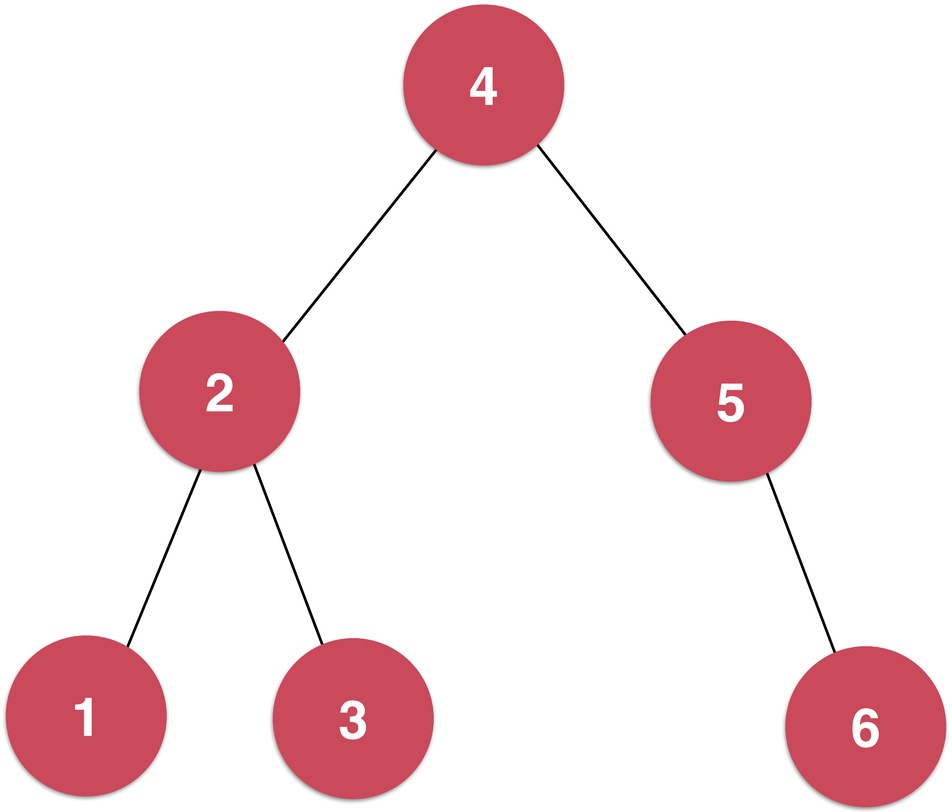
算法与数据结构体系课程

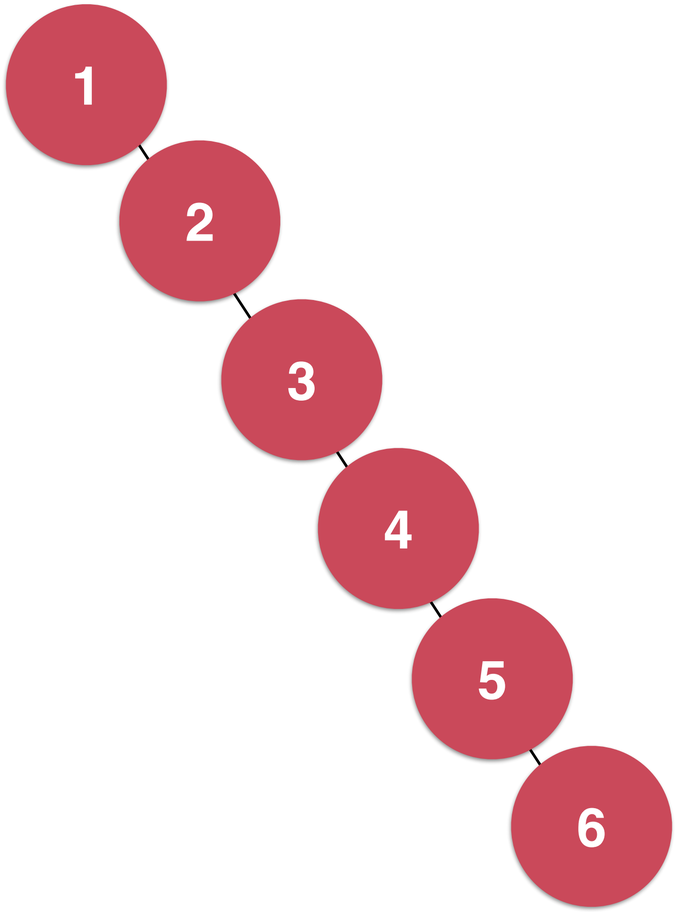
liuyubobobo

平衡二叉树与AVL树

回忆二分搜索树的问题

1，2，3，4，5，6





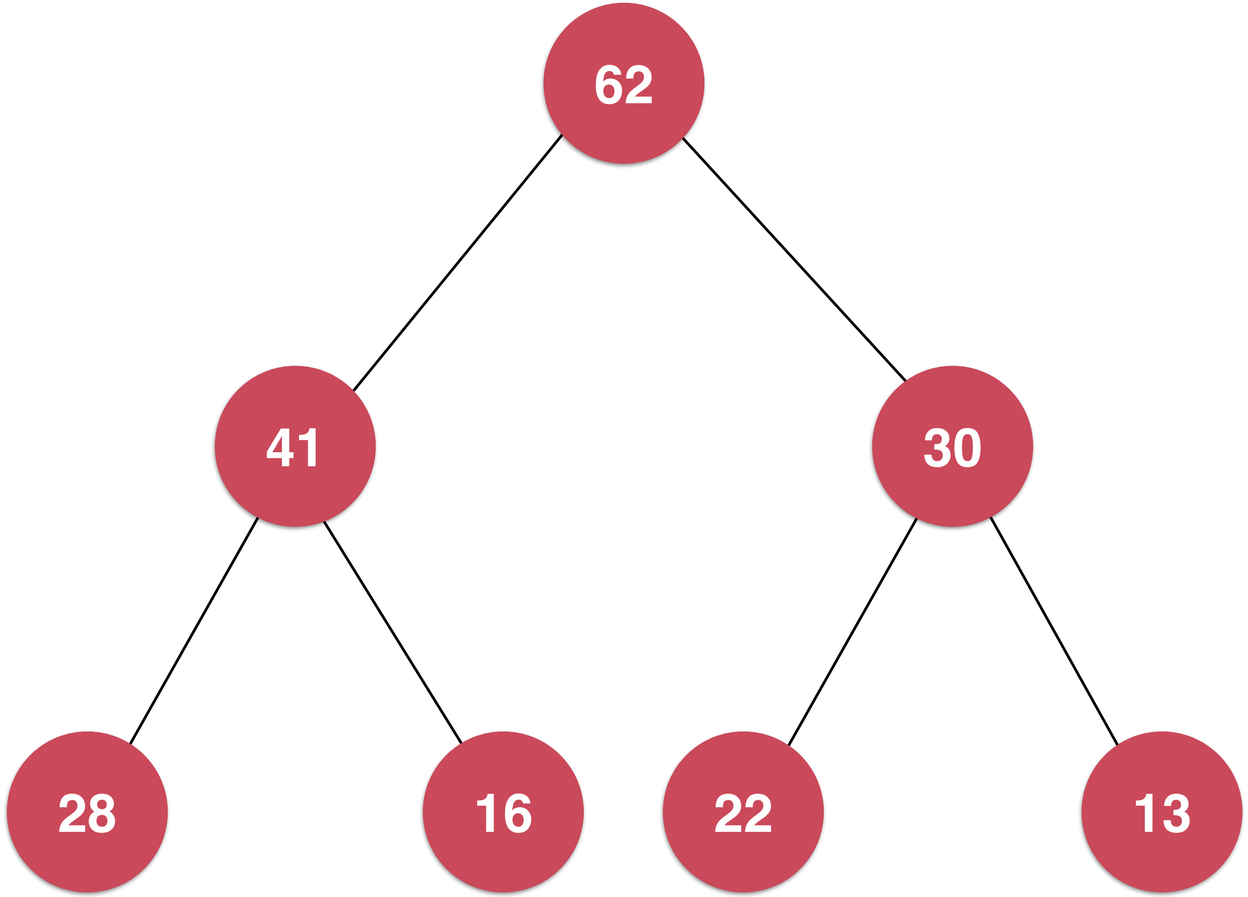
AVL 树

G. M. Adelson-Velsky 和 E. M. Landis

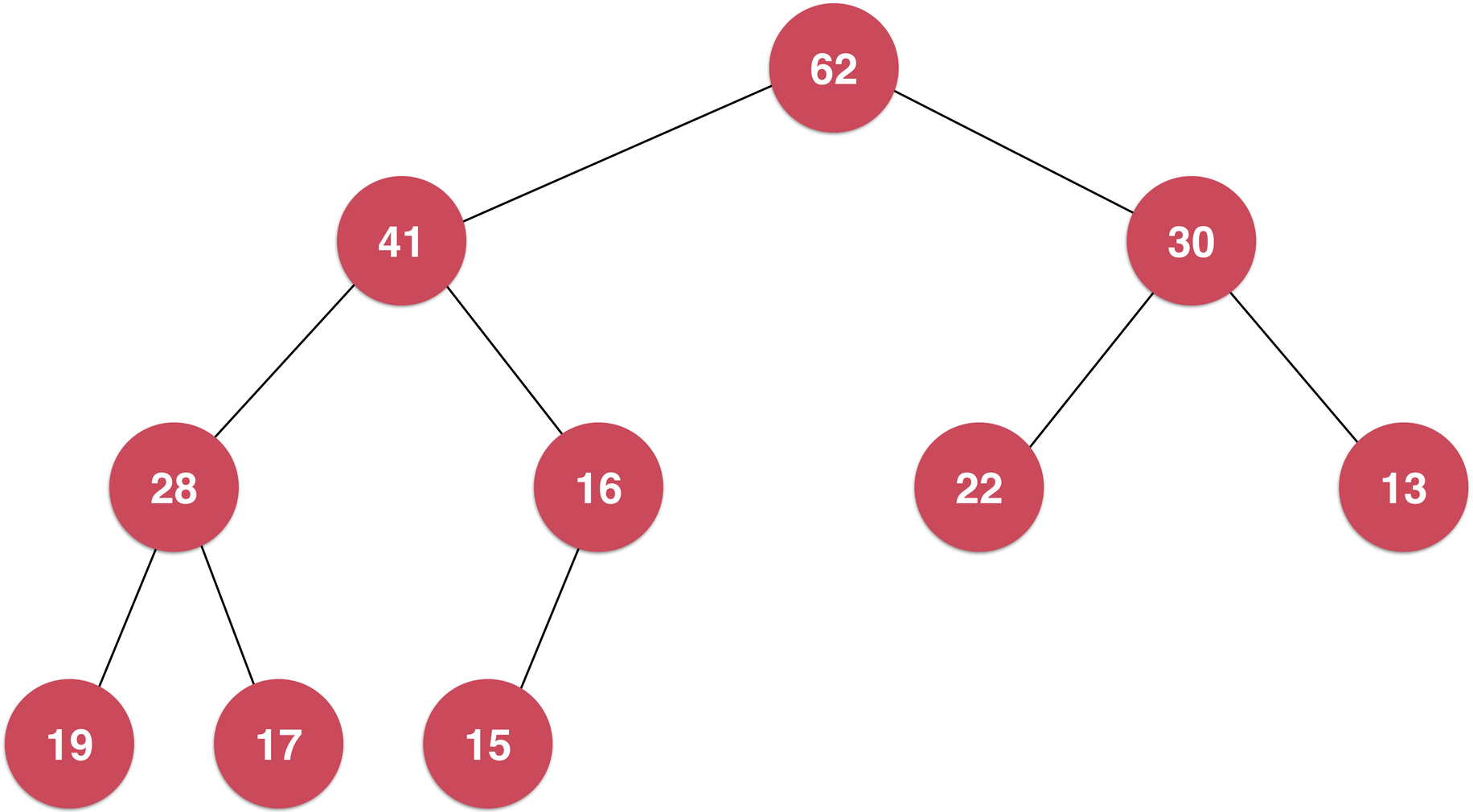
1962年的论文首次提出

最早的自平衡二分搜索树结构

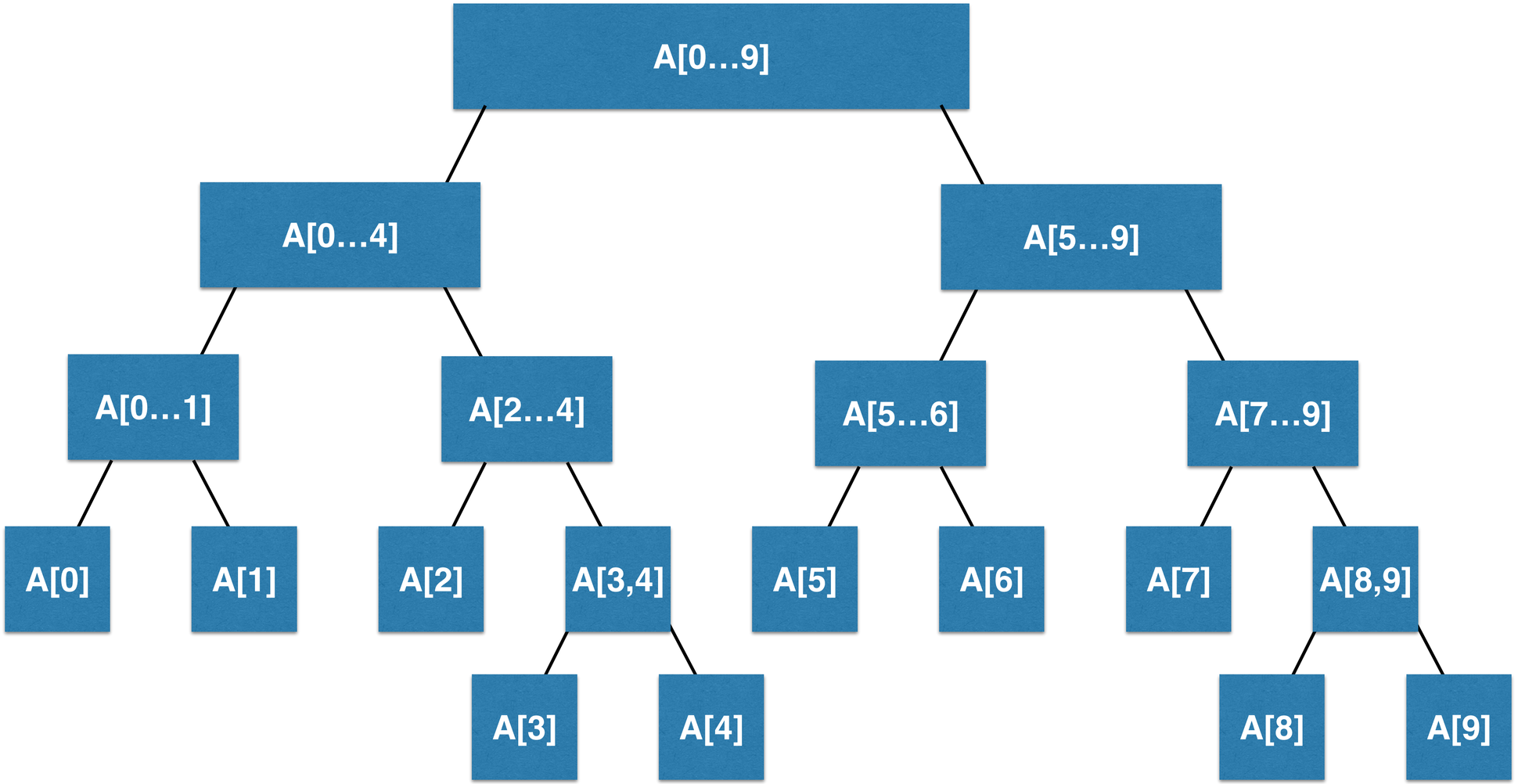
平衡二叉树



平衡二叉树



平衡二叉树



平衡二叉树

对于任意一个节点，左子树和右子树的高度差不能为超过1

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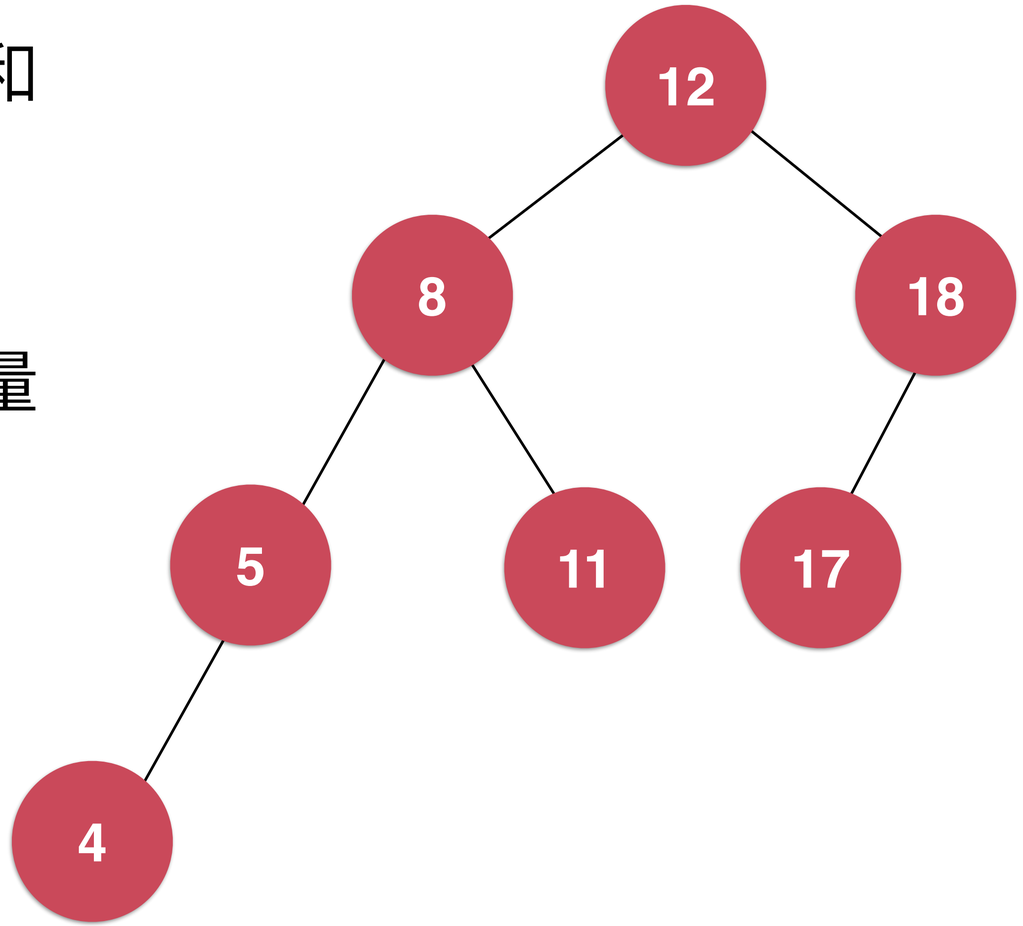
平衡二叉树的高度和节点数量之间的关系也是O(logn)的



