Quick Sort

SCSJ2013 Data Structures & Algorithms

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Quick Sort Operation

- Quick sort is similar with merge sort in using divide and conquer technique.

- Differences of Quick sort and Merge sort :

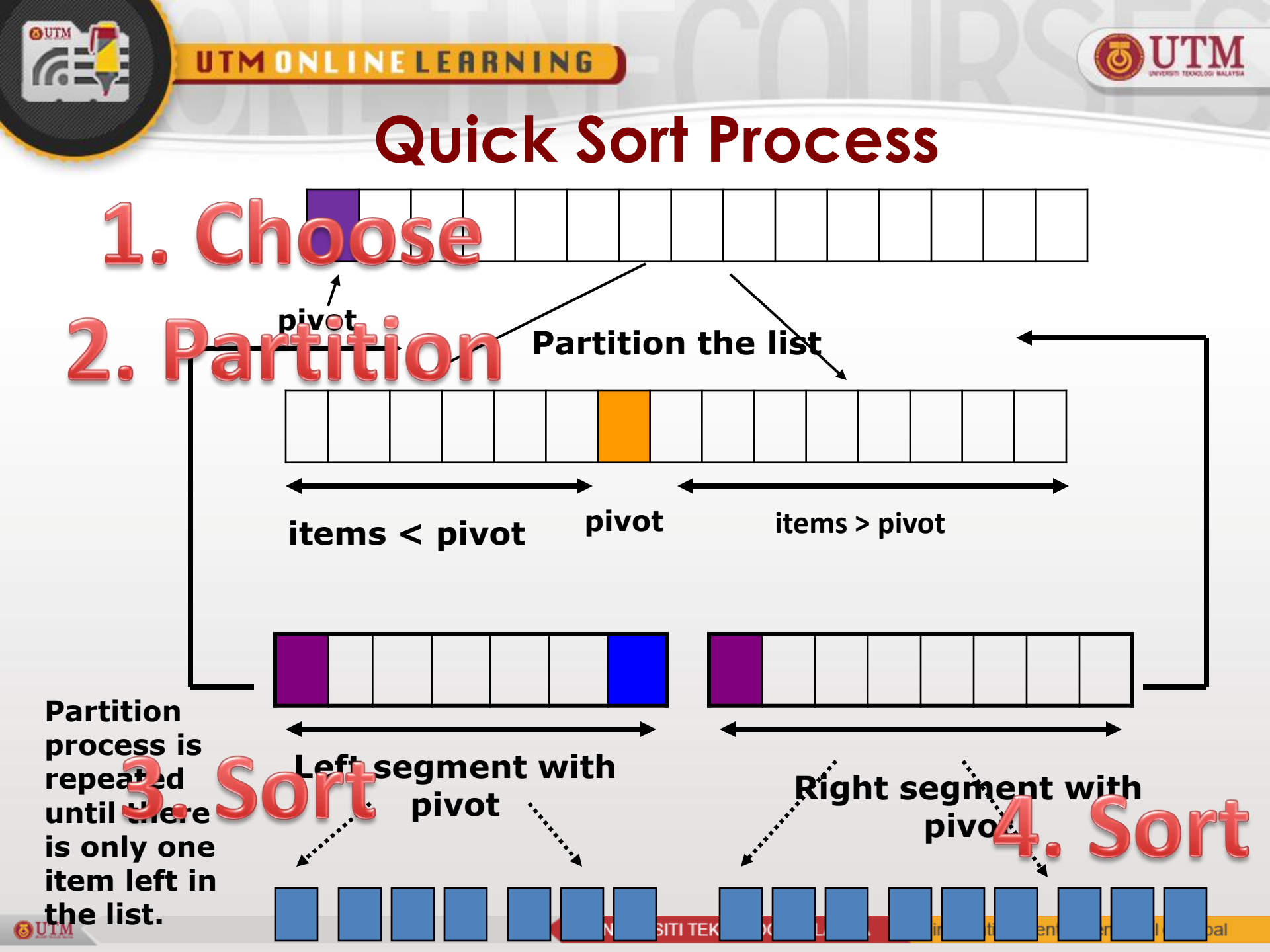
Quick Sort	Merge Sort
Partition the list based on the ***pivot*** **value**	Partition the list by dividing the list into **two**
No merge operation is needed since when there is only one item left in the list to be sorted, all other items are already in sorted position.	**Merge operation** is needed to sort and merge the item in the left and right segment.

