二叉树

二叉树实现

05-D

Anyone who loves his father or mother more than me is not worthy of me; anyone who loves his son or daughter more than me is not worthy of me.

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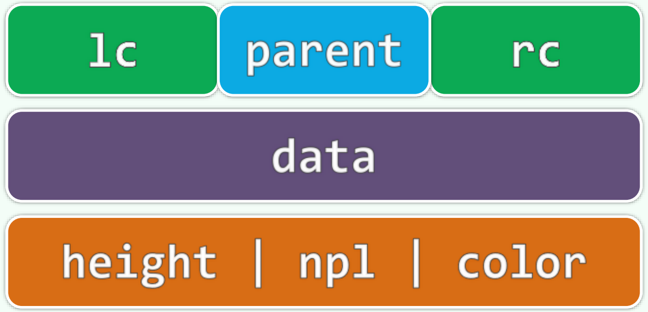
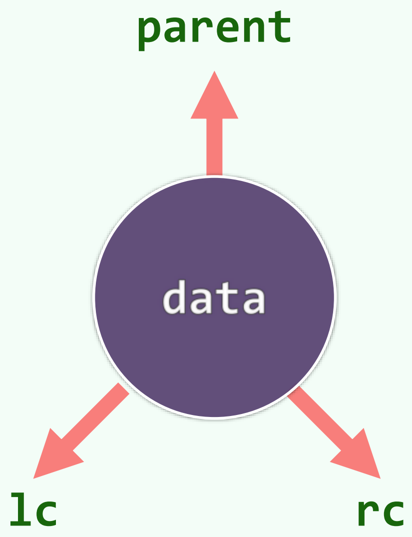
BinNode模板类

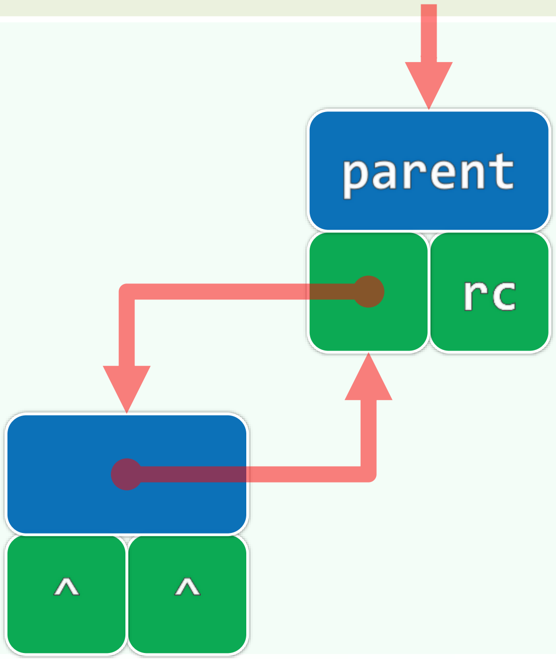
```
template <typename T> using BinNodePosi = BinNode<T>*; //节点位置

template <typename T> struct BinNode {

   BinNodePosi<T> parent, lc, rc; //父亲、孩子

   T data; int height; int size(); //高度、子树规模

   BinNodePosi<T> insertAsLC( T const & ); //作为左孩子插入新节点

   BinNodePosi<T> insertAsRC( T const & ); //作为右孩子插入新节点

   BinNodePosi<T> succ(); //（中序遍历意义下）当前节点的直接后继

   template <typename VST> void travLevel( VST & ); //层次遍历

   template <typename VST> void travPre( VST & ); //先序遍历

   template <typename VST> void travIn( VST & ); //中序遍历

   template <typename VST> void travPost( VST & ); //后序遍历

};
```





BinNode接口实现

```
❖ template <typename T> BinNodePosi<T> BinNode<T>::insertAsLC( T const & e )
      { return lc = new BinNode( e, this ); }
❖ template <typename T> BinNodePosi<T> BinNode<T>::insertAsRC( T const & e )
      { return rc = new BinNode( e, this ); }
❖ template <typename T> int BinNode<T>::size() { //后代总数
      int s = 1; //计入本身
      if (lc) s += lc->size(); //递归计入左子树规模
      if (rc) s += rc->size(); //递归计入右子树规模
      return s;
  } //O( n = |size| )
```

