Problem solving Technique

Lesson 3: Algorithm Design Techniques

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Lesson Objectives

- **To enhance the logic building by designing algorithms efficiently for the given problem.**
- **To understand and compare different Sorting methods under different design techniques:**
  - Bubble Sort
  - Insertion Sort
  - Merge Sort
- **To understand and compare different algorithms designed for a given problem under different design techniques:**

Algorithm Design Technique

- **There are different techniques to design an Algorithm. They are**
  - Brute Force
  - Divide and Conquer
  - Decrease and Conquer
  - Transform and Conquer
  - Space and Time Tradeoffs
  - Dynamic Programming
  - Greedy Technique
  - Backtracking
  - Branch and Bound

Brute Force – Bubble Sort

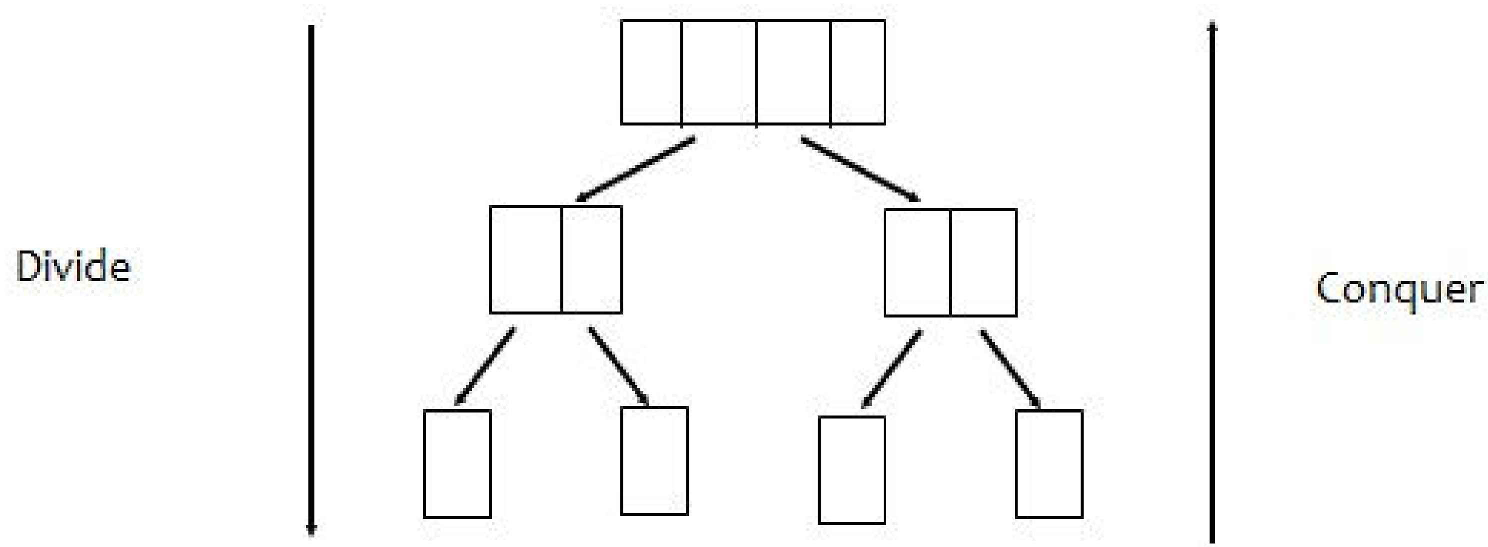
- **Brute Force: Just do it!!**
- **Easiest solution is found for a problem without any concern of the efficiency parameter.**
- **Ex: Bubble Sort and Selection Sort.**
- **Logic for Bubble Sort Algorithm**
  - Compare adjacent elements (n) and (n+1), starting with n=1.
    - If the first is greater than the second, swap them
  - Repeat this for each pair of adjacent elements, starting with the "first two elements", and ending with the "last two elements"
    - At any point, the last element should be the largest
  - Repeat the steps for all elements except the last one
  - Keep repeating for one fewer element each time, until you have no more pairs to compare

Bubble Sort Algorithm

- **Write the Pseudo Code for the above logic**
- **Exchange your code with another participant**
  - Do a peer review of the pseudo code, and report defects that are found
- **How many passes, how many comparisons does this process involve for n=10?**
  - The number of passes are always n-1
- **If the data were mostly sorted, how can we do it faster?**
  - If there are no swaps in a particular iteration of the INNER loop, we can stop
- **Write a separate function SWAP to improve readability of the above code**
- **Efficiency is O(n^2)**

Divide and Conquer

- **Divide and Conquer:**
  - A problem is divided into several subproblems of the same type, ideally of about equal size.
  - The subproblems are solved.
  - If necessary, the solutions to the subproblems are combined to get a solution to the original problem.

