算法与数据结构体系课程

liuyubobobo

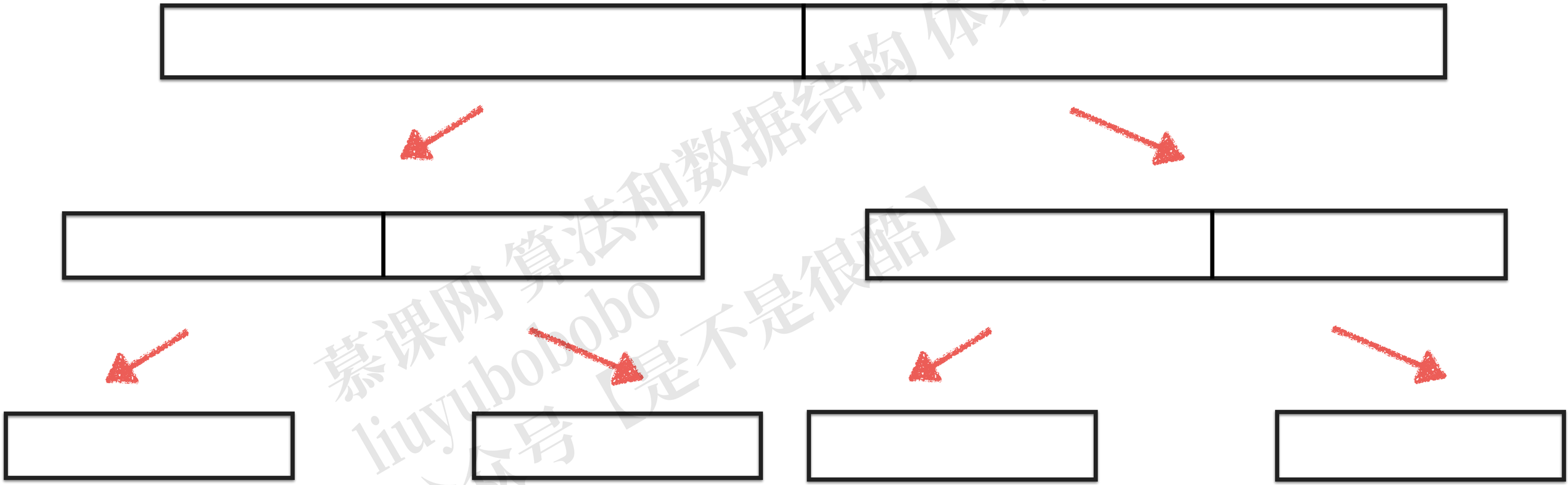
归并排序法

归并排序法

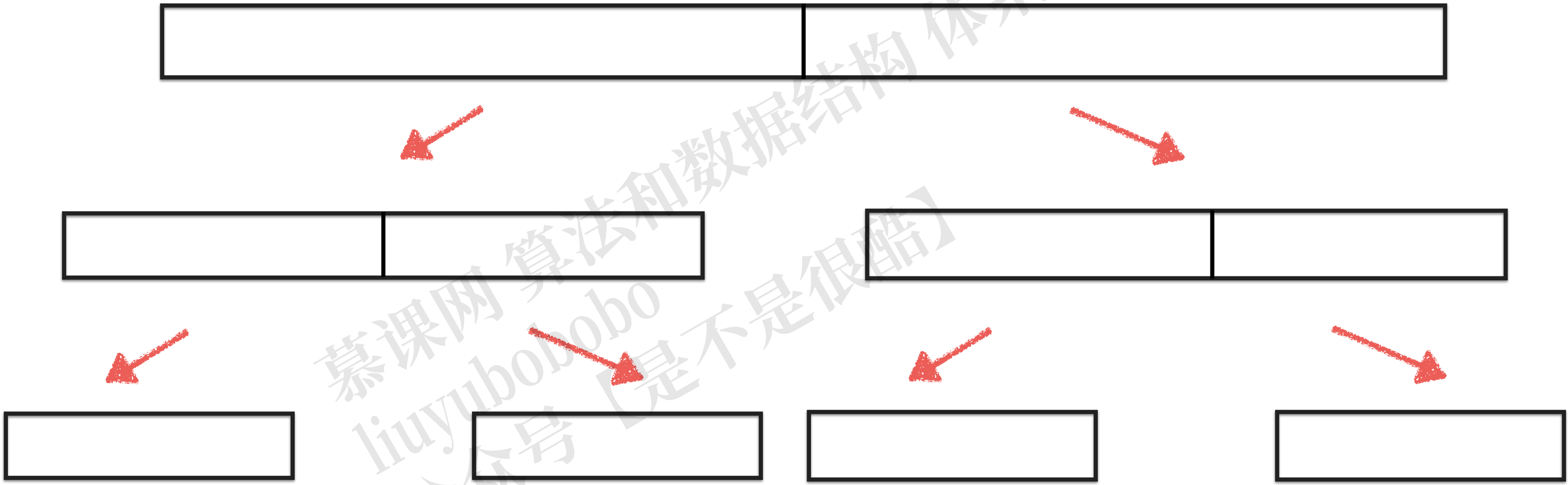
更复杂的递归算法

O(nlogn) 的排序算法

归并排序法



归并排序法



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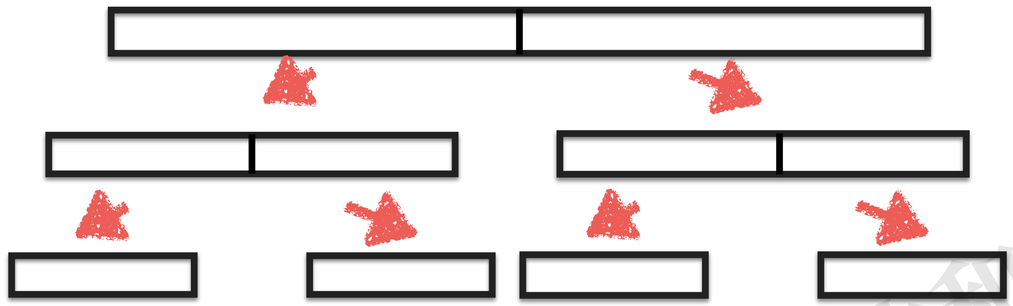


注意递归函数的“宏观”语意

MergeSort(arr, l, r)

对 arr 的 [l, r] 部分排序

```
MergeSort(arr, l, r){

    if(l >= r) return;

    int mid = (l + r) / 2;

    // 对 arr[l, mid] 进行排序
    MergeSort(arr, l, mid);

    // 对 arr[mid + 1, r] 进行排序
    MergeSort(arr, mid + 1, r);

    // 将arr[l,mid]和arr[mid+1,r]合并
    merge(arr, l, mid, r);

}
```

归并排序法

```
MergeSort(arr, l, r){

    if(l >= r) return;

    int mid = (l + r) / 2;

    // 对 arr[l, mid] 进行排序
    MergeSort(arr, l, mid);

    // 对 arr[mid + 1, r] 进行排序
    MergeSort(arr, mid + 1, r);

    // 将arr[l,mid]和arr[mid+1,r]合并
    merge(arr, l, mid, r);

}
```

求解最基本问题

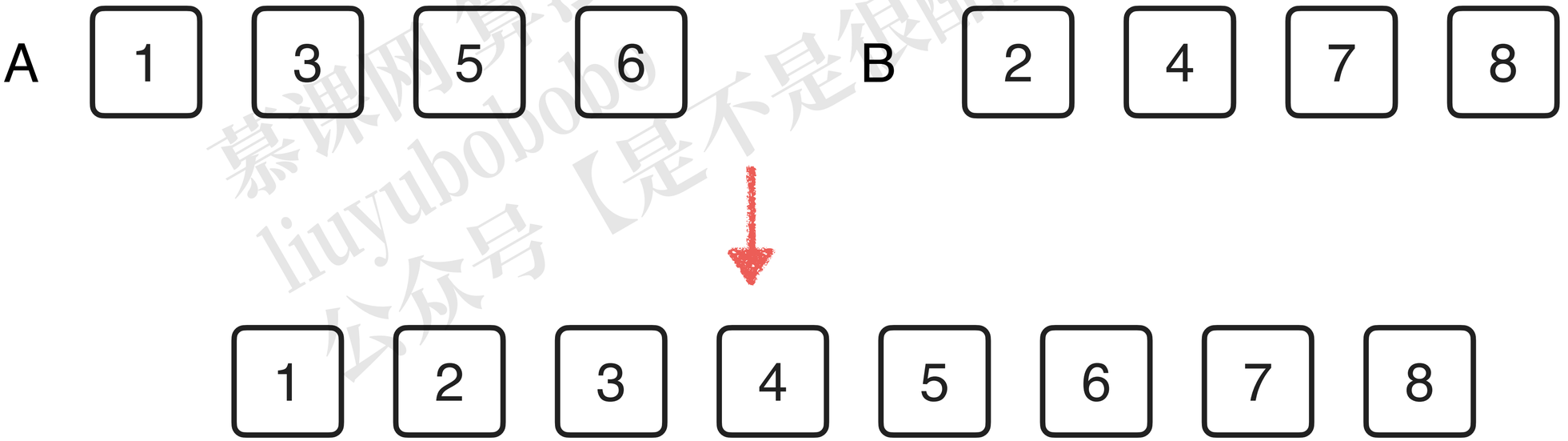
把原问题转化成更小的问题

如何归并?

归并过程

归并过程

已知两个有序数组 A 和 B　　将 A 和 B 合并成一个有序数组?



归并过程

已知两个有序数组 A 和 B　　将 A 和 B 合并成一个有序数组?

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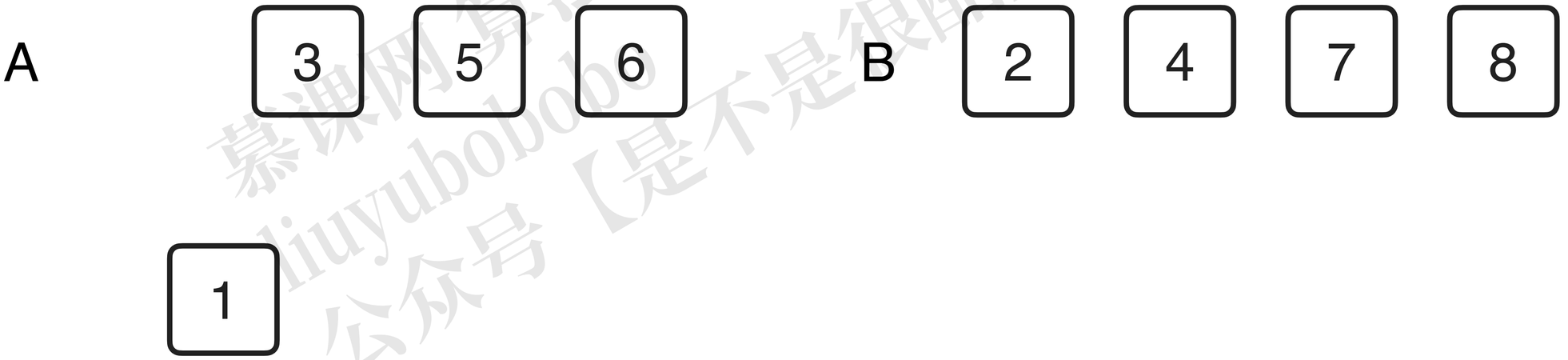

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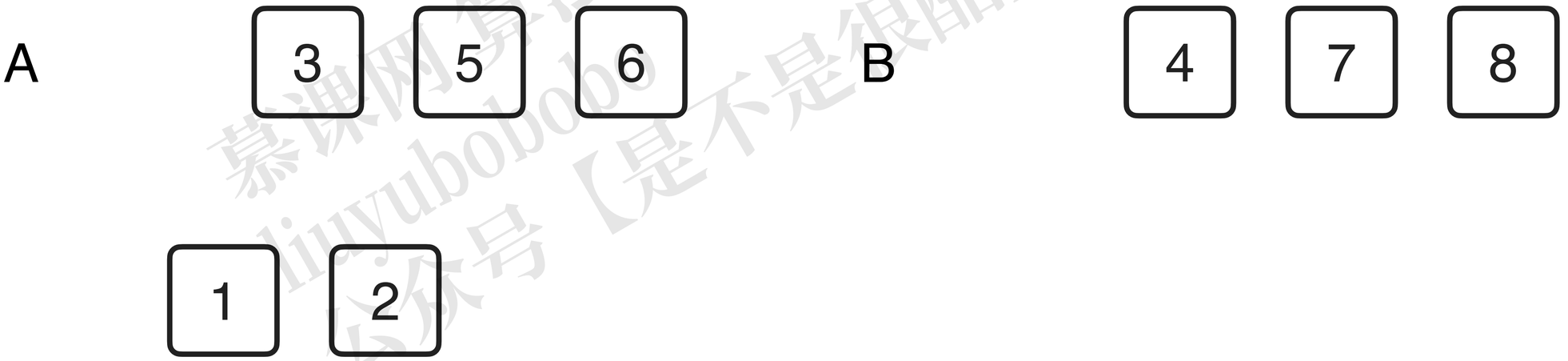

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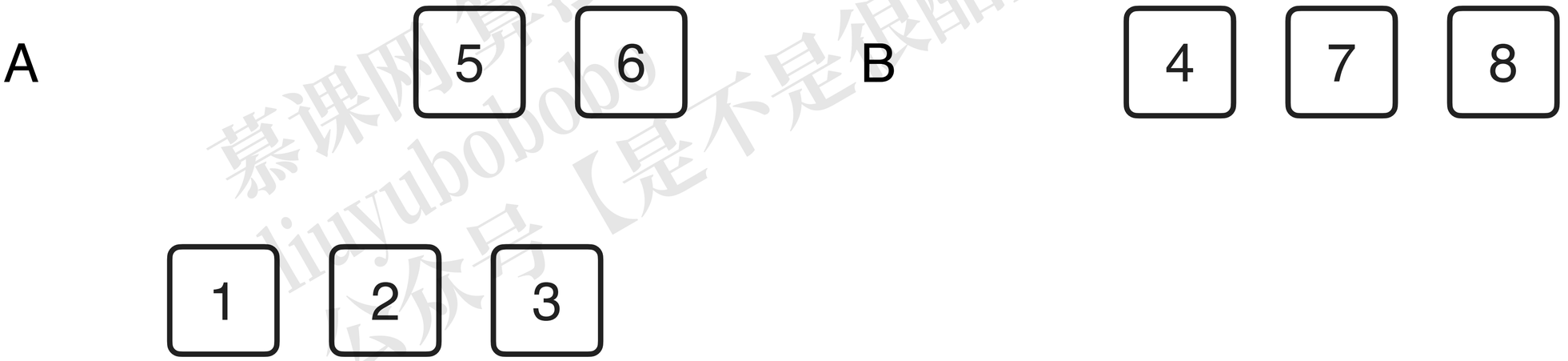

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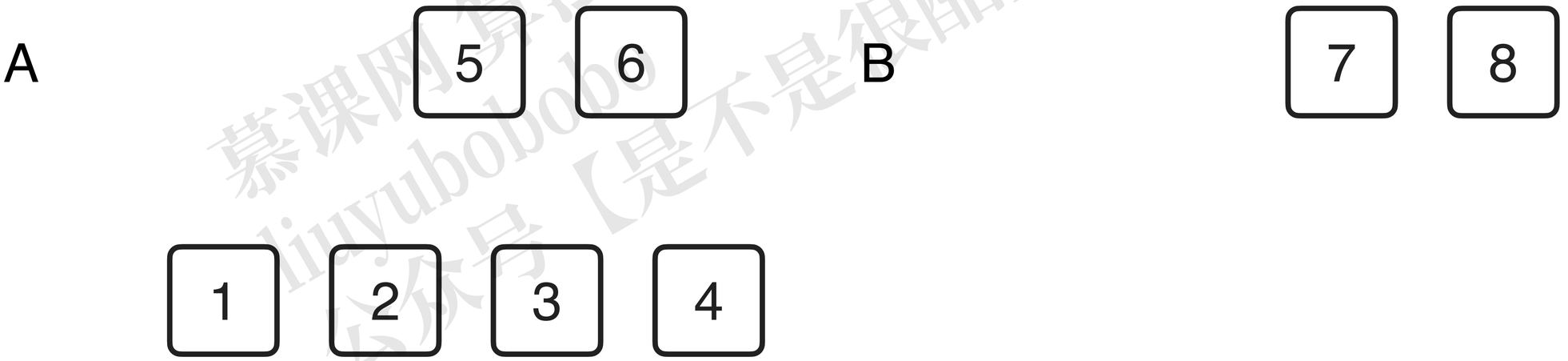

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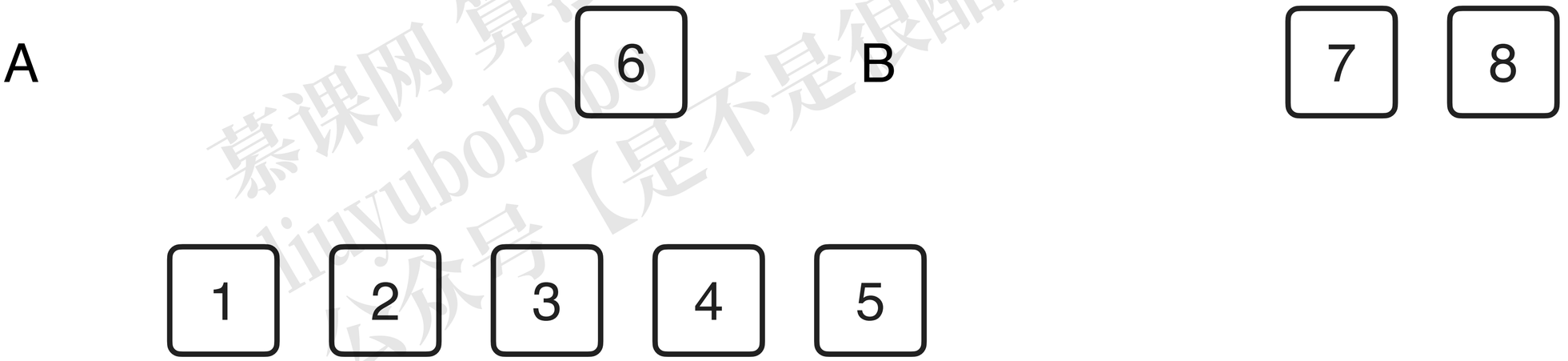
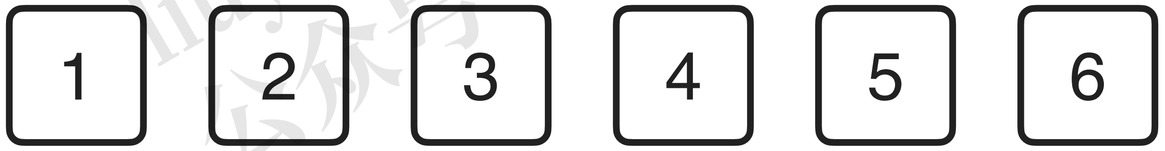


归并过程

已知两个有序数组 A 和 B　　将 A 和 B 合并成一个有序数组?

A



B

归并过程

已知两个有序数组 A 和 B　　将 A 和 B 合并成一个有序数组?

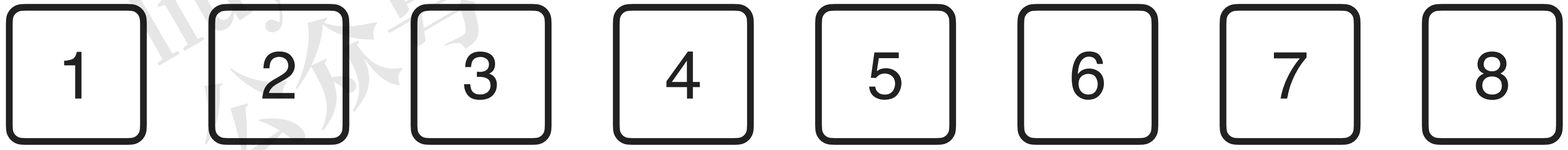
A

B

归并过程

已知两个有序数组 A 和 B　　将 A 和 B 合并成一个有序数组?

