Data Structures and Algorithms

Merge Sort Cont.
External Sort.

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This presentation is based on the slides of Prof. David Galles

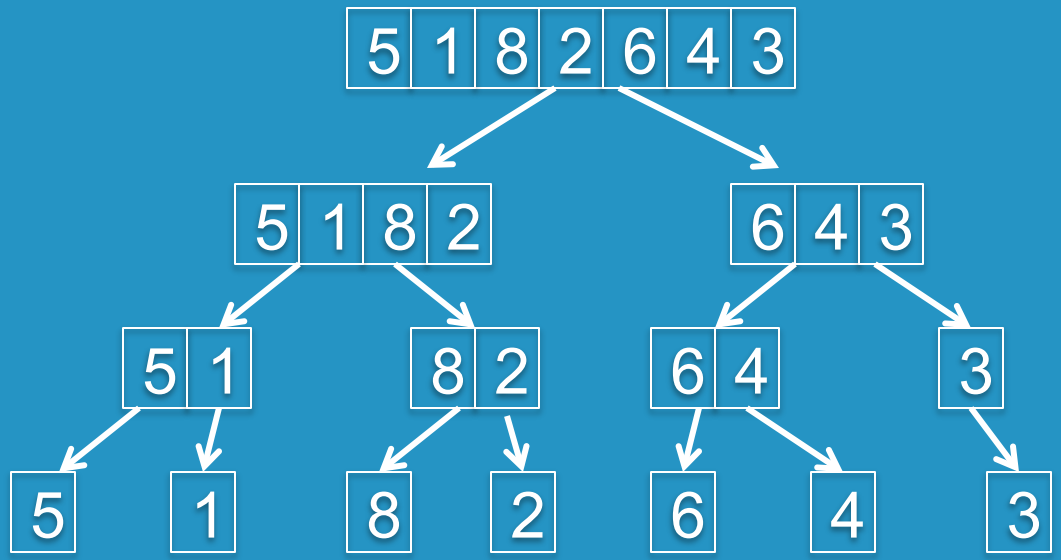
Announcements

- Project 1 is out

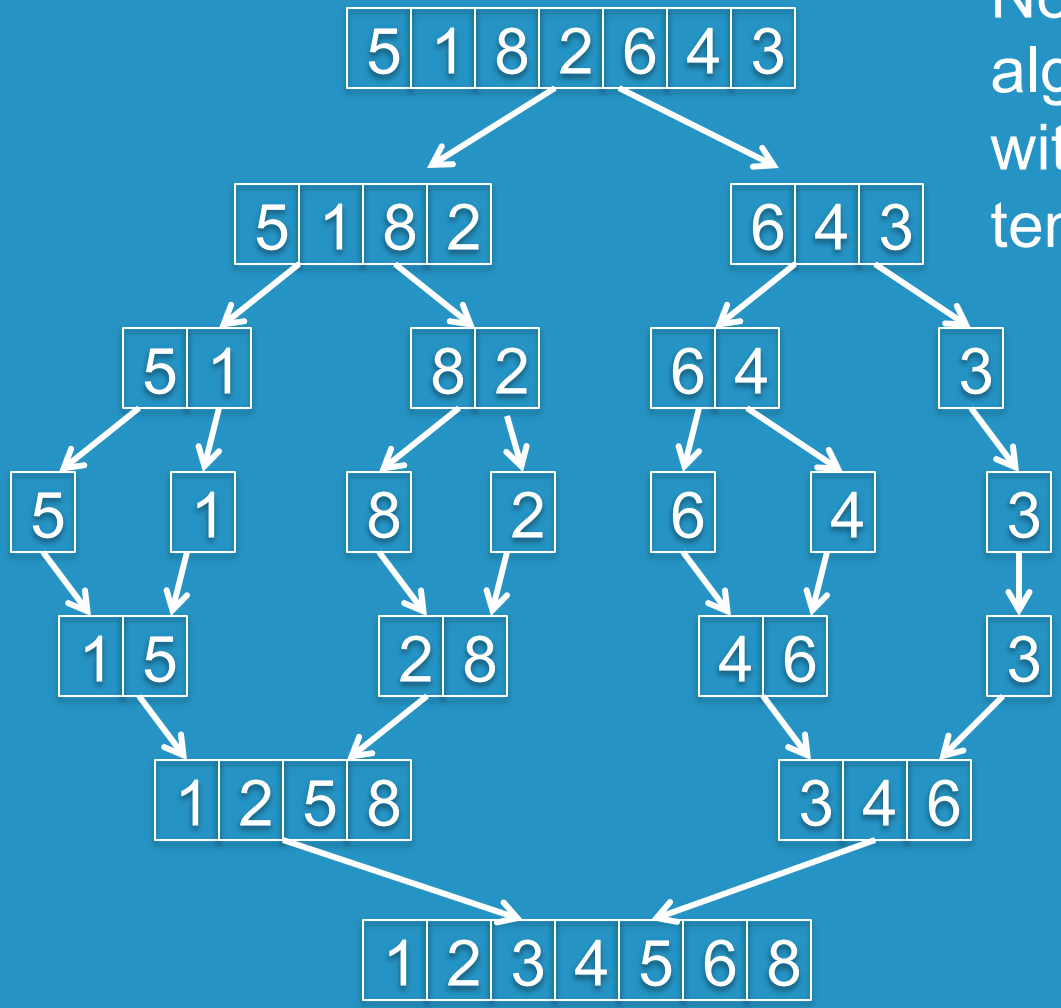
Merge Sort

- Base Case:
  - A list of length 1 or length 0 is already sorted
- Recursive Case:
  - Split the list in half
  - Recursively sort two halves
  - Merge sorted halves together
- Example: 5 1 8 2 6 4 3

Merge Sort

