Merge Sort

Merge Sort is a Divide & Conquer principle based algorithm. The main idea of merge sort is to divide large data-sets into smaller sets of data, and then solve them.

Merge Sort is a recursive algorithm, it divides the given array into smaller half's and then calls itself repeatedly to solve them.

Time Complexity	Θ(n Log n)
Best Case	Ω(n Log n)
Worst Case	O(n Log n)
Space Complexity	O(n)

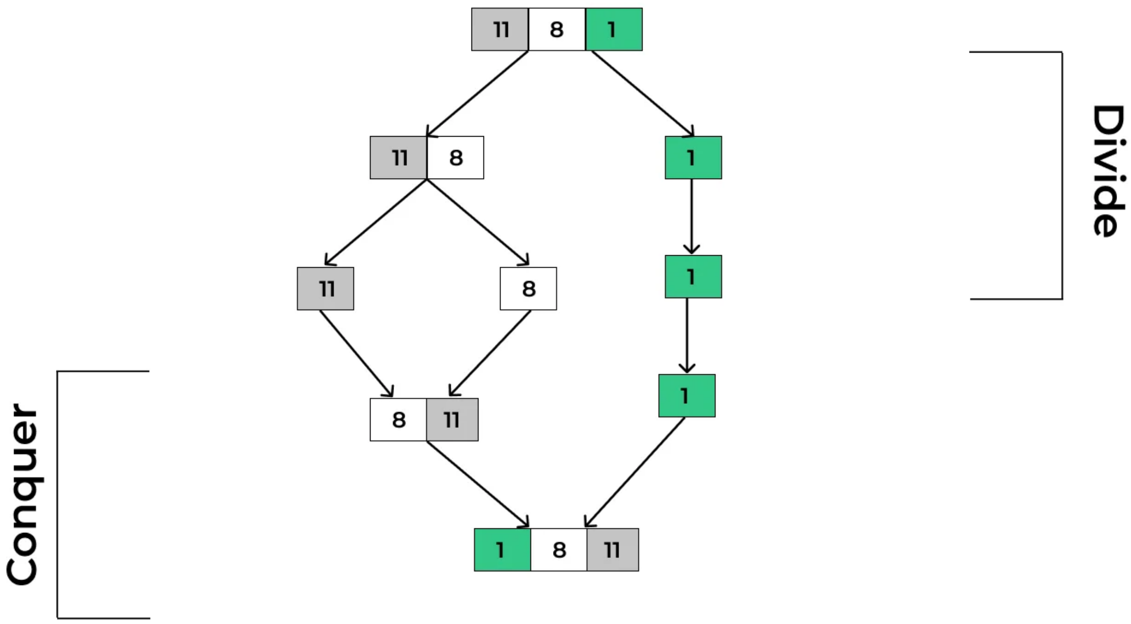
Steps for Merge Sort in Java

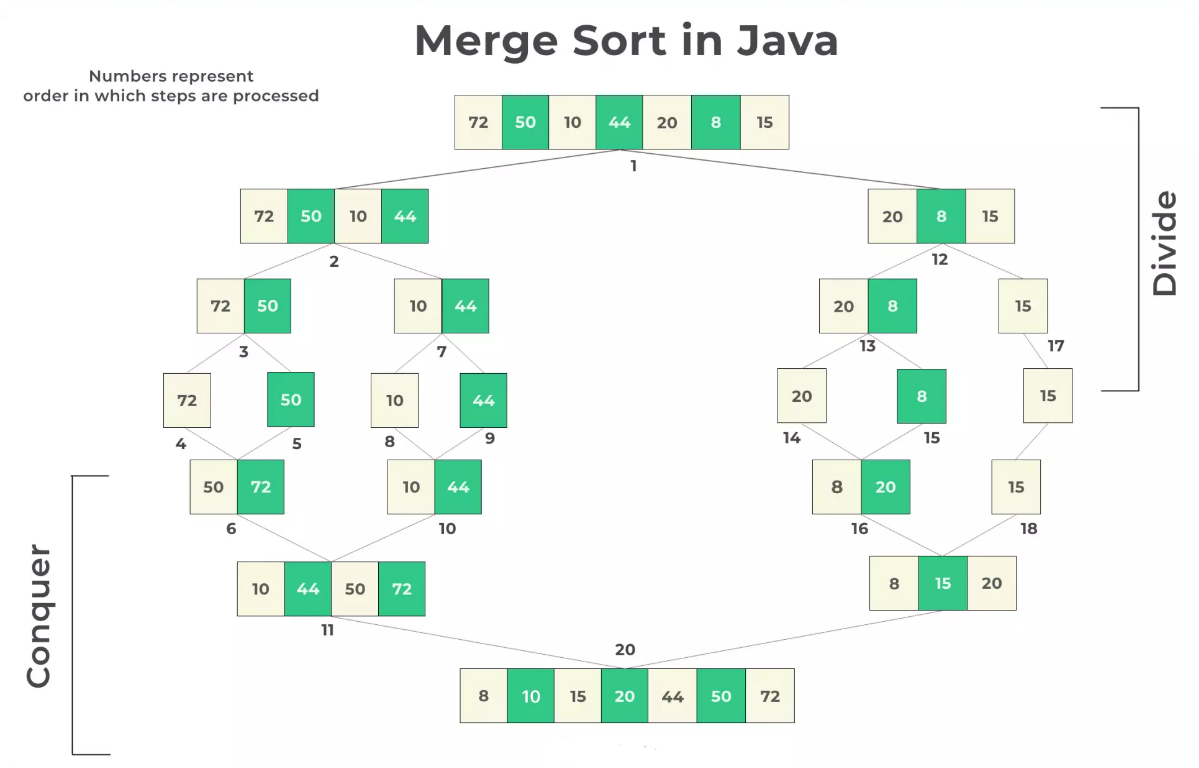
Divide

- The **original array** is divided into sub-arrays.
- The sub-arrays are further divided into further sub-arrays until they contain a single element using recursion.

