MERGE SORT

RECURSION + MERGE SORT ALGORITHM

References:
http://algs4.cs.princeton.edu/home/
http://homepages.math.uic.edu/~leon/cs-mcs401-s08/handouts/quicksort.pdf

RECURSIVE METHODS

Properties of good recursive methods

- **Identify a base case:**
  - When should the recursion stop?
  - The base case is a condition that makes the method return without calling itself.
- **Method arguments**
  - Recursive methods must have at least one argument as a means of communication.
- **Recursive calls must lead to the base case.**
  - Each call to the same function must modify the argument such that reaching the base case is guaranteed.

RECURSIVE ALGORITHMS

How to write a recursive algorithm:

- **Break down the original problem into smaller parts**
  - The parts should be of the same type as the original problem.
- **Identify the cases where the problem can be solved directly:**
  - When it can’t get any simpler
- **Combine the solutions of the smaller problems.**
  - This should be the solution to the original problem

MERGE SORT

- **Divide the array into two equal subarrays**
- **Recursively sort each subarray**
- **Merge the two sorted subarrays into one sorted array.**
  - Use an auxiliary array to hold the elements
  - Keep track of index in subarray 1 and 2 with i and j respectively
  - Compare elements at index i & j
  - Copy smaller element to the array at index k

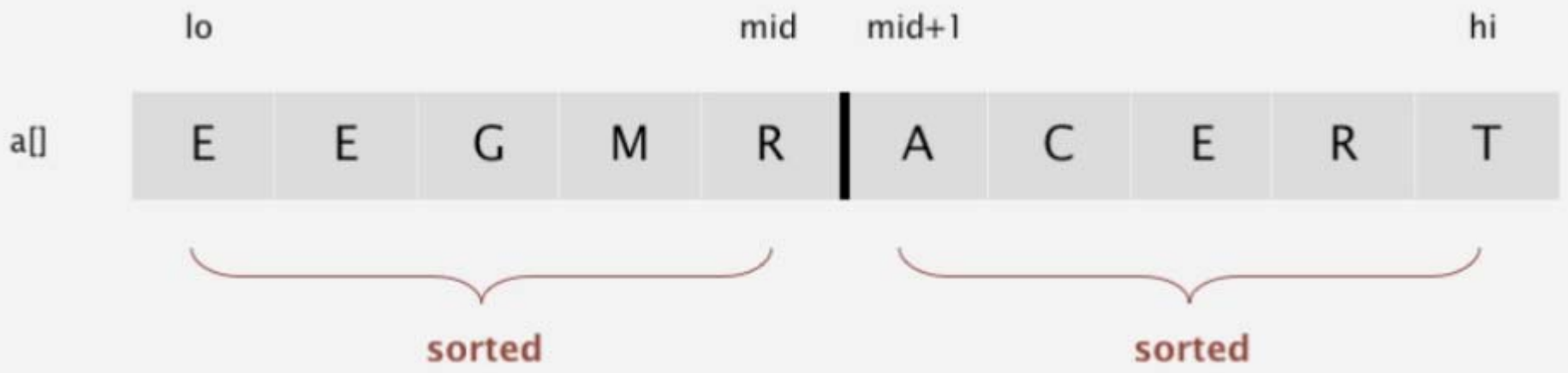
MERGE SORT

```
private static void mergeSort(int[] data, int lo, int hi) {
        if (lo<hi){
                //find index of middle element
                int mid=(lo+hi)/2;
                //recursive calls for first and second half of the array
                mergeSort(data, lo, mid);
                mergeSort(data, mid+1, hi);
                //merge the elements of each side of the array
                merge(data, lo, mid, hi);
        }
}
```

MERGE METHOD

```
Merge (data, lo, mid, hi)
Create a temporary array
Set i=lo, and j=mid+1
Loop while (i<=mid and j<=hi)
        compare elements at i and j
        copy smaller element to temp and increment i or j
while (i<=mid)
        copy element at i to temp, increment i
While (j<=hi)
        copy element at j to temp, increment j
Copy elements from temp back to data array
```

MERGE DEMO



MERGE DEMO

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compare minimum in each subarray

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compare minimum in each subarray

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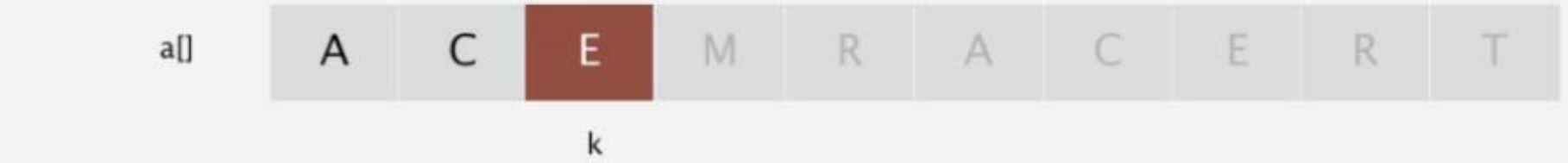

compare minimum in each subarray

MERGE DEMO

compare minimum in each subarray

MERGE DEMO


a[]
A C E E E A C E R T
k
compare minimum in each subarray
aux[]
E E G M R A C E R T
i
j

MERGE DEMO

compare minimum in each subarray

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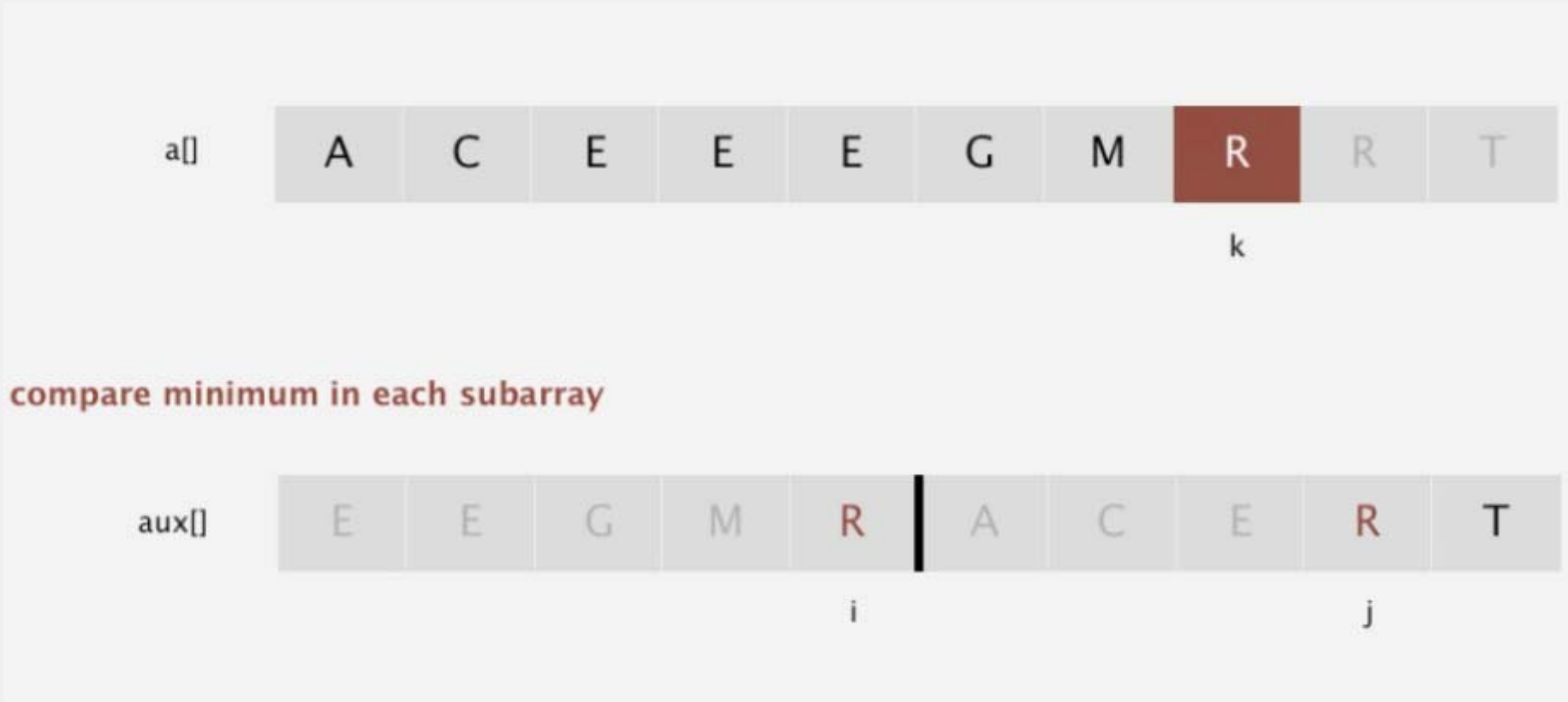
compare minimum in each subarray

MERGE DEMO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E E G M R A C E R T
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MERGE DEMO

