Bubble Sort

```
void bubble_Sort(int arr[], int n)
{
    int i, j;
    for (i = 0; i < n - 1; i++) {
        for (j = 0; j < n - i - 1; j++) {
            if (arr[j] > arr[j + 1])
                swap(arr[j], arr[j + 1]);
            }
        }
}
```

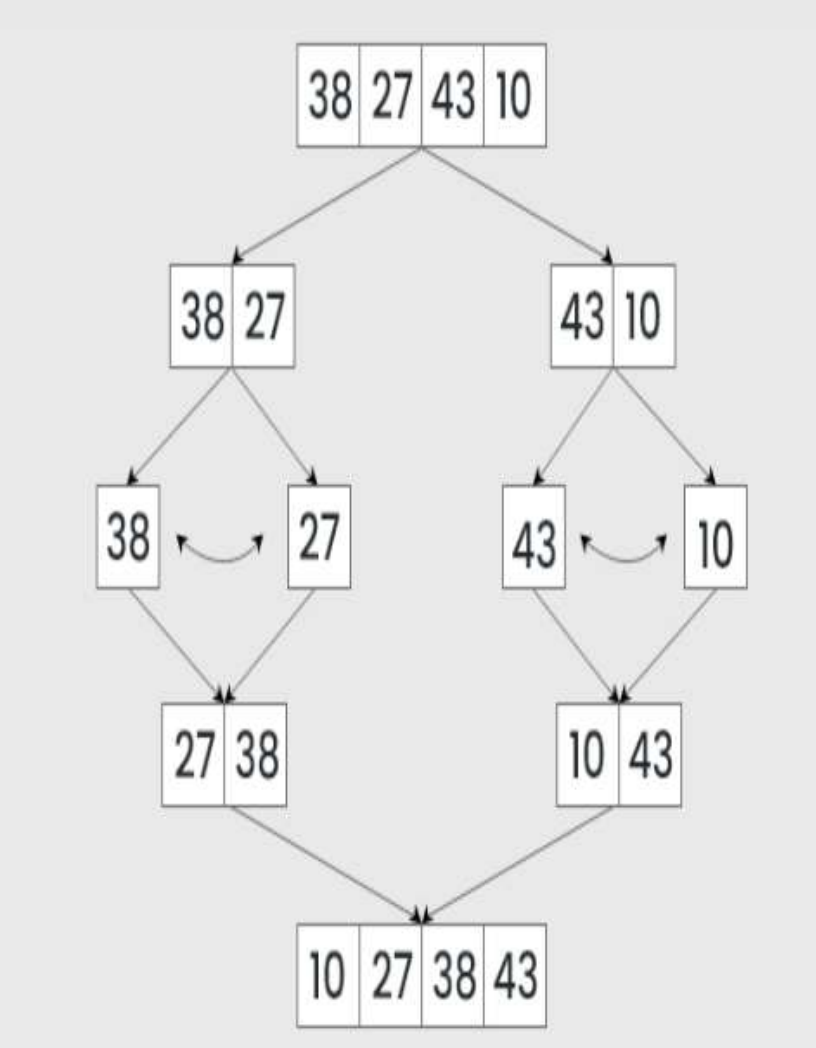
Selection Sort

```
void selectionSort(int arr[], int n) {
    for (int i = 0; i < n - 1; i++) {
            int min= i;
             for (int j = i + 1; j < n; j++)
                        {
                         if (arr[j] < arr[min])
                                    {min = j;}
                        }
        int temp = arr[i];
        arr[i] = arr[min];
        arr[min] = temp;
    }
}
```

Insertion Sort

```
void insertion_Sort(int arr[], int n)
{
    int i, key, j;
        for (i = 1; i < n; i++) {
                key = arr[i];
                j = i - 1;
               while (j >= 0 && arr[j] > key) {
                        arr[j + 1] = arr[j];
                        j = j - 1;
                }
       arr[j + 1] = key;
    }
}
```

Merge sort




```
MERGE_SORT(arr, beg, end)
    if beg < end
        set mid = (beg + end)/2
        MERGE_SORT(arr, beg, mid)
        MERGE_SORT(arr, mid + 1, end)
        MERGE (arr, beg, mid, end)
    end of if

END MERGE_SORT
```

```
void merge(int arr[], int l, int m, int r) {
    // Calculate sizes of two subarrays to be merged
    int n1 = m - l + 1;
    int n2 = r - m;

    // Create temporary arrays to hold the subarrays
    int L[n1], R[n2];

    // Copy data to temporary arrays
    for (int i = 0; i < n1; i++)
        L[i] = arr[l + i];
    for (int j = 0; j < n2; j++)
        R[j] = arr[m + 1 + j];

int i = 0, j = 0, k = l;
    while (i < n1 && j < n2) {
        if (L[i] <= R[j]) {
            arr[k] = L[i];
            i++;
        } else {
            arr[k] = R[j];
            j++;
        }
        k++;
    }
while (i < n1) {
        arr[k] = L[i];
        i++;
        k++;
}
 while (j < n2) {
        arr[k] = R[j];
        j++;
        k++;
```

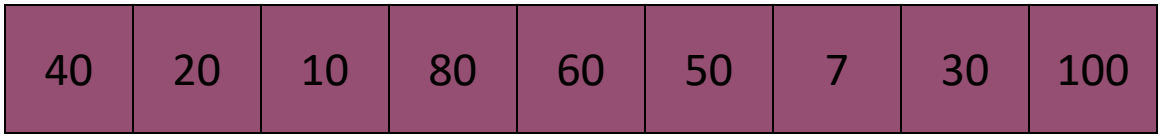
Quicksort Algorithm

Given an array of *n* elements (e.g., integers):

- If array only contains one element, return
- Else
  - pick one element to use as *pivot.*
  - Partition elements into two sub-arrays:
    - Elements less than or equal to pivot
    - Elements greater than pivot
  - Quicksort two sub-arrays
  - Return results

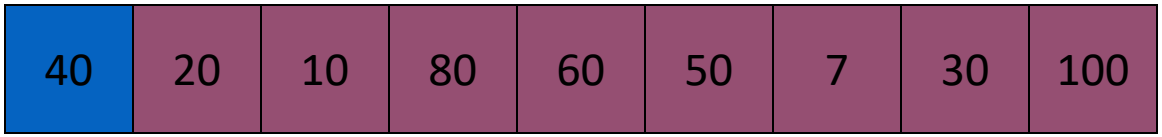
Example

We are given array of n integers to sort:



Pick Pivot Element

There are a number of ways to pick the pivot element. In this example, we will use the first element in the array:



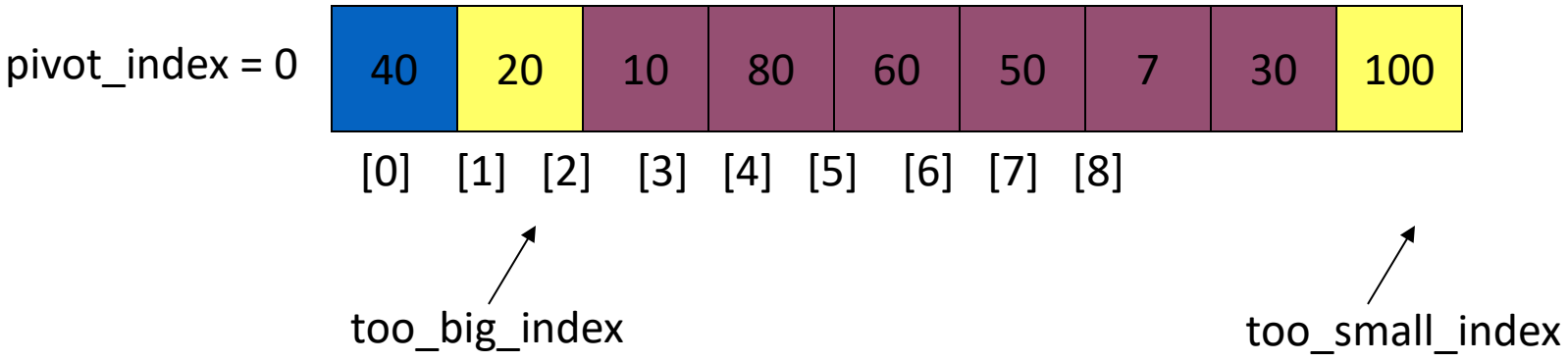
Partitioning Array

Given a pivot, partition the elements of the array such that the resulting array consists of:

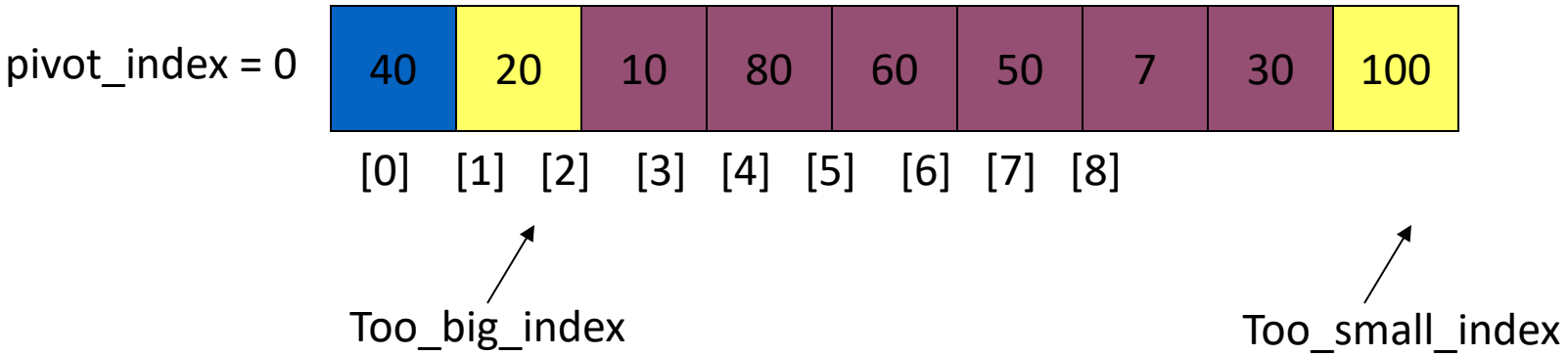
1. One sub-array that contains elements >= pivot
2. Another sub-array that contains elements < pivot

The sub-arrays are stored in the original data array.

