**Data Structures Lab**

***Session 07***

**Course:** Data Structures (CS2001) **Semester:** Fall 2022

**Instructor: Ali Fatmi**  **T.A:** N/A

**Note:**

* + - * Lab manual cover following below Advance sorting algorithms

**{Merge Sort, Quick Sort, Radix Sort, Comb Sort, Linear Searching, Binary Searching, Interpolation Search}**

* Maintain discipline during the lab.
* Just raise hand if you have any problem.
* Completing all tasks of each lab is compulsory.
* Get your lab checked at the end of the session.

**Merge Sort:**

Merge Sort Algorithm is a Divide & Conquer algorithm. It divides input array in two halves, calls itself for the two halves (recursively) and then merges the two sorted halves. A separate merge () function is used for merging two halves.

There are 3 Phases in the Merge Sort Algorithm

**Division Phase:** Divide the array into 2 halves by finding the mid of the array.

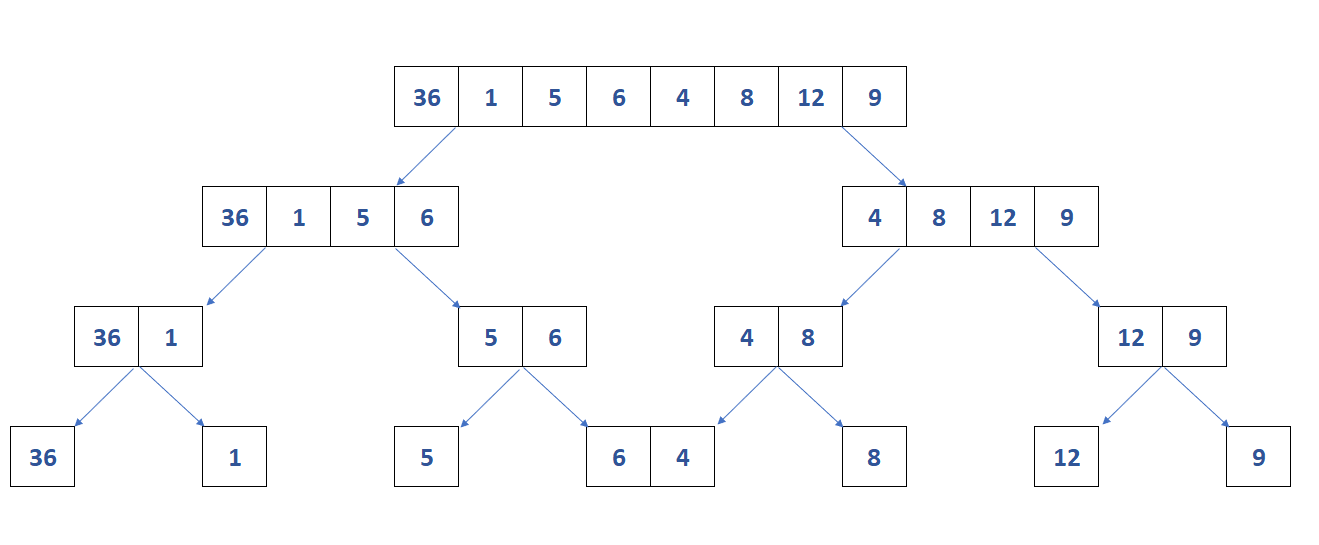
1. Mid (m) = (left + right)/ 2
2. left is the starting index & right is the last index of the array