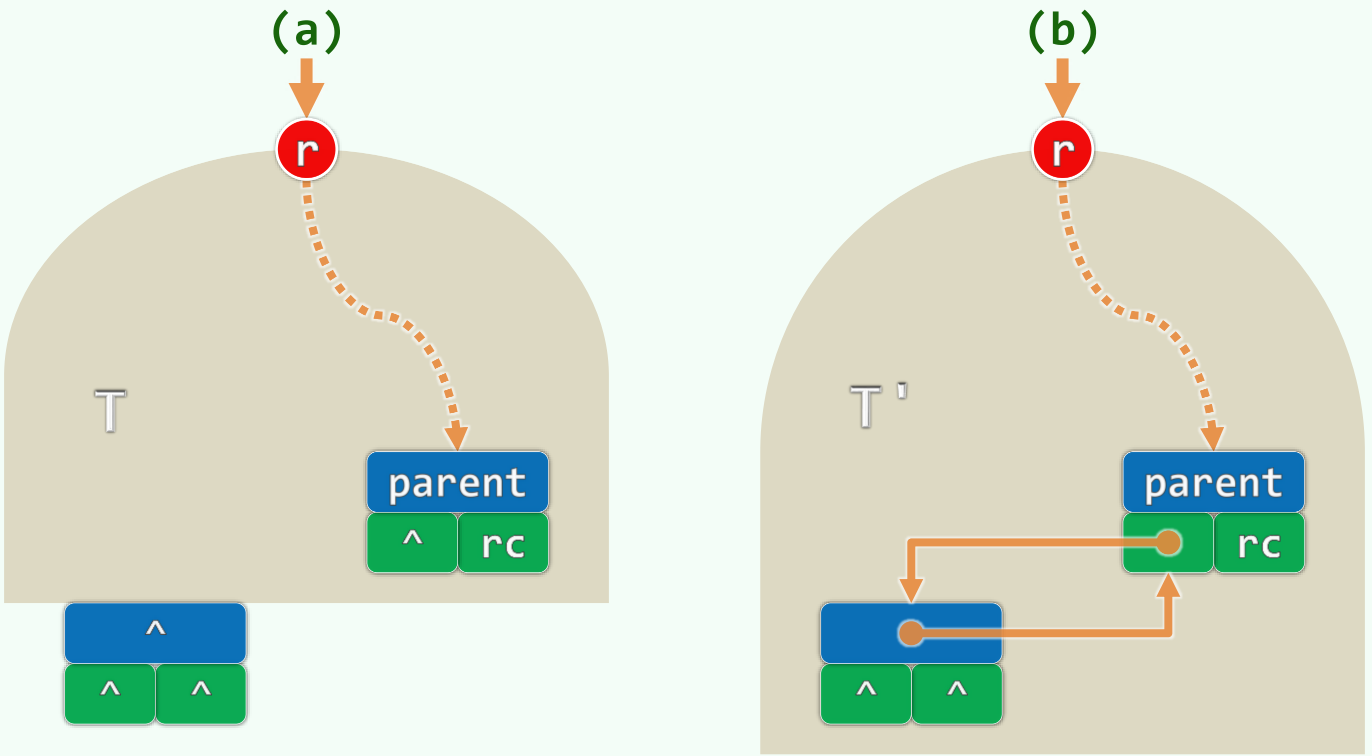


BinTree模板类

```
template <typename T> class BinTree {
protected: int _size; //规模
           BinNodePosi<T> _root; //根节点
           virtual int updateHeight( BinNodePosi<T> x ); //更新节点x的高度
           void updateHeightAbove( BinNodePosi<T> x ); //更新x及祖先的高度
public:    int size() const { return _size; } //规模
           bool empty() const { return !_root; } //判空
           BinNodePosi<T> root() const { return _root; } //树根
           /* ... 子树接入、删除和分离接口；遍历接口 ... */
}
```