one subarray exhausted, take from other

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Copy elements from temp back to data array
```

MERGE DEMO

one subarray exhausted, take from other

MERGE DEMO


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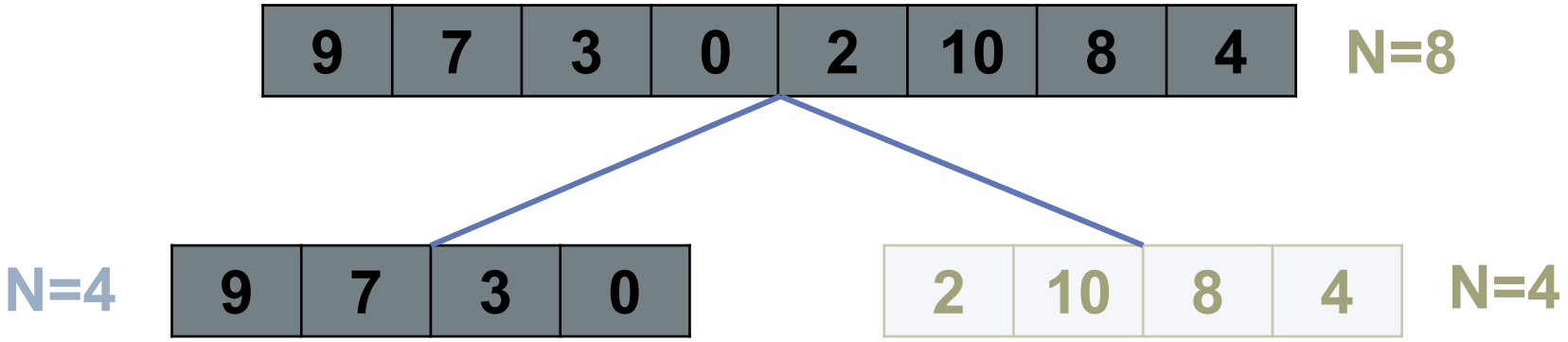

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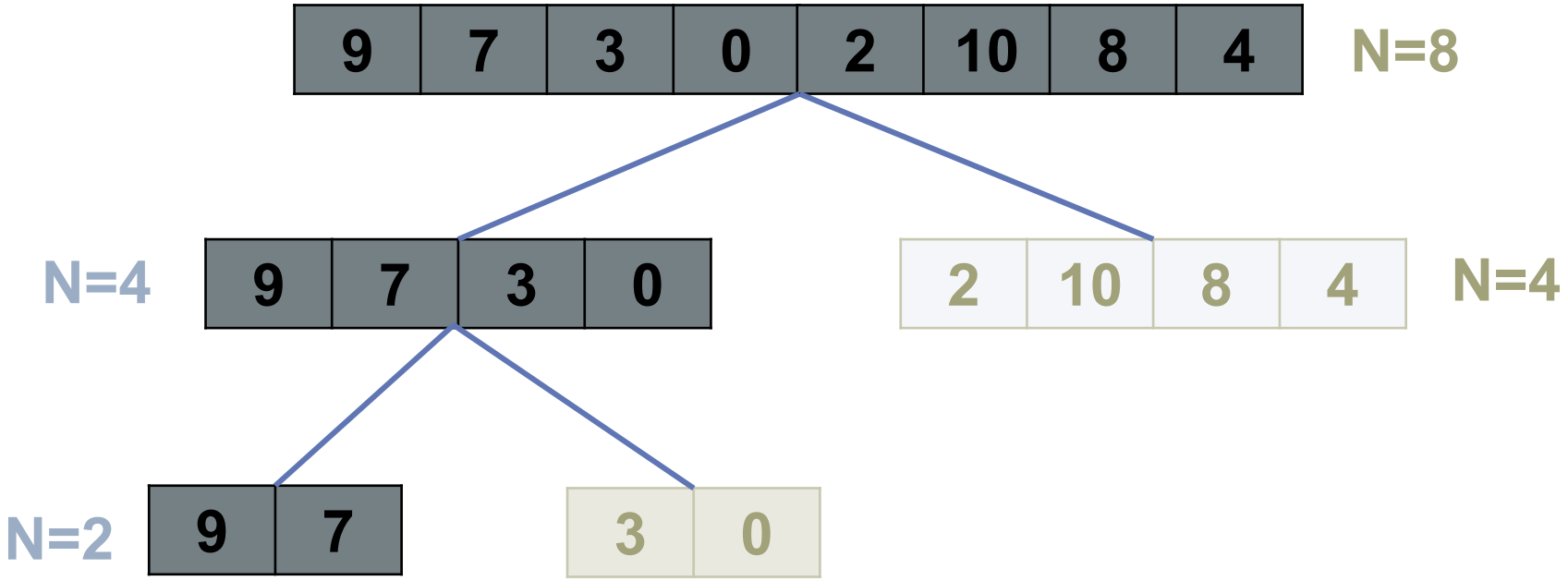

