**Assignment 4**

**Heap Data Structures:**

**Implementation, Analysis, and Application**

**Heap Sort Implementation and Analysis:**

The implementation of Heapsort in python is show in the given code snippet:

A screenshot of a computer program

Description automatically generated

**Analysis of Implementation:**

The Time Complexity of the Heapsort is given below:

* Worst Case: O(nlogn)
* Average Case:O(nlogn)
* Best Case: O(n)

The recurrence relation for the Heapsort is T(n) = T(n - 1) + O(logn), which on solving gives T(n) = O(n) + O(nlogn). In this O(n) is the time taken to construct the heap and is less than O(nlogn) and thus we have the time complexity of O(nlogn). A reason for being Heapsort O(nlogn) in all cases is because, each heapify operation takes (logn), but the nodes number decreases exponentially at each level, which sums to be O(n) for building the heap. Then the sorting phase takes place which is O(logn), which is performed n - 1 times. Thus, the time complexity is to be O(nlogn).

Heapsort does not require an additional space, as it is an in-place sorting method and thus it requires an auxiliary space of O(1).

**Comparison:**

**Quicksort** will perform well on average but might degrade to O(n^2) in the worst case (if the pivot is poorly chosen).

**Merge Sort** runs in O(n log n) consistently, but it requires extra space O(n).

**Heapsort** will have O(n log n) performance, but due to higher constant factors, it might perform slower than Quicksort on average.

**Priority Queue Implementation:**

A **priority queue** is a data structure where each element has a priority. The element with the highest priority is processed first. It’s like a line where the most urgent person is helped before others, no matter when they arrive. A **heap** is often used to efficiently organize the elements in the queue. The heap ensures that the highest priority element is always easy to access and remove.

The code snipped given below shows the implementation of Priority Queue in python:

A computer screen shot of a program code

Description automatically generated

In the above code, highest priority task will be performed first.