UNIT - 5

Searching and Sorting

Searching

Searching means to find whether a particular value is present in an array or not.

If the value is present in the array, then searching is said to be successful and the searching process gives the location of that value in the array.

However, if the value is not present in the array, the searching process displays an appropriate message and in this case searching is said to be unsuccessful.

Searching

There are two popular methods for searching the array elements: *linear search and binary search.*

Linear Search

Linear search, also called as *sequential search, is a very simple method used for searching an array* for a particular value.

It works by comparing the value to be searched with every element of the array one by one in a sequence until a match is found.

Linear search is mostly used to search an unordered list of elements (array in which data elements are not sorted). For example, if an array

A[] is declared and initialized as,

int A[] = {10, 8, 2, 7, 3, 4, 9, 1, 6, 5};

Linear Search

the value to be searched is VAL = 7, then searching means to find whether the value ‘7’ is present in the array or not.

If yes, then it returns the position of its occurrence. Here,

POS = 3 (index starting from 0).

Linear Search

```
#include<stdio.h>
#include<conio.h>

void main()
{
   int a[20],i,x,n;
   clrscr();
   printf("How many elements?");
   scanf("%d",&n);

   printf("Enter array elements:\n");
   for(i=0;i<n;++i)
   {
           scanf("%d",&a[i]);
   }
   printf("\nEnter element to search:");
   scanf("%d",&x);
```

Linear Search

```
for(i=0;i<n;++i)
  {
        if(a[i]==x)
           break;
  }
  if(i<n)
        printf("Element found at index %d",i);
  else
        printf("Element not found");

  getch();
}
```

Binary Search

Search a sorted array by repeatedly dividing the search interval in half is called Binary Search.

Binary search is a searching algorithm that works efficiently with a sorted list. The mechanism of binary search can be better understood by an analogy of a telephone directory.

When we are searching for a particular name in a directory, we first open the directory from the middle and then decide whether to look for the name in the first part of the directory or in the second part of the directory.

Again, we open some page in the middle and the whole process is repeated until we finally find the right name

Binary Search

Now, let us consider how this mechanism is applied to search for a value in a sorted array.

Consider an array A[] that is declared and initialized as int A[] = {0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10};

and the value to be searched is VAL = 9. The algorithm will proceed in the following manner.

BEG = 0, END = 10, MID = (0 + 10)/2 = 5

Now, VAL = 9 and A[MID] = A[5] = 5

A[5] is less than VAL, therefore, we now search for the value in the second half of the array. So, we change the values of BEG and MID.

Binary Search

Now, BEG = MID + 1 = 6, END = 10, MID = (6 + 10)/2 =16/2 = 8

VAL = 9 and A[MID] = A[8] = 8

A[8] is less than VAL, therefore, we now search for the value in the second half of the segment.

So, again we change the values of BEG and MID.

Now, BEG = MID + 1 = 9, END = 10, MID = (9 + 10)/2 = 9

Now, VAL = 9 and A[MID] = 9.

Binary Search

```
#include<stdio.h>
#include<conio.h>

void main()
{
  int c, first, last, middle, n, search, array[100];

  printf("Enter number of elements\n");
  scanf("%d", &n);

  printf("Enter %d integers\n", n);

  for (c = 0; c < n; c++)
    scanf("%d", &array[c]);

  printf("Enter value to find\n");
  scanf("%d", &search);

  first = 0;
  last = n - 1;
  middle = (first+last)/2;
```

Binary Search

```
while (first <= last)
 {
  if (array[middle] < search)
  {
   first = middle + 1;
  }
  else if (array[middle] == search)
  {
   printf("%d found at location %d.\n", search, middle+1);
   break;
  }
  else
  {
   last = middle - 1;
  }
  middle = (first + last)/2;
 }
 if (first > last)
  printf("Not found! %d isn't present in the list.\n", search);

 getch();
}
```

Difference Between Linear Search and Binary Search

LINEAR SEARCH	BINARY SEARCH
An algorithm to find an element in a list by sequentially checking the elements of the list until finding the matching element	An algorithm that finds the position of a target value within a sorted array
Also called sequential search	Also called half-interval search and logarithmic search
Best case is to find the element in the first position	Best case is to find the element in the middle position
It is not required to sort the array before searching the element	It is necessary to sort the array before searching the element
Less efficient	More efficient
Less complex	More complex

SORTING

Sorting means arranging the elements of an array so that they are placed in some relevant order which may be either ascending or descending.

For example, if we have an array that is declared and initialized as

int A[] = {21, 34, 11, 9, 1, 0, 22};

Then the sorted array (ascending order) can be given as:

A[] = {0, 1, 9, 11, 21, 22, 34};

BUBBLE SORT

Bubble sort is a very simple method that sorts the array elements by repeatedly moving the largest element to the highest index position of the array segment (in case of arranging elements in ascending order).

In *bubble sorting, consecutive adjacent pairs of elements in the array are* compared with each other. If the element at the lower index is greater than the element at the higher index, the two elements are interchanged so that the element is placed before the bigger one.

