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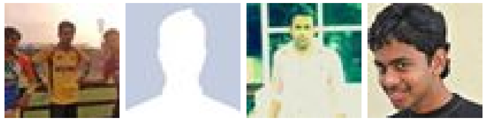
Bucket Sort

Bucket sort is mainly useful when input is uniformly distributed over a range. For example, consider the following problem.
Sort a large set of floating point numbers which are in range from 0.0 to 1.0 and are uniformly distributed across the range. How do we sort the numbers efficiently?

A simple way is to apply a comparison based sorting algorithm. The lower bound for Comparison based sorting algorithm (Merge Sort, Heap Sort, Quick-Sort .. etc) is $\Omega(nLogn)$, i.e., they cannot do better than nLogn.
Can we sort the array in linear time? Counting sort can not be applied here as we use keys as index in counting sort. Here keys are floating point numbers.
The idea is to use bucket sort. Following is bucket algorithm.

```
bucketSort(arr[], n)
1) Create n empty buckets (Or lists).
2) Do following for every array element arr[i].
.......a) Insert arr[i] into bucket[n*array[i]]
3) Sort individual buckets using insertion sort.
4) Concatenate all sorted buckets.
```

Following diagram (taken from CLRS book) demonstrates working of bucket sort.



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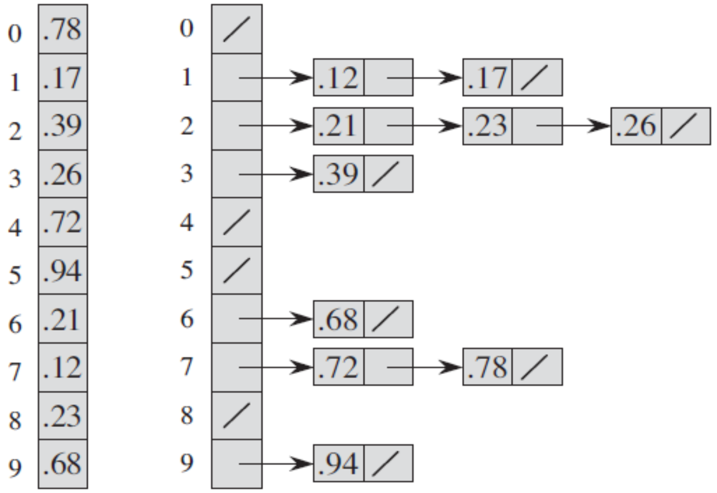

Input array Buckets created for input array

Time Complexity: If we assume that insertion in a bucket takes O(1) time then steps 1 and 2 of the above algorithm clearly take O(n) time. The O(1) is easily possible if we use a linked list to represent a bucket (In the following code, C++ vector is used for simplicity). Step 4 also takes O(n) time as there will be n items in all buckets.
The main step to analyze is step 3. This step also takes O(n) time on average if all numbers are uniformly distributed (please refer CLRS book for more details)

Following is C++ implementation of the above algorithm.

```
// C++ program to sort an array using bucket sort
#include <iostream>
#include <algorithm>
#include <vector>
using namespace std;

// 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]; // Index in bucket
       b[bi].push_back(arr[i]);
```

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```
    }

    // 3) Sort individual buckets
    for (int i=0; i<n; i++)
       sort(b[i].begin(), b[i].end());

    // 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 funtion */
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
```

References:

Introduction to Algorithms 3rd Edition by Clifford Stein, Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest

http://en.wikipedia.org/wiki/Bucket_sort

Please write comments if you find anything incorrect, or you want to share more information about the topic discussed above

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The main step to analyze is step 3. This step also takes O(n) time on average
distributed? How?

Insertion Sort is quadratic.

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The main point to note here is there are total n elements and are unifor
divided in n buckets. To get some idea, consider the ideal situation wh
sum of 1<sup>2</sup> for n times is O(n). Please refer CLRS book fo

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It is not clear to me why we need an insertion sort in step 3. Wh
can make sure we are inserting in right place i.e. we will keep t
So we don't need step 3 at all.

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To keep the list sorted u need to do insertion sort...
consider u r having 0.03 and 0.05 in a bucket and a new
the same bucket....u need to check 0.03 but also 0.05 a
insertion sort....so worst case complexity in ur case is a

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Your idea looks good. Please note that the array elemer
loop. So it doesn't seem to be an improvement, but ano
complexity.

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Insertion sort has worst case complexity O(^2) (http://e
the approach that I mentioned has worst case complexi

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