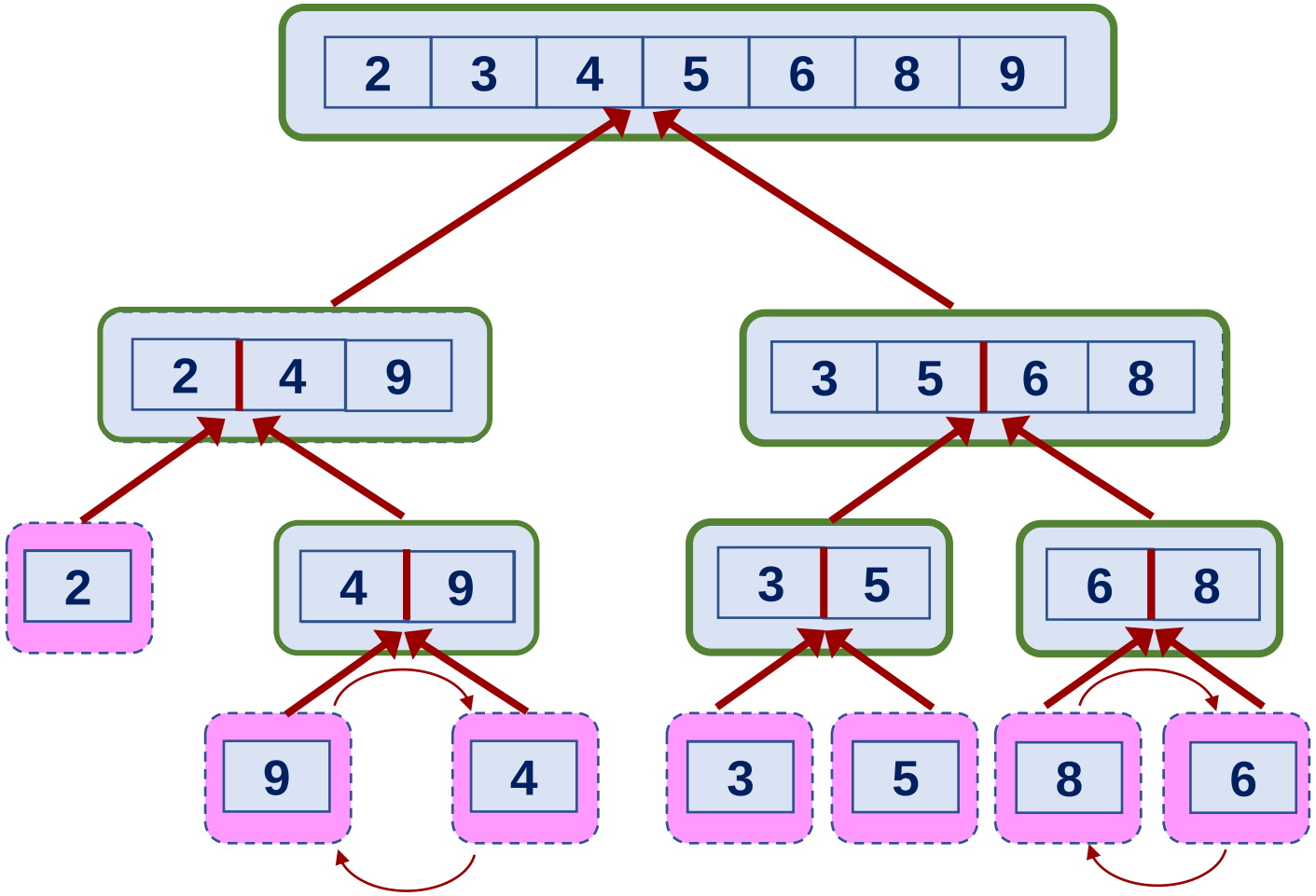
- How can we know if the list is sorted?
- The pass go through the list but no swaps are needed, which indicates that the list is sorted.