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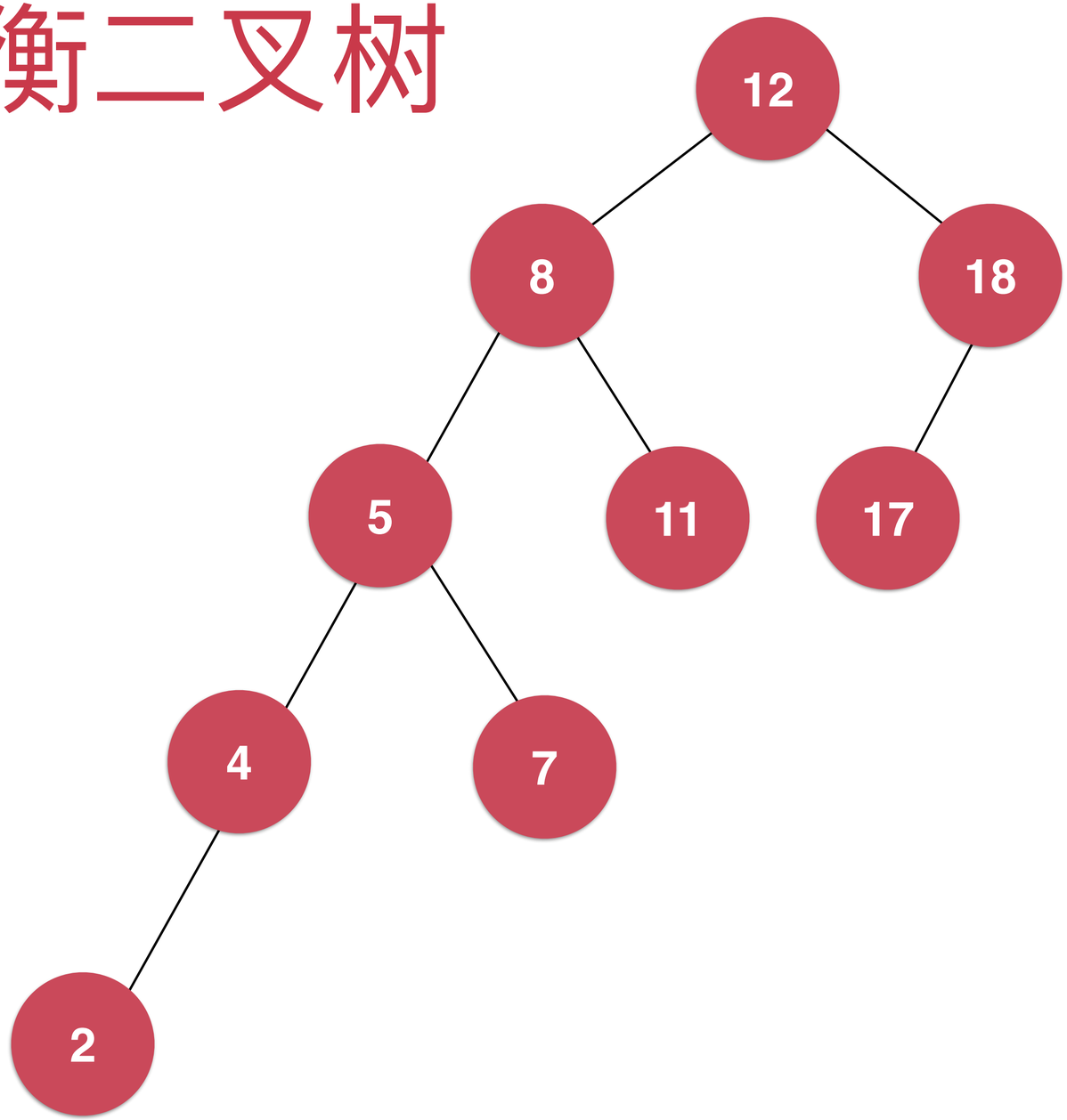

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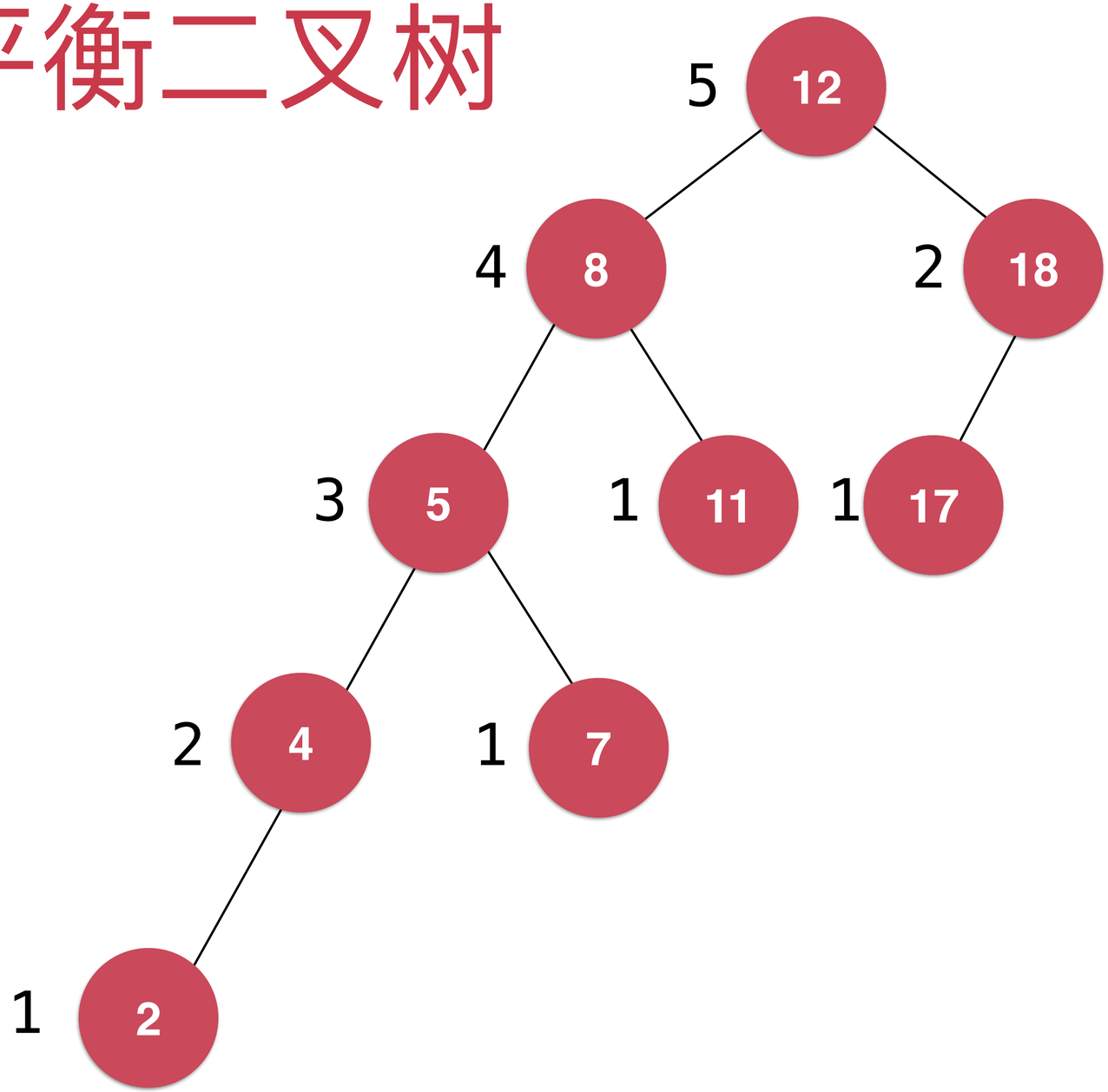
标注节点的高度



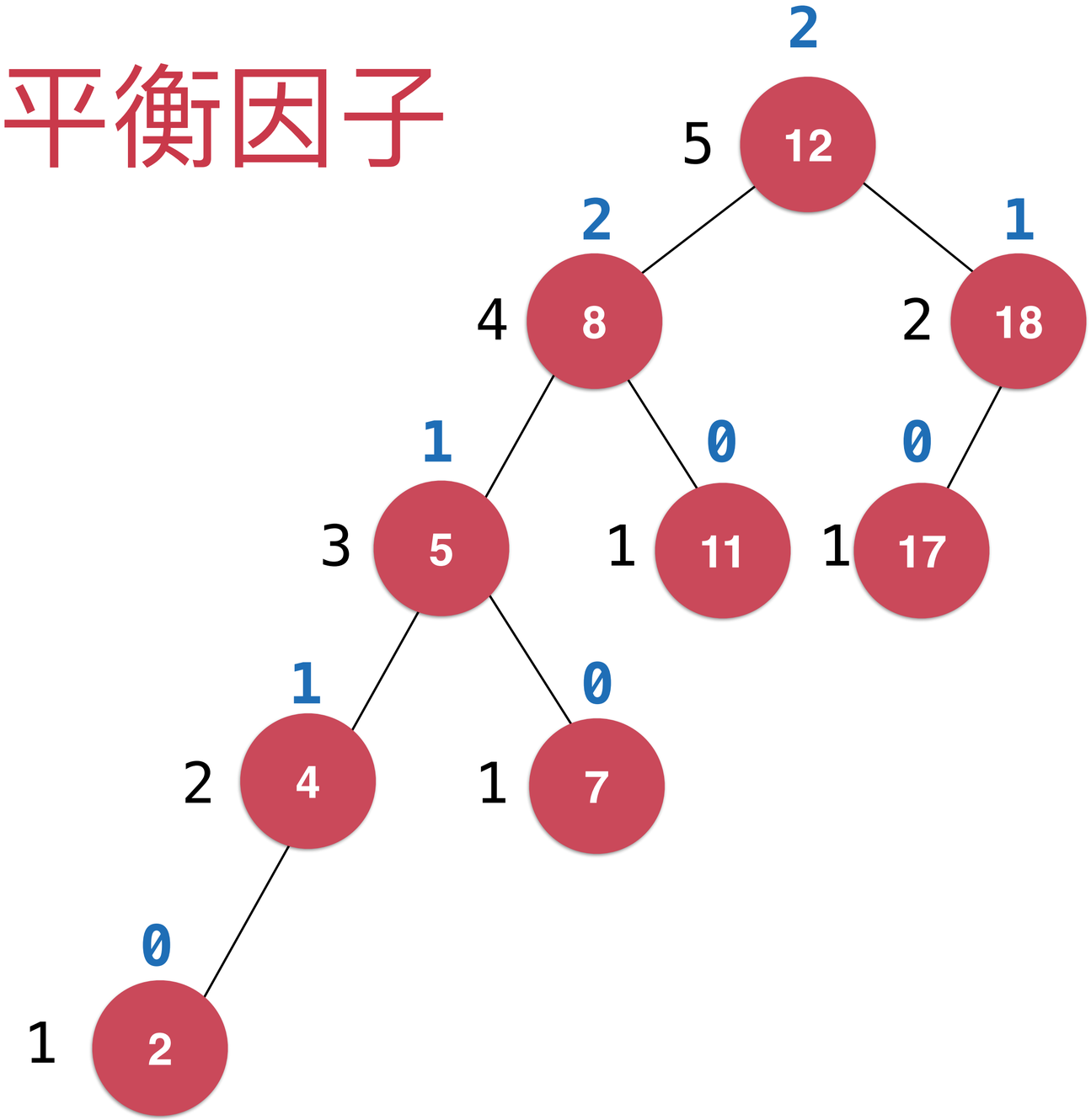
平衡因子

对于任意一个节点，左子树和右子树的高度差不能为超过1

平衡二叉树的高度和节点数量之间的关系也是O(logn)的

标注节点的高度

计算平衡因子



在二分搜索树中记录节点高度和计算平衡因子

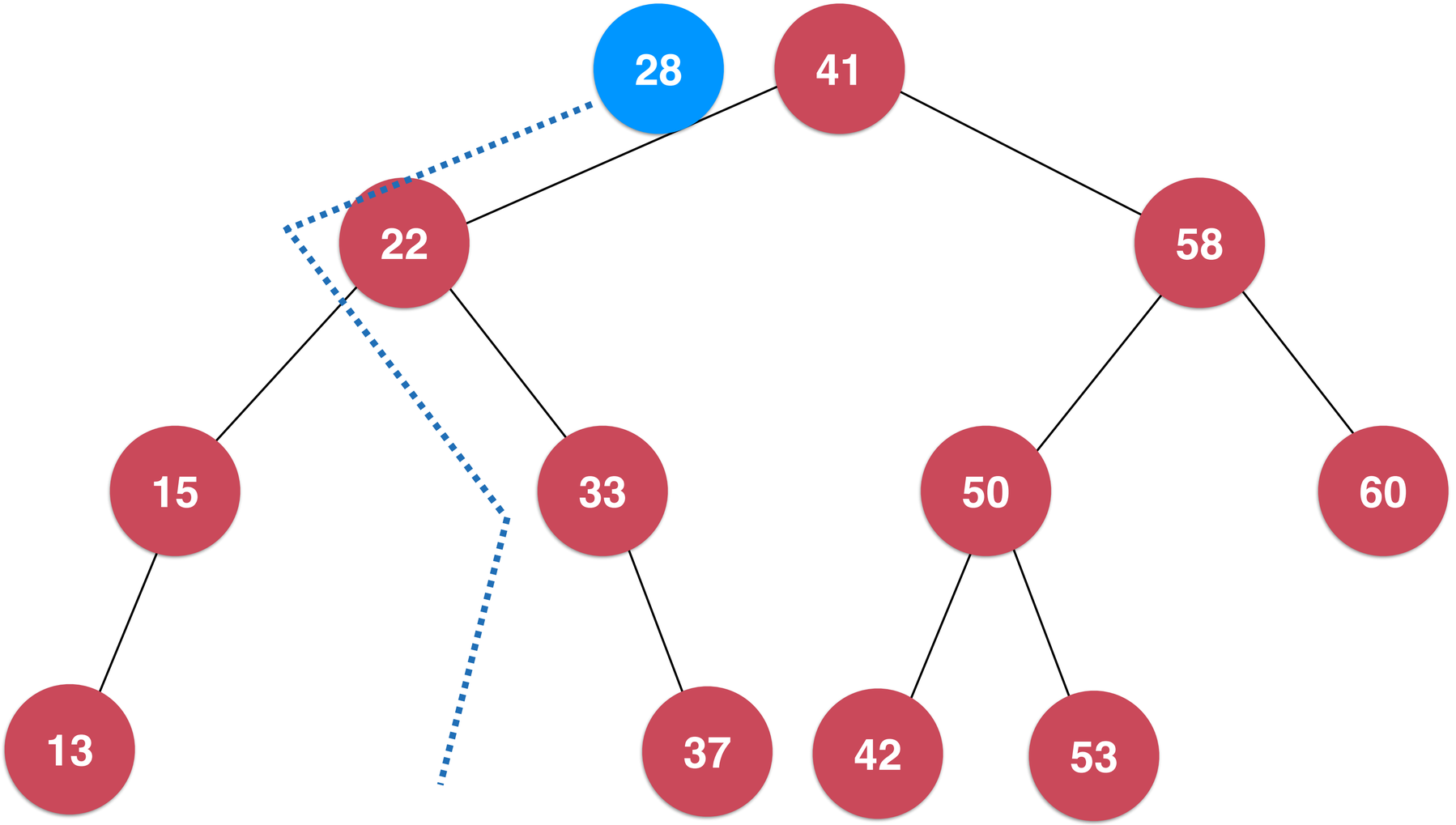
实践：计算高度和平衡因子

验证二分搜索树性质和平衡性

实践：验证二分搜索树性质和平衡性

AVL树的左旋转和右旋转

在什么时候维护平衡



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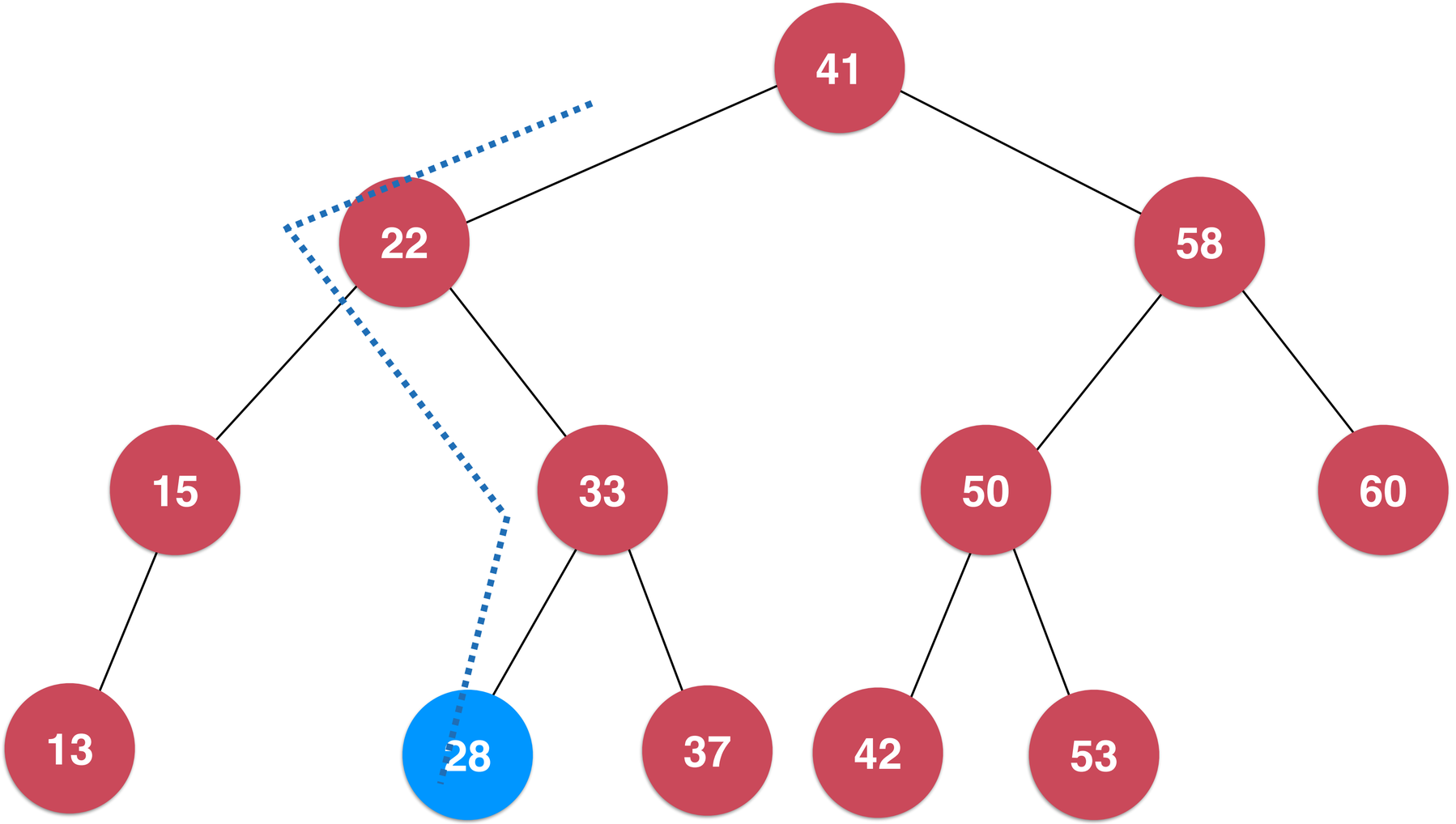