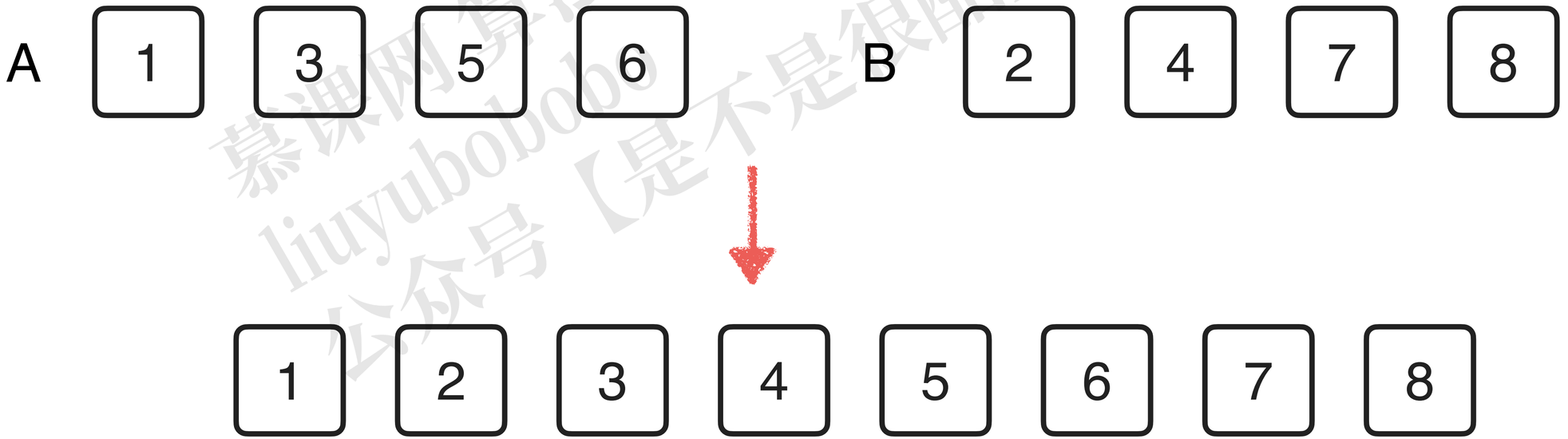
A　　B



归并过程

已知两个有序数组 A 和 B　　将 A 和 B 合并成一个有序数组?

```
// 将arr[l,mid]和arr[mid+1,r]合并
merge(arr, l, mid, r);
```



归并过程

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// 将arr[l,mid]和arr[mid+1,r]合并
merge(arr, l, mid, r);
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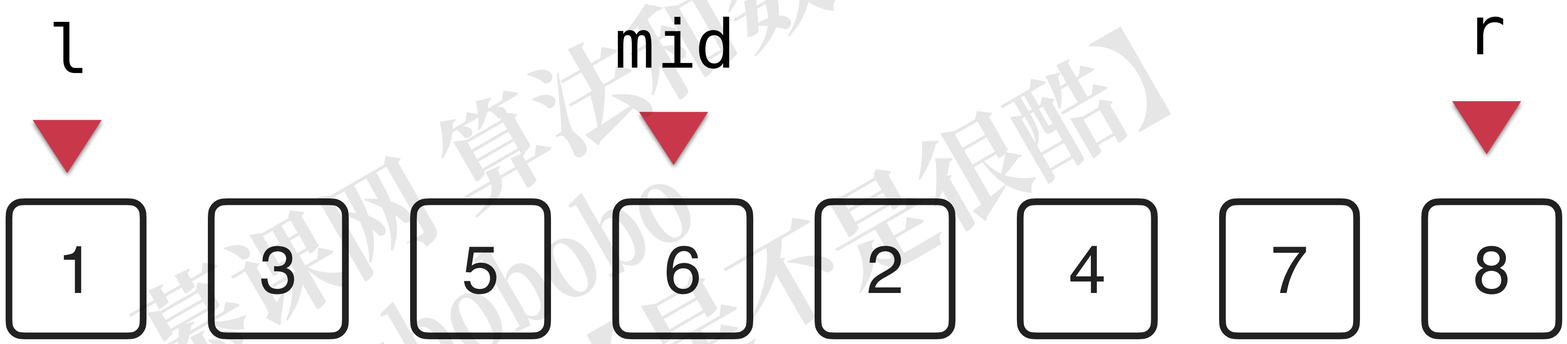

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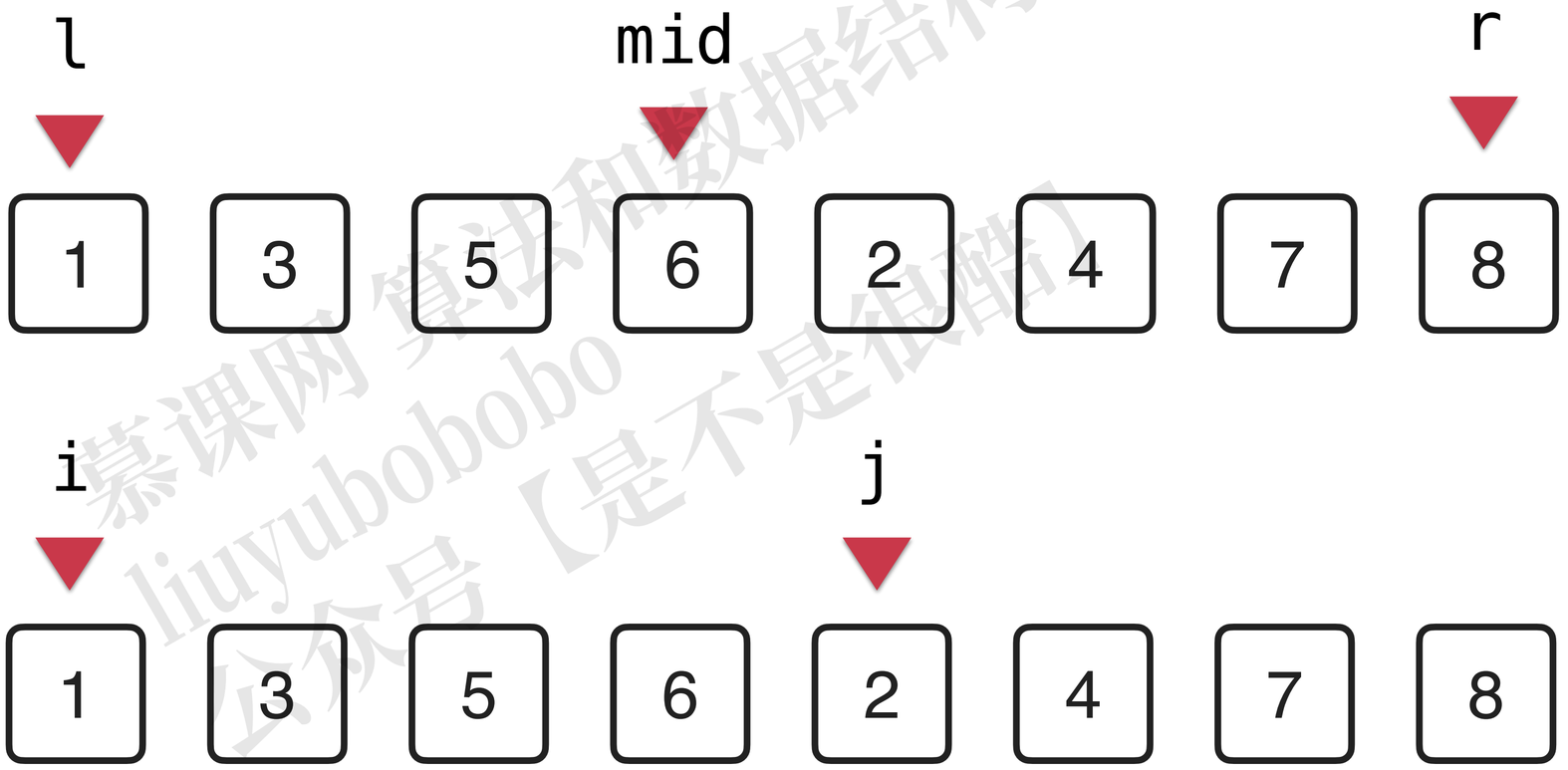

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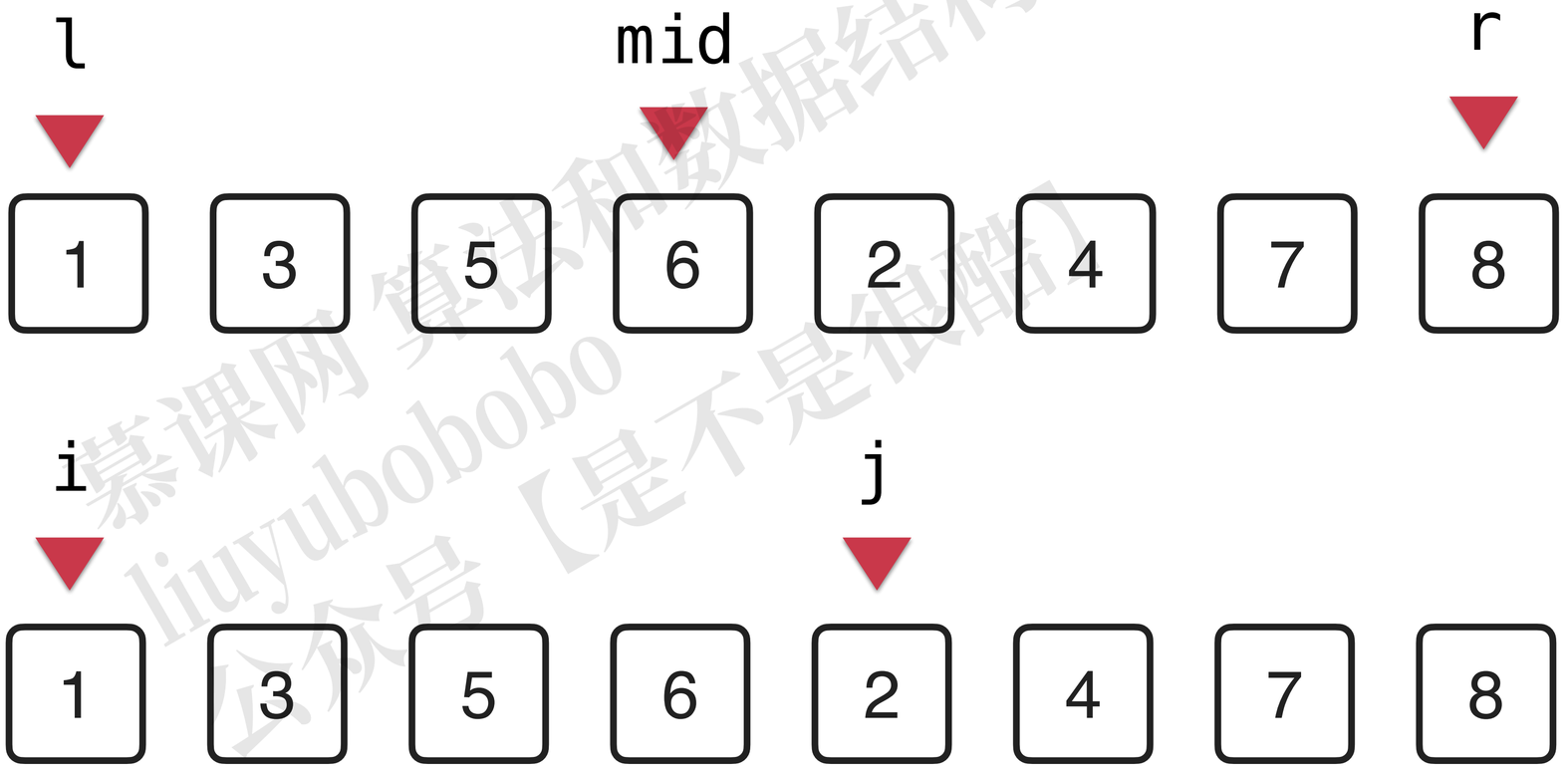

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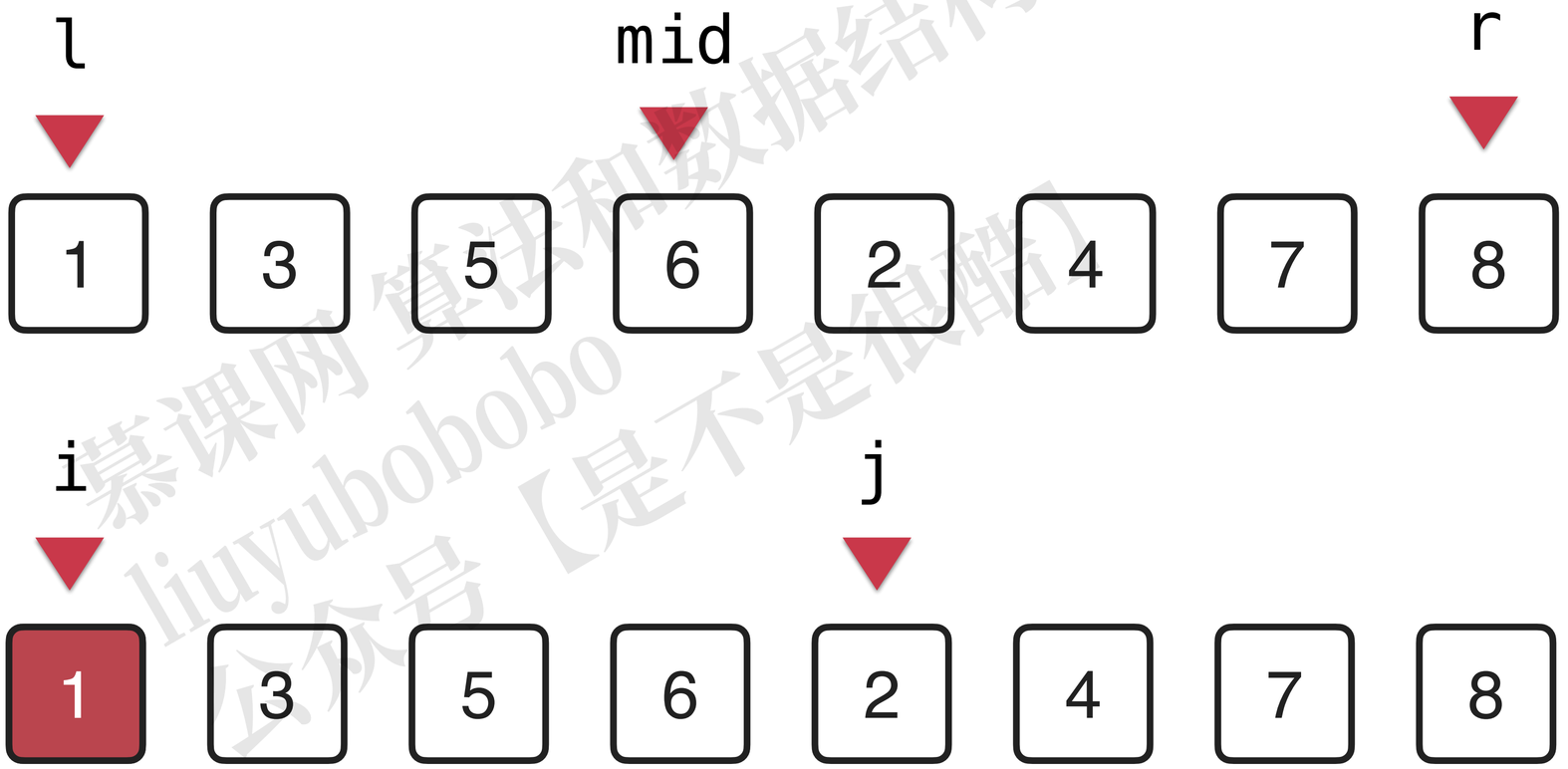

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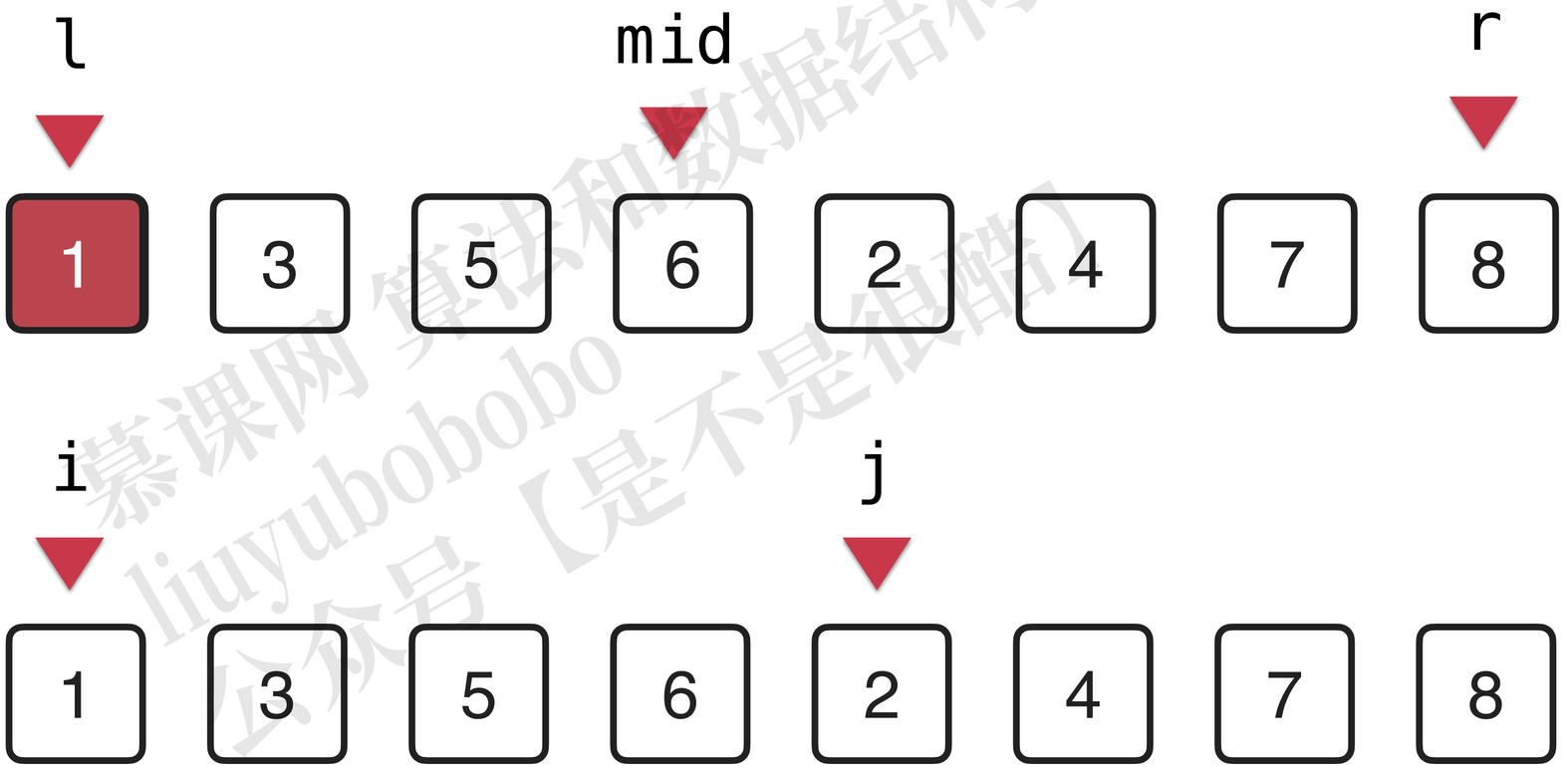

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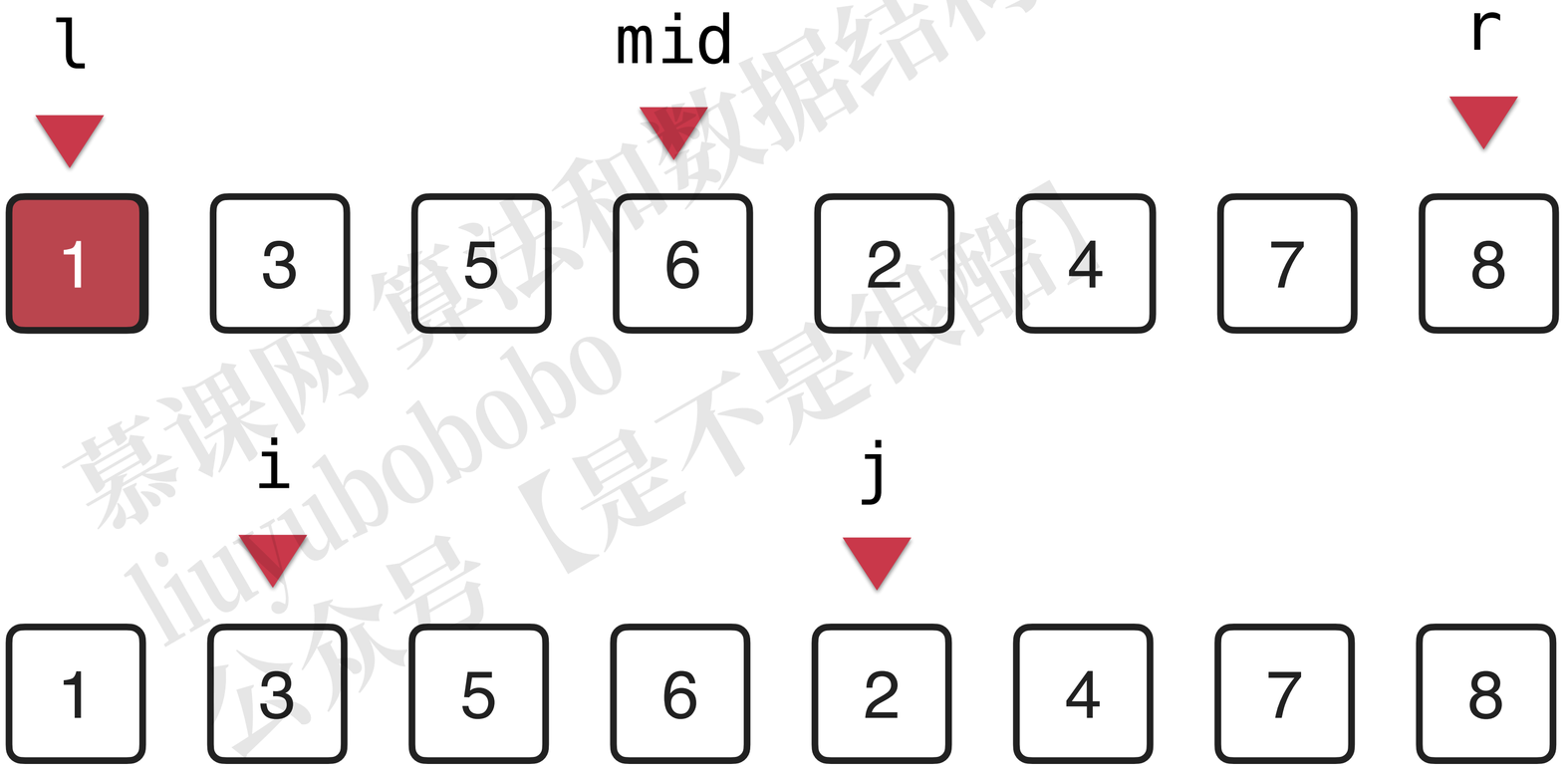