Partitioning loops through, swapping elements below/above pivot.


pivot_index = 0
40
20
10
80
60
50
7
30
100
[0]
[1]
[2]
[3]
[4]
[5]
[6]
[7]
[8]
too_big_index
too_small_index

1. While data[Too_big_index] <= data[pivot]
   ++Too_big_index



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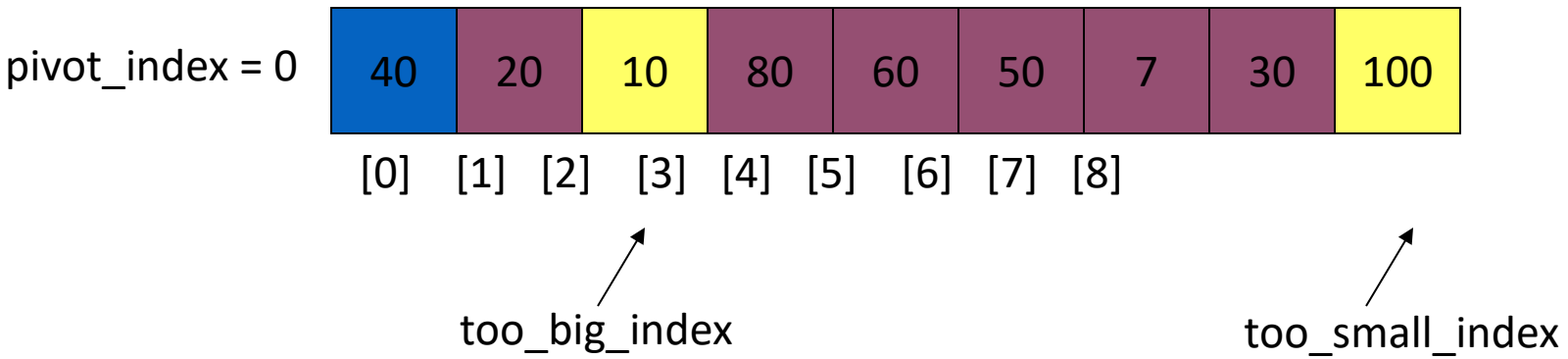

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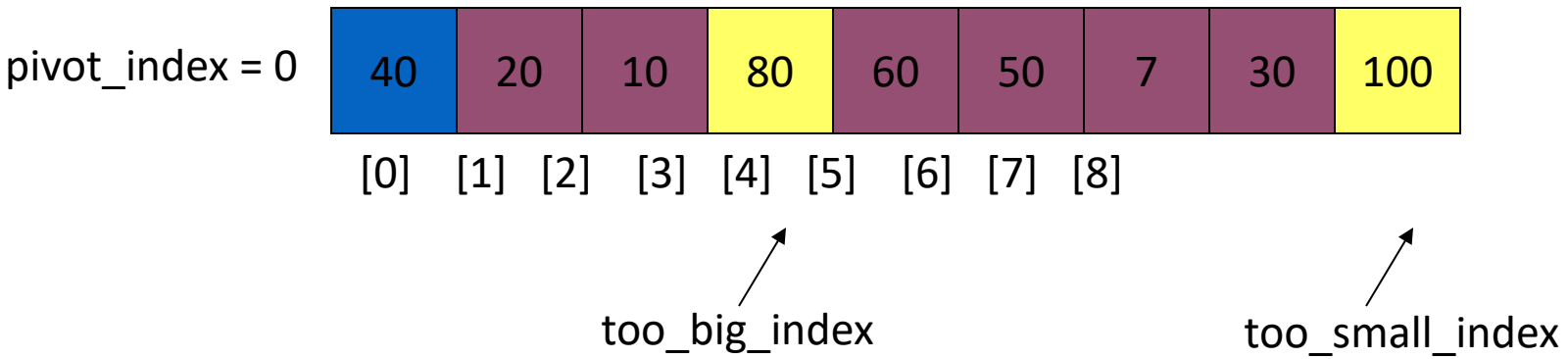

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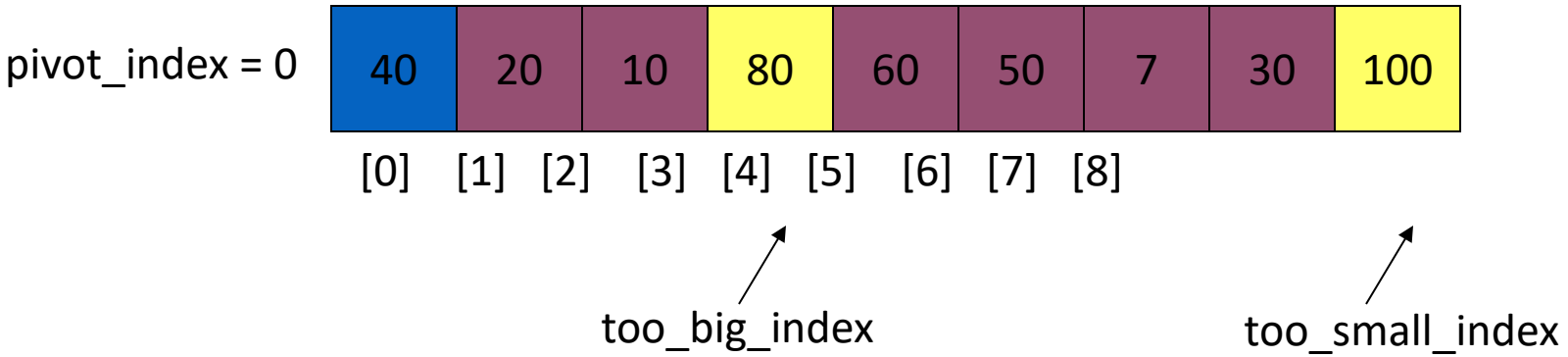
   --too_small_index



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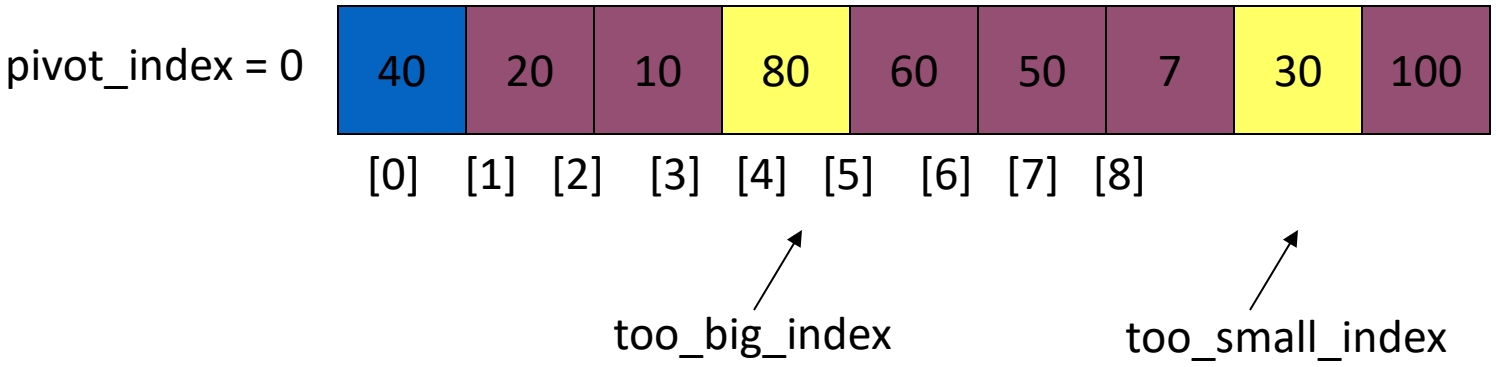

