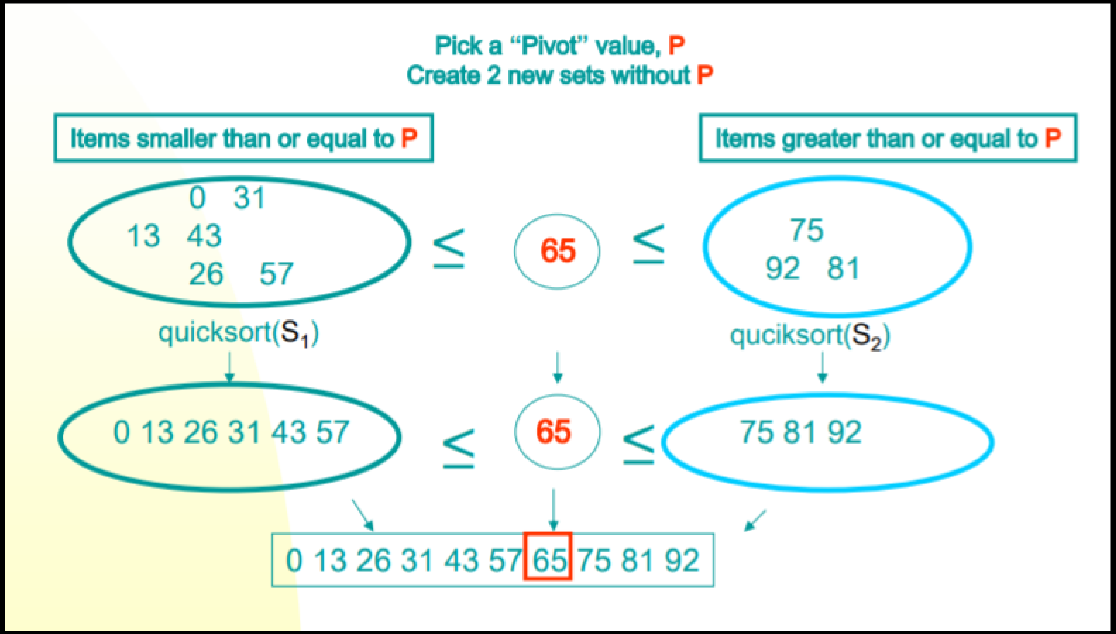
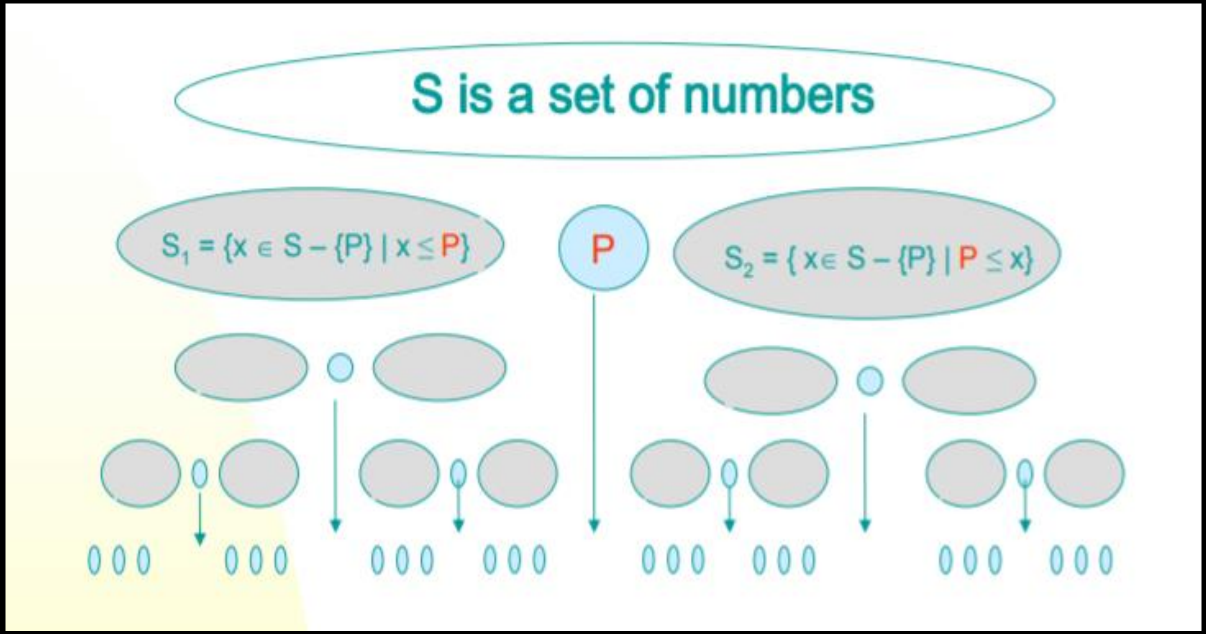
Quick Sorting & Quick Selecting