This process will continue till the list of unsorted elements exhausts.

BUBBLE SORT

Algorithm

```
begin BubbleSort(arr)
   for all array elements
      if arr[i] > arr[i+1]
         swap(arr[i], arr[i+1])
      end if
   end for
   return arr
end BubbleSort
```

BUBBLE SORT

Let the elements of array are -

13	32	26	35	10

First Pass

Sorting will start from the initial two elements. Let compare them to check which is greater.

13	32	26	35	10

Here, 32 is greater than 13 (32 > 13), so it is already sorted. Now, compare 32 with 26.

13	32	26	35	10

Here, 26 is smaller than 36. So, swapping is required. After swapping new array will look like -

13	26	32	35	10

Now, compare 32 and 35.

BUBBLE SORT

13	26	32	35	10

Here, 35 is greater than 32. So, there is no swapping required as they are already sorted.

Now, the comparison will be in between 35 and 10.

13	26	32	35	10

Here, 10 is smaller than 35 that are not sorted. So, swapping is required. Now, we reach at the end of the array. After first pass, the array will be -

13	26	32	10	35

Now, move to the second iteration.

BUBBLE SORT

Second Pass

The same process will be followed for second iteration.

13	26	32	10	35

13	26	32	10	35

13	26	32	10	35

Here, 10 is smaller than 32. So, swapping is required. After swapping, the array will be -

13	26	10	32	35

13	26	10	32	35

Now, move to the third iteration.

BUBBLE SORT

Third Pass

The same process will be followed for third iteration.

13	26	10	32	35

13	26	10	32	35

Here, 10 is smaller than 26. So, swapping is required. After swapping, the array will be -

13	10	26	32	35

13	10	26	32	35

13	10	26	32	35

Now, move to the fourth iteration.

BUBBLE SORT

Fourth pass

Similarly, after the fourth iteration, the array will be -

10	13	26	32	35

Hence, there is no swapping required, so the array is completely sorted.

BUBBLE SORT

```
#include<stdio.h>
#include<conio.h>
void main()
{
 int array[100], n,i,j, swap;
 clrscr();

 printf("Enter number of elements\n");
 scanf("%d", &n);

 printf("Enter %d integers\n", n);

 for (i = 0; i < n; i++)
 {
  scanf("%d", &array[i]);
 }
```

BUBBLE SORT

```
for (i = 0 ; i < n - 1; i++)
{
  for (j = 0 ; j < n - i - 1; j++)
  {
    if (array[j] > array[j+1])
    {
              swap       = array[j];
              array[j]   = array[j+1];
              array[j+1] = swap;
    }
  }
}

printf("Sorted list in ascending order:\n");

for (i = 0; i < n; i++)
   printf("%d\n", array[i]);

getch();
}
```

INSERTION SORT

Insertion Sort in C is a simple and efficient sorting algorithm, that creates the final sorted array one element at a time.

The main idea behind insertion sort is that it inserts each item into its proper place in the final list. To save memory, most implementations of the insertion sort algorithm work by moving the current data element past the already sorted values and repeatedly interchanging it with the preceding value until it is in its correct place. If the given input array is sorted or nearly sorted, then it gives best performance.

INSERTION SORT

Insertion sort works similar to the sorting of playing cards in hands. It is assumed that the first card is already sorted in the card game, and then we select an unsorted card. If the selected unsorted card is greater than the first card, it will be placed at the right side; otherwise, it will be placed at the left side. Similarly, all unsorted cards are taken and put in their exact place.

INSERTION SORT

Let the elements of array are -

12	31	25	8	32	17

Initially, the first two elements are compared in insertion sort.

12	31	25	8	32	17

Here, 31 is greater than 12. That means both elements are already in ascending order. So, for now, 12 is stored in a sorted sub-array.

12	31	25	8	32	17

INSERTION SORT

Now, move to the next two elements and compare them.

12	31	25	8	32	17

12	31	25	8	32	17

Here, 25 is smaller than 31. So, 31 is not at correct position. Now, swap 31 with 25. Along with swapping, insertion sort will also check it with all elements in the sorted array.

For now, the sorted array has only one element, i.e. 12. So, 25 is greater than 12. Hence, the sorted array remains sorted after swapping.

INSERTION SORT

12	25	31	8	32	17

Now, two elements in the sorted array are 12 and 25. Move forward to the next elements that are 31 and 8.

12	25	31	8	32	17

12	25	31	8	32	17

Both 31 and 8 are not sorted. So, swap them.

12	25	8	31	32	17

After swapping, elements 25 and 8 are unsorted.

12	25	8	31	32	17

INSERTION SORT

So, swap them.

12	8	25	31	32	17

Now, elements 12 and 8 are unsorted.

12	8	25	31	32	17

So, swap them too.

8	12	25	31	32	17

Now, the sorted array has three items that are 8, 12 and 25. Move to the next items that are 31 and 32.

8	12	25	31	32	17

Hence, they are already sorted. Now, the sorted array includes 8, 12, 25 and 31.

8	12	25	31	32	17

Move to the next elements that are 32 and 17.