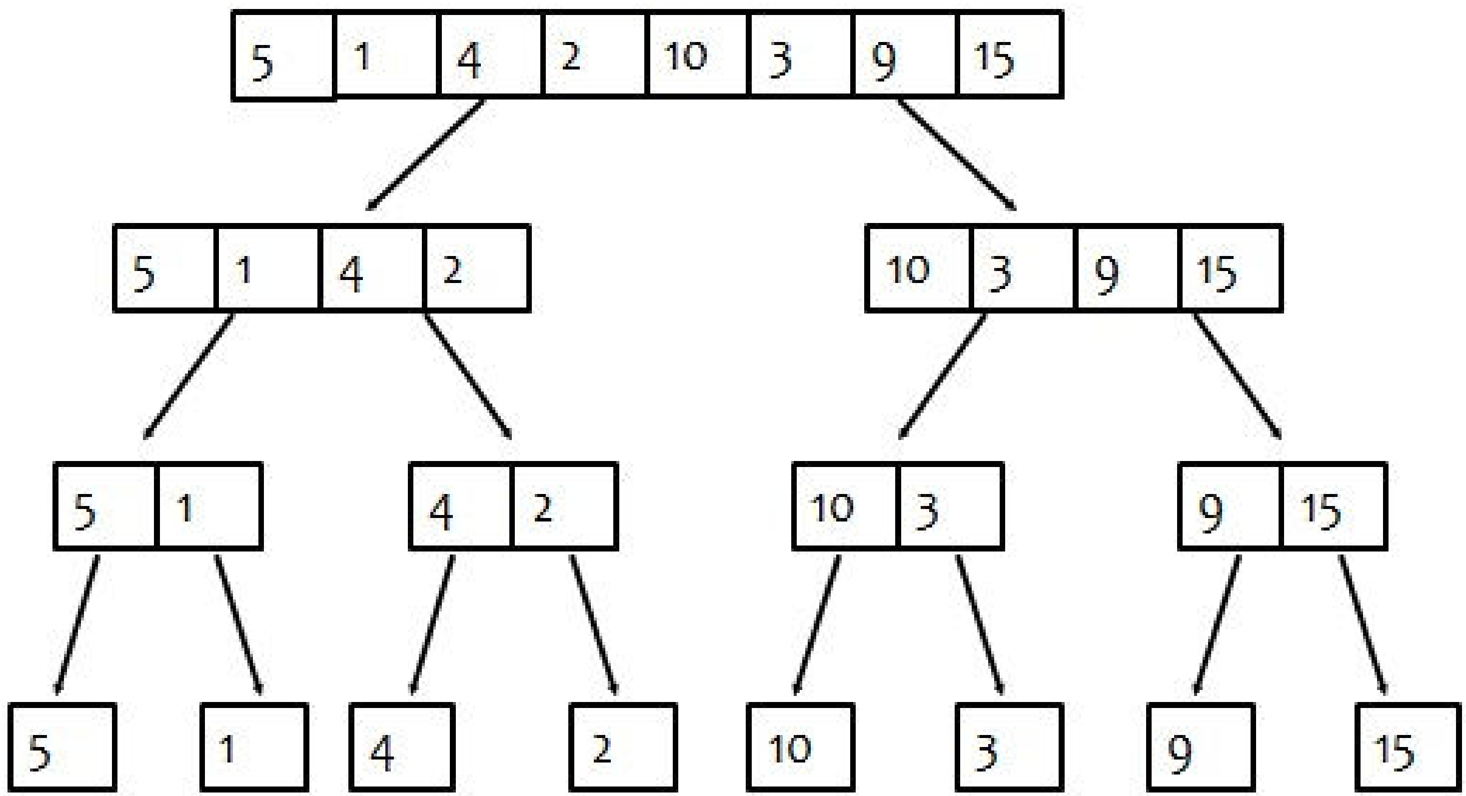


Divide and conquer Approach

- **Ex: Merge Sort, Quick Sort etc.**

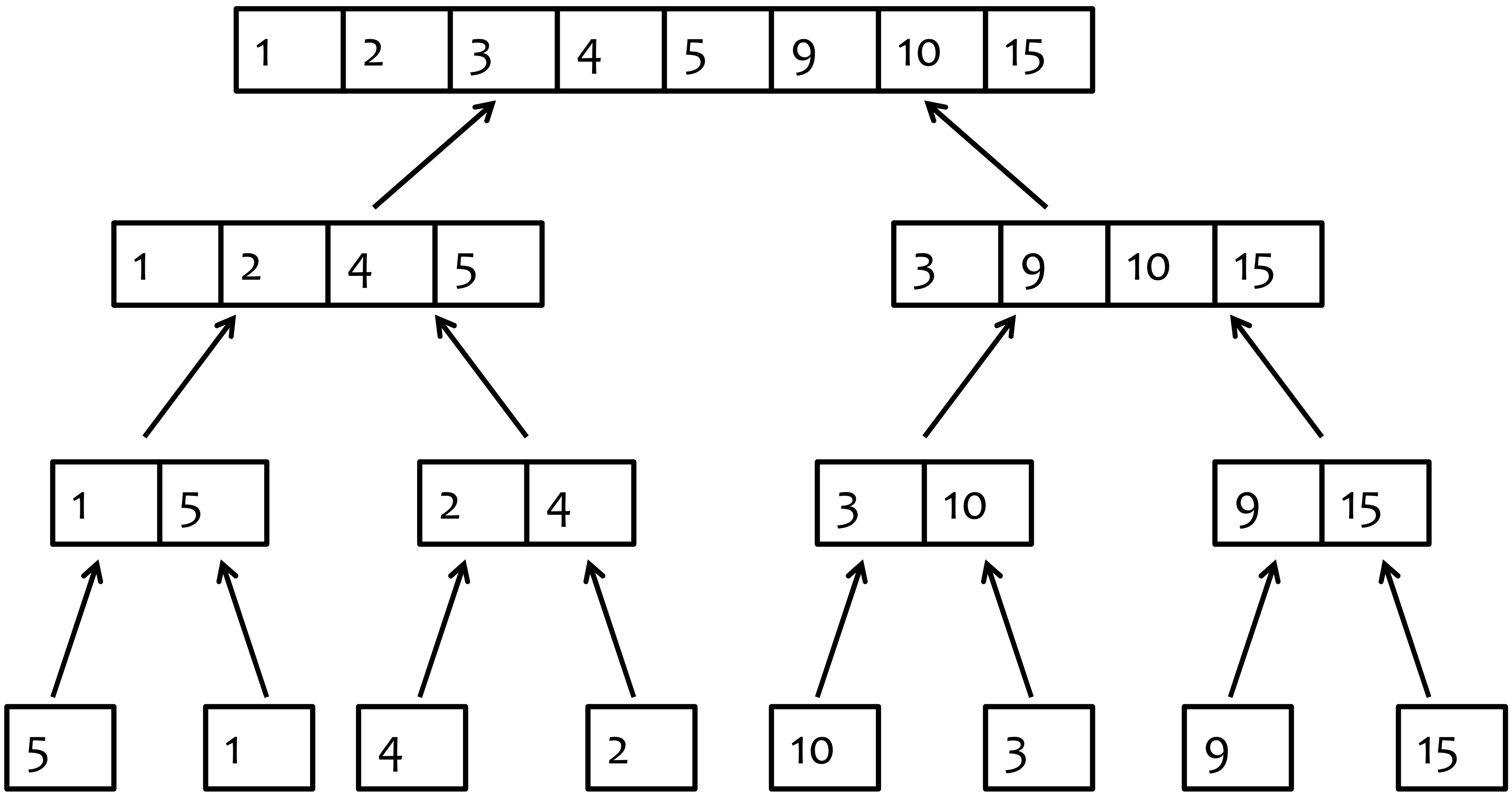
Divide and Conquer – Merge Sort

- **Merge sort sorts a given array *A*[0..*n* – 1] by dividing it into two halves *A*[0..*n*/2 – 1] and *A*[*n*/2..*n* – 1], sorting each of them recursively, and then merging the two smaller sorted arrays into a single sorted one.**