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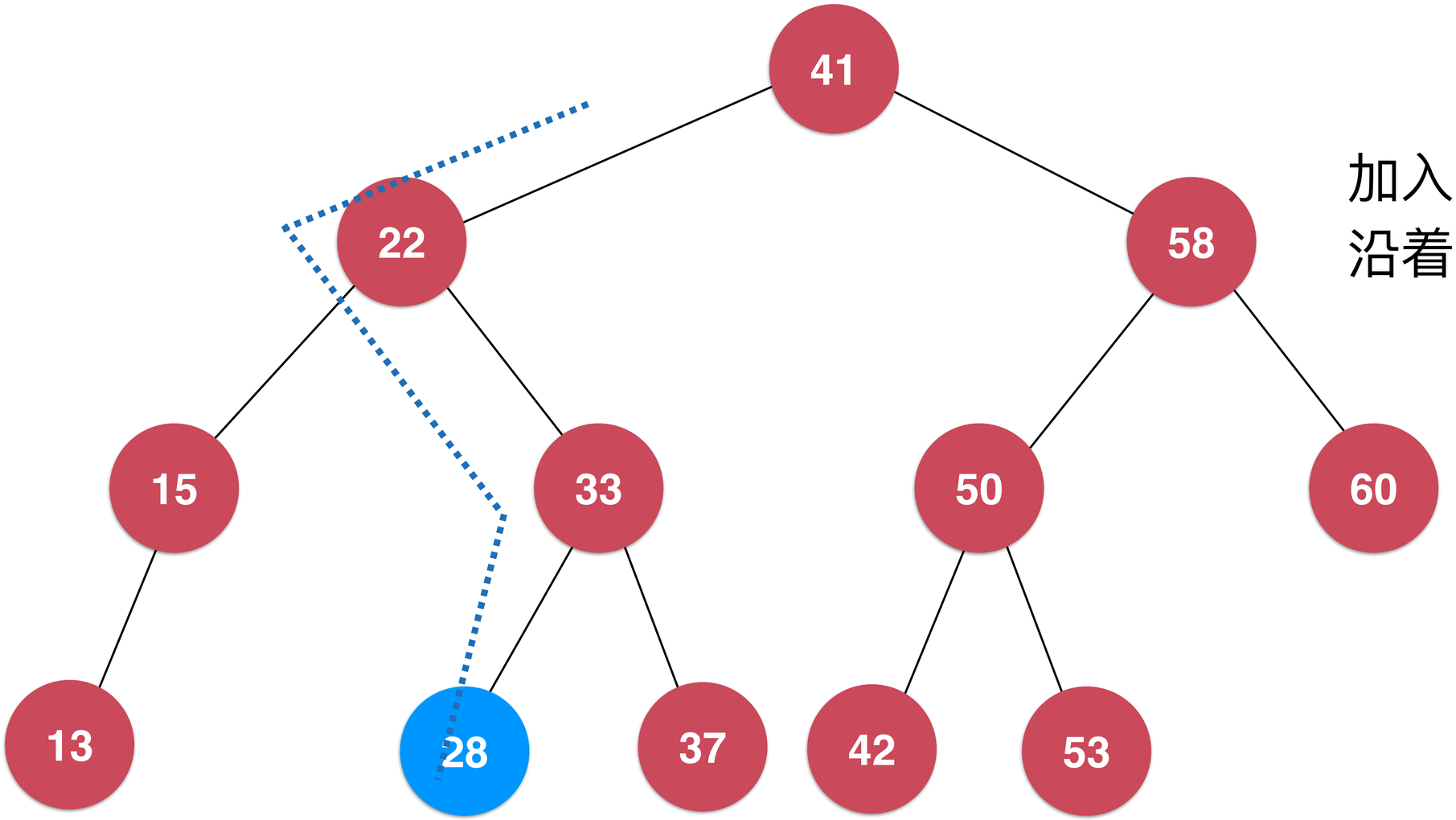

加入节点后，
沿着节点向上维护平衡性

在什么时候维护平衡?

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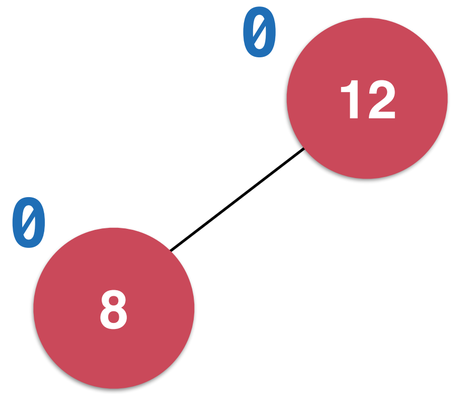
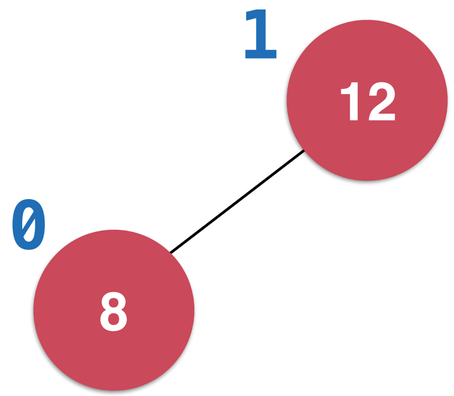
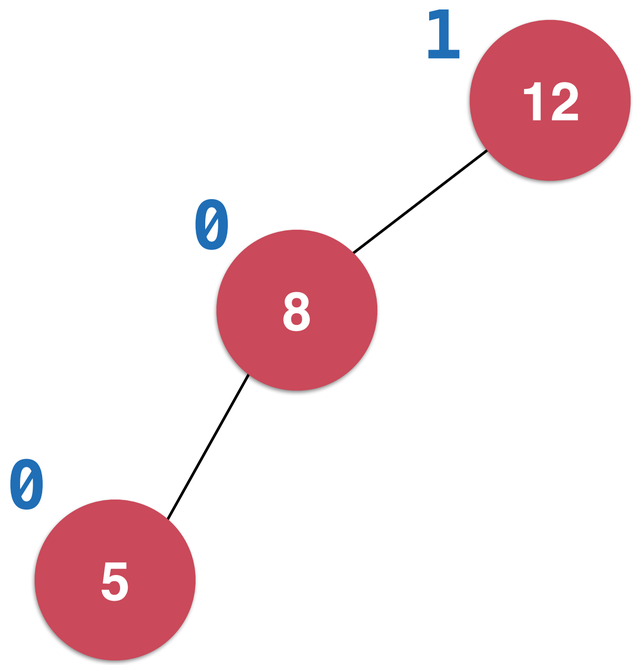


在什么时候维护平衡?



在什么时候维护平衡?



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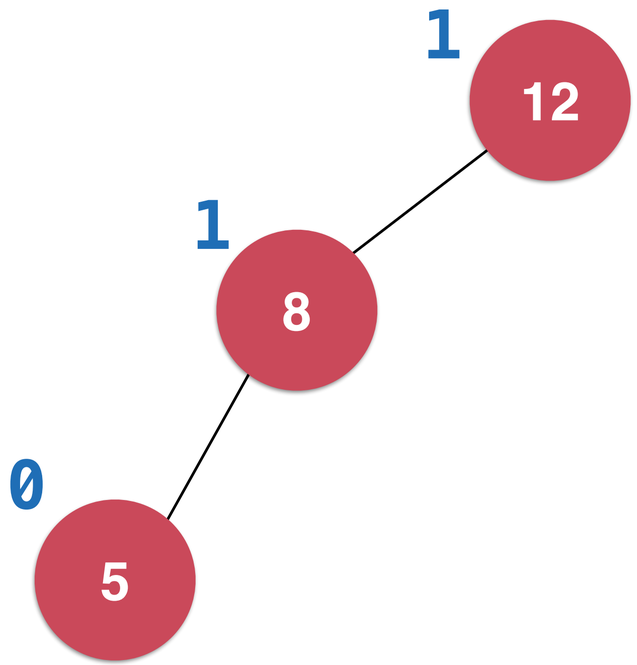
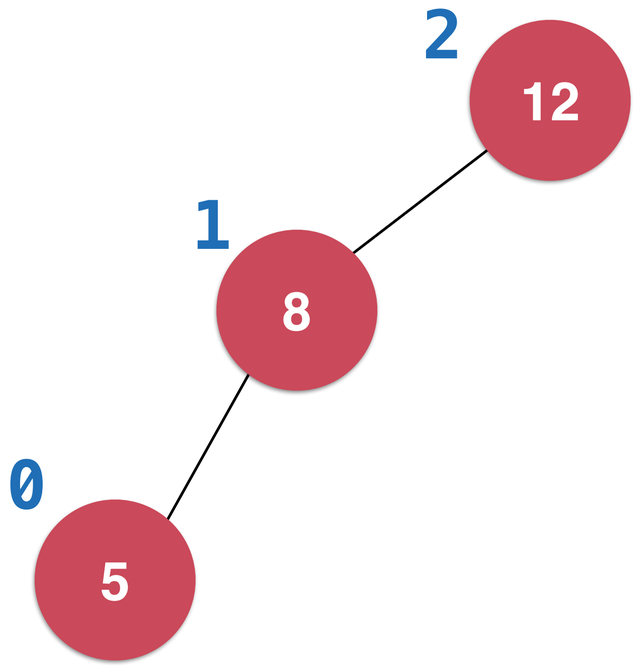
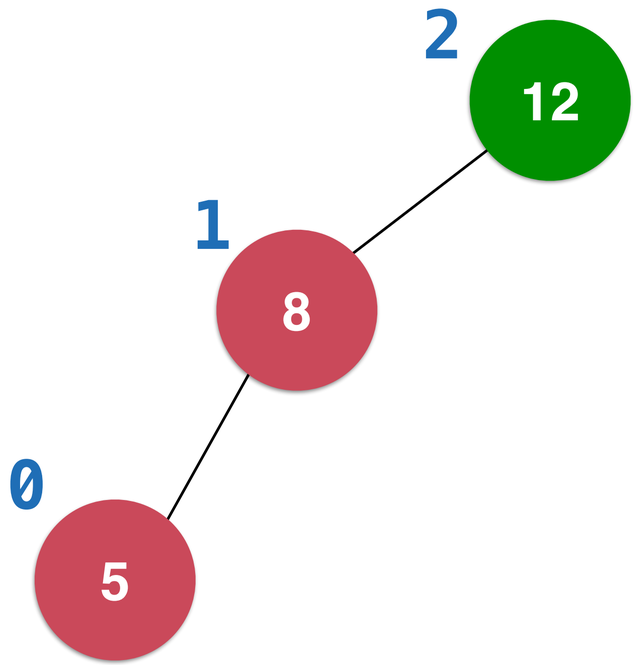


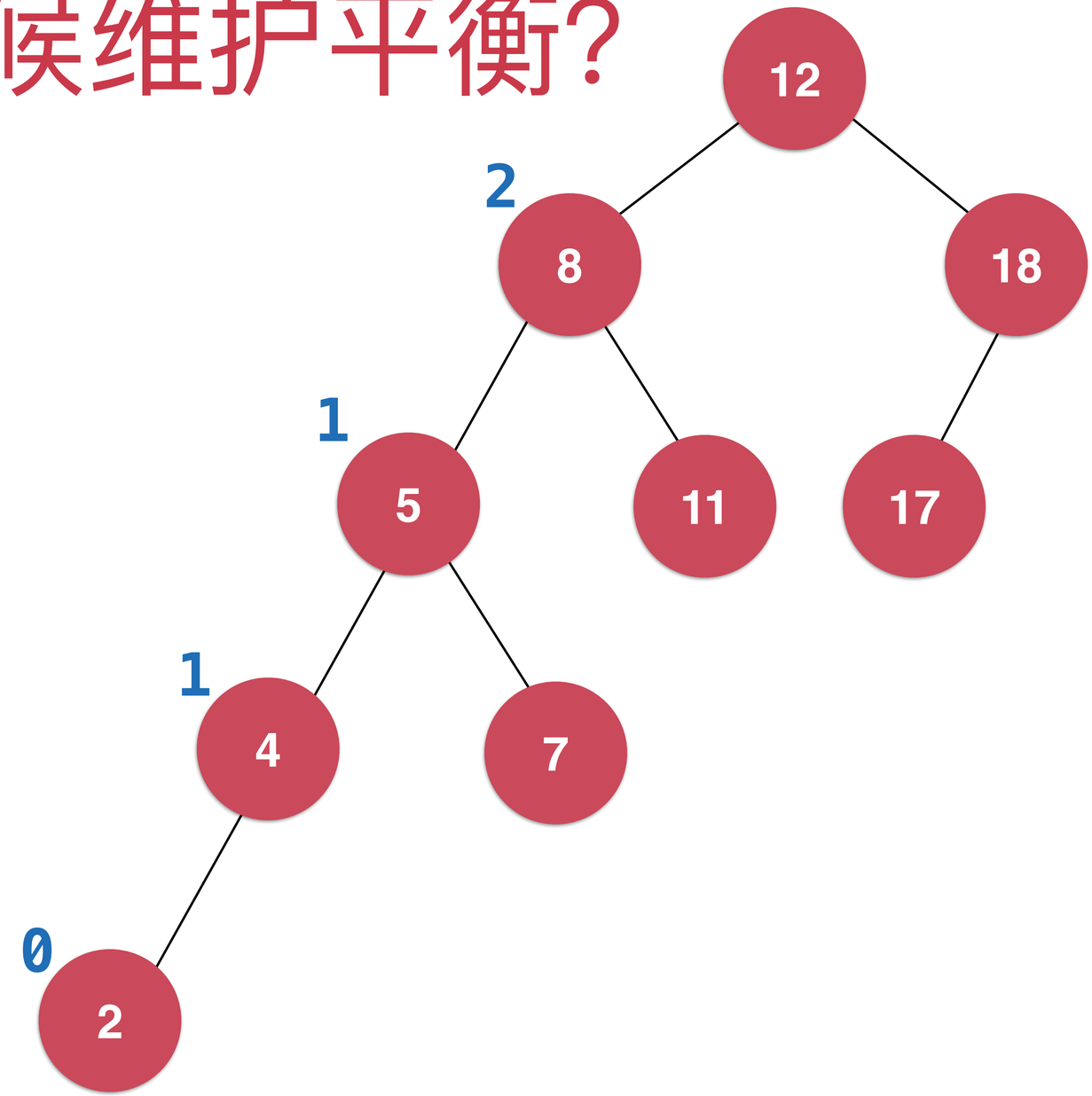
在什么时候维护平衡?



在什么时候维护平衡?



在什么时候维护平衡?



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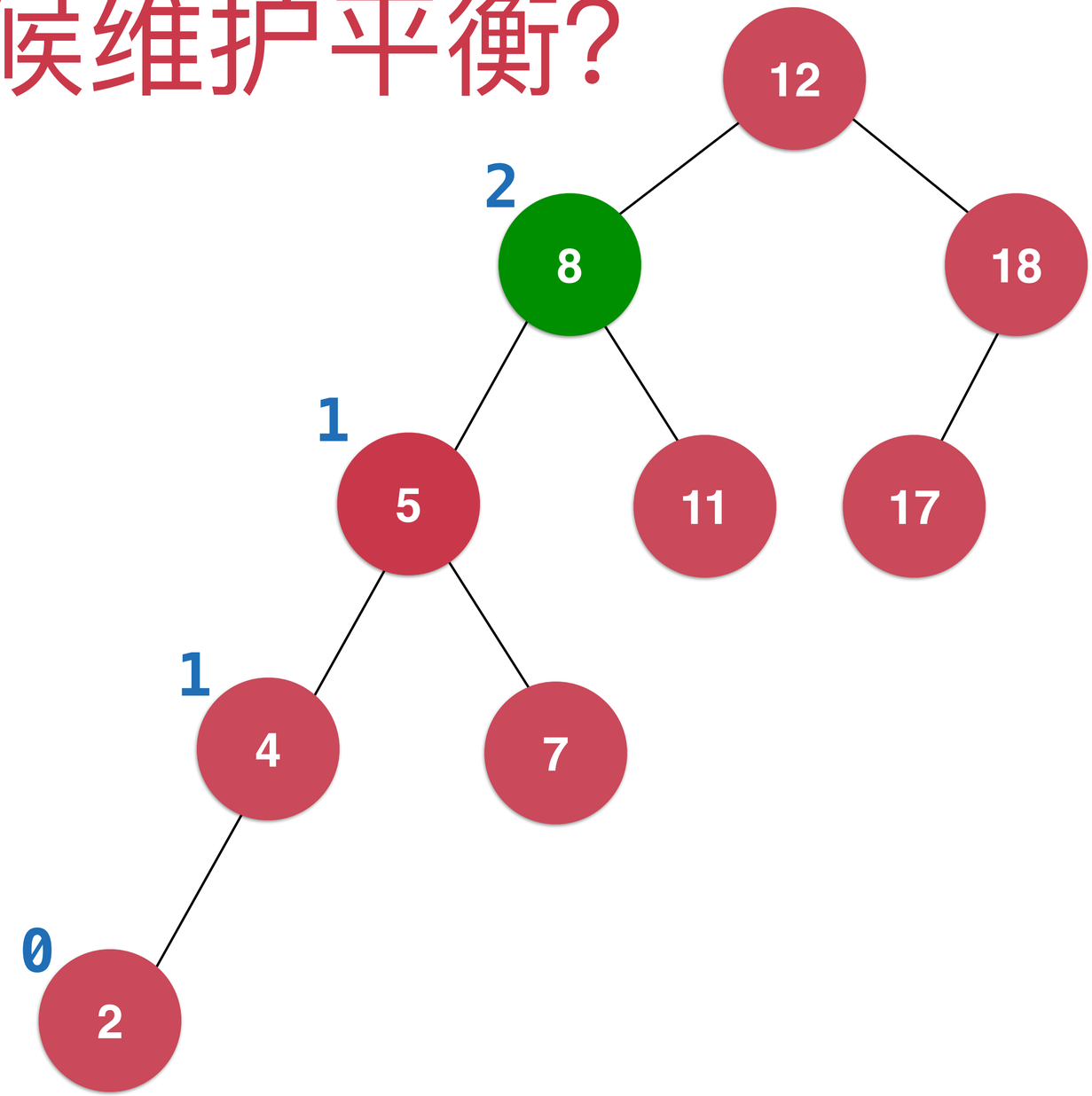