1. While data[too_big_index] <= data[pivot]
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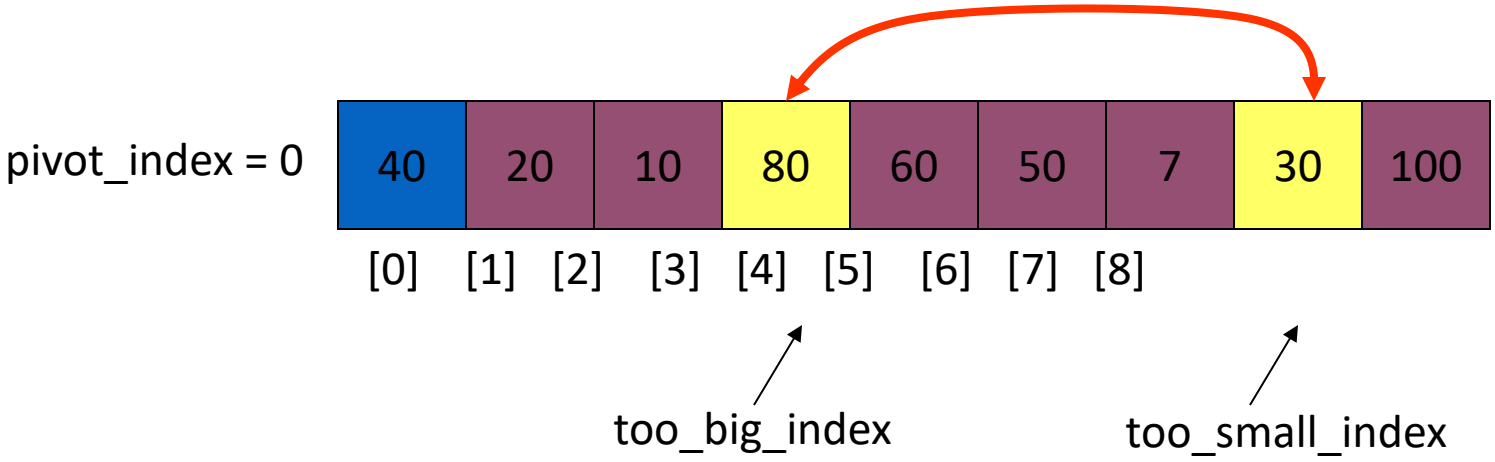
   --too_small_index
3. If too_big_index < too_small_index
   swap data[too_big_index] and data[too_small_index]



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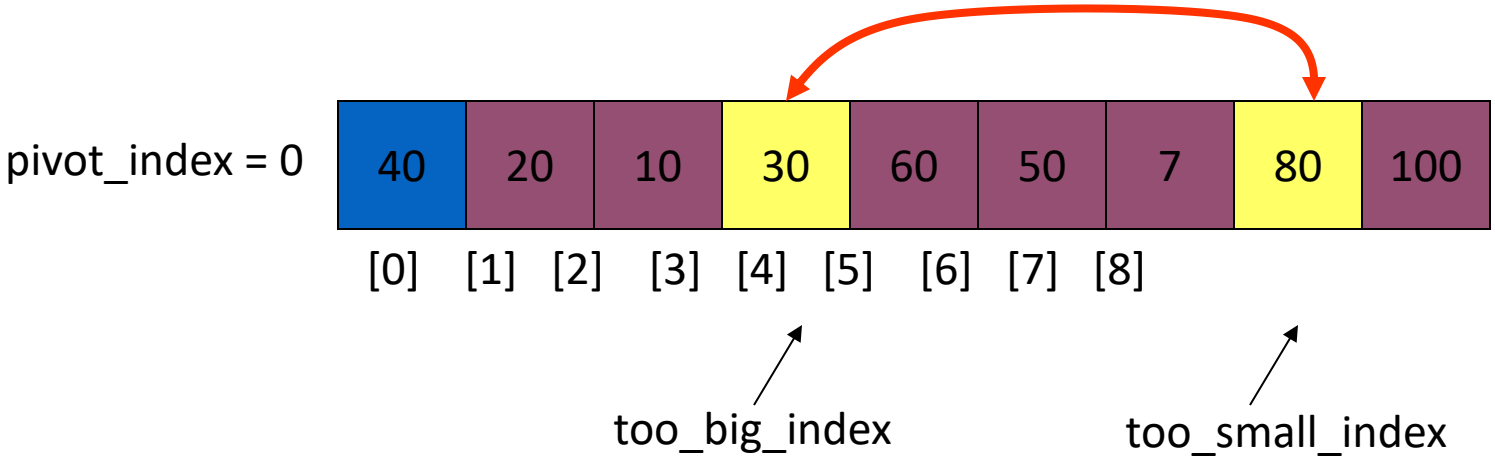

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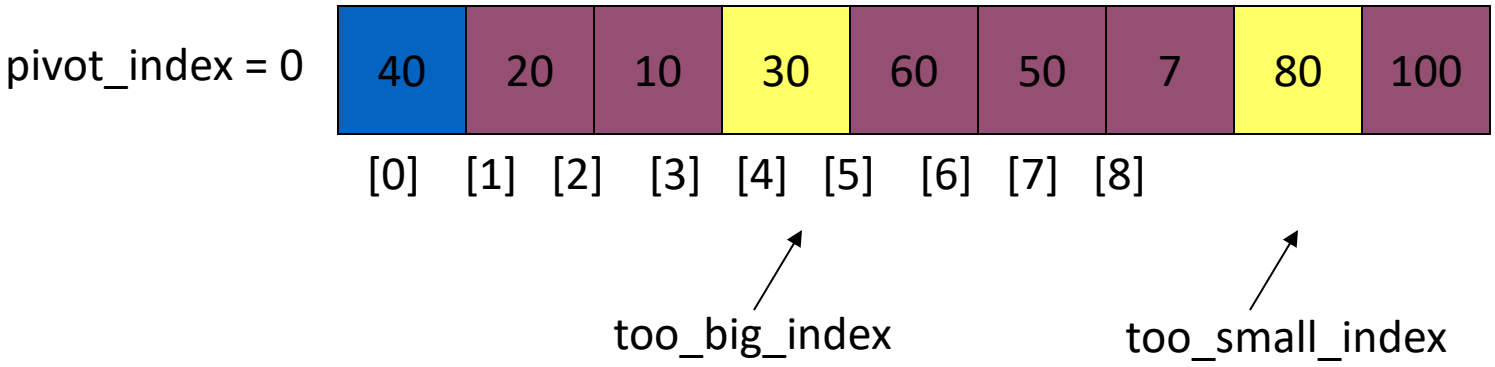

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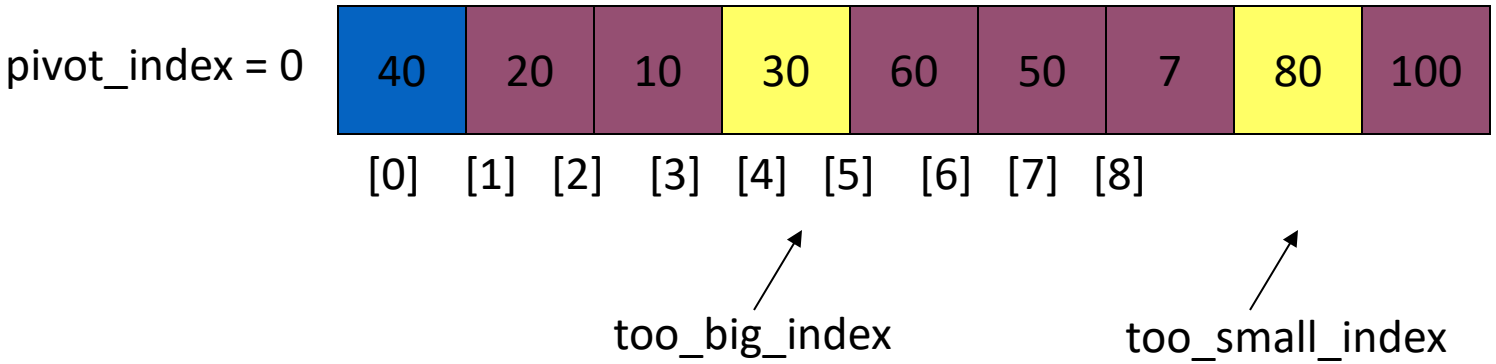

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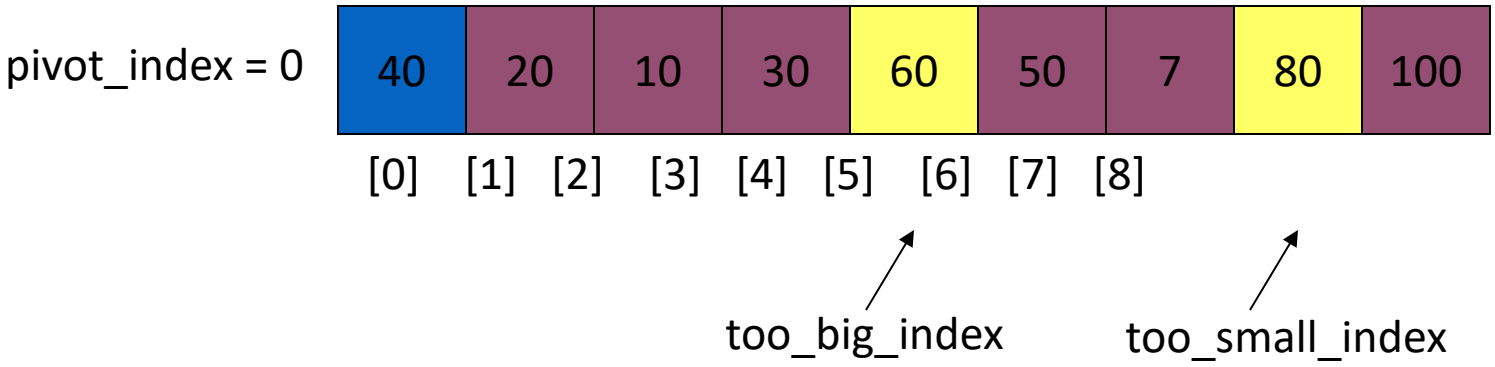

