# 玩儿转数据结构

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# 链表与递归

# 从Leetcode上一个问题开始

# 203. 删除链表中的元素

在链表中删除值为val的所有节点

- 如 1->2->6->3->4->5->6->NULL，要求删除值为6的节点
- 返回 1->2->3->4->5->NULL

# 实践：解决203，不使用虚拟头结点

# 实践：测试leetcode上的链表程序

# 实践：解决203，使用虚拟头结点

# 递归与递归的宏观语意

# 递归

- 本质上，将原来的问题，转化为更小的同一问题

- 举例：数组求和

Sum( arr[0…n-1] ) = arr[0] + Sum( arr[1…n-1] ) ← 更小的同一问题

Sum( arr[1…n-1] ) = arr[1] + Sum( arr[2…n-1] ) ← 更小的同一问题

……

Sum( arr[n-1…n-1] ) = arr[n-1] + Sum( [] ) ← 最基本的问题

# 实践：递归数组求和

# 递归

- 注意递归函数的“宏观”语意
- 递归函数就是一个函数，完成一个功能

```
// 计算 arr[l…n) 范围里的数字和
public static int sum(int[] arr, int l){

    if(l == arr.length)
        return 0;

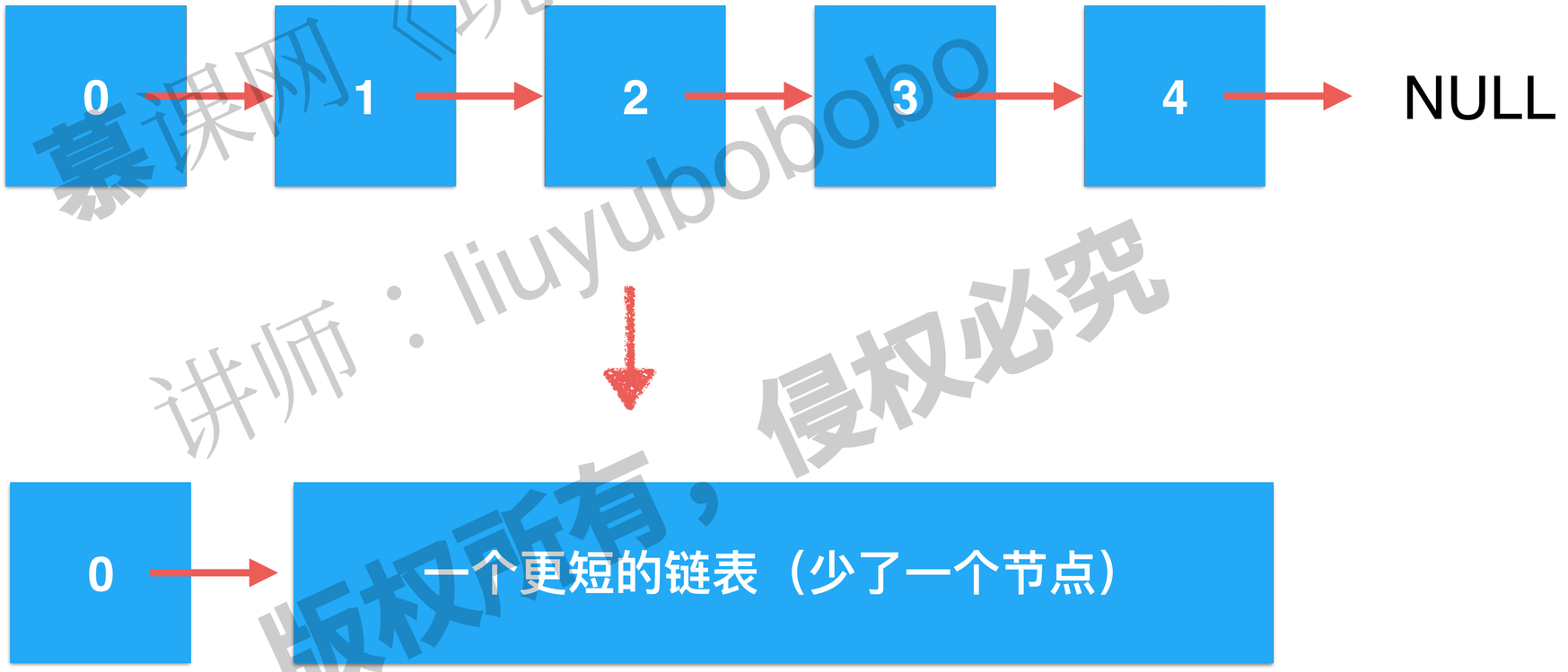
    return arr[l] + sum(arr, l + 1);
}
```