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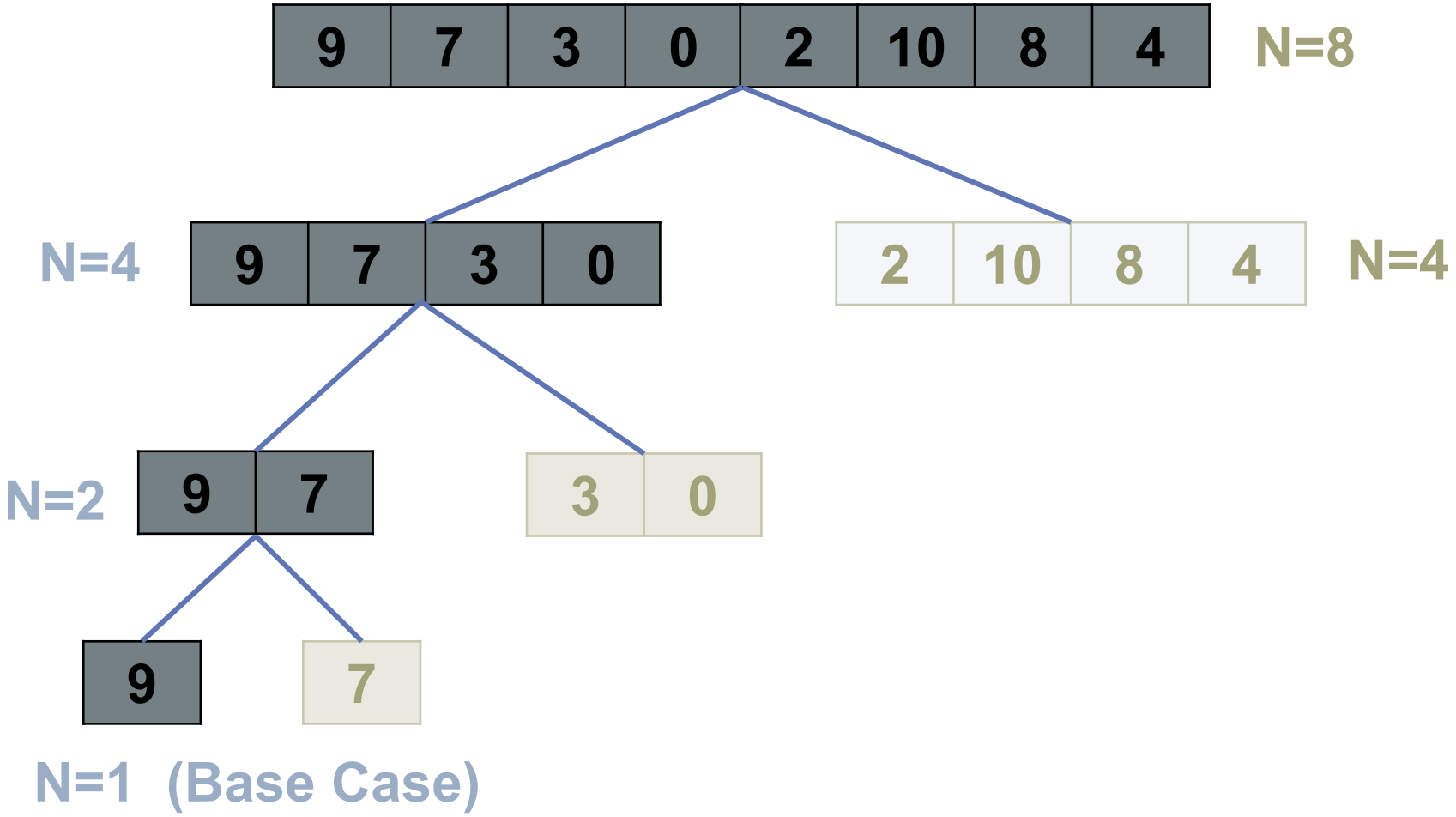

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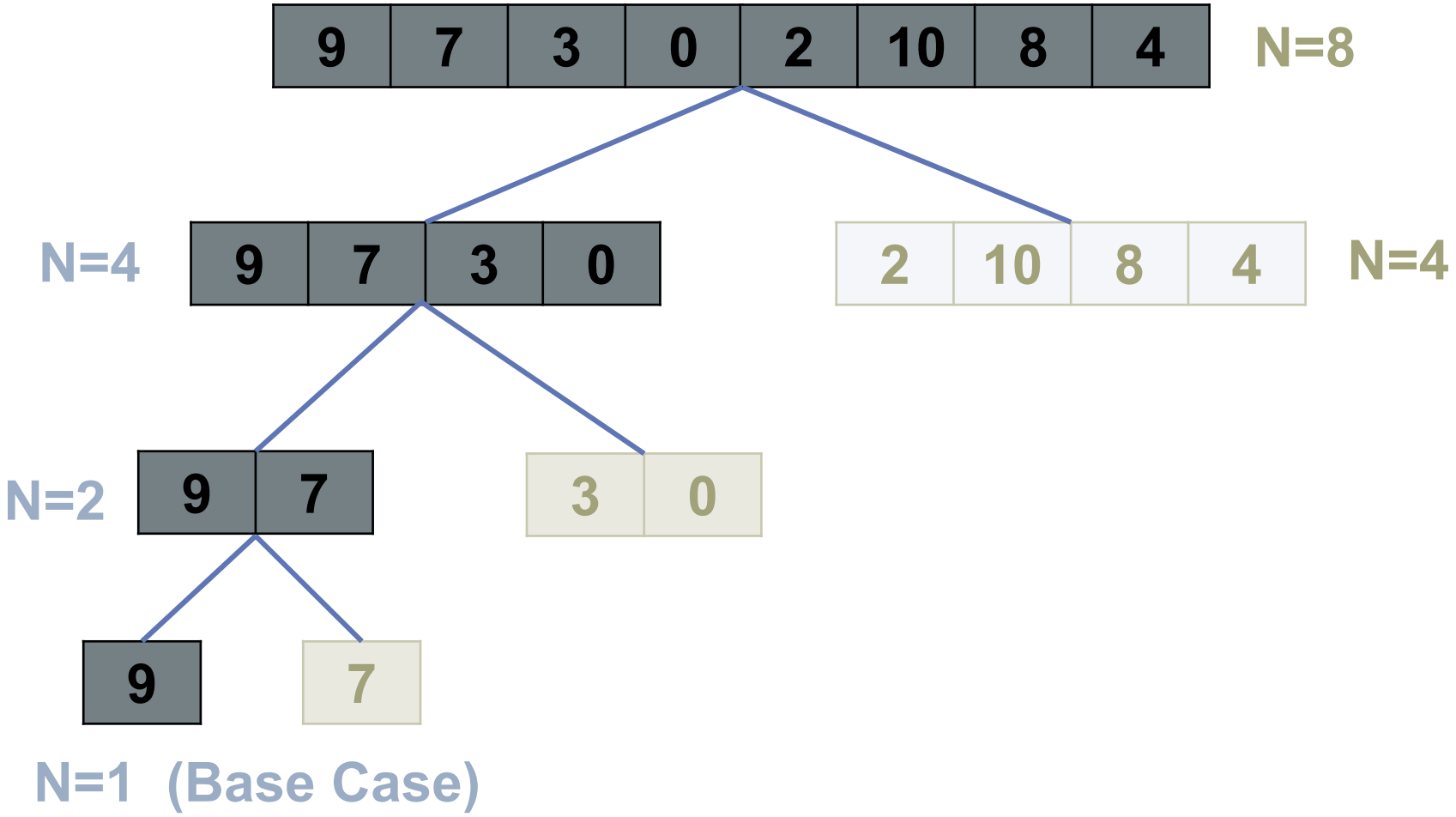

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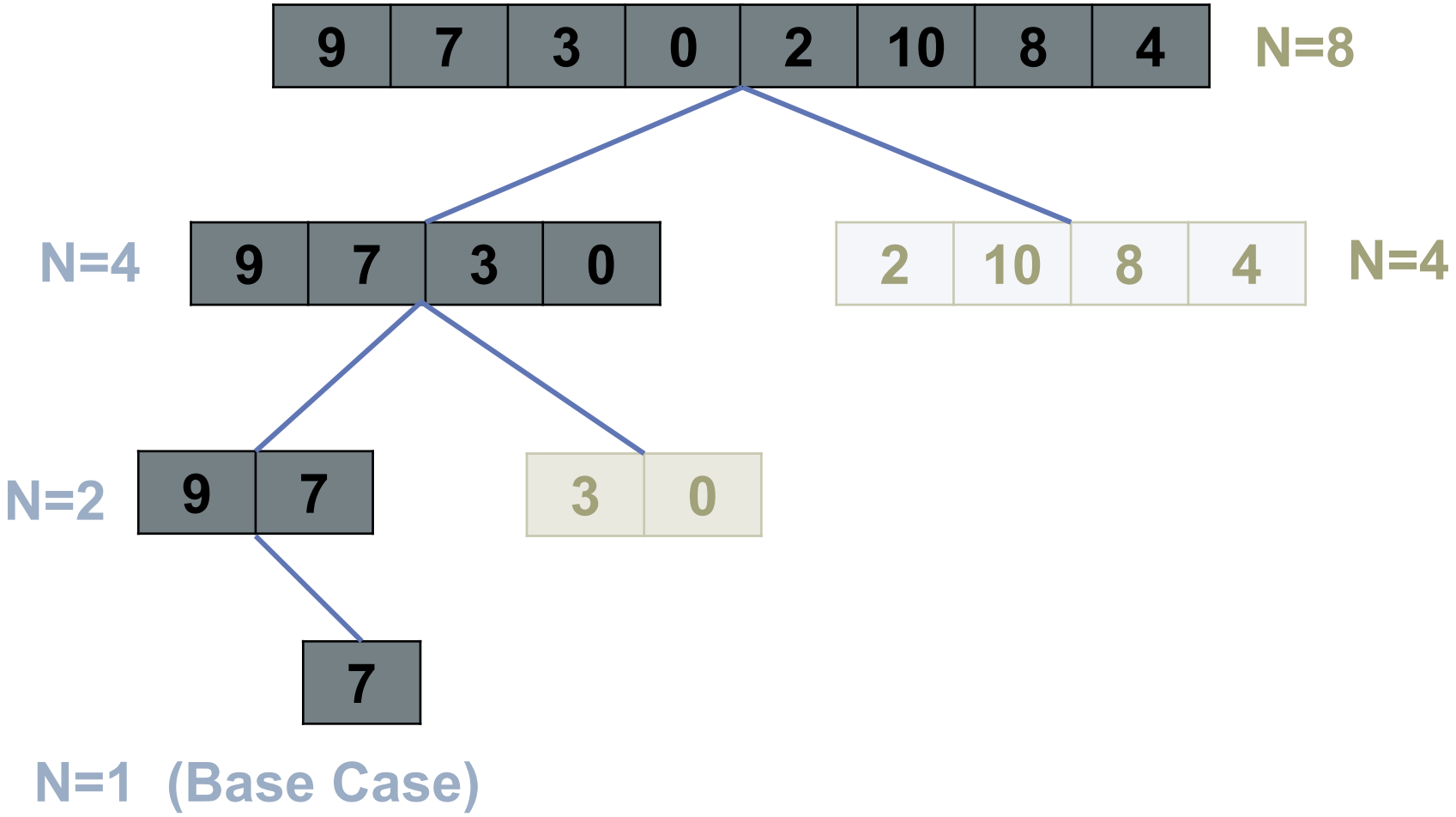

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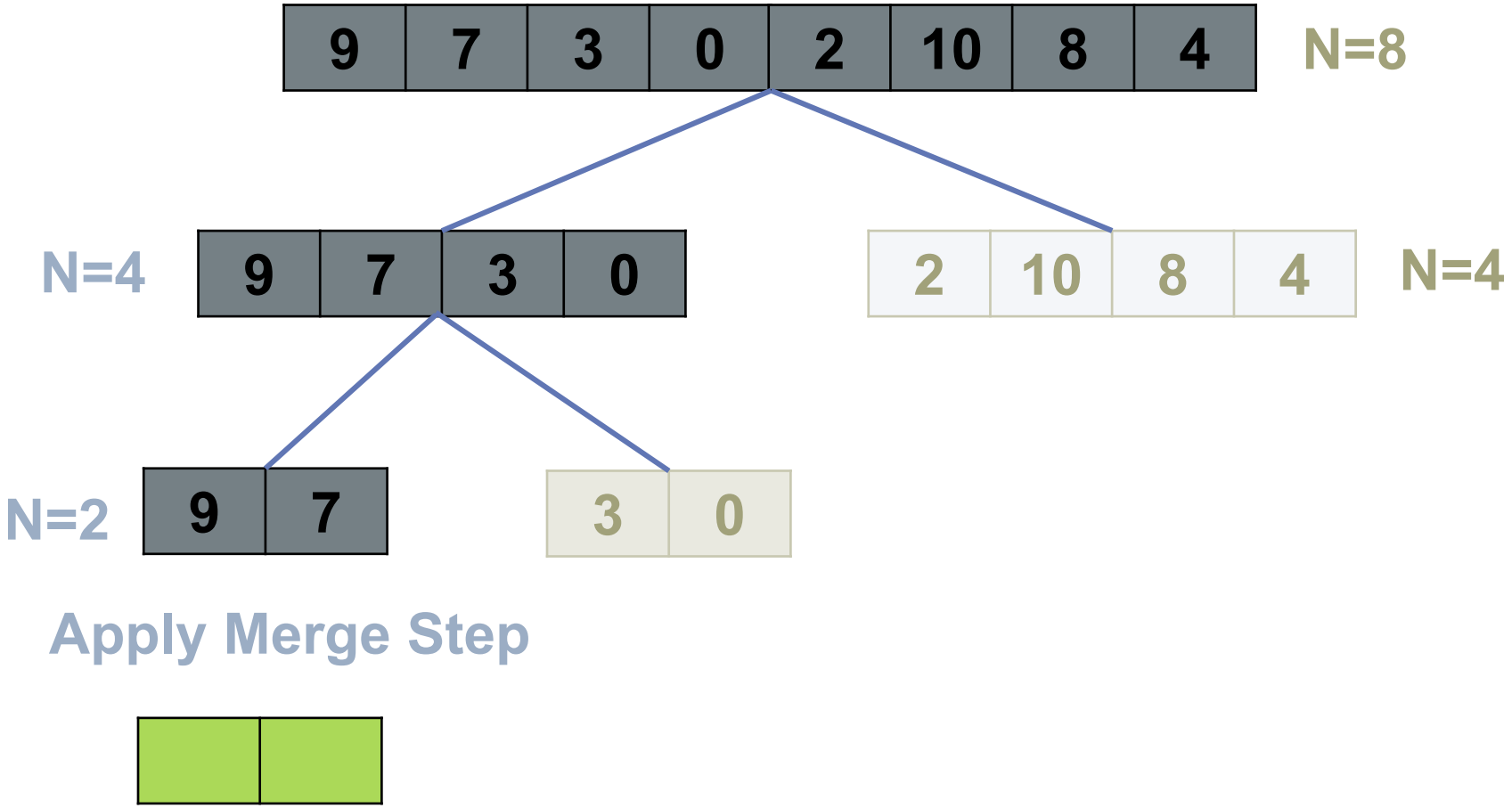