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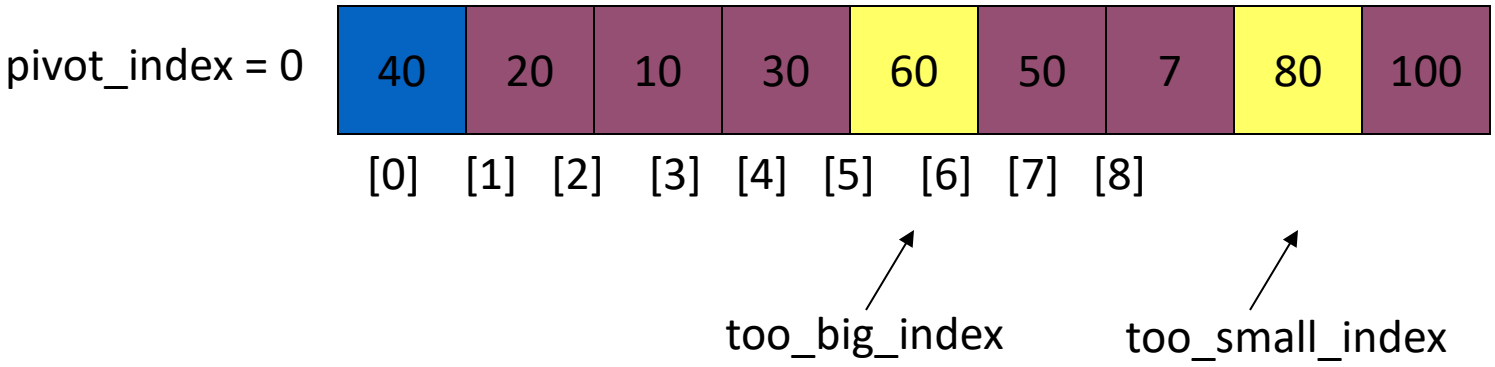

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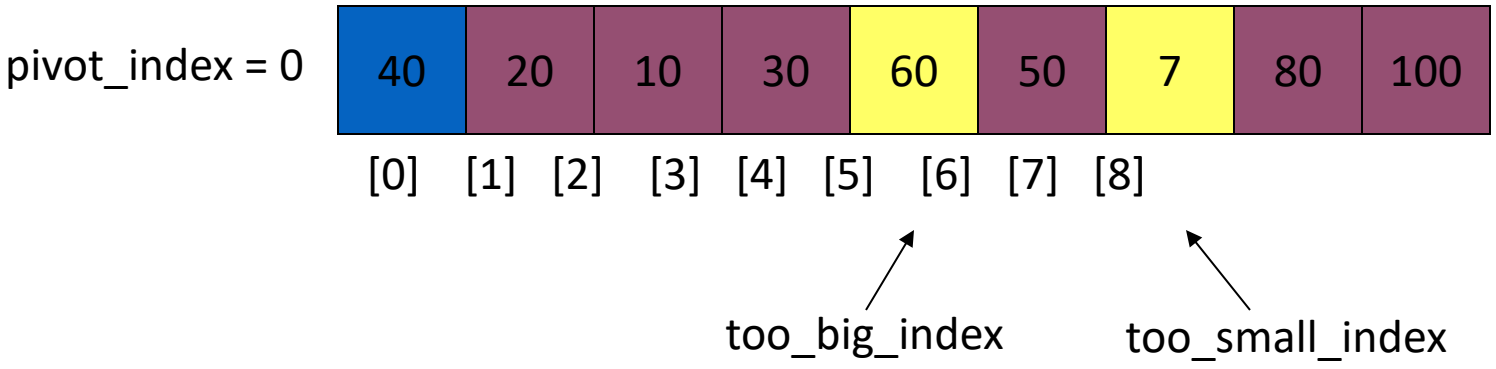

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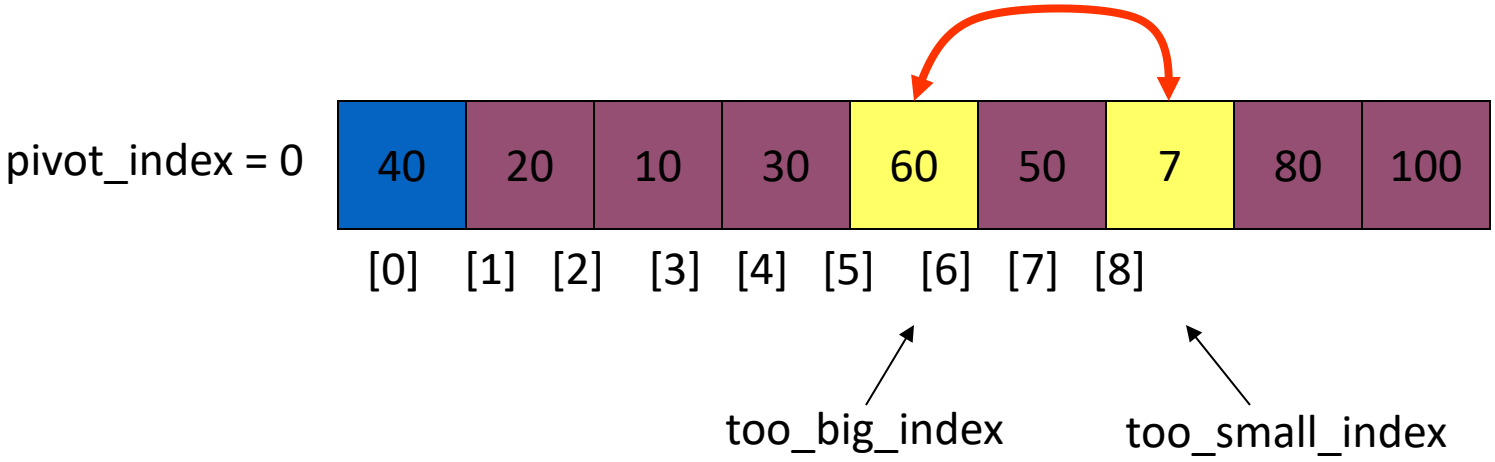

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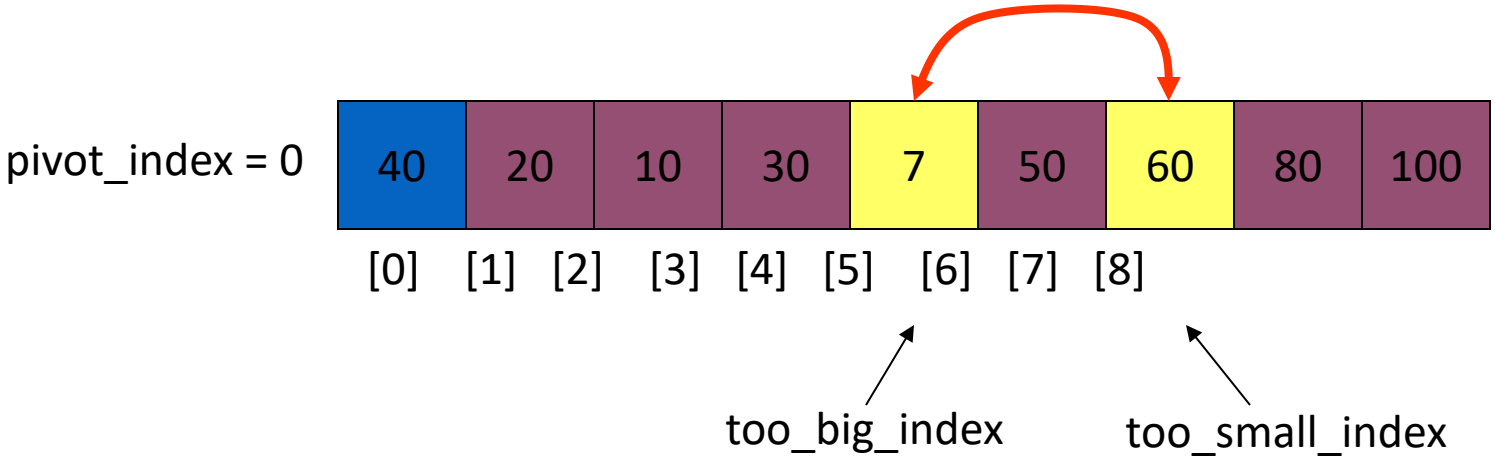