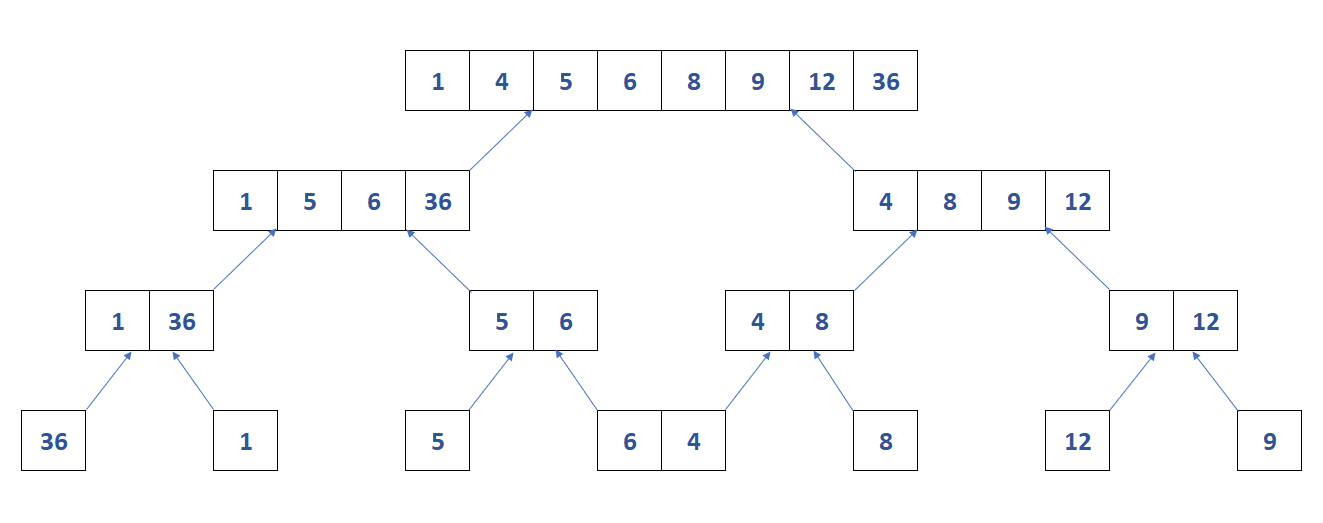
**Recursion Phase**

1. Call Merge Sort on the left sub-array
2. Call Merge Sort on the right sub-array

**Merge Phase**

1. Call merge function to merge the divided sub-arrays back to the original array.
2. Perform sorting of these smaller sub arrays before merging them back





**Quick Sort:**

Quick Sort Algorithm is a Divide & Conquer algorithm. It divides input array in two partitions, calls itself for the two partitions (recursively) and performs in-place sorting while doing so. A separate partition () function is used for performing this in-place sorting at every iteration.

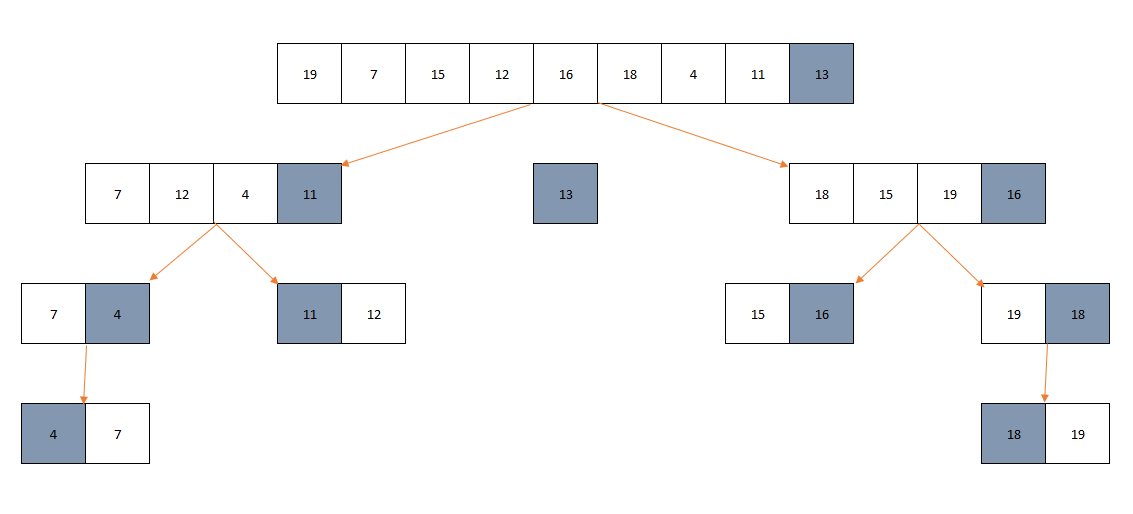
There are 2 Phases in the Quick Sort Algorithm.

