Arrays: Sort algorithm stability

Agenda

- To understand the meaning of a stable sort algorithm
- To explore the properties of a stable sort algorithm
- To analyze the stability of:
  - Bubble sort
  - Insertion sort
  - Merge sort
  - Quick sort

Stable sort algorithms

- Stable sorting algorithm
  - Multiple sort criteria: Often the case when objects are stored.
  - Based on the scenario when at least one “key” used for sorting has duplicates.

- Example scenario: eCommerce customers inventory
  - Object attributes:
    - First name
    - Last name
    - IP Address
    - Last login timestamp

Stable sort algorithms

- Example scenario: eCommerce customers inventory
  - First sort by last login timestamp.
    - You get a certain relative order of first names.
  - Save a copy of this sorted list.
  - Next, sort by first name of the users.
  - Compare this final sorted result, with the saved copy.
- Is the relative order of duplicate first names unchanged?

Stable sort: properties

- Property of Stable sort
  - Elements with equal keys, maintain their relative order after a sort.
  - When re-sorted by a different key, this order does not change.

- Where is stable sort useful?
  - When we sort objects with multiple attributes.
  - Sort according to different criteria - select a different attribute each time.

Stable sort: Analysis

- Let us examine the following sort algorithms for stability:
    - Bubble sort
    - Insertion sort
    - Mergesort
    - Quicksort

Is Bubble sort stable?

- **A closer look at the pseudocode of Bubblesort:**

Code For Bubble Sort

```
def swap(array, i, j):
    temp = array[i]
    array[i] = array[j]
    array[j] = temp
```

```
def bubble_sort(array):
    size = len(array)
    for i in range(0, size):
        for j in range(size-i-1):
            if array[j] > array[j+1]:
                swap(array, j, j+1)
            else:
                break
```

Is Bubble sort stable?

- In the algorithm, the swap happens only when array[j] is strictly greater than array[j+1].
- Above condition ensures that if array[j] and array[j+1] have same value, then there will be no swapping and position of the elements will not change.
- Conclusion: Bubble sort is stable.

Is Insertion sort stable?

- A closer look at the pseudocode of Insertionsort():

Code For Insertion Sort

```
def swap(array, i, j):
    temp = array[i]
    array[i] = array[j]
    array[j] = temp
```

```
def insertion_sort(array):
    size = len(array)
    for i in range(0, size):
        for j in range(i, 0, -1):
            if array[j] < array[j-1]:
                swap(array, j, j-1)
            else:
                break
```

Is Insertion sort stable?

- If we have duplicate (equal) elements in the array:
  - Equal elements never move past each other.
  - The relative order is maintained, even after the sort procedure completes.

- Conclusion: Insertion sort is stable.

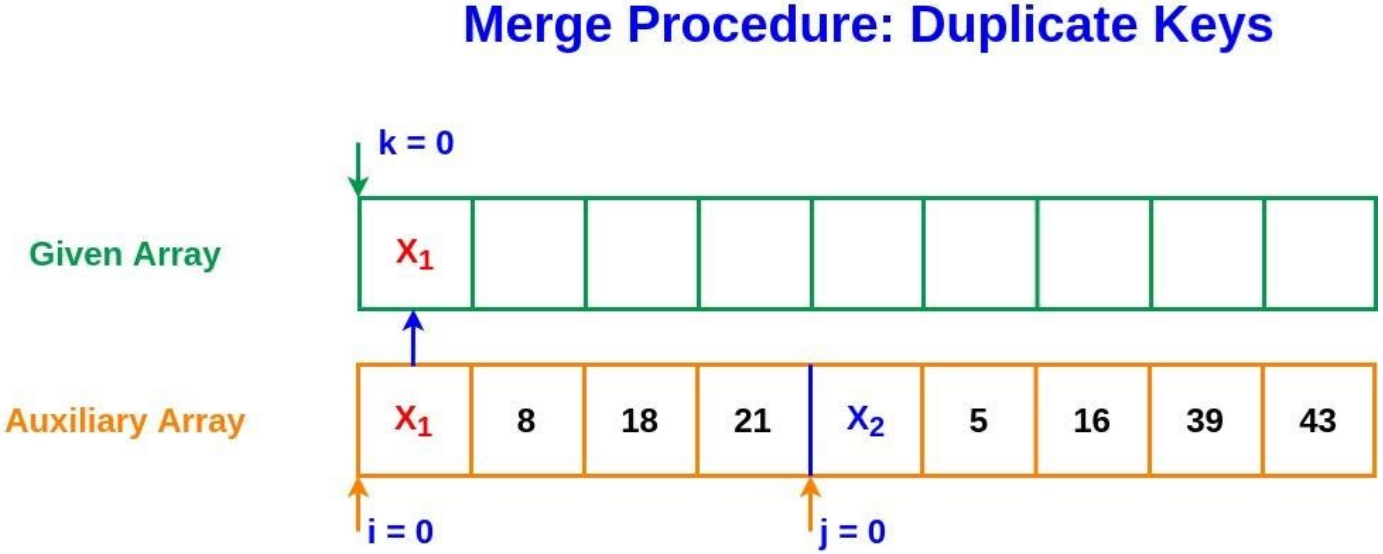
Is Merge sort stable?

