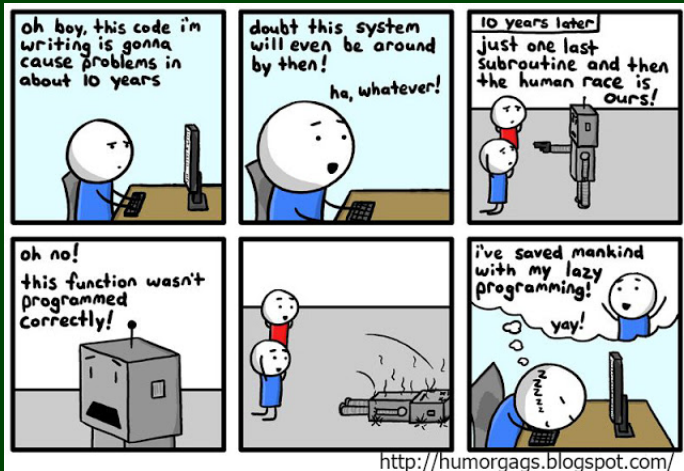


# CSE 143

## Computer Programming II

# More BSTs



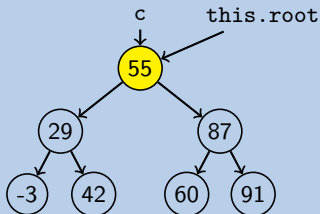
- 1 More (BST) Set Operations

## Code

```
1 private Node add(Node c, int value) {  
2     if (c == null) {  
3         c = new Node(value);  
4     }  
5     else if (c.data > value) { // 55 > 49  
6         c.left = add(c.left, value);  
7     }  
8     else if (c.data < value) {  
9         c.right = add(c.right, value);  
10    }  
11    return c;  
12 }
```

## Example (tree.add(49))

value = 49

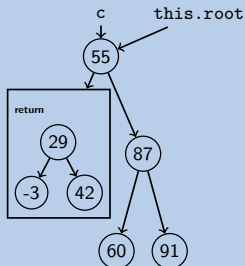


## Code

```
1 private Node add(Node c, int value) {  
2     if (c == null) {  
3         c = new Node(value);  
4     }  
5     else if (c.data > value) {  
6         c.left = add(c.left, value);  
7     }  
8     else if (c.data < value) {  
9         c.right = add(c.right, value);  
10    }  
11    return c;  
12 }
```

## Example (tree.add(49))

value = 49

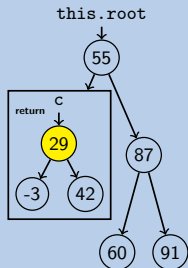


## Code

```
1 private Node add(Node c, int value) {  
2     if (c == null) {  
3         c = new Node(value);  
4     }  
5     else if (c.data > value) {  
6         c.left = add(c.left, value);  
7     }  
8     else if (c.data < value) { // 29 < 49  
9         c.right = add(c.right, value);  
10    }  
11    return c;  
12 }
```

## Example (tree.add(49))

value = 49

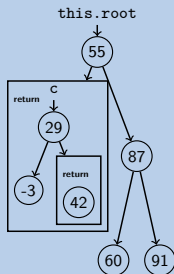


## Code

```
1 private Node add(Node c, int value) {  
2     if (c == null) {  
3         c = new Node(value);  
4     }  
5     else if (c.data > value) {  
6         c.left = add(c.left, value);  
7     }  
8     else if (c.data < value) { // 29 < 49  
9         c.right = add(c.right, value);  
10    }  
11    return c;  
12 }
```

## Example (tree.add(49))

value = 49

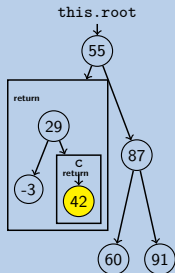


## Code

```
1 private Node add(Node c, int value) {  
2     if (c == null) {  
3         c = new Node(value);  
4     }  
5     else if (c.data > value) {  
6         c.left = add(c.left, value);  
7     }  
8     else if (c.data < value) { // 42 < 49  
9         c.right = add(c.right, value);  
10    }  
11    return c;  
12 }
```

## Example (tree.add(49))

value = 49



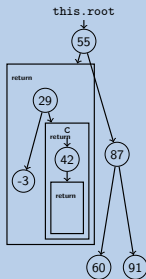


## Code

```
1 private Node add(Node c, int value) {  
2     if (c == null) {  
3         c = new Node(value);  
4     }  
5     else if (c.data > value) {  
6         c.left = add(c.left, value);  
7     }  
8     else if (c.data < value) { // 42 < 49  
9         c.right = add(c.right, value);  
10    }  
11    return c;  
12 }
```

## Example (tree.add(49))

value = 49

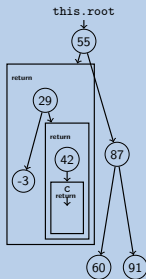


## Code

```
1 private Node add(Node c, int value) {  
2     if (c == null) {  
3         c = new Node(value);  
4     }  
5     else if (c.data > value) {  
6         c.left = add(c.left, value);  
7     }  
8     else if (c.data < value) {  
9         c.right = add(c.right, value);  
10    }  
11    return c;  
12 }
```

## Example (tree.add(49))

value = 49

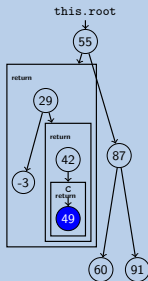


## Code

```
1 private Node add(Node c, int value) {  
2     if (c == null) {  
3         c = new Node(value);  
4     }  
5     else if (c.data > value) {  
6         c.left = add(c.left, value);  
7     }  
8     else if (c.data < value) {  
9         c.right = add(c.right, value);  
10    }  
11    return c;  
12 }
```