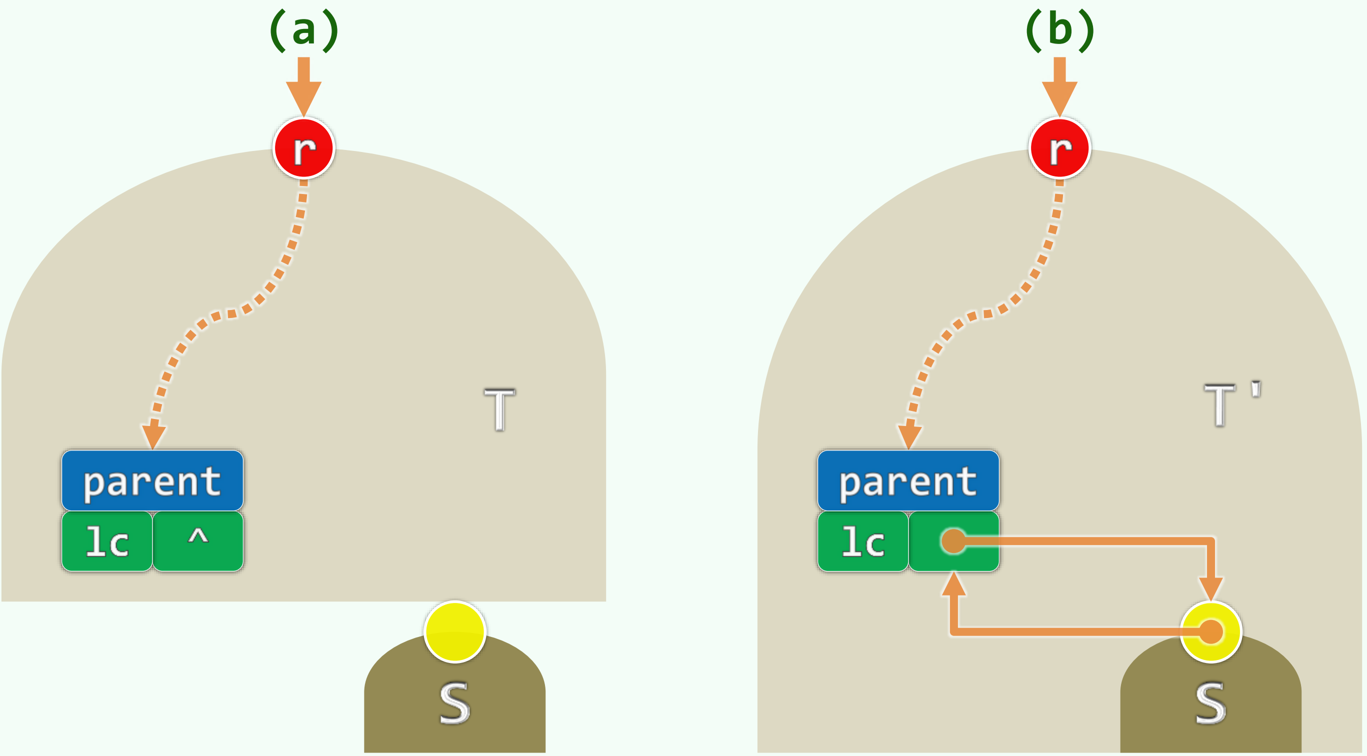
节点插入

```
BinNodePosi<T> BinTree<T>::insert( BinNodePosi<T> x, T const & e );  //作为右孩子

BinNodePosi<T> BinTree<T>::insert( T const & e, BinNodePosi<T> x ) { //作为左孩子

   _size++;

   x->insertAsLC( e );

   updateHeightAbove( x );

   return x->lc;

}
```



子树接入

```
BinNodePosi<T> BinTree<T>::attach( BinTree<T>* &S, BinNodePosi<T> x );  //接入左子树

BinNodePosi<T> BinTree<T>::attach( BinNodePosi<T> x, BinTree<T>* &S ) { //接入右子树
   if ( x->rc = S->_root )
      x->rc->parent = x;
   _size += S->_size;
   updateHeightAbove(x);
   S->_root = NULL; S->_size = 0;
   release(S); S = NULL;
   return x;
}
```



高度更新

```
#define stature(p) ( (p) ? (p)->height : -1 ) //节点高度——空树 ~ -1
```

```
template <typename T> //更新节点x高度，具体规则因树不同而异
int BinTree<T>::updateHeight( BinNodePosi<T> x ) //此处采用常规二叉树规则，O(1)
   { return  x->height  =  1 + max( stature( x->lc ), stature( x->rc ) ); }
```

```
template <typename T> //更新节点及其历代祖先的高度
void BinTree<T>::updateHeightAbove( BinNodePosi<T> x ) //O( n = depth(x) )
   { while (x) { updateHeight(x); x = x->parent; } } //可优化
```

子树删除

❖
```
template <typename T> int BinTree<T>::remove( BinNodePosi<T> x ) {
    FromParentTo( * x ) = NULL;
    updateHeightAbove( x->parent ); //更新祖先高度（其余节点亦不变）
    int n = removeAt(x); _size -= n; return n;
}
```

❖
```
template <typename T> static int removeAt( BinNodePosi<T> x ) {
    if ( ! x ) return 0;
    int n = 1 + removeAt( x->lc ) + removeAt( x->rc );
    release(x->data); release(x); return n;
}
```

子树分离

```
template <typename T> BinTree<T>* BinTree<T>::secede( BinNodePosi<T> x ) {
   FromParentTo( * x ) = NULL; updateHeightAbove( x->parent );
// 以上与BinTree<T>::remove()一致；以下还需对分离出来的子树重新封装
   BinTree<T> * S = new BinTree<T>; //创建空树
   S->_root = x; x->parent = NULL; //新树以x为根
   S->_size = x->size(); _size -= S->_size; //更新规模
   return S; //返回封装后的子树
}
```