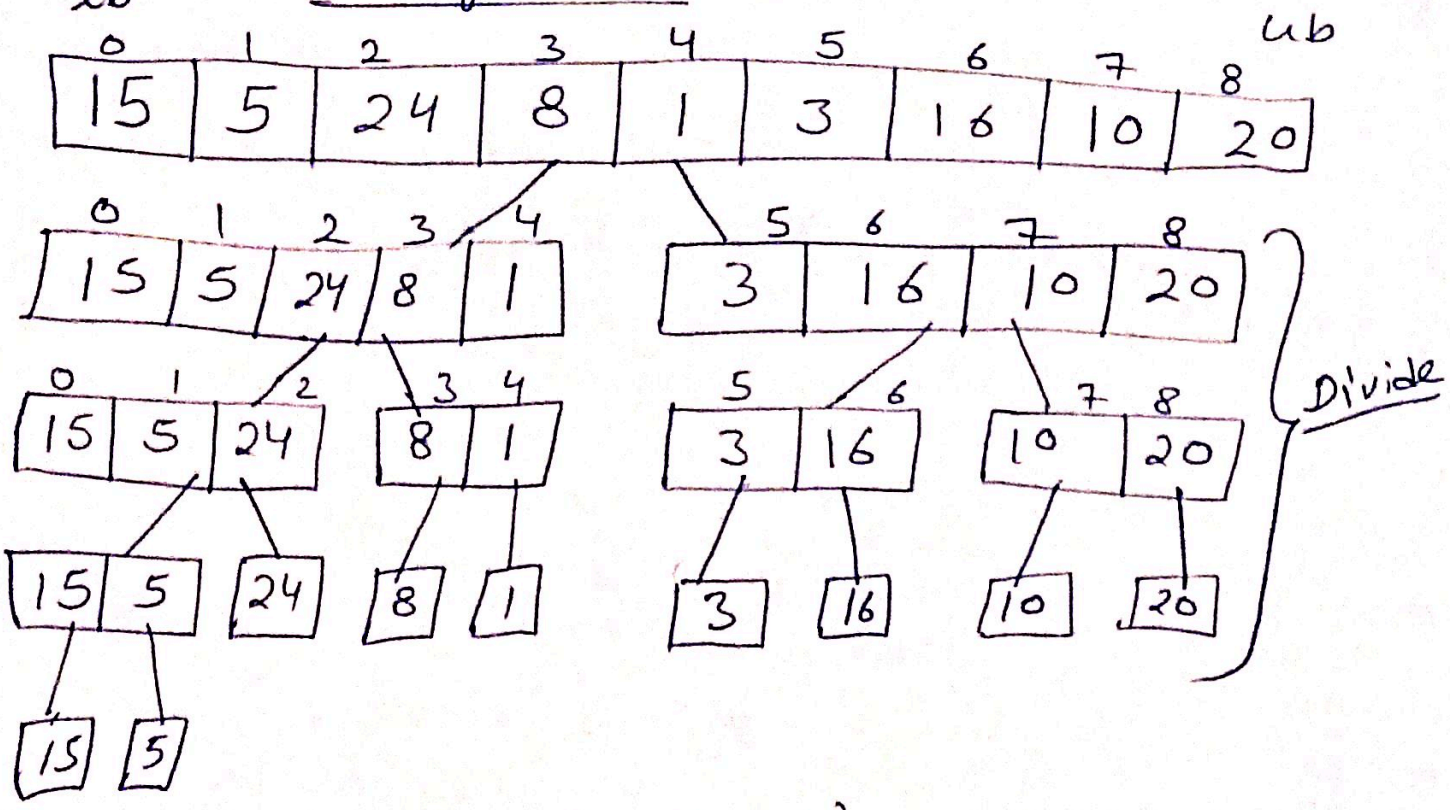
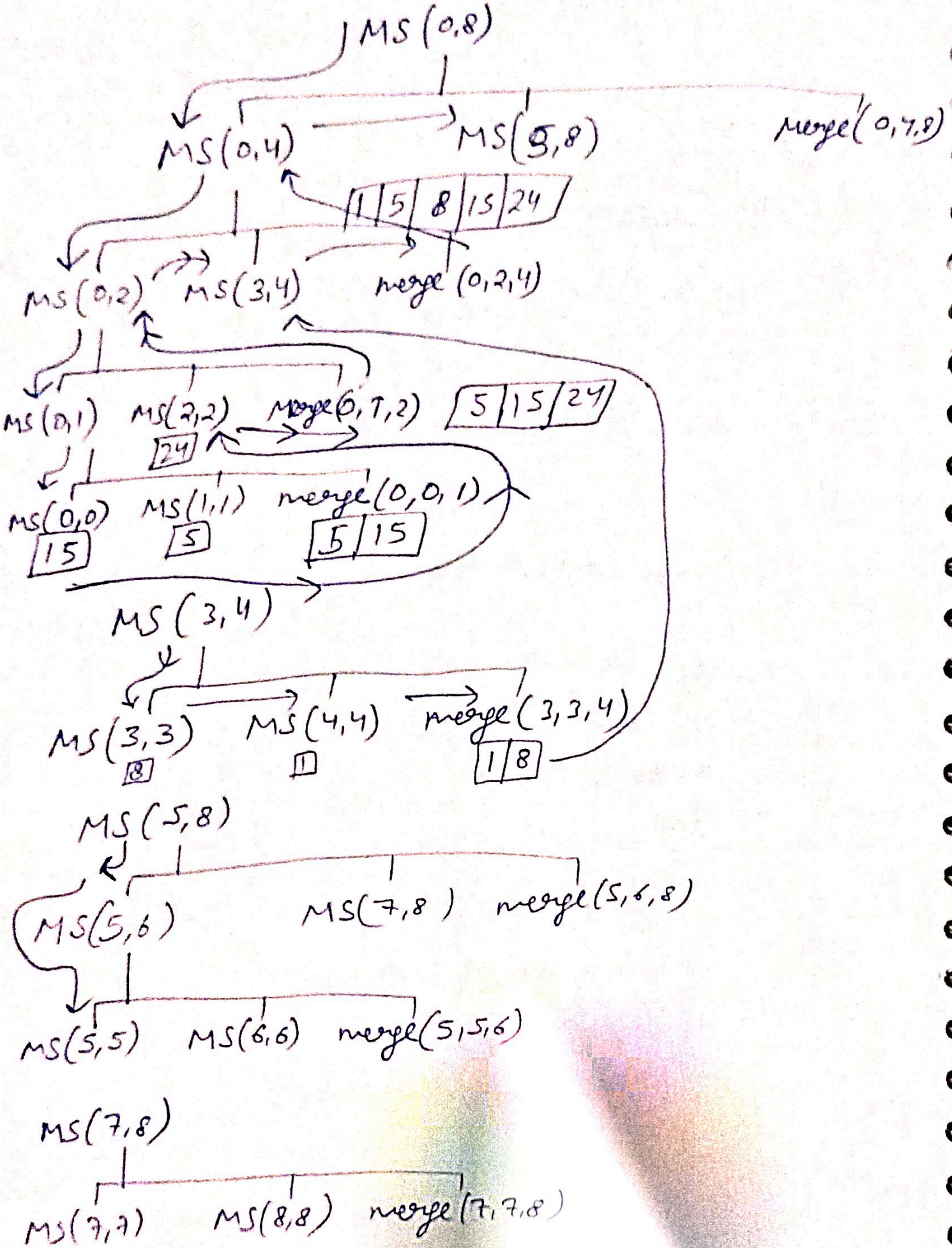
Merge Sort




```
MergeSort (A, lb, ub)
{
  if (lb == ub)
  return (a[lb]);
  else
    {
      mid = (lb+ub)/2
      MergeSort (A, lb, mid);
      MergeSort (A, mid+1, ub);
      Merge (A, lb, mid, ub);
    }
```


