CS206

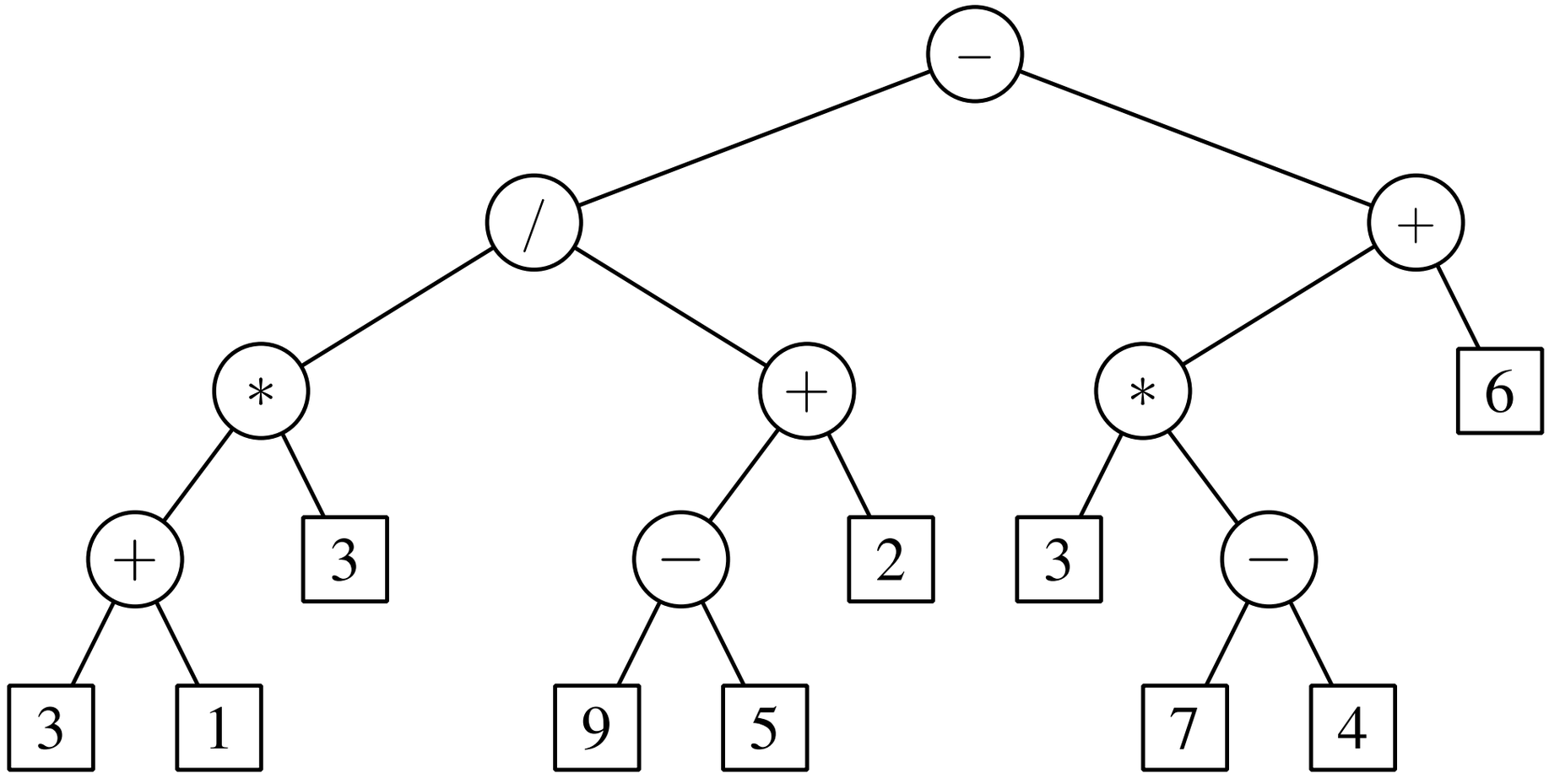
Trees

Part 2

March 24

Binary Tree

- An ordered tree with every node having at most two children – left and right



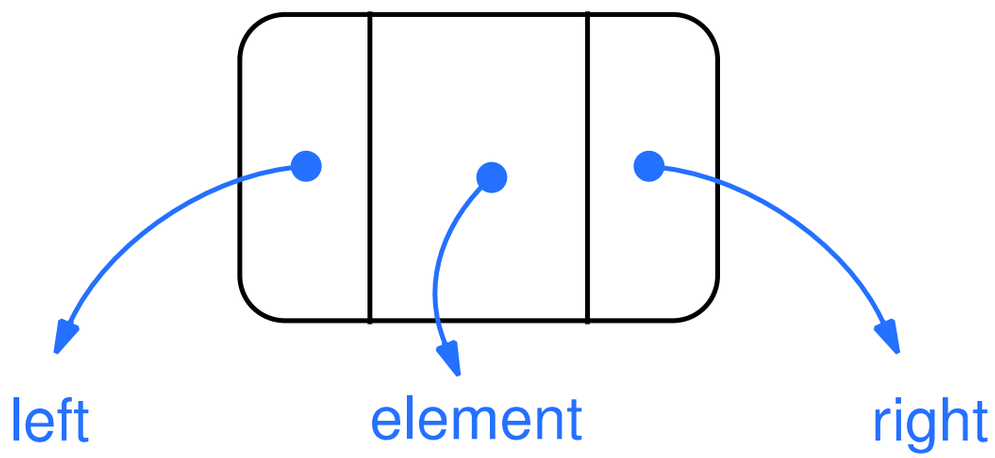
Interface

```
public interface BinaryTreeInterface<B>
{
     int size();
     boolean isEmpty();
     boolean contains(B element);
     void insert(B element);
     int height();
     B remove(B element);
}
```

Implementation

```
private class Node {
     E payload;
     Node right;
     Node left;

     public Node(E e) {
          payload=e;
          right=null;
