**Learning Journal Unit 2**

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CS 3304: Analysis of Algorithms

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**Part A: Sorting a List Using MergeSort**

**1. Application of the Divide and Conquer Algorithm:** For sorting the list 36,25,44,2,8,88,11 we will use the MergeSort algorithm, which is a classic example of the divide-and-conquer technique. MergeSort works by dividing the list into smaller sub-lists, sorting these sub-lists, and then merging them back together.

**2. Intermediary Steps of the Algorithm:** Here is the step-by-step process for MergeSort:

1. **Divide:** Split the list into two approximately equal halves.
   * Original list: 36,25,44,2,8,88,11
   * Split into: 36,25,4436, 25 and 2,8,88,11
2. **Recursive Sort:** Recursively apply MergeSort to the sub-lists.
   * First half: 36,25,44
     + Split into: 36 and 25,44
     + 25,44 is further split into: 25 and 44
     + Merge 25 and 44: 25,44
     + Merge 36 and 25, 44, 25, 36, 44
   * Second half: 2,8,88,11
     + Split into: 2,8 and 88,11
     + 2,8 is further split into: 2 and 8
     + Merge 2 and 8: 2, 8
     + 88,11 is further split into: 88 and 11
     + Merge 88 and 11: 11,88
     + Merge 2, 8 and 11, 88: 2,8,11,88
3. **Merge:** Combine the sorted sub-lists.
   * Merge 25, 36, 44 and 2,8,11,88:
   * Compare and merge elements: 2,8,11,25,36,44,88

**3. Space and Time Complexities:**

* **Time Complexity:** MergeSort has a time complexity of O(n log n) because the list is divided in half each time (log n splits), and merging the sub-lists takes linear time (O(n)).
* **Space Complexity:** MergeSort requires O(n) extra space for the temporary arrays used during the merging process.

**Proposed Algorithm:** MergeSort is appropriate due to its efficiency and stable nature.

**Step-by-Step Solution:**

1. Divide: 36, 25, 44 and 2, 8, 88, 11
2. Recursive Sort:
   * 36, 25, 44 : 25, 36, 44
   * 2, 8, 88, 11 : 2, 8, 11, 88
3. Merge: 25, 36, 44 and 2,8,11,88 : 2,8,11, 25, 36, 44, 88

**Sorted List:** 2, 8, 11, 25, 36, 44, 88

**Part B: Finding the Lighter Carton**

**Problem:** Identify the lighter carton among 7 cartons (C1, C2, C3, C4, C5, C6, C7) in exactly two measurements.

**Step-by-Step Solution Using Divide-and-Conquer:**

1. **Divide the Cartons:** Split the 7 cartons into three groups:
   * Group 1: C1,C2,C3
   * Group 2: C4,C5,C6
   * Group 3: C7 (the remaining carton)
2. **First Measurement:** Compare the weights of Group 1 and Group 2.
   * If they balance, the lighter carton is in Group 3 (C7).
   * If they do not balance, the lighter carton is in the lighter group.
3. **Second Measurement:** If the lighter carton is among C1,C2,C3 or C4, C5, C6 compare any two cartons in the lighter group.
   * If they balance, the lighter carton is the one not measured.
   * If they do not balance, the lighter carton is the lighter one from the comparison.

**Example:**

* Cartons: C1, C2, C3, C4, C5, C6, C7
* Groups: C1, C2, C3, C4, C5, C6, C7

First Measurement:

* Compare C1, C2, C3 and C4, C5, C6
* Suppose C1, C2, C3 is lighter.

Second Measurement:

* Compare C1 and C2
* If they balance, C3 is lighter.
* If they do not balance, the lighter one is the lighter carton.

**References**

Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2009). *Introduction to Algorithms* (3rd ed.). MIT Press.

Dasgupta, S., Papadimitriou, C., & Vazirani, U. (2008). *Algorithms*. McGraw-Hill.