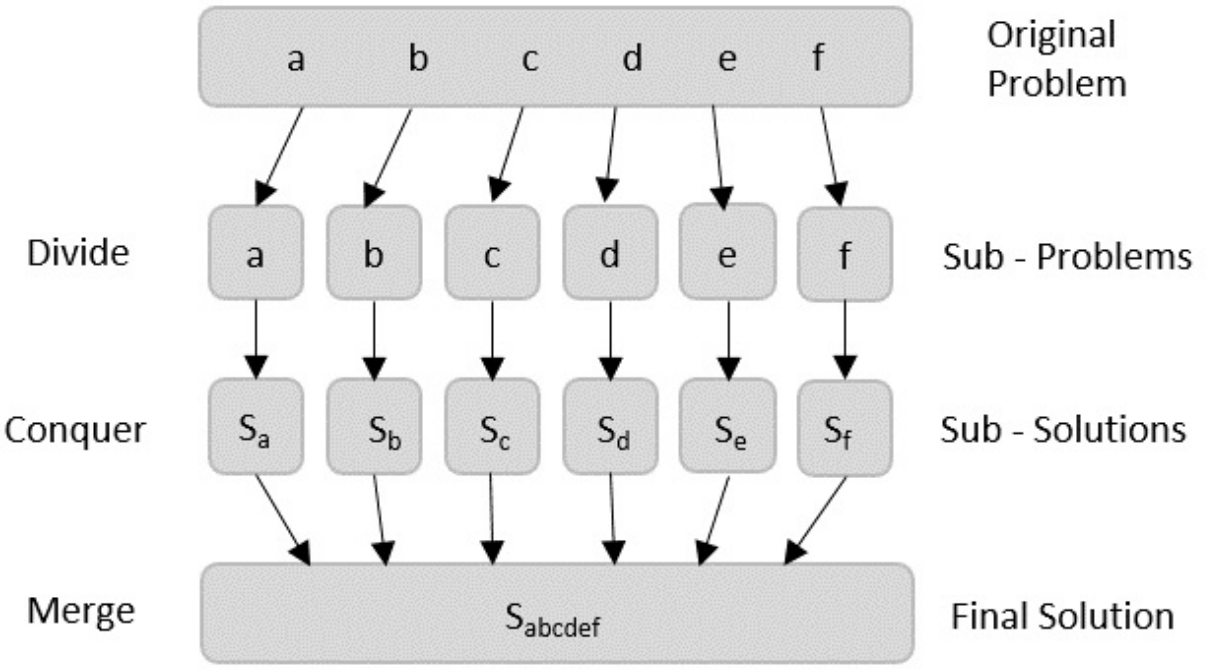
Divide & Conquer Algorithm

Using divide and conquer approach, the problem in hand, is divided into smaller sub-problems and then each problem is solved independently. When we keep dividing the sub-problems into even smaller sub-problems, we may eventually reach a stage where no more division is possible. Those smallest possible sub-problems are solved using original solution because it takes lesser time to compute. The solution of all sub-problems is finally merged in order to obtain the solution of the original problem.



Broadly, we can understand **divide-and-conquer** approach in a three-step process.

Divide/Break

This step involves breaking the problem into smaller sub-problems. Sub-problems should represent a part of the original problem. This step generally takes a recursive approach to divide the problem until no sub-problem is

further divisible. At this stage, sub-problems become atomic in size but still represent some part of the actual problem.

Conquer/Solve

This step receives a lot of smaller sub-problems to be solved. Generally, at this level, the problems are considered 'solved' on their own.