求解最基本问题

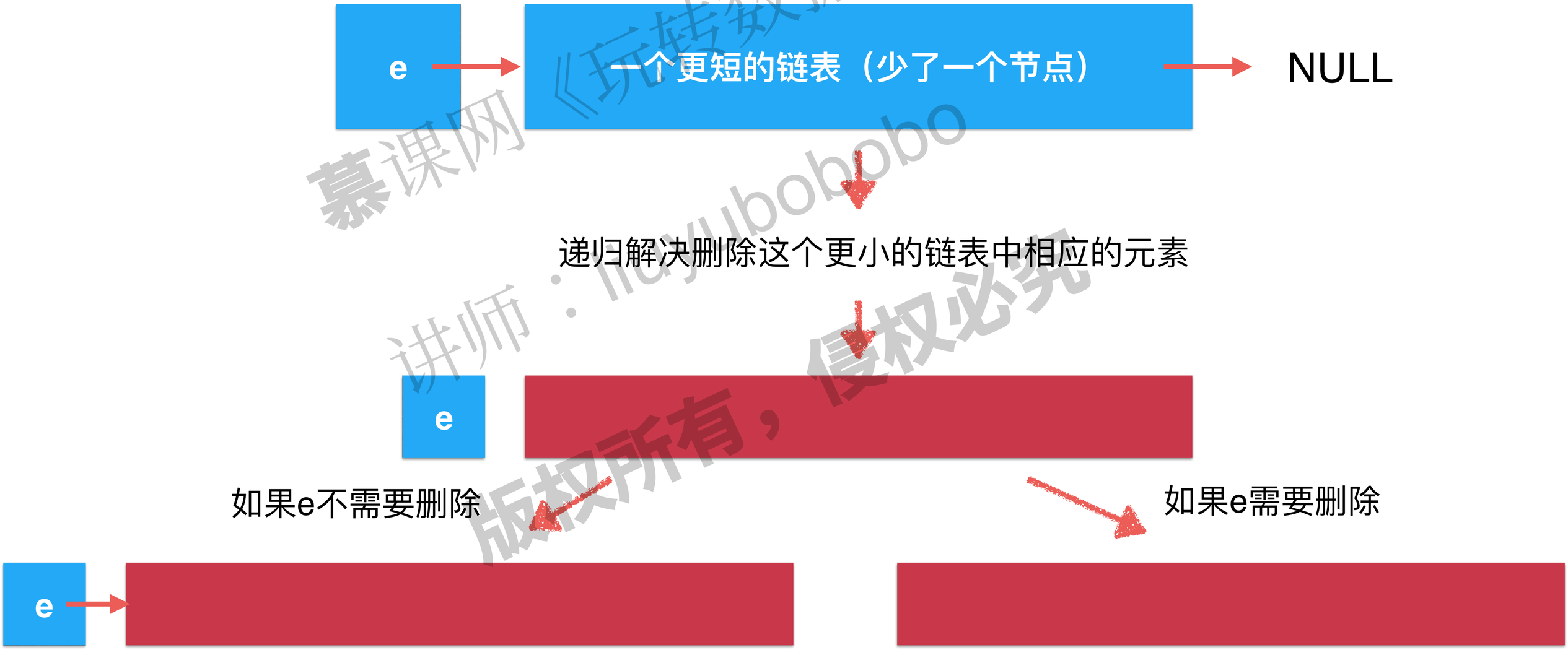
把原问题转化成更小的问题

# 链表和递归

# 链表天然的递归性



# 解决链表中删除元素的问题



# 实践：Leetcode 203 使用递归思路求解

# 递归函数的“微观”解读

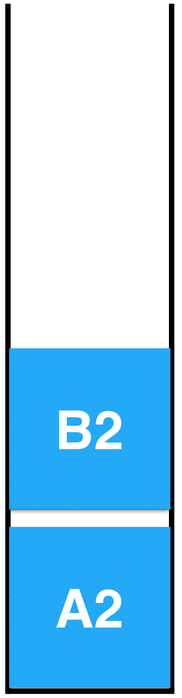
# 栈的应用

- 程序调用的系统栈

```
func A(){
1    …
2    B()
3    …
}
```

```
func B(){
1    …
2    C()
3    …
}
```

```
func C(){
1    …
2    …
3    …
}
```



# 递归函数的“微观”解读

```
public static int sum(int[] arr, int l){

    if(l == arr.length)
        return 0;

    return arr[l] + sum(arr, l + 1);
}
```

# 递归函数的“微观”解读

- 递归函数的调用，本质就是函数调用
- 只不过调用的函数是自己而已

```
public static int sum(int[] arr, int l){

    if(l == arr.length)
        return 0;

    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

# 递归函数的“微观”解读

arr = [6, 10]

调用sum(arr, 0)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

# 递归函数的“微观”解读

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调用sum(arr, 0)

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    if(l == n) return 0;
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    int res = arr[l] + x;
    return res;
}
```

# 递归函数的“微观”解读

arr = [6, 10]

调用sum(arr, 0)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

调用sum(arr, 1)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

# 递归函数的“微观”解读

arr = [6, 10]

调用sum(arr, 0)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

调用sum(arr, 1)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

# 递归函数的“微观”解读

arr = [6, 10]

调用sum(arr, 0)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

调用sum(arr, 1)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

调用sum(arr, 2)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

# 递归函数的“微观”解读

arr = [6, 10]