ADT – Divide and Conquer

- **Below figure shows conquering steps. And Final list is sorted.**



Decrease and Conquer – Insertion Sort

- **Decrease and Conquer:**
  - It is based on exploiting the relationship between a solution to a given instance of a problem and a solution to a smaller instance of the same problem.
- **Ex: Insertion Sort, Topological Sorting etc.**
- **Insertion Sort**
  - Implemented by inserting a particular element at the appropriate position
  - While inserting the element we need to find the position to insert the element
  - All other elements will be shifted one location on right to make place for new element and then the element will be inserted at the position
  - This is normally done in place (by using single array)

Insertion Sort - Example

- **Example: Consider the following array**
- **5 7 0 3 4 2 6 1**
- **On the left side the sorted part of the sequence is shown as underline. For each iteration, the number of positions the inserted element has moved is shown in brackets**
- **5 7 0 3 4 2 6 1 (0) – only a[0] is in sorted part**
- **5 7 0 3 4 2 6 1 (0) – array is sorted till a[1]**

Insertion Sort - Example

- 0 5 7 3 4 2 6 1 (2) - 0 will be inserted at a[0] location
- 0 3 5 7 4 2 6 1 (2) - 3 will be inserted at a[1] position
- 0 3 4 5 7 2 6 1 (2) - 4 will be inserted at a[2] position
- 0 2 3 4 5 7 6 1 (4) - 2 will be inserted at a[1] position
- 0 2 3 4 5 6 7 1 (1) - 6 will get inserted at a[5] position
- 0 1 2 3 4 5 6 7 (5) - 1 will be inserted at a[1] position

Insertion Sort - Features

- **Less efficient on large lists than more advanced algorithms such as quick sort, heap sort, or merge sort**
- **Advantages**
  - simple implementation
  - efficient for (quite) small data sets
  - efficient for data sets that are already substantially sorted: the time complexity is O (n + d), where d is the number of inversions
- **Efficiency is $O(n^2)$.**

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Space and Time Tradeoffs– Sorting

- **In this technique, Problem's input is preprocessed and the additional information is stored, used while solving the problem.**
- **Ex: Sorting by counting, Boyer-Moore etc**
- **Sorting by Counting:**
  - Idea to count, for each element of a list to be sorted, the total number of elements smaller than an element and record the results in a table.
  - These numbers will indicate the positions of the elements in the sorted list
- **Consider the array,**

78	**12**	**45**	**67**	**23**	**37**

- **After applying the algorithm as said above the Count_Array [] would be,**

5	**0**	**3**	**4**	**1**	**2**

- **Final sorted list would be,**

0	1	2	3	4	5
12	23	37	45	67	78

Space and Time Tradeoffs– Sorting

- **Efficiency: It should be quadratic because the algorithm considers all the different pairs of an *n*-element array.**
- **Same as Selection sort.**
- **On the positive note, the algorithm makes the minimum number of key moves possible, placing each of them directly in their final position in a sorted array.**

Lesson Summary

- **To understand and compare different Sorting techniques:**
  - Bubble Sort
  - Insertion Sort
- **To understand and compare different design techniques**
- **To identify proper design technique for the given problem and design an efficient algorithm accordingly.**

Review Questions

- **Question 1: Which of the following sorting techniques uses swapping of two elements to sort the array:**
  - A: Bubble sort
  - B: Quick sort
  - C: Insertion sort
- **Question 2: What is the efficiency of bubble sort algorithm?**
  - O(n)
  - $O(n^2)$
  - O(nlogn)
  - O(logn)
- **Question 3: Arranging elements in an ascending or descending order is called as ___**
- **Question 4: ____________ techniques are mainly used to solve difficult combinatorial problems.**

Review Questions: Match the Following

- **Question 3:**

1.	Bubble sort
2.	Sequential search
3.	Binary search
4.	Insertion sort

a. Best case is finding element at the fist position
b. Require to use nested loops
c. Find position before inserting element
d. Best case is finding the element at the middle
e. Collision