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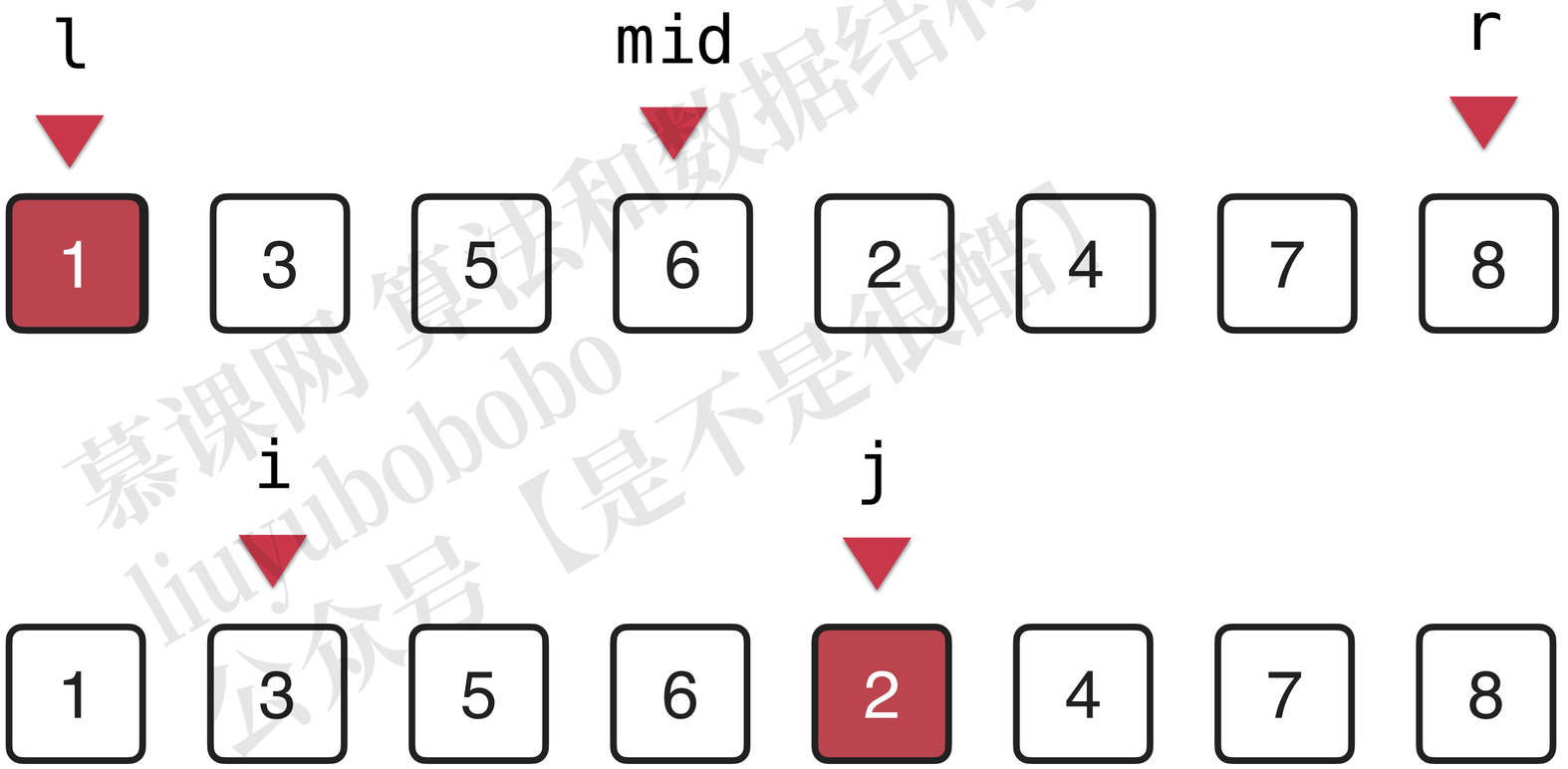

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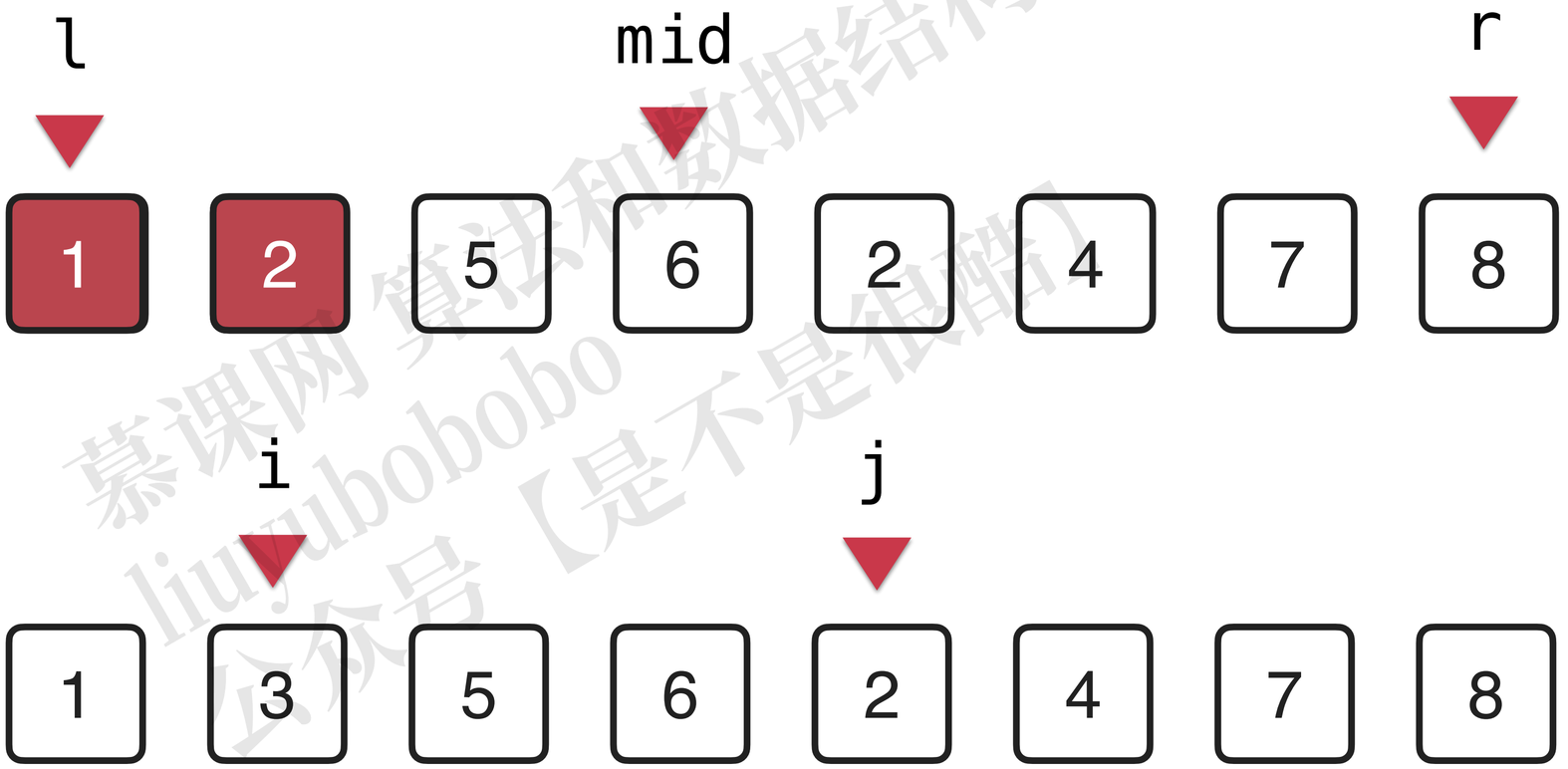

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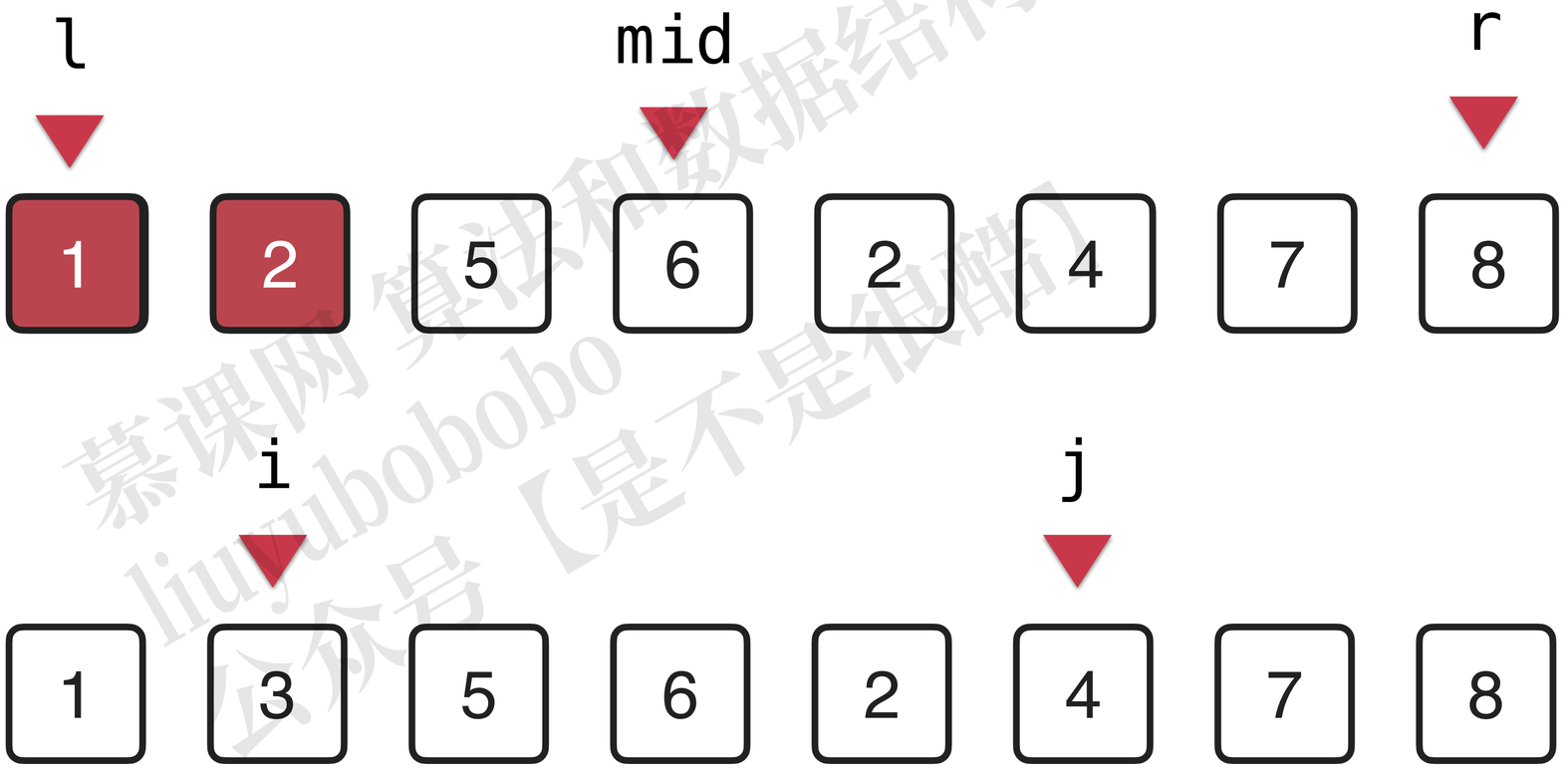

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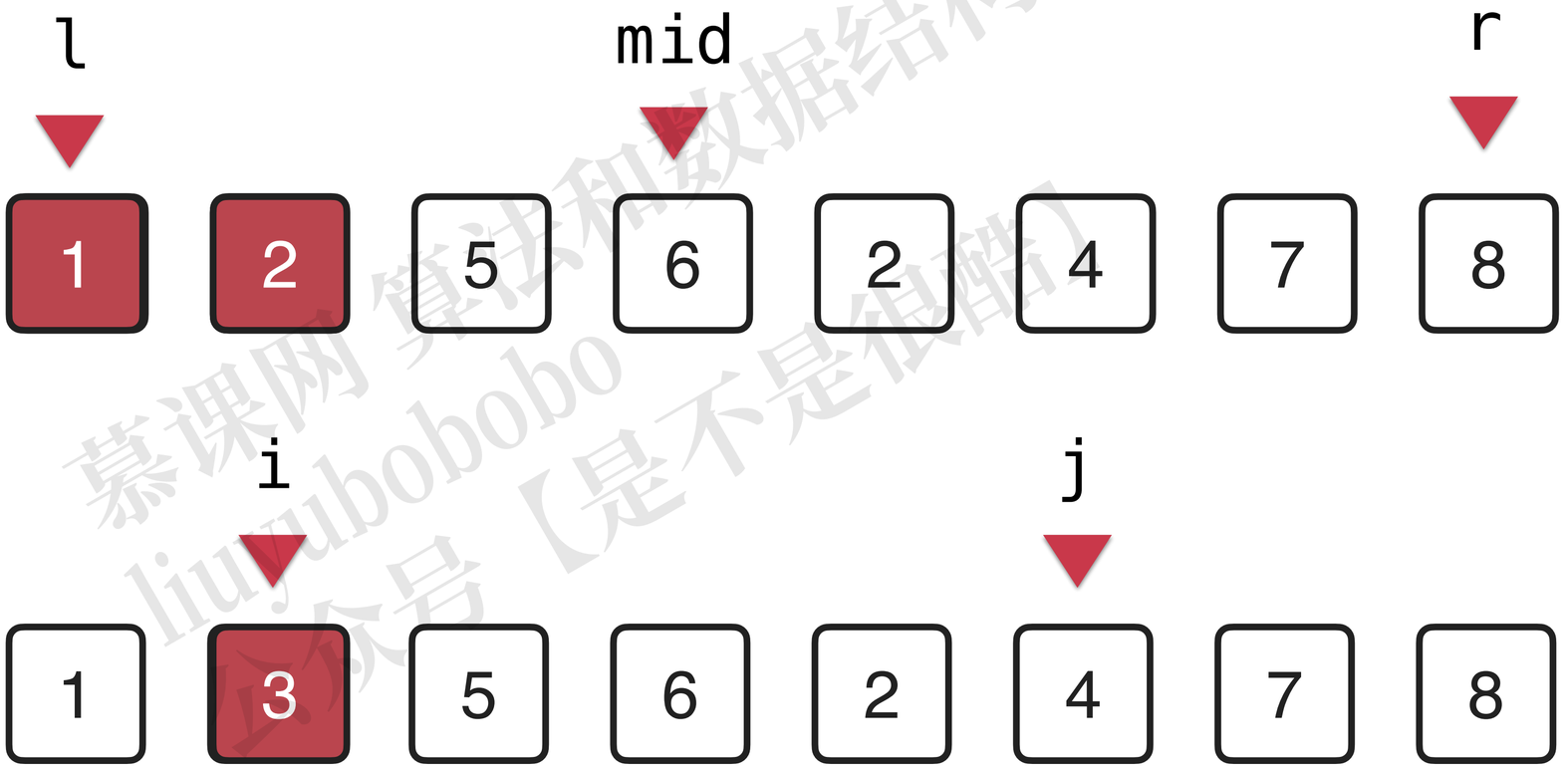

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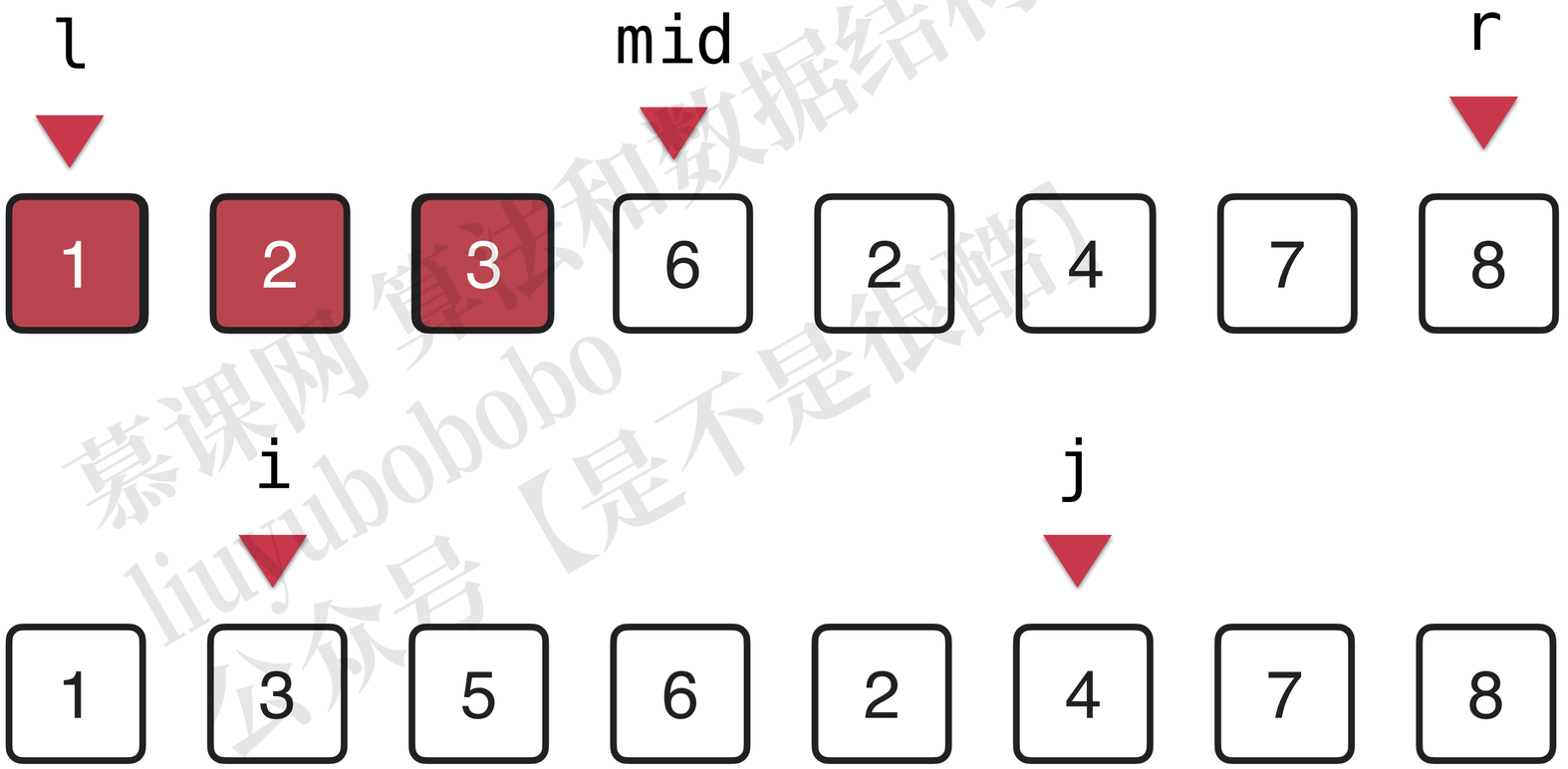

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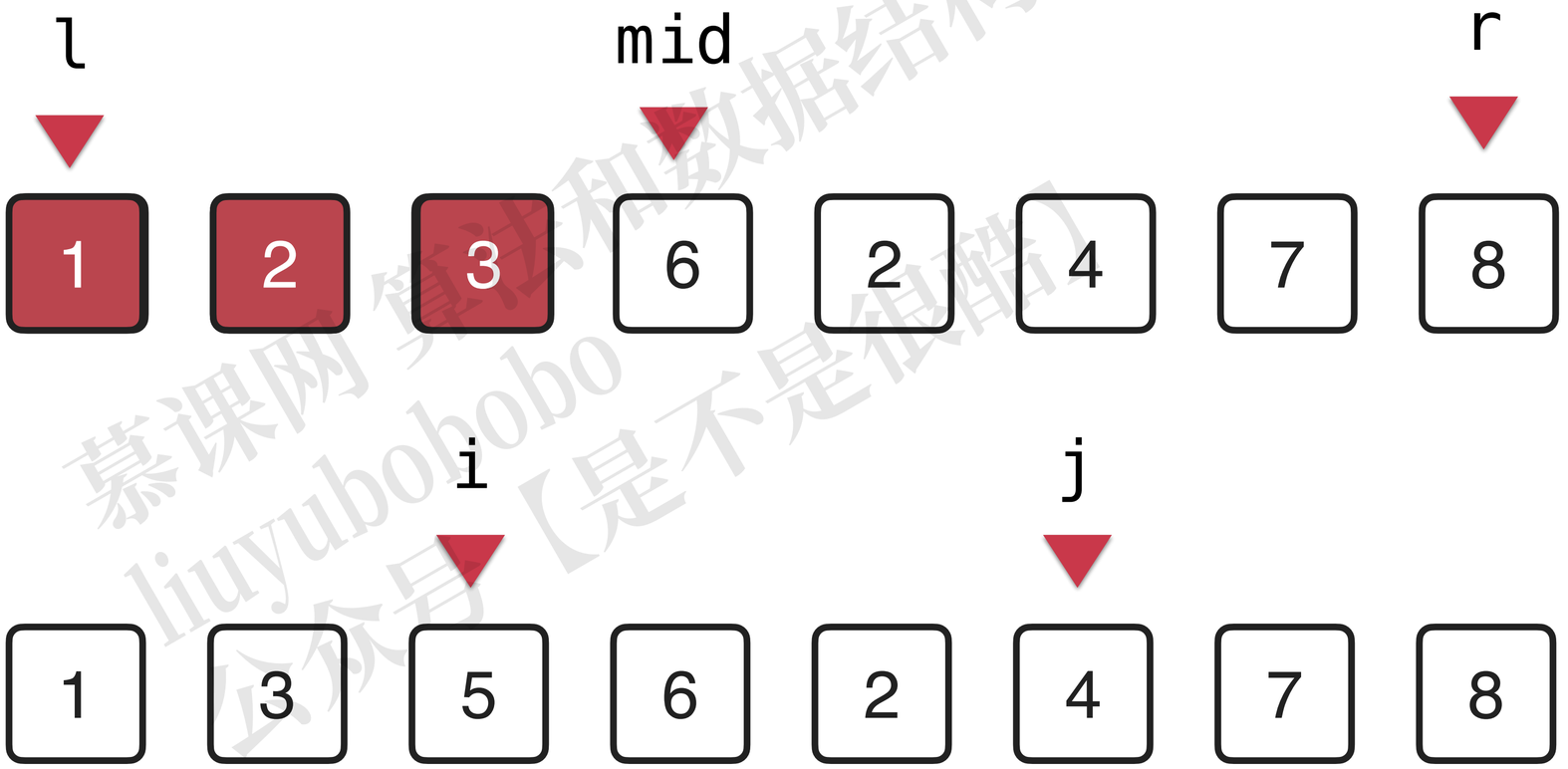