调用sum(arr, 0)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

调用sum(arr, 1)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

调用sum(arr, 2)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

x = 0

# 递归函数的“微观”解读

arr = [6, 10]

调用sum(arr, 0)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

调用sum(arr, 1)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

调用sum(arr, 2)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

x = 0

res = 10

# 递归函数的“微观”解读

arr = [6, 10]

调用sum(arr, 0)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

调用sum(arr, 1)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

调用sum(arr, 2)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

x = 0

res = 10

# 递归函数的“微观”解读

arr = [6, 10]

调用sum(arr, 0)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

调用sum(arr, 1)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

调用sum(arr, 2)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

x = 0

res = 10

# 递归函数的“微观”解读

arr = [6, 10]

调用sum(arr, 0)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

x = 10

调用sum(arr, 1)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

x = 0

res = 10

调用sum(arr, 2)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

# 递归函数的“微观”解读

arr = [6, 10]

调用sum(arr, 0)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

x = 10

res = 16

调用sum(arr, 1)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

x = 0

res = 10

调用sum(arr, 2)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

# 递归函数的“微观”解读

arr = [6, 10]

调用sum(arr, 0)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

x = 10

res = 16

调用sum(arr, 1)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

x = 0

res = 10

调用sum(arr, 2)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

# 递归函数的“微观”解读

arr = [6, 10]

调用sum(arr, 0)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

x = 10

res = 16

调用sum(arr, 1)

```
int sum(int[] arr, int l){

    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

x = 0

res = 10

调用sum(arr, 2)

```
int sum(int[] arr, int l){

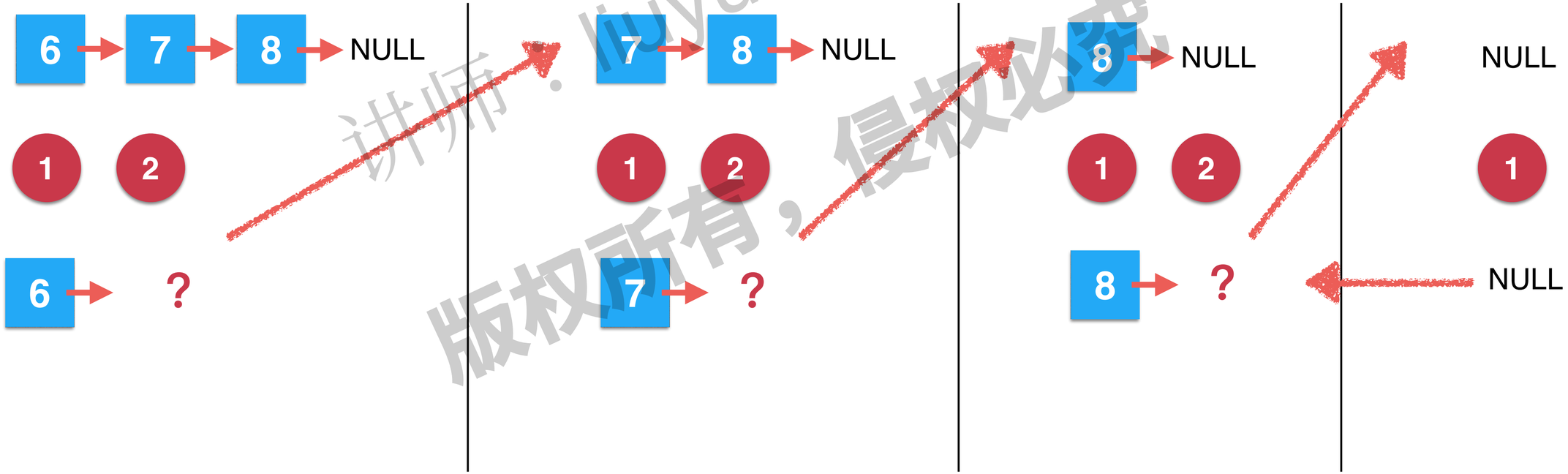
    if(l == n) return 0;
    int x = sum(arr, l + 1);
    int res = arr[l] + x;
    return res;
}
```

```java
public ListNode removeElements(ListNode head, int val) {

1    if(head == null)
         return null;