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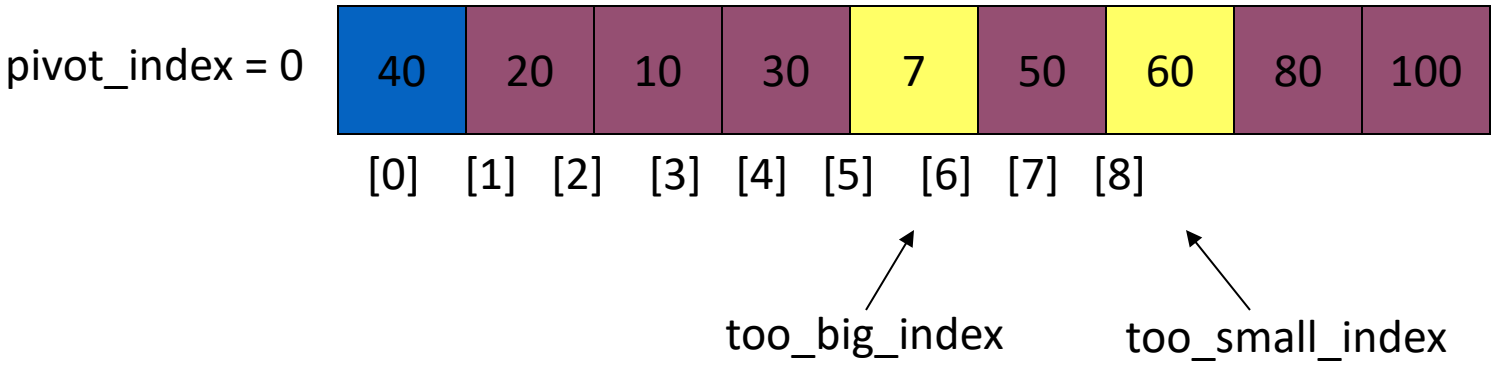

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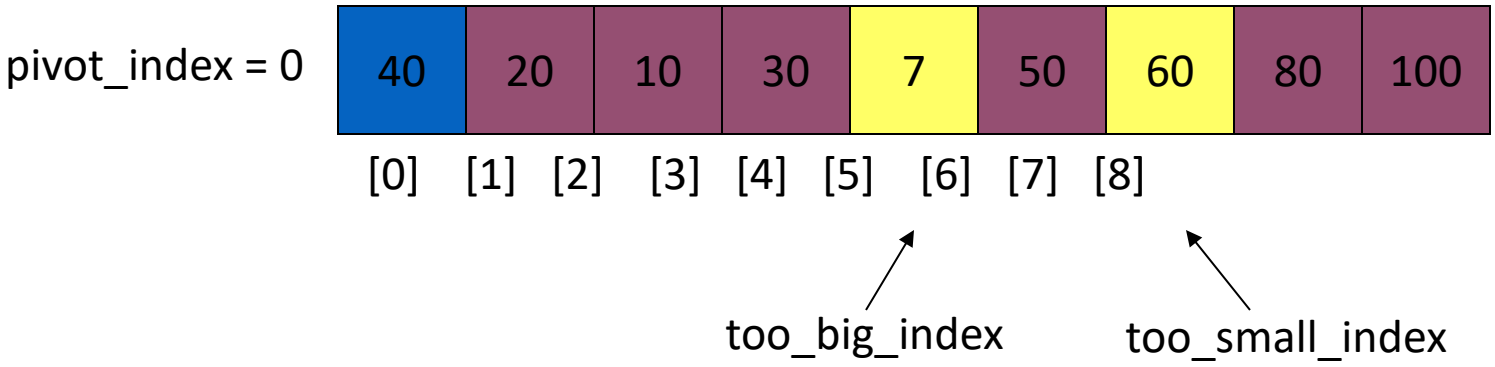

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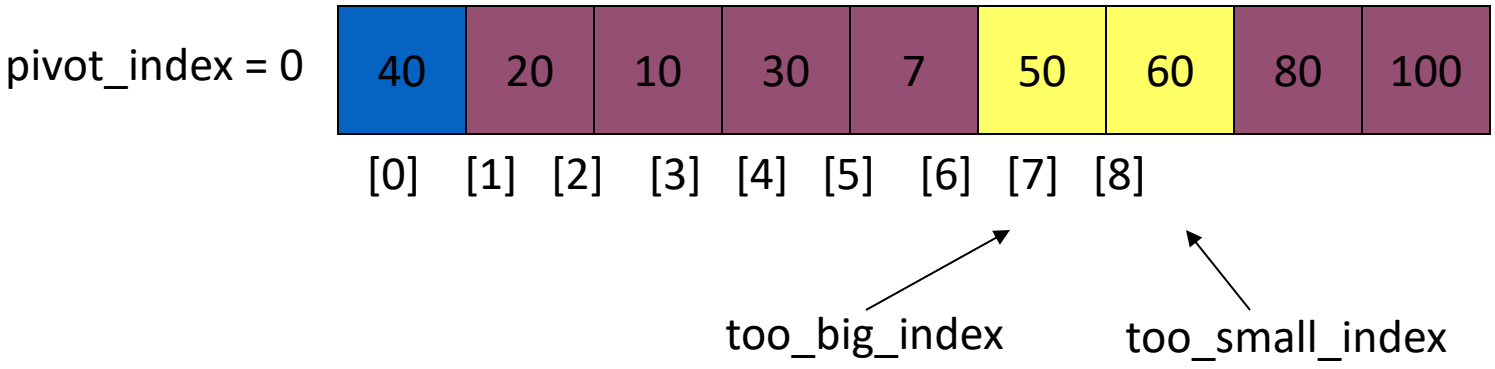

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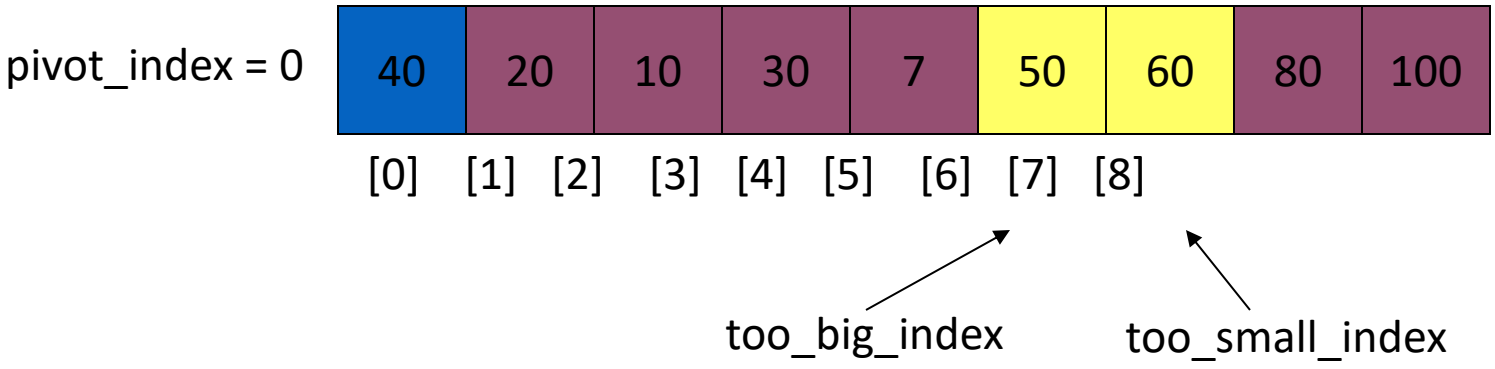

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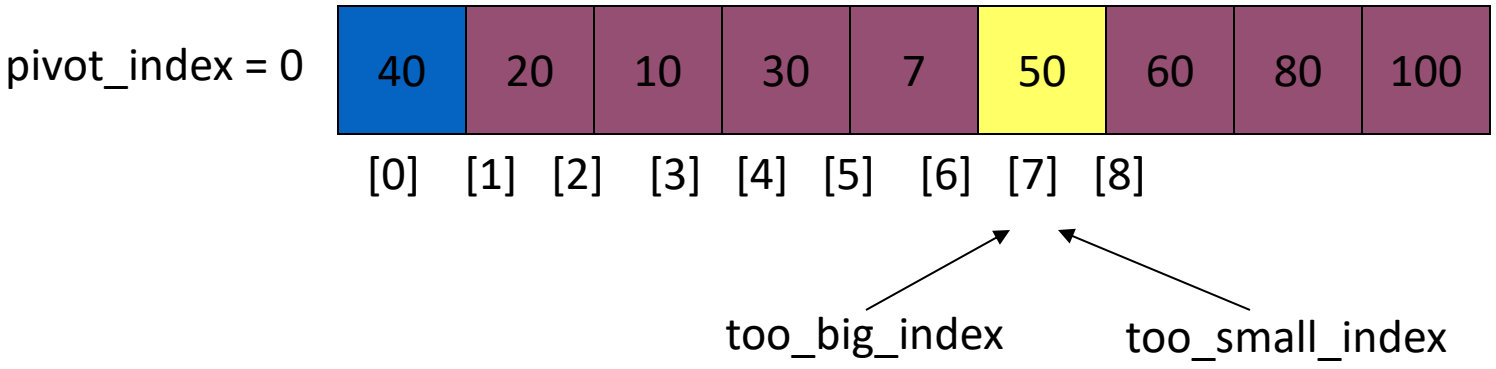

