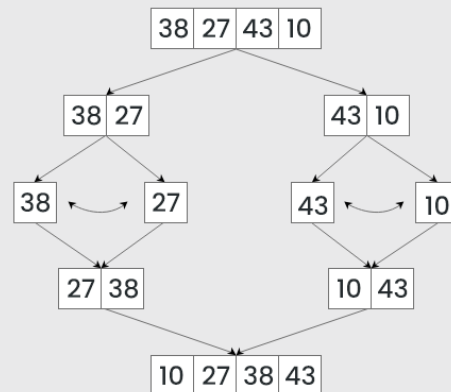# Merge Sort

💡 **Merge sort** is a sorting algorithm that follows the divide and conquer approach. It works by recursively dividing the input array into smaller subarrays and sorting those subarrays then merging them back together to obtain the sorted array.
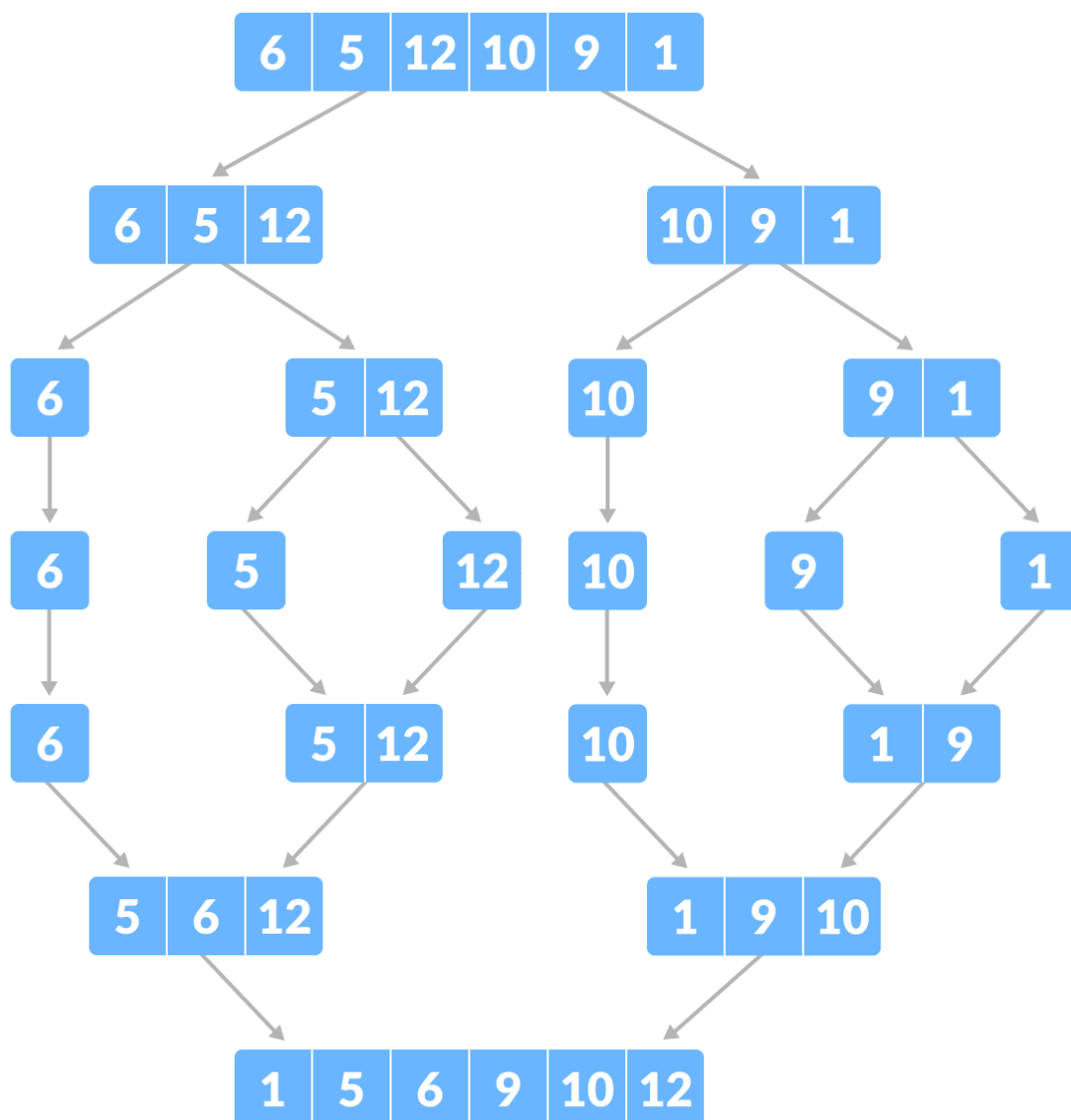
Algorithm steps

1. **Divide:** Divide the list or array recursively into two halves until it can no more be divided.