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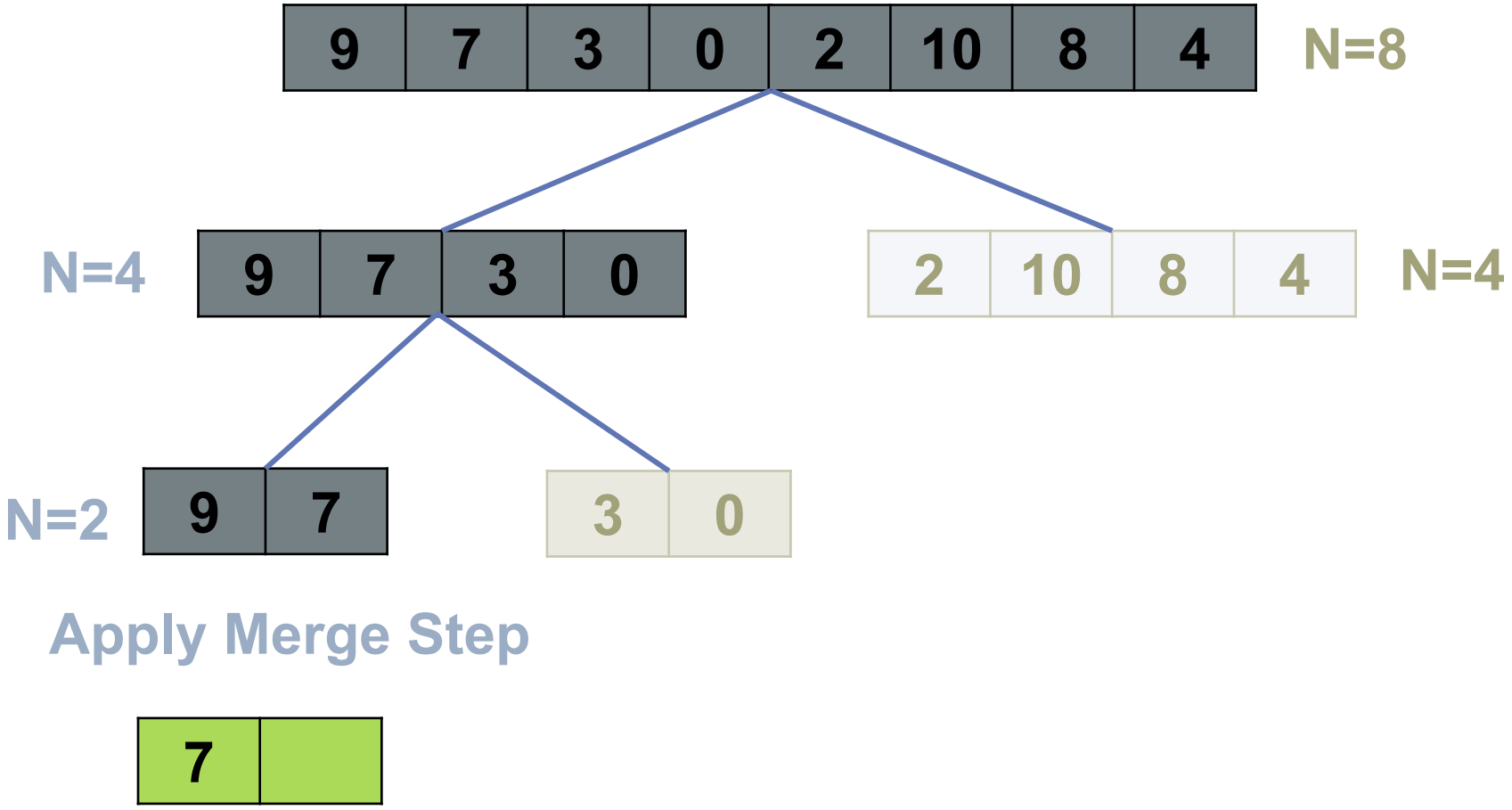

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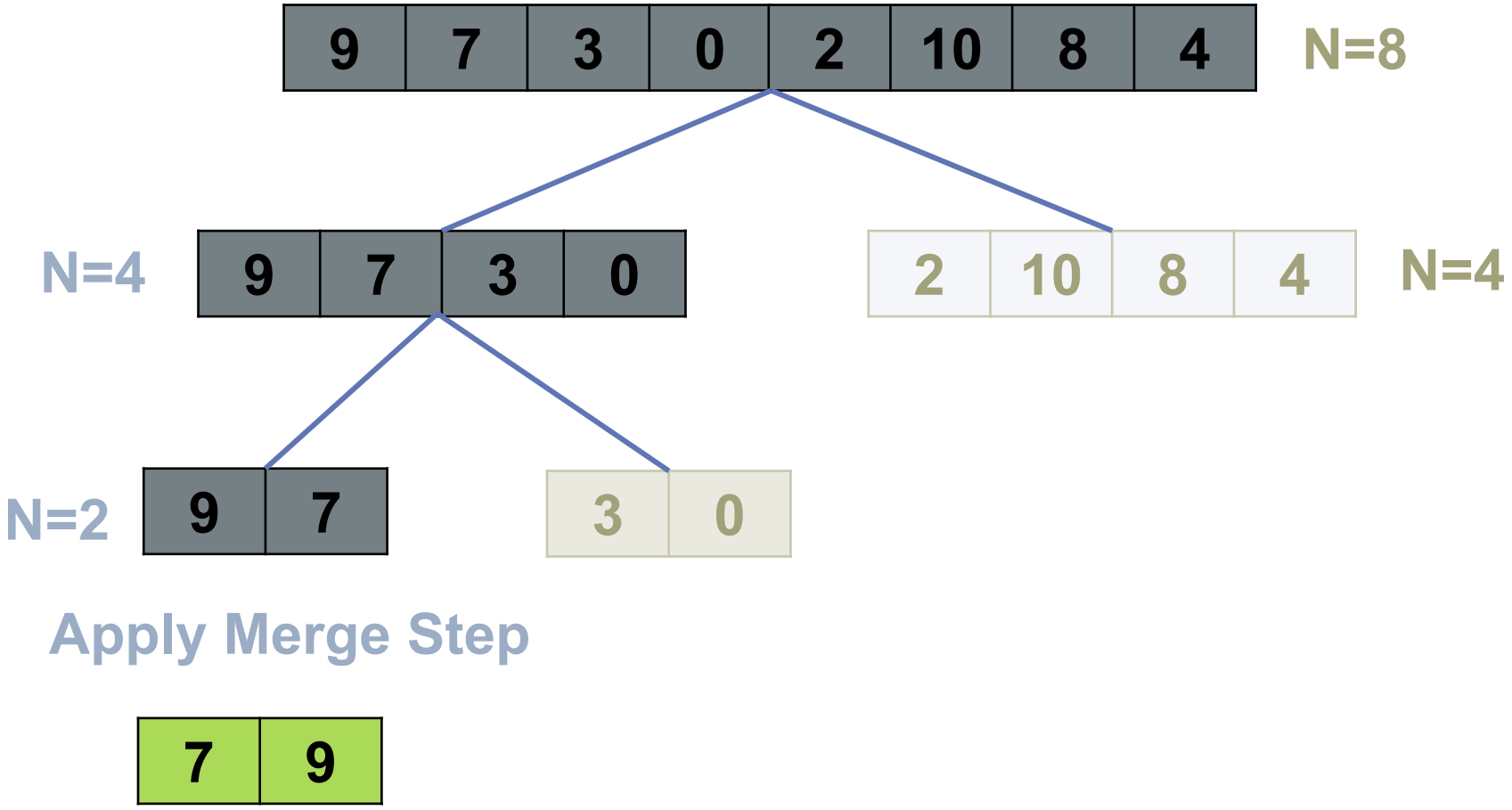

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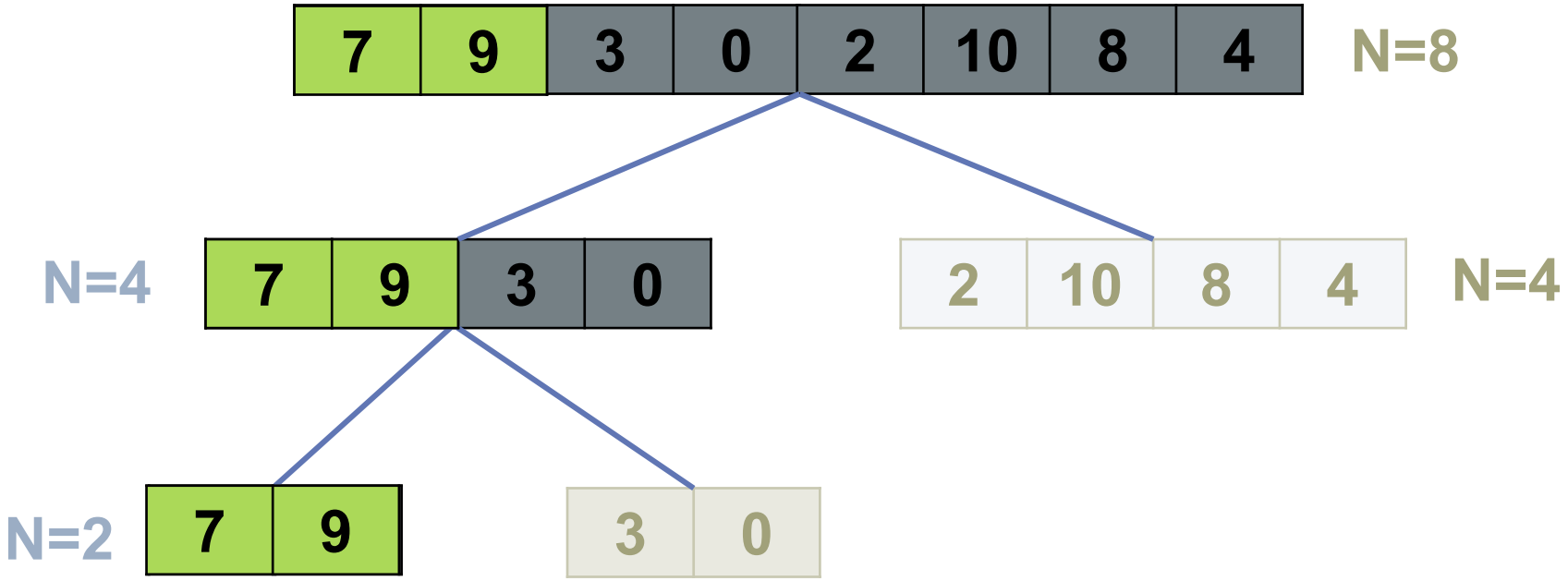
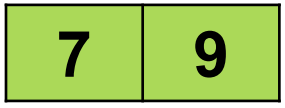


Copy Merged Elements



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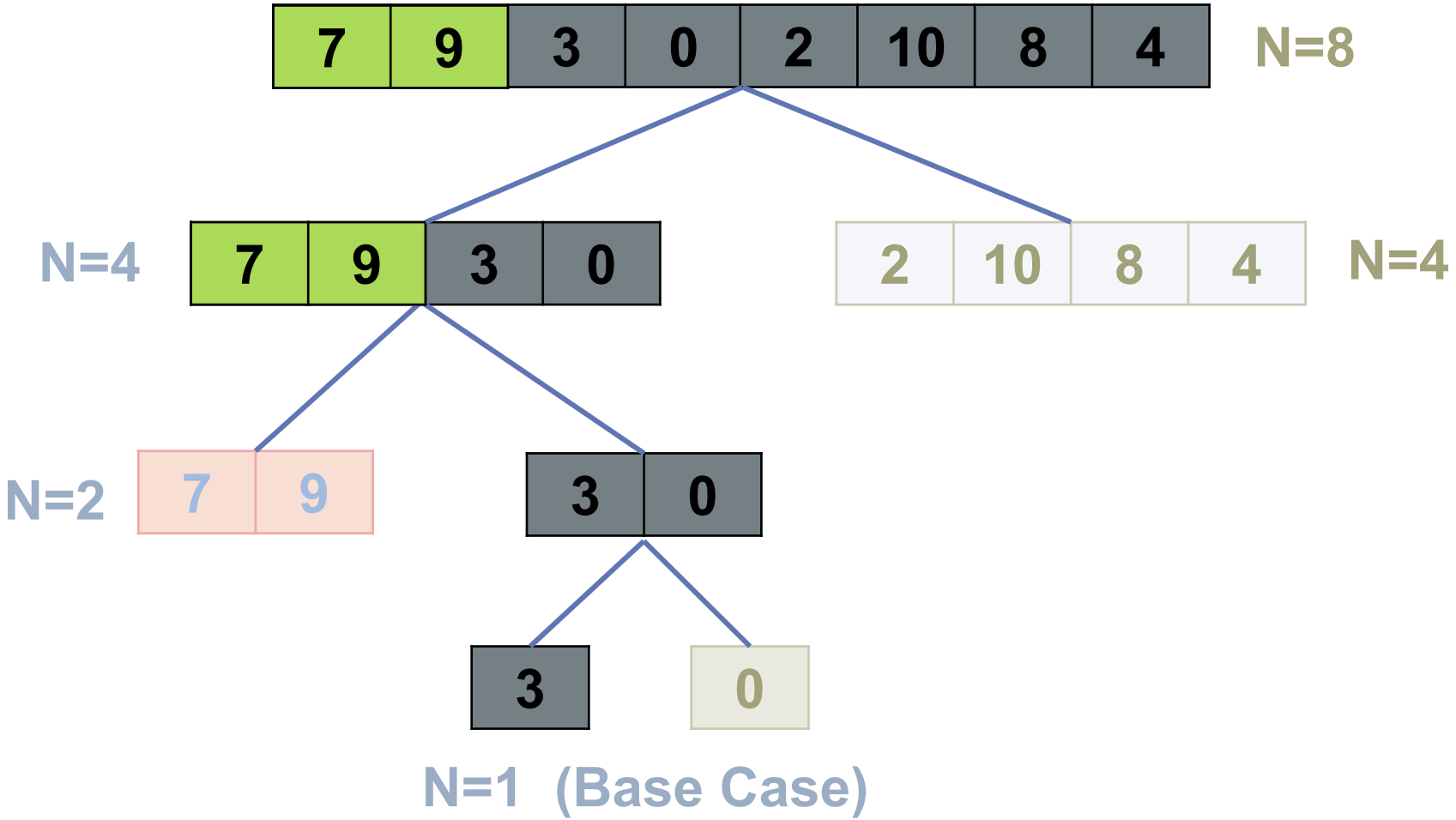