Conquering/ Merging

- Then the sub-lists are combined together in the desired (sorted) order.
- The time complexity of the merge sort is *O*(n log n) for best/ worst / average cases






```
package Sort;

public class Merge1 {
```

```
  public static void printArray(int[] arr, int size) {
    for (int i = 0; i < size; i++) {
      System.out.print(arr[i] + " ");
    }
    System.out.println();
  }


  // this function apply merging and sorting in the array
  static void mergeSort(int[] a, int left, int right) {
    int mid;
    if (left < right) {
      // can also use mid = left + (right - left) / 2
      // this can avoid data type overflow
      mid = (left + right) / 2;

      // recursive calls to sort first half and second half sub-arrays
      mergeSort(a, left, mid);
      mergeSort(a, mid + 1, right);
      merge(a, left, mid, right);
    }
  }

  // after sorting this function merge the array
  static void merge(int[] arr, int left, int mid, int right) {
    int i, j, k;
    int n1 = mid - left + 1;
    int n2 = right - mid;

    // create temp arrays to store left and right sub-arrays
    int L[] = new int[n1];
    int R[] = new int[n2];

    // Copying data to temp arrays L[] and R[]
    for (i = 0; i < n1; i++)
      L[i] = arr[left + i];

    for (j = 0; j < n2; j++)
      R[j] = arr[mid + 1 + j];

    // here we merge the temp arrays back into arr[l..r]
    i = 0; // Starting index of L[i]
    j = 0; // Starting index of R[i]
    k = left; // Starting index of merged sub-array
//10,9,7,12,78,34,33,101,23,44        L->10,9,7,101,23,44  R->12,78,34,33
    while (i < n1 && j < n2) {
      // place the smaller item at arr[k] pos
      if (L[i] <= R[j]) {
        arr[k] = L[i];
        i++;
      } else {
        arr[k] = R[j];
        j++;
      }
      k++;
    }
    // Copy the remaining elements of L[], if any
    while (i < n1) {
```

```
      arr[k] = L[i];
      i++;
      k++;
    }
    // Copy the remaining elements of R[], if any
    while (j < n2) {
      arr[k] = R[j];
      j++;
      k++;
    }
  }

  public static void main(String[] args) {
    int[] a = { 12, 8, 4, 14, 36, 64, 15, 72, 67, 84 };

    int size = a.length;

    System.out.println("Array Before Sort:");
    printArray(a, size);

    mergeSort(a, 0, size - 1);

    System.out.println("Array After Sort:");
    printArray(a, size);
  }
}
```

```
package Sort;

public class Merge2 {
  // this function display the array
  public static void printArray(int[] arr, int size) {
    for (int i = 0; i < size; i++) {
      System.out.print(arr[i] + " ");
    }
    System.out.println();
  }

  // main function of the program
  public static void main(String[] args) {
    int[] a = { 12, 8, 4, 14, 36, 64, 15, 72, 67, 84 };

    int size = a.length;

    System.out.println("Array Before Sort:");
    printArray(a, size);

    mergeSort(a, 0, size - 1);

    System.out.println("Array After Sort:");
    printArray(a, size);
  }
```

```java
// this function apply merging and sorting in the array
static void mergeSort(int[] a, int left, int right) {
  int mid;
  if (left < right) {
    // can also use mid = left + (right - left) / 2
    // this can avoid data type overflow
    mid = (left + right) / 2;

    // recursive calls to sort first half and second half sub-arrays
    mergeSort(a, left, mid);
    mergeSort(a, mid + 1, right);
    merge(a, left, mid, right);
  }
}

// after sorting this function merge the array
static void merge(int[] a, int left, int mid, int right) {
  int i = left; // starting index of left sub-array
  int j = mid + 1; // starting index of right sub-array
  int index = left; // used to place items in temp[]
  int[] temp = new int[10];

  while (i <= mid && j <= right) {
    // place the smaller item at temp[index]
    if (a[i] < a[j]) {
      temp[index] = a[i];
      i = i + 1;
    } else {
      temp[index] = a[j];
      j = j + 1;
    }
    index++;
  }

  // i > mid would mean all items for left
  // sub-array were successfully placed, and there
  // must be unplaced right sub-array items
  if (i > mid) {
    while (j <= right) {
      temp[index] = a[j];
      index++;
      j++;
    }
  } else {
    while (i <= mid) {
      temp[index] = a[i];
      index++;
      i++;
    }
  }
  int p = left;

  while (p < index) {
    a[p] = temp[p];
    p++;
  }
}
```

```
}
```

The space complexity is the same i.e. O(n) in both cases as even though there are two subarrays in method 1 they in total have n array items and method 2 also with one single array also has n array items.

- Merge sort is quick algorithm and does sorting in only O(n log n) time
- However, it comes with a cost, which is extra space complexity which is too high in comparison to others which is o(n)
- While, one good thing is there that for all cases, the time complexity remains the same i.e. average, best, worst