Quicksort

- A divide-and-conquer algorithm

- Strategy
  1. Choose a pivot (first element in the array)
  2. Partition the array about the pivot
     - items < pivot
     - items >= pivot
     - Pivot is now in correct sorted position
  3. Sort the left section
  4. Sort the right section

Quick Sort Process



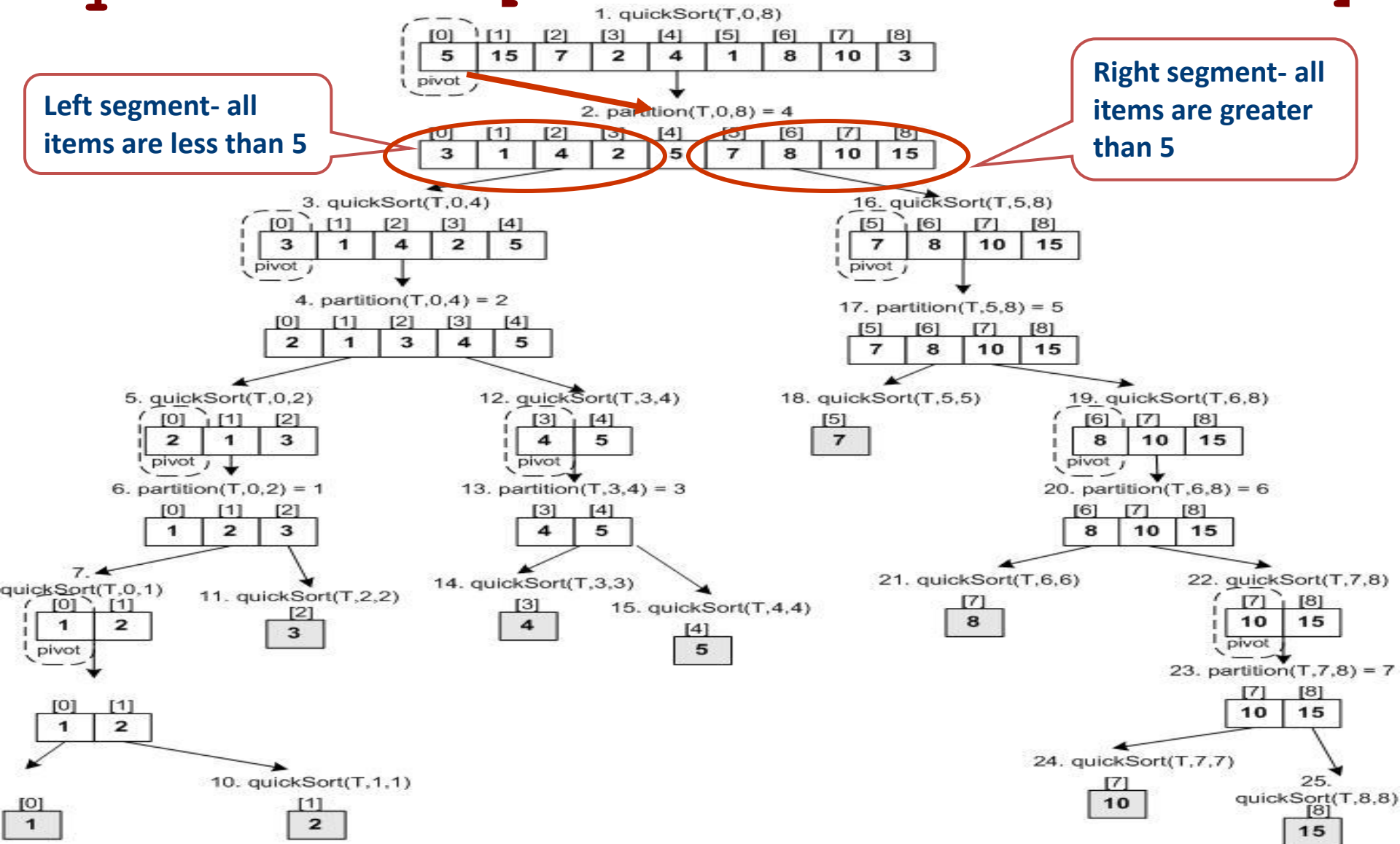
quickSort() function

```
void quickSort (dataType arrayT[],
                    int first , int last)
{
      int cut;
      if (first<last){
         cut = partition(T, first,last);
         quickSort(T, first,cut);
         quickSort (T, cut+1, last);
      }
}
```