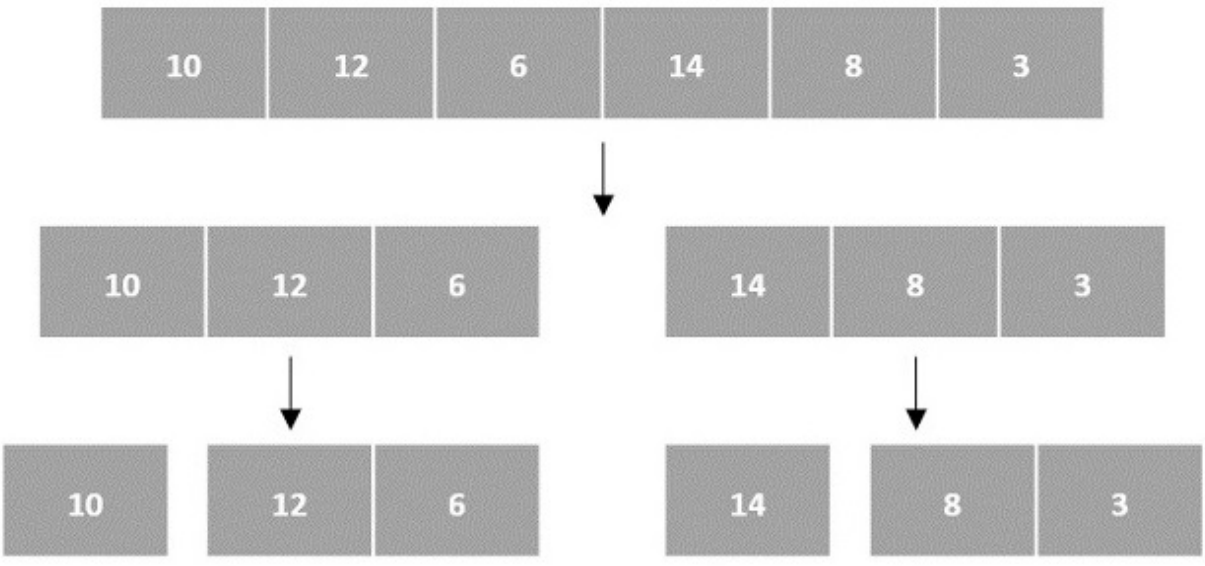
Merge/Combine

When the smaller sub-problems are solved, this stage recursively combines them until they formulate a solution of the original problem. This algorithmic approach works recursively and conquer & merge steps works so close that they appear as one.

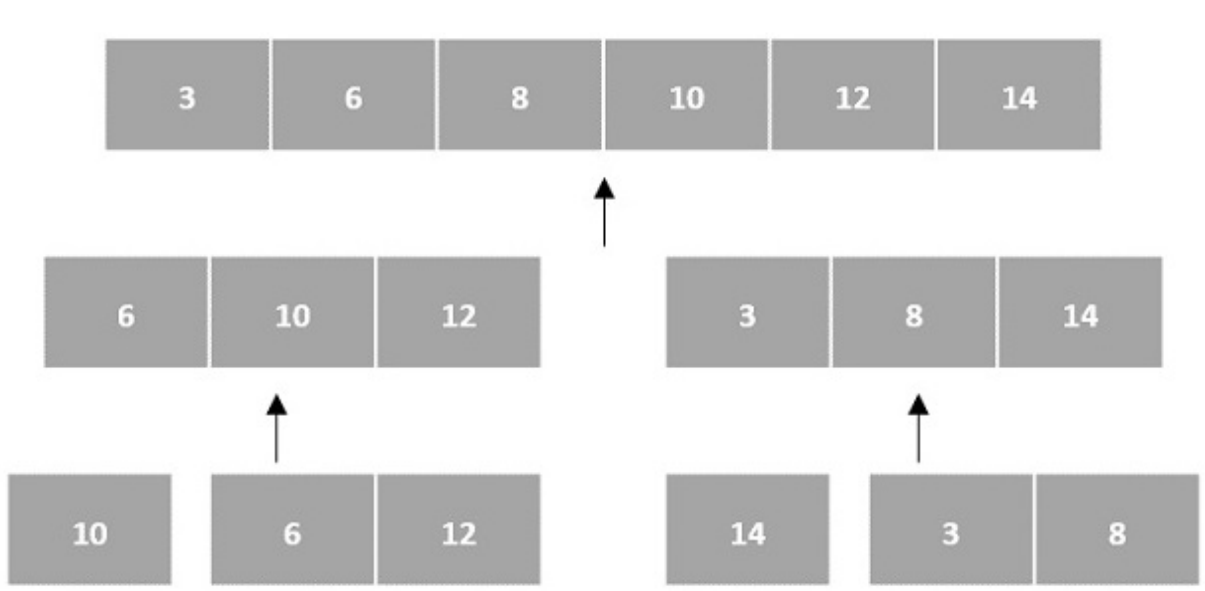
Arrays as Input

There are various ways in which various algorithms can take input such that they can be solved using the divide and conquer technique. Arrays are one of them. In algorithms that require input to be in the form of a list, like various sorting algorithms, array data structures are most commonly used.

In the input for a sorting algorithm below, the array input is divided into subproblems until they cannot be divided further.



Then, the subproblems are sorted (the conquer step) and are merged to form the solution of the original array back (the combine step).