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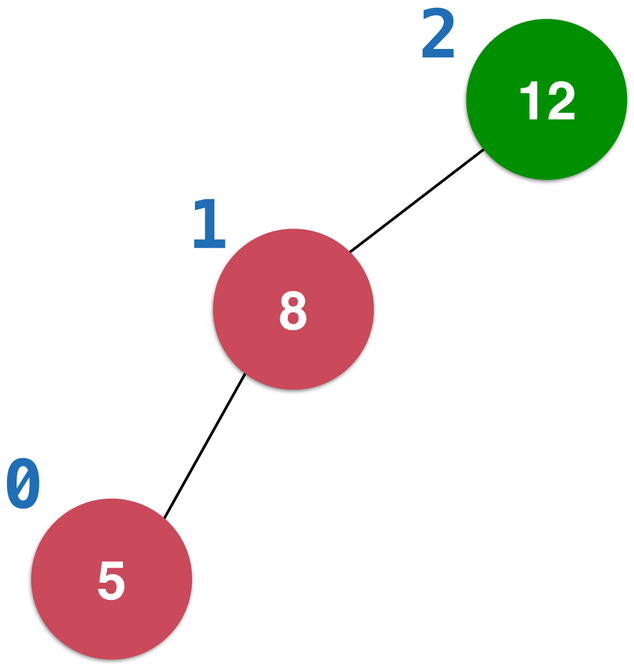
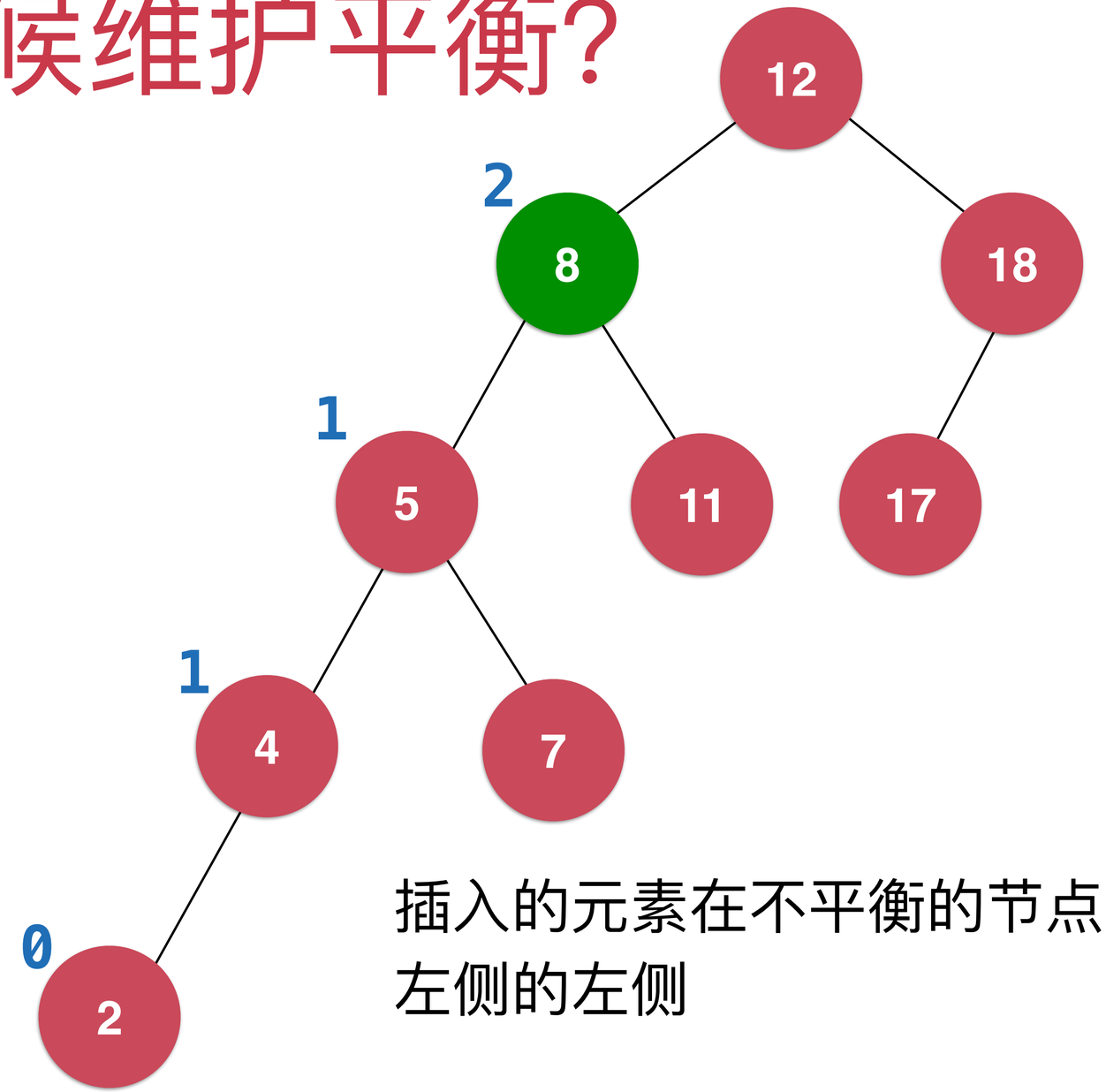
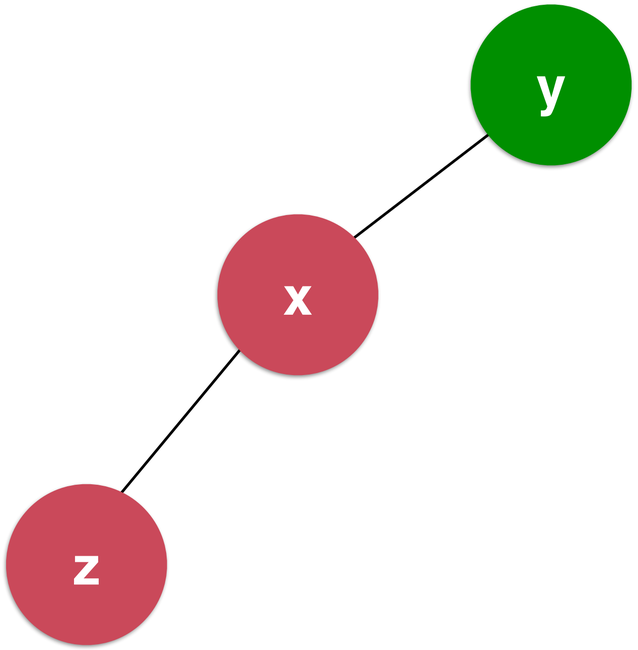