MS(0,8)
MS(0,4)
MS(5,8)
merge(0,7,8)
1 5 8 15 24
MS(0,2)
MS(3,4)
merge(0,2,4)
MS(0,1)
MS(2,2)
merge(0,1,2)
5 15 24
24
MS(0,0)
MS(1,1)
merge(0,0,1)
15
5
5 15
MS(3,4)
MS(3,3)
MS(4,4)
merge(3,3,4)
8
1
1 8
MS(5,8)
MS(5,6)
MS(7,8)
merge(5,6,8)
MS(5,5)
MS(6,6)
merge(5,5,6)
MS(7,8)
MS(7,7)
MS(8,8)
merge(7,7,8)

Merge-Sort $(A, p, r) \Rightarrow T(n)$

1. if $p < r$
2. then $q \leftarrow \lfloor (p+r)/2 \rfloor$
3. Merge-Sort $(A, p, q) \Rightarrow T(\frac{n}{2})$
4. Merge-Sort $(A, q+1, r)$ $T(\frac{n}{2})$

Merge-Sort $(A, p, q, r) \Rightarrow O(n)$

1- $n_1 \leftarrow q - p + 1$

2- $n_2 \leftarrow r - q$

3- Create array $L[1, \ldots, n_1+1]$ and $R[1, \ldots, n_2+1]$

4. For $i \leftarrow 1$ to n_1

5. $L[i] \leftarrow A[p+i-1]$

6. For $j \leftarrow 1$ to n_2

7. $R[j] \leftarrow A[q+j]$

8. $L[n_1+1] \leftarrow \infty$

9. $R[n_2+1] \leftarrow \infty$

10. $i \leftarrow 1$

11. $j \leftarrow 1$

12. For $k \leftarrow p$ to r

13. d if $L[i] \leq R[j]$

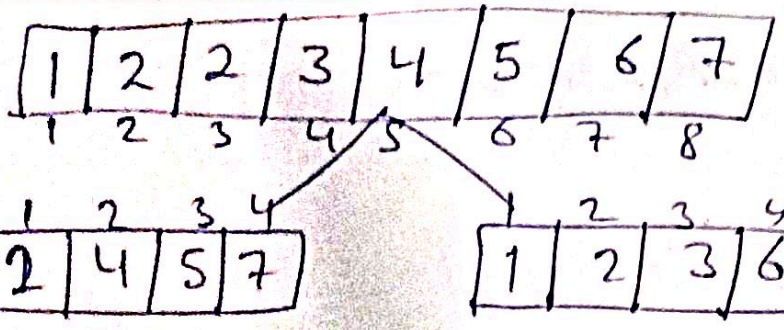
14. then $A[k] \leftarrow L[i]$

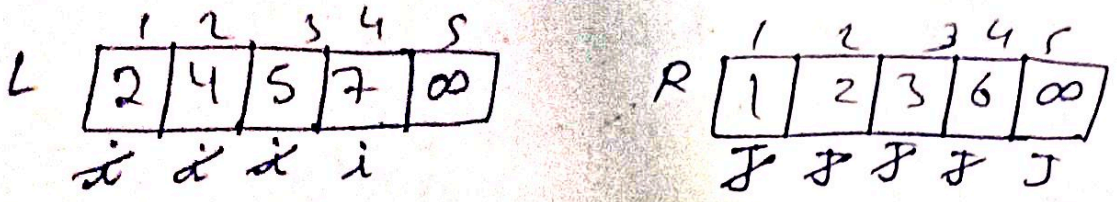
15. $i \leftarrow i+1$

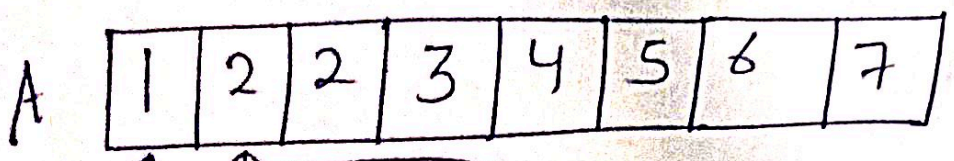
16. else $A[k] \leftarrow R[j]$

17. $j \leftarrow j+1$

example.







$q = \left\lfloor \frac{p+r}{2} \right\rfloor = \left\lfloor \frac{1+8}{2} \right\rfloor = 4$

$n_1 = 4-1+1 = 4$

$n_2 = 8-4 = 4$

For $i \leftarrow 1$ to 4

$L[1] \leftarrow A[1+2-1]$
$L[2] \leftarrow A[1+2-1]$
$L[3] \leftarrow A[1+3-1]$
$L[4] \leftarrow A[1+4-1]$

For $j \leftarrow 1$ to n_2
1 to 4

$R[1] \leftarrow A[4+1]$
$R[2] \leftarrow A[4+2]$
$R[3] \leftarrow A[4+3]$
$R[4] \leftarrow A[4+4]$

$L[n_1+1] \leftarrow \infty$
$L[5] = \infty$
$R[5] = \infty$

For $k \leftarrow p$ to r
1 to 8

$k=1$ if $L[1] \leq R[1]$ ✗
else $A[k] \leftarrow R[j]$
$A[1] \leftarrow R[1]$ $j=2$

$k=2$ if $L[1] \leq R[2]$
$A[2] = L[1]$
$i=2$

$k=3$