INSERTION SORT

8	12	25	31	32	17

17 is smaller than 32. So, swap them.

8	12	25	31	17	32

8	12	25	31	17	32

Swapping makes 31 and 17 unsorted. So, swap them too.

8	12	25	17	31	32

8	12	25	17	31	32

Now, swapping makes 25 and 17 unsorted. So, perform swapping again.

8	12	17	25	31	32

Now, the array is completely sorted.

INSERTION SORT

```
#include<stdio.h>
#include<conio.h>
void main()
{
  int n, array[100], c, d, t, flag = 0;
  clrscr();

  printf("Enter number of elements\n");
  scanf("%d", &n);

  printf("Enter %d integers\n", n);

  for (c = 0; c < n; c++)
    scanf("%d", &array[c]);

  for (c = 1 ; c <= n - 1; c++)
  {
    t = array[c];

    for (d = c - 1 ; d >= 0; d--)
    {
```

INSERTION SORT

```
if (array[d] > t)
      {
        array[d+1] = array[d];
        flag = 1;
      }
      else
        break;
    }
    if (flag)
      array[d+1] = t;
  }

  printf("Sorted list in ascending order:\n");

  for (c = 0; c <= n - 1; c++)
  {
    printf("%d\n", array[c]);
  }

  getch();
}
```

Differentiate Bubble Sort and

BUBBLE SORT	INSERTION SORT
A simple sorting algorithm that repeatedly goes through the list, comparing adjacent pairs and swapping them if they are in the wrong order	A simple sorting algorithm that builds the final sorted list by transferring one element at a time
Checks the neighboring elements and swaps them accordingly	Transfers an element at a time to the partially sorted array
More number of swaps	Less number of swaps
Bubble sort is slower than insertion sort	Insertion sort is twice as fast as bubble sort
Simple	Complex than bubble sort

SELECTION SORT

Selection Sort algorithm is an in-place comparison-based algorithm in which the list is divided into two parts, the sorted part at the left end and the unsorted part at the right end.

Although selection sort performs worse than insertion sort algorithm, it is noted for its simplicity and also has performance advantages over more complicated algorithms in certain situations. Selection sort is generally used for sorting files with very large objects (records) and small keys.

SELECTION SORT

Selection sort works as follows:

First find the smallest value in the array and place it in the first position. Then, find the second smallest value in the array and place it in the second position. Repeat this procedure until the entire array is sorted.

Selection sort is not a stable sorting algorithm.

Consider the situation in which assignment operation is very costly. so that the number of assignment operations is minimized in general.

SELECTION SORT

Now, let's see the working of the Selection sort Algorithm.

To understand the working of the Selection sort algorithm, let's take an unsorted array. It will be easier to understand the Selection sort via an example.

Let the elements of array are -

12	29	25	8	32	17	40

Now, for the first position in the sorted array, the entire array is to be scanned sequentially.

At present, **12** is stored at the first position, after searching the entire array, it is found that **8** is the smallest value.

12	29	25	8	32	17	40

So, swap 12 with 8. After the first iteration, 8 will appear at the first position in the sorted array.

SELECTION SORT

8	29	25	12	32	17	40

For the second position, where 29 is stored presently, we again sequentially scan the rest of the items of unsorted array. After scanning, we find that 12 is the second lowest element in the array that should be appeared at second position.

8	29	25	12	32	17	40

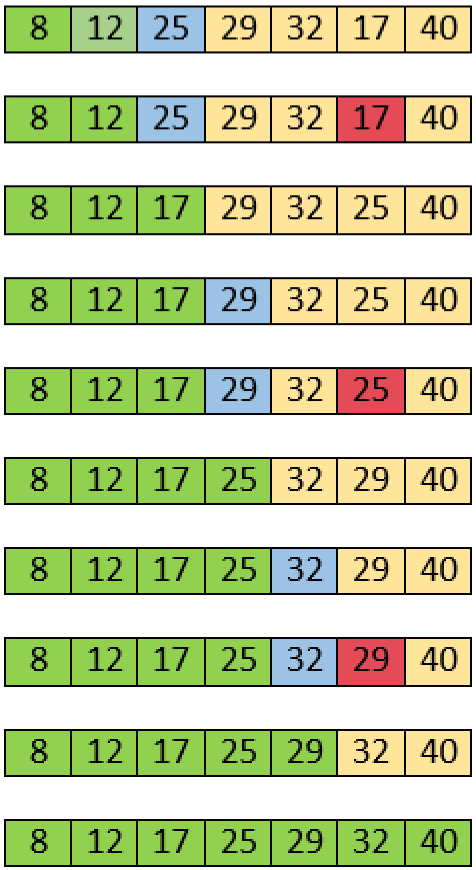
Now, swap 29 with 12. After the second iteration, 12 will appear at the second position in the sorted array. So, after two iterations, the two smallest values are placed at the beginning in a sorted way.

8	12	25	29	32	17	40

The same process is applied to the rest of the array elements. Now, we are showing a pictorial representation of the entire sorting process.