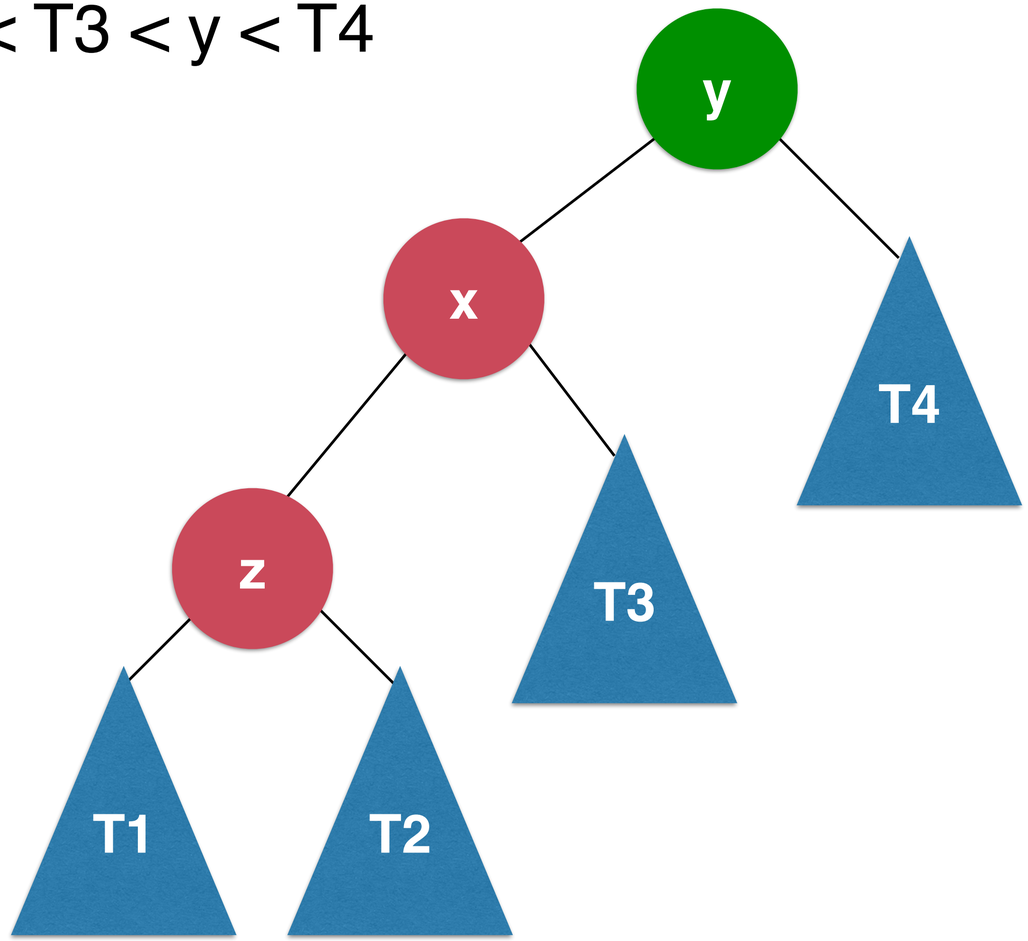
插入的元素在不平衡的节点的左侧的左侧

右旋转



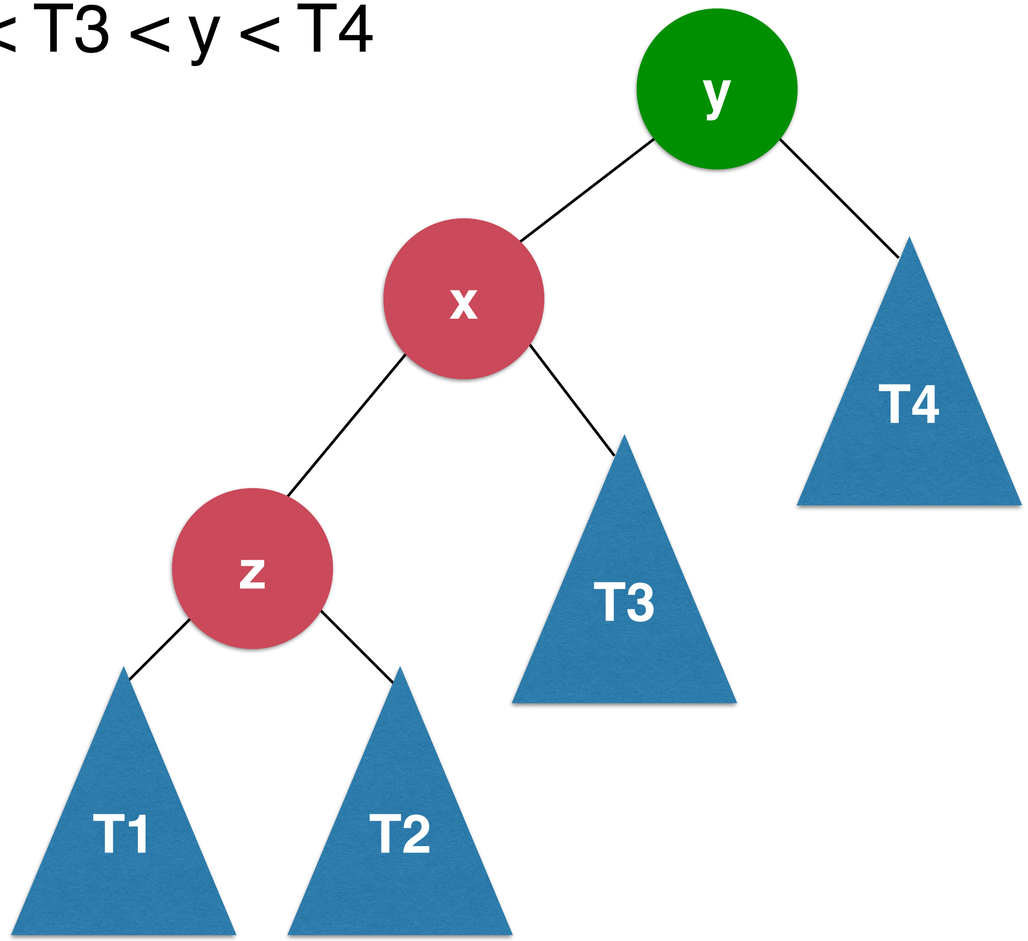
右旋转

T1 < z < T2 < x < T3 < y < T4



右旋转

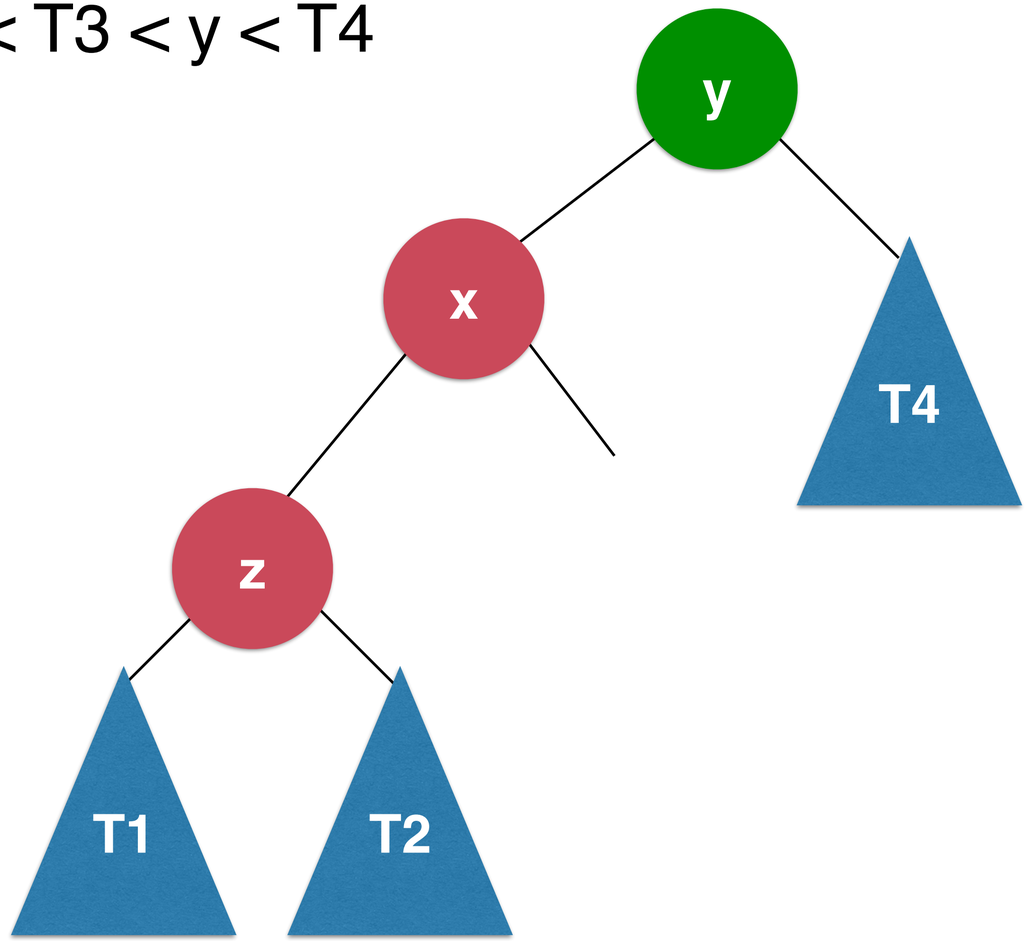
T1 < z < T2 < x < T3 < y < T4



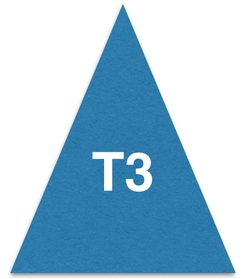

```
x.right = y
```

右旋转

T1 < z < T2 < x < T3 < y < T4

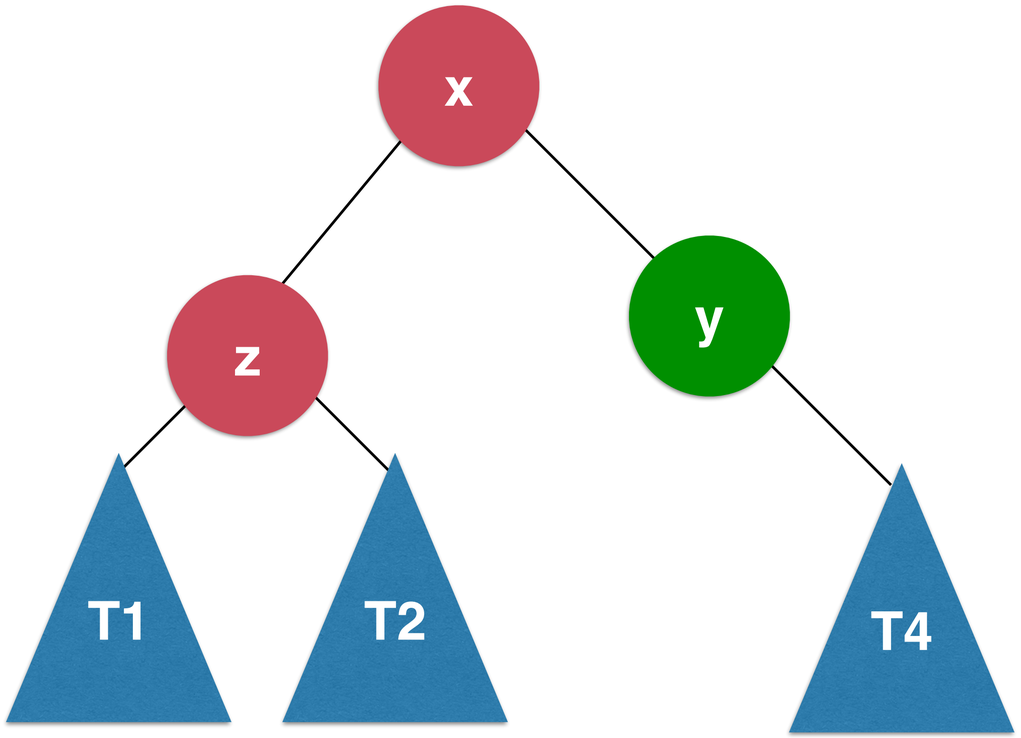



```
x.right = y
```

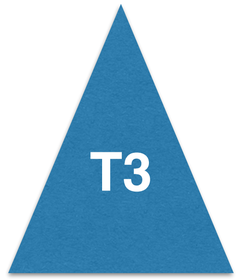


右旋转

T1 < z < T2 < x < T3 < y < T4

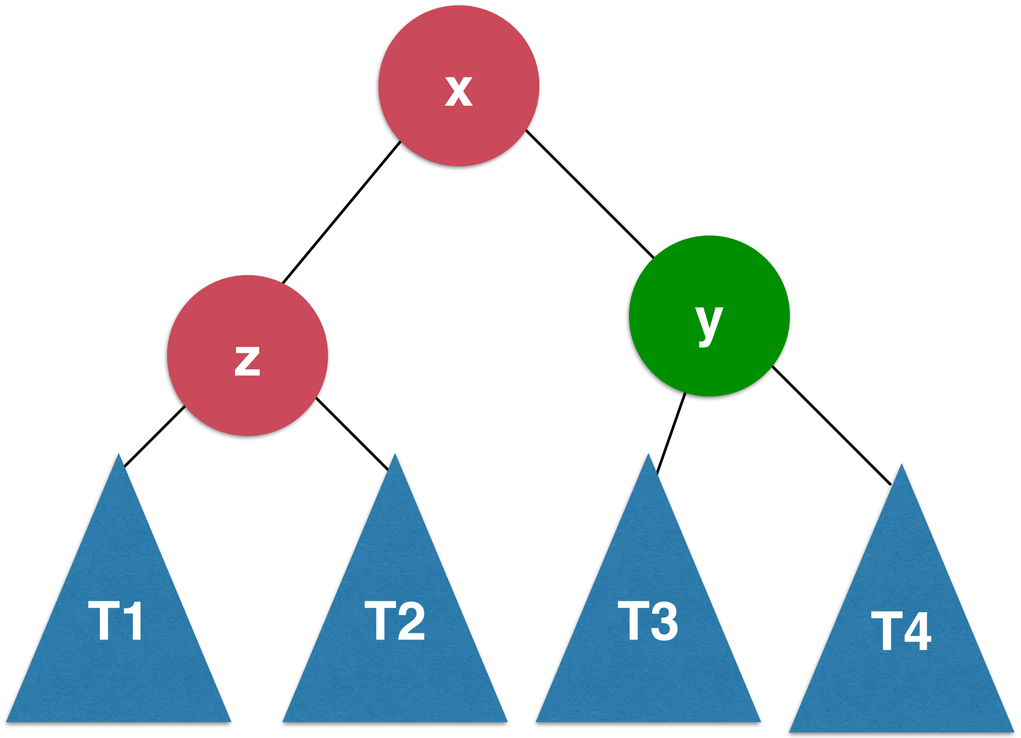



```
x.right = y
y.left = T3
```



右旋转

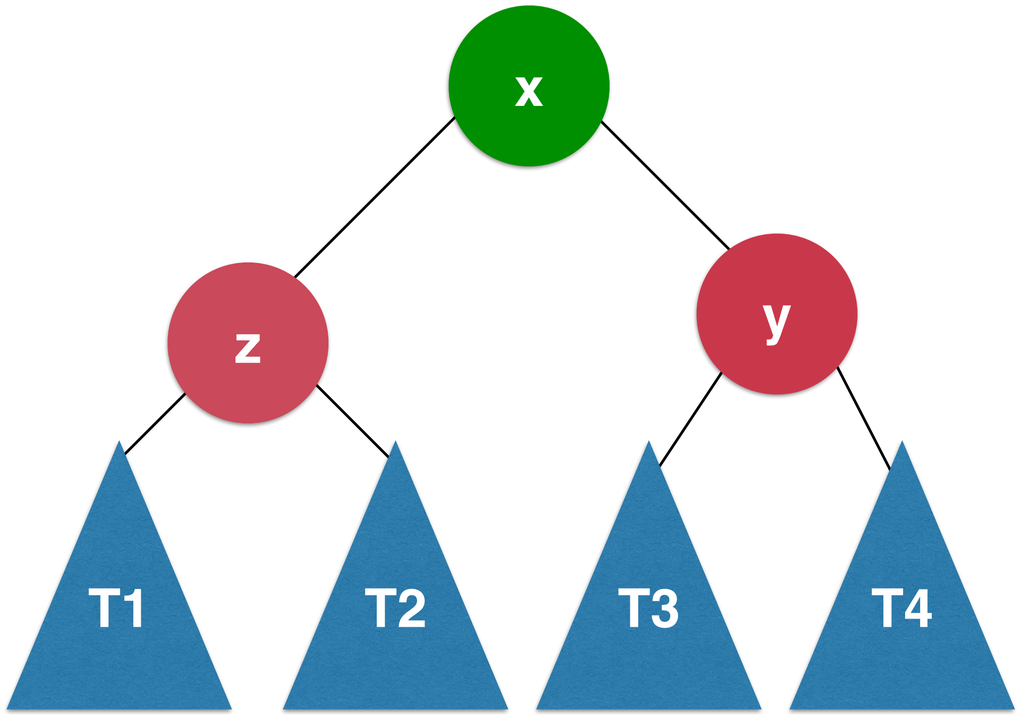
T1 < z < T2 < x < T3 < y < T4




```
x.right = y
y.left = T3
```

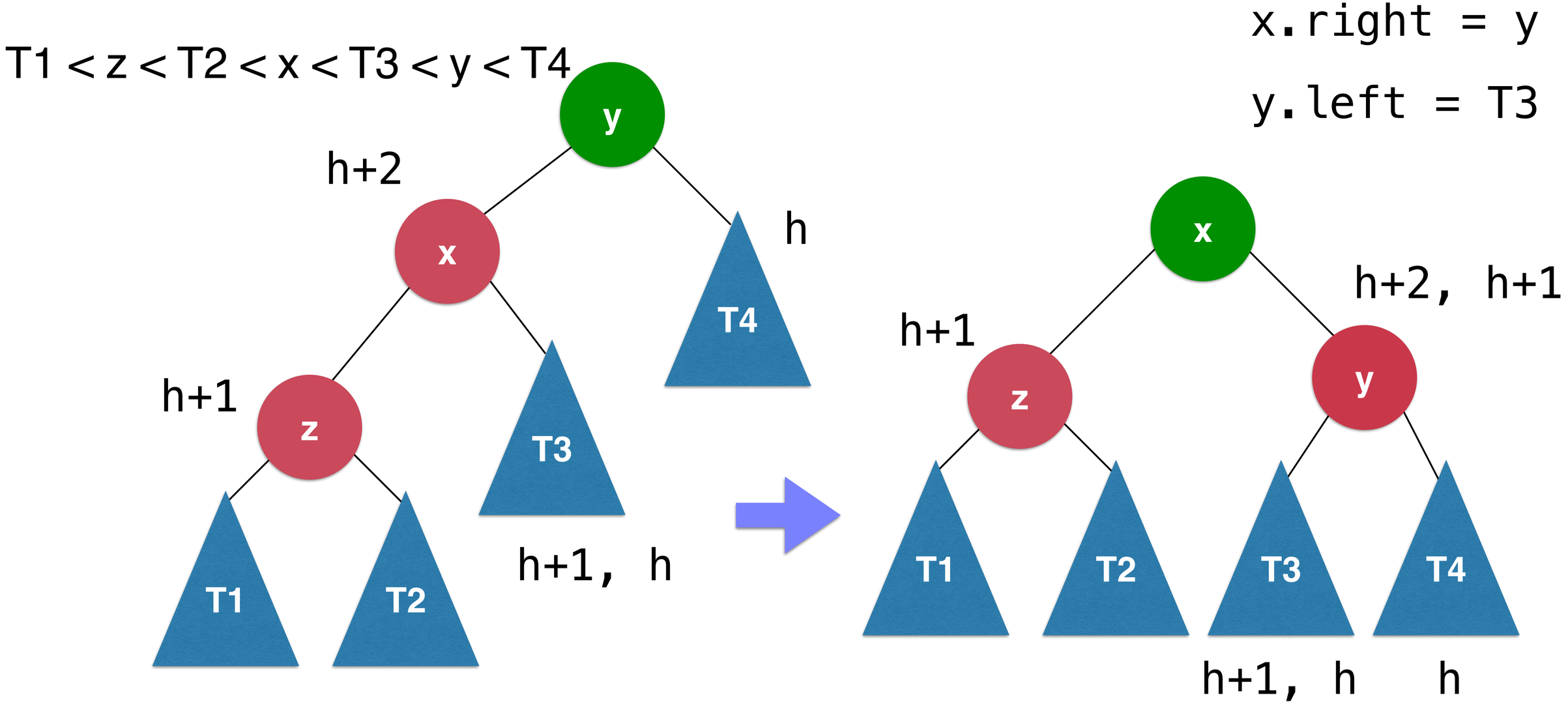
右旋转

T1 < z < T2 < x < T3 < y < T4




```
x.right = y
y.left = T3
```

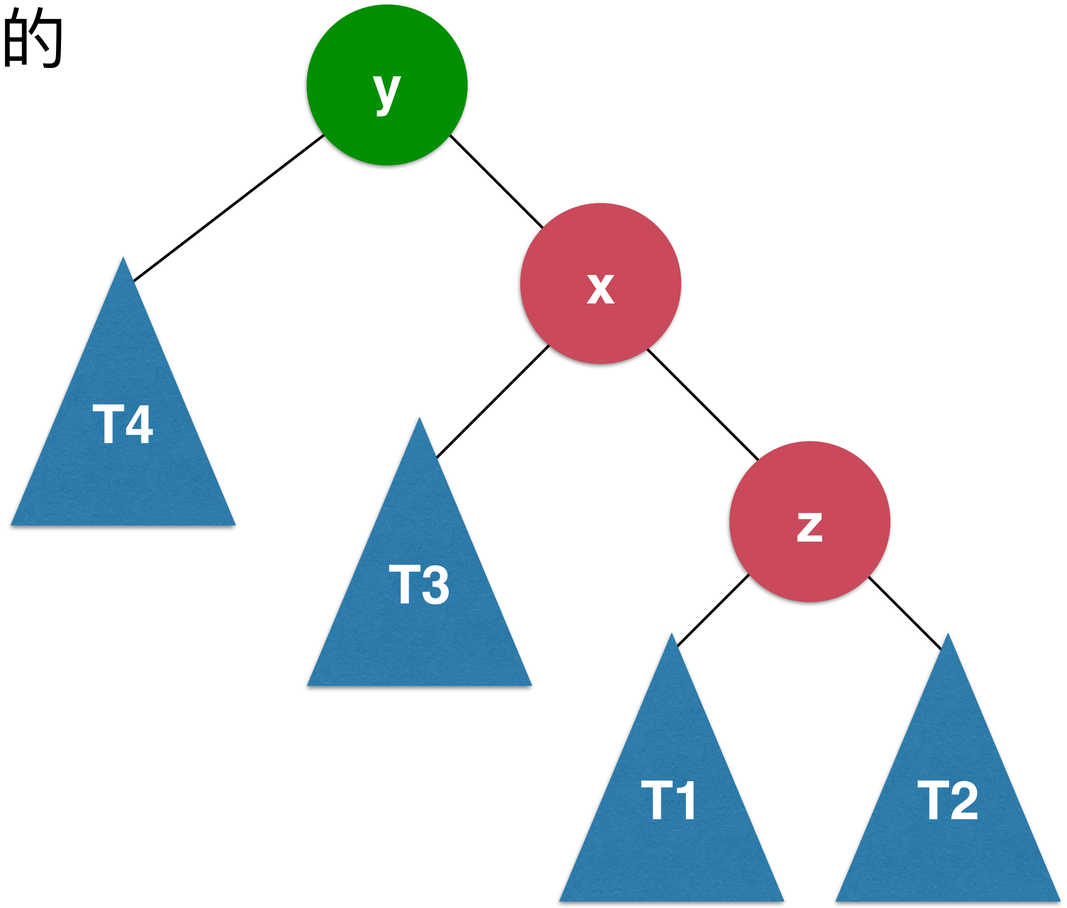
右旋转


T1 < z < T2 < x < T3 < y < T4
y
h+2
x
h
T4
h+1
z
T3
T1
T2
h+1, h
x.right = y
y.left = T3
x
h+2, h+1
h+1
z
y
T1
T2
T3
T4
h+1, h
h