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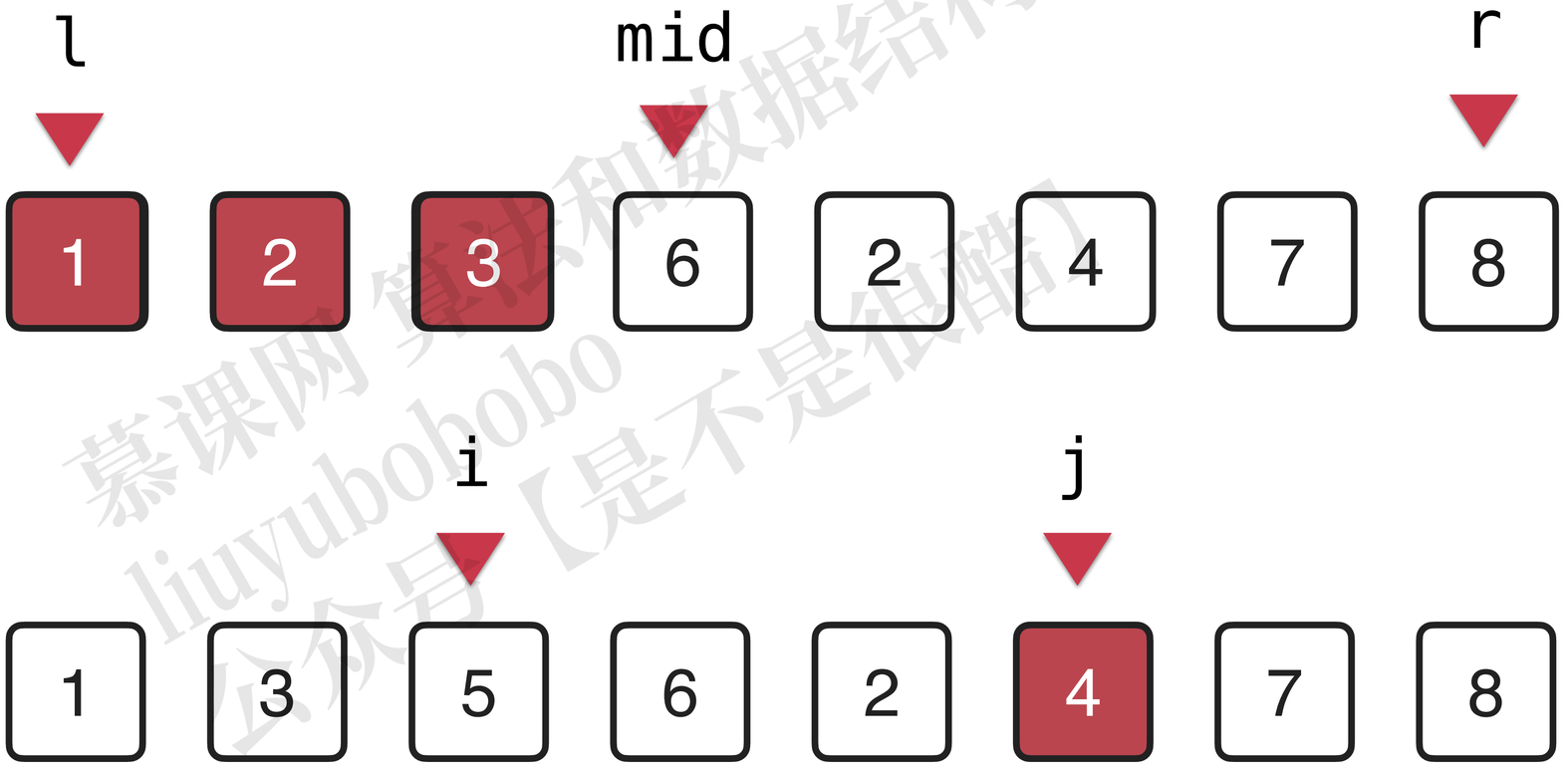

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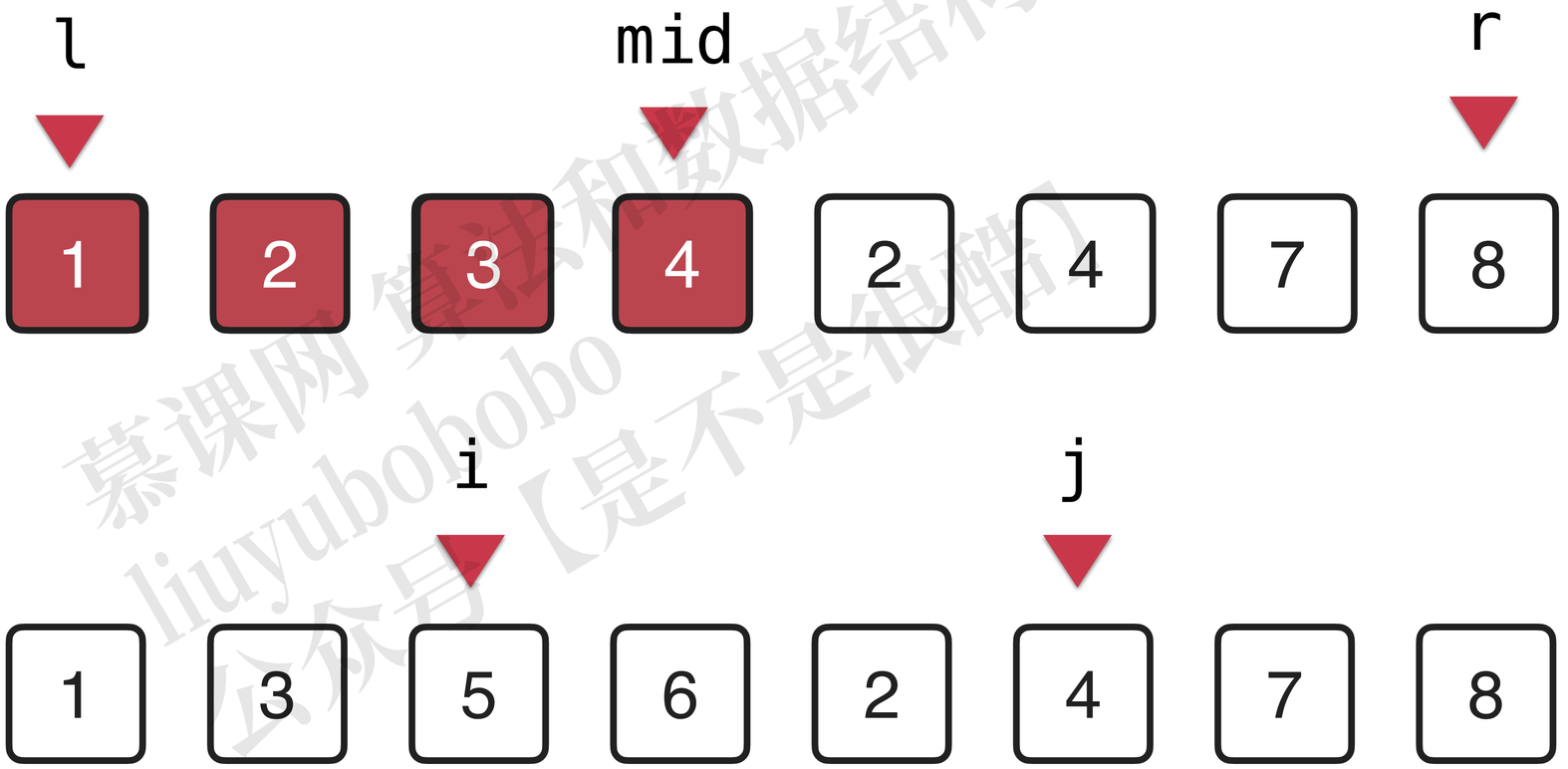

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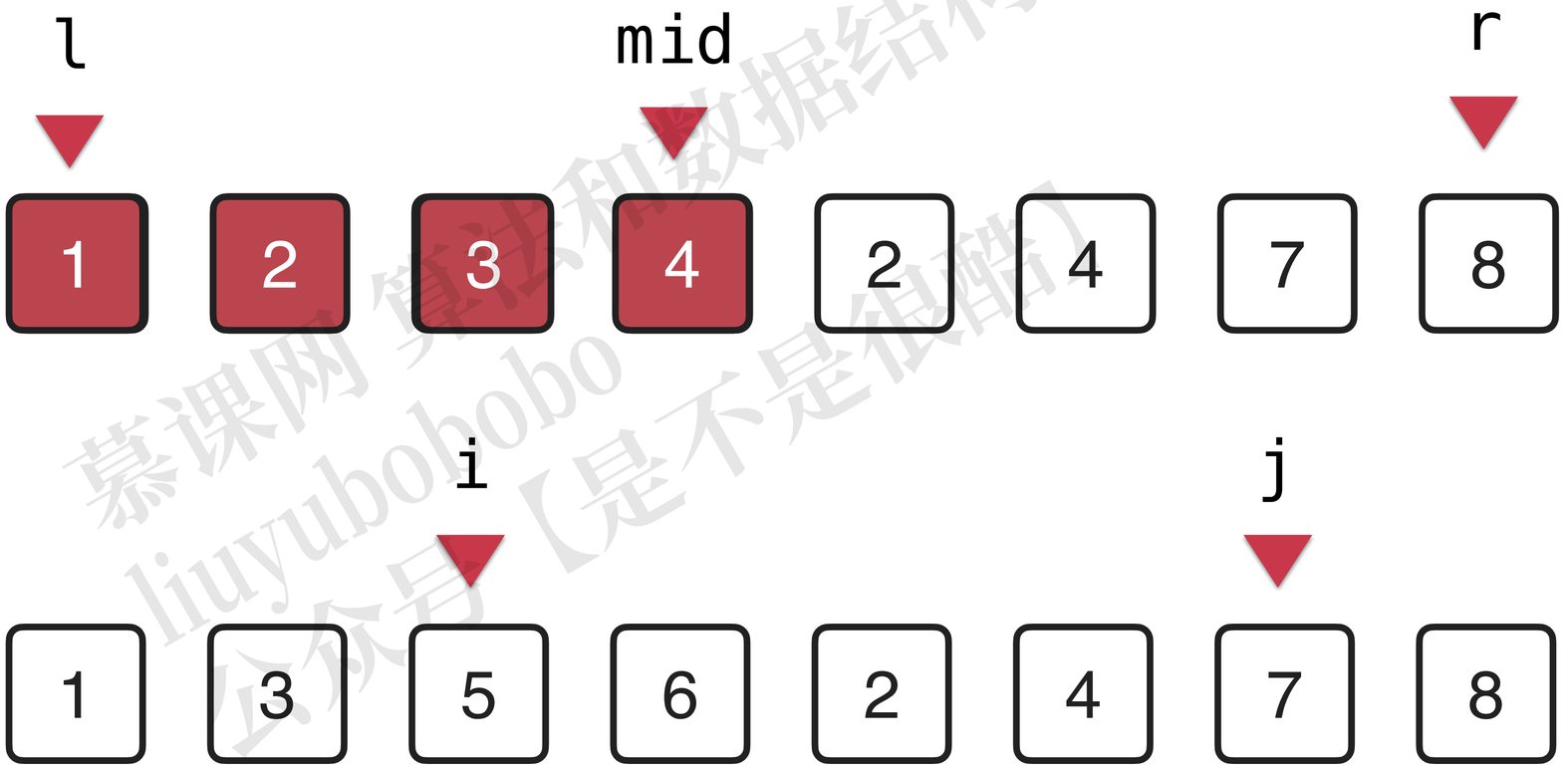

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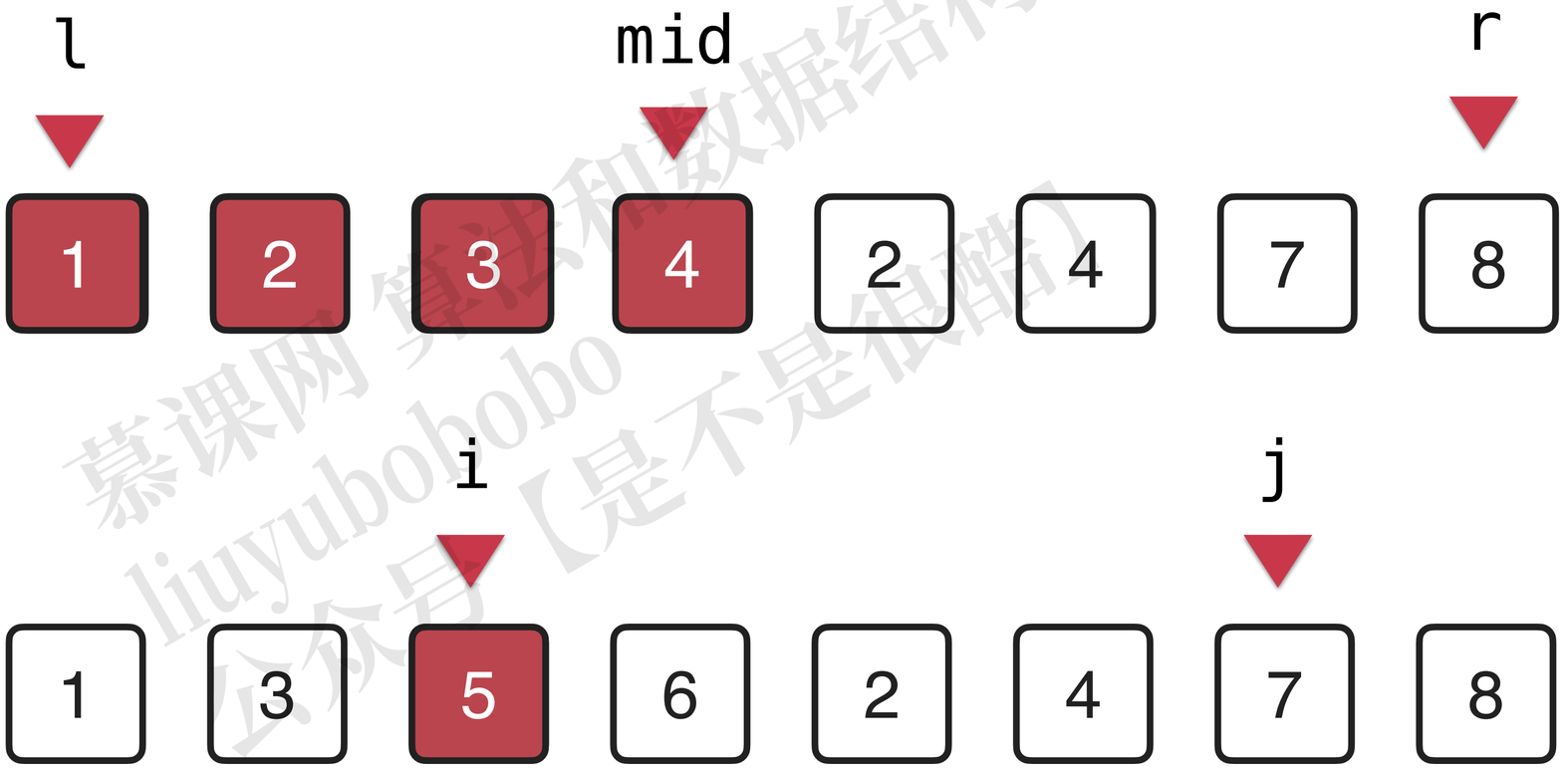

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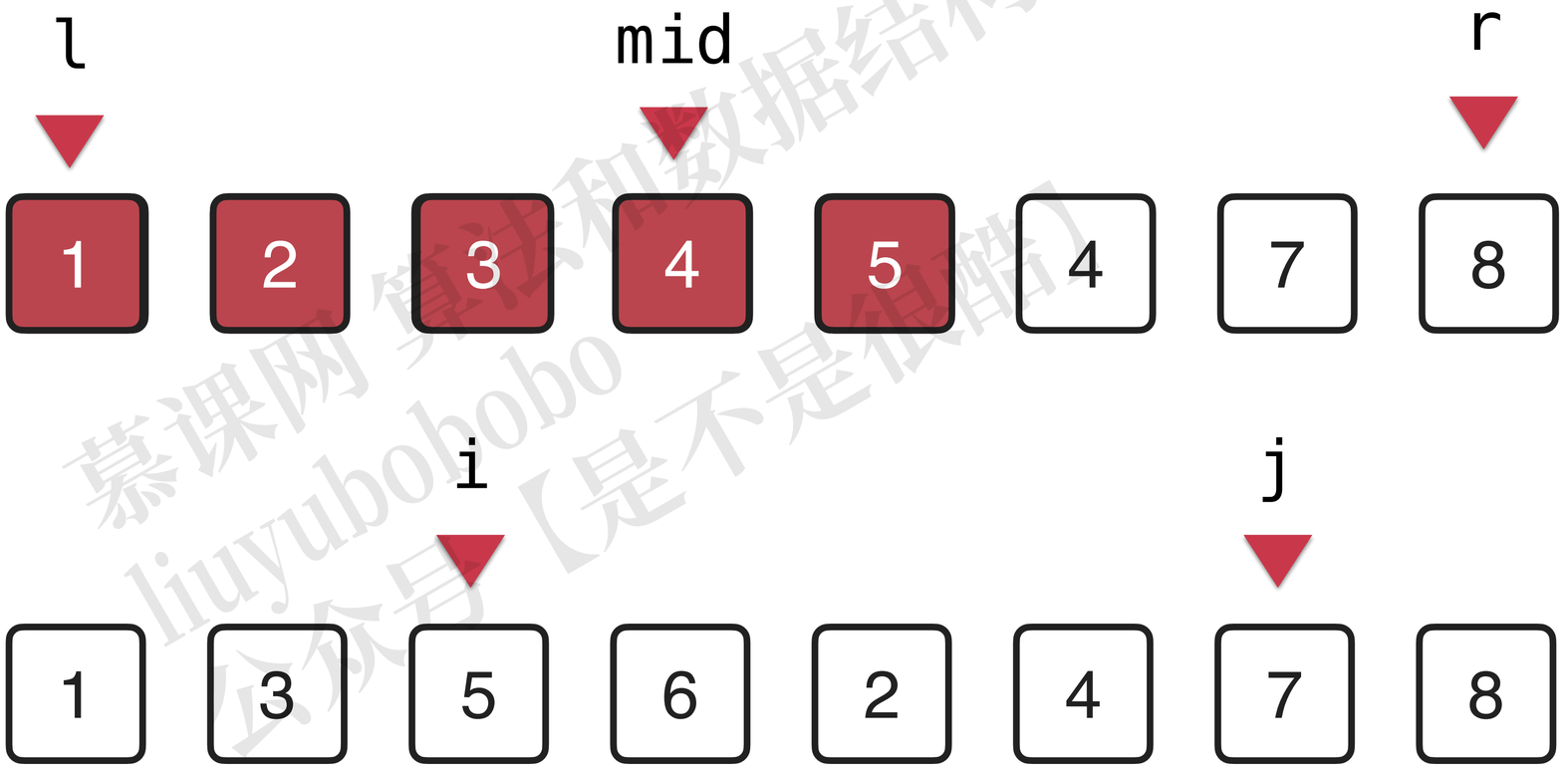

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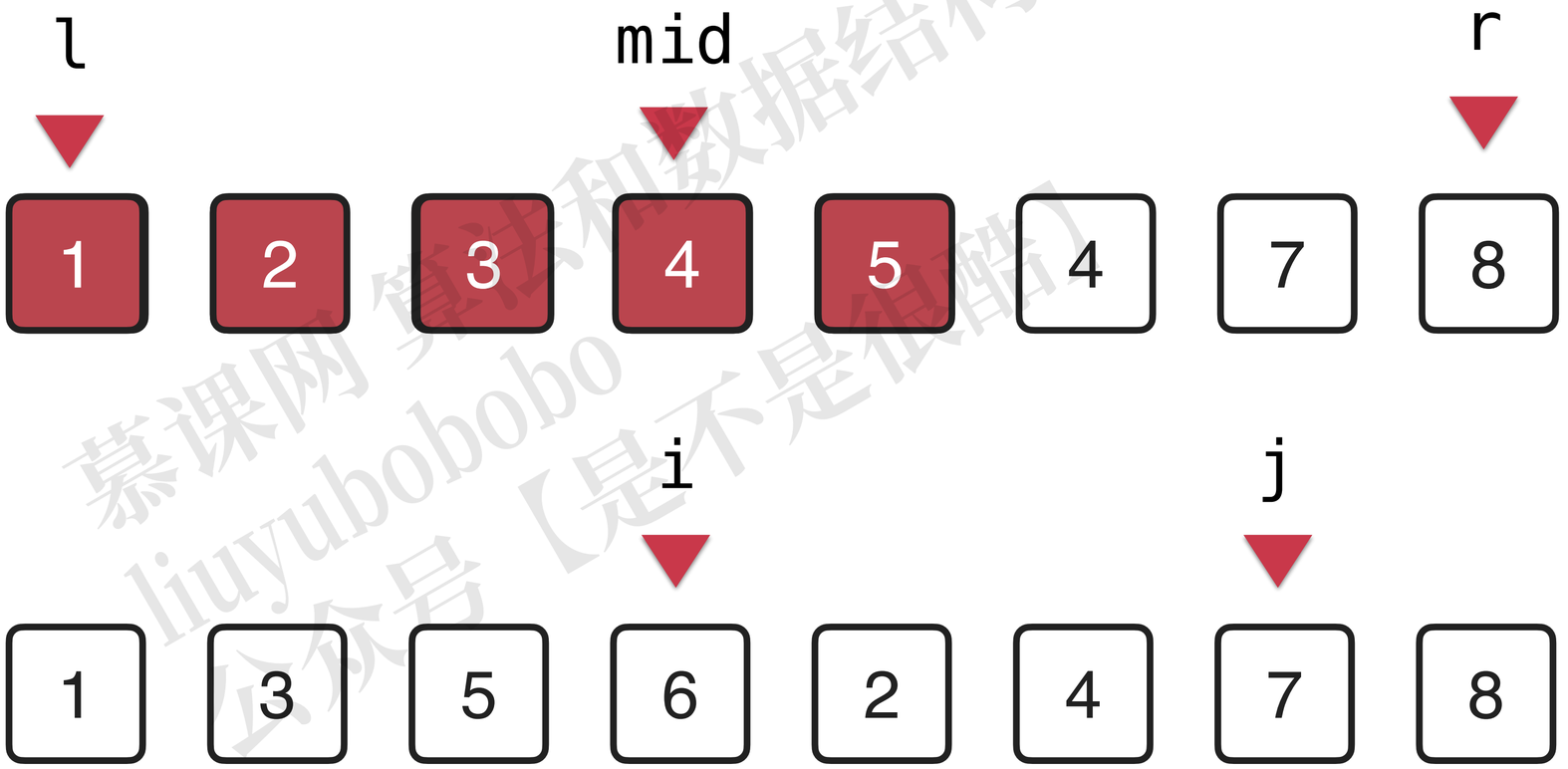

