CL2001 **Data Structures Lab**	**Lab 7** **Advance Sorting**

NATIONAL UNIVERSITY OF COMPUTER AND EMERGING SCIENCES

Fall 2025

Lab Content

1. Quick Sort
2. Merge Sort
3. Radix Sort

Quick Sort

Quick Sort Algorithm is a **Divide & Conquer algorithm**. It divides input arrays 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:

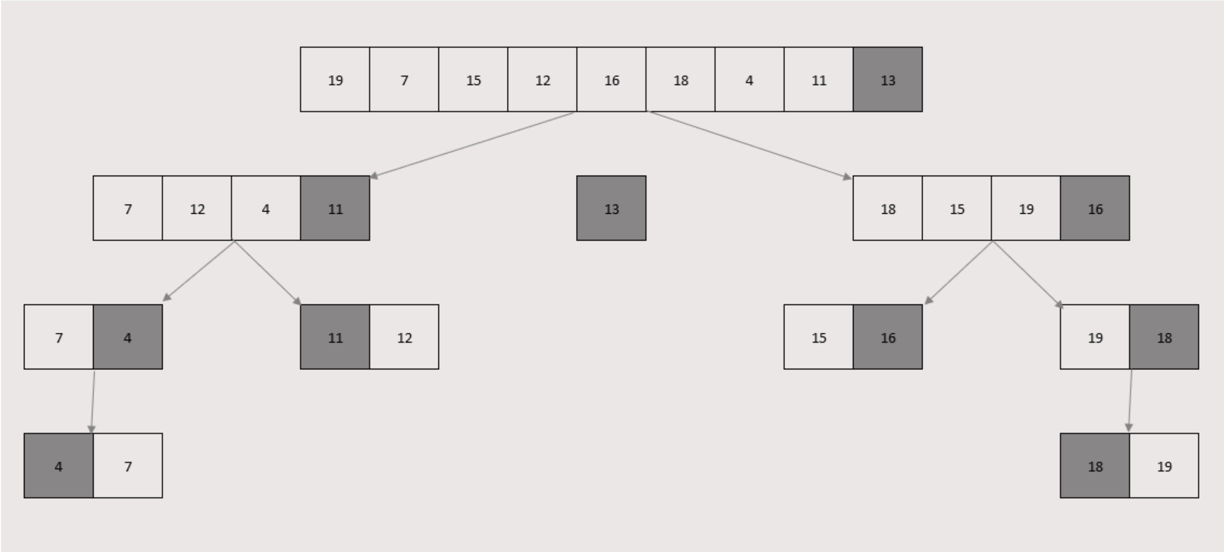
- Divide the array into 2 halves by finding the pivot point to perform the partition of the array.
- The in-place sorting happens in this partition process itself.

Recursion Phase:

- Call Quick Sort on the left partition
- Call Quick Sort on the right partition.

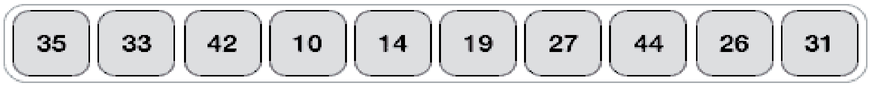
Quick Sort Algorithm:

- Make the right-most index value pivot
- Partition the array using pivot value
- Quicksort left partition recursively
- Quicksort right partition recursively



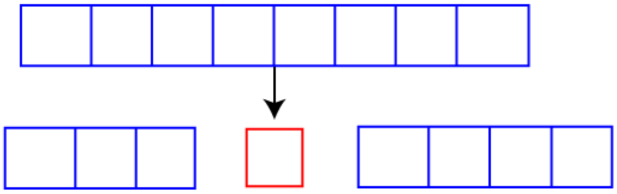
Pivot Selection:

Unsorted Array



35	33	42	10	14	19	27	44	26	31

- ➔ Choose the any index value as pivot
- ➔ Take two variables to point left and right of the list excluding pivot
- ➔ Left points to the low index & Right points to the high index
- ➔ While value at left is less than pivot move right & While value at right is greater than pivot move left
- ➔ If both left & right step does not match swap left and right
- ➔ If left = right, the point where they met is new pivot