2    head.next = removeElements(head.next, val);
3    return head.val == val ? head.next : head;
}
```

模拟调用,对 6->7->8->null 删除7



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```

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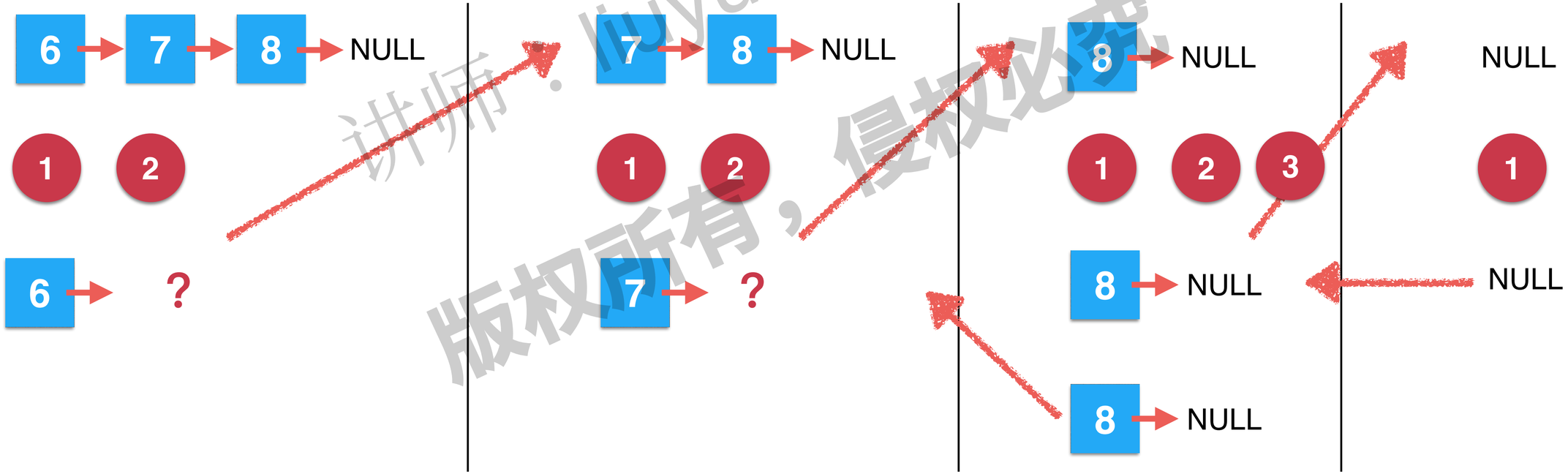

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}
```
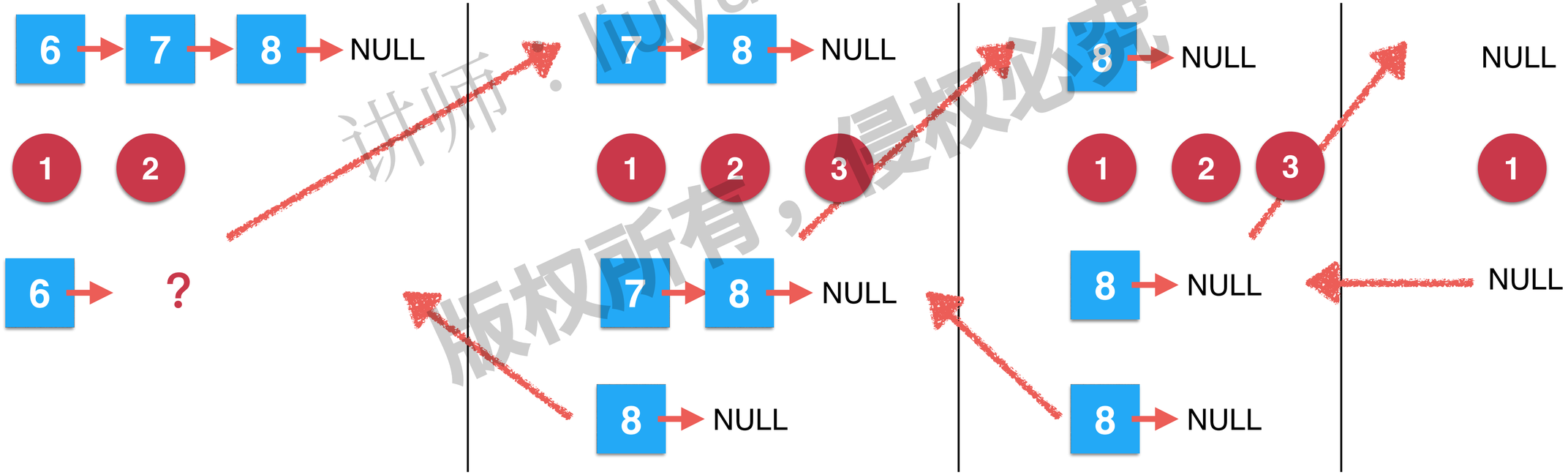