**Division Phase** – Divide the array into 2 halves by finding the pivot point to perform the partition of the array.

1. The in-place sorting happens in this partition process itself.

**Recursion Phase** –

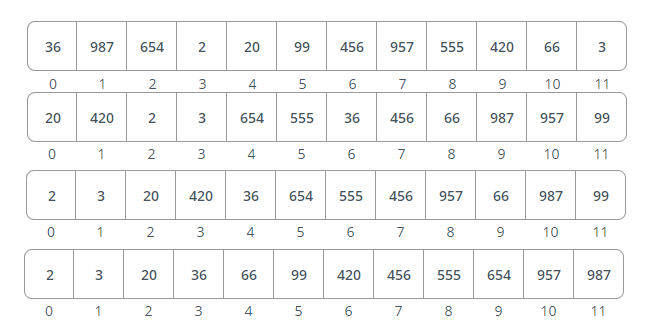
1. Call Quick Sort on the left partition
2. Call Quick Sort on the right partition.



**Radix Sort:**

Radix sort is a non-comparative sorting algorithm. It avoids comparison by creating and distributing elements into buckets according to their radix. For elements with more than one significant digit, this bucketing process is repeated for each digit, while preserving the ordering of the prior step, until all digits have been considered. For this reason, radix sort has also been called bucket sort and digital sort.

* Step 1 – Take input array and find MAX number in the array
* Step 2 – Define 10 queues each representing a bucket for each digit from 0 to 9.
* Step 3 – Consider the least significant digit of each number in the list which is to be sorted.
* Step 4 – Insert each number into their respective queue based on the least significant digit.
* Step 5 – Group all the numbers from queue 0 to queue 9 in the order they have inserted into their respective queues.
* Step 6 – Repeat from step 3 based on the next least significant digit.
* Step 7 – Repeat from step 2 until all the numbers are grouped based on the most significant digit.



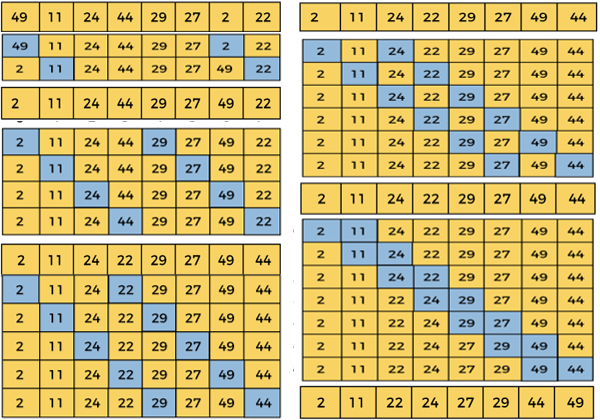
**Comb Sort:**

Comb sort is a comparison based sorting algorithm which improves on bubble sort.  
Comb sort uses a larger gap and works on bubble sort strategy. We define a variable gap and the elements separated by the gap are compared and swapped to get sorted order of elements.

The gap is initialized as size of the array and after every iteration the gap is reduced by a shrink factor as described in the below algorithm steps.

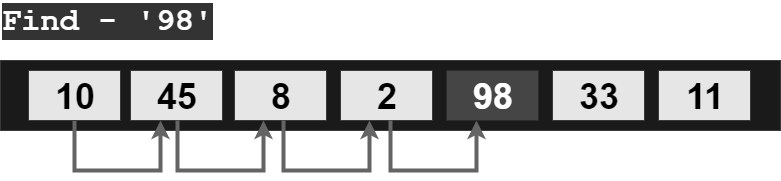
The iteration continues till the gap becomes 1. So the last iteration of this algorithm is same as a bubble sort iteration.

The best shrink factor has been found to be 1.3.



**Linear Search**

Linear search algorithm or sequential search is a method for finding an element within a list. It sequentially checks each element of the list until a match is found or the whole list has been searched.