Identify pivot or cutting point & **rearrange** the list based on **pivot value**

cut the list into 2 sub lists based on **cut value**

quickSort [5 15 7 2 4 1 8 10 3]



partition() function

```
int partition(int T[], int first,int last)
{
      int pivot, temp;
      int loop, cutPoint, bottom, top;
      pivot=T[first];
      bottom=first; top= last;
      loop=1;    //always TRUE
      while (loop) {
          while (T[top]>pivot){
           // find smaller value than
           // pivot from top array
                top--;
          }
          while(T[bottom]<pivot){
           //find larger value than
        //pivot from bottom
                 bottom++;
          }
```

Identify pivot

From top
Find value < pivot
& **skip** value > pivot

From bottom
Find value > pivot
& **skip** value < pivot

partition() function

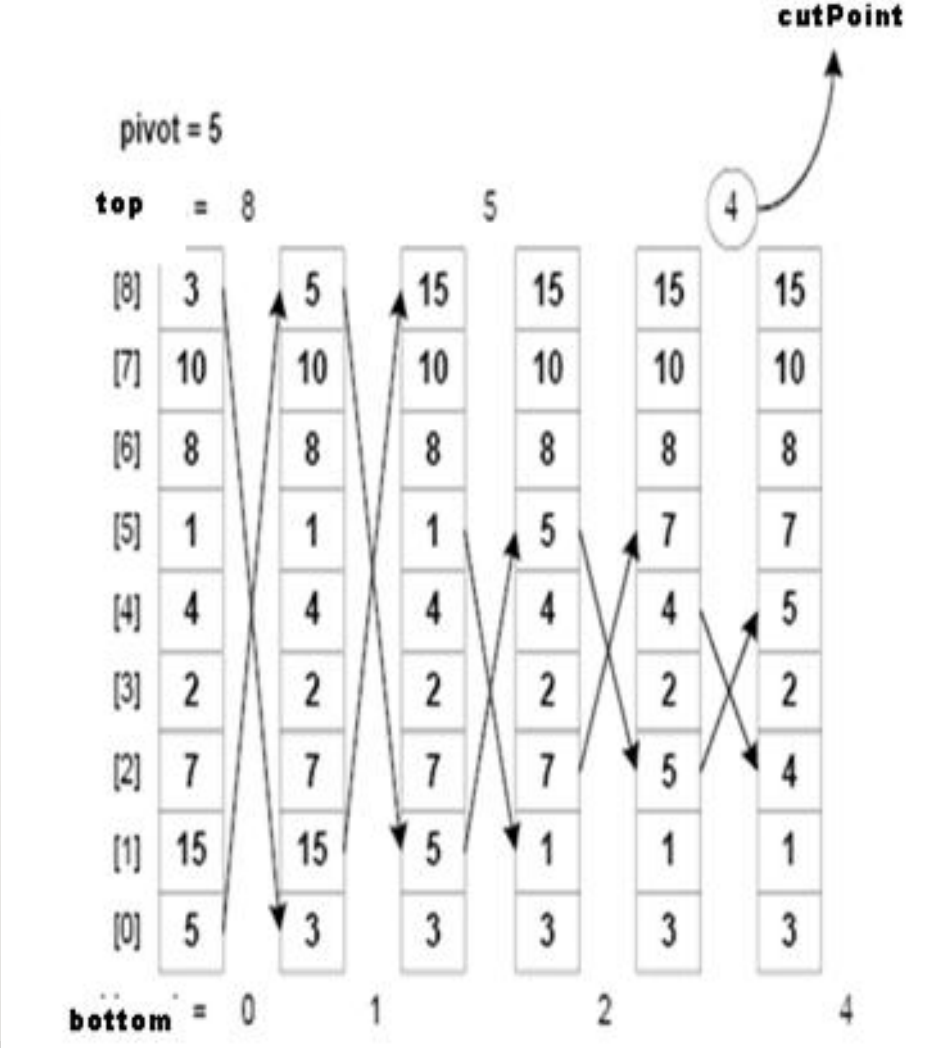
```
    if (bottom<top) {
          // change pivot place
          temp=T[bottom];
          T[bottom]=T[top];
          T[top]=temp;
    }
    else {
           loop=0; //loop false
           cutPoint = top;
    }//end if
  }// end while
  return cutPoint;
}//end function
```