Pseudocode:

```
function partitionFunc(left, right, pivot)
   leftPointer = left
   rightPointer = right - 1
   while True do
      while A[++leftPointer] < pivot do
      //do-nothing
      end while
      while rightPointer > 0 && A[--rightPointer] > pivot do
         //do-nothing
      end while
      if leftPointer >= rightPointer
         break
      else
         swap leftPointer,rightPointer
      end if
   end while
   swap leftPointer,right
   return left pointer
end function
```

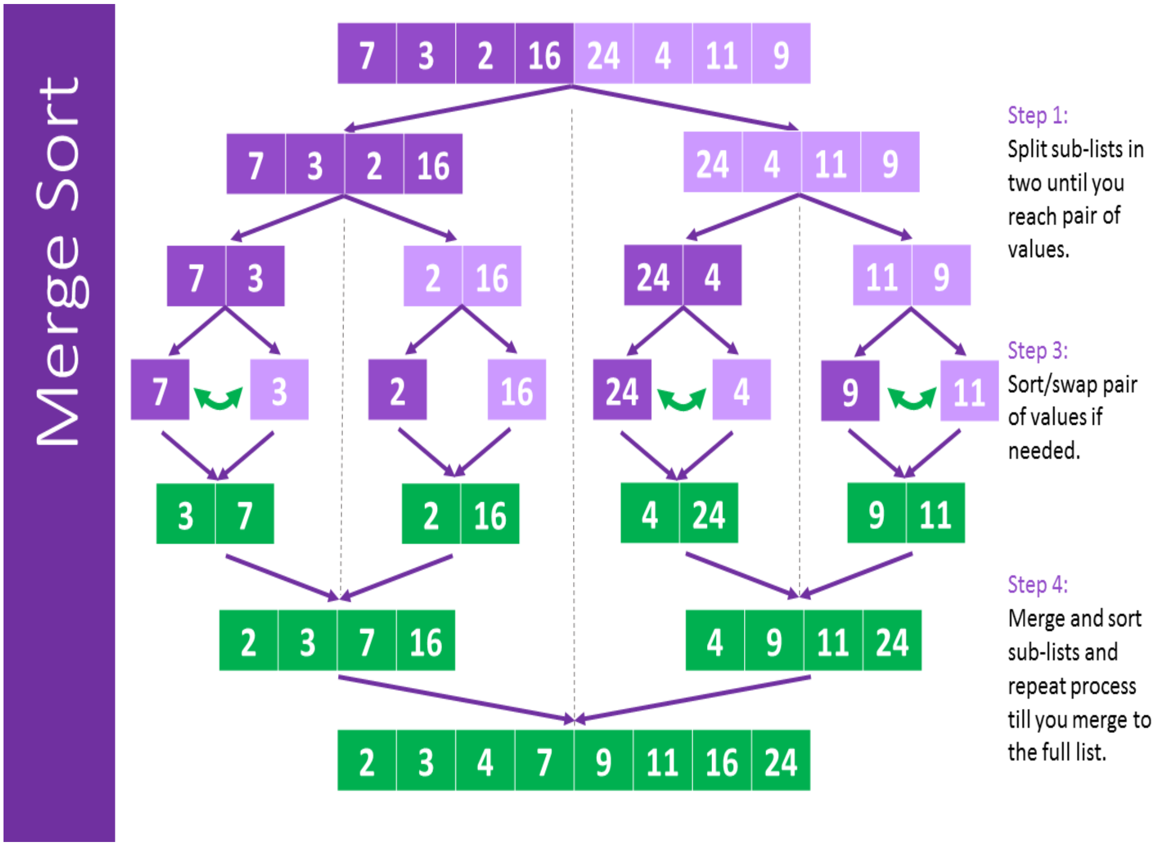
Merge Sort

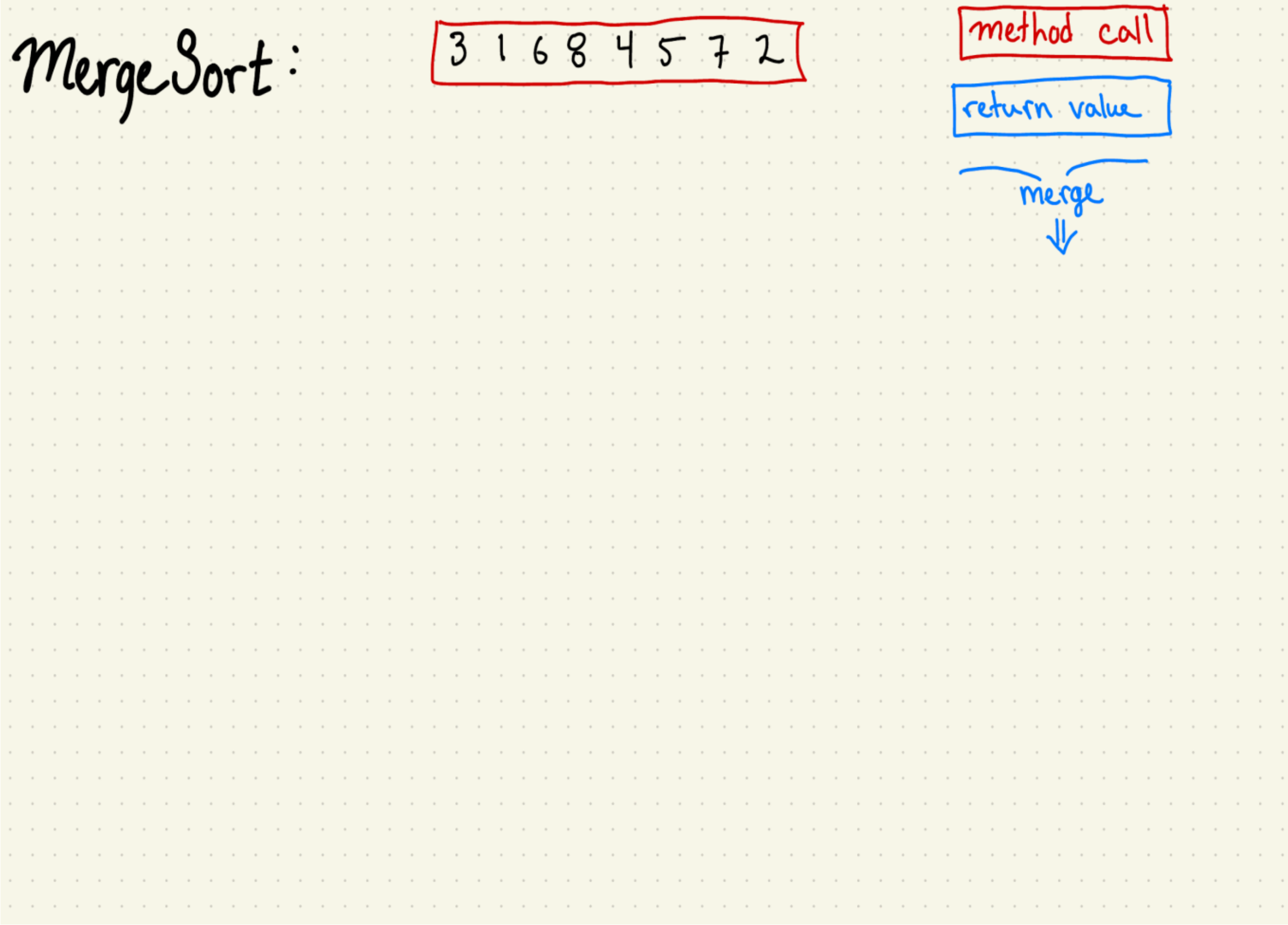
Merge sort is a sorting algorithm that follows the **divide-and-conquer approach**. It works by recursively dividing the input array into smaller subarrays and sorting those subarrays then merging them back together to obtain the sorted array. In simple word, it **continuously splits the array in half** until it cannot be further divided i.e., the array has **only one element left** (an array with one element is always sorted). Then the sorted subarrays are merged into one sorted array.

Merge sort is a popular sorting algorithm known for its efficiency and stability. It follows the **divide-and-conquer** approach to sort a given array of elements.