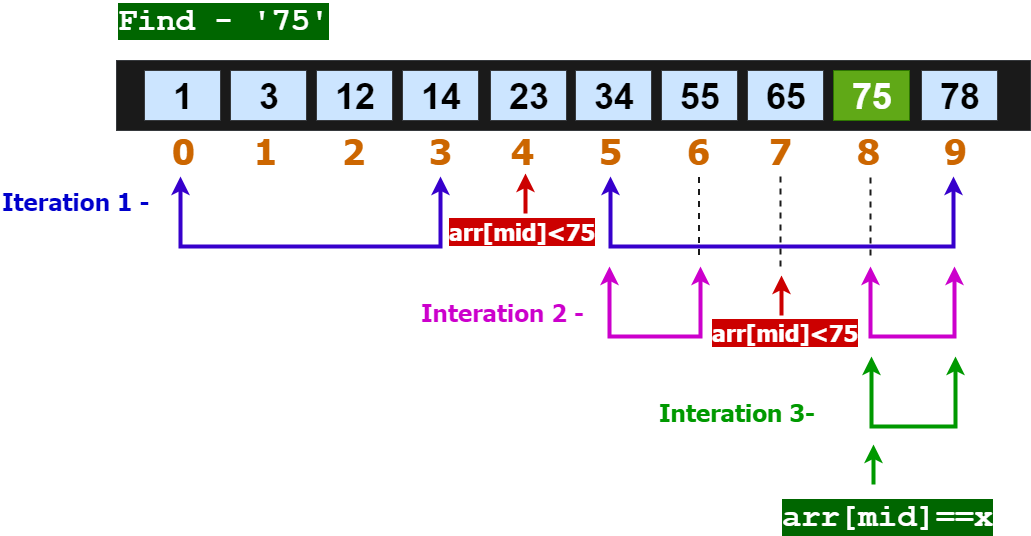


**Binary Search**

Binary search algorithm falls under the category of interval search algorithms. This algorithm is much more efficient compared to linear search algorithm. Binary search only works on sorted data structures. This algorithm repeatedly target the center of the sorted data structure & divide the search space into half till the match is found.

**Algorithm:**

* ***Take input array, left, right & x***
* ***START LOOP – while(left greater than or equal to right)***
  + ***mid = left + (right-left)/2***
  + ***if(arr[mid]==x) then***
    - ***return m***
  + ***else if(arr[mid] less than x) then***
    - ***left = m + 1***
  + ***else***
    - ***right= mid – 1***
* ***END LOOP***
* ***return -1***



**Interpolation Search**

Interpolation search is an improvement over binary search. Binary Search always checks the value at middle index. But, interpolation search may check at different locations based on the value of element being searched. For interpolation search to work efficiently the array elements/data should be sorted and uniformly distributed.

***Position = start +***

**Algorithm**

1. **start = 0 & end = n-1**
2. **calculate position to start searching at using formula:**

***Position = start +***

1. **If A [pos] == Element, element found at index pos.**
2. **Otherwise if element > A[pos] we make start = pos + 1**
3. **Else if element < A[pos] we make end = pos -1**
4. **Do steps 2,3, 4, 5, While : start <= end && element >= A[start] && element =< A[end]**
   * **Start <= end - that is until we have elements in the sub-array.**
   * **Element >= A[start] - element we are looking for is greater than or equal to the starting element of sub-array we are looking in.**
   * **Element =< A[end] - element we are looking for is less than or equal to the last element of sub-array we are looking in.**

**Tasks:**

1. Modify the algorithm of merge so that merge works in O (1) extra space and algorithm still works in

O (n Log n) time.

Examples:

Input: 5 4 3 2 1

Output: 1 2 3 4 5

Input: 999 612 589 856 56 945 243

Output: 56 243 589 612 856 945 999

1. Implement that quick sort simply chooses the middle element as the pivot.
2. Given an array of integers, sort the array in ascending as well as descending order and return it using radix sort.
3. Given an array of integers, sort the array in ascending as well as descending order and return it using Comb sort.
4. Write code for interpolation and Binary Search and show the iteration of both algorithm for uniformly distributed array.