SELECTION SORT

The same process is applied to the rest of the array elements. Now, we are showing a pictorial representation of the entire sorting process.



Now, the array is completely sorted.

SELECTION SORT

```
#include <stdio.h>
#include <conio.h>
void main()
{
        int a[100], n, i, j, position, swap;
        clrscr();
        printf("Enter number of elements\n");
        scanf("%d", &n);
        printf("Enter %d Numbers\n", n);
        for (i = 0; i < n; i++)
        {
                scanf("%d", &a[i]);
        }
        for(i = 0; i < n - 1; i++)
        {
                position=i;
                for(j = i + 1; j < n; j++)
                {
                        if(a[position] > a[j])
                        position=j;
                }
                if(position != i)
                {
                        swap=a[i];
                        a[i]=a[position];
                        a[position]=swap;
                }
        }
```

SELECTION SORT

```
        printf("Sorted Array:\n");
        for(i = 0; i < n; i++)
        {
                printf("%d\n", a[i]);
        }
        getch();
}
```

DIFFERENTIATE INSERTION AND SELECTION SORT

INSERTION SORT	SELECTION SORT
A simple sorting algorithm that builds the final sorted list by transferring one element at a time	A simple sorting algorithm that repeatedly searches remaining items to find the smallest element and moves it to the correct location
Transfers an element at a time to the partially sorted array	Finds the least element and moving it accordingly
More efficient than selection sort	Less efficient than insertion sort
Complex than selection sort	Simpler than insertion sort

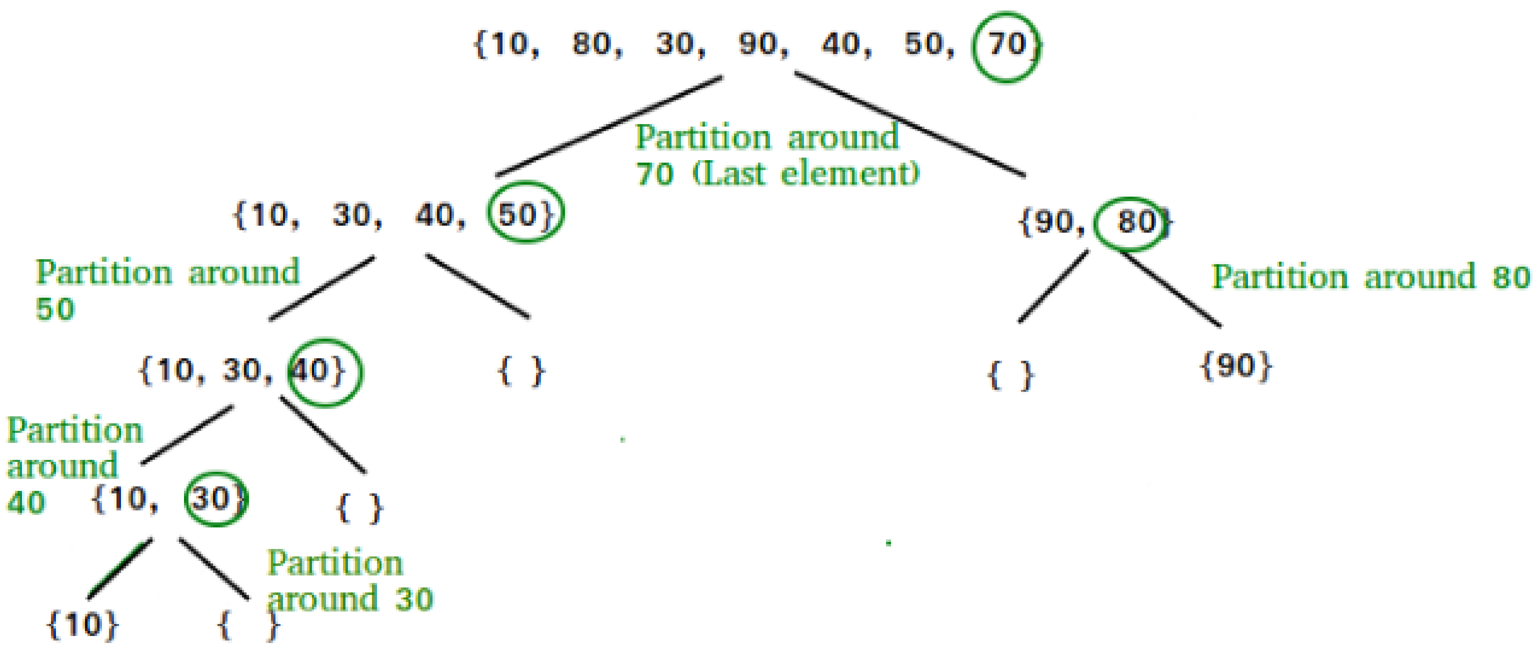
QUICK SORT

Quicksort is a divide and conquer algorithm.

