Bucket Sort – Data Structures and Algorithms Tutorials

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> ***Bucket sort*** *is a sorting technique that involves dividing elements into various groups, or buckets. These buckets are formed by uniformly distributing the elements. Once the elements are divided into buckets, they can be sorted using any other sorting algorithm. Finally, the sorted elements are gathered together in an ordered fashion.*

Bucket Sort Algorithm:

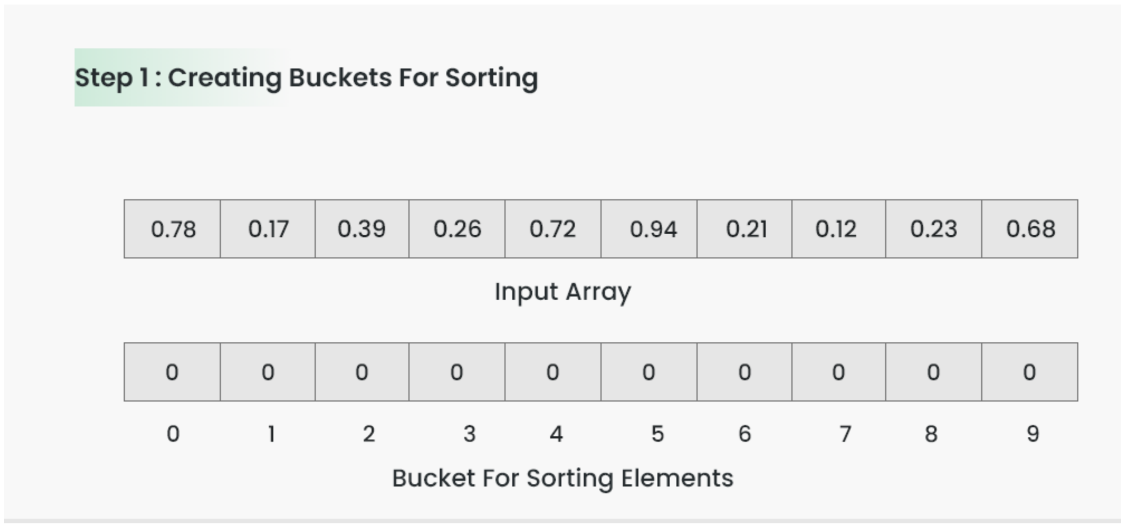
Create **n** empty buckets (Or lists) and do the following for every array element arr[i].

- Insert arr[i] into bucket[n*array[i]]
- Sort individual buckets using insertion sort.
- Concatenate all sorted buckets.

How does Bucket Sort work?

To apply bucket sort on the input array **[0.78, 0.17, 0.39, 0.26, 0.72, 0.94, 0.21, 0.12, 0.23, 0.68]**, we follow these steps:

Step 1: Create an array of size 10, where each slot represents a bucket.