- Divide-and-Conquer **Sorting Algorithm** with Time-Complexing of **O(n log n)**
- Algorithm for **finding the Kth smallest element** in unsorted array at **O(n)**

Basic Ideas



Pick a "Pivot" value, P
Create 2 new sets without P
Items smaller than or equal to P
Items greater than or equal to P
0 31
13 43
26 57
≤
65
≤
75
92 81
quicksort(S1)
quciksort(S2)
0 13 26 31 43 57
≤
65
≤
75 81 92
0 13 26 31 43 57 65 75 81 92



S is a set of numbers
S1 = {x ∈ S – {P} | x ≤ P}
P
S2 = { x∈ S – {P} | P ≤ x}

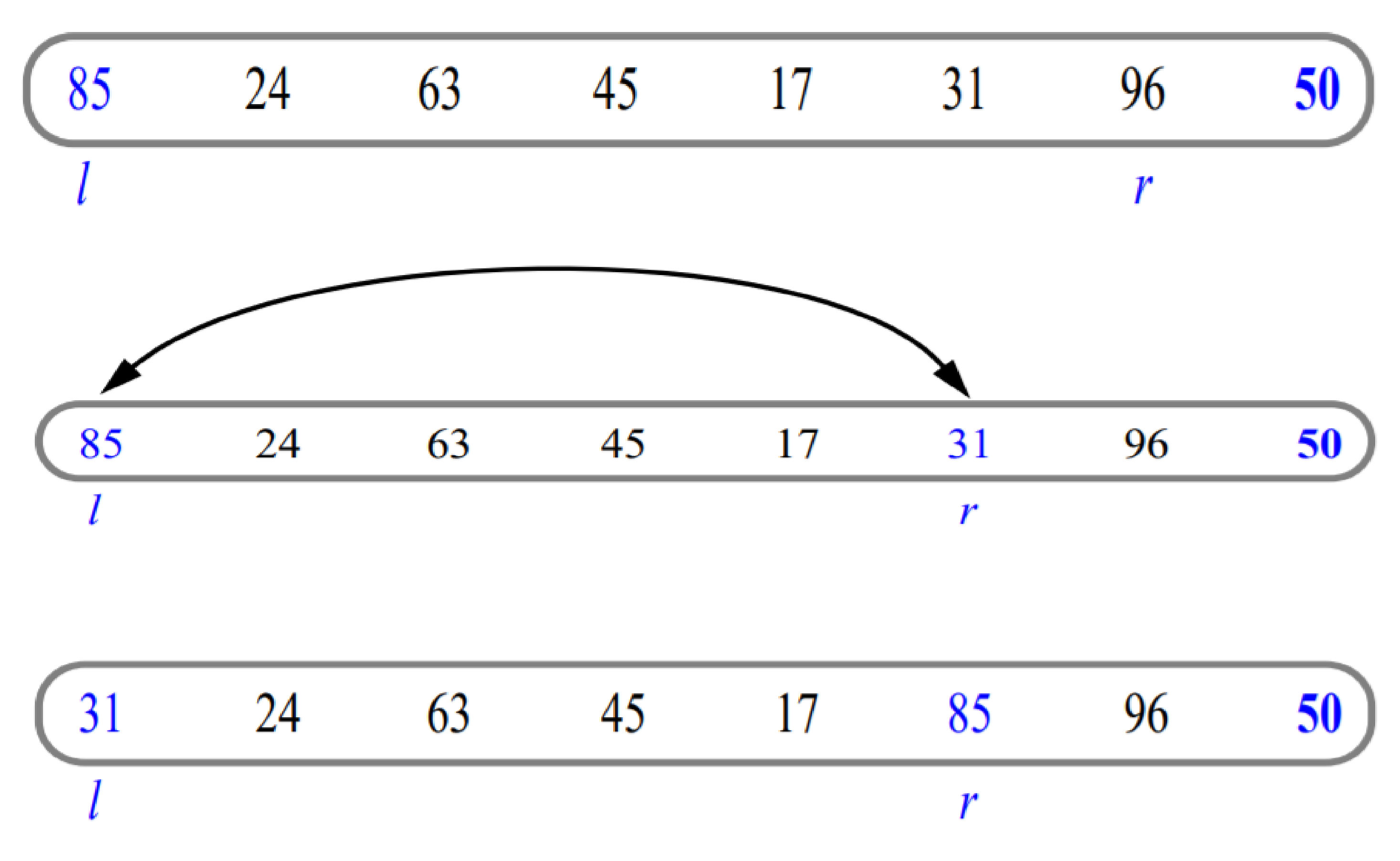
Basic Ideas

- Pick an element, say P (the pivot)
- Re-arrange the elements into 3 sub-blocks,
  1. L: those less than or equal to (≤) P (the left-block S1)
  2. P: the pivot (the only element in the middle-block)
  3. G: those greater than or equal to (≥) P (the right block S 2)
- Repeat the process recursively for the left- and right- sub-blocks.
- Return {quicksort(S 1), P, quicksort(S 2) }.