The steps are: 1) Pick an element from the array, this element is called as pivot element. 2) Divide the unsorted array of elements in two arrays with values less than the pivot come in the first sub array, while all elements with values greater than the pivot come in the second sub-array (equal values can go either way). This step is called the partition operation. 3) Recursively repeat the step 2(until the sub-arrays are sorted) to the sub-array of elements with smaller values and separately to the sub-array of elements with greater values.

The same logic we have implemented in the following C program.

QUICK SORT



{10, 80, 30, 90, 40, 50, 70}
Partition around 70 (Last element)
{10, 30, 40, 50}
{90, 80}
Partition around 50
Partition around 80
{10, 30, 40}
{ }
{ }
{90}
Partition around 40
{10, 30}
{ }
Partition around 30
{10}
{ }

QUICK SORT

```
#include<stdio.h>
#include<conio.h>

void quicksort(int number[25],int first,int last)
{
  int i, j, pivot, temp;

  if(first<last)
  {
    pivot=last;
    i=first;
    j=last;

    while(i<j)
    {
      while(number[i]<=number[pivot]&&i<last)
        i++;
      while(number[j]>number[pivot])
        j--;
      if(i<j)
      {
        temp=number[i];
        number[i]=number[j];
        number[j]=temp;
      }
    }
```

QUICK SORT

```
 temp=number[pivot];
     number[pivot]=number[j];
     number[j]=temp;
     quicksort(number,first,j-1);
     quicksort(number,j+1,last);

  }
}

void main()
{
  int i, count, number[25];
  clrscr();

  printf("How many elements are u going to enter?: ");
  scanf("%d",&count);

  printf("Enter %d elements: ", count);
  for(i=0;i<count;i++)
     scanf("%d",&number[i]);

  quicksort(number,0,count-1);

  printf("Order of Sorted elements: ");
  for(i=0;i<count;i++)
     printf(" %d",number[i]);

  getch();
}
```

HEAP SORT

Heap sort is a comparison based sorting technique based on Binary Heap data structure.

It is similar to selection sort where we first find the maximum element and place the maximum element at the end. We repeat the same process for remaining element.

HEAP SORT

Now, let's see the working of the Heapsort Algorithm.

In heap sort, basically, there are two phases involved in the sorting of elements. By using the heap sort algorithm, they are as follows –

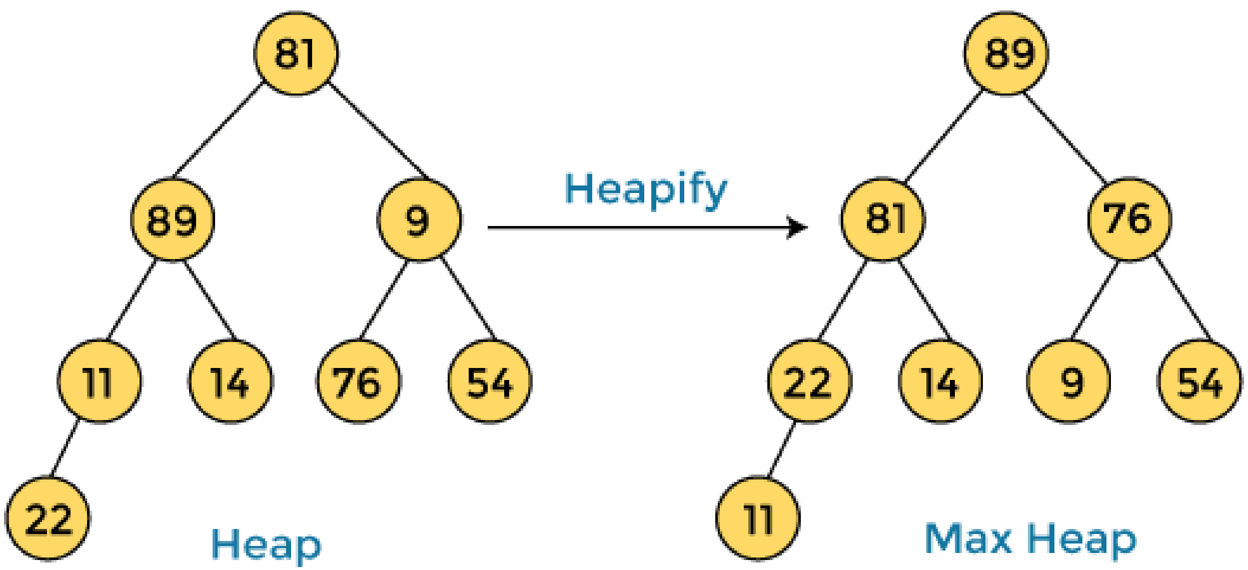
- The first step includes the creation of a heap by adjusting the elements of the array.

- After the creation of heap, now remove the root element of the heap repeatedly by shifting it to the end of the array, and then store the heap structure with the remaining elements.

HEAP SORT

81	89	9	11	14	76	54	22

First, we have to construct a heap from the given array and convert it into max heap.