          left=null;
     }
     public String toString() {
          return payload.toString();
     }
}
```



Class

```
public class LinkedBinaryTree<E
extends Comparable<E>> implements
BinaryTreeInterface<E>
{
    /** The number of elements
     * in the tree
     * (optional but useful) */
  private int size;

  /** The root of the tree */
  private Node root;
```

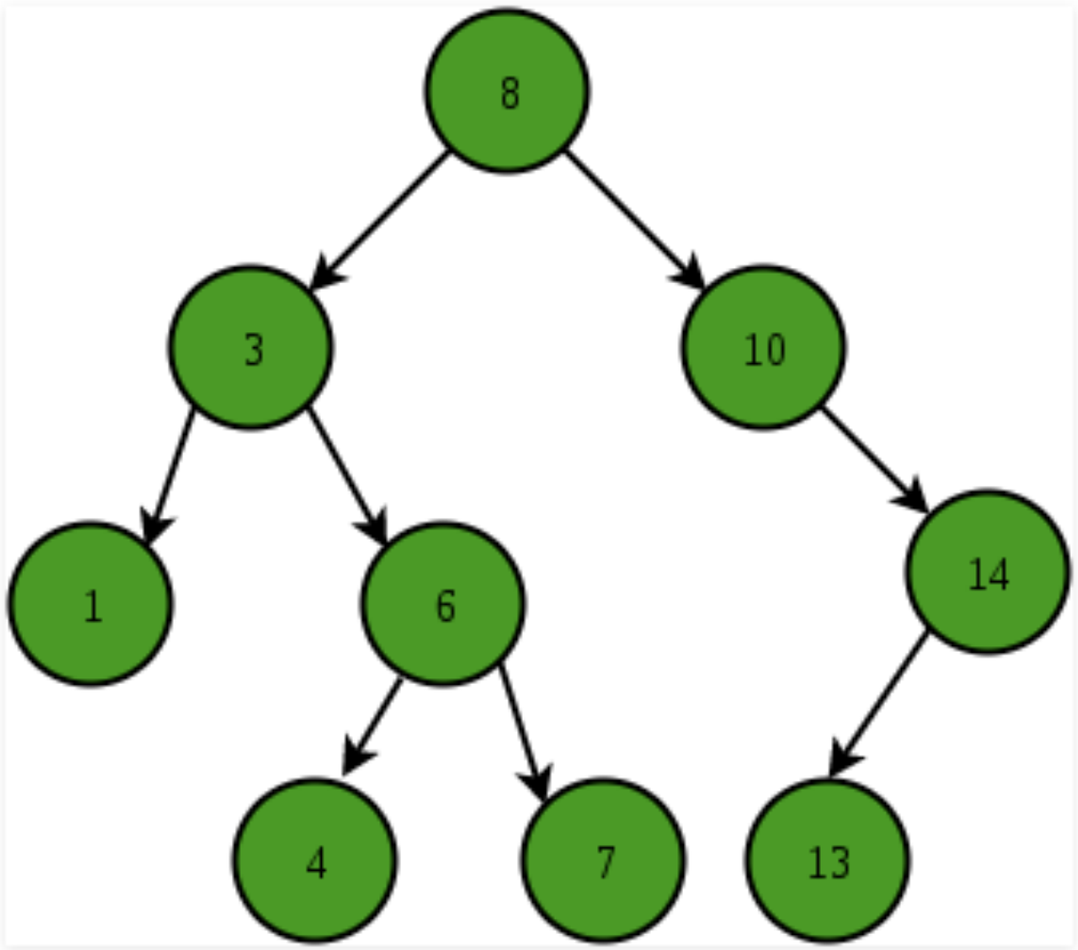
size() and isEmpty()

```
@Override
    public int size()
    {
        return size;
    }
```

```
@Override
public boolean isEmpty()
{
    return size==0;
}
```