- A closer look at the pseudocode of Merge():

Pseudocode For Merge

```
i = lo

j = mid+1

for k in range(lo, hi+1):
     if i > mid:
        array[k] = aux[j]
         j+=1
     elif j > hi:
        array[k] = aux[i]
        i += 1
    elif aux[j] < aux[i]:
        array[k] = aux[j]
        j += 1
        else:

          array[k] = aux[i]
             i += 1
```

Is Merge sort stable?



- **Conclusion: Mergesort is stable.**

Is Merge sort stable?

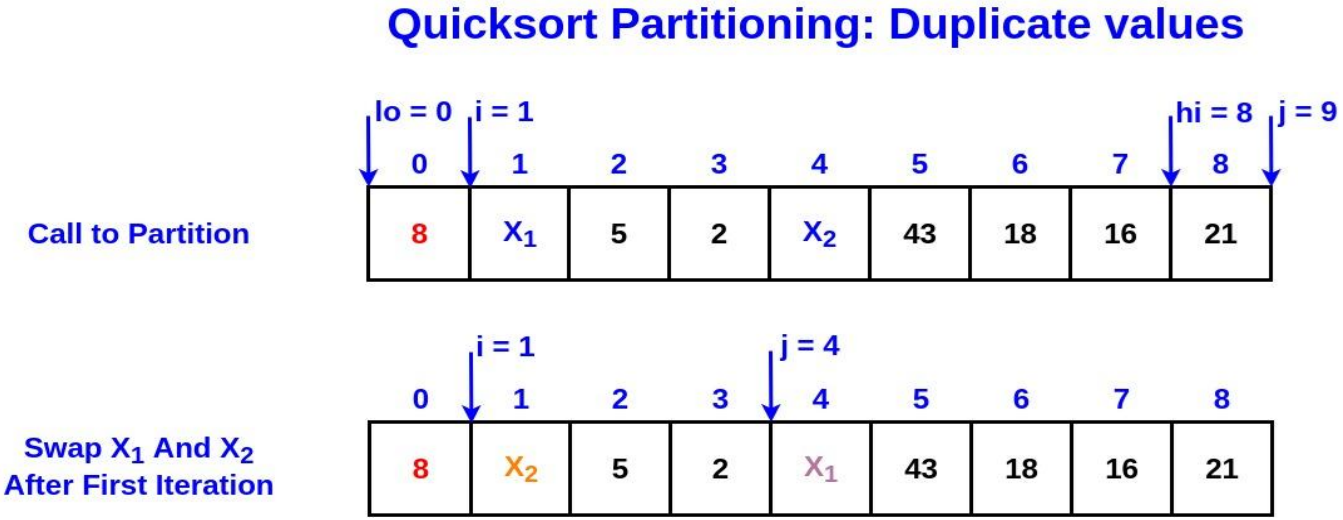
- Merge sort is stable.
  - Used in Java for object-based sort.
  - Used in other languages too:
    - Python
    - C++
    - Perl

Is Quick sort stable?

```
def partition(array, lo, hi):
            i = lo
            j = hi+1


          while True:
             i += 1
             while array[i] < array[lo]:
                if i == hi:
                   break


                i += 1


             j -= 1
             while array[lo] < array[j]:
                if j == lo:
                   break

                j -= 1


          if i >= j:

              break

          swap(array, i, j)

       swap(array, lo, j)
           return j
```

- There is an initial shuffling of Array elements.
- Also, the pseudocode for Partition()

Is Quick sort stable?



- **Conclusion: Quicksort is NOT stable.**

Is Quick sort stable?

- Quick sort is NOT stable.
  - Used in Java for sorting primitive data types.
  - Used in other languages too:
    - Python
    - C qsort() function
    - Unix/Linux

Summary

- We understood the meaning of a stable sort algorithm.
- We explored the properties of a stable sort algorithm.
- We analyzed the following algorithms for stability:
  - Bubble sort
  - Insertion sort
  - Merge sort
  - Quick sort

Thank You