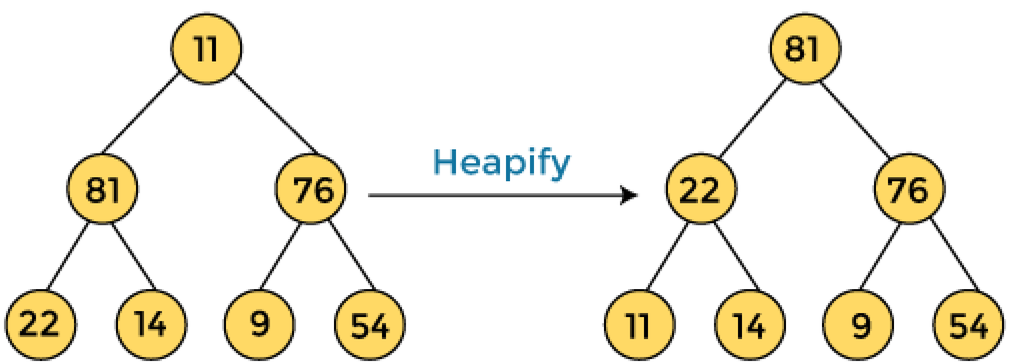


HEAP SORT

After converting the given heap into max heap, the array elements are -

89	81	76	22	14	9	54	11

Next, we have to delete the root element **(89)** from the max heap. To delete this node, we have to swap it with the last node, i.e. **(11).** After deleting the root element, we again have to heapify it to convert it into max heap.



Heap after deleting 89

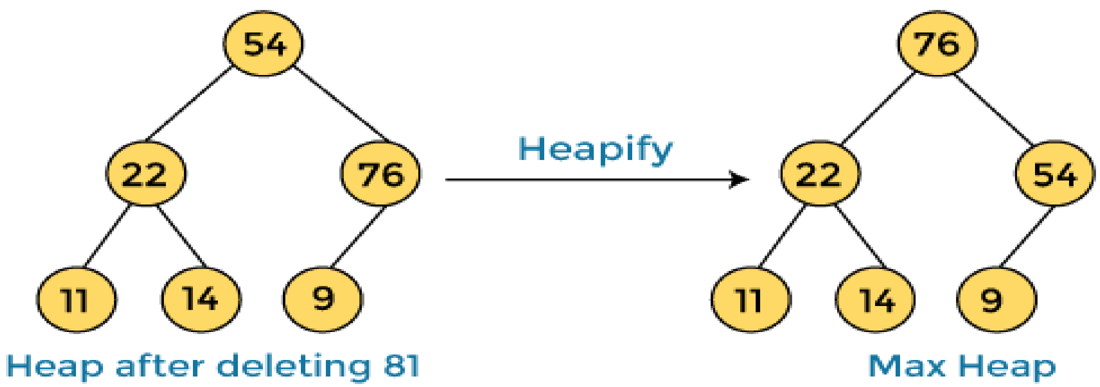
Max Heap

HEAP SORT

After swapping the array element **89** with **11,** and converting the heap into max-heap, the elements of array are -

81	22	76	11	14	9	54	89

In the next step, again, we have to delete the root element **(81)** from the max heap. To delete this node, we have to swap it with the last node, i.e. **(54).** After deleting the root element, we again have to heapify it to convert it into max heap.

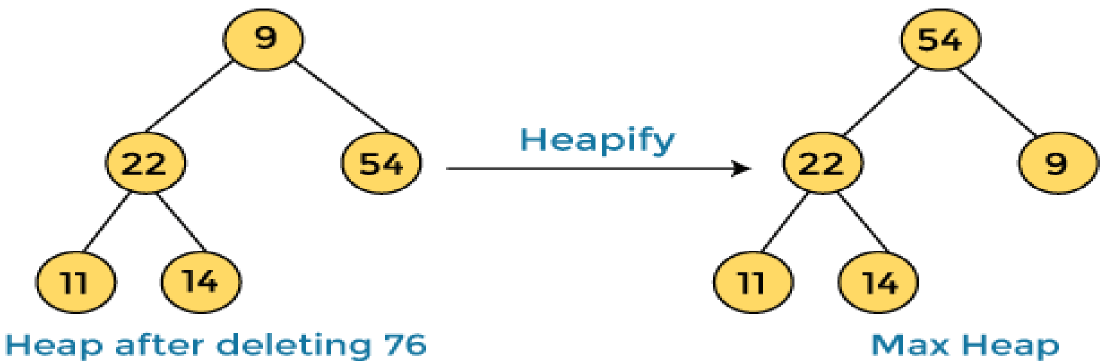


After swapping the array element **81** with **54** and converting the heap into max-heap, the elements of array are -

76	22	54	11	14	9	81	89

HEAP SORT

In the next step, we have to delete the root element **(76)** from the max heap again. To delete this node, we have to swap it with the last node, i.e. **(9).** After deleting the root element, we again have to heapify it to convert it into max heap.