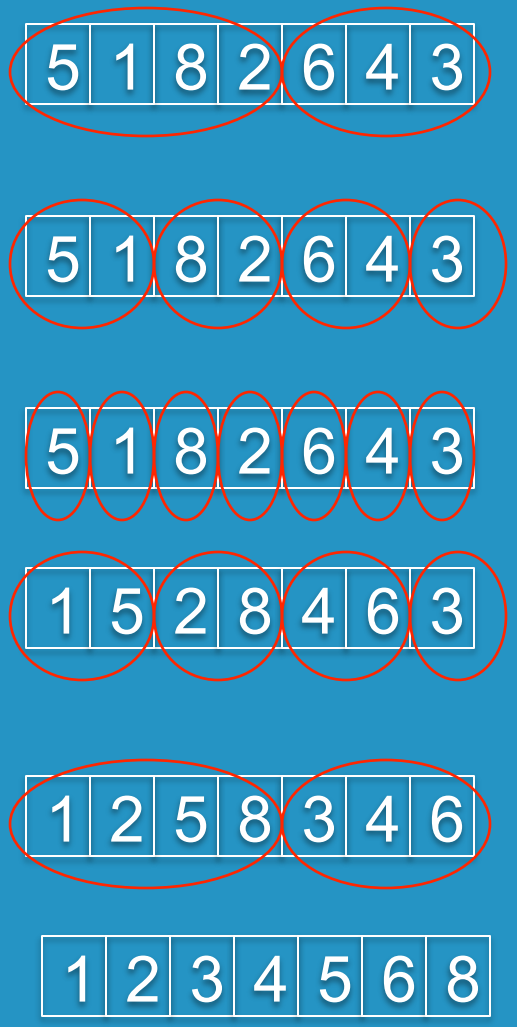


Merge Sort



No tree in the actual algorithm; we work with one array + temp array

Merge Sort



Showing the array at different points in time

Code: MergeSort

```
private static void mergeSort(int[] arr, int[]
temp, int low, int high) {
    if (low >= high)
        return;

  int mid = (low + high) / 2;
  mergeSort(arr, temp, low, mid);
  mergeSort(arr, temp, mid + 1, high);

  merge(arr, temp, low, mid, high); // merge
two sorted halves into one
  // arr is now sorted from low to high

}
```