2. **Conquer:** Each subarray is sorted individually using the merge sort algorithm.

3. **Merge:** The sorted subarrays are merged back together in sorted order. The process continues until all elements from both subarrays have been merged.

Pseudocode

```
procedure mergesort( var a as array )
   if ( n == 1 ) return a
      var l1 as array = a[0] ... a[n/2]
      var l2 as array = a[n/2+1] ... a[n]
      l1 = mergesort( l1 )
      l2 = mergesort( l2 )
      return merge( l1, l2 )
end procedure
procedure merge( var a as array, var b as array )
   var c as array
   while ( a and b have elements )
      if ( a[0] > b[0] )
         add b[0] to the end of c
         remove b[0] from b
      else
         add a[0] to the end of c
         remove a[0] from a
      end if
   end while
   while ( a has elements )
      add a[0] to the end of c
      remove a[0] from a
   end while
   while ( b has elements )
      add b[0] to the end of c
      remove b[0] from b
   end while
   return c
end procedure
```

Complexity Analysis
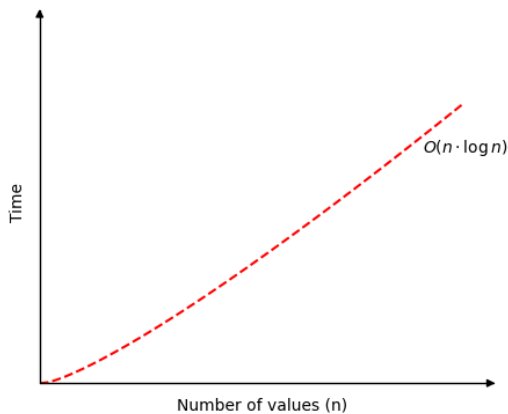
- **Best Case:** O(n log n), When the array is already sorted or nearly sorted.

- **Average Case:** O(n log n), When the array is randomly ordered.

- **Worst Case:** O(n log n), When the array is sorted in reverse order.

Applications of Merge Sort:

- Sorting large datasets

- **External Sorting** (when the dataset is too large to fit in memory)

- Inversion Carting

- Merge Sort and its variations are used in library methods of programming languages. For example its variation TimSort is used in Python, Java Android and Swift. The main reason why it is preferred to sort non-primitive types is stability which is not there in QuickSort. For example **Arrays.sort in Java** uses QuickSort while Collections sort uses MergeSort.

- It is a preferred algorithm for sorting Linked lists.

- It can be easily parallelized as we can independently sort subarrays and then merge.

- The merge function of merge sort to efficiently solve the problems like union and intersection of two sorted arrays

Advantages of Merge Sort:

- **Stability** : Merge sort is a stable sorting algorithm, which means it maintains the relative order of equal elements in the input array.

- **Guaranteed worst-case performance:** Merge sort has a worst-case time complexity of **O(N logN)** , which means it performs well even on large datasets.

- **Simple to implement:** The divide-and-conquer approach is straightforward.

- **Naturally Parallel** : We independently merge subarrays that makes it suitable for parallel processing.

Disadvantages of Merge Sort:

- **Space complexity:** Merge sort requires additional memory to store the merged sub-arrays during the sorting process.

- **Not in-place:** Merge sort is not an in-place sorting algorithm, which means it requires additional memory to store the sorted data. This can be a disadvantage in applications where memory usage is a concern.

- S**lower than QuickSort in general**. QuickSort is more cache friendly because it works in-place.

📌   Java implementation can be found under Implementation_Java folder

📚 References

Merge Sort (With Code in Python/C++/Java/C)

Merge Sort is a kind of Divide and Conquer algorithm in computer programming. In this tutorial, you will understand the working of merge sort with working code in C, C++, Java, and Python.

🅟 https://www.programiz.com/dsa/merge-sort

Merge Sort Algorithm

Merge Sort Algorithm - Merge sort is a sorting technique based on divide and conquer technique. With worst-case time complexity being O(n log n), it is one of the most used

🄣 https://www.tutorialspoint.com/data_structures_algorithms/merge_sort_algorithm.htm

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SerhatKumas - Overview

Computer engineering student who loves coding in different fields instead of focusing on a one spesific area. - SerhatKumas

 https://github.com/SerhatKumas