模拟调用,对 6->7->8->null 删除7



```java
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1    if(head == null)
         return null;

2    head.next = removeElements(head.next, val);
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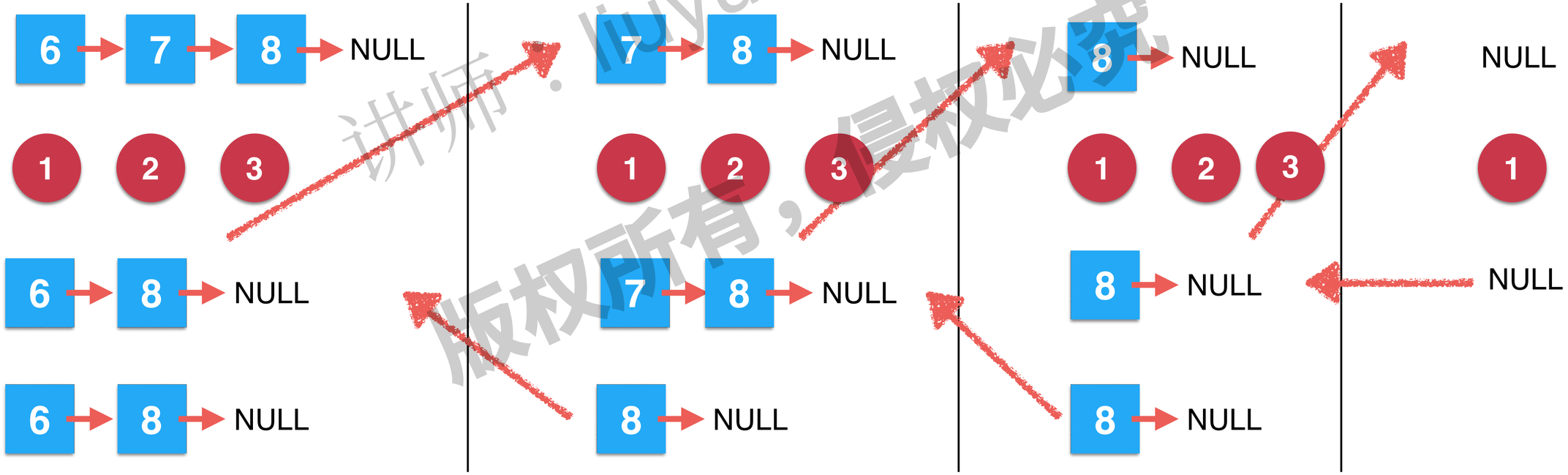
```

模拟调用,对 6->7->8->null 删除7



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         return null;

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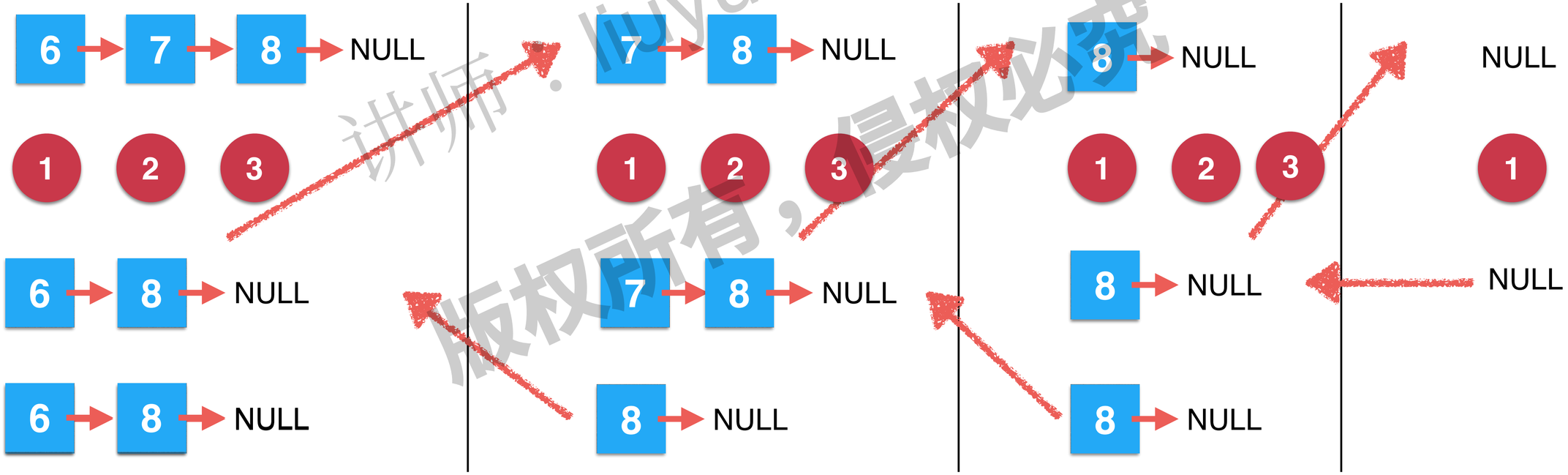
}
```

模拟调用,对 6->7->8->null 删除7



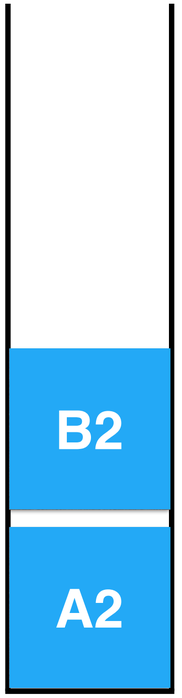
# 栈的应用

- 程序调用的系统栈