Merging Sorted Sublists

- Merge lists into a new temporary list, T
- Maintain three pointers (indices) i, j, and n
  - i is index of left hand list
  - j is index of right hand list
  - k is index of temporary list T

```
if A[i] < A[j]
   T[k] = A[i], increment k and i
else
   T[k] = A[j], increment k and j
```

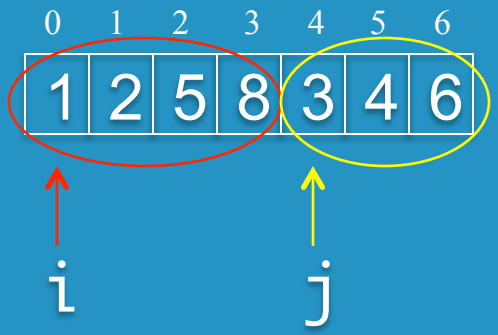
Exercise: Merging Sorted Lists

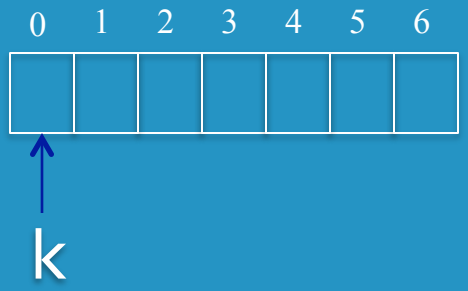
```
public static int[] merge(int[] arr1, int[] arr2)  {
    // FILL IN CODE




}
```

Back to Merge Sort

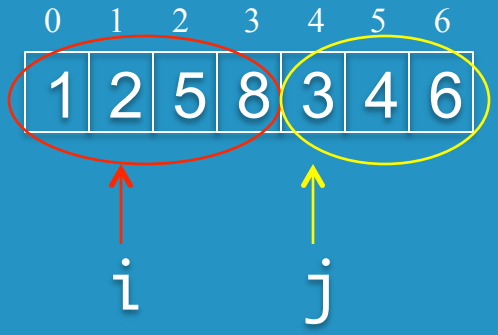
- In the Merge sort, we need to merge two sorted sublists of the same list
- Need to keep track of where the first sublist starts
- Where the second sublist ends
- How can I find:
  - the index where the first sublist ends?
  - the index where the second sublist starts?