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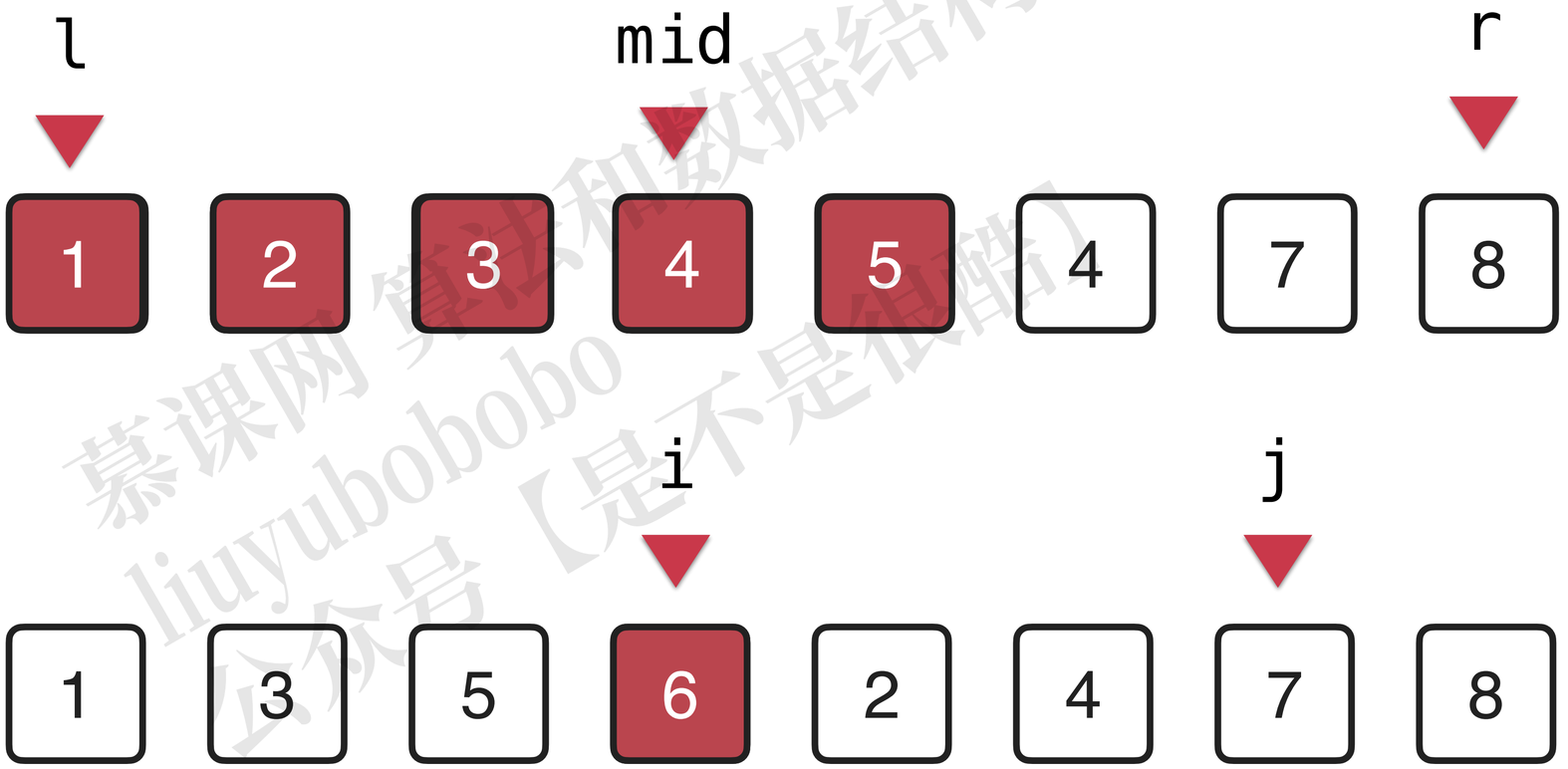

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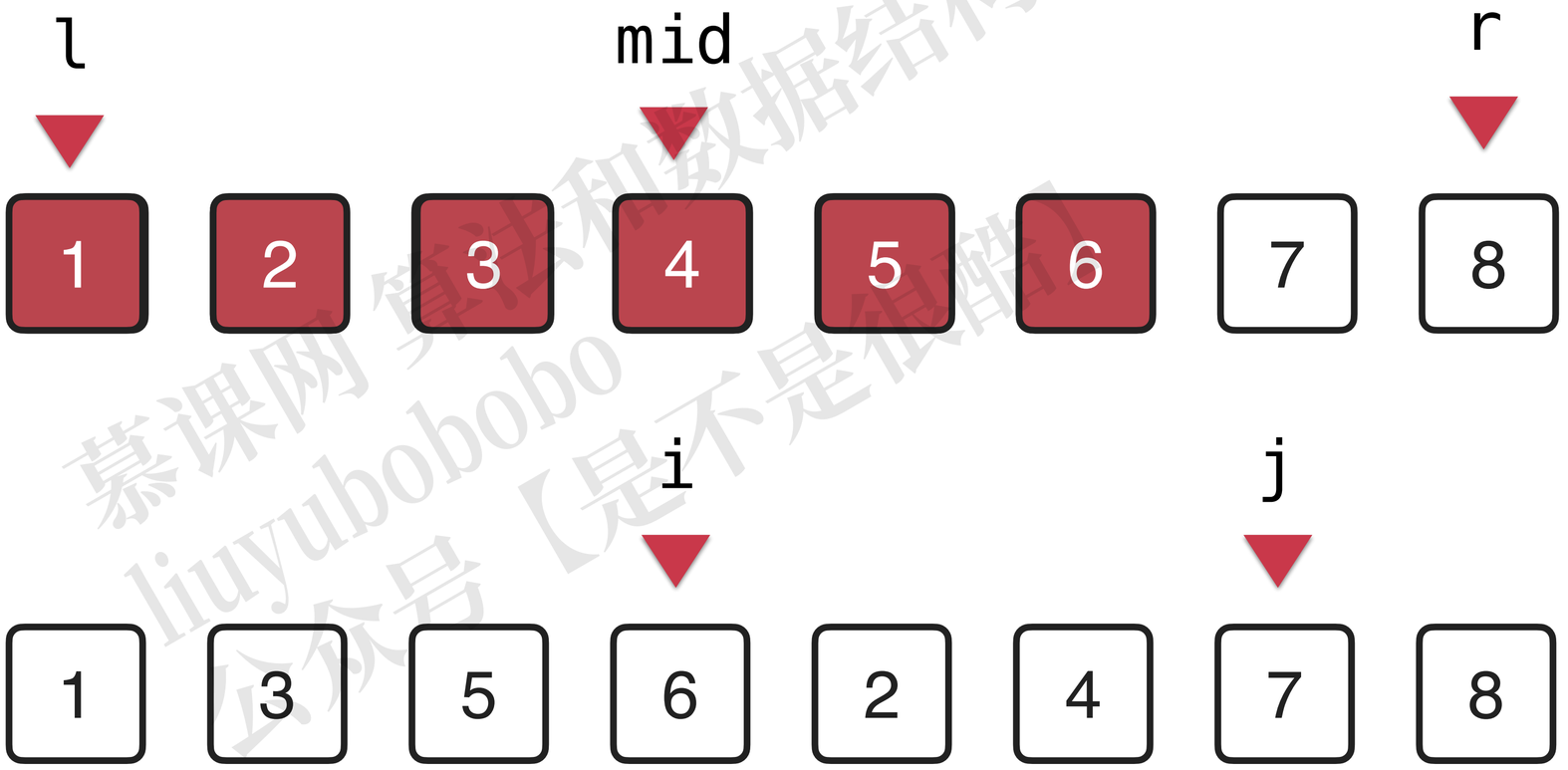

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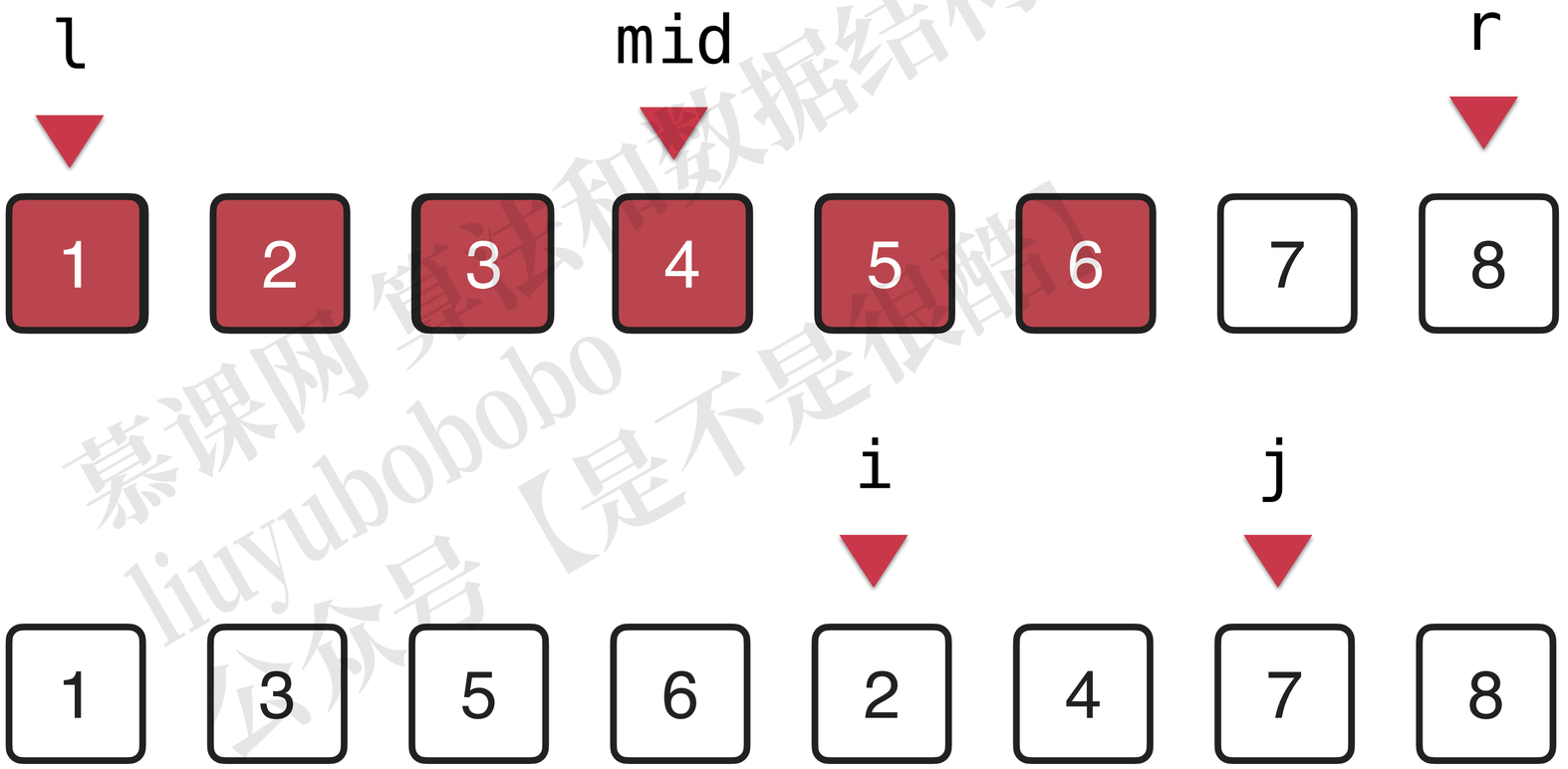

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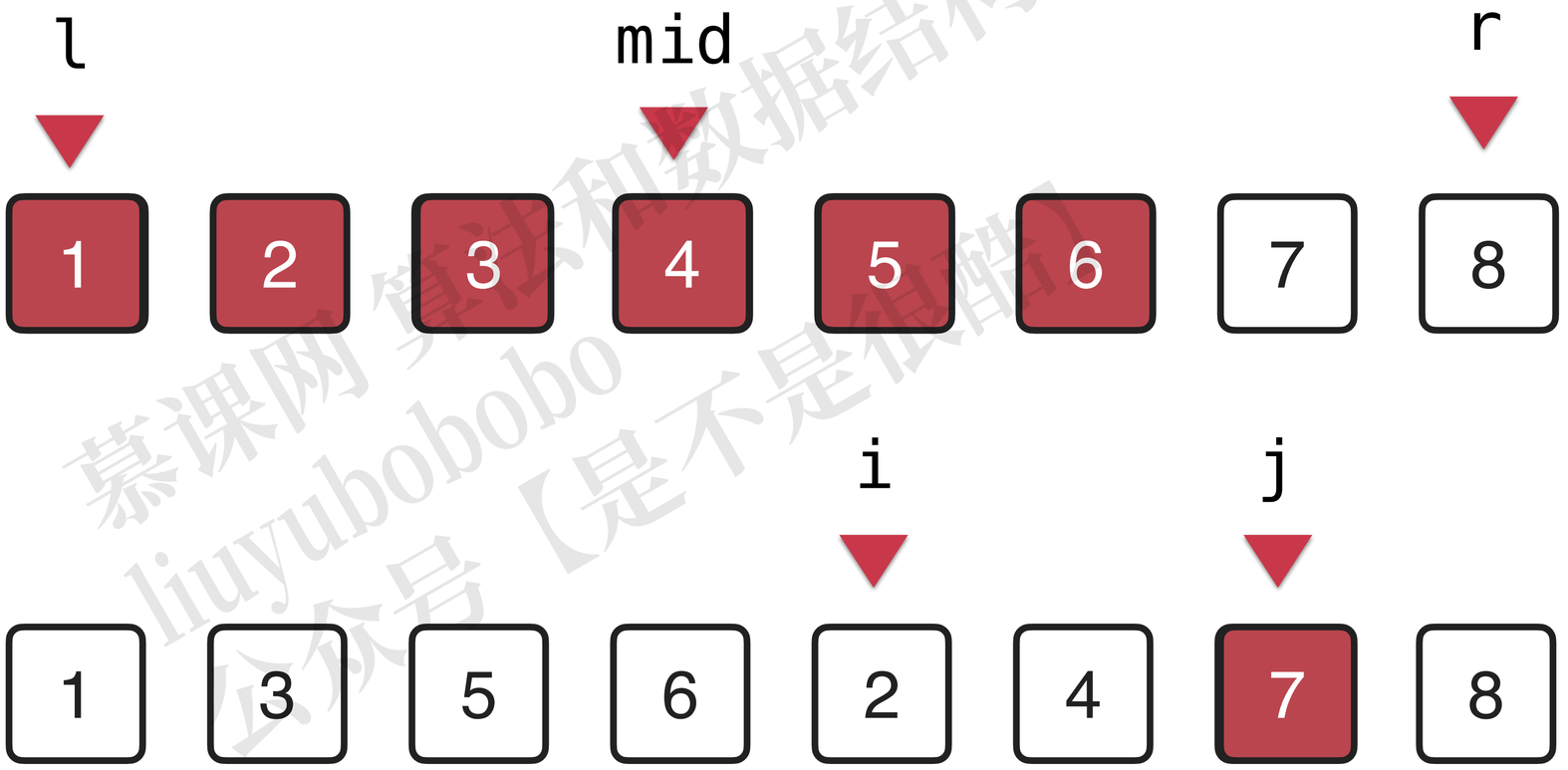

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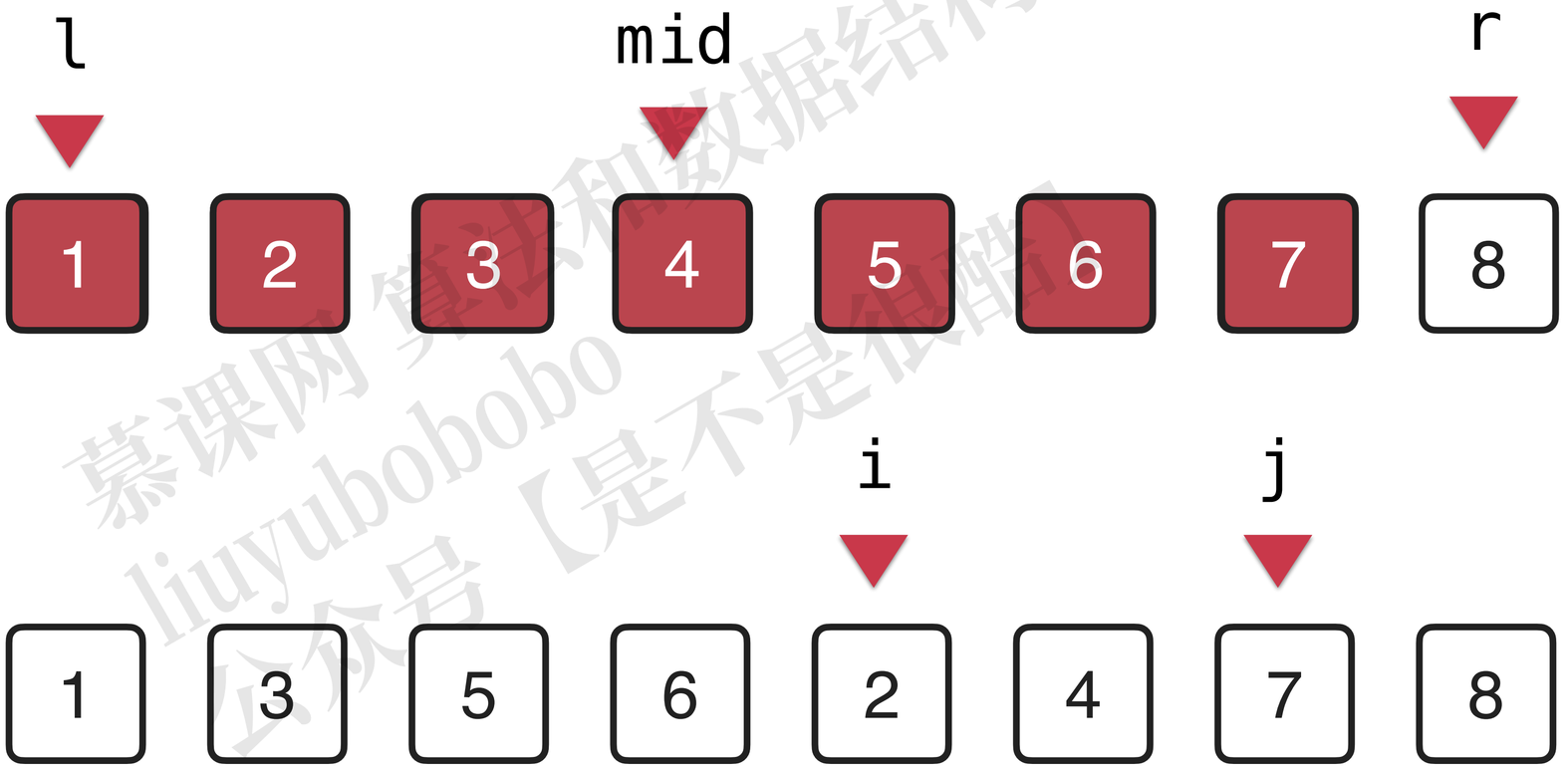

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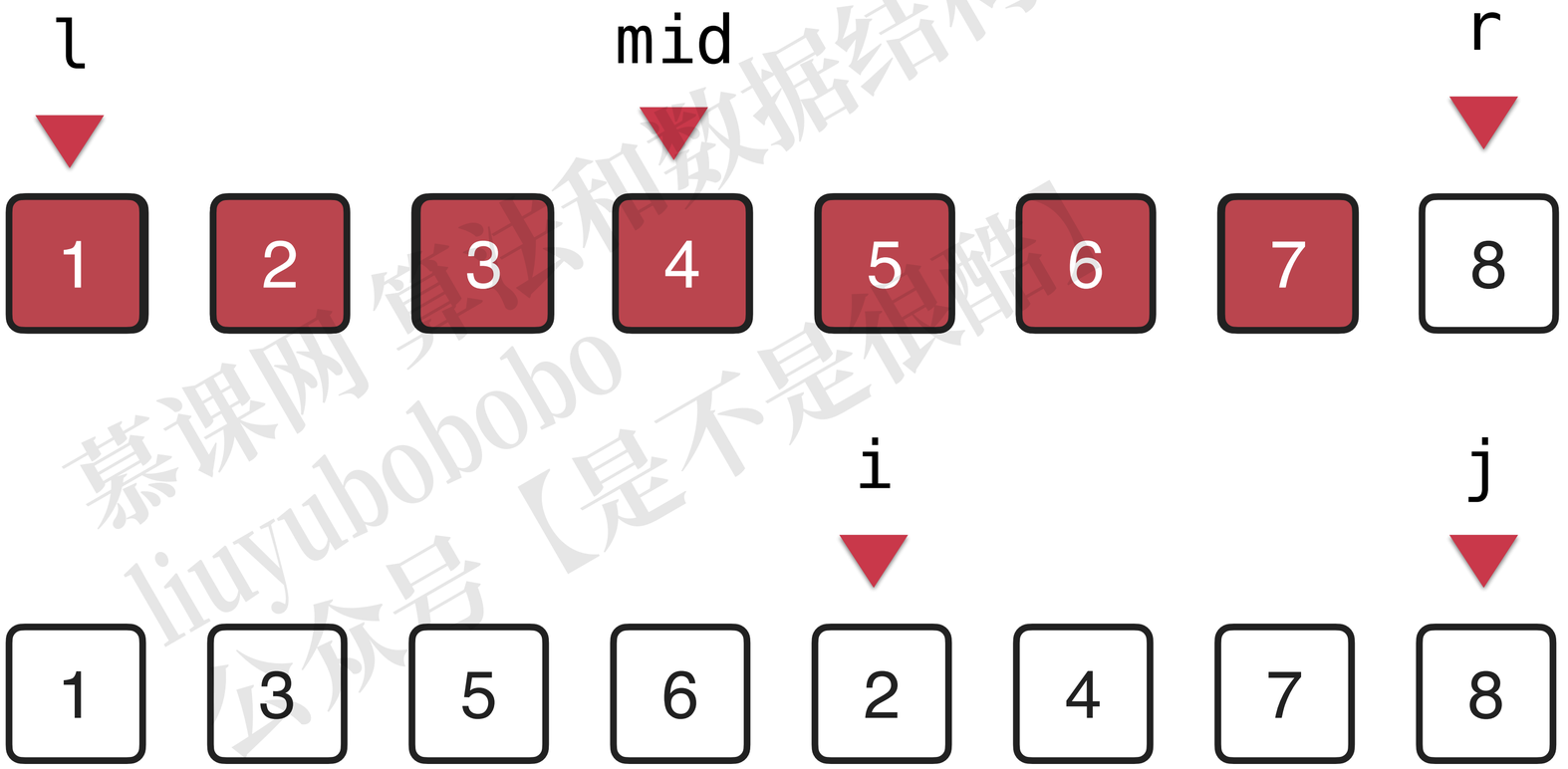