实践：右旋转

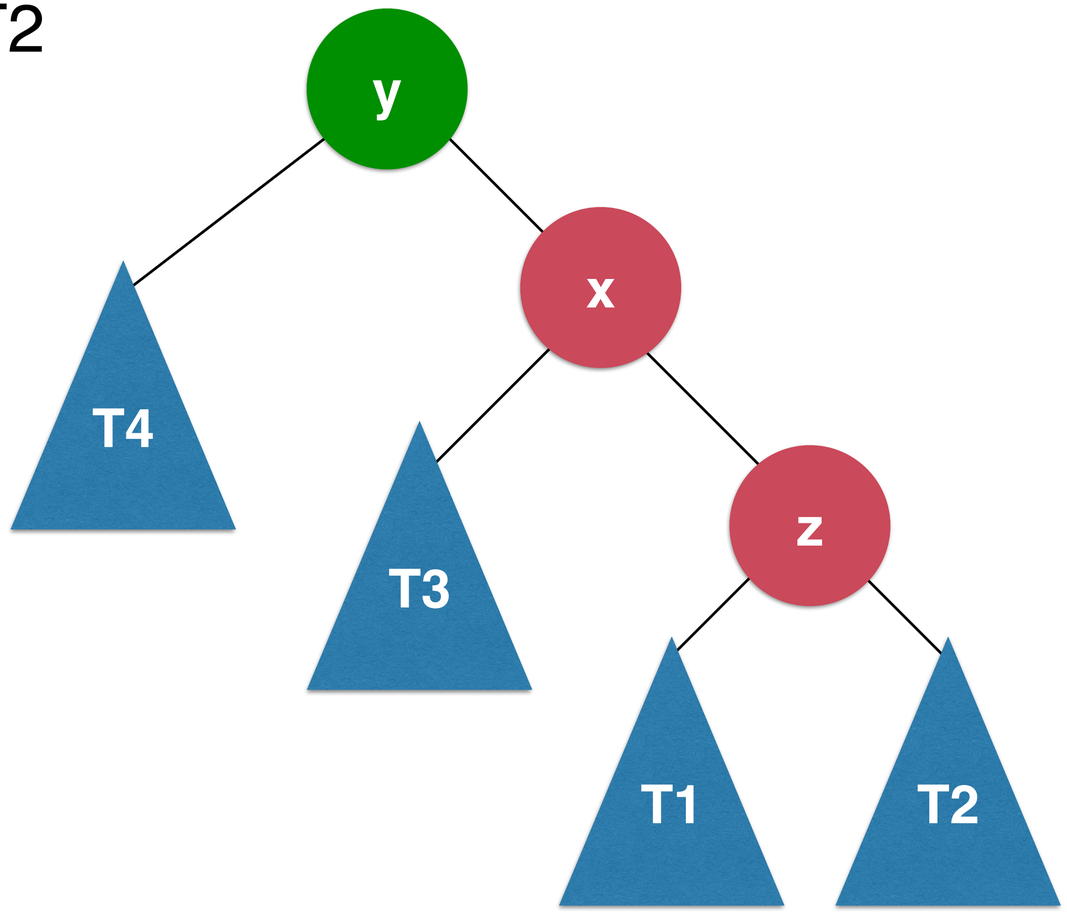
左旋转

插入的元素在不平衡的节点的
右侧的右侧



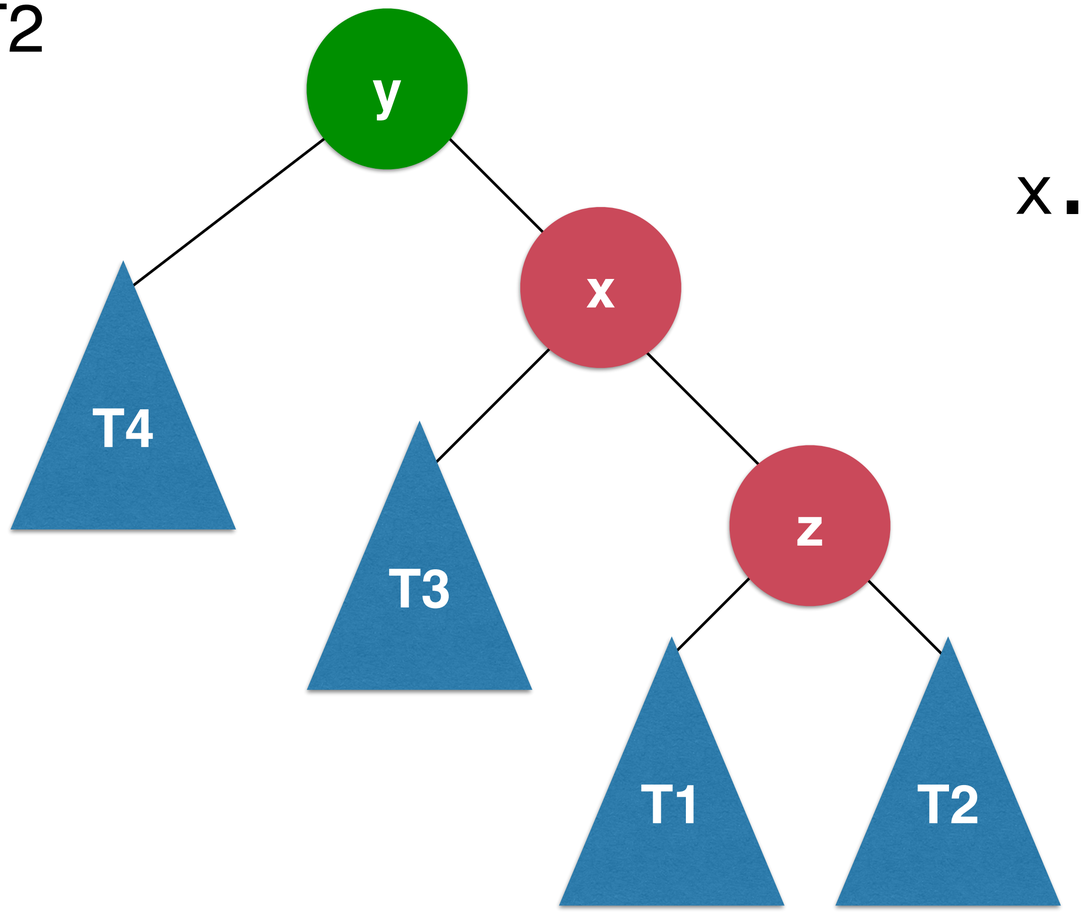
左旋转

T4 < y < T3 < x < T1 < z < T2



左旋转

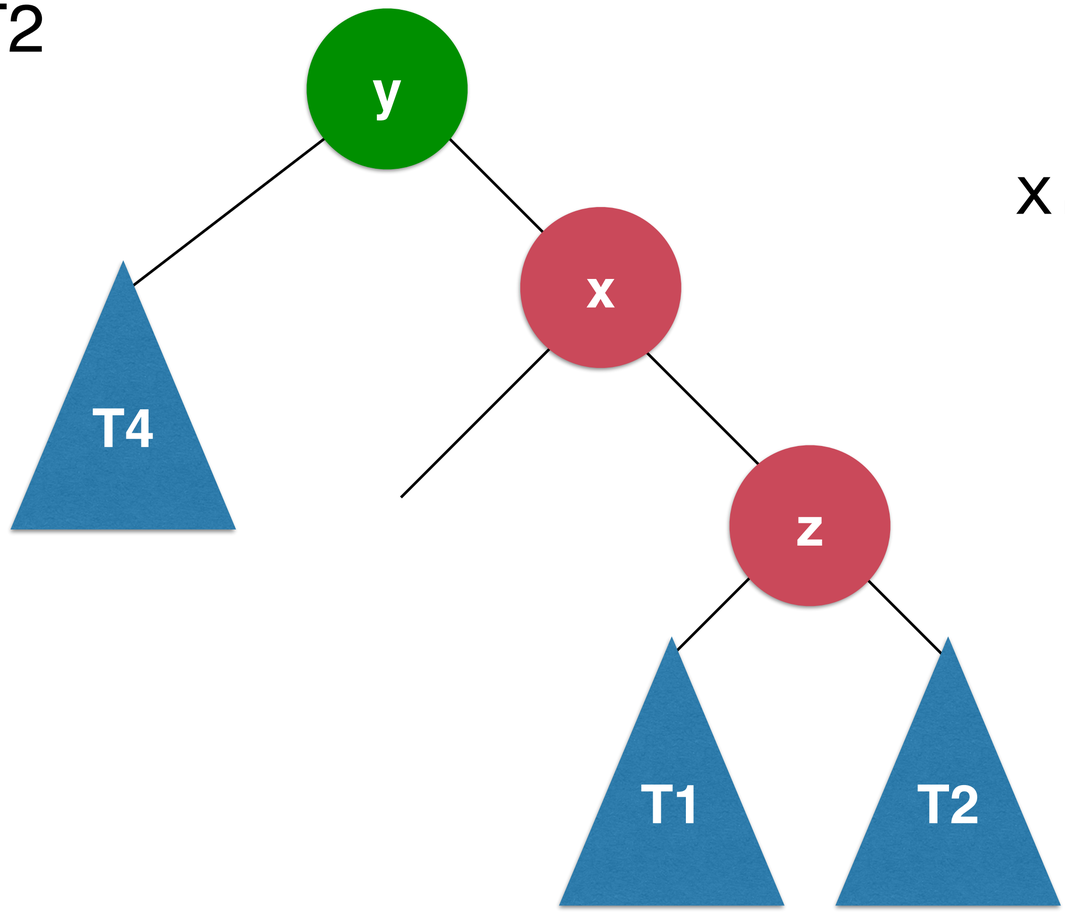
T4 < y < T3 < x < T1 < z < T2




```
x.left = y
```

左旋转

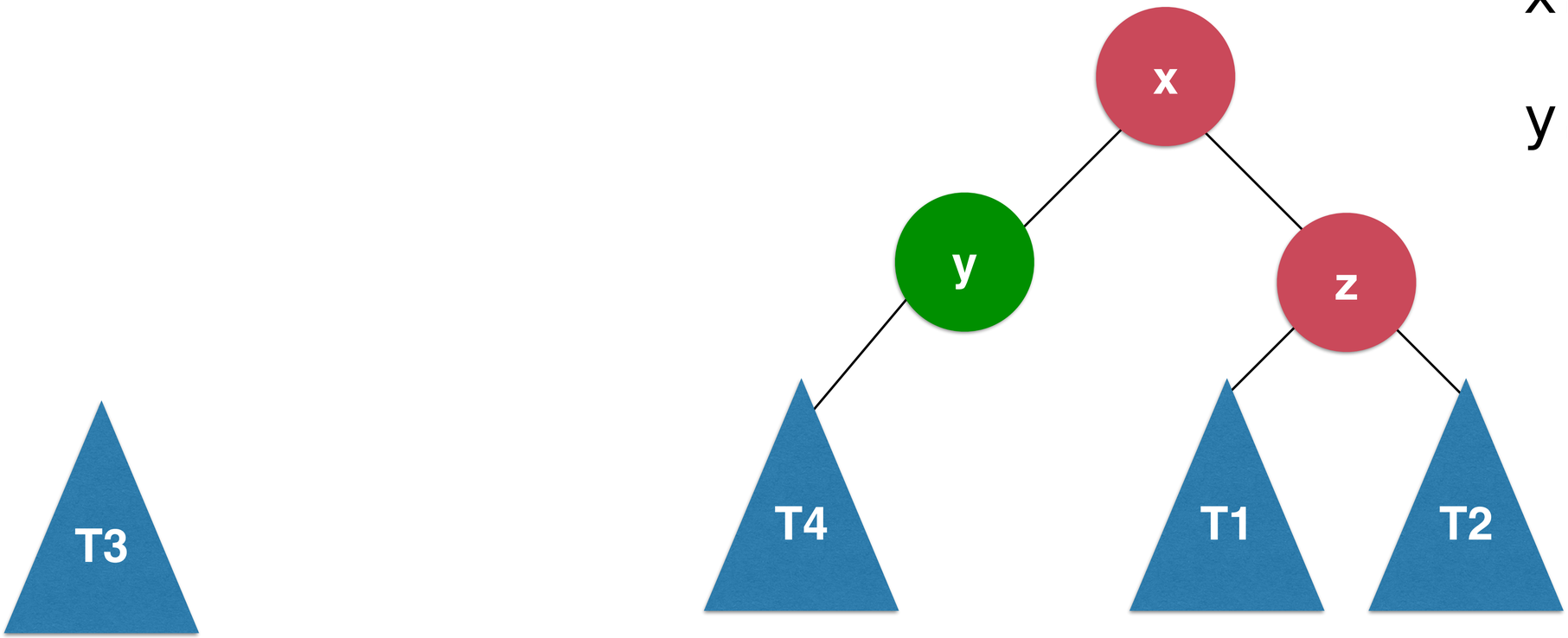
$T4 < y < T3 < x < T1 < z < T2$




```
x.left = y
```

左旋转

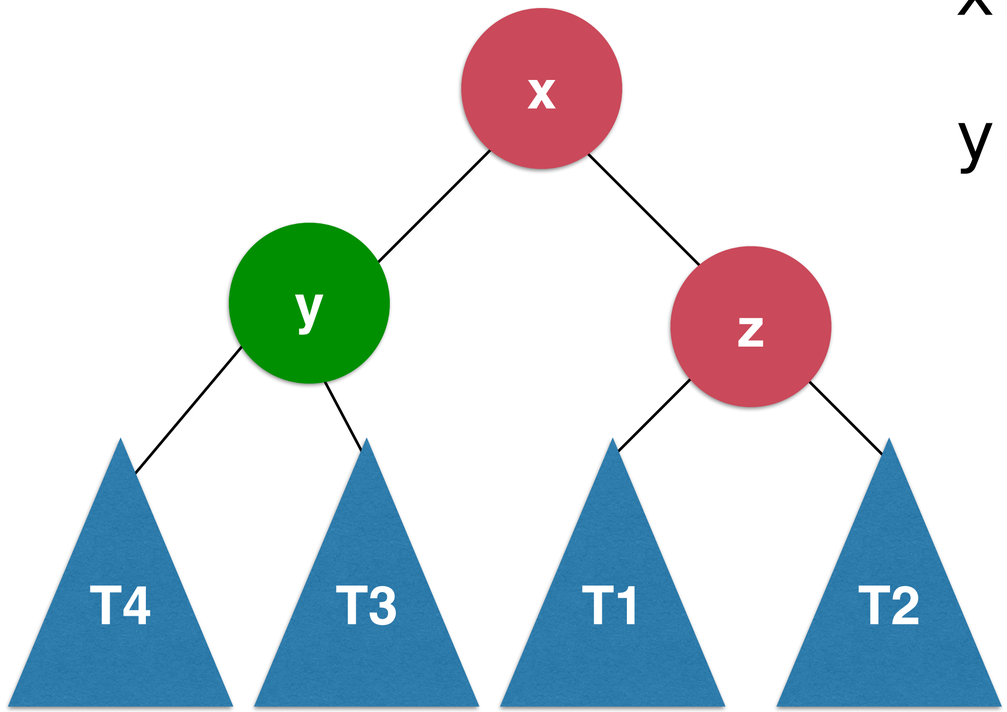
T4 < y < T3 < x < T1 < z < T2




```
x.left = y

y.right = T3
```

左旋转

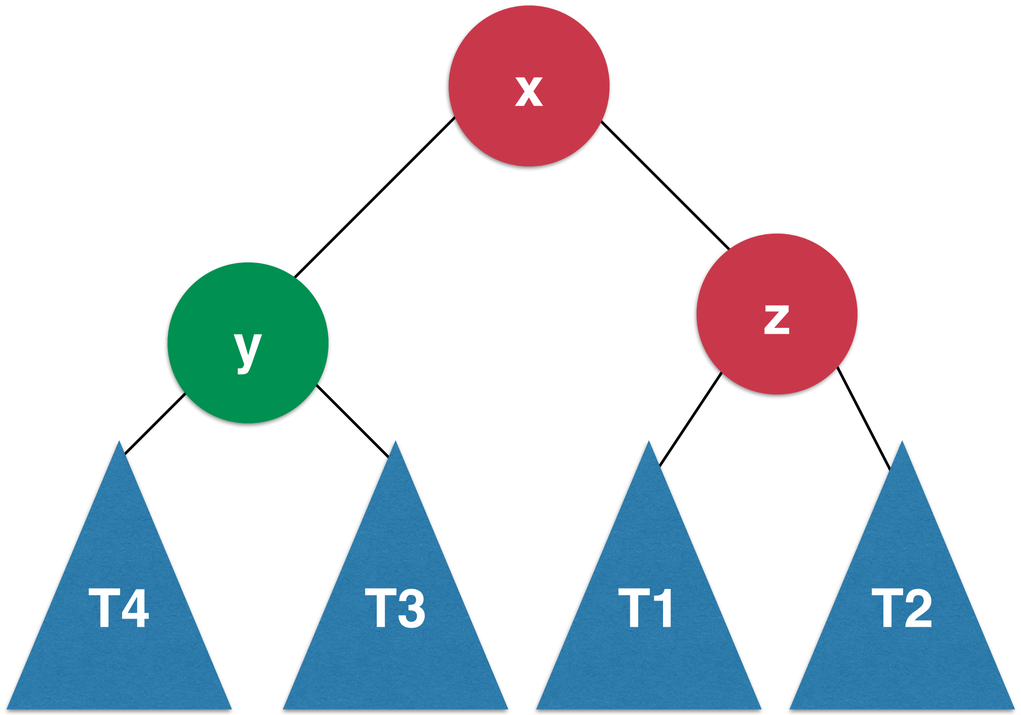
T4 < y < T3 < x < T1 < z < T2




```
x.left = y

y.right = T3
```

左旋转

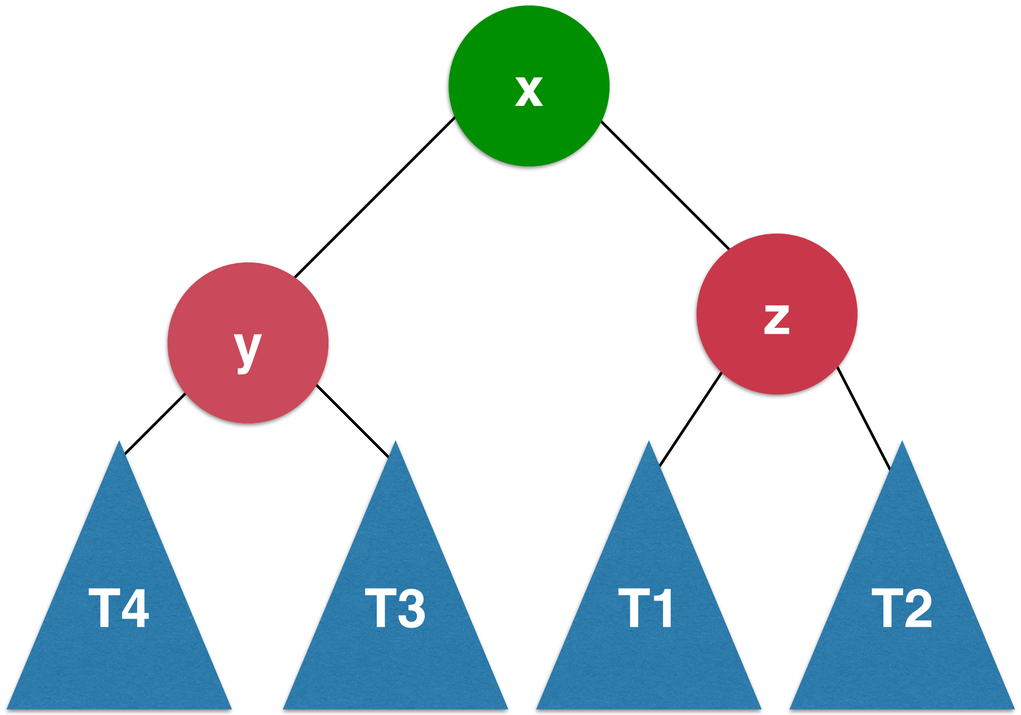
T4 < y < T3 < x < T1 < z < T2




```
x.left = y

y.right = T3
```

左旋转

T4 < y < T3 < x < T1 < z < T2



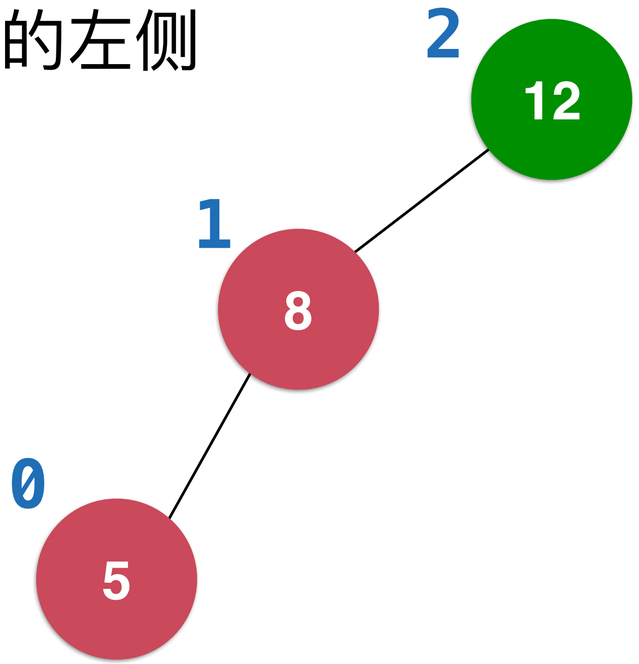

```
x.left = y

y.right = T3
```

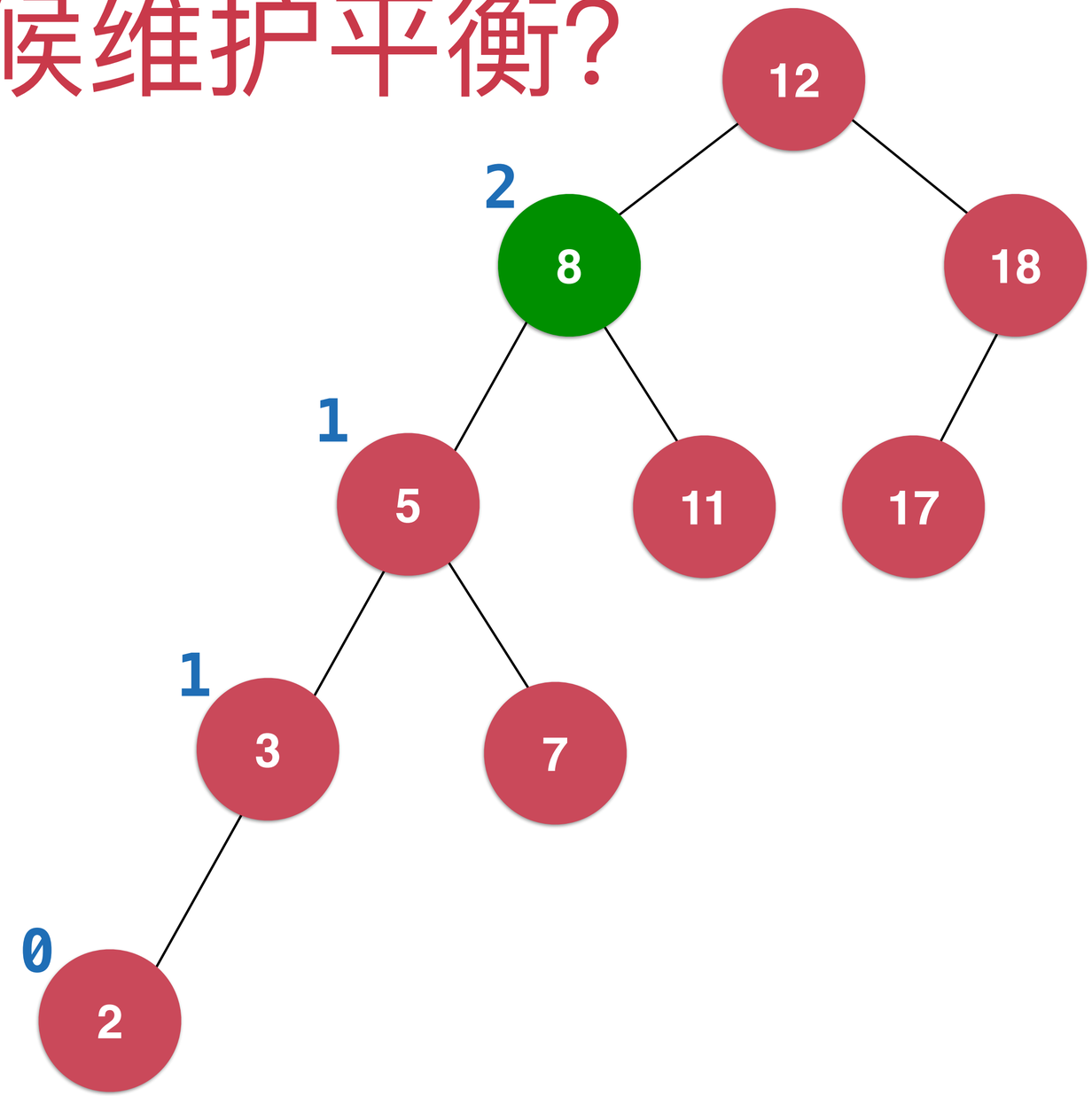
实践：左旋转

LR和RL

在什么时候维护平衡?