## Example (tree.add(49))

value = 49

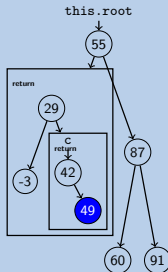


## Code

```
1 private node add(node c, int value) {  
2     if (c == null) {  
3         c = new node(value);  
4     }  
5     else if (c.data > value) {  
6         c.left = add(c.left, value);  
7     }  
8     else if (c.data < value) {  
9         c.right = add(c.right, value);  
10    }  
11    return c;  
12 }
```

## Example (tree.add(49))

value = 49

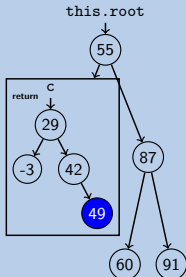


## Code

```
1 private node add(node c, int value) {  
2     if (c == null) {  
3         c = new node(value);  
4     }  
5     else if (c.data > value) {  
6         c.left = add(c.left, value);  
7     }  
8     else if (c.data < value) {  
9         c.right = add(c.right, value);  
10    }  
11    return c;  
12 }
```

## Example (tree.add(49))

value = 49

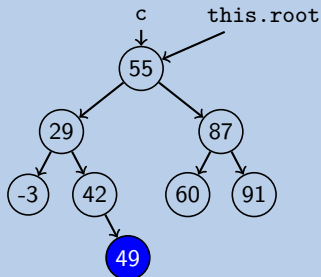


## Code

```
1 private node add(node c, int value) {  
2     if (c == null) {  
3         c = new node(value);  
4     }  
5     else if (c.data > value) {  
6         c.left = add(c.left, value);  
7     }  
8     else if (c.data < value) {  
9         c.right = add(c.right, value);  
10    }  
11    return c;  
12 }
```

## Example (tree.add(49))

value = 49



**first**

Write a function `first` in the `BST` class with the following signature:

```
public int first();
```

that returns the smallest value in the tree. If the tree is empty, `first` should throw a `NoSuchElementException`.

```
1 public int first() {
2     return first(this.root);
3 }
4
5 private int first(IntTreeNode current) {
6     if (current == null) {
7         throw new NoSuchElementException();
8     }
9     /* Keep on going left as far as we can */
10    else if (current.left != null) {
11        return first(current.left);
12    }
13    else {
14        return current.data;
15    }
16 }
```

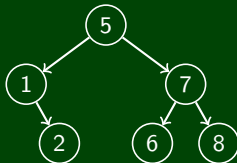
## remove

Write a function `remove` in the `BST` class with the following signature:

```
public void remove(int value);
```

that removes `value` from the tree if it exists.

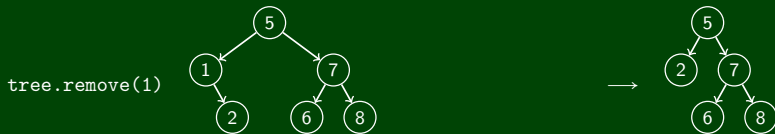
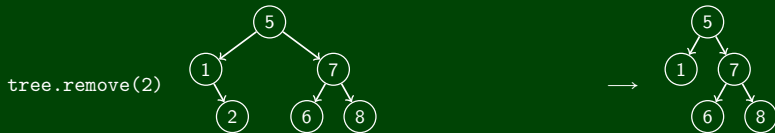
Consider the following tree:

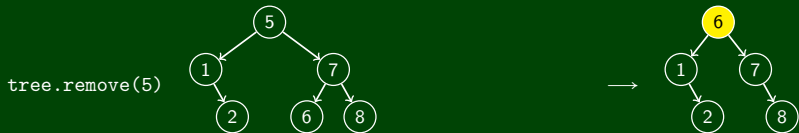
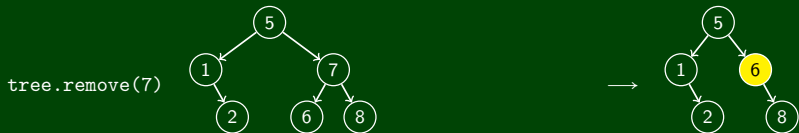
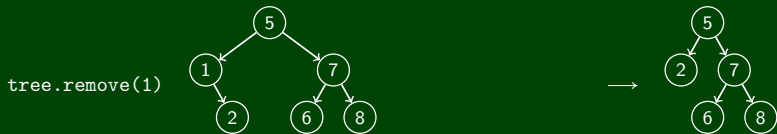
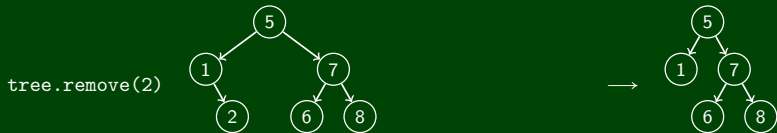


Let's try the following removals:

- `tree.remove(2)`
- `tree.remove(1)`
- `tree.remove(7)`
- `tree.remove(5)`







```
1 public void remove(int value) {
2     this.root = remove(this.root, value);
3 }
4 private IntTreeNode remove(IntTreeNode current, int value) {
5     if (current == null) { return null; }
6     else if (current.data > value) {
7         current.left = remove(current.left, value);
8     }
9     else if (current.data < value) {
10        current.right = remove(current.right, value);
11    }
12    else if (current.left == null && current.right == null) {
13        current = null;
14    }
15    else if (current.left == null && current.right != null) {
16        current = current.right;
17    }
18    else if (current.left != null && current.right == null) {
19        current = current.left;
20    }
21    else {
22        current.data = first(current.right);
23        current.right = remove(current.right, current.data);
24    }
25    return current;
26 }
```