Here's a step-by-step explanation of how merge sort works:

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.


Merge Sort
7 3 2 16 24 4 11 9
7 3 2 16
24 4 11 9
7 3
2 16
24 4
11 9
7
3
2
16
24
4
9
11
3 7
2 16
4 24
9 11
2 3 7 16
4 9 11 24
2 3 4 7 9 11 16 24
Step 1:
Split sub-lists in two until you reach pair of values.
Step 3:
Sort/swap pair of values if needed.
Step 4:
Merge and sort sub-lists and repeat process till you merge to the full list.



Merge Sort Algorithm:

➔ Divide the list recursively into two halves until it can no more be divided.

➔ Merge the smaller lists into new list in sorted order.

Pseudocode:

```
function mergeSort(arr, left, right)
    if left < right do
        mid = left + (right - left) / 2
        mergeSort(arr, left, mid)
        mergeSort(arr, mid + 1, right)
        merge(arr, left, mid, right)
    end if
end function

function merge(arr, left, mid, right)
    n1 = mid - left + 1
    n2 = right - mid
    leftArr[n1], rightArr[n2]
    for i = 0 to n1 - 1 do
        leftArr[i] = arr[left + i]
    end for
    for j = 0 to n2 - 1 do
        rightArr[j] = arr[mid + 1 + j]
    end for

    i = 0, j = 0, k = left

    while i < n1 and j < n2 do
        if leftArr[i] <= rightArr[j] then
            arr[k] = leftArr[i]
            i = i + 1
        else
            arr[k] = rightArr[j]
            j = j + 1
        end if
        k = k + 1
    end while

    while i < n1 do
        arr[k] = leftArr[i]
        i = i + 1
        k = k + 1
    end while

    while j < n2 do
        arr[k] = rightArr[j]
        j = j + 1
        k = k + 1
    end while
end function
```

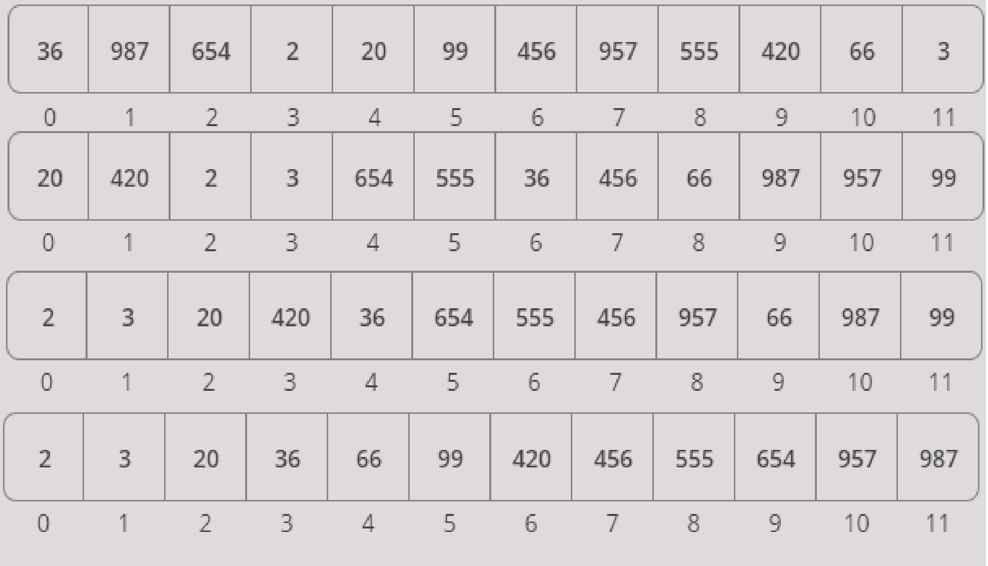
Radix Sort

Radix Sort is a linear sorting algorithm that sorts elements by processing them **digit by digit**. It is an efficient sorting algorithm for integers or strings with fixed-size keys. It is a **non-comparative sorting algorithm** and 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.