Swap values disorder at top & bottom position

Stop loop

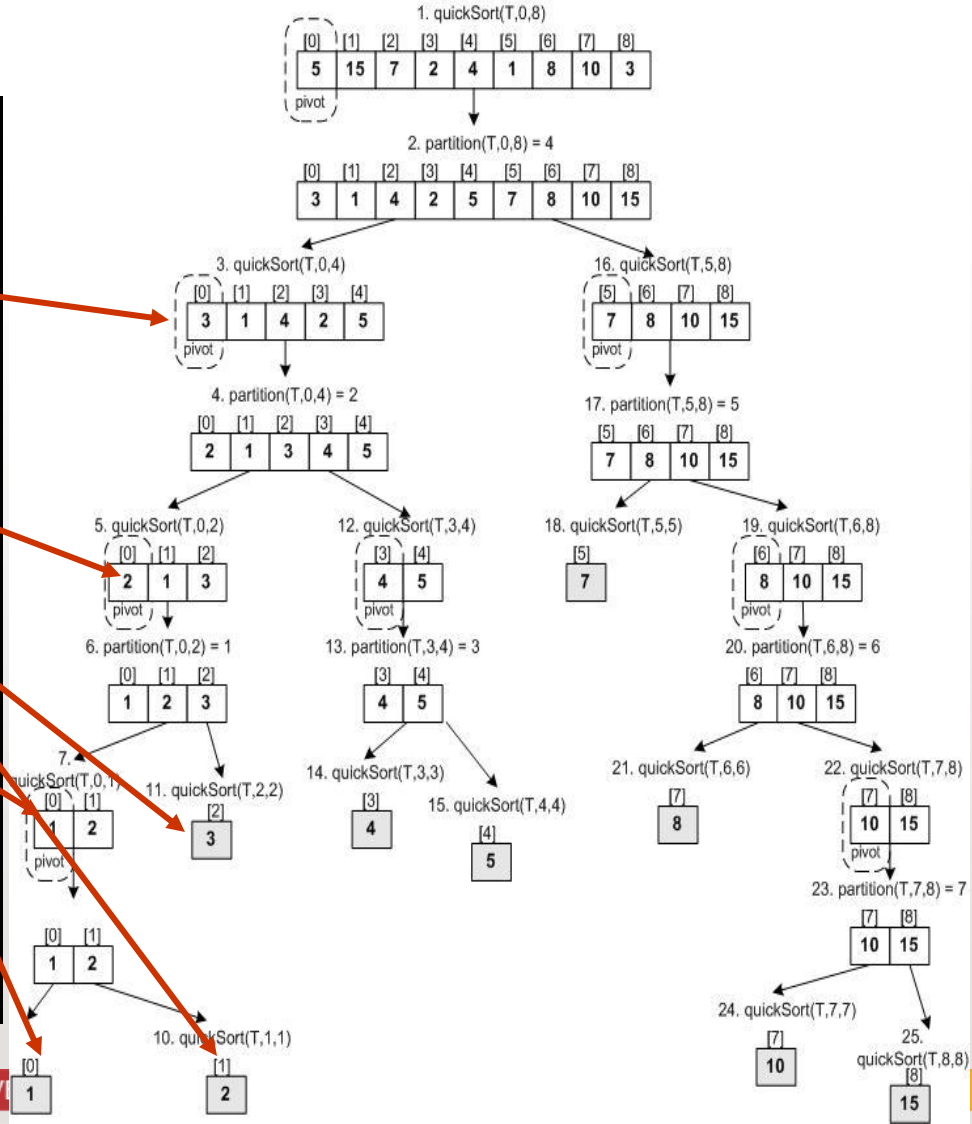
Return cut value

Partition process for array:



quickSort[5 15 7 2 4 1 8 10 3]