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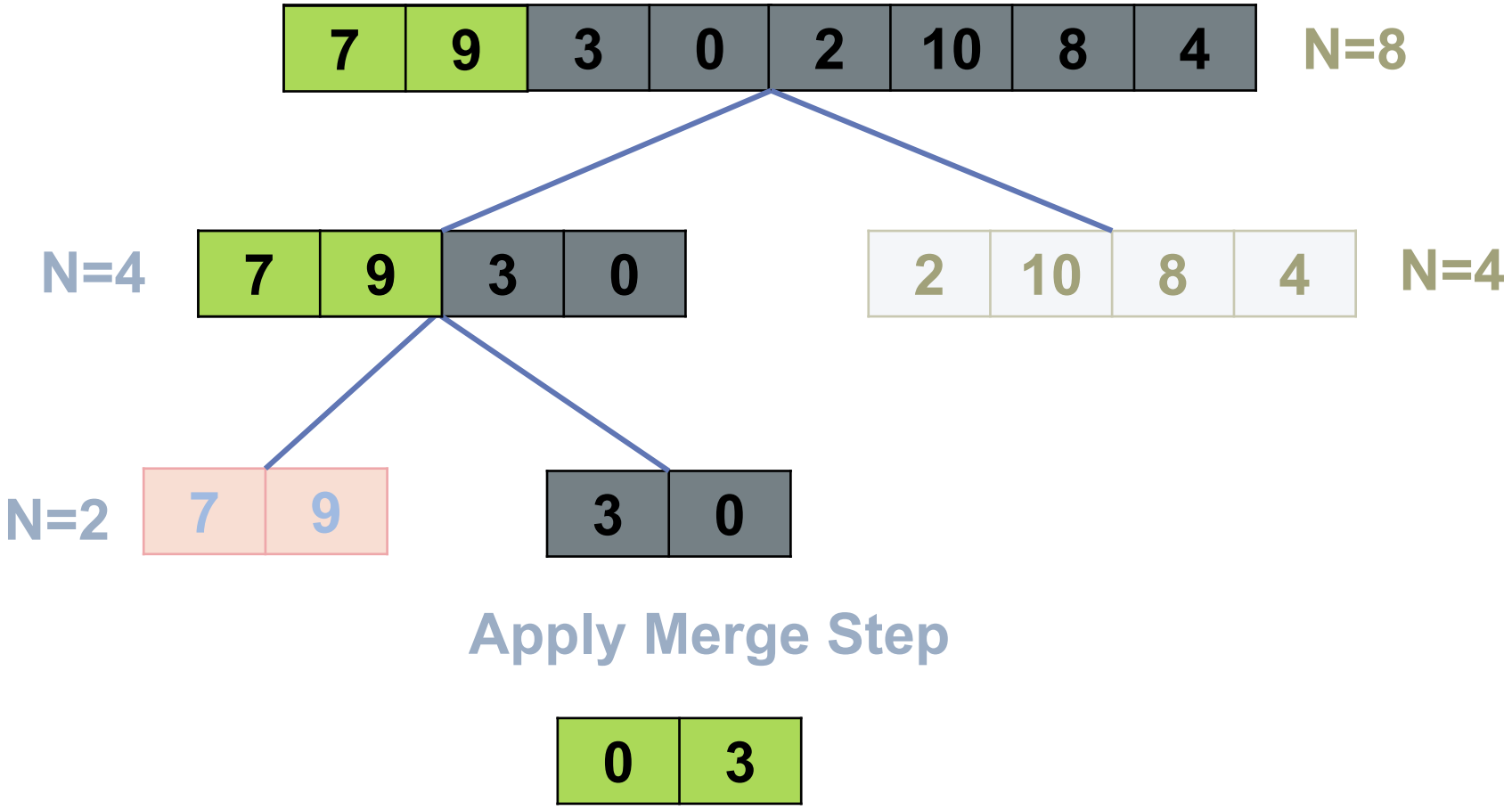

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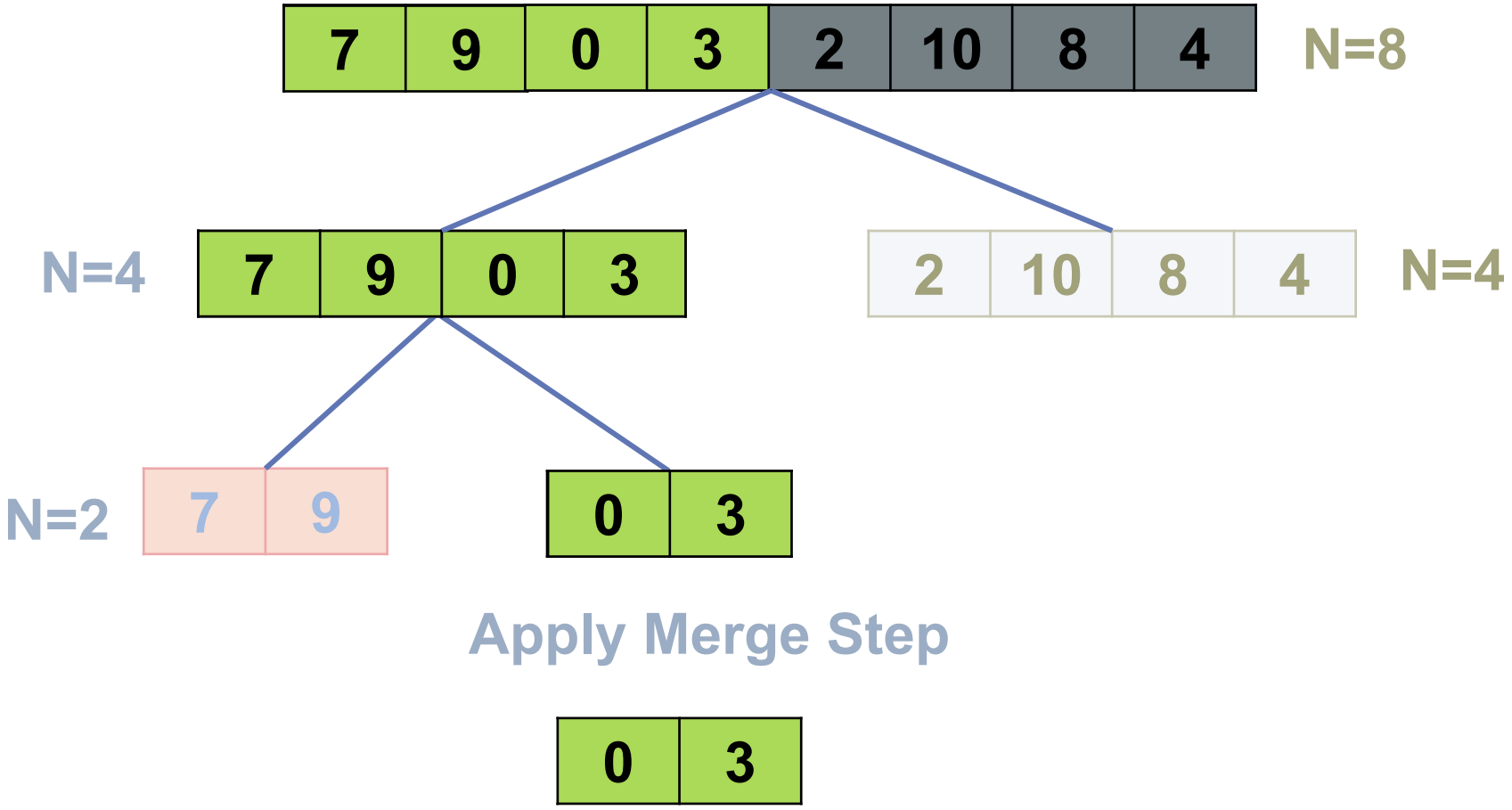

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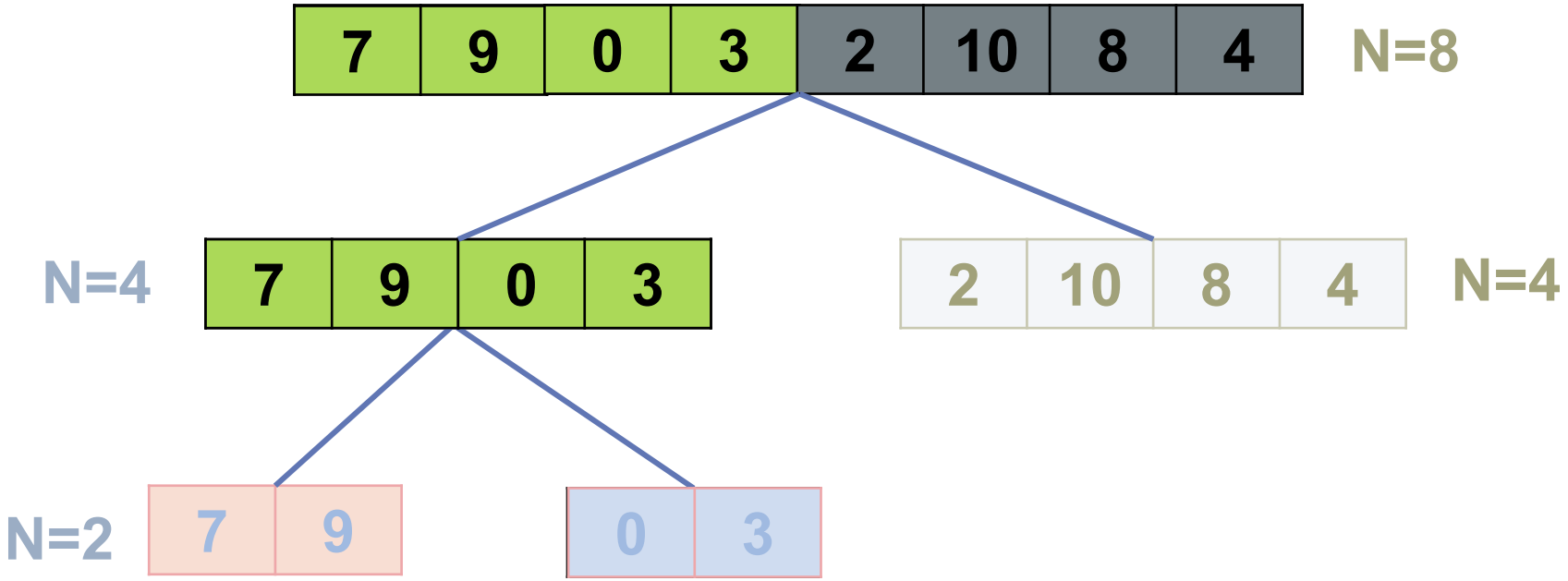

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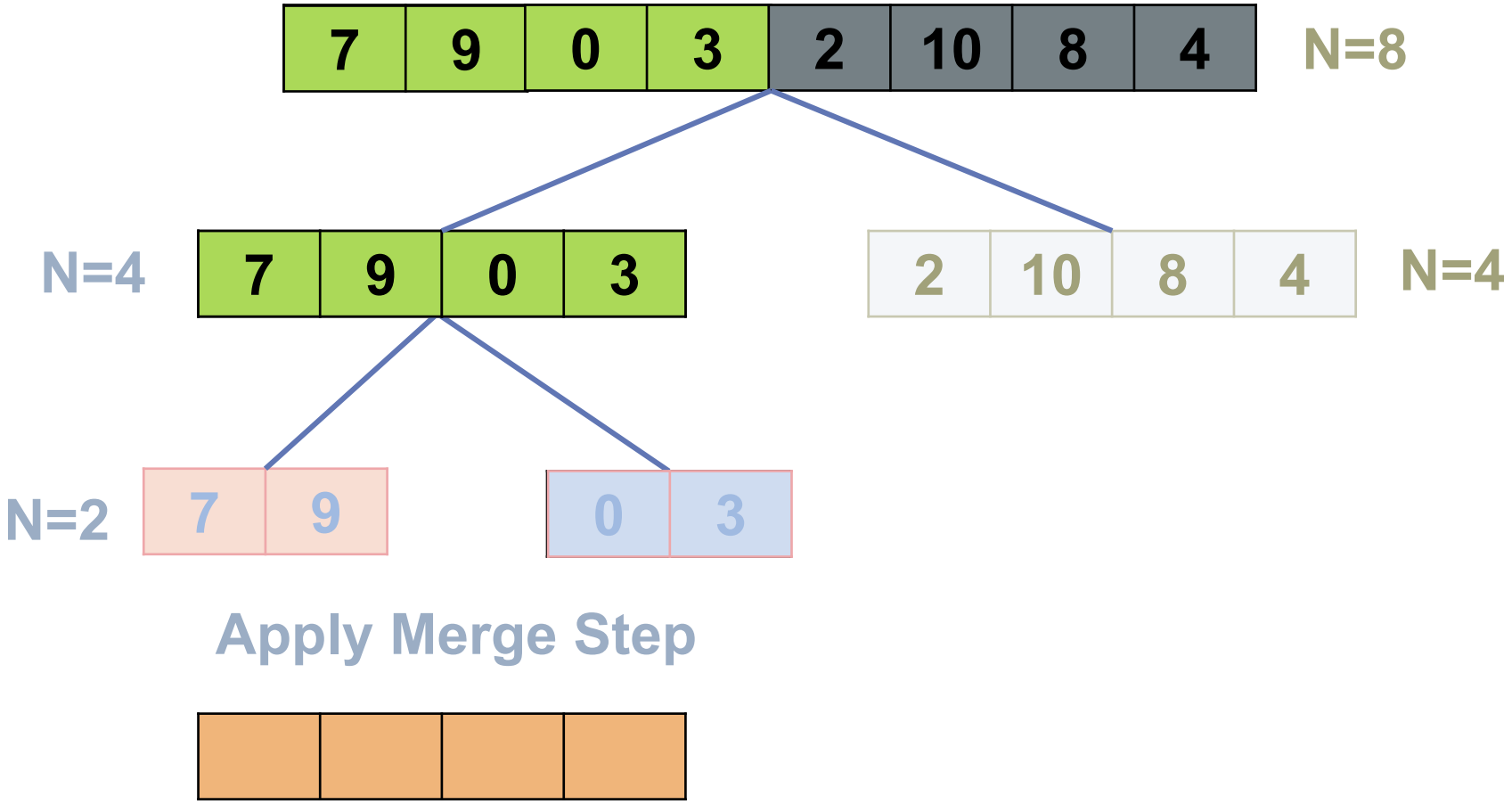