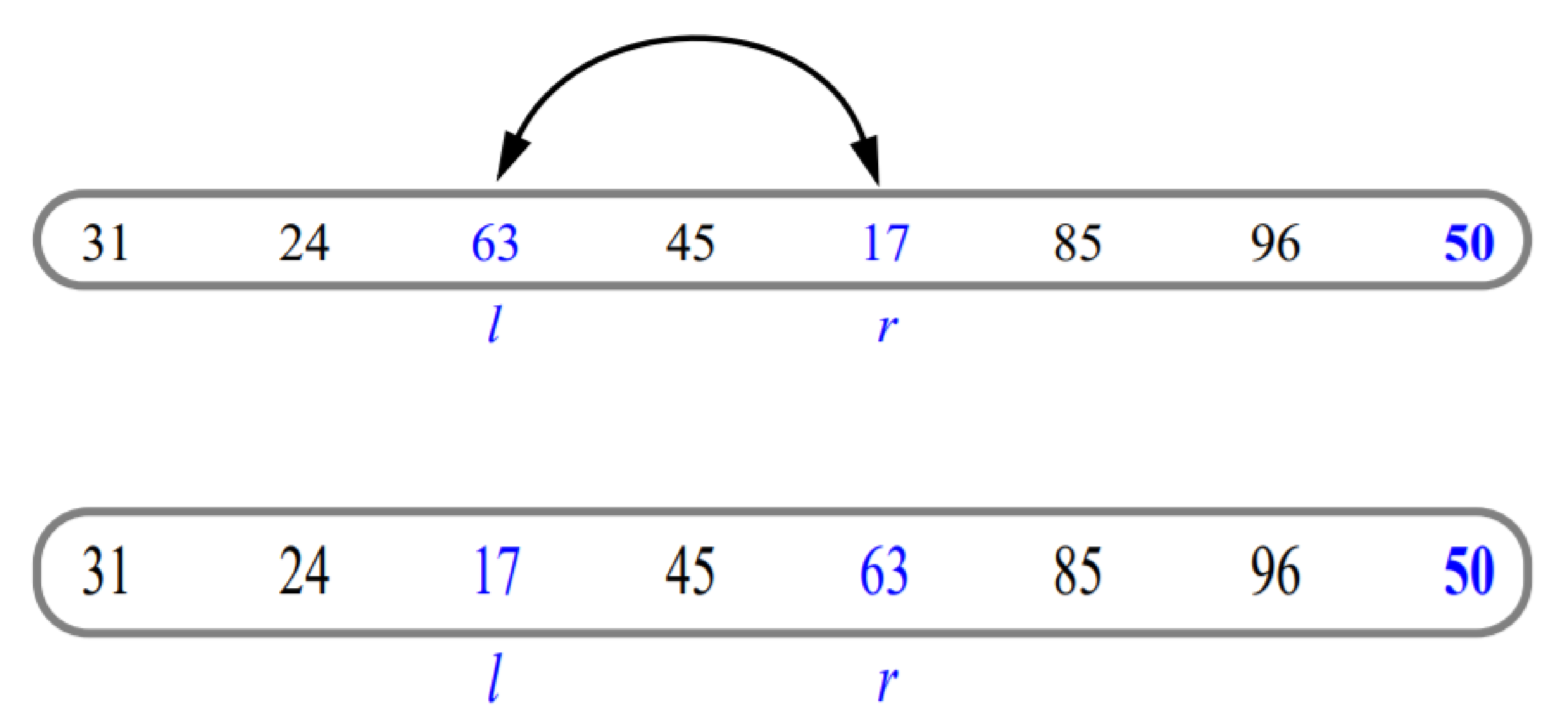
Basic Ideas

- Note:
  - The main idea is to find the “right” position for the pivot element P.
  - After each “pass”, the pivot element, P, should be “in place”.
  - Eventually, the elements are sorted since each pass puts at least one element (i.e., P) into its final position.
- Issues:
  - How to choose the pivot P ?
  - How to partition the block into sub-blocks?