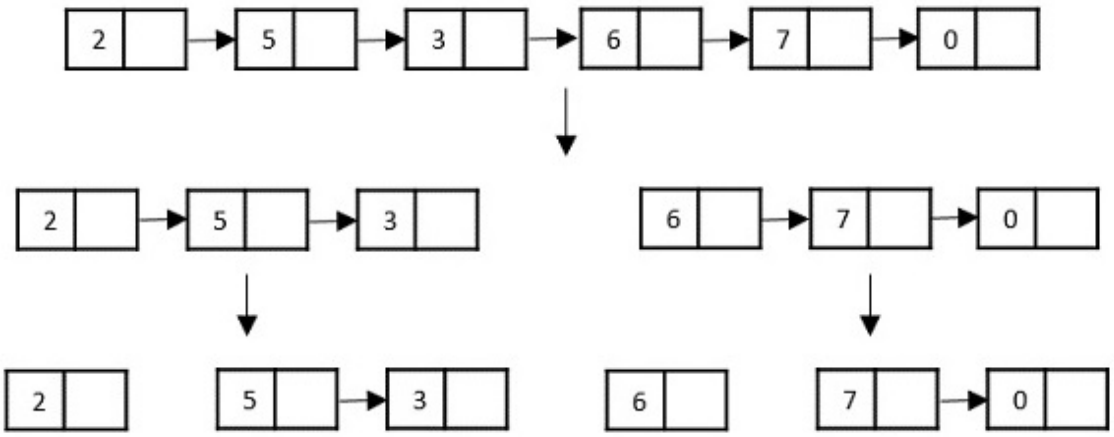


Since arrays are indexed and linear data structures, sorting algorithms most popularly use array data structures to receive input.

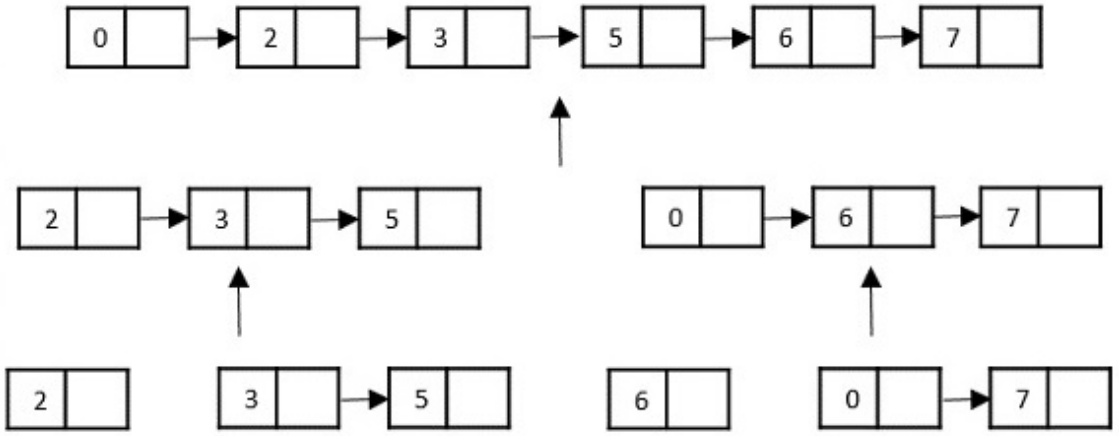
Linked Lists as Input

Another data structure that can be used to take input for divide and conquer algorithms is a linked list (for example, merge sort using linked lists). Like arrays, linked lists are also linear data structures that store data sequentially.

Consider the merge sort algorithm on linked list; following the very popular tortoise and hare algorithm, the list is divided until it cannot be divided further.



Then, the nodes in the list are sorted (conquered). These nodes are then combined (or merged) in recursively until the final solution is achieved.



Various searching algorithms can also be performed on the linked list data structures with a slightly different technique as linked lists are not indexed linear data structures. They must be handled using the pointers available in the nodes of the list.

Pros and cons of Divide and Conquer Approach

Divide and conquer approach supports parallelism as sub-problems are independent. Hence, an algorithm, which is designed using this technique, can run on the multiprocessor system or in different machines simultaneously.

In this approach, most of the algorithms are designed using recursion, hence memory management is very high. For recursive function stack is used, where function state needs to be stored.

Examples of Divide and Conquer Approach

The following computer algorithms are based on divide-and-conquer programming approach –

- Max-Min Problem
- Merge Sort Algorithm
- Quick Sort Algorithm
- Binary Search Algorithm
- Strassen's Matrix Multiplication
- Karatsuba Algorithm
- Closest pair (points)

There are various ways available to solve any computer problem, but the mentioned are a good example of divide and conquer approach.