```
func A(){
1    …
2    B()
3    …
}
```

```
func B(){
1    …
2    C()
3    …
}
```

```
func C(){
1    …
2    …
3    …
}
```



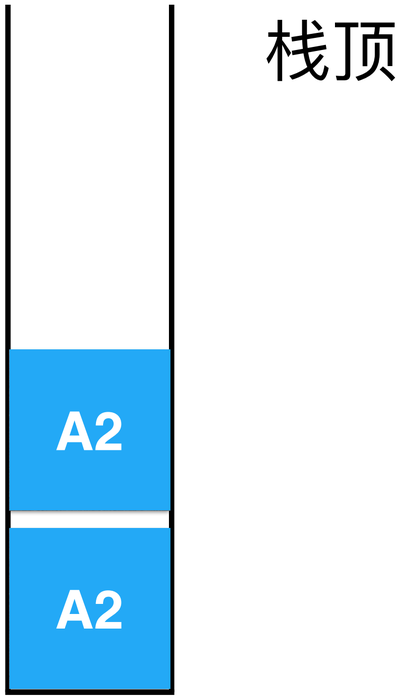
# 栈的应用

- 程序调用的系统栈
- 递归调用是有代价的：函数调用 + 系统栈空间

```
func A(){
1    …
2    A()
3    …
}
```

```
func A(){
1    …
2    A()
3    …
}
```

```
func A(){
1    …
2    …
3    …
}
```



# 调试递归程序

# 实践：调试递归程序

# 更多和链表相关的话题

# 更多和链表相关的话题

- 关于递归