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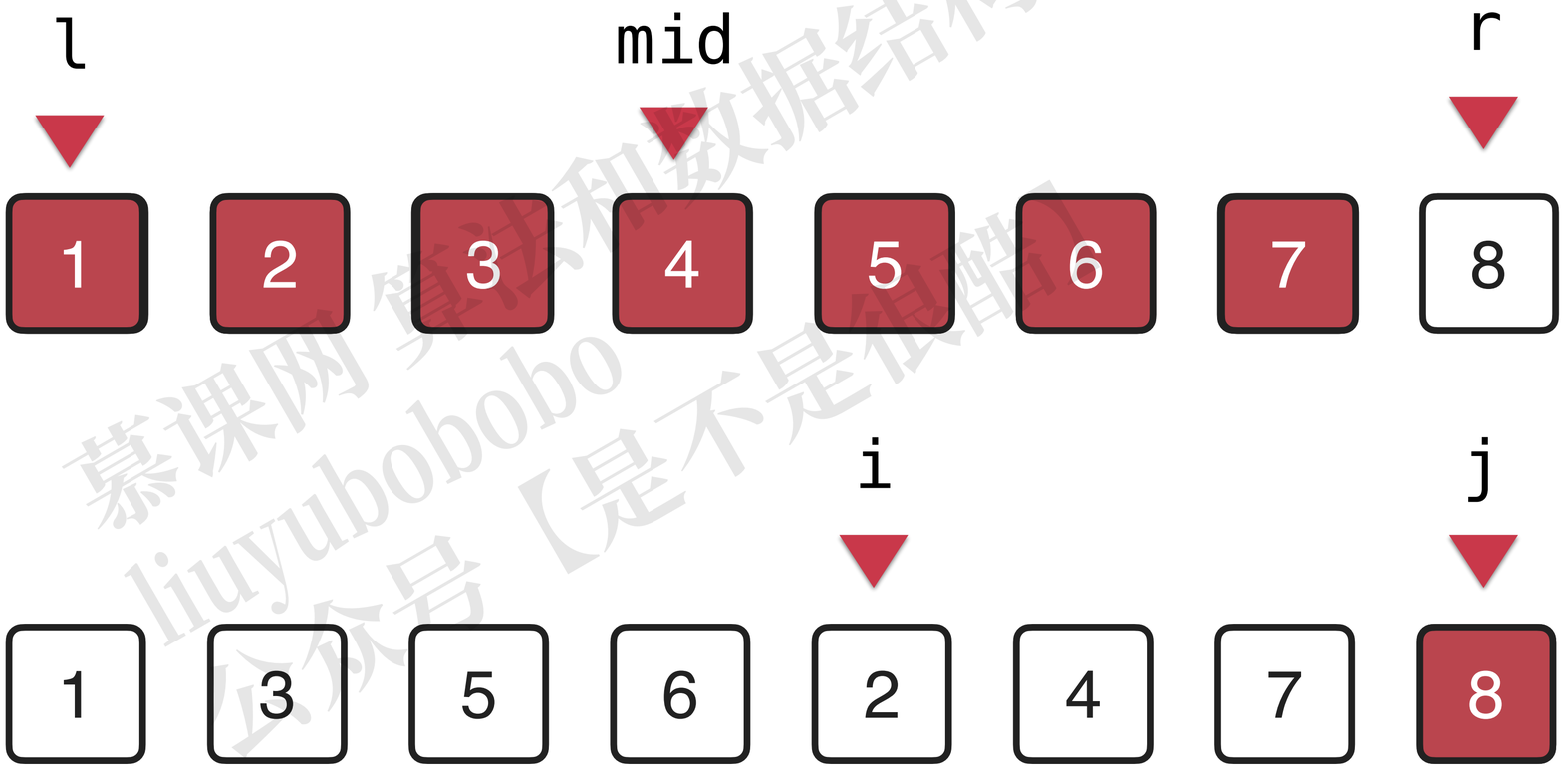

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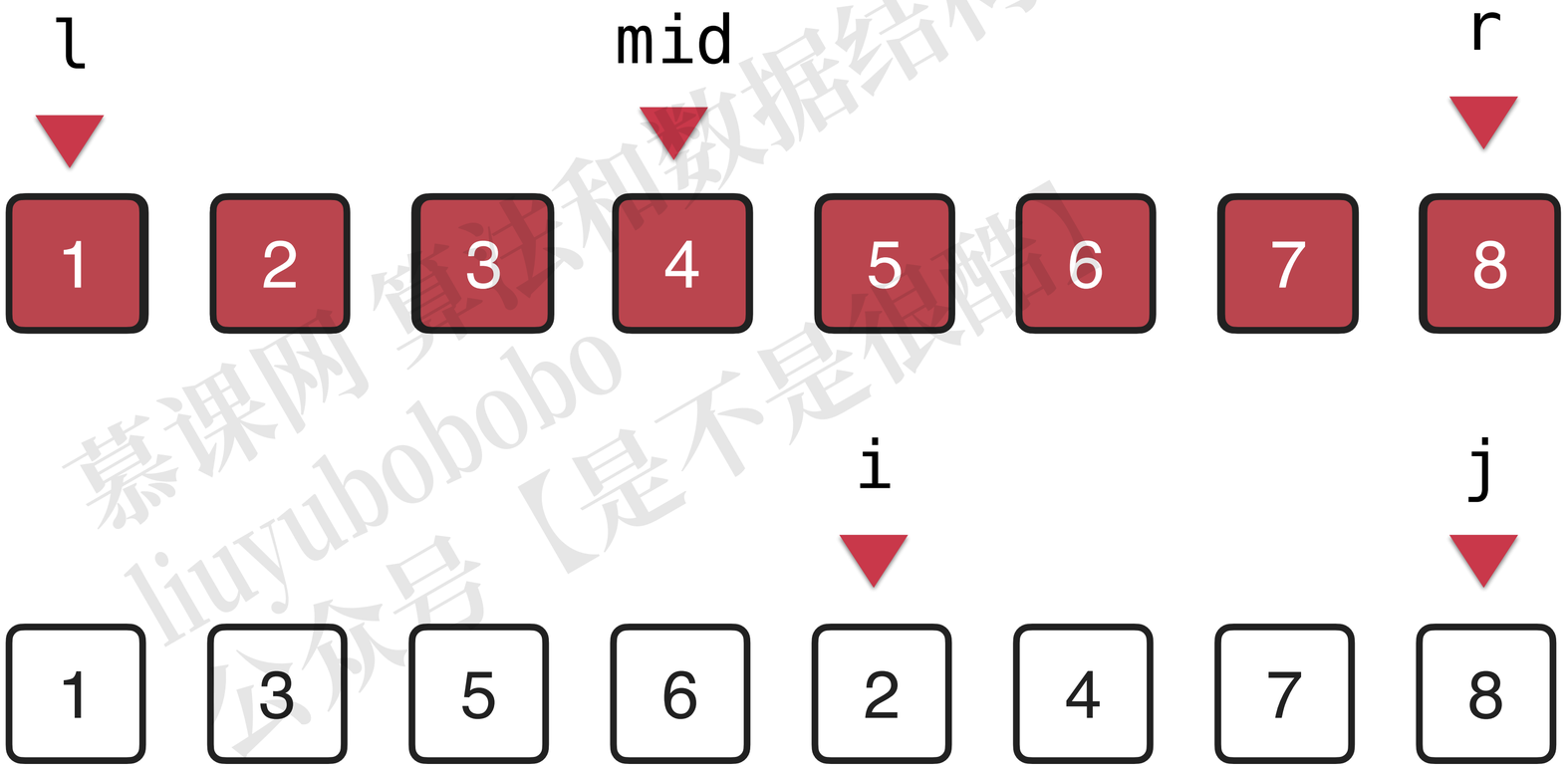
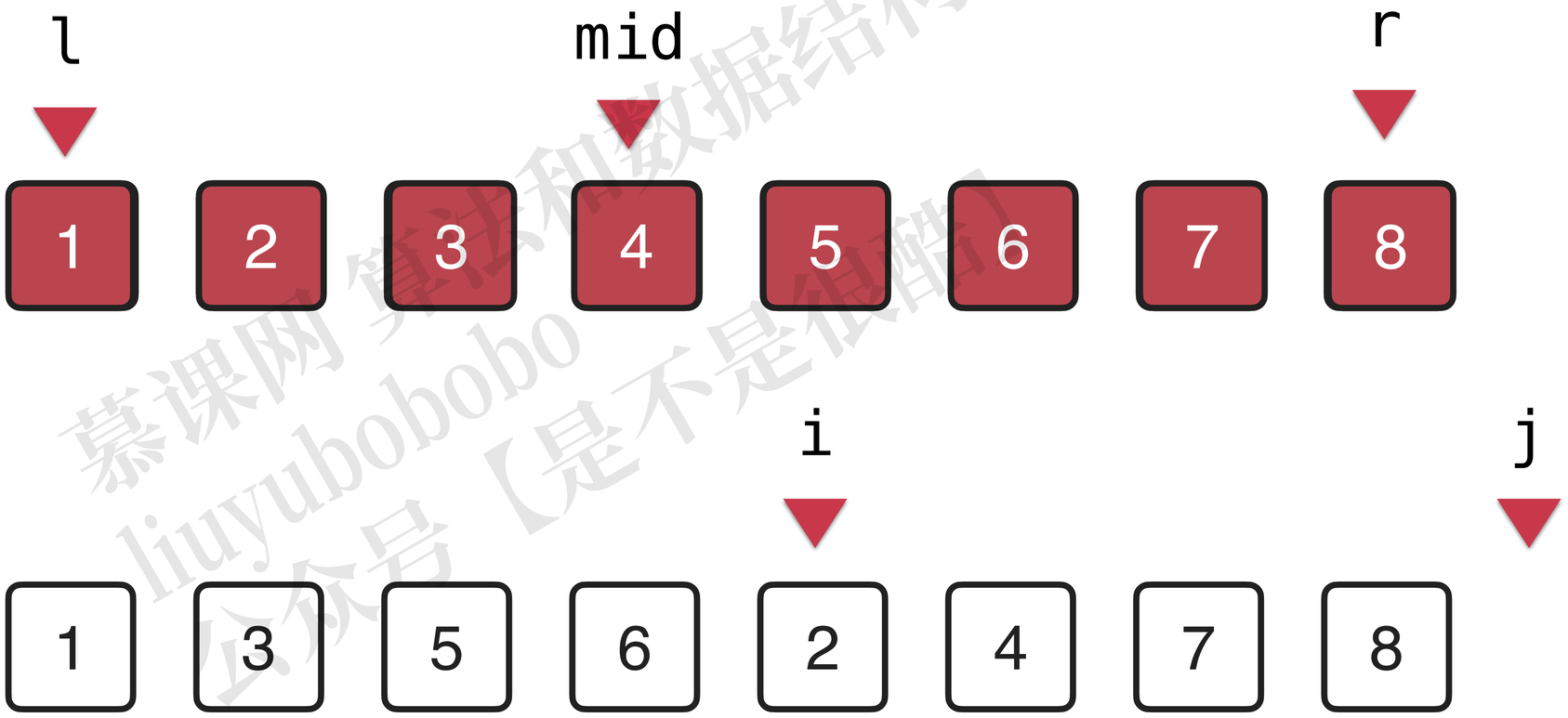


归并过程

归并的过程无法原地完成



实现归并过程

实践：实现归并过程

实现归并排序法

归并排序法

```
MergeSort(arr, l, r){

    if(l >= r) return;

    int mid = (l + r) / 2;

    // 对 arr[l, mid] 进行排序
    MergeSort(l, mid);

    // 对 arr[mid + 1, r] 进行排序
    MergeSort(mid + 1, r);

    // 将arr[l,mid]和arr[mid+1,r]合并
    merge(arr, l, mid, r);

}
```

求解最基本问题

把原问题转化成更小的问题

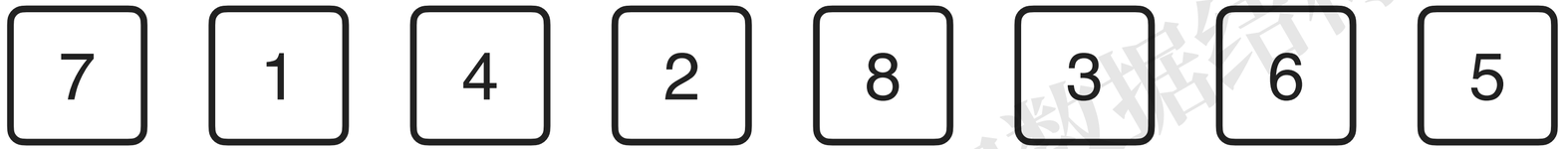
实践：实现归并排序法

归并排序算法的微观解读

归并排序算法的微观解读

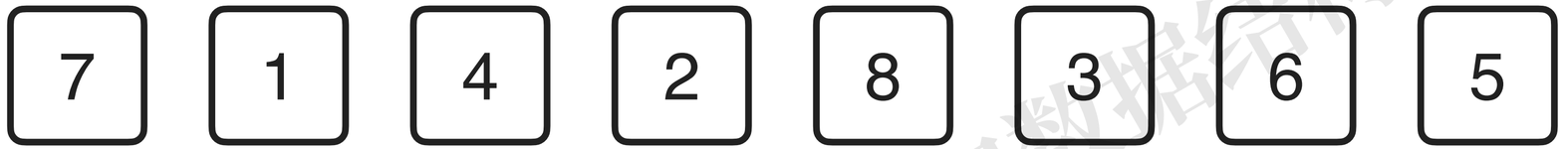
```
mergeSort(arr, l, r){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

归并排序算法的微观解读




```
mergeSort(arr, l, r){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

归并排序算法的微观解读

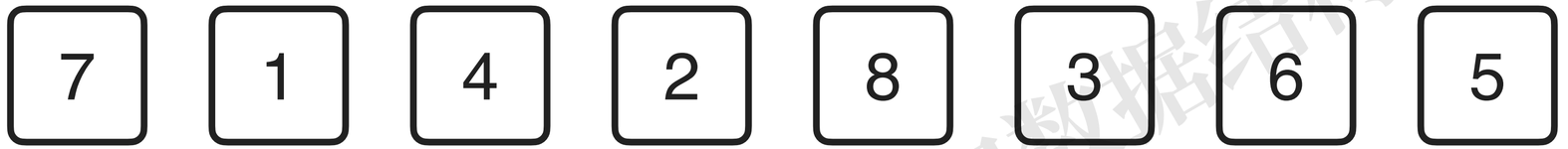


调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

```
mergeSort(arr, l, r){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

归并排序算法的微观解读




```
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    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
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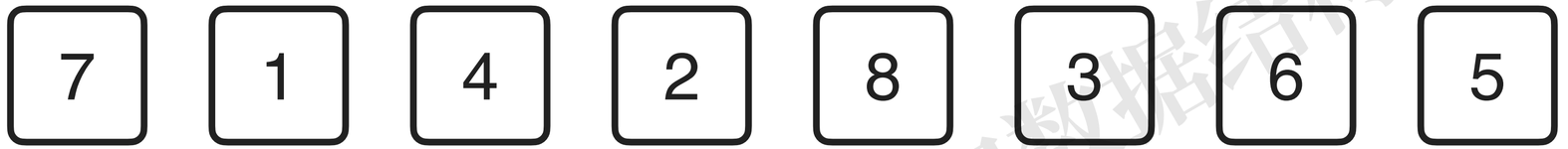
调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 3)

```
mergeSort(arr, l=0, r=3){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

归并排序算法的微观解读




```
mergeSort(arr, l, r){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

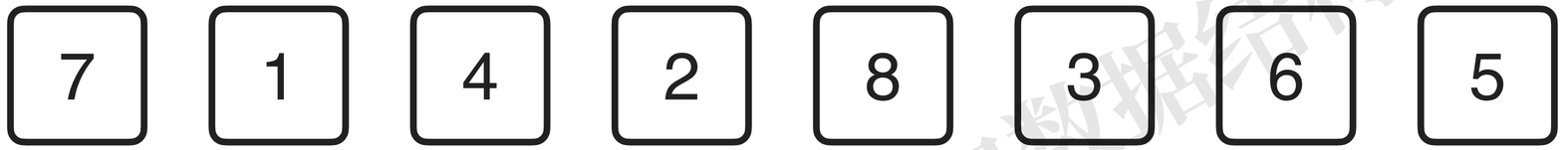
调用sort(arr, 0, 3)

```
mergeSort(arr, l=0, r=3){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 1)

```
mergeSort(arr, l=0, r=1){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

归并排序算法的微观解读




```
mergeSort(arr, l, r){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
→   mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 3)

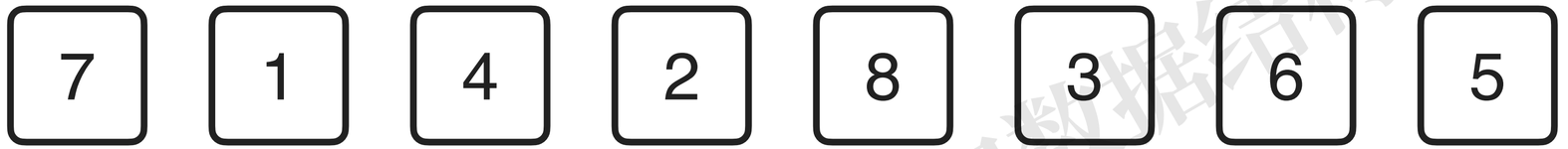
```
mergeSort(arr, l=0, r=3){
    if(l >= r) return;
→   mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 1)

```
mergeSort(arr, l=0, r=1){
    if(l >= r) return;
→   mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 0)

归并排序算法的微观解读




```
mergeSort(arr, l, r){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

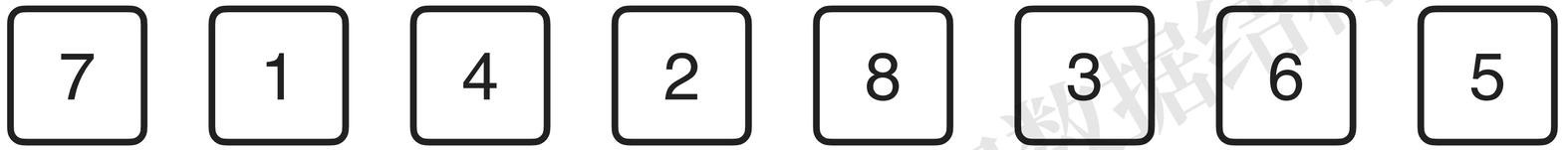
调用sort(arr, 0, 3)

```
mergeSort(arr, l=0, r=3){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 1)

```
mergeSort(arr, l=0, r=1){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

归并排序算法的微观解读




```
mergeSort(arr, l, r){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
→   mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 3)

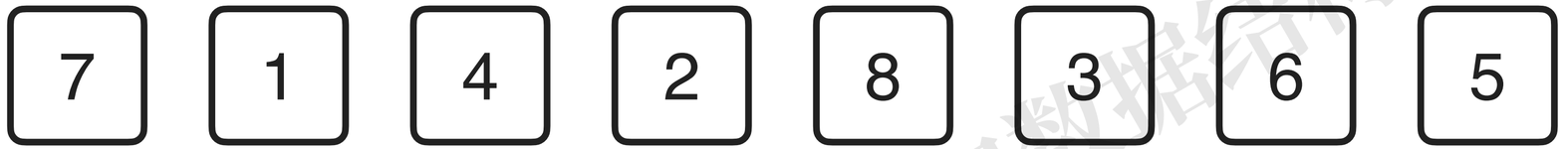
```
mergeSort(arr, l=0, r=3){
    if(l >= r) return;
→   mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 1)

```
mergeSort(arr, l=0, r=1){
    if(l >= r) return;
    mergeSort(arr, l, mid);
→   mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 1, 1)

归并排序算法的微观解读




```
mergeSort(arr, l, r){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
→   mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 3)

```
mergeSort(arr, l=0, r=3){
    if(l >= r) return;
→   mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 1)