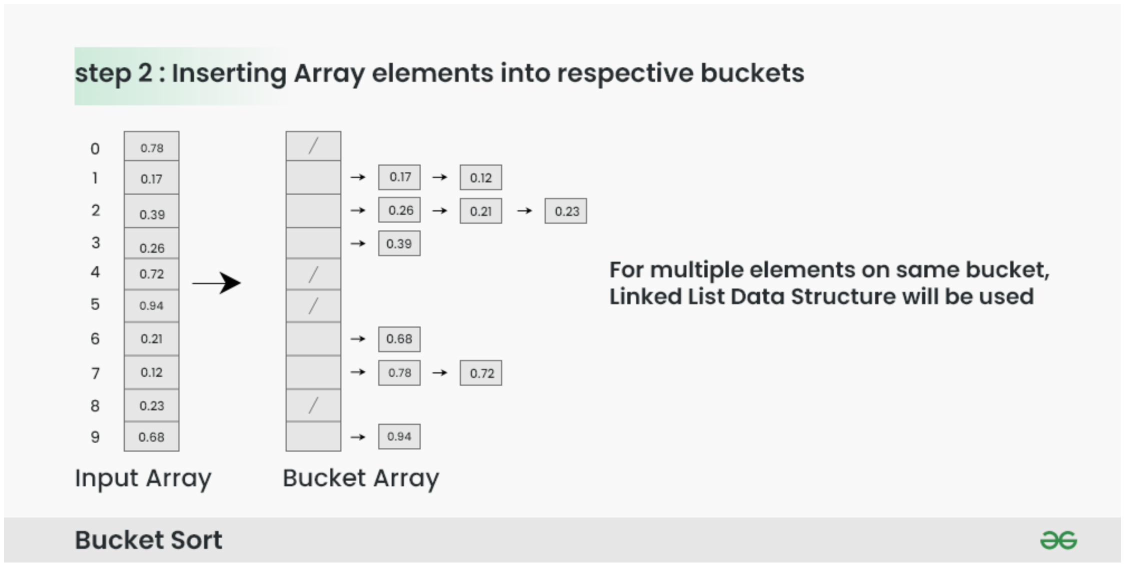


Creating Buckets for sorting

Step 2: Insert elements into the buckets from the input array based on their range.

Inserting elements into the buckets:

- Take each element from the input array.
- Multiply the element by the size of the bucket array (10 in this case). For example, for element 0.23, we get 0.23 * 10 = 2.3.
- Convert the result to an integer, which gives us the bucket index. In this case, 2.3 is converted to the integer 2.
- Insert the element into the bucket corresponding to the calculated index.
- Repeat these steps for all elements in the input array.

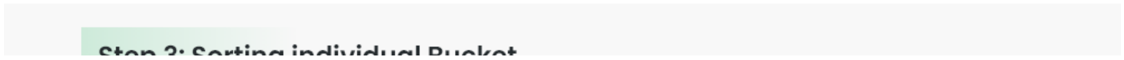


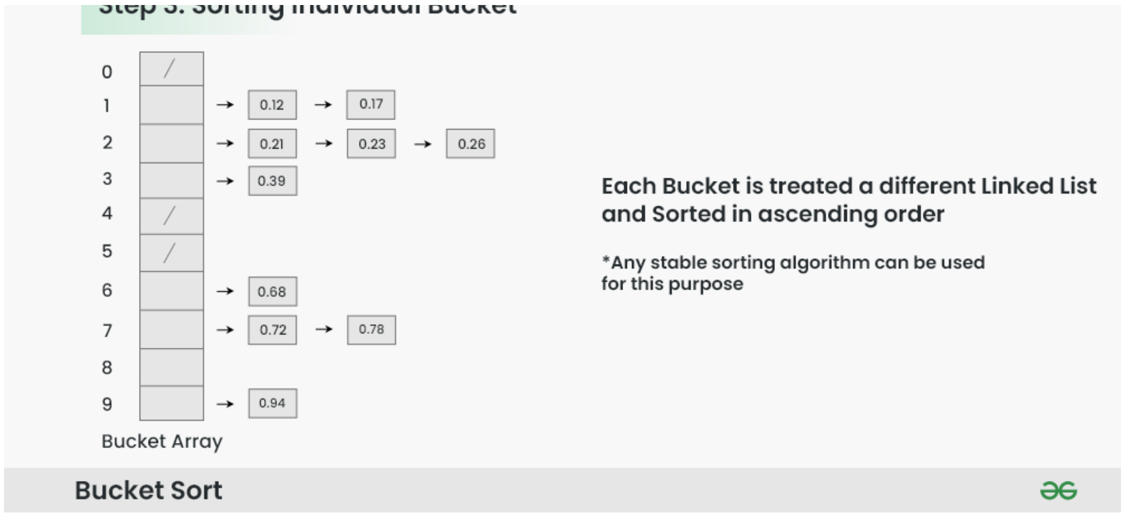
Inserting Array elements into respective buckets

Step 3: Sort the elements within each bucket. In this example, we use quicksort (or any stable sorting algorithm) to sort the elements within each bucket.