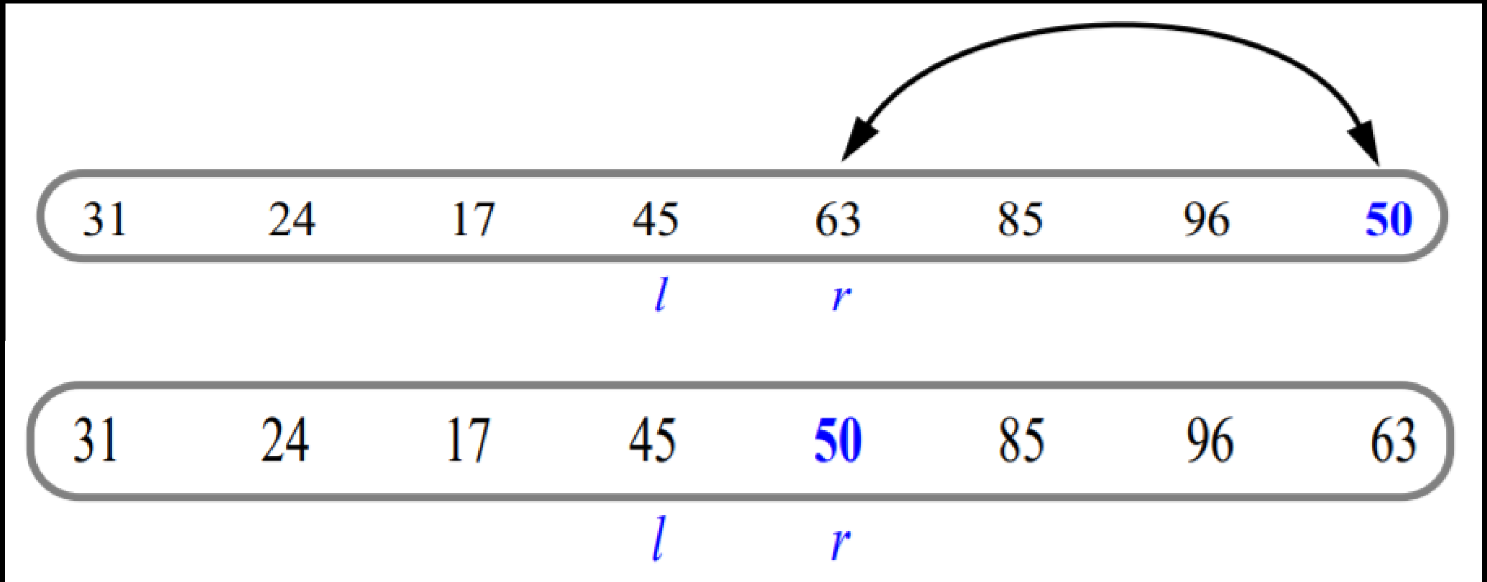
Example of Partitioning



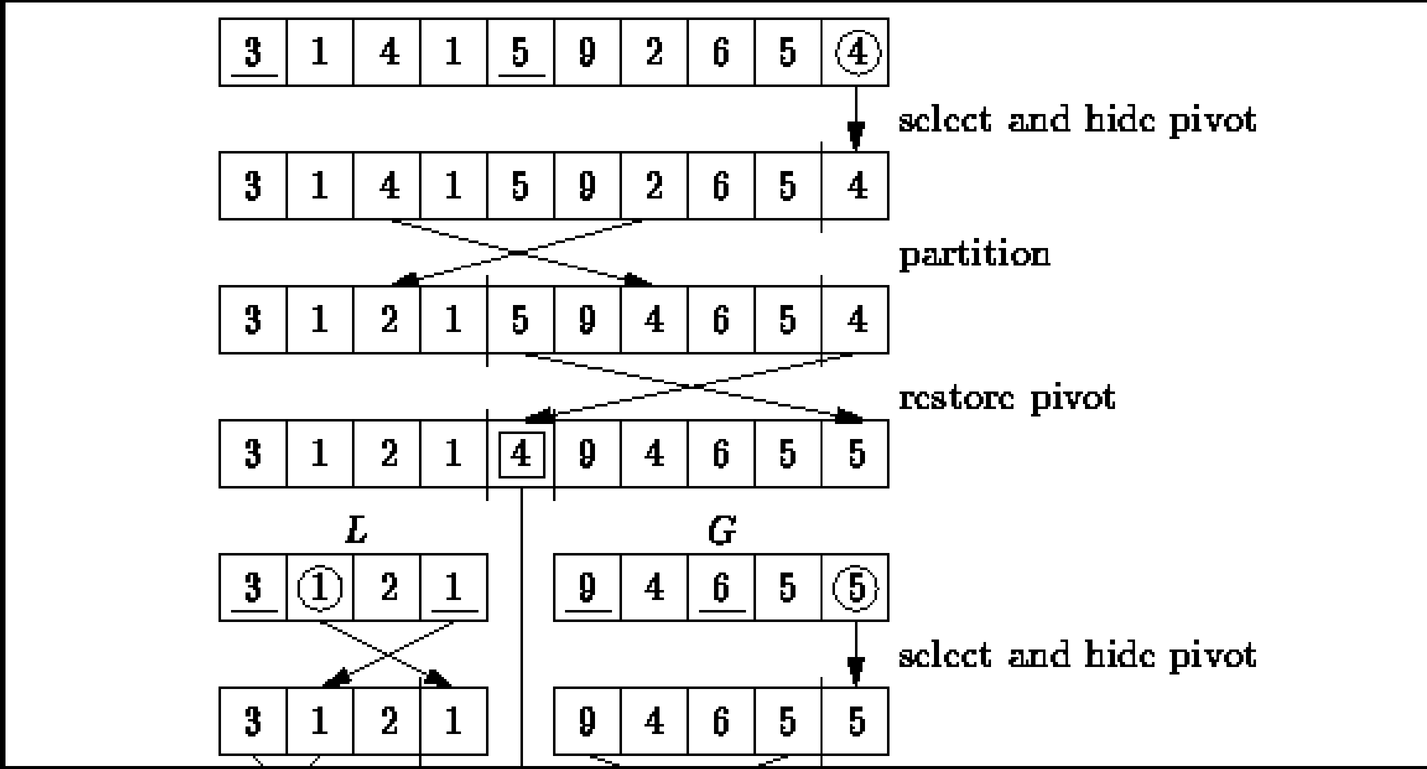
…Example of Partitioning continued



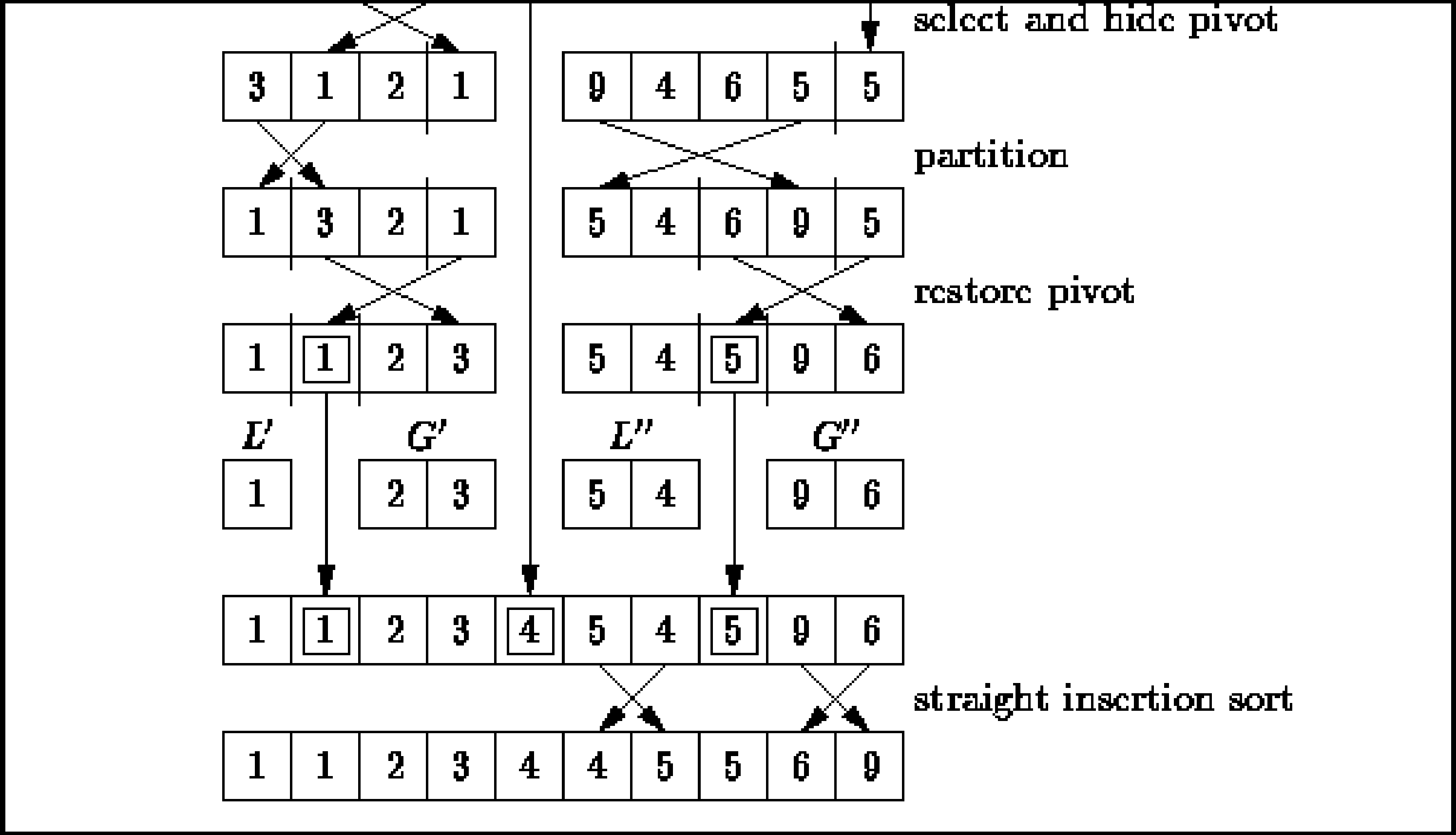
…Example of Partitioning continued



Another Quick Example



… Another Quick Example continued



Implementation : Quick Sort function

```
// low    --> Starting index
// high   --> Ending index
void quicksort (arr[], low, high) {
    if (low < high) {
// pi is partitioning index
// arr[pi] is now at right place
        pi = partition(arr, low, high);
        quickSort(arr, low, pi - 1);      // Before pi
        quickSort(arr, pi + 1, high);     // After pi
    }
}
```

Implementation : Partitioning function

```
// This function sorts the array into left sub-block, pivot, right sub-block
// and returns pivot index
int partition (int arr[], int low, int high) {
    int pivot = arr[high];          // pivot
    int i = (low - 1);              // Index of smaller element
    for (int j = low; j <= high-1; j++) {
      if (arr[j] <= pivot) {        // If current element is smaller than or equal to pivot
          i++;                      // increment index of smaller element
          swap(&arr[i], &arr[j]);
       }
    }
    swap(&arr[i + 1], &arr[high]);
    return (i + 1);
}
```

Driver Code

```
void printArray(int arr[], int size) {
    int i;
    for (i=0; i < size; i++)
        printf("%d ", arr[i]);
    printf("n");
}

// Driver program to test above functions
int main() {
    int arr[] = {10, 7, 8, 9, 1, 5};
    int n = sizeof(arr) / sizeof(arr[0]);
    quickSort(arr, 0, n-1);
    printf("Sorted array: n");
    printArray(arr, n);
    return 0;
}
```

```
#include<stdio.h>

// A utility function to swap two elements

void swap(int* a, int* b) {
    int t = *a;
    *a = *b;
    *b = t;
}
```