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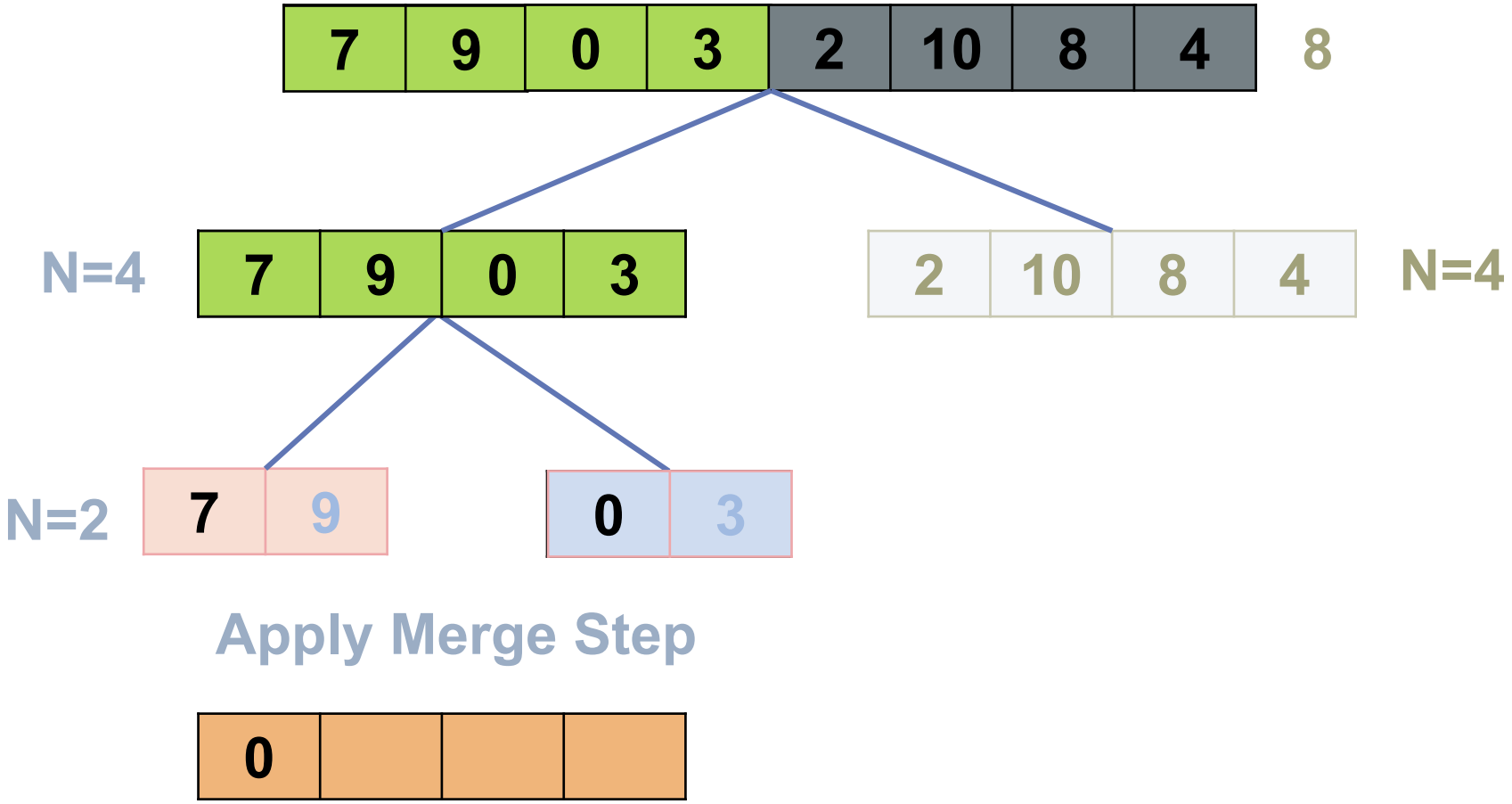

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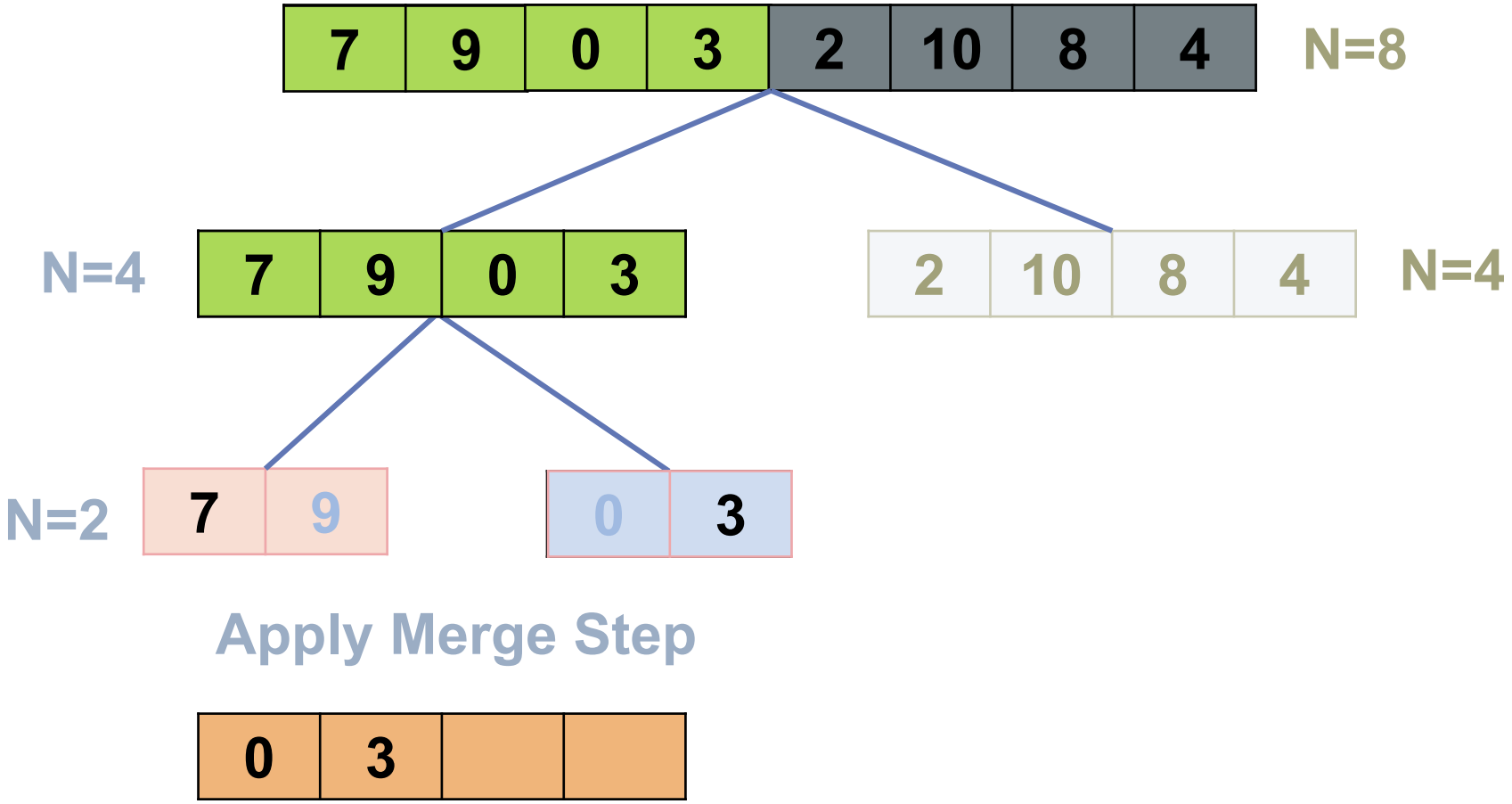

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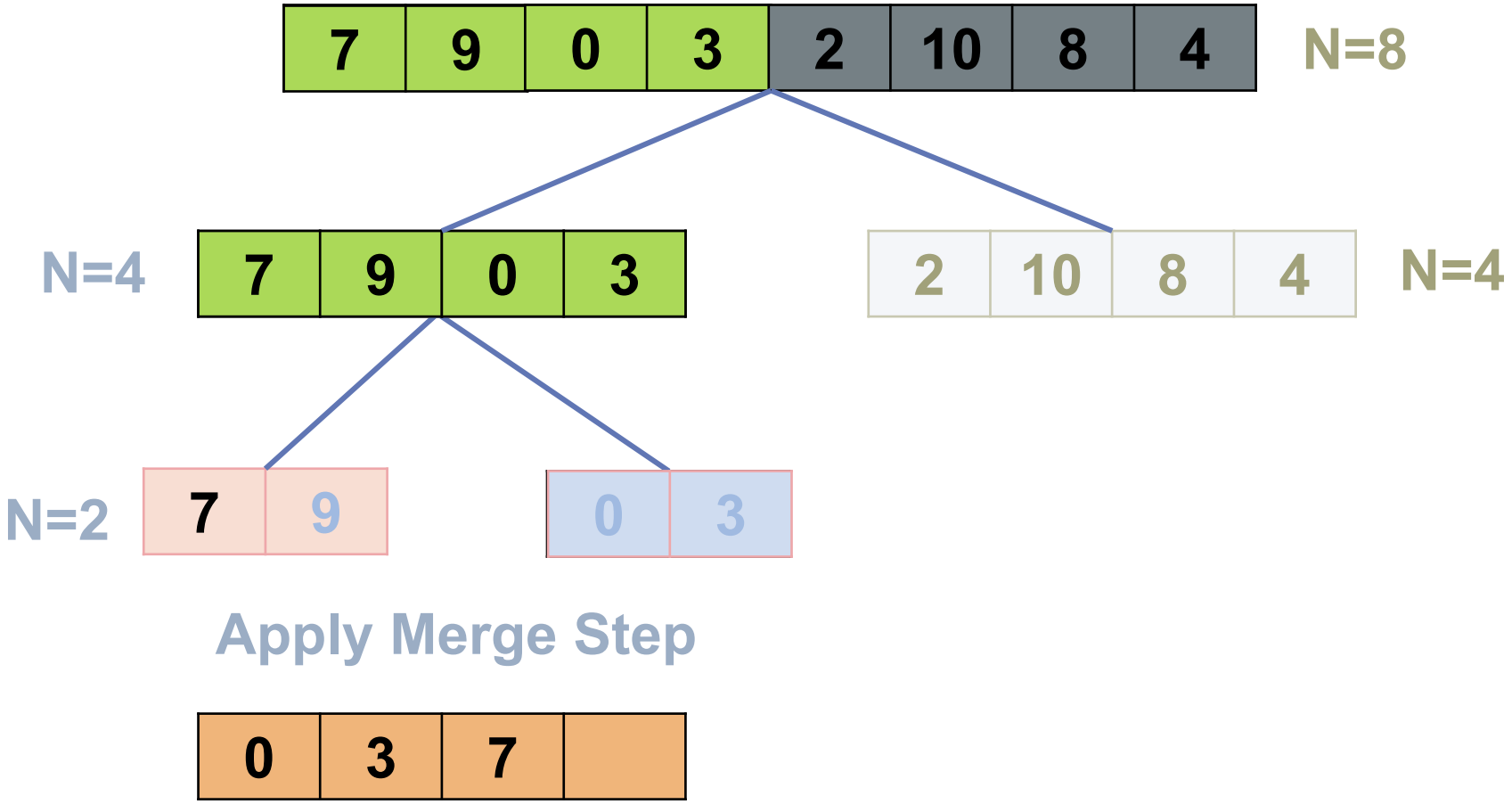

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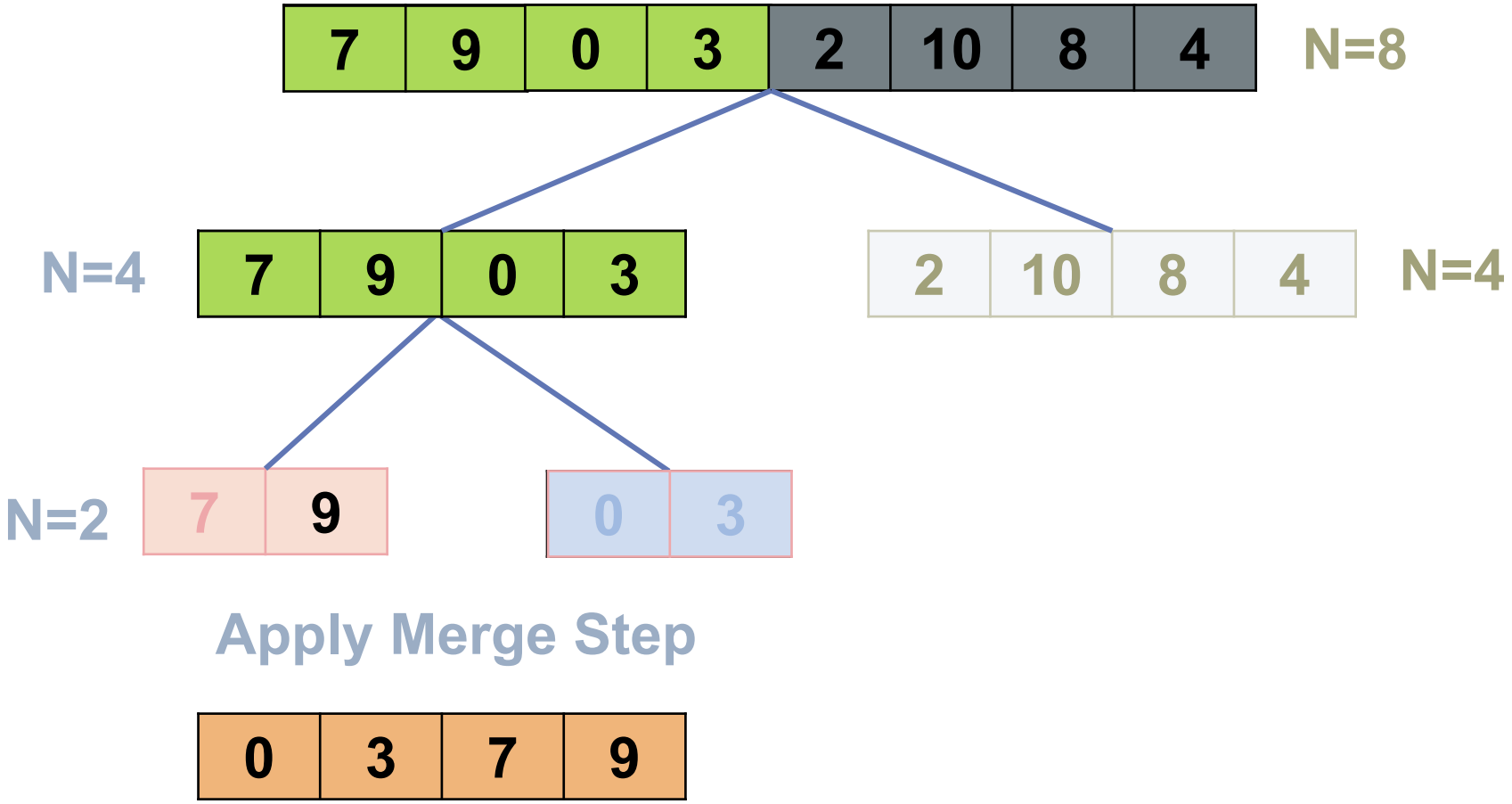

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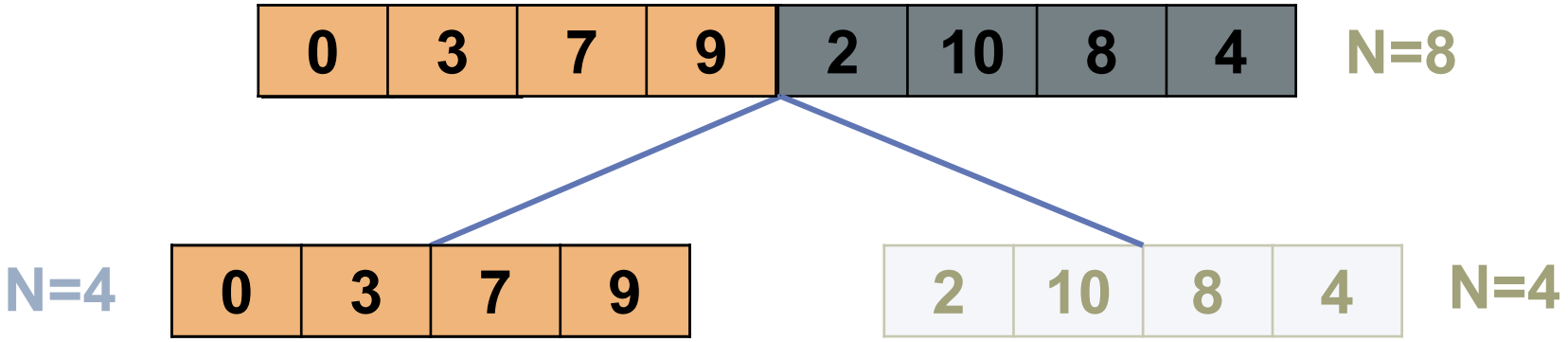