```
mergeSort(arr, l=0, r=1){
    if(l >= r) return;
    mergeSort(arr, l, mid);
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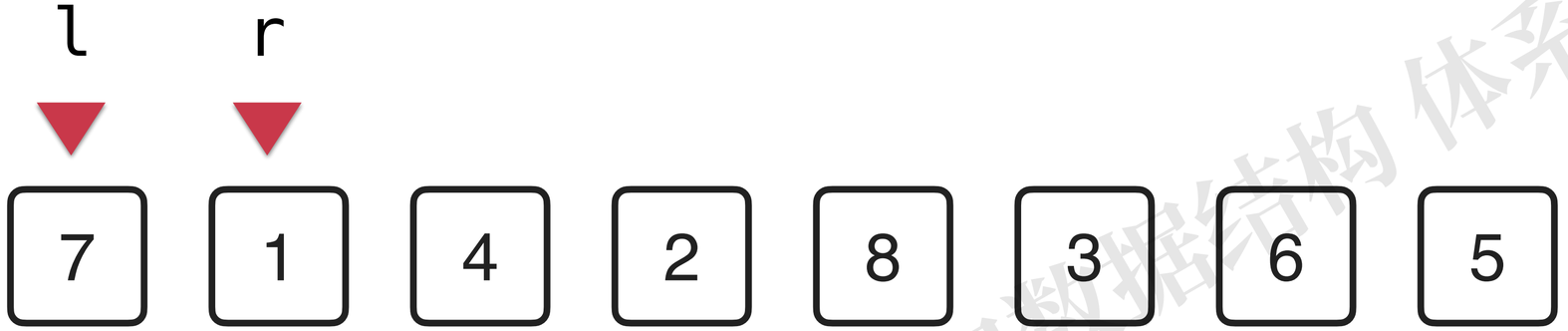
    merge(arr, l, mid, r);
}
```

归并排序算法的微观解读




```
mergeSort(arr, l, r){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
→   mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 3)

```
mergeSort(arr, l=0, r=3){
    if(l >= r) return;
→   mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

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mergeSort(arr, l=0, r=1){
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}
```

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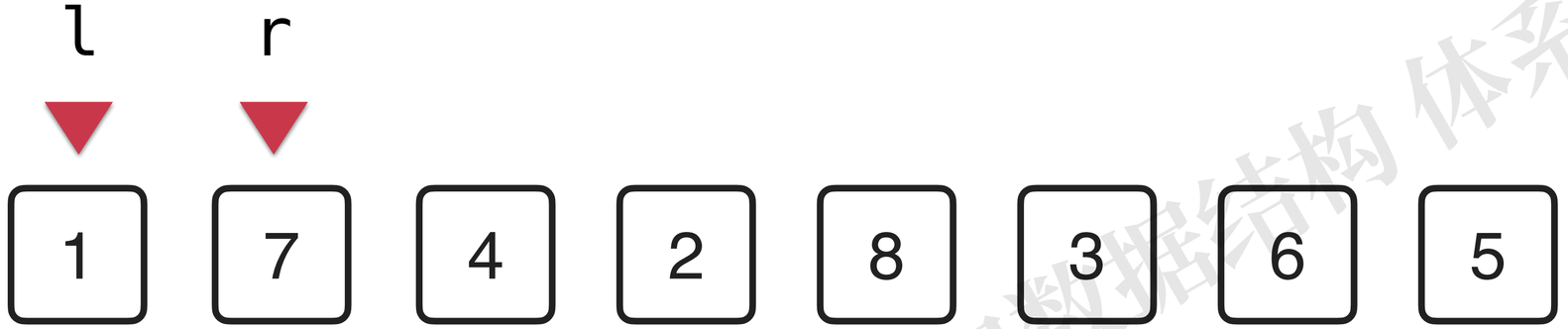


```
mergeSort(arr, l, r){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
→   mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 3)

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mergeSort(arr, l=0, r=3){
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}
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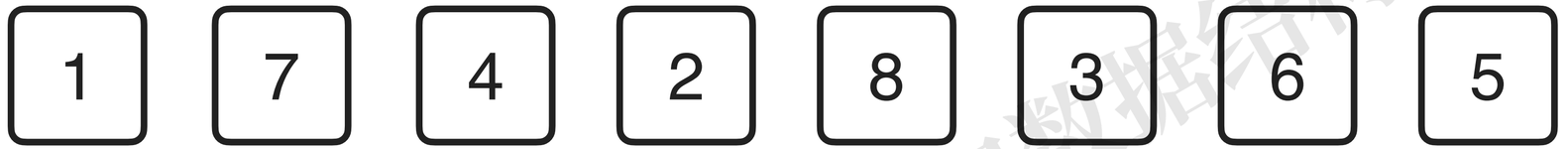
归并排序算法的微观解读

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    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
→   mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 3)

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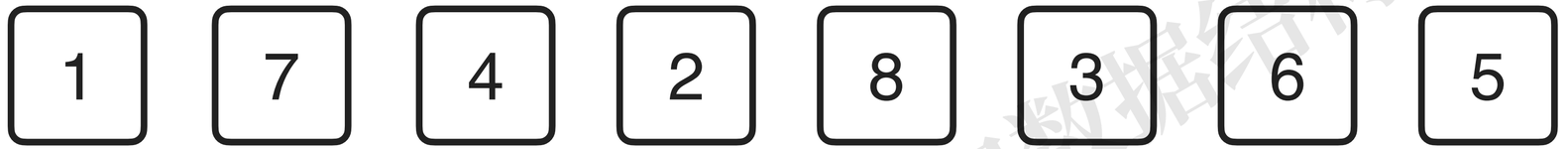


```
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    if(l >= r) return;
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    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
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    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 3)

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    if(l >= r) return;
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    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 1)

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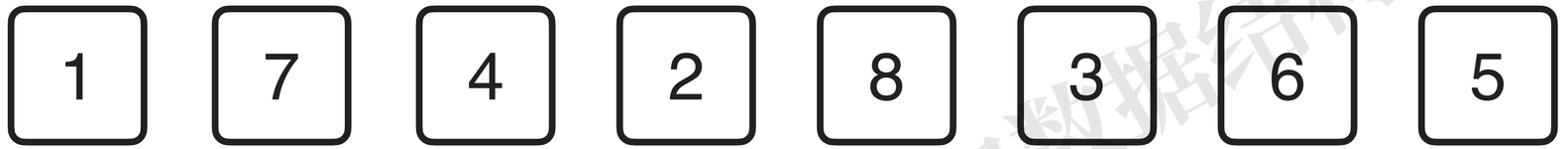
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

归并排序算法的微观解读




```
mergeSort(arr, l, r){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
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    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
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调用sort(arr, 0, 3)

```
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    merge(arr, l, mid, r);
}
```
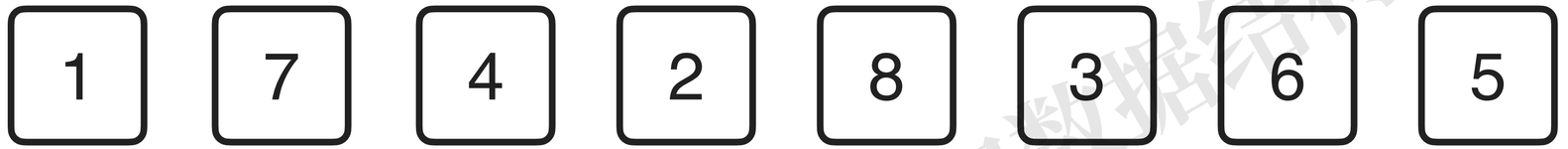

归并排序算法的微观解读




```
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    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
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    merge(arr, l, mid, r);
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调用sort(arr, 0, 3)

```
mergeSort(arr, l=0, r=3){
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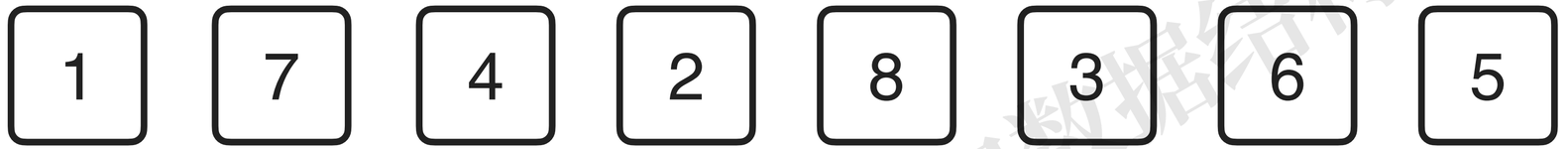
    merge(arr, l, mid, r);
}
```

归并排序算法的微观解读




```
mergeSort(arr, l, r){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
→   mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

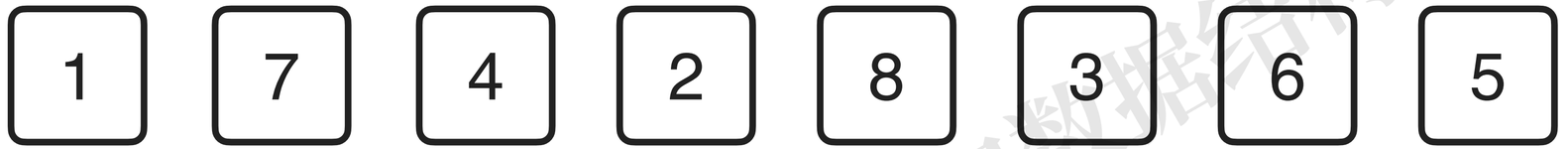
调用sort(arr, 0, 3)

```
mergeSort(arr, l=0, r=3){
    if(l >= r) return;
    mergeSort(arr, l, mid);
→   mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 2, 3)

```
mergeSort(arr, l=2, r=3){
→   if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

归并排序算法的微观解读




```
mergeSort(arr, l, r){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
→   mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 3)

```
mergeSort(arr, l=0, r=3){
    if(l >= r) return;
    mergeSort(arr, l, mid);
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    merge(arr, l, mid, r);
}
```

调用sort(arr, 2, 3)

```
mergeSort(arr, l=2, r=3){
    if(l >= r) return;
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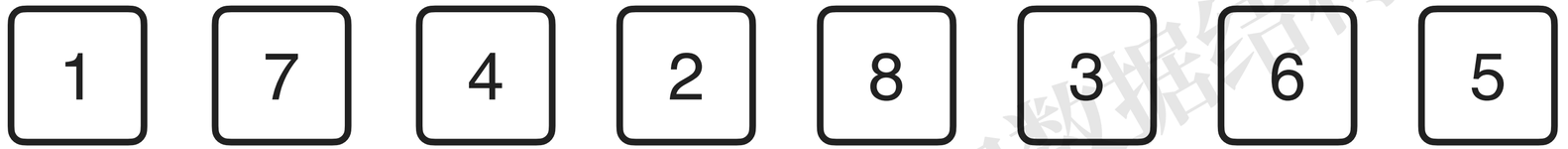
    merge(arr, l, mid, r);
}
```

归并排序算法的微观解读




```
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    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
→   mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 3)

```
mergeSort(arr, l=0, r=3){
    if(l >= r) return;
    mergeSort(arr, l, mid);
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    merge(arr, l, mid, r);
}
```

调用sort(arr, 2, 3)

```
mergeSort(arr, l=2, r=3){
    if(l >= r) return;
    mergeSort(arr, l, mid);
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    merge(arr, l, mid, r);
}
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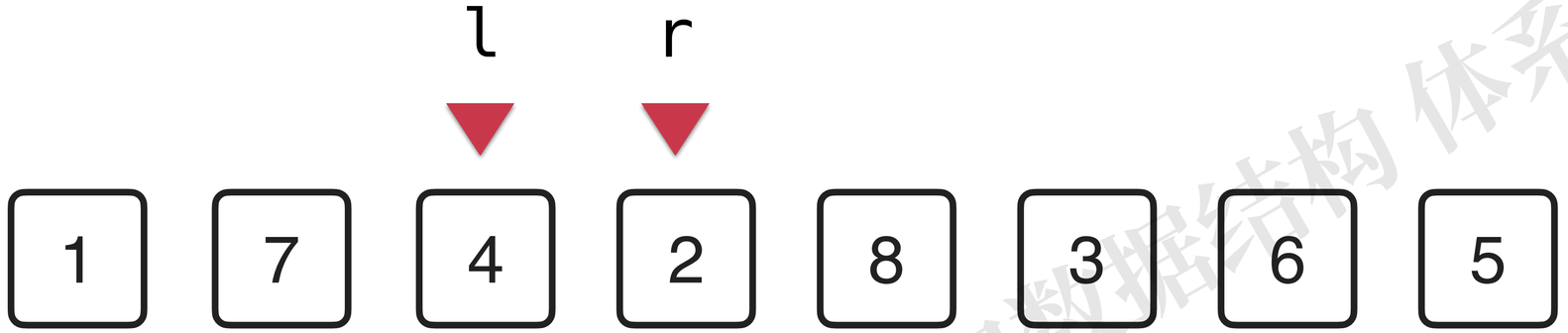
归并排序算法的微观解读




```
mergeSort(arr, l, r){
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    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
→   mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 3)

```
mergeSort(arr, l=0, r=3){
    if(l >= r) return;
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    merge(arr, l, mid, r);
}
```

调用sort(arr, 2, 3)

```
mergeSort(arr, l=2, r=3){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
→   merge(arr, l, mid, r);
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```
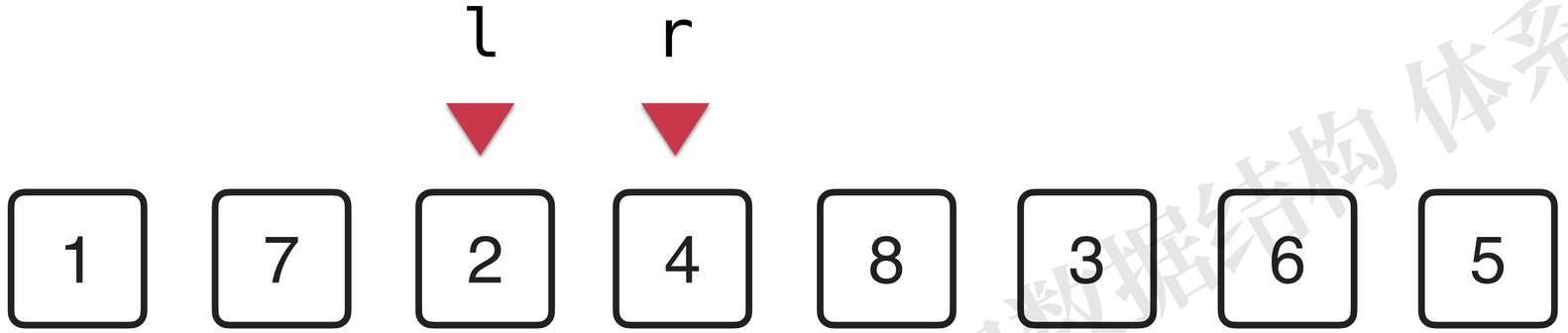

归并排序算法的微观解读

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调用sort(arr, 0, 7)

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调用sort(arr, 0, 3)

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    if(l >= r) return;
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调用sort(arr, 2, 3)

```
mergeSort(arr, l=2, r=3){
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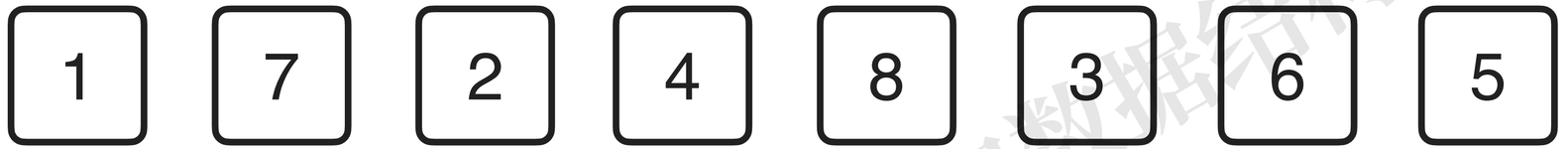


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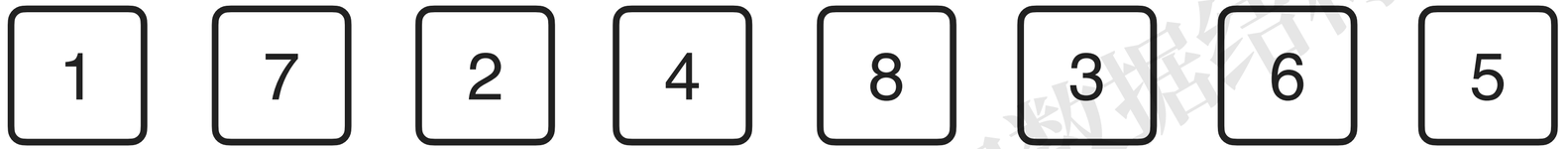


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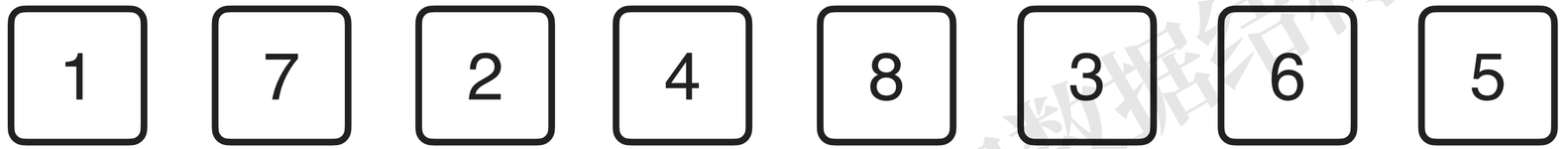
```
mergeSort(arr, l=0, r=3){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 2, 3)

```
mergeSort(arr, l=2, r=3){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

归并排序算法的微观解读




```
mergeSort(arr, l, r){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

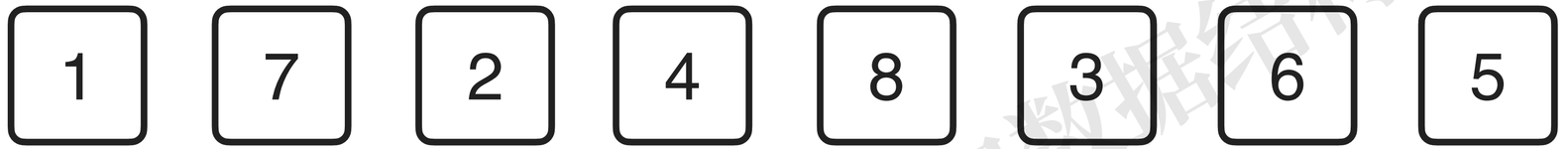
调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 3)

```
mergeSort(arr, l=0, r=3){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

归并排序算法的微观解读




```
mergeSort(arr, l, r){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

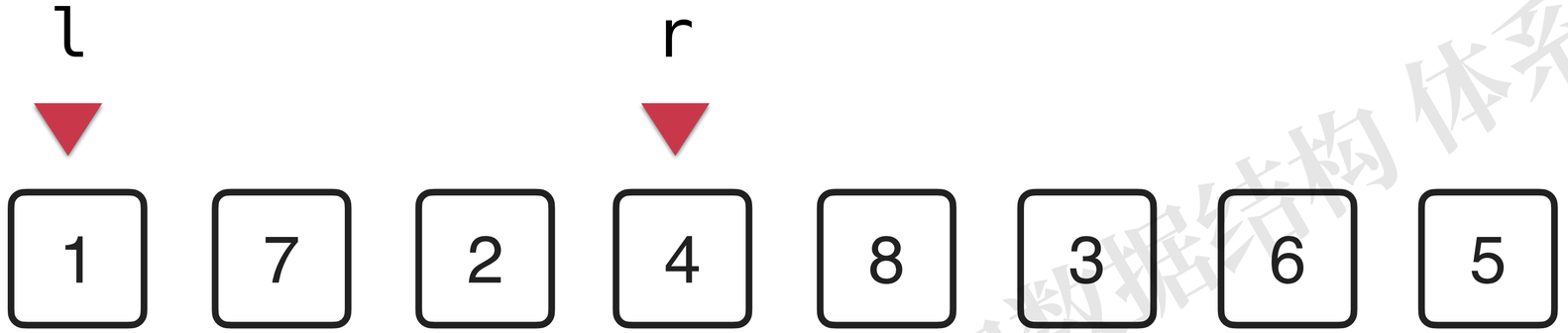
调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 3)

```
mergeSort(arr, l=0, r=3){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

归并排序算法的微观解读




```
mergeSort(arr, l, r){
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    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
    mergeSort(arr, l, mid);
    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
}
```

调用sort(arr, 0, 3)

```
mergeSort(arr, l=0, r=3){
    if(l >= r) return;
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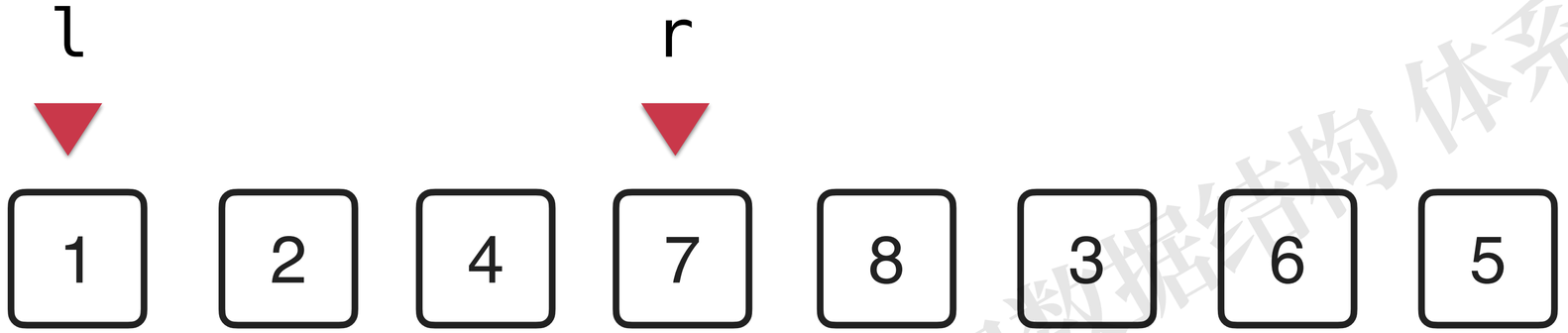
    merge(arr, l, mid, r);
}
```

归并排序算法的微观解读