- 近乎和链表相关的所有操作，都可以使用递归的形式完成
- 建议同学们对链表的增，删，改，查，进行递归实现
- 有问题在问答区讨论交流

# 更多和链表相关的话题

- Leetcode上和链表相关的问题

- 有问题在问答区讨论交流

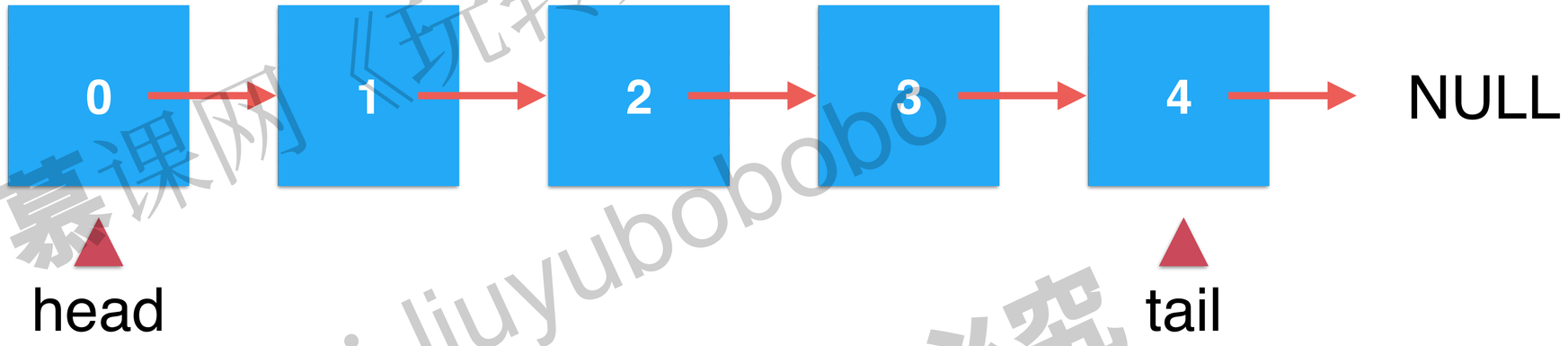
# 更多和链表相关的话题

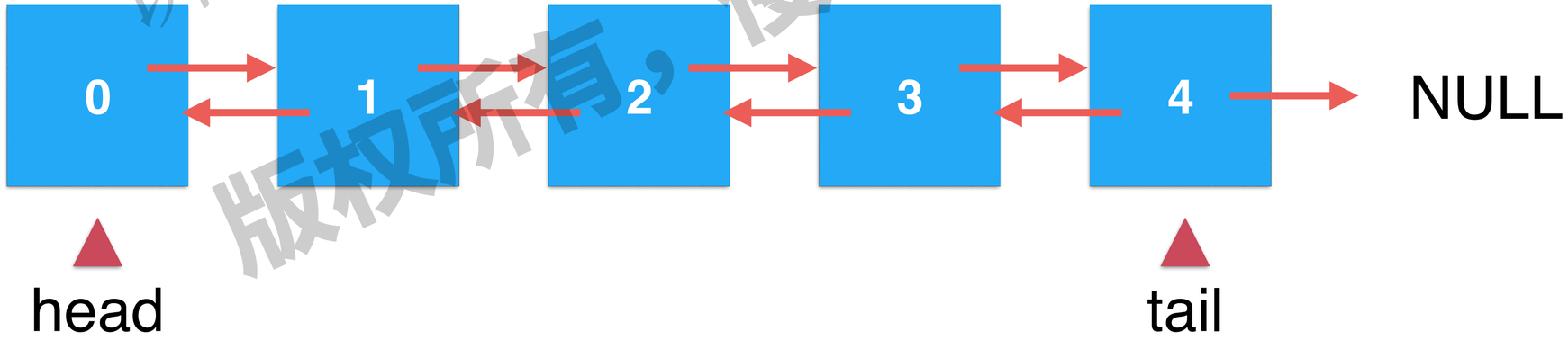
- 玩转算法面试课程

# 更多和链表相关的话题

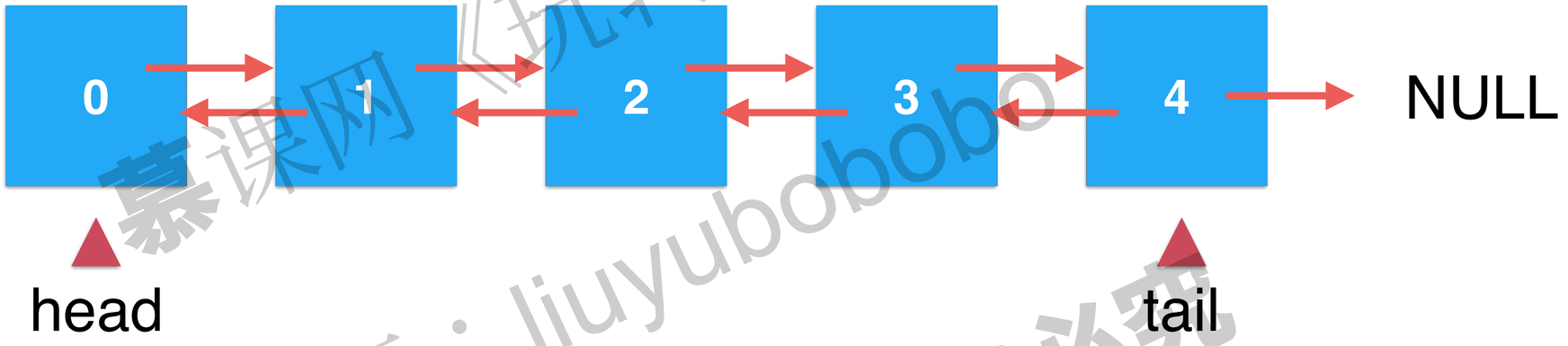
- 斯坦福大学的链表问题集
- 文档地址在问答区放出
- 有问题在问答区讨论交流

# 双链表



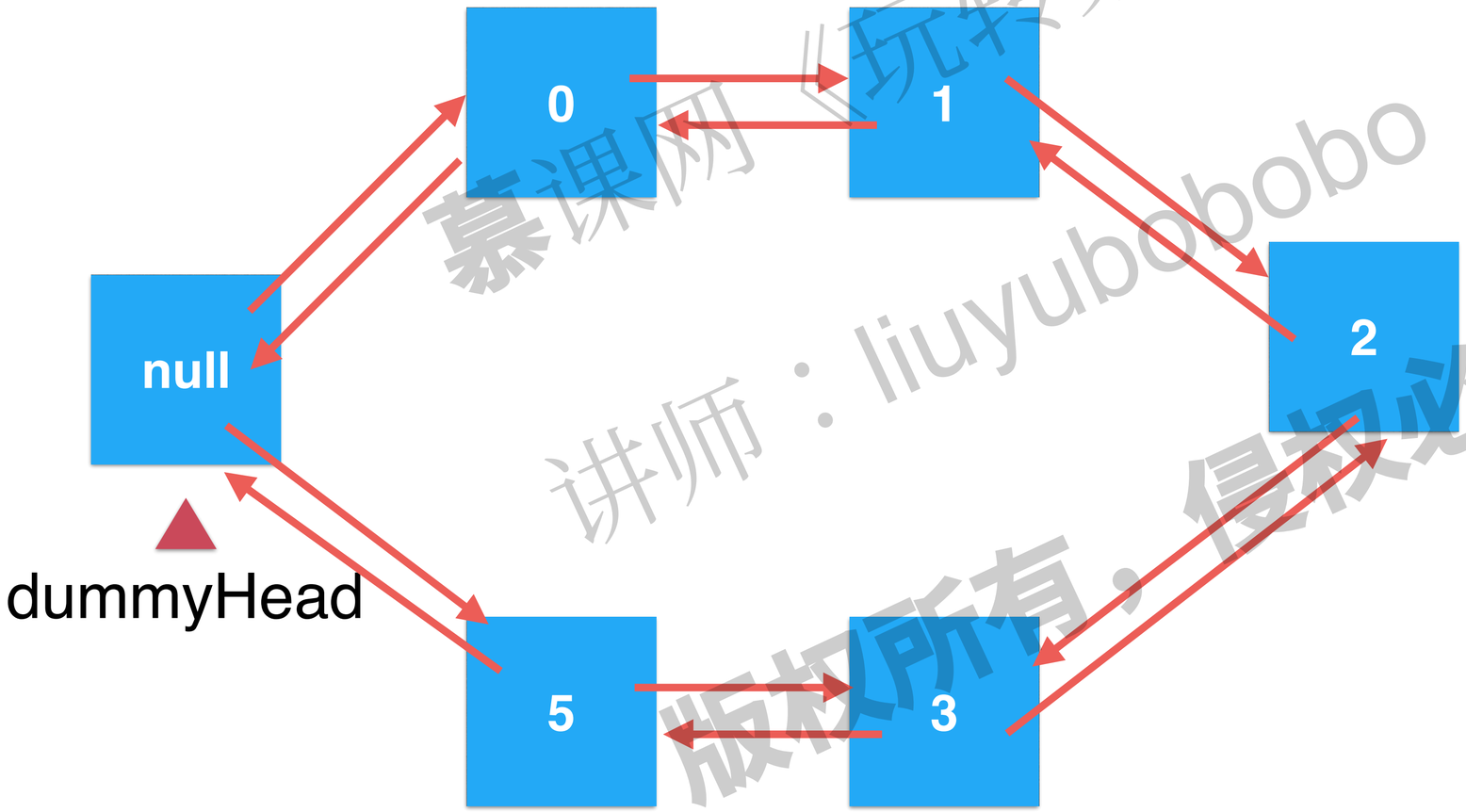



# 双链表



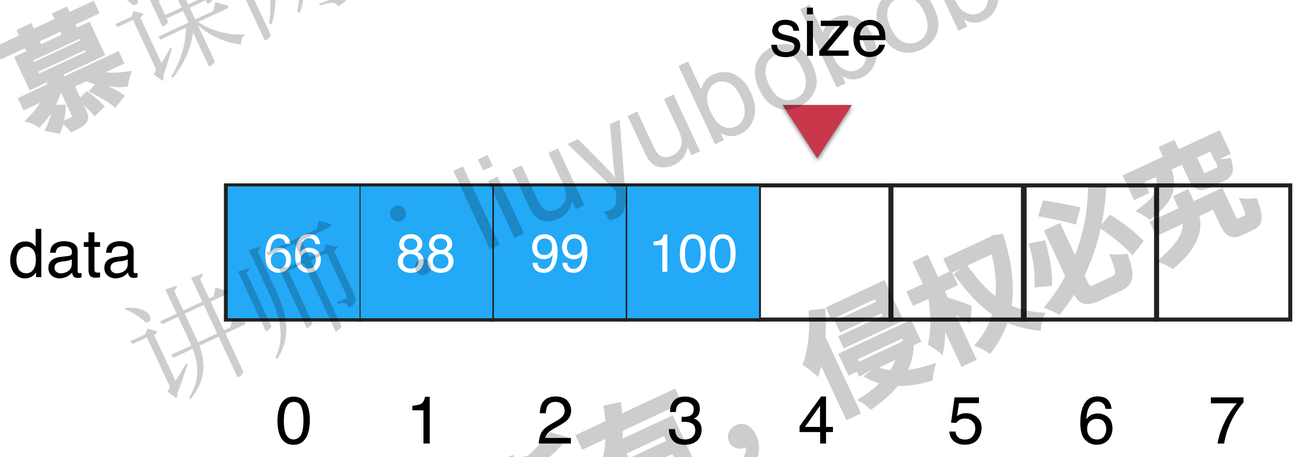