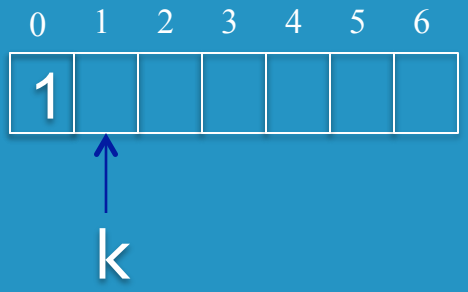
Example



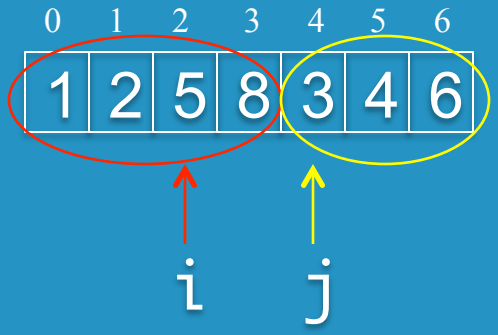


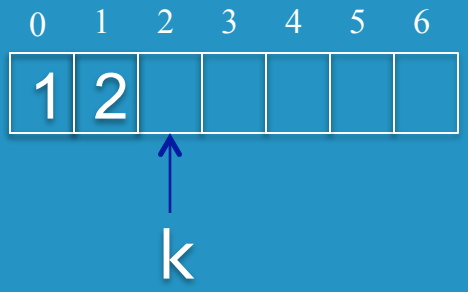
Example



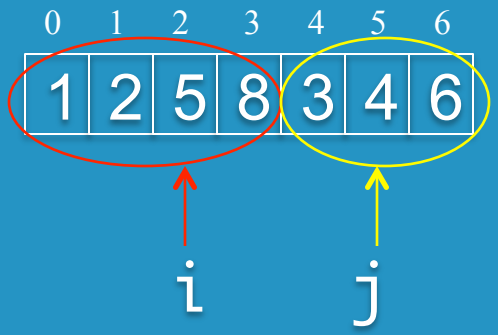


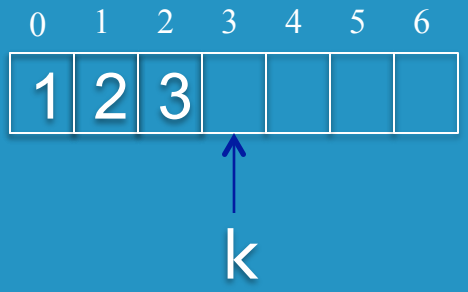
Example



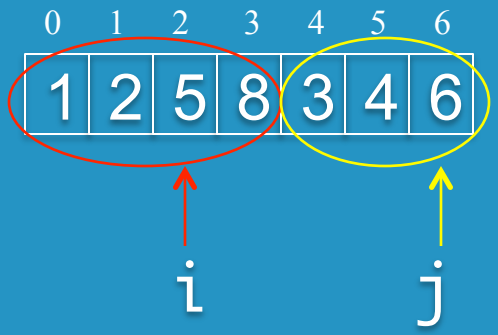


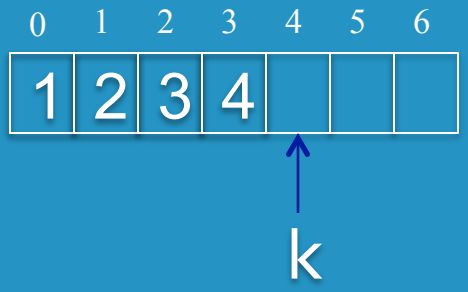
Example



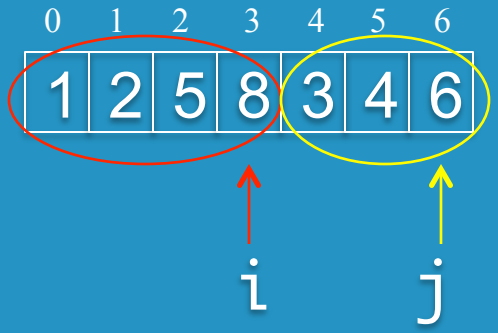


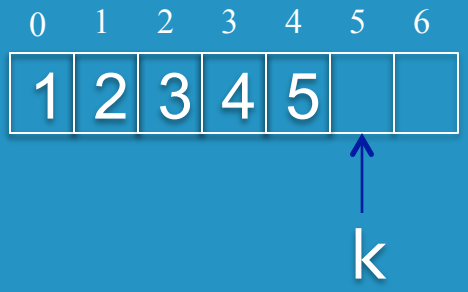
Example



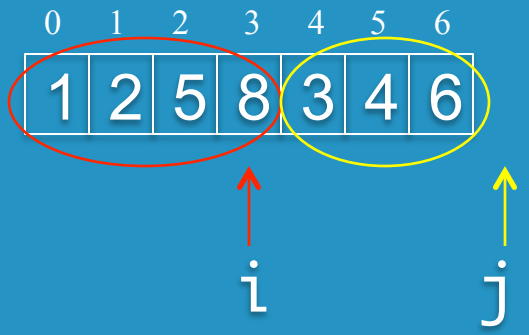


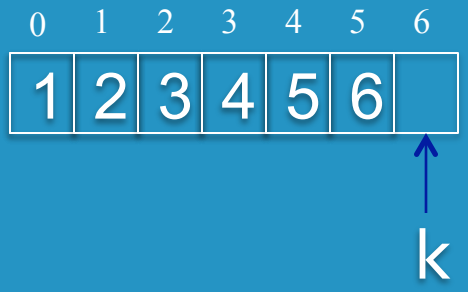
Example



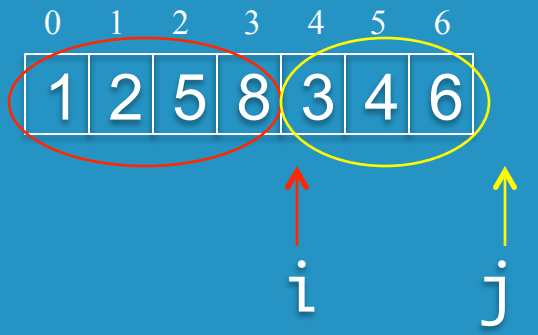


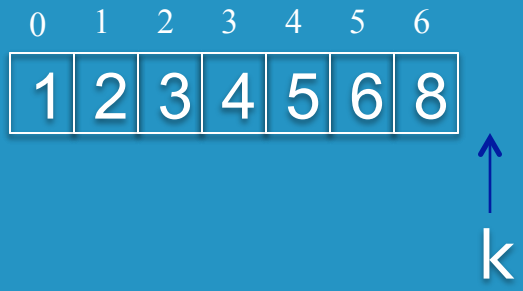
Example



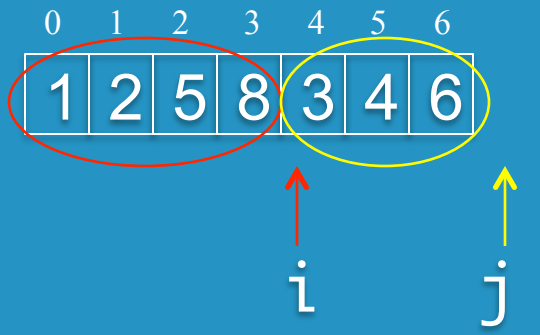


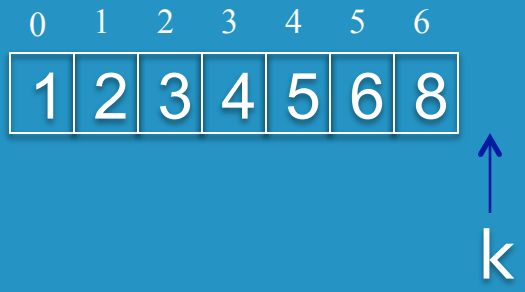
Example





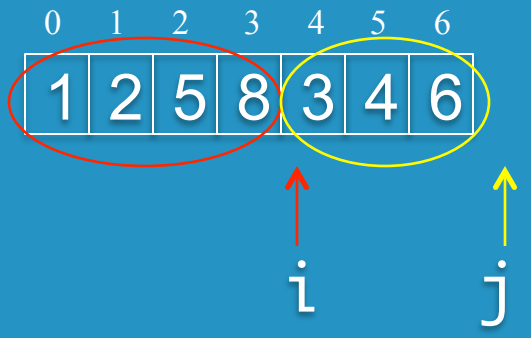
Example

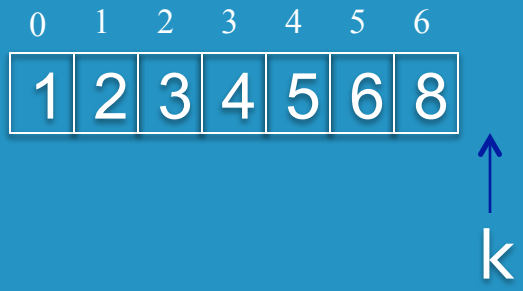




What is the running time of this subroutine?

Example





What is the running time of this subroutine?
Theta(n)

Note: in general, i does not start with 0!

Code: Helper Method "merge"

- Subarray 1: from low to mid
- Subarray 2: from mid+1 to high

```
public static void merge(int[] arr, int[] temp,
                         int low, int high) {

    // find mid
    // initialize i, j, k
    // while k <= high
    // compare elements and merge
```

Code: MergeSort

```
private static void mergeSort(int[] arr, int[]
temp, int low, int high) {
    if (low >= high)
        return;

  int mid = (low + high) / 2;
  mergeSort(arr, temp, low, mid);
  mergeSort(arr, temp, mid + 1, high);

  merge(arr, temp, low, mid, high); // merge
two sorted halves into one
  // arr is now sorted from low to high

}
```

Code

- See `SortingAlgorithms.java`, methods `mergeSort` and `merge`

Theta for Merge Sort

- How do we do algorithm analysis for recursive pieces of code?
- Let's learn that and then come back and analyze the running time for merge sort