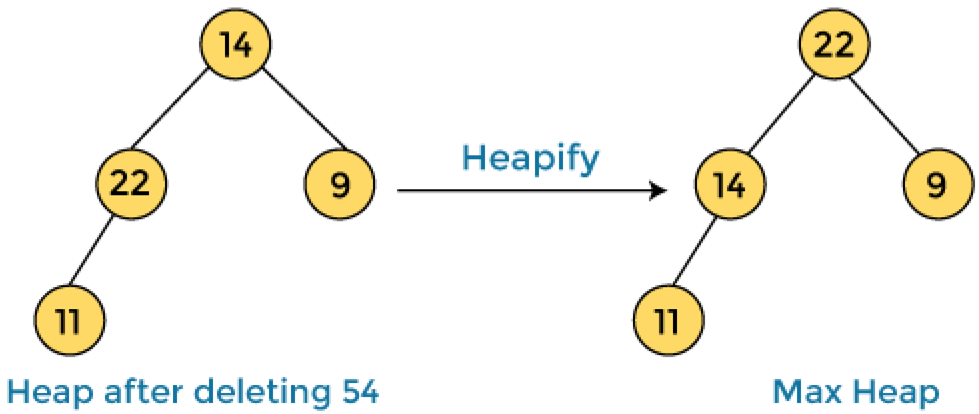


After swapping the array element **76** with **9** and converting the heap into max-heap, the elements of array are -

54	22	9	11	14	76	81	89

HEAP SORT

In the next step, again we have to delete the root element **(54)** from the max heap. To delete this node, we have to swap it with the last node, i.e. **(14).** After deleting the root element, we again have to heapify it to convert it into max heap.

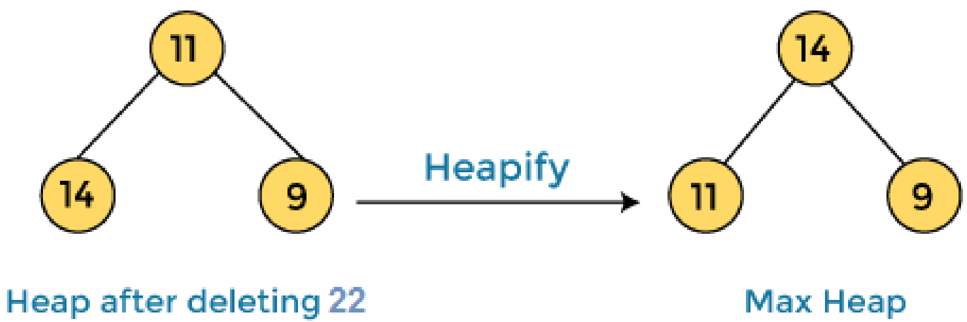


After swapping the array element **54** with **14** and converting the heap into max-heap, the elements of array are -

22	14	9	11	54	76	81	89

HEAP SORT

In the next step, again we have to delete the root element **(22)** from the max heap. To delete this node, we have to swap it with the last node, i.e. **(11).** After deleting the root element, we again have to heapify it to convert it into max heap.

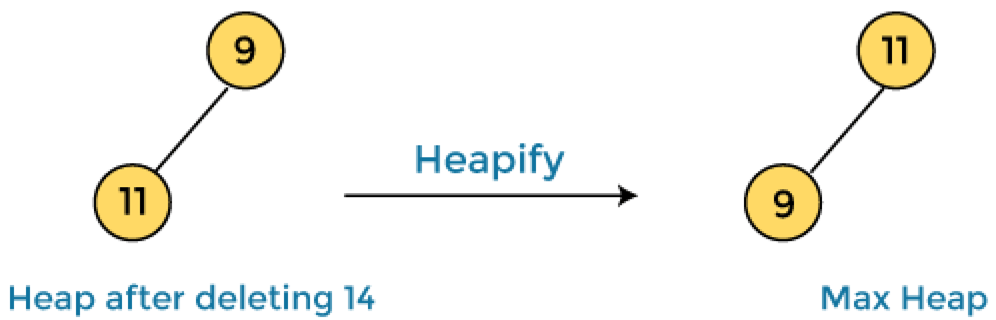


After swapping the array element **22** with **11** and converting the heap into max-heap, the elements of array are -

14	11	9	22	54	76	81	89

HEAP SORT

In the next step, again we have to delete the root element **(14)** from the max heap. To delete this node, we have to swap it with the last node, i.e. **(9).** After deleting the root element, we again have to heapify it to convert it into max heap.



After swapping the array element **14** with **9** and converting the heap into max-heap, the elements of array are -

11	9	14	22	54	76	81	89

HEAP SORT

After swapping the array element **14** with **9** and converting the heap into max-heap, the elements of array are -

11	9	14	22	54	76	81	89

In the next step, again we have to delete the root element **(11)** from the max heap. To delete this node, we have to swap it with the last node, i.e. **(9).** After deleting the root element, we again have to heapify it to convert it into max heap.

After swapping the array element **11** with **9,** the elements of array are -

9	11	14	22	54	76	81	89

HEAP SORT

Now, heap has only one element left. After deleting it, heap will be empty.

After completion of sorting, the array elements are -

9	11	14	22	54	76	81	89

Now, the array is completely sorted.

MERGE SORT

Merge Sort is a Divide and Conquer algorithm. It divides input array in two halves, calls itself for the two halves and then merges the two sorted halves.