```
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    merge(arr, l, mid, r);
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```

调用sort(arr, 0, 7)

```
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调用sort(arr, 0, 3)

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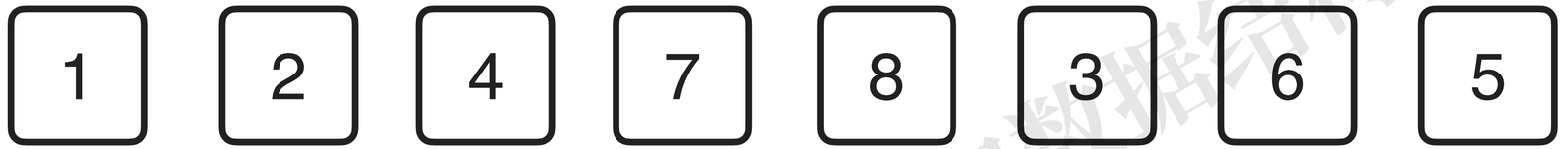
归并排序算法的微观解读

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调用sort(arr, 0, 7)

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调用sort(arr, 0, 3)

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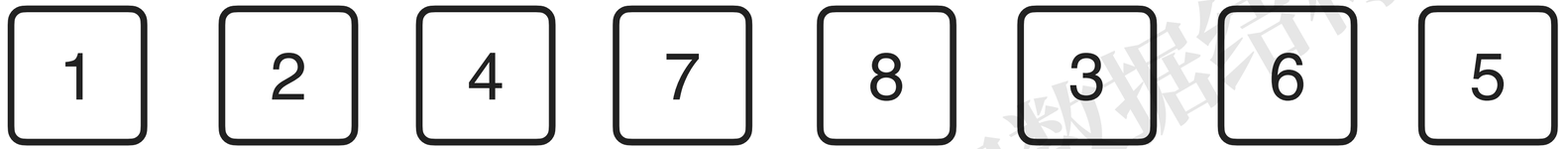
归并排序算法的微观解读

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    merge(arr, l, mid, r);
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调用sort(arr, 0, 3)

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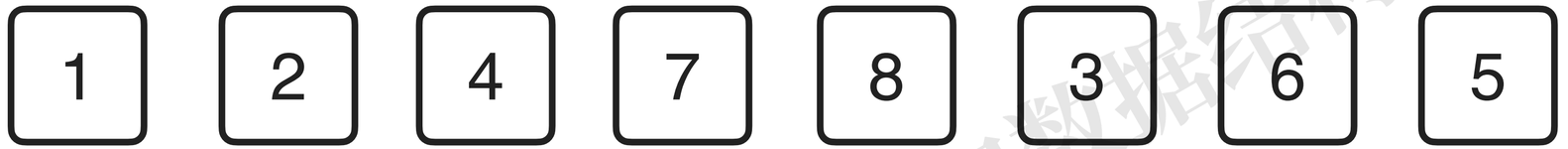
    merge(arr, l, mid, r);
}
```

归并排序算法的微观解读

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```
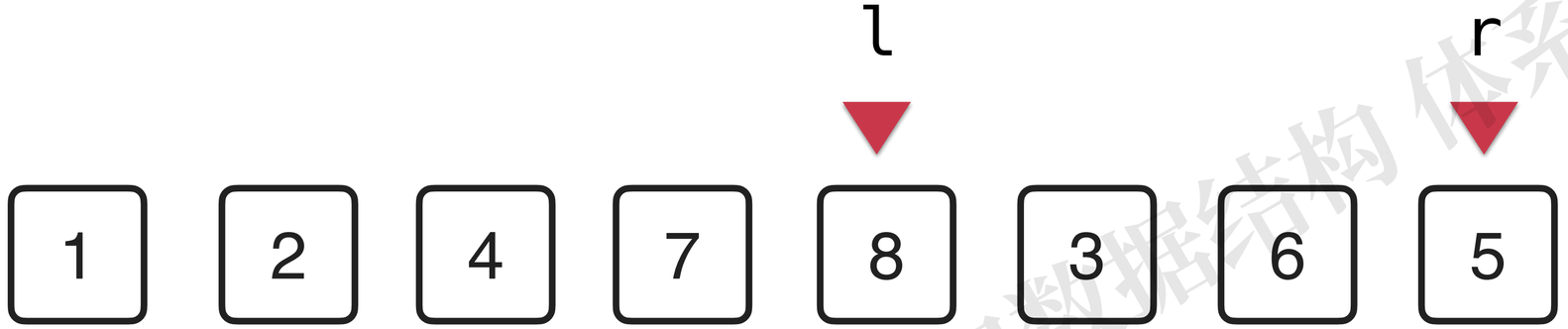

归并排序算法的微观解读

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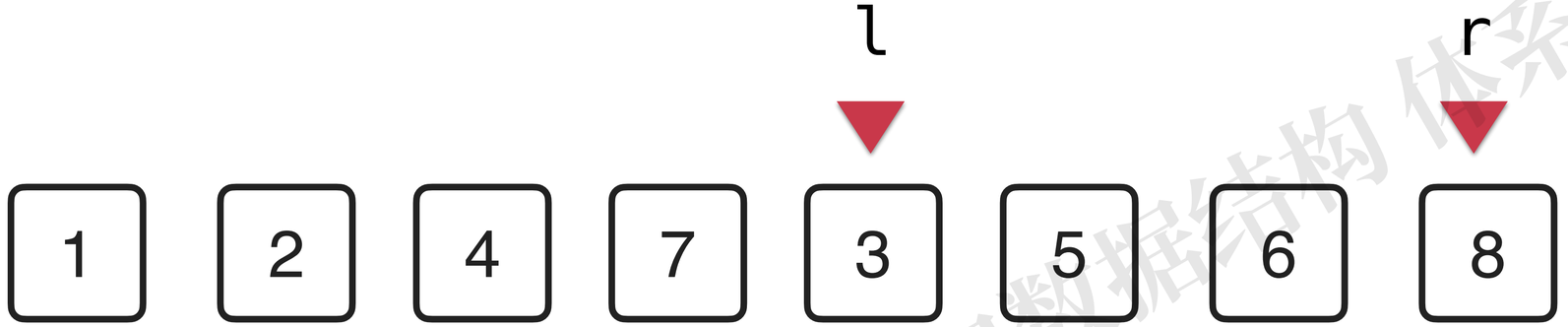


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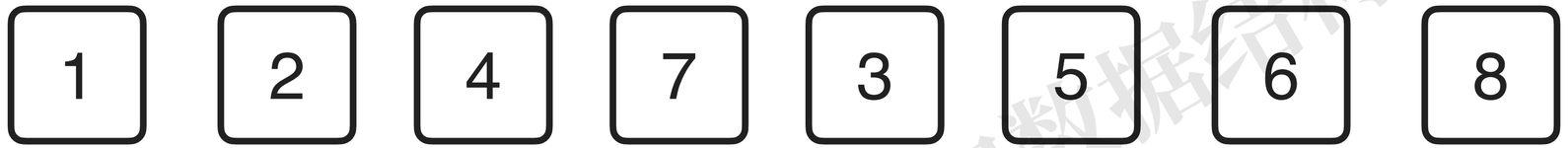
归并排序算法的微观解读



调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
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    mergeSort(arr, mid+1, r);
    merge(arr, l, mid, r);
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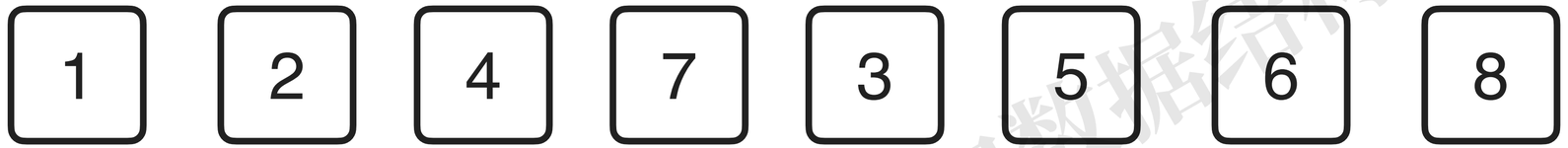
归并排序算法的微观解读

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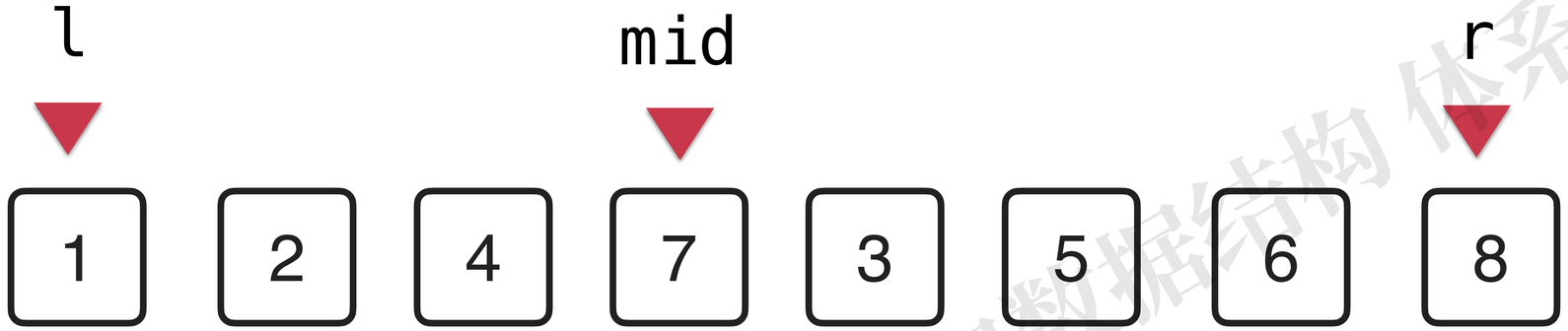
归并排序算法的微观解读



调用sort(arr, 0, 7)

```
mergeSort(arr, l=0, r=7){
    if(l >= r) return;
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```
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}
```
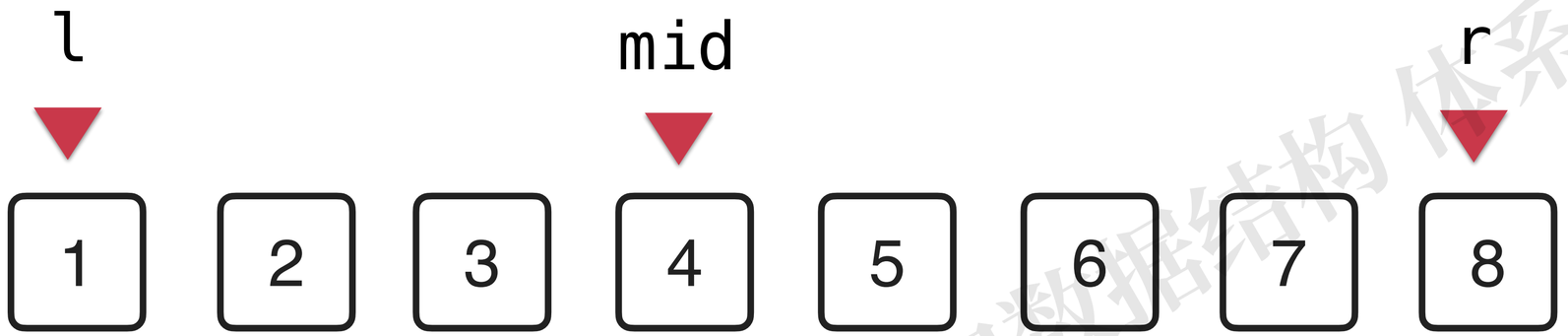

归并排序算法的微观解读



调用sort(arr, 0, 7)

```
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    mergeSort(arr, mid+1, r);
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}
```
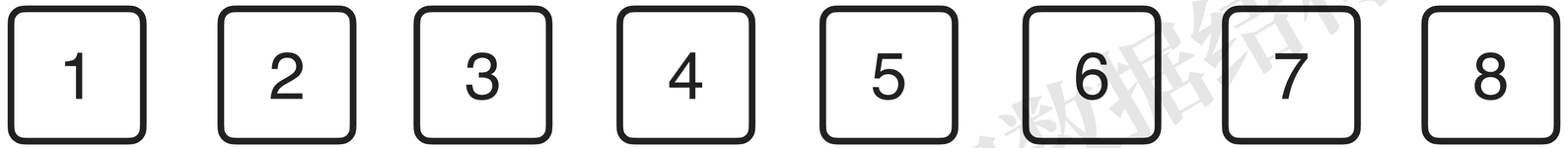

归并排序算法的微观解读



调用sort(arr, 0, 7)

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mergeSort(arr, l=0, r=7){
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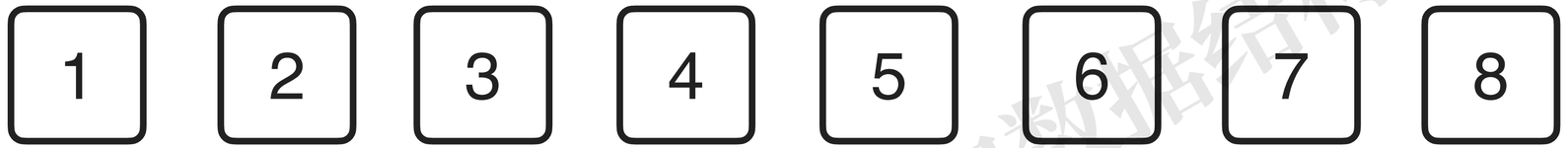
归并排序算法的微观解读



调用sort(arr, 0, 7)

```
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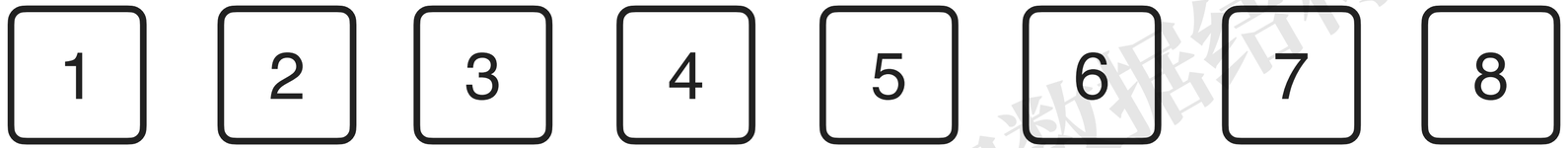
归并排序算法的微观解读

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    merge(arr, l, mid, r);
}
```

作业：打印输出看归并排序的过程

作业解析：打印输出看归并排序的过程

归并排序法的复杂度分析

实践：归并排序法的性能测试

归并排序法的复杂度分析

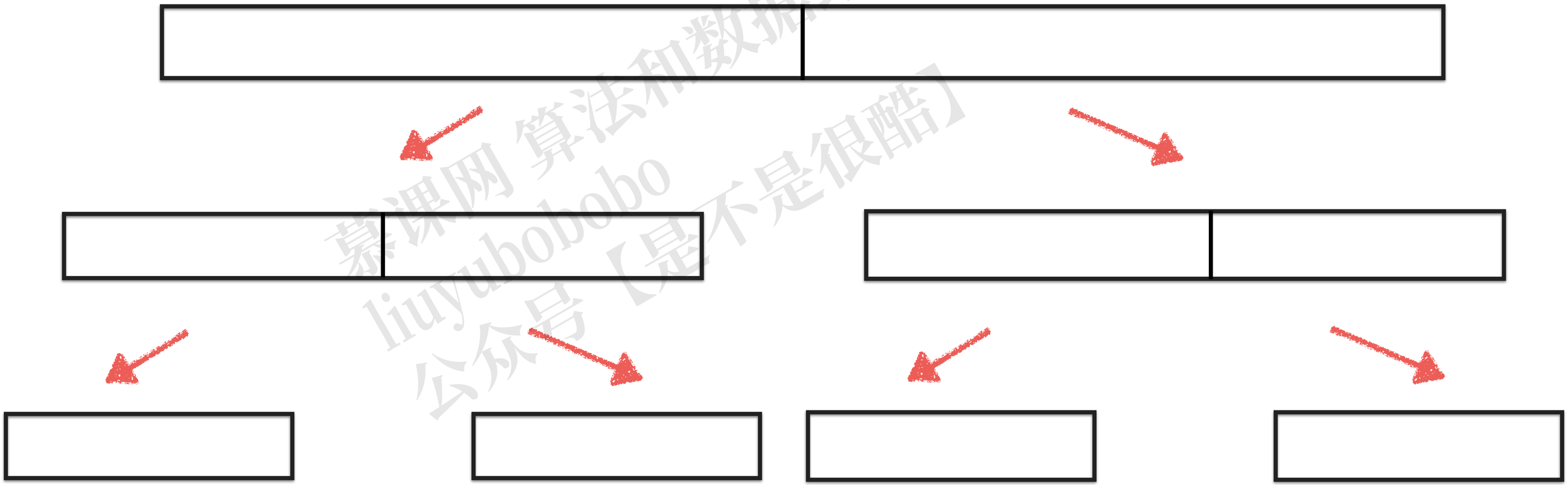
O(nlogn)

nlogn 比 n^2 快多少?

	n^2	nlogn	faster
n = 10	100	33	3
n = 100	10000	664	15
n = 1000	10^6	9966	100
n = 10000	10^8	132877	753
n = 100000	10^10	1660964	6020

归并排序法的复杂度分析

O(nlogn)

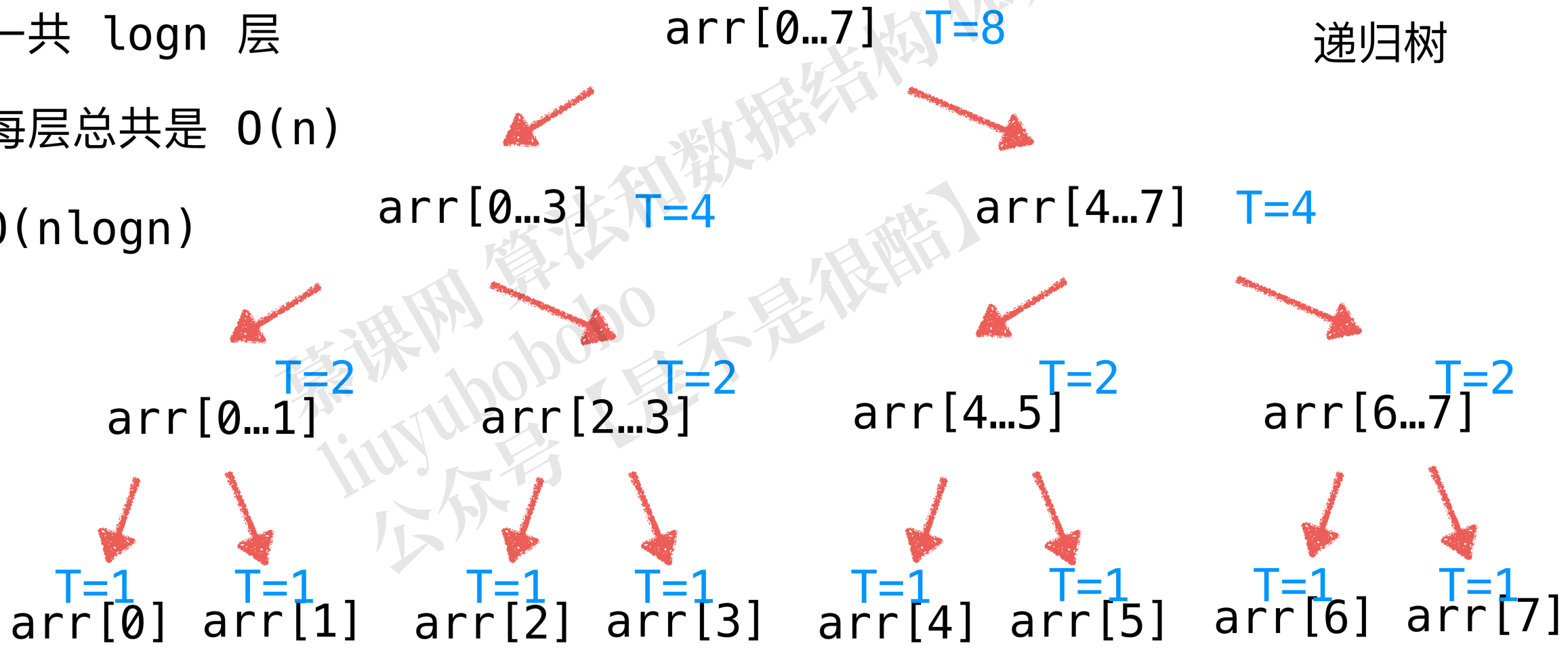


归并排序法的复杂度分析

一共 logn 层

每层总共是 O(n)

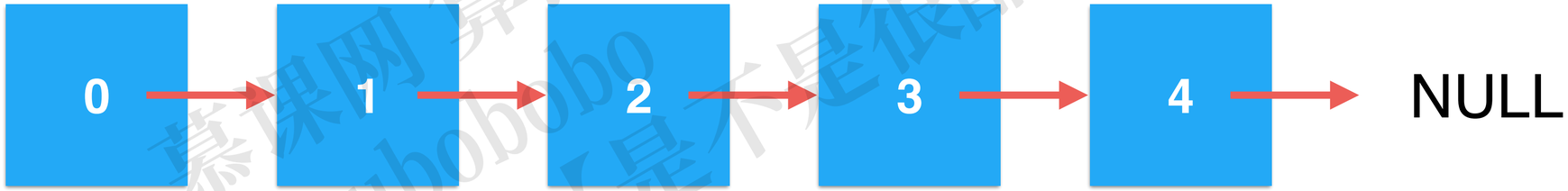
O(nlogn)



归并排序法的复杂度分析

递归函数的复杂度分析　　递归树

回忆链表？也有递归树



[0…4]删除 → [1…4]删除 → [2…4]删除 → [3…4]删除 → [4]删除

递归树退化成链表

归并排序法的复杂度分析

递归函数的复杂度分析　　递归树

主定理

过于理论化，对于一般面试没必要掌握

如果感兴趣可以参考《算法导论》

其他

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