HEAP SORT

INTRODUCTION

In heap sort, the given elements are first arranged in a heap. Then the elements are removed one by one. After every deletion, the elements are re-heapified. If the heap in question is a max-heap, then we get the elements in the descending order. In the case of a min-heap, the output is an ascending sequence.

The following algorithm presents the formal procedure of heapsort.

Algorithm 6.3 Heapsort

Input: A list of elements
Output: Sorted elements
Strategy: Discussed above

```
Heapsort (List elements) returns sorted_list
     {
     heap h=heapify (elements);
//the elements are heapified and inserted into a heap namely h
     i=0;
     while(i!=n)
          {
          x=delete(
//the delete function removes the element at the root of the heap and inserts
it into x
          insert(sorted_list, x);
//the element x is inserted into sorted_list
          }
      }
```

Complexity: As explained earlier, the algorithm requires heapify. The worst-case complexity of heapify is (log(*n*)); therefore, the complexity of the algorithm is $O(n \log n)$.

Analysis of Heap sort Algorithm:

• In-place sorting algorithm – memory efficient

• Time complexity – O (n log (n))

• 1st Step- Build heap, O (n) time complexity

• 2nd Step – perform n delete Max operations, each with O (log (n)) time complexity

Total time complexity = O (n log (n))

• Fast sorting algorithm, memory efficient, especially for very large values of n.

• **Slower of the O (n log(n)) sorting algorithms**

The binary heap data structure is an array that can be viewed as a complete binary tree. Each node of the binary tree corresponds to an element of the array. The array is completely filled on all levels except possibly lowest.

An Array A that presents a heap with two attribute:

- Length [A]: the number of elements in the array.
- heap- size [A] : the number of elements in the heap stored with array A.
- Length [A] ≥ heap-size [A].

To convert the heap tree into a heap array as shown in the figure below , the root of the tree A[0] and given index i of a node , the indices of its parent , left child and right child can be computed as :

- A[0] is the root of the tree
- The PARENT (i) is at [(i-1)/2] if i≠ 0 .
- The left child LEFT (i) is at [2i+1]
- The right child RIGHT(i) is at [2i+2]

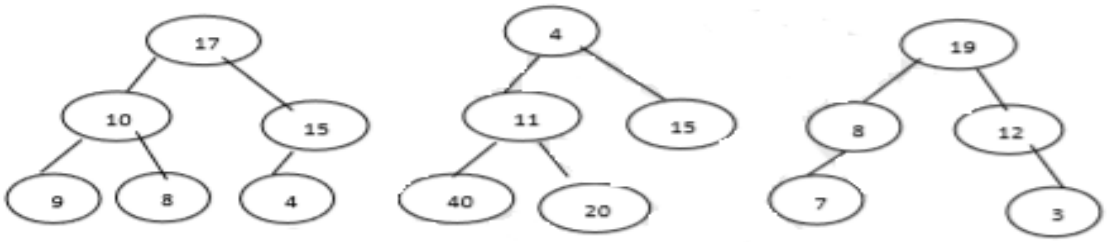
Complete Binary Trees , and Heap

Array representation:

0	1	2	3	4	5	6	7	8	9
50	24	30	20	21	18	3	12	5	6

Heap Sort is the one of the most efficient comparison-based algorithms, is a sorting algorithm that works by first organizing the data to be sorted into a binary heap data structure (uses a heap as its data structure).

Example: which of the following trees is max-heap, min-heap ,non heap



Max-heap min-heap non-heap

Step by step Example:

The heap sort algorithm consists of procedure :

BuildHeap (A)

Build a heap out of array A , the procedure BuildHeap goes through the remaining nodes of the tree and runs MaxHeapify procedure on each one.

MaxHeapify(A,i) or MinHeapify(A,i)

Make the sub tree of A starting in node i fulfill the heap property (MaxHeapify picks the largest child and compare it to the parent . If parent is larger than MaxHeapify quits , otherwise it swaps the parent with the largest child . So that the parent is now becomes larger than its children).

HeapSort(A)

Make A heap , then take out the root , repeat until the array is sorted.