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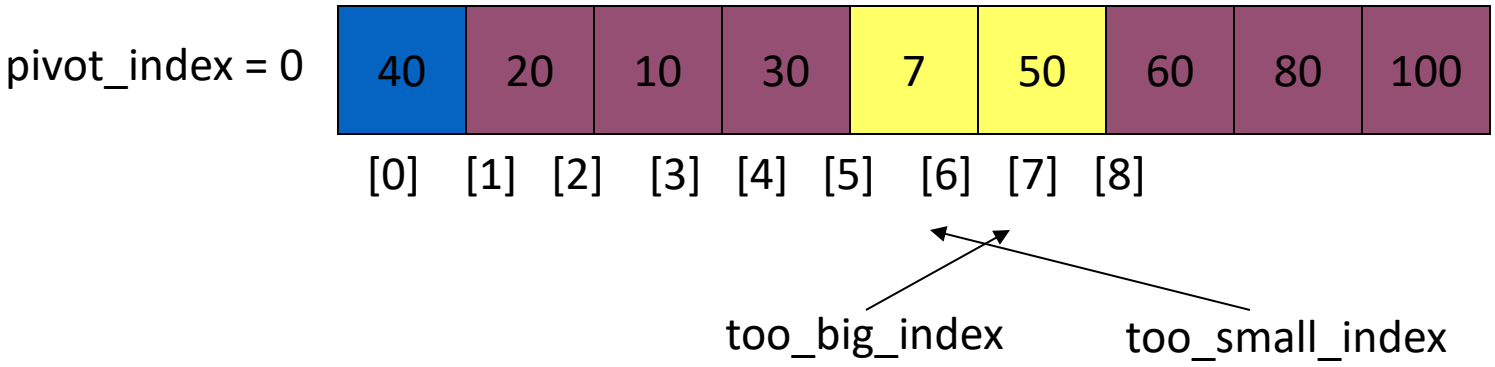

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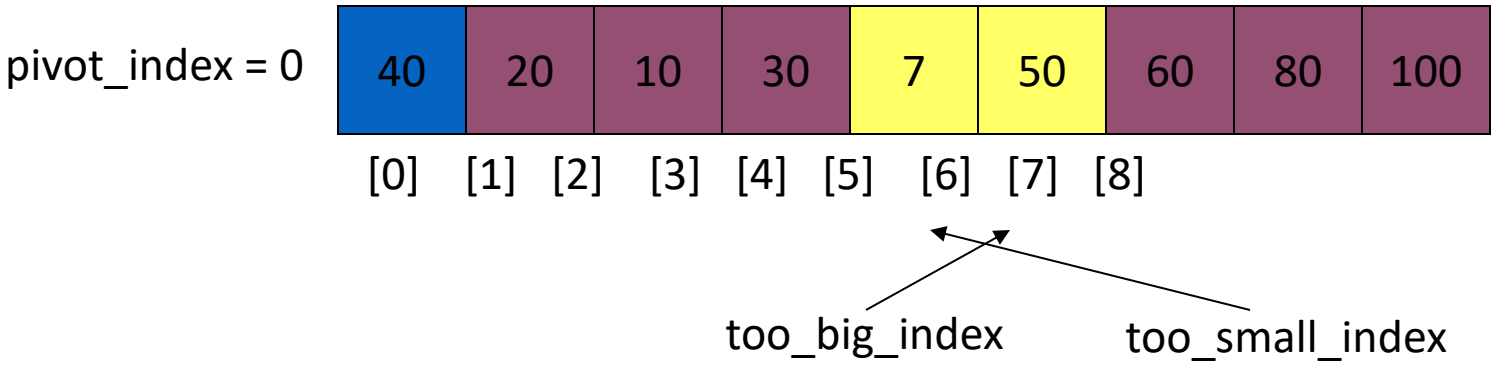

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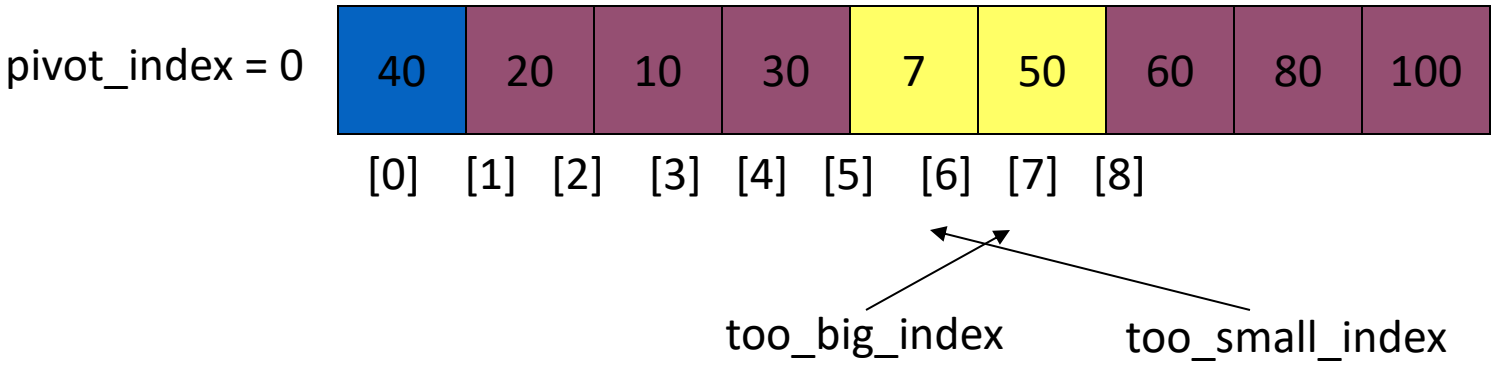

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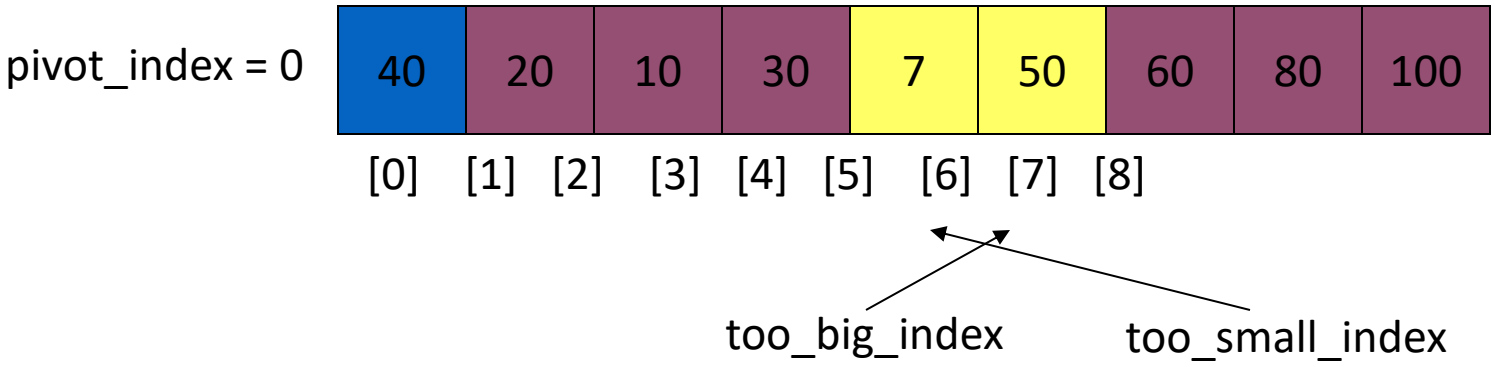