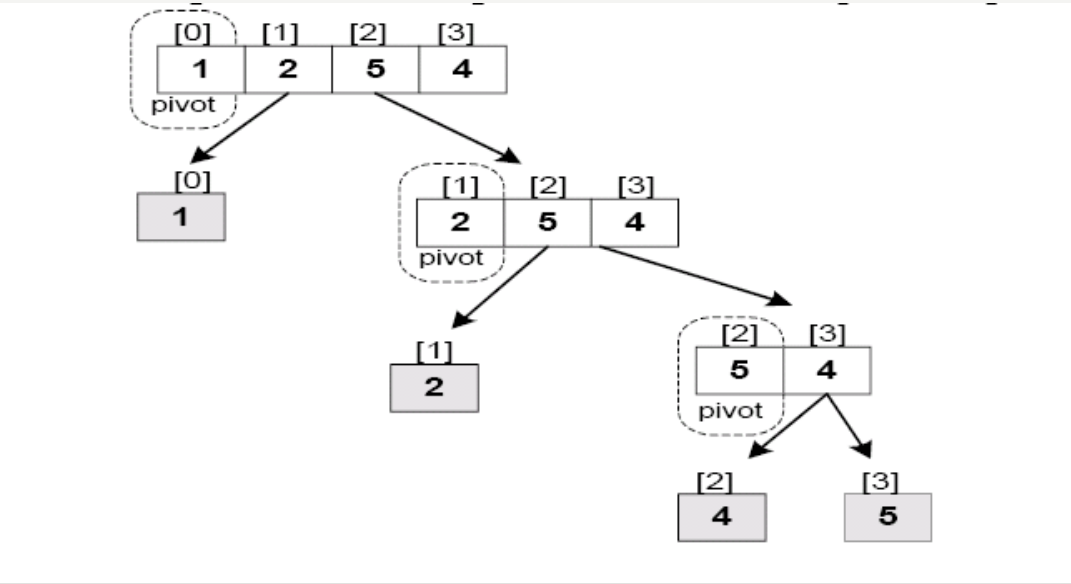
```
Content of the array before sorting  :5  15  7  2  4  1  8

The sublist -> 1 with pivot = 5
5  15  7  2  4  1  8  10  3

The sublist -> 2 with pivot = 3
3  1  4  2  5

The sublist -> 3 with pivot = 2
2  1  3

The sublist -> 4 with pivot = 1
1  2

The sublist -> 5 with one piece item = 1

The sublist -> 6 with one piece item = 2

The sublist -> 7 with one piece item = 3

The sublist -> 8 with pivot = 4
4  5

The sublist -> 9 with one piece item = 4

The sublist -> 10 with one piece item = 5

The sublist -> 11 with pivot = 7
7  8  10  15

The sublist -> 12 with one piece item = 7

The sublist -> 13 with pivot = 8
8  10  15

The sublist -> 14 with one piece item = 8

The sublist -> 15 with pivot = 10
10  15

The sublist -> 16 with one piece item = 10

The sublist -> 17 with one piece item = 15
```



Quick Sort Analysis

- The efficiency of quick sort depends on the pivot value.
- The worse case for quick sort occur when the smallest item or the largest item always be chosen as pivot value
  - causing the left partition and the right partition not balance.

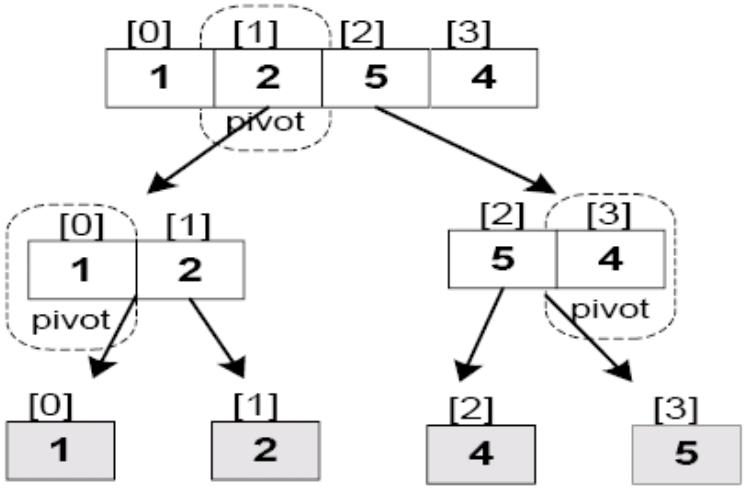
Example of worse case quick sort:
sorted array [1 2 5 4]
causing imbalance partition.