Here's a step-by-step explanation of how radix sort works:

1. Take input array and find MAX number in the array
2. Define 10 queues each representing a bucket for each digit from 0 to 9.
3. Consider the least significant digit of each number in the list which is to be sorted.
4. Insert each number into their respective queue based on the least significant digit.

5. Group all the numbers from queue 0 to queue 9 in the order they have inserted into their respective queues.
6. Repeat from step 3 based on the next least significant digit.
7. Repeat from step 2 until all the numbers are grouped based on the most significant digit.
8. https://www.youtube.com/watch?v=XiuSW_mEn7g

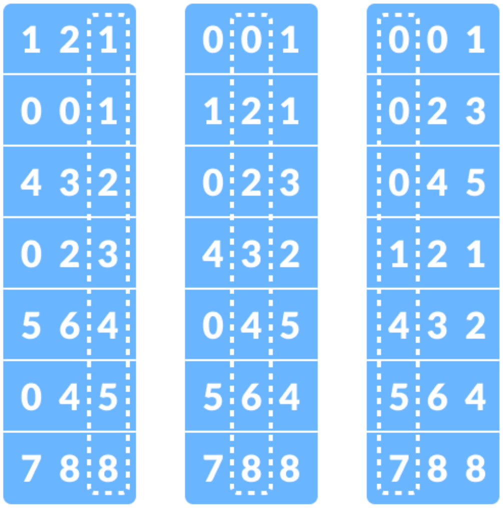


36	987	654	2	20	99	456	957	555	420	66	3
0	1	2	3	4	5	6	7	8	9	10	11

20	420	2	3	654	555	36	456	66	987	957	99
0	1	2	3	4	5	6	7	8	9	10	11

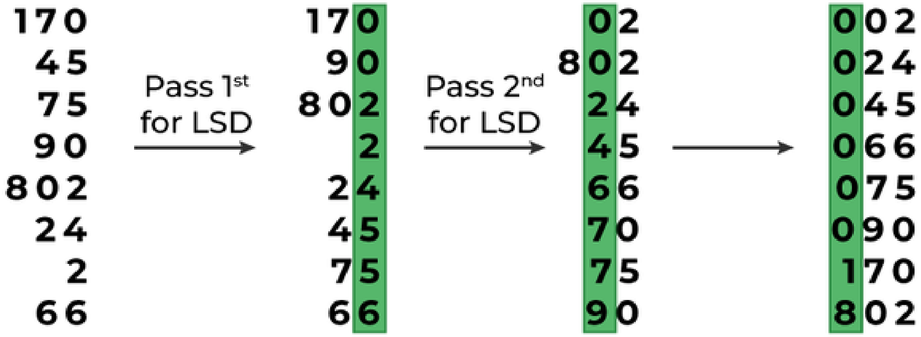
2	3	20	420	36	654	555	456	957	66	987	99
0	1	2	3	4	5	6	7	8	9	10	11

2	3	20	36	66	99	420	456	555	654	957	987
0	1	2	3	4	5	6	7	8	9	10	11

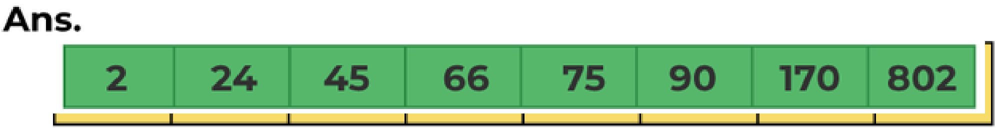


1 2 1	0 0 1	0 0 1
0 0 1	1 2 1	0 2 3
4 3 2	0 2 3	0 4 5
0 2 3	4 3 2	1 2 1
5 6 4	0 4 5	4 3 2
0 4 5	5 6 4	5 6 4
7 8 8	7 8 8	7 8 8

