Bubble Sorting

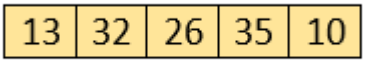
Bubble Sort is the simplest sorting algorithm that works by repeatedly swapping the adjacent elements if they are in the wrong order. This algorithm is not suitable for large data sets as its average and worst-case time complexity is quite high.

Working of Bubble sort Algorithm

Now, let's see the working of Bubble sort Algorithm.

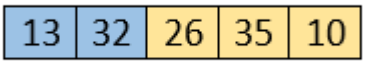
To understand the working of bubble sort algorithm, let's take an unsorted array. We are taking a short and accurate array, as we know the complexity of bubble sort is **$O(n^2)$.**

Let the elements of array are -

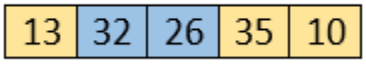


First Pass

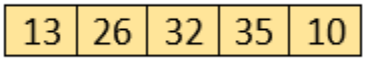
Sorting will start from the initial two elements. Let compare them to check which is greater.



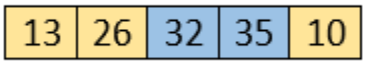
Here, 32 is greater than 13 (32 > 13), so it is already sorted. Now, compare 32 with 26.



Here, 26 is smaller than 36. So, swapping is required. After swapping new array will look like -

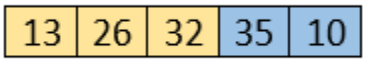


Now, compare 32 and 35.

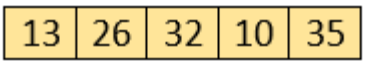


Here, 35 is greater than 32. So, there is no swapping required as they are already sorted.

Now, the comparison will be in between 35 and 10.



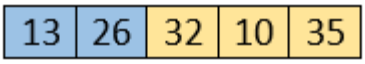
Here, 10 is smaller than 35 that are not sorted. So, swapping is required. Now, we reach at the end of the array. After first pass, the array will be -

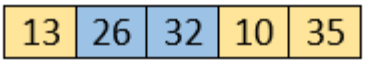


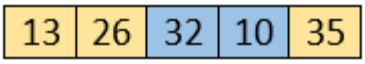
Now, move to the second iteration.

Second Pass

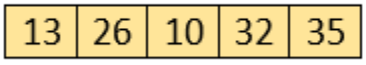
The same process will be followed for second iteration.

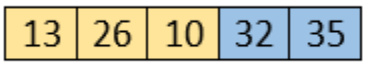






Here, 10 is smaller than 32. So, swapping is required. After swapping, the array will be -

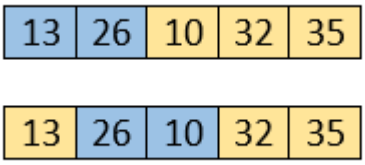




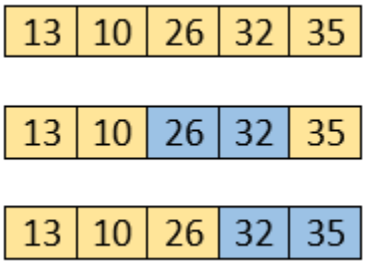
Now, move to the third iteration.

Third Pass

The same process will be followed for third iteration.



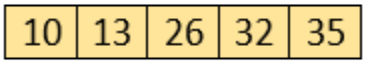
Here, 10 is smaller than 26. So, swapping is required. After swapping, the array will be -



Now, move to the fourth iteration.

Fourth pass

Similarly, after the fourth iteration, the array will be -



Hence, there is no swapping required, so the array is completely sorted.

Bubble sort complexity

Now, let's see the time complexity of bubble sort in the best case, average case, and worst case. We will also see the space complexity of bubble sort.

1. Time Complexity

Case	Time Complexity
Best Case	O(n)
Average Case	$O(n^2)$
Worst Case	$O(n^2)$

- **Best Case Complexity -** It occurs when there is no sorting required, i.e. the array is already sorted. The best-case time complexity of bubble sort is **O(n).**
- **Average Case Complexity -** It occurs when the array elements are in jumbled order that is not properly ascending and not properly descending. The average case time complexity of bubble sort is **$O(n^2)$.**
- **Worst Case Complexity -** It occurs when the array elements are required to be sorted in reverse order. That means suppose you have to sort the array elements in ascending order, but its elements are in descending order. The worst-case time complexity of bubble sort is **$O(n^2)$.**

2. Space Complexity

Space Complexity	O(1)
Stable	YES

- The space complexity of bubble sort is O(1). It is because, in bubble sort, an extra variable is required for swapping.
- The space complexity of optimized bubble sort is O(2). It is because two extra variables are required in optimized bubble sort.

Now, let's discuss the optimized bubble sort algorithm.

Optimized Bubble sort Algorithm

In the bubble sort algorithm, comparisons are made even when the array is already sorted. Because of that, the execution time increases.

To solve it, we can use an extra variable *swapped.* It is set to true if swapping requires; otherwise, it is set to false**.**

It will be helpful, as suppose after an iteration, if there is no swapping required, the value of variable swapped will be false**.** It means that the elements are already sorted, and no further iterations are required.

This method will reduce the execution time and also optimizes the bubble sort.

Code for Bubble Sort

```java
package Sorting;

import java.util.Arrays;
public class BubbleSort  {
    public static void main(String[] args) {
        int[] arr = {4,3,5,6,2,1};
        sort(arr);
    }

    public static void sort (int[] arr) {
        boolean swapped;
        int end = arr.length;
        for (int i = 0; i < arr.length-1; i++) {
            swapped = false;
            for (int j = 0 ; j < arr.length-1-i; j++) {
                if (arr[j] > arr[j+1]) {
                    int temp = arr[j];
                    arr[j]=arr[j+1];
                    arr[j+1]=temp;
                    swapped = true;
                }
            }

            if(!swapped) {  // time complexity O(n)
                break;
            }
        }
        System.out.println(Arrays.toString(arr));
    }
}
```