Lecture 21
Binary Trees

(C) Princeton University
Binary Tree

Similar to linked list but with two links at each node.

A link is from a parent.

Links are to children.
Classes KeyObj and BTree

```java
class KeyObj {
    String key;
    Object obj;
    KeyObj left;
    KeyObj right;
}

class BTree {
    KeyObj z, head;
    
    
    
}
```
public Object lookUp(String key) {
    KeyObj x = head.right;
    z.key = key;
    while ( !x.key.equals(key) ) {
        if (x.key.compareTo(key)>0){
            x = x.left;
        } else {
            x = x.right;
        }
    }
    return x.obj;
}
public void add(String key, Object obj) {
    KeyObj p=head, x=head.right;
    while (x != z) {
        p = x;
        if (x.key.compareTo(key) > 0 )
            { x = x.left;  }
        else
            { x = x.right; }
    }
    x = new KeyObj();
    x.key = key; x.obj = obj;
    x.left = z; x.right = z;
    if (p.key.compareTo(key) > 0) {
        p.left = x;
    } else {
        p.right = x;
    }
}
Three cases (\(t\) denotes node to be deleted):

- \(t\) has no right child - set child of parent node to the left child of \(t\). (Rob, Cal, Pat, Max, and Les).
- \(t\) has a right child but no left child - set child of parent node to the right child of \(t\). (Ann and Hal).
- Otherwise - see next page. (Ely and Ned).
Deleting Ely

Find node with the smallest key in the subtree to the right of \( t \).

That node’s right link is copied to the left link of its parent and both of its links are set from \( t \).
Delete - The Code

```java
public void delete(String key) {
    KeyObj c, p, x, t;
    z.key = key;
    p = head;
    x = head.right;
    while ( !x.key.equals(key) ) {
        p = x;
        if ( x.key.compareTo(key) > 0) { x = x.left; } 
        else { x = x.right; }
    }
    t = x;
    if (t.right == z) {
        x = x.left;
    } else
    if (it.right.left == z) {
        x = x.right;
        x.left = t.left;
    } else {
        c = x.right;
        while (c.left.left != z) { 
            c = c.left;
        }
        x = c.left;
        c.left = x.right;
        x.left = t.left;
        x.right = t.right;
    }
    if (p.key.compareTo(key) > 0) { p.left = x; } 
    else { p.right = x; }
}
```