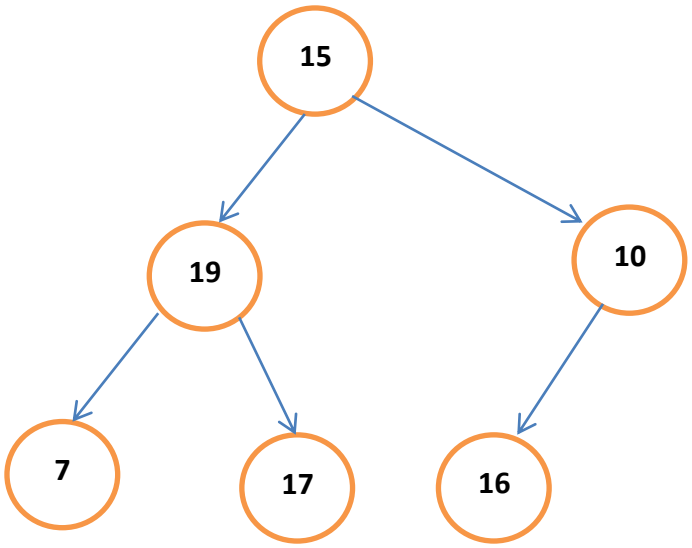
Example:

Here is the array: 15, 19, 10, 7, 17, 6

Building the heap tree

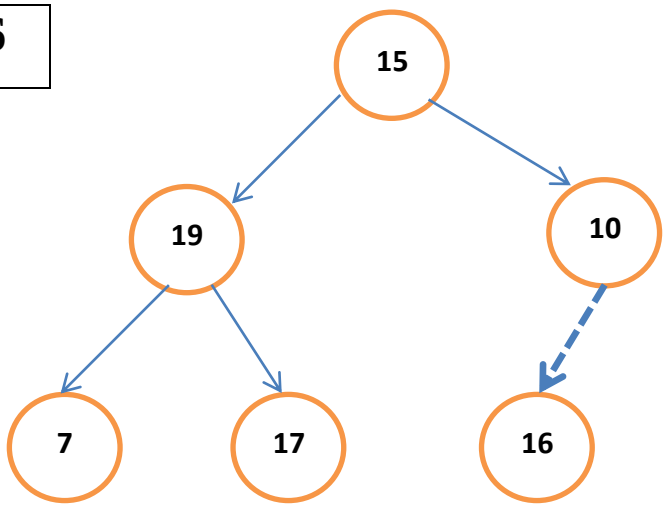
The array represented as a tree, complete but not ordered.

15	19	10	7	17	16



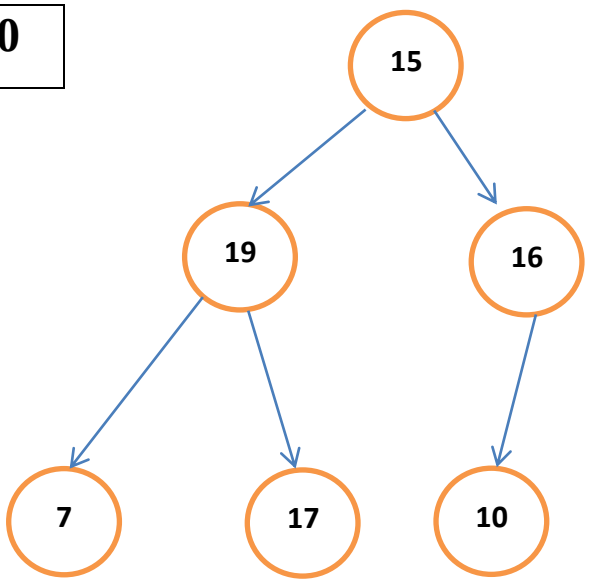
Start with the rightmost node at height 1-the node at position 3=size/2.
It has one grater child and has to be percolated down:

15	19	10	7	17	16



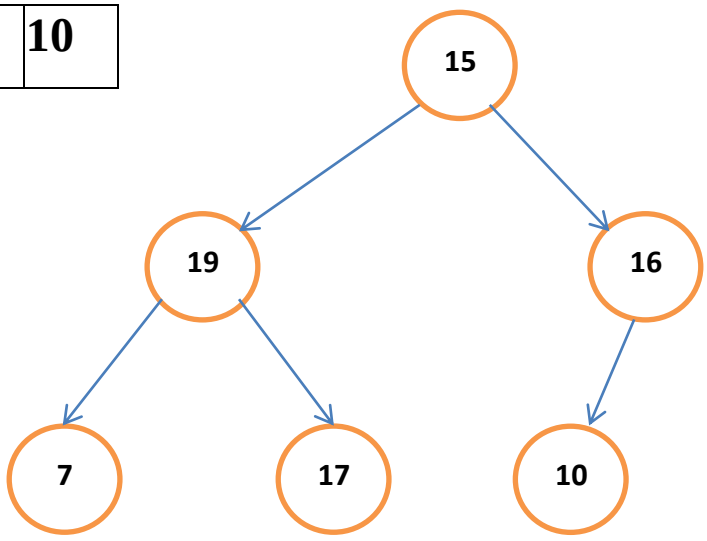
After processing array [3] the situation is:

15	19	16	7	17	10



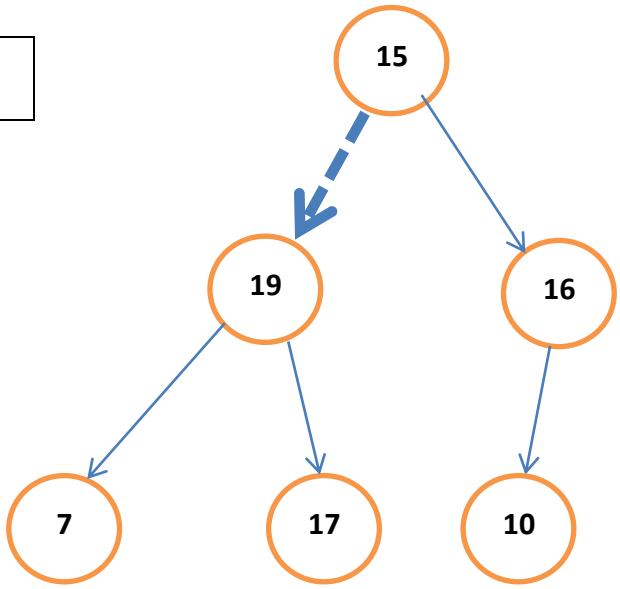
Next coms array [2]. Its children are smaller, so no percolation is needed.

15	19	16	7	17	10



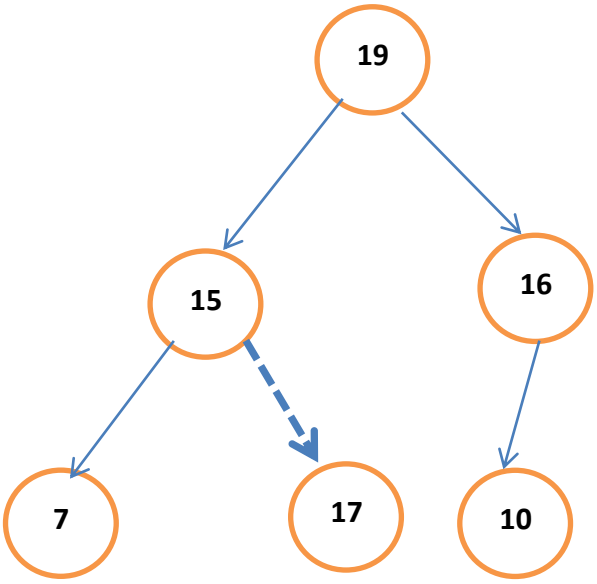
The last node be processed is array [1]. Its left child is the grater of the children. The item at array [1] has to be percolated down to the left, swapped with array [2].

15	19	16	7	17	10



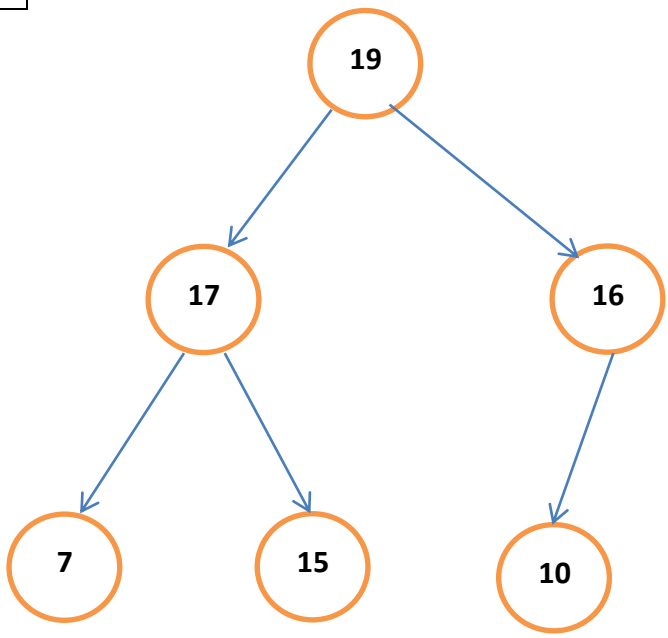
As a result the situation is:

19	15	16	7	17	10



The children of array [2] are grater, and item 15 has to be moved down further, swapped with array [5].

19	**17**	**16**	**7**	**15**	**10**



Now the tree is ordered, and the binary heap is built.