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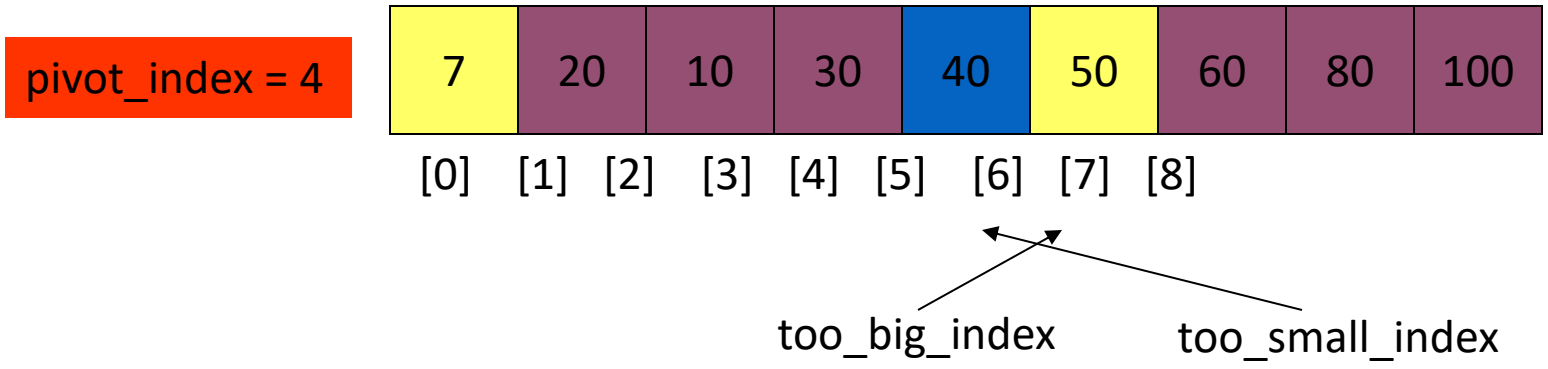
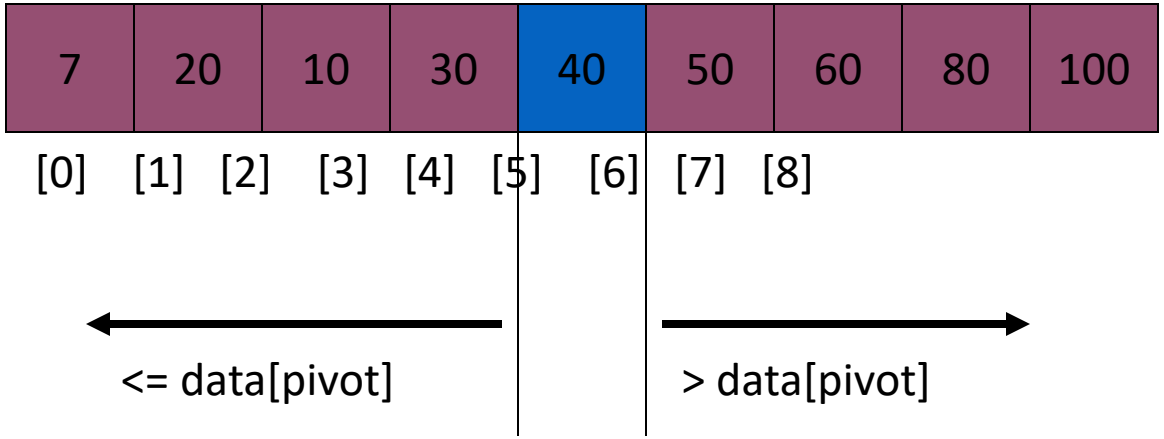
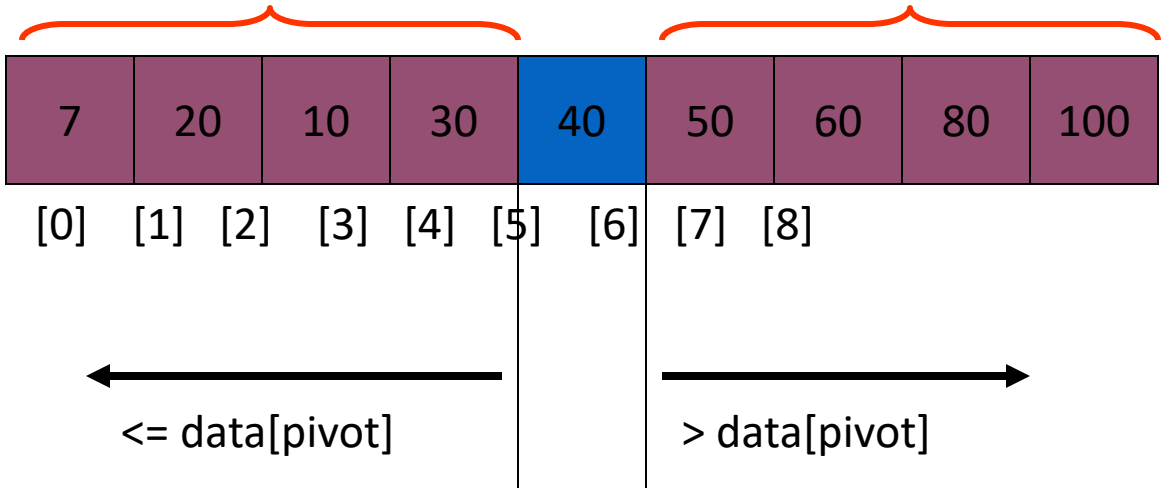


Partition Result

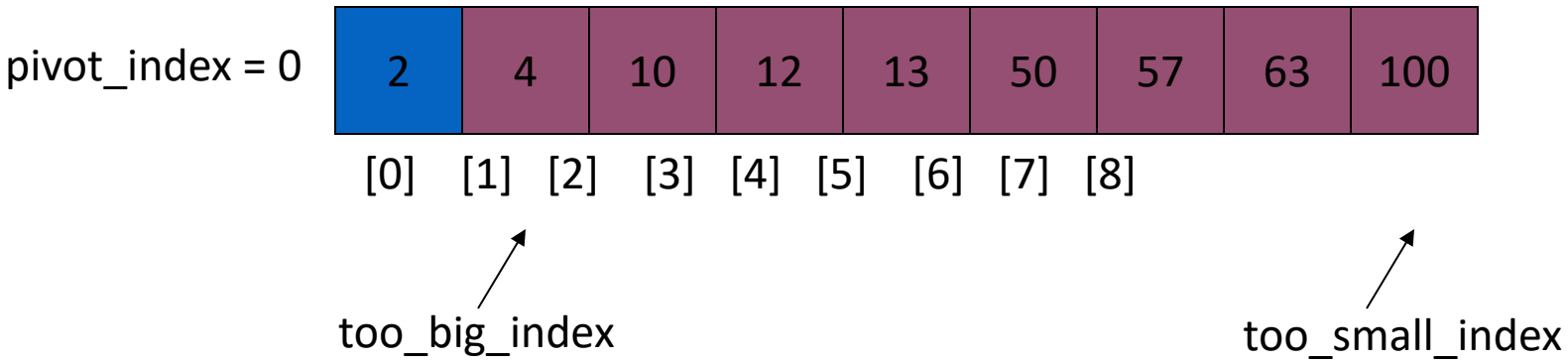


Recursion: Quicksort Sub-arrays



Quicksort: Worst Case

- Assume first element is chosen as pivot.
- Assume we get array that is already in order:



1. While data[too_big_index] <= data[pivot]
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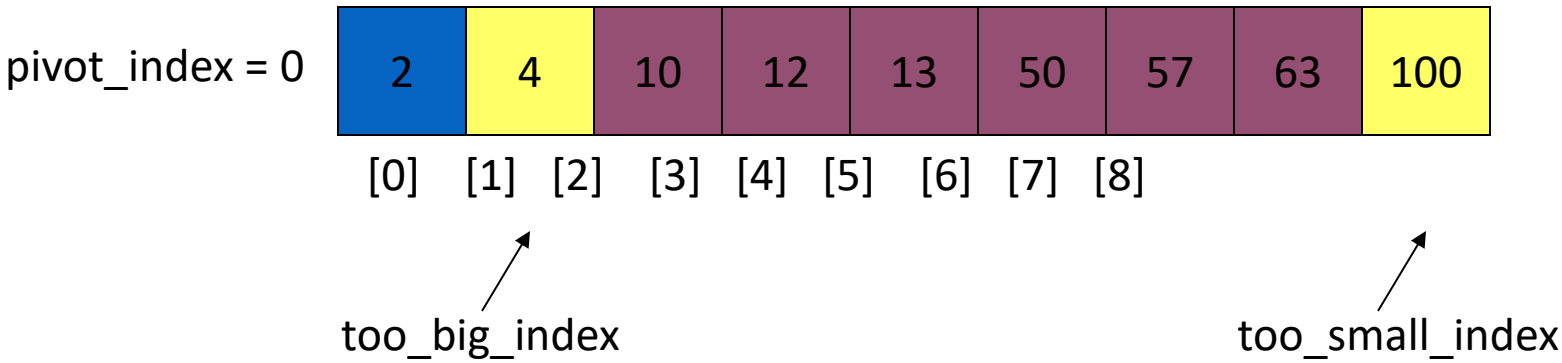

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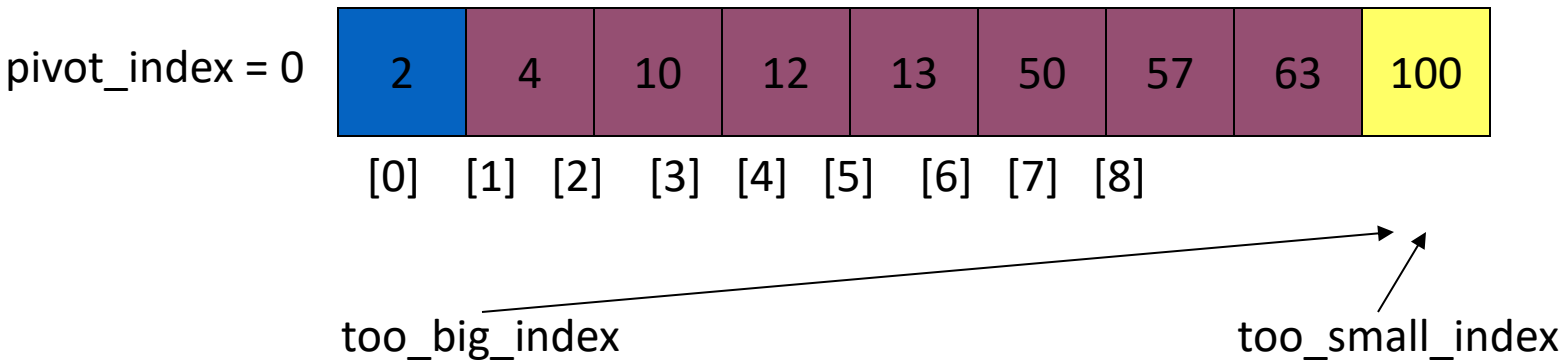