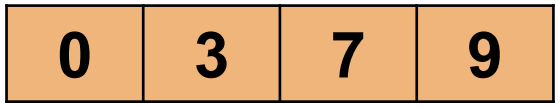


Copy Merged Elements



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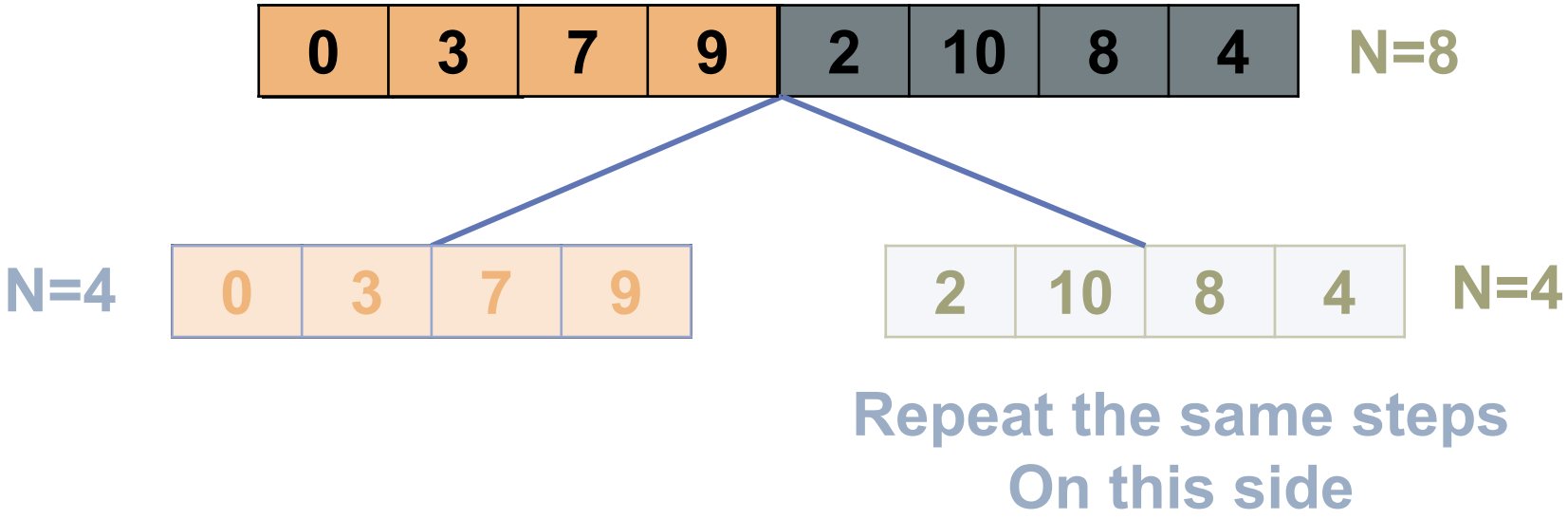
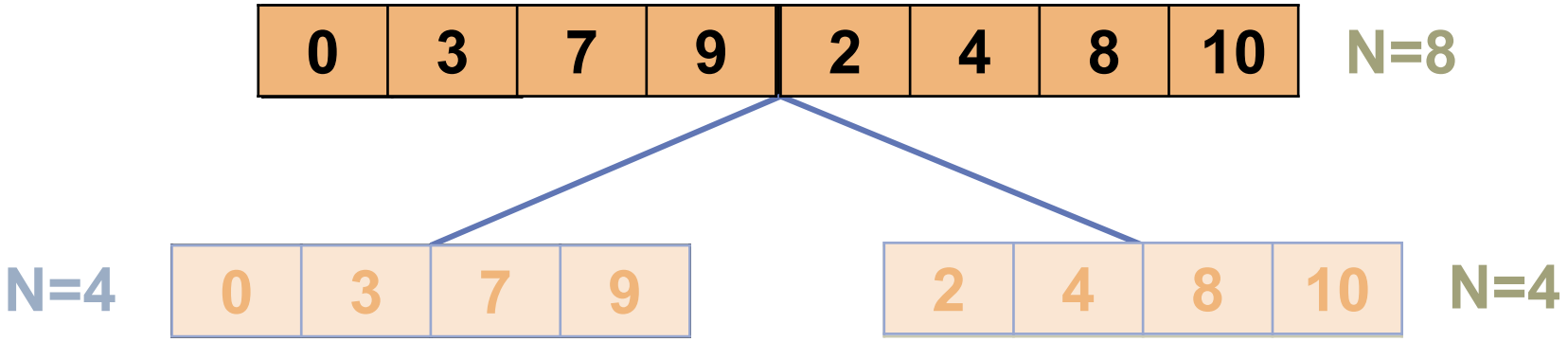

0 3 7 9 2 10 8 4
N=8
N=4
0 3 7 9
2 10 8 4
N=4
Repeat the same steps
On this side

MERGE SORT



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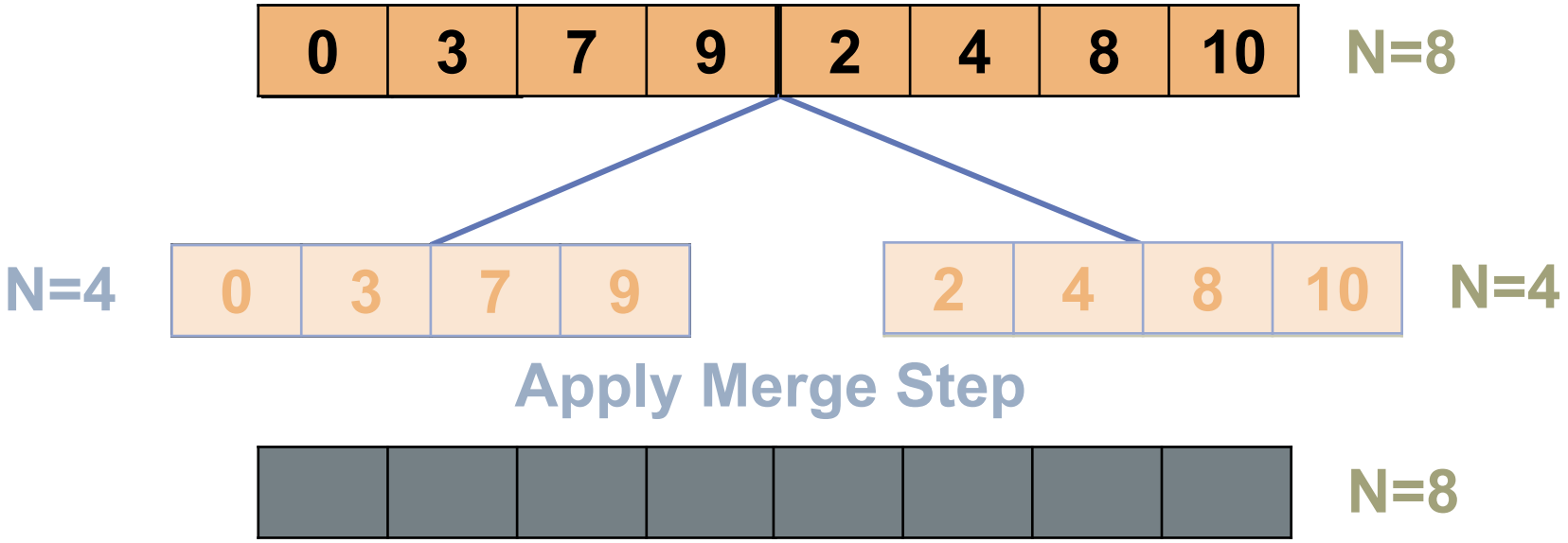