```
class Node {
    E e;
    Node next, prev;
}
```

# 循环链表

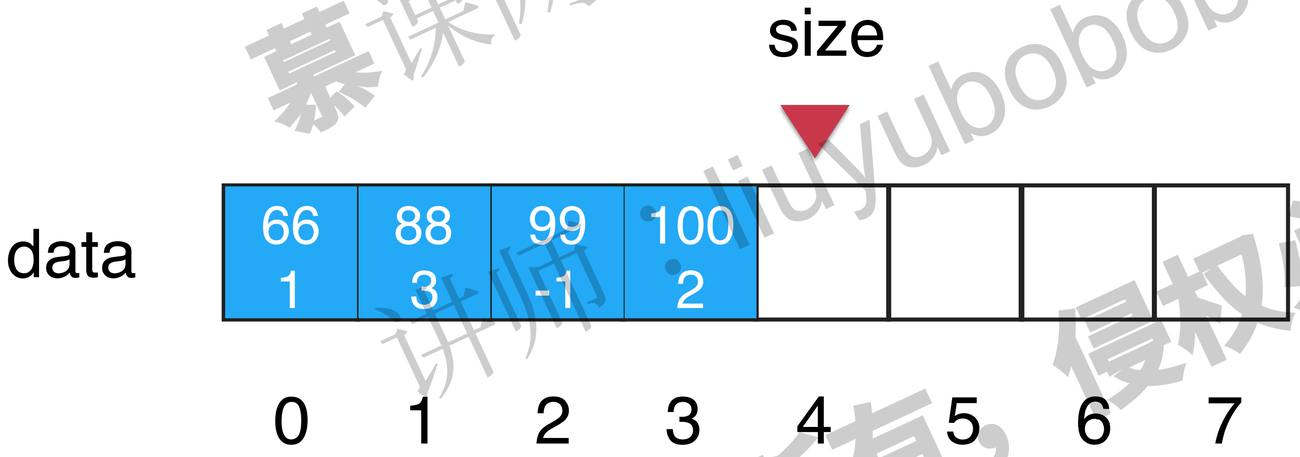



```
class Node {
    E e;
    Node next, prev;
}
```

# 数组链表



# 数组链表




```
class Node {
    E e;
    int next;
}
```

# 链表

# 其他

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# 玩儿转数据结构

liuyubobobo