sorting the integers according to units, tens and hundreds places digits

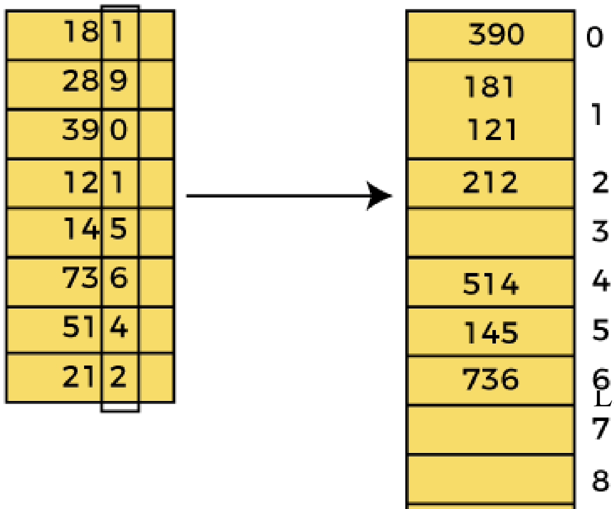


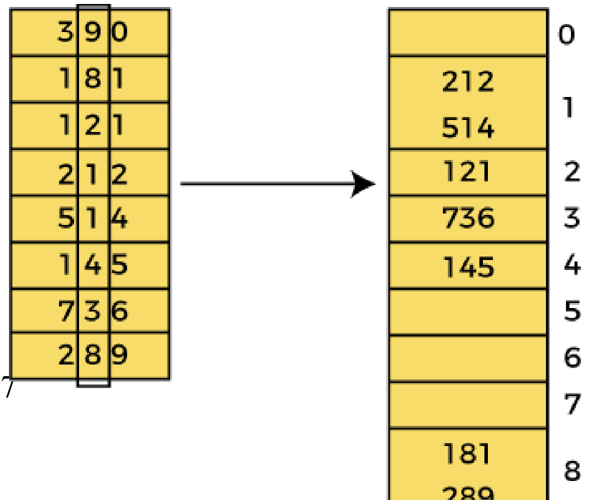
Original Arr



Pass 1:

Pass 2:

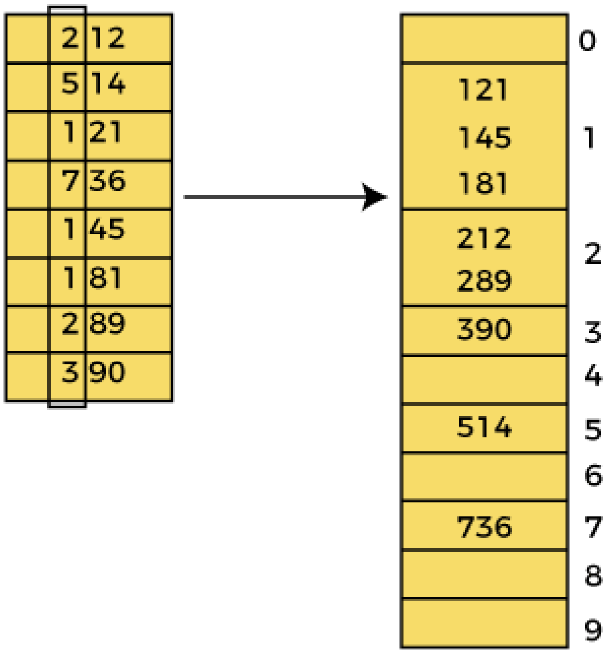




390	181	121	212	514	145	736	289

212	514	121	736	145	181	289	390

Pass 3:



121	145	181	212	289	390	514	736

Pseudocode:

```
function getMax(arr, n)
    mx = arr[0]
    for i = 1 to n - 1 do
        if arr[i] > mx then
            mx = arr[i]
        end if
    end for
    return mx
end function

function countSort(arr, n, exp)
    output[n]
    count[10] = {0}

    for i = 0 to n - 1 do
        count[(arr[i] / exp) % 10] += 1
    end for

    for i = 1 to 9 do
        count[i] += count[i - 1]
    end for

    for i = n - 1 downto 0 do
        output[count[(arr[i] / exp) % 10] - 1] = arr[i]
        count[(arr[i] / exp) % 10] -= 1
    end for

    for i = 0 to n - 1 do
        arr[i] = output[i]
    end for
end function

function radixsort(arr, n)
    m = getMax(arr, n)
    for exp = 1 to m do
        countSort(arr, n, exp)
```