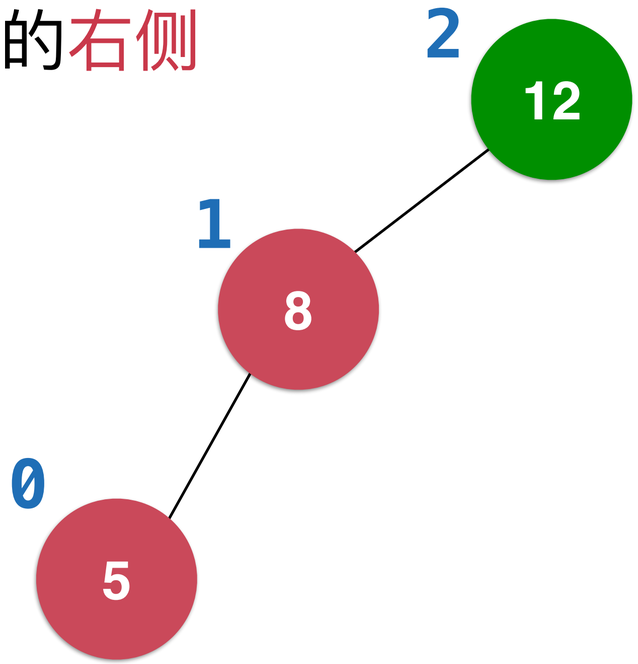
插入的元素在不平衡的
节点的左侧的左侧

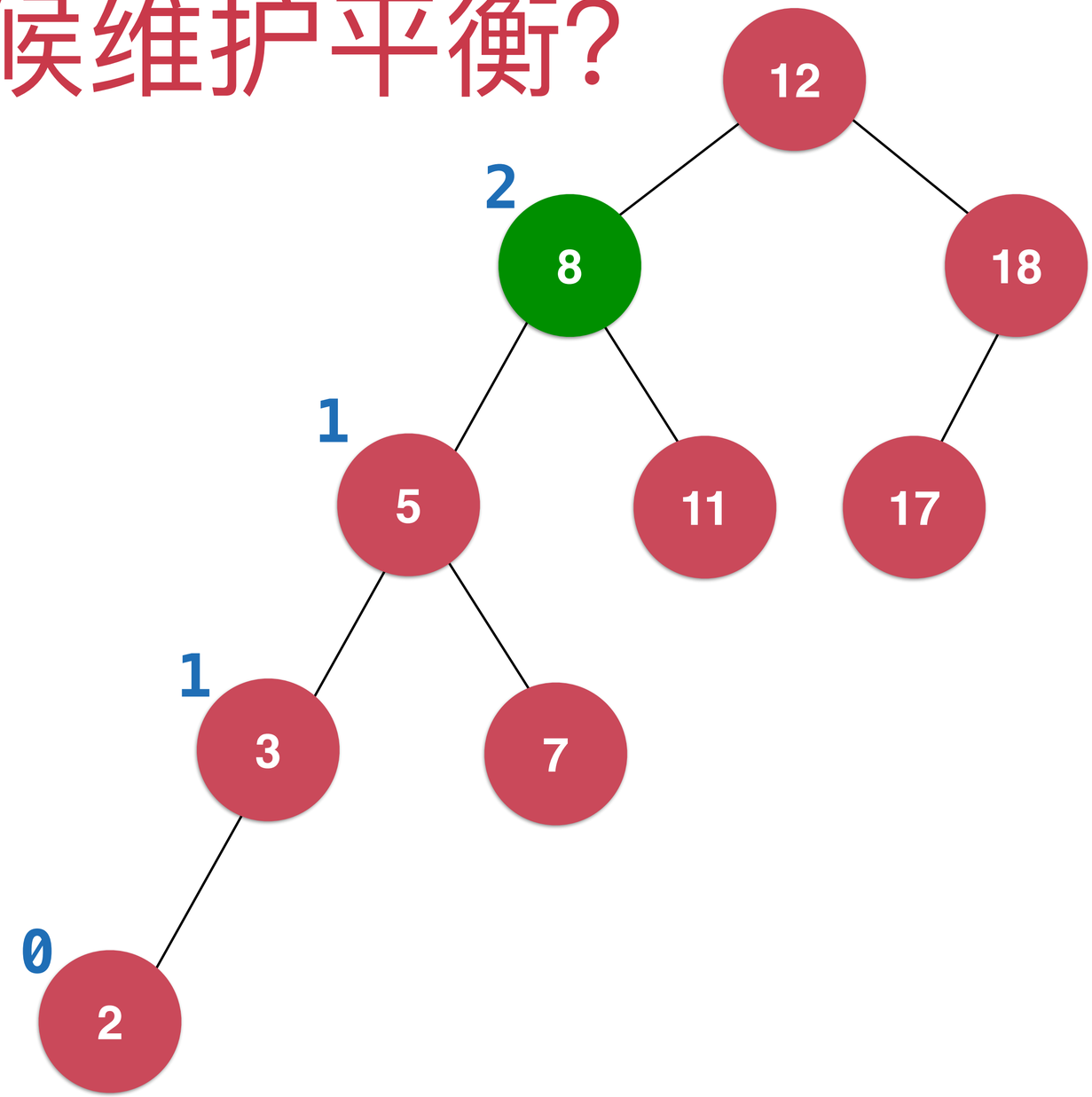




在什么时候维护平衡?

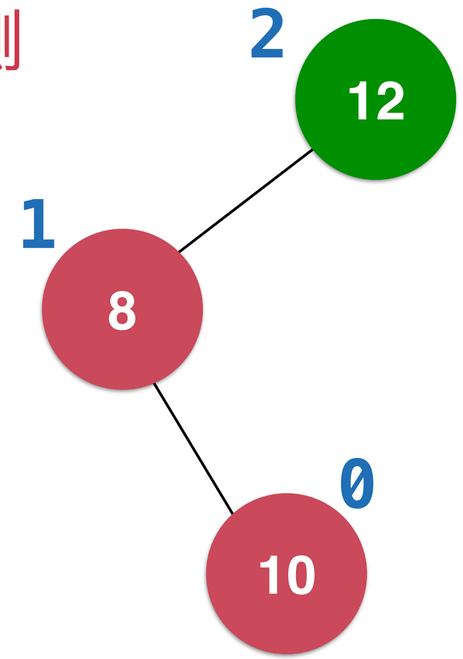
插入的元素在不平衡的
节点的左侧的右侧

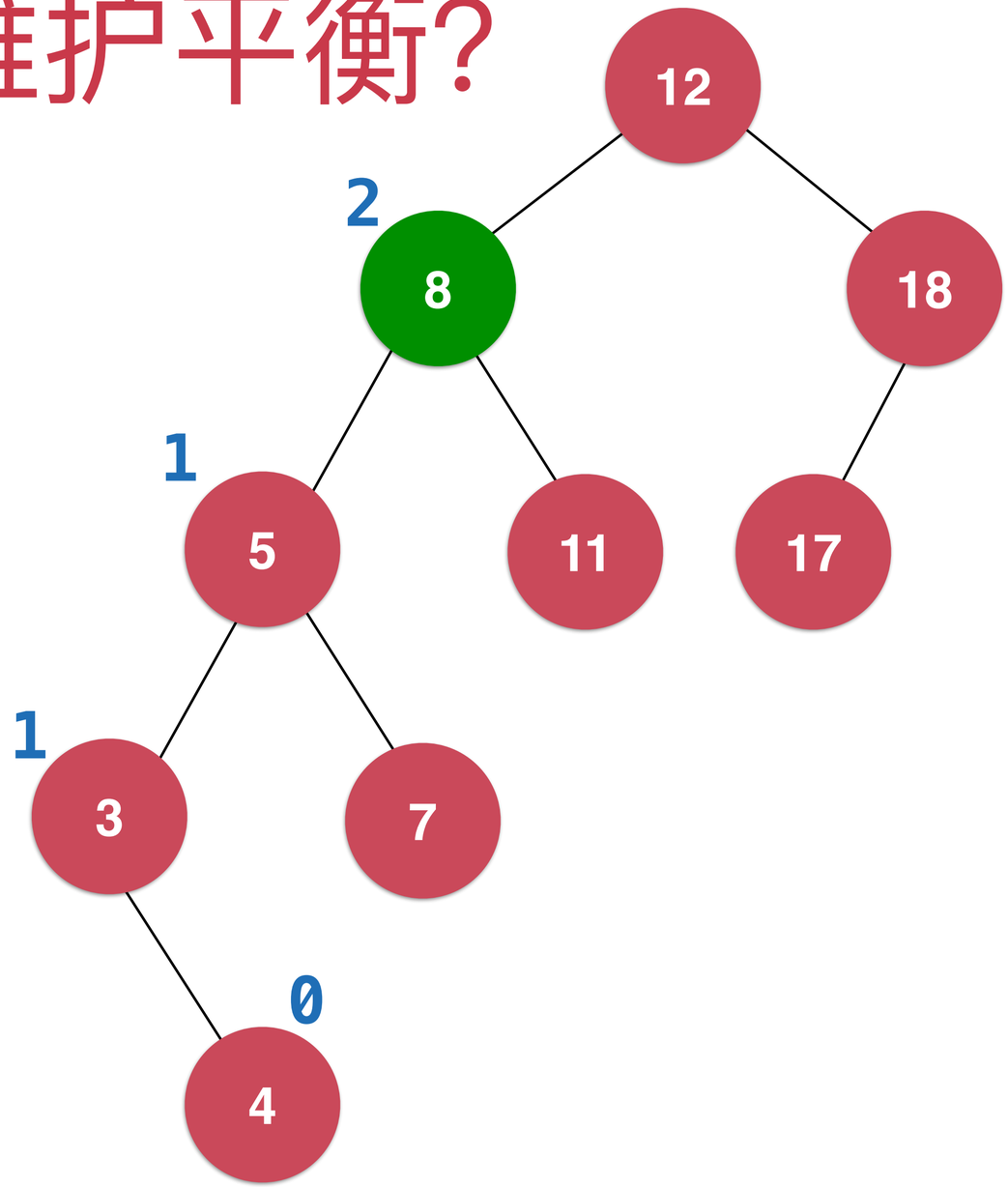




在什么时候维护平衡?

插入的元素在不平衡的
节点的左侧的右侧

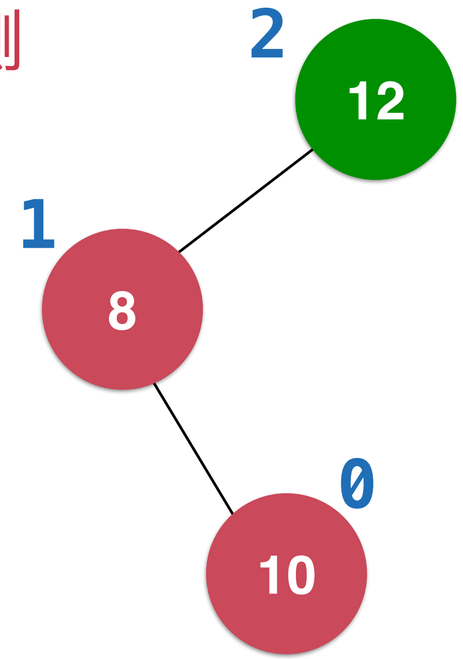


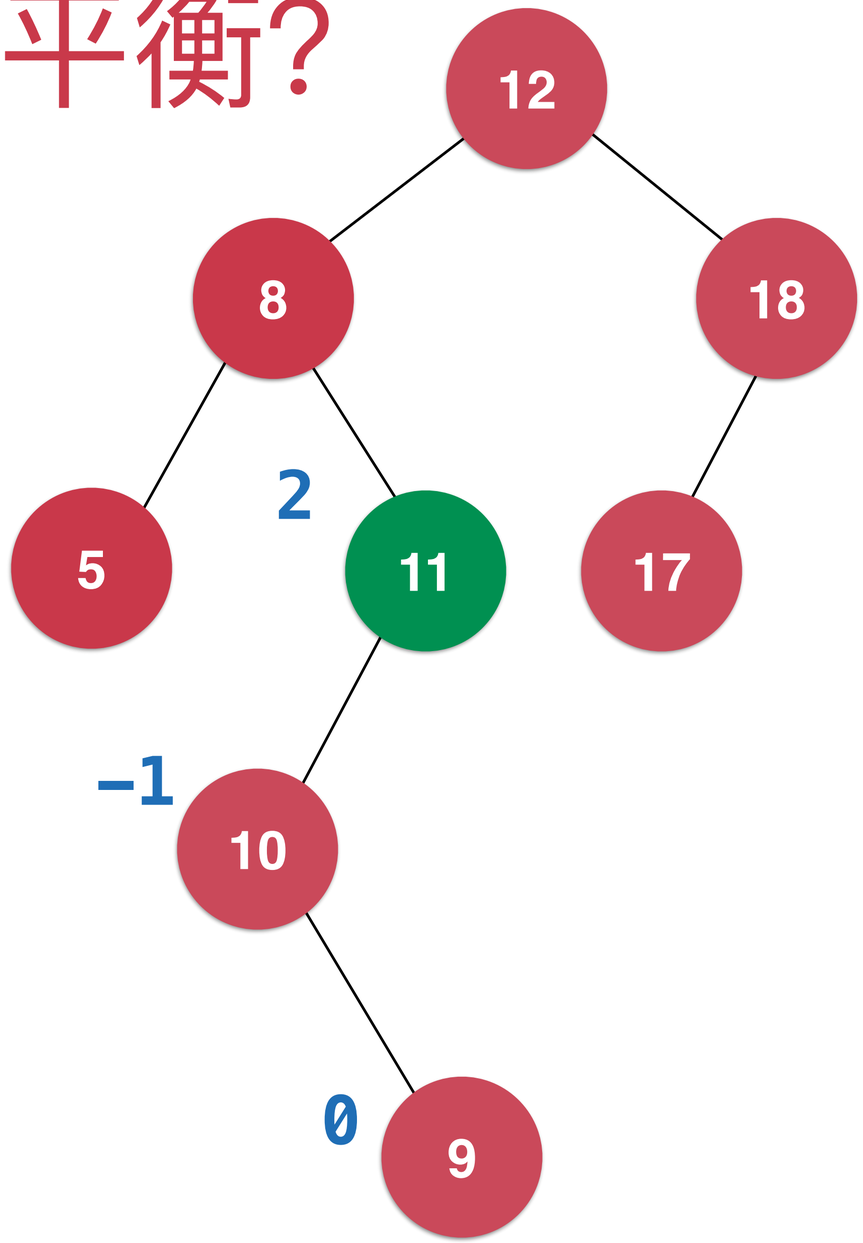


更正！！！

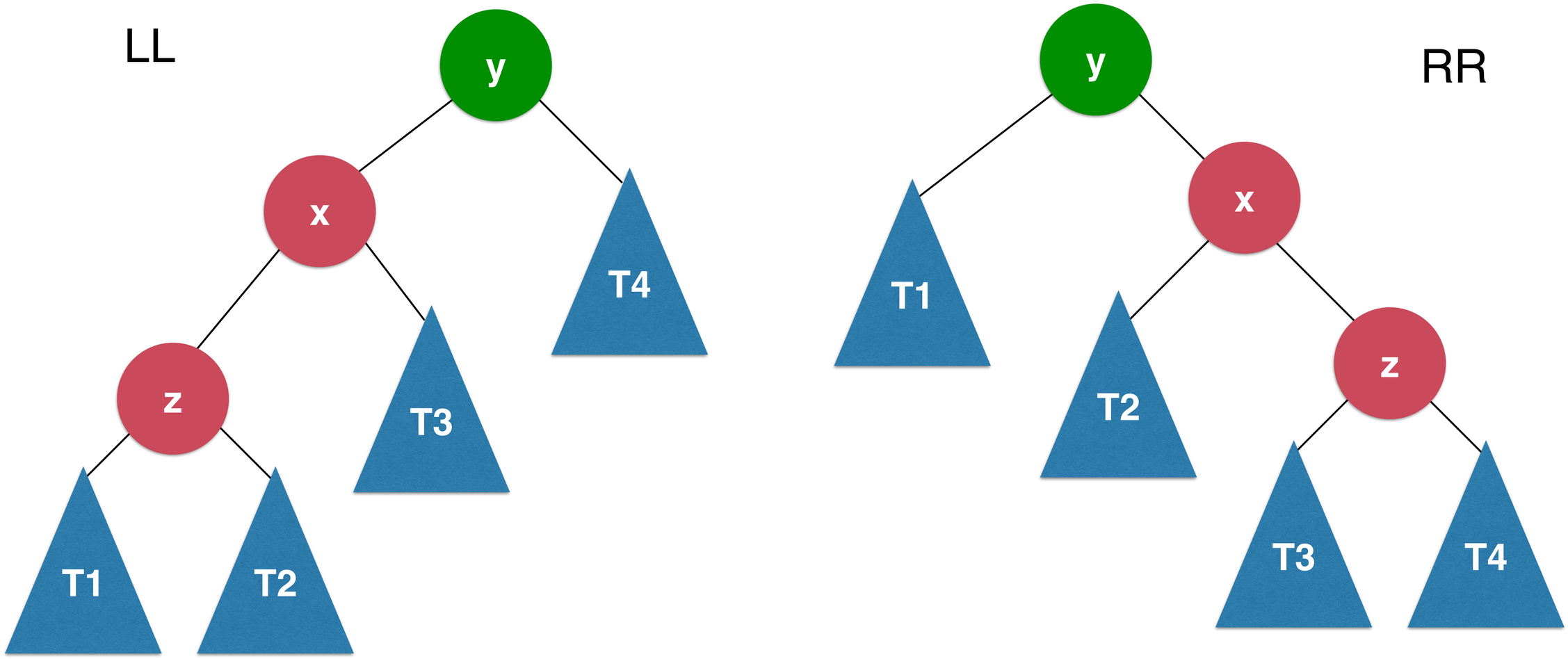
在什么时候维护平衡?