Improved Code of Bubble Sort: Run

```
def bubbleSort(alist):
    for passnum in range(len(alist)-1):
        swapped = False
        for i in range(len(alist) -passnum-1):
            if alist[i]>alist[i+1]:
                temp = alist[i]
                alist[i] = alist[i+1]
                alist[i+1] = temp
                swapped = True
        print("pass",passnum+1, ":",alist)
        if not swapped:
            break;

alist = [1,2,3,4,5,6]
bubbleSort(alist)
print(alist)
```

pass 1 : [1, 2, 3, 4, 5, 6]
[1, 2, 3, 4, 5, 6]

Recall: Merge Sort - Execution Example



Merge Sort Algorithm

Step 1: If the input sequence has fewer than two elements, return.

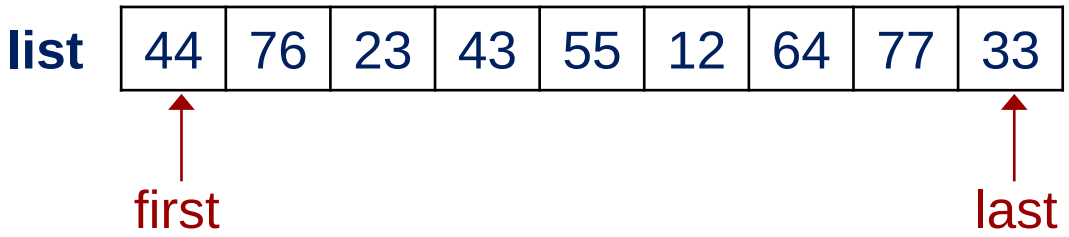
Step 2: Partition the input sequence into two halves.

Step 3: Sort the two subsequences **using the same algorithm**.

Step 4: Merge the two sorted subsequences to form the output sequence.

Pseudocode

```
MergeSort(list, first, last)
if (first < last)
      middle = (first + last) div 2
      MergeSort(list, first, middle)
      MergeSort(list, middle+1, last)
      Merge(list, first, middle, last)
end if
```



Merge Sort Function

```
def mergesort(list_of_items):
    list_len = len(list_of_items)

    # base case
    if list_len < 2:
        return list_of_items
    left_list = list_of_items[:list_len // 2]    # //
    right_list = list_of_items[list_len // 2:]   # "//" to force division

    # merge sort left and right list recursively
    left_list = mergesort(left_list)
    right_list = mergesort(right_list)
    return merge(left_list, right_list)
```

Merge Adjacent List

This means we have a list on the left and a list on the right.

Step 1 Compare the first elements of both lists one by one.

Step 2 Add this value to the list of “sorted items”. Move the smaller element out of the list that it was found in.

Step 3 Repeat the process until only a single list remains.

Step 4 One list should still contain elements. This list is sorted. Move its contents into the result list.

Suggested code

```
while left_list and right_list:
    if left_list[0] < right_list[0]:
        result_list.append(left_list[0])
        left_list.pop(0)
    else:
        result_list.append(right_list[0])
        right_list.pop(0)
    if left_list:
        result_list.extend(left_list)
    else:
        result_list.extend(right_list)
```

Merge Function

```
def merge(left_list, right_list):

    result_list = []

    # while left and right list has elements
    while left_list and right_list:
        if left_list[0] < right_list[0]:
            result_list.append(left_list[0])
            left_list.pop(0)
        else:
            result_list.append(right_list[0])
            right_list.pop(0)

    #left list still contain elements. Append its contents to end of the result
    if left_list:
        result_list.extend(left_list)
    else:
    #right list still contain elements. Append its contents to end of the result
       result_list.extend(right_list)

    return result_list
```

Application

```
list_test = [21, 1, 26, 45, 3, 3, 4, 27, 43, 34, 46, 40]
new_list = mergesort(list_test)
for item in new_list:
    print(item, end = ', ')
```

1, 3, 3, 4, 21, 26, 27, 34, 40, 43, 45, 46,

Summary

SORTING in PYTHON

Bubble Sort Algorithm

Pseudocode

```
while k < N
        for i = 0 to N = 1
                if a[i] > a[i + 1]
                then
                        swap()
        end
        k = k + 1
end
```

Merge Sort Algorithm

Pseudocode

```
MergeSort(list, first, last)
if (first < last)
      middle = (first + last) div 2
      MergeSort(list, first, middle)
      MergeSort(list, middle+1, last)
      Merge(list, first, middle, last)
end if
```