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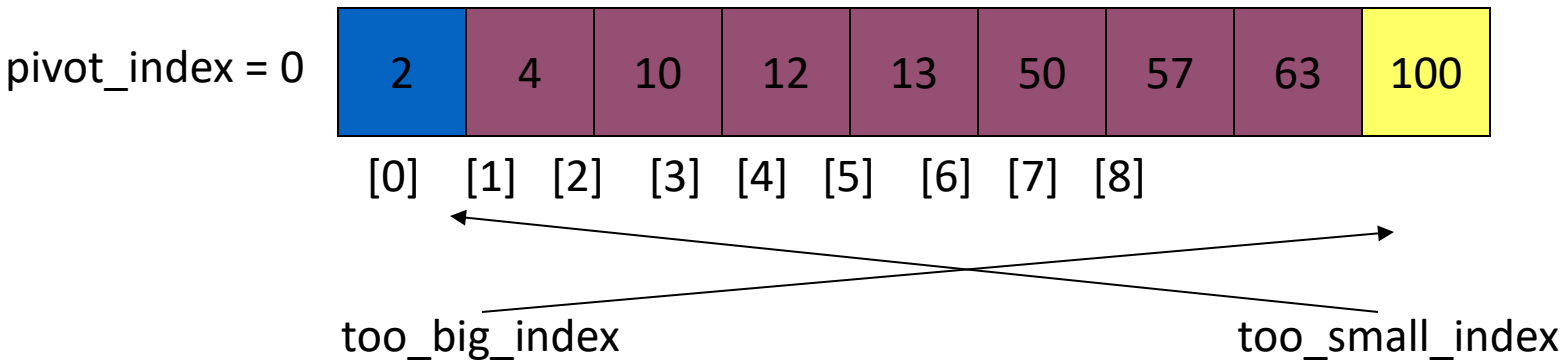
   swap data[too_big_index] and data[too_small_index]
4. While too_small_index > too_big_index, go to 1.
5. Swap data[too_small_index] and data[pivot_index]



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2. While data[too_small_index] > data[pivot]
   --too_small_index
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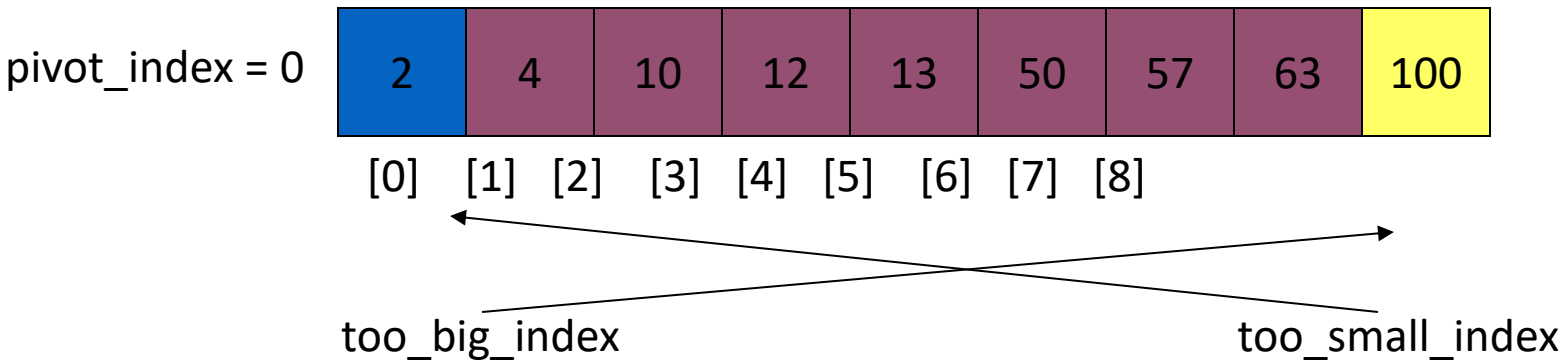

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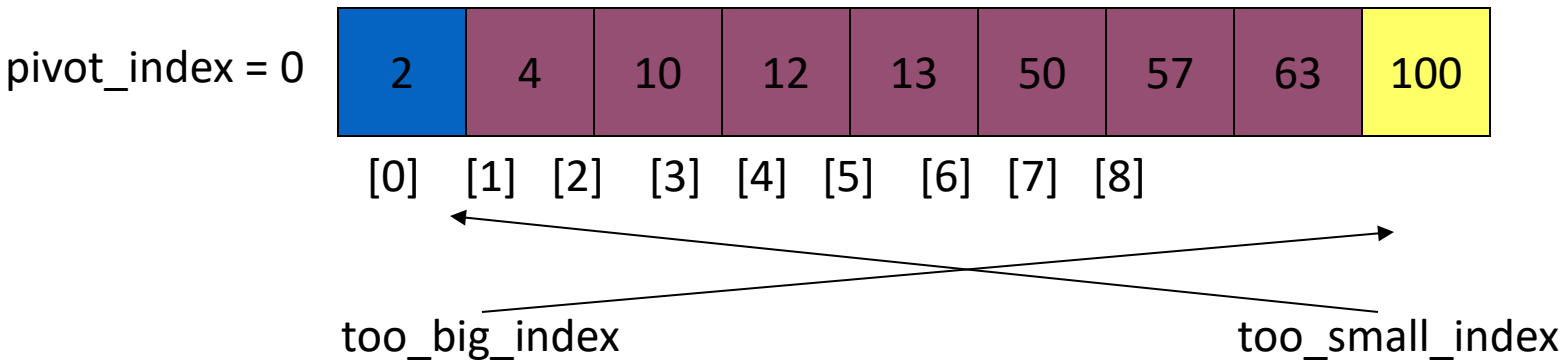

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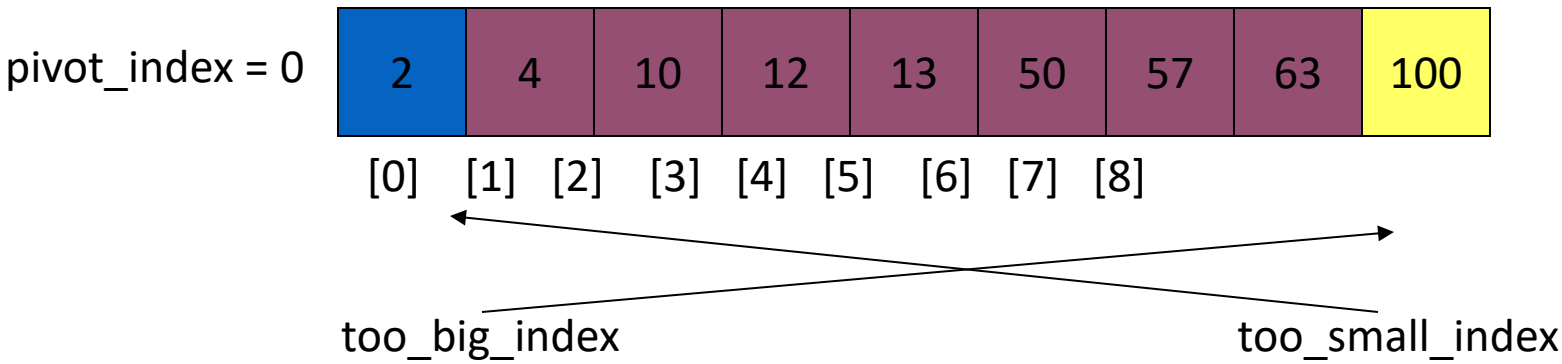

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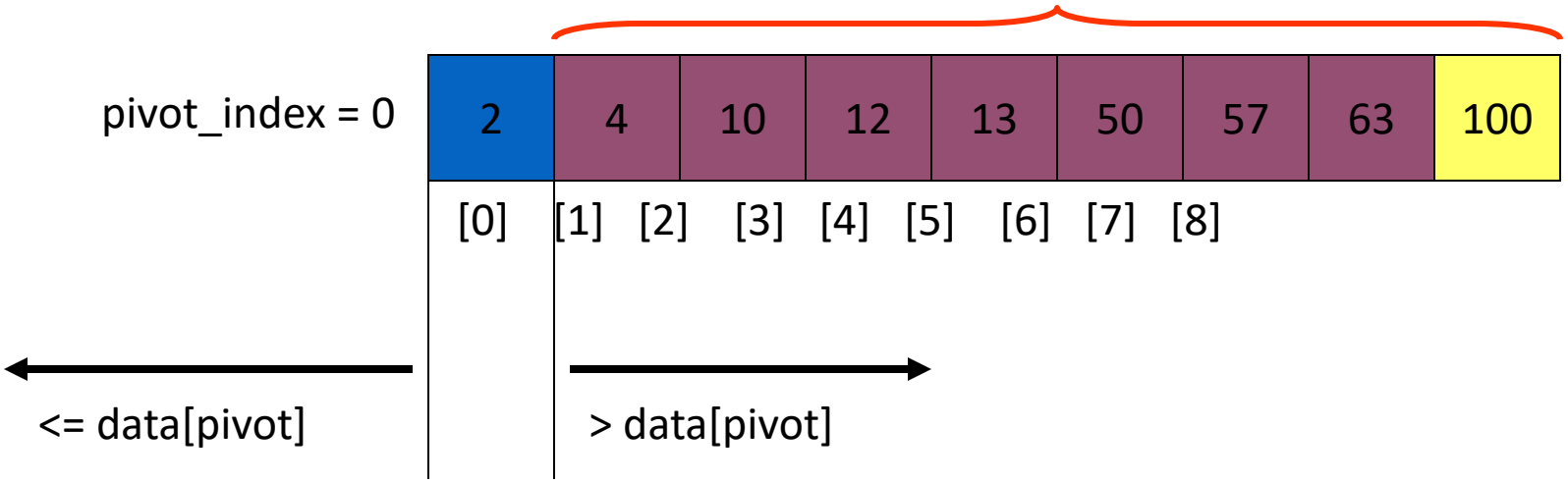

Performance comparison of various Sorting

- Examples of stable sort-Bubble, Insertion, Merge, Count
- Not stable-Merge, Heap, Selection, Quick

- Examples of In-place sorting-Bubble, Selection, Insertion, Heap, Quick
- Not In-Place sort-Merge, Count.

- Which sorting runs with minimum complexity when array already sorted? --- Insertion Sort