Sorting the elements within each bucket:

- Apply a stable sorting algorithm (e.g., Bubble Sort, Merge Sort) to sort the elements within each bucket.
- The elements within each bucket are now sorted.



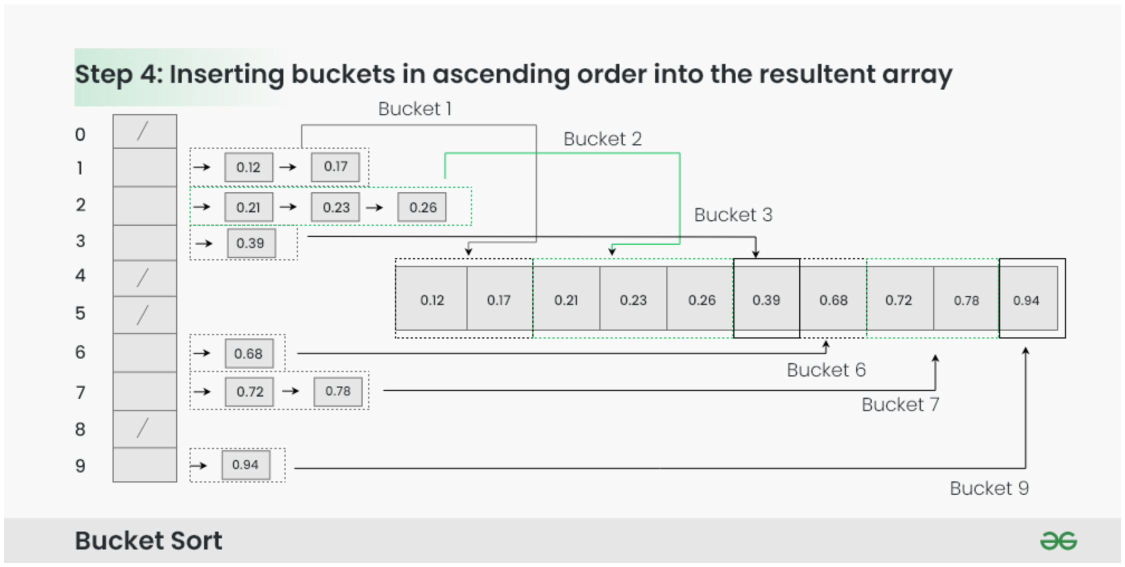

0
1
2
3
4
5
6
7
8
9
0.12
0.17
0.21
0.23
0.26
0.39
0.68
0.72
0.78
0.94
Bucket Array
Each Bucket is treated a different Linked List and Sorted in ascending order
*Any stable sorting algorithm can be used for this purpose
Bucket Sort

Sorting individual bucket

Step 4: Gather the elements from each bucket and put them back into the original array.

Gathering elements from each bucket:

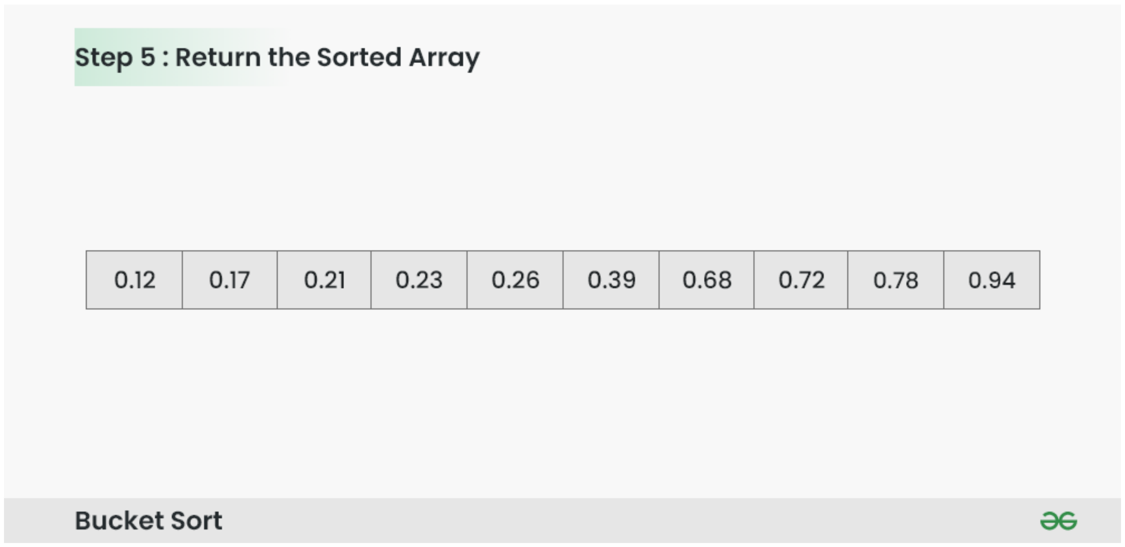
- Iterate through each bucket in order.
- Insert each individual element from the bucket into the original array.
- Once an element is copied, it is removed from the bucket.
- Repeat this process for all buckets until all elements have been gathered.



Inserting buckets in ascending order into the resultant array

Step 5: The original array now contains the sorted elements.

The final sorted array using bucket sort for the given input is [0.12, 0.17, 0.21, 0.23, 0.26, 0.39, 0.68, 0.72, 0.78, 0.94].



Return the Sorted Array

Implementation of Bucket Sort Algorithm:

Below is the implementation for the Bucket Sort:

C++ Java Python C# JavaScript

```cpp
#include <iostream>
#include <vector>
using namespace std;

// Insertion sort function to sort individual buckets
void insertionSort(vector<float>& bucket) {
    for (int i = 1; i < bucket.size(); ++i) {
        float key = bucket[i];
        int j = i - 1;
        while (j >= 0 && bucket[j] > key) {
            bucket[j + 1] = bucket[j];
            j--;
        }
        bucket[j + 1] = key;
    }
}

// Function to sort arr[] of size n using bucket sort
void bucketSort(float arr[], int n) {
    // 1) Create n empty buckets
    vector<float> b[n];

    // 2) Put array elements in different buckets
    for (int i = 0; i < n; i++) {
        int bi = n * arr[i];
        b[bi].push_back(arr[i]);
    }

    // 3) Sort individual buckets using insertion sort
    for (int i = 0; i < n; i++) {
        insertionSort(b[i]);
    }

    // 4) Concatenate all buckets into arr[]
    int index = 0;
    for (int i = 0; i < n; i++) {
        for (int j = 0; j < b[i].size(); j++) {
            arr[index++] = b[i][j];
        }
    }
}

// Driver program to test above function
int main() {
    float arr[] = {0.897, 0.565, 0.656, 0.1234, 0.665, 0.3434};
    int n = sizeof(arr) / sizeof(arr[0]);
    bucketSort(arr, n);

    cout << "Sorted array is \n";
    for (int i = 0; i < n; i++) {
        cout << arr[i] << " ";
    }
    return 0;
}
```

Output

```
Sorted array is
0.1234 0.3434 0.565 0.656 0.665 0.897
```

Complexity Analysis of Bucket Sort Algorithm:

Worst Case Time Complexity: O(n^2) The worst case happens when one bucket gets all the elements. In this case, we will be running insertion sort on all items which will make the time complexity as O(n^2). We can reduce the worst case time complexity to O(n Log n) by using a O(n Log n) algorithm like Merge Sort or Heap Sort to sort the individual buckets, but that will improve the algorithm time for cases when buckets have small number of items as insertion sort works better for small arrays.

Best Case Time Complexity : O(n + k) The best case happens when every bucket gets equal number of elements. In this case every call to insertion sort will take constant time as the number of items in every bucket would be constant (Assuming that k is linearly proportional to n).

Auxiliary Space: O(n+k)