插入的元素在不平衡的
节点的左侧的右侧



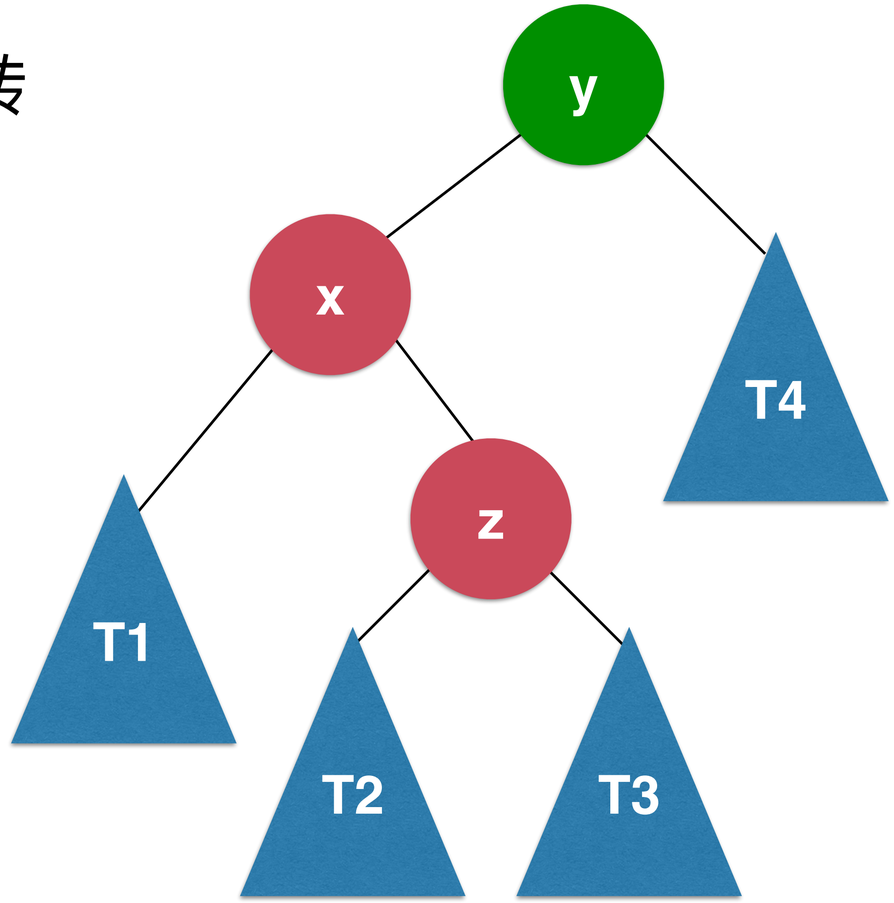


LL 和 RR



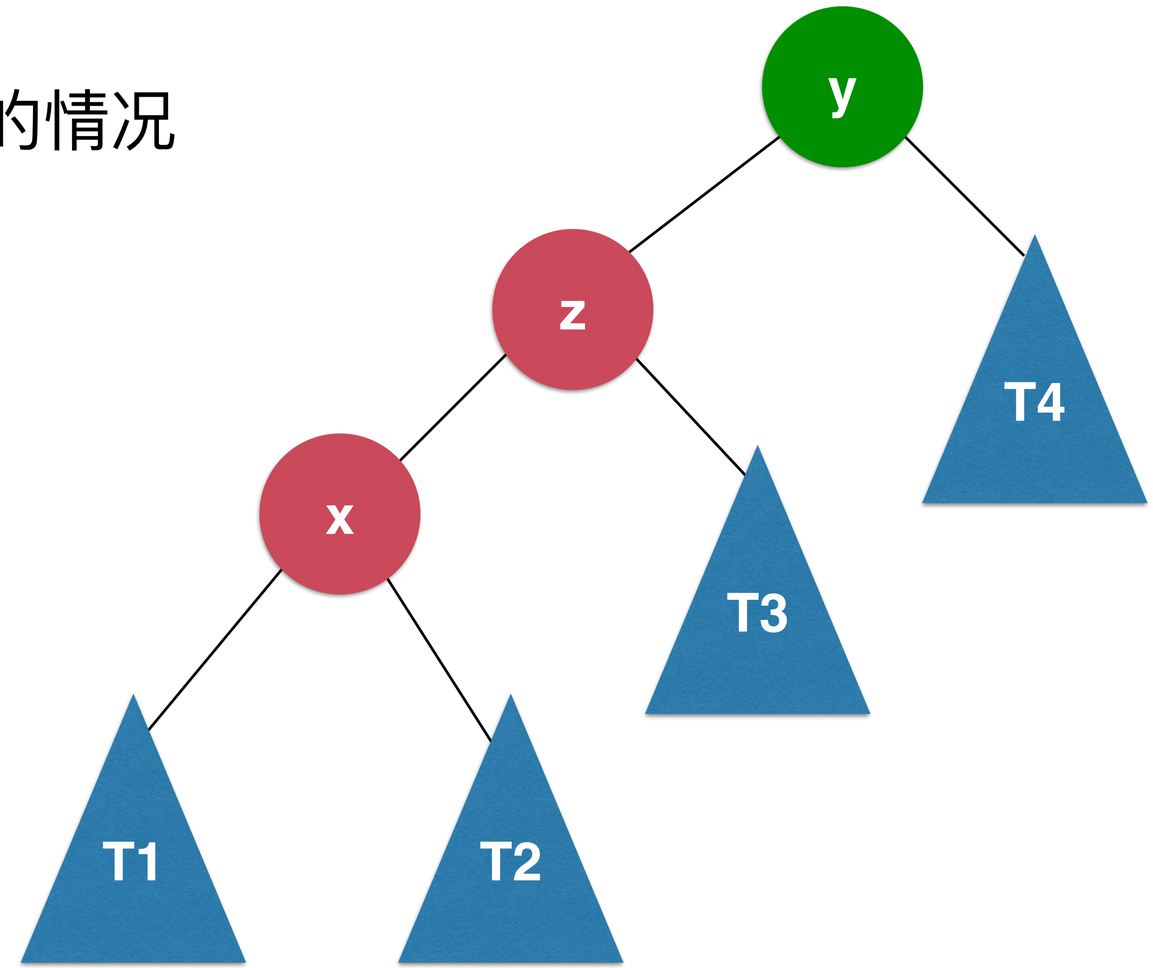
LR

首先对x进行左旋转



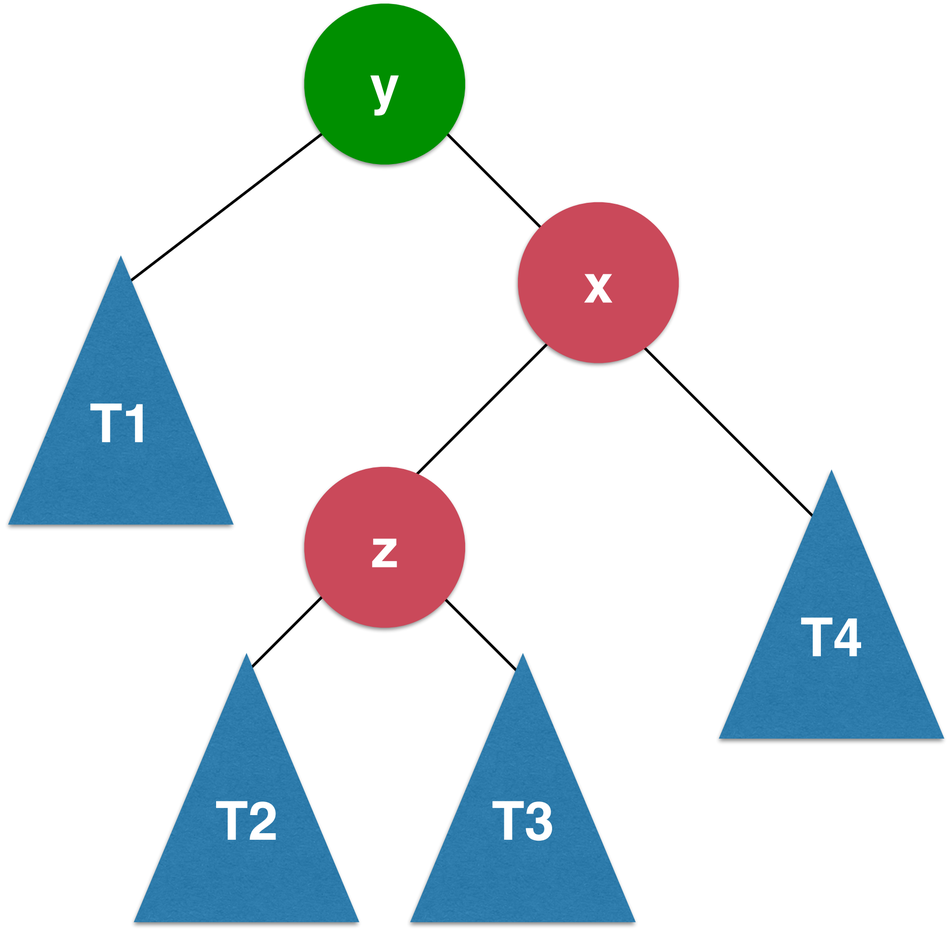
LR

转化为了LL的情况



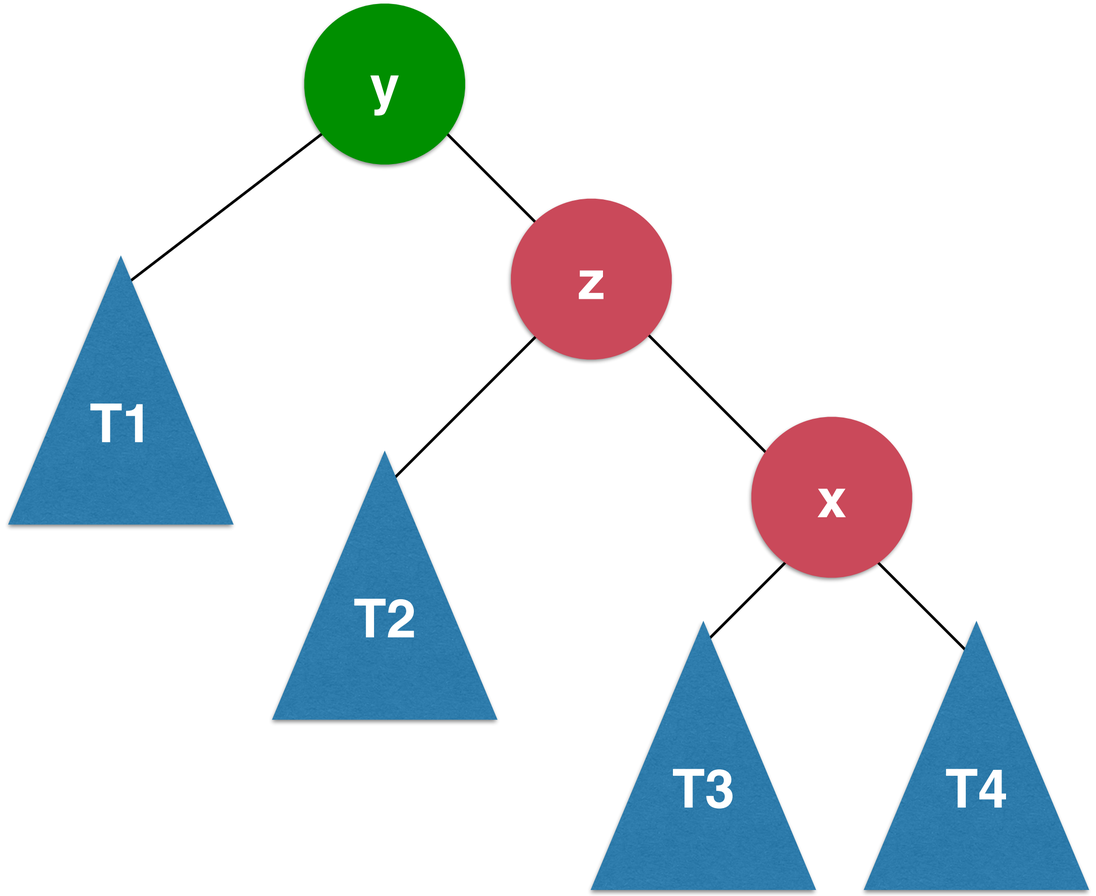
RL

首先对x进行右旋转



RL

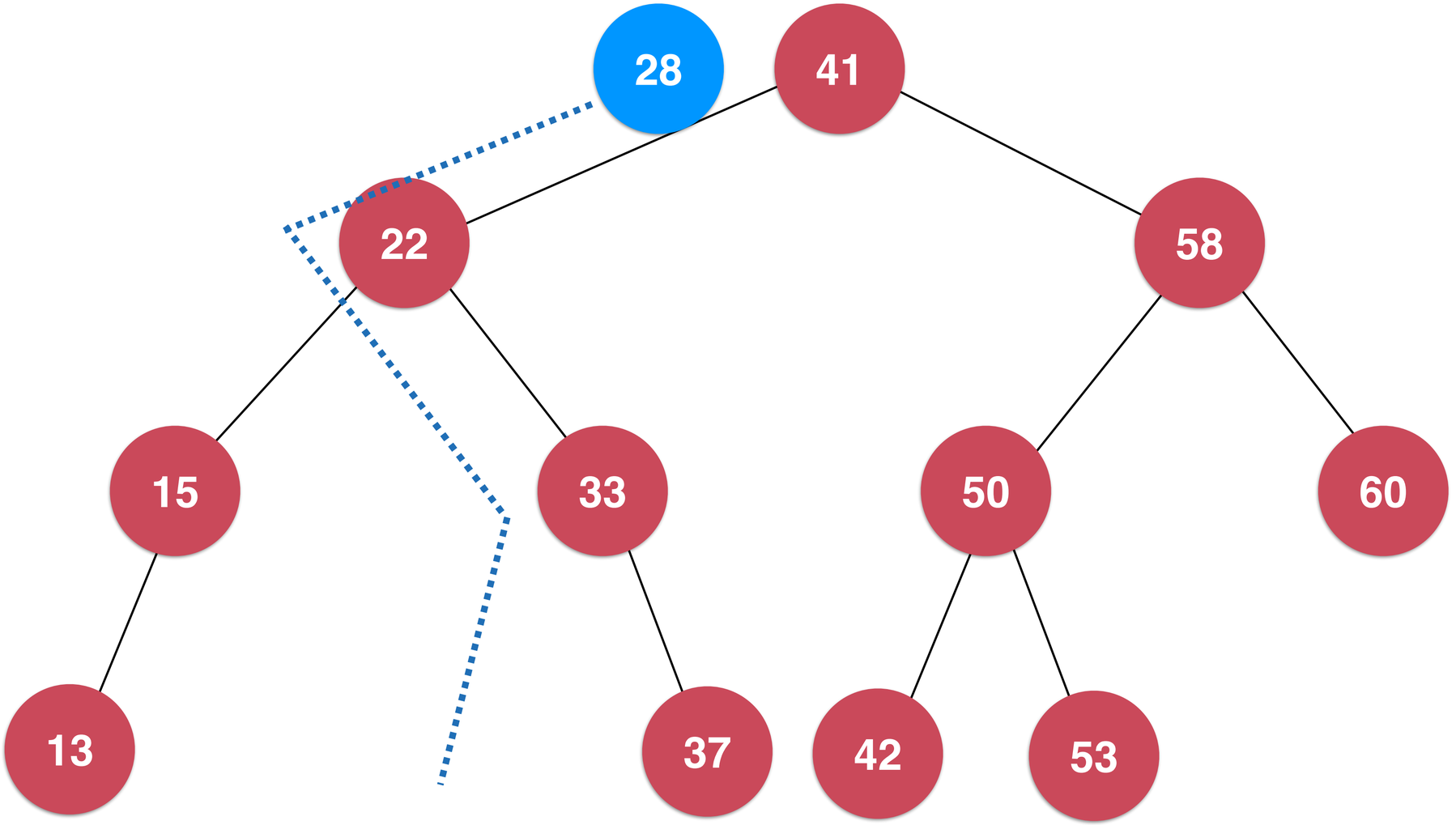
转化成了RR的情况



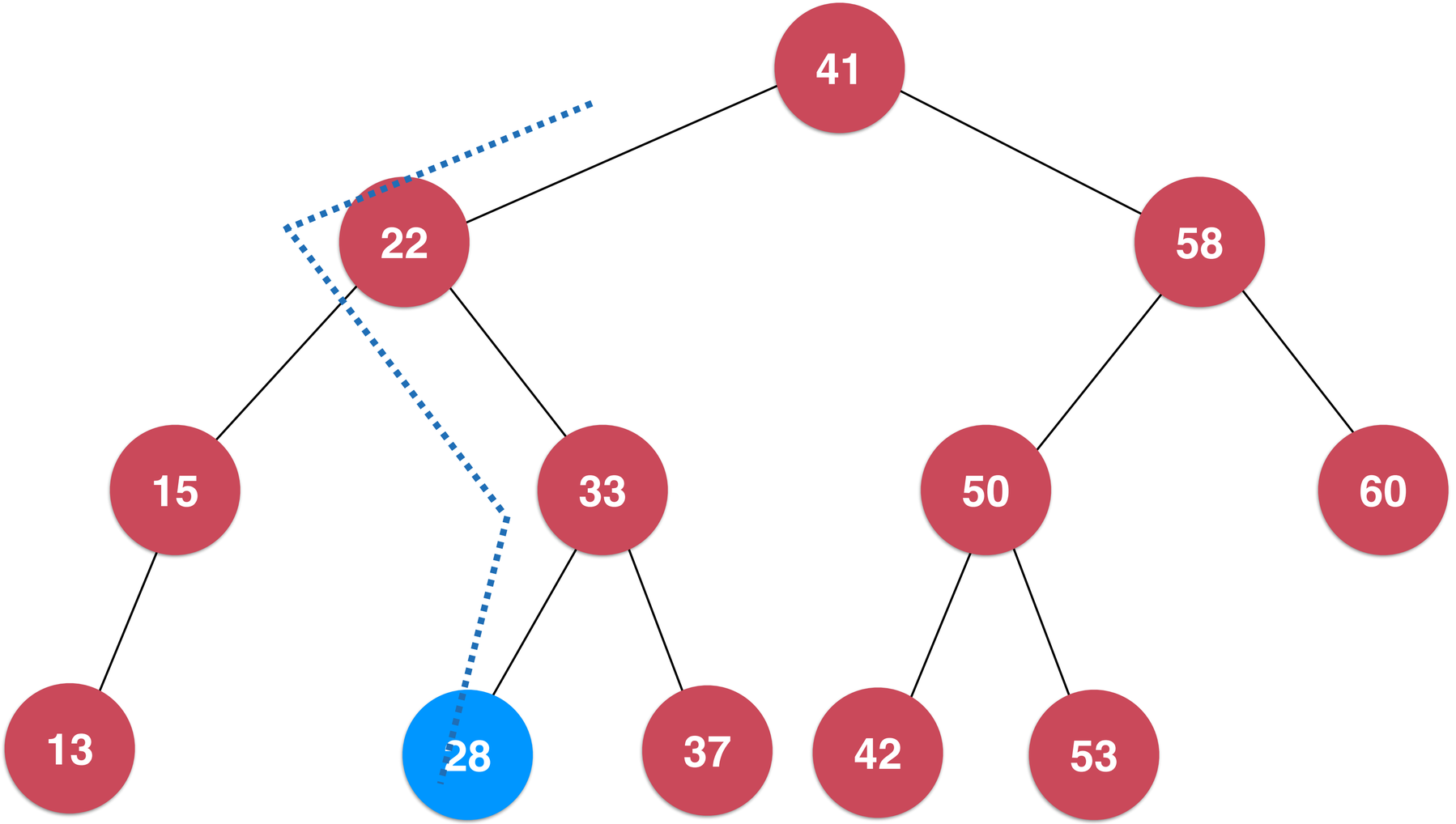
实践：处理LR和RL的情况

AVL树的删除

在什么时候维护平衡



在什么时候维护平衡



实践：AVL树的删除

更多AVL树的相关问题

基于AVL树的set和map

实践：基于AVL树的set和map

AVL树的优化

AVL树的局限性

AVL 树

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