Quick Sort Analysis

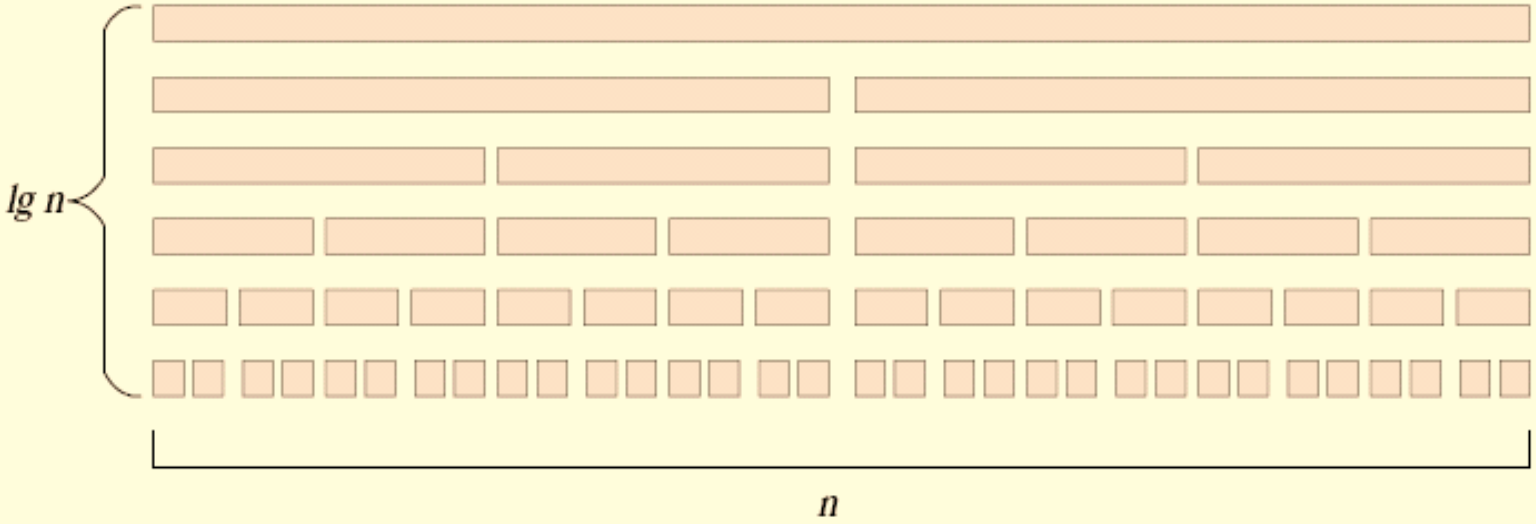
- The **best case** for quick sort happen when **the left segment and the right segment is balanced**
- Must **choose the right pivot** that can put other items in **balance situation**.

Example of best case quick sort: array[1 2 5 4].



Quick Sort Analysis

- The number of steps to get the balance segment



The number of comparisons

$$n + 2\frac{n}{2} + 4\frac{n}{4} + 8\frac{n}{8} + 16\frac{n}{16} + \ldots\ldots x\frac{n}{x}$$

Quick Sort Analysis

- Average case: $O(n * \log_2 n)$
- Worst case: $O(n^2)$
  - When the array is already sorted and the smallest/largest item is chosen as the pivot

- Quicksort is usually extremely fast in practice
- Even if the worst case occurs, quicksort's performance is acceptable for moderately large arrays

Summary

- Un-optimized simple sorting algorithms (selection sort, bubble sort, and insertion sort) are all $O(n^2)$ algorithms

- Quicksort and Mergesort are two very fast recursive sorting algorithms


Thank
You