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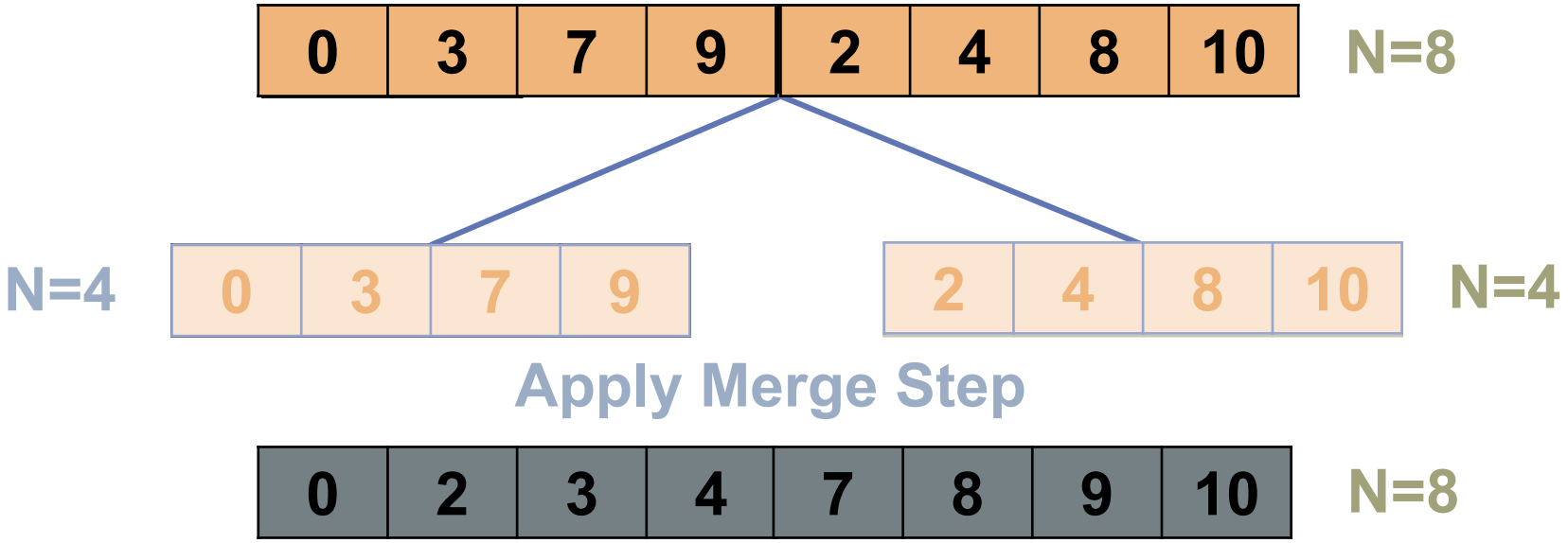


MERGE SORT

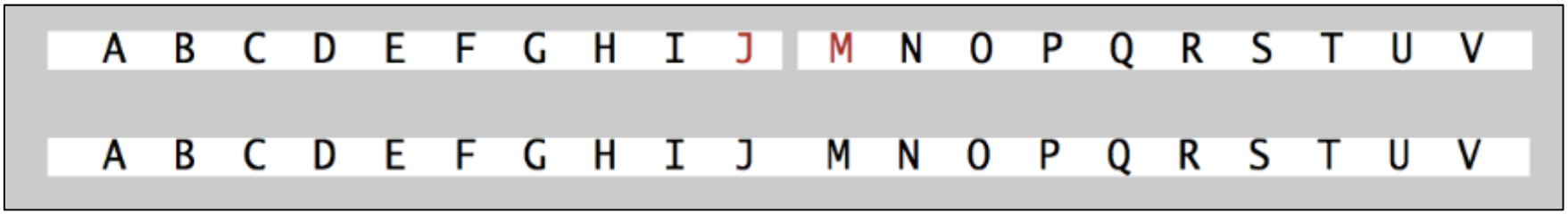
N=8

Copy Merged Elements

N=8

IMPROVING MERGE SORT

- **Stop if array is already sorted.**
  - If largest item in first half <= smallest item in second half
    - Array is already sorted, return.



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