It is very efficient sorting algorithm with near optimal number of comparison. Recursive Algorithm used for merge sort comes under the category of divide and conquer technique. It is stable sorting algorithm.

You can sort lots of amount of data using small available main memory using merge sort.

An array of n elements is split around its center producing two smaller arrays. After these two arrays are sorted independently, they can be merged to produce the final sorted array.

MERGE SORT

Working of Merge sort Algorithm

Now, let's see the working of merge sort Algorithm.

To understand the working of the merge sort algorithm, let's take an unsorted array. It will be easier to understand the merge sort via an example.

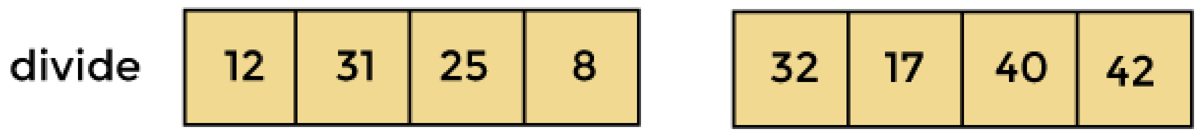
Let the elements of array are –

12	31	25	8	32	17	40	42

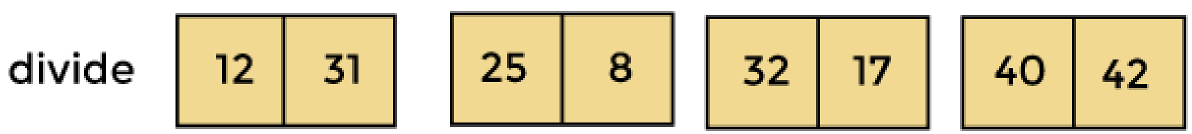
According to the merge sort, first divide the given array into two equal halves. Merge sort keeps dividing the list into equal parts until it cannot be further divided.

As there are eight elements in the given array, so it is divided into two arrays of size 4.

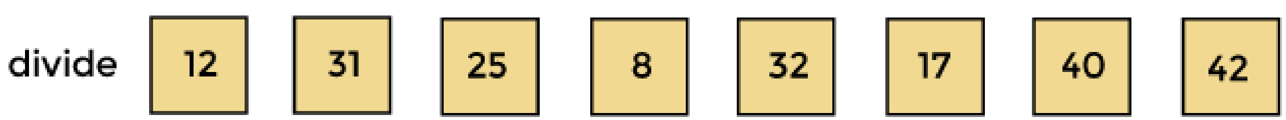
MERGE SORT



Now, again divide these two arrays into halves. As they are of size 4, so divide them into new arrays of size 2.



Now, again divide these arrays to get the atomic value that cannot be further divided.



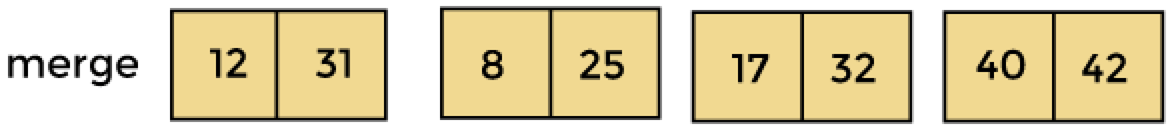
MERGE SORT

Now, combine them in the same manner they were broken.

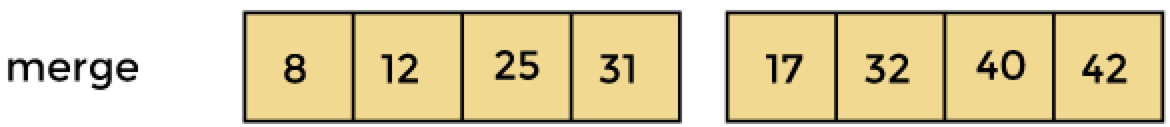
In combining, first compare the element of each array and then combine them into another array in sorted order.

So, first compare 12 and 31, both are in sorted positions. Then compare 25 and 8, and in the list of two values, put 8 first followed by 25. Then compare 32 and 17, sort them and put 17 first followed by 32. After that, compare 40 and 42, and place them sequentially.

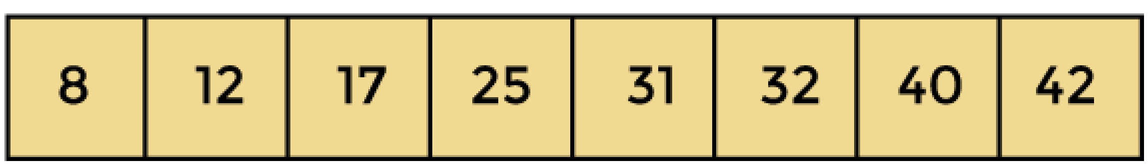
MERGE SORT



In the next iteration of combining, now compare the arrays with two data values and merge them into an array of found values in sorted order.



Now, there is a final merging of the arrays. After the final merging of above arrays, the array will look like -



Now, the array is completely sorted.

THANK YOU