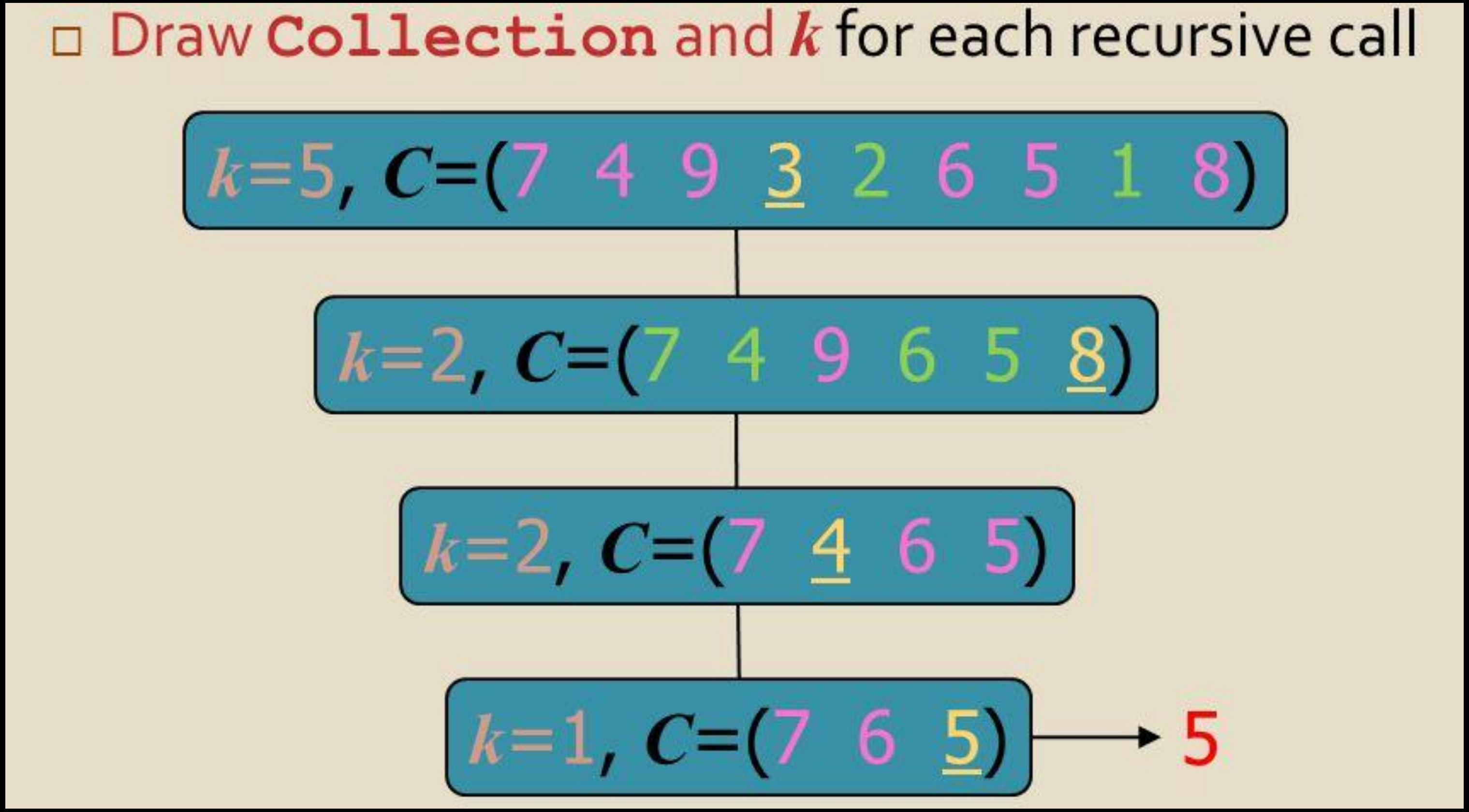
Why Quick Sort is preferred over Merge Sort for sorting Arrays?

- Quick Sort in its general form is an **in-place sort** (i.e. it doesn't require any extra storage)
- whereas merge sort requires **O(N) extra storage**, N denoting the array size which may be quite expensive.
- But because it has the best performance in the average case for most inputs, Quicksort is generally considered the "**fastest**" sorting algorithm.
- Allocating and de-allocating the extra space used for merge sort increases the running time of the algorithm.
- Comparing average complexity we find that both type of sorts have O(N log N) average complexity but the constants differ..

Quick Select

Finding the Kth smallest element in an unsorted array

Quick Select Visualization



Implementation :

This function returns k'th smallest element in arr[l..r] using QuickSort based method.
ASSUMPTION: ALL ELEMENTS IN ARR[] ARE DISTINCT

```
int kthSmallest(int arr[], int l, int r, int k) {          //Only if k is in the range of the array
    if (k > 0 && k <= r - l + 1) {                         // Partition the array and get new position of pivot
        int index = partition(arr, l, r);                  // If position is same as k
        if (index - l == k – 1) {
            return arr[index];                             // If position is more, recur for left subarray
        }
        if (index - l > k - 1) {
            return kthSmallest(arr, l, index - 1, k);
        }
        return kthSmallest(arr, index + 1, r, k - index + l - 1);
    }  else {
        return INT_MAX;
}
```