contains

- `boolean contains(E element);`
- returns true if found in the tree, false otherwise



Algorithm

- compare with root of **current subtree**
  - root is empty – return false
  - root == element – return true
  - root < element – recurse on right child
  - root > element - recurse on left child

Pseudo Code

```
findRec(root, key):
  if root == null:
    return false
  if root.key == key:
    return true
  if root.key > key:
    return findRec(root.left, key)
  else
    return findRec(root.right, key)
```

Recursive Helper Method

- The signature of `contains` doesn't allow any `Node` references (it cannot since `Node` is private)
- so define a private , recursive "helper" method.

```
public boolean contains(E element) {
    if (root==null) return false;
    return iContains(root, element)!=null;
}
private Node iContains(Node treepart, E toBeFound) {
     … }
```

write iContains at chalkboard

insert

- `void insert(E element);`
- new node is always inserted as a leaf
- inserts to
  - left subtree if element is smaller than subtree root
  - right subtree if larger

Pseudo Code

```
insertRec(node, key):
   if node == null:
      add key to tree
   if node.key > key:
      node.left =
      insertRec(node.left, key)
   else
      node.right =
      insertRec(node.right, key)
```

Insert, with a helper

```
public void insert(E element)
{
    size++;
    if (root==null)
    {
        root=new Node(element);
        return;
    }
iInsert(root, element);
}

private void iInsert(Node treepart, E toBeAdded) {
  … }
```

size (again)

- Suppose the LinkedBinary tree class did not keep size instance variable.

- Need new implementations of isEmpty() and size()

```
@Override
public boolean isEmptyAlt() {
    return root==null;
}
```

size() without size

```
public int sizeAlt() {
     return iSize(root);
}
private int iSize(Node treepart) {
     if (treepart==null) return 0;
     return 1 + iSize(treepart.left) +
                iSize(treepart.right);
}
```

iContains

```
/**
 * Recursive helper function for determining if an element is in tree.
 * @param treepart the root of the current subtree to examine
 * @param toBeFound the element being searched for
 * @return true iff the element is in the tree.
 */
private Node iContains(Node treepart, E toBeFound) {
    int cmp = treepart.payload.compareTo(toBeFound);
    if (cmp==0) return treepart;
    if (cmp<0) {
        if (treepart.left==null) return null;
        else
            return iContains(treepart.left, toBeFound);
    }
    else {
        if (treepart.right==null) return null;
        else {
            return iContains(treepart.right, toBeFound);
        }
    }
}
```

“in class” exercise

- Complete the implementation of iInsert using pencil and paper **only**
- Strive to be correct
- Think
- Take a picture of your hand written code and send it to me