Trees

Johan Montelius

KTH

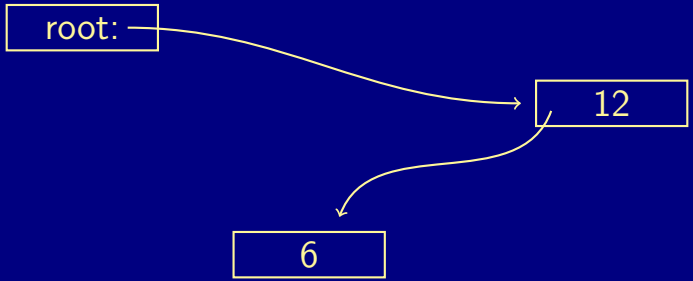
HT22

a tree

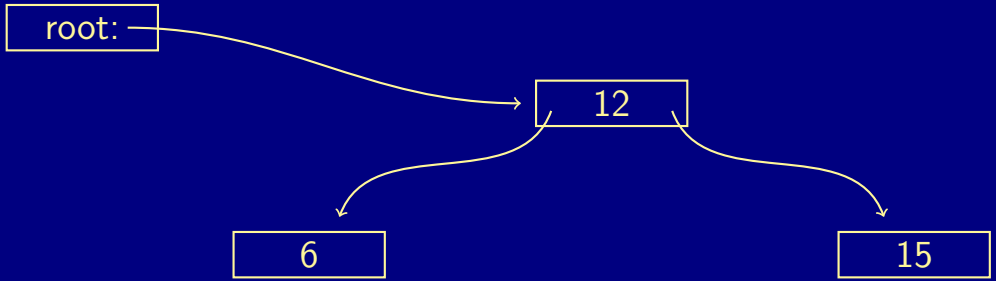
root:

a tree

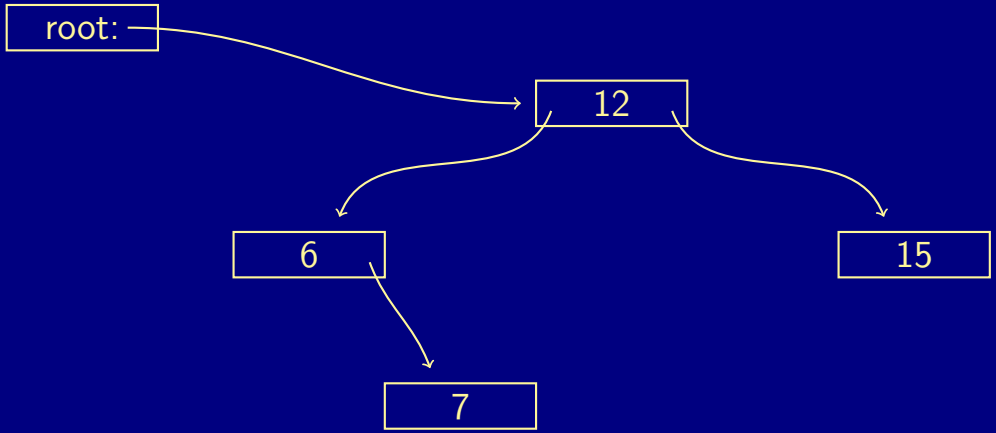
a tree



a tree



a tree



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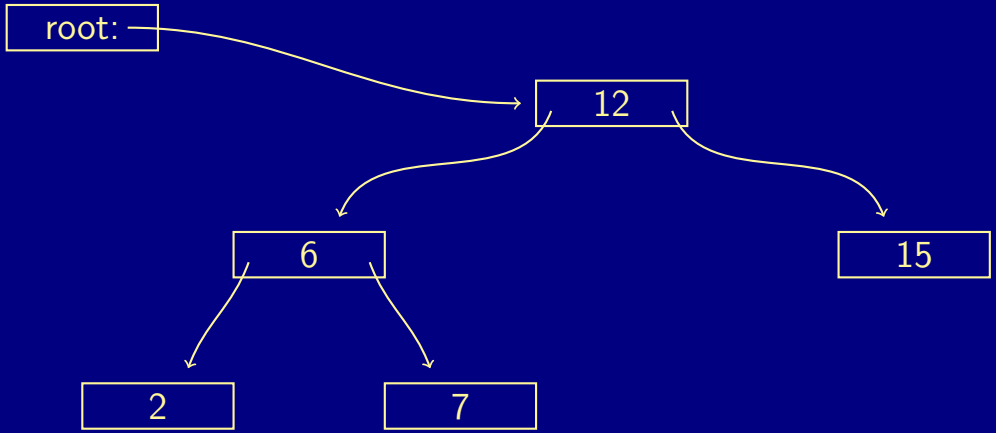


the node

```
public class BinaryTree {
  public Node root;
  :
  :


}
```

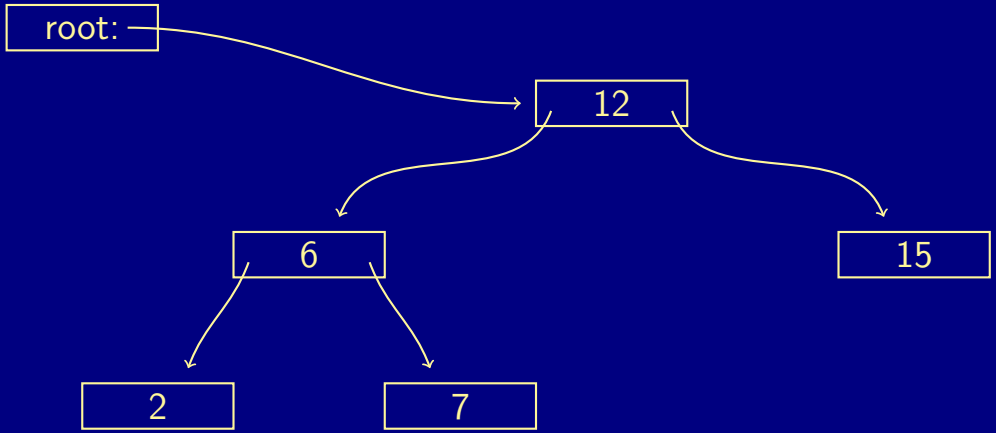
the node

```
public class BinaryTree {
  public Node root;
  :
  :


}
```

```
private Node {
  Integer key;
  Integer value;
  Node left;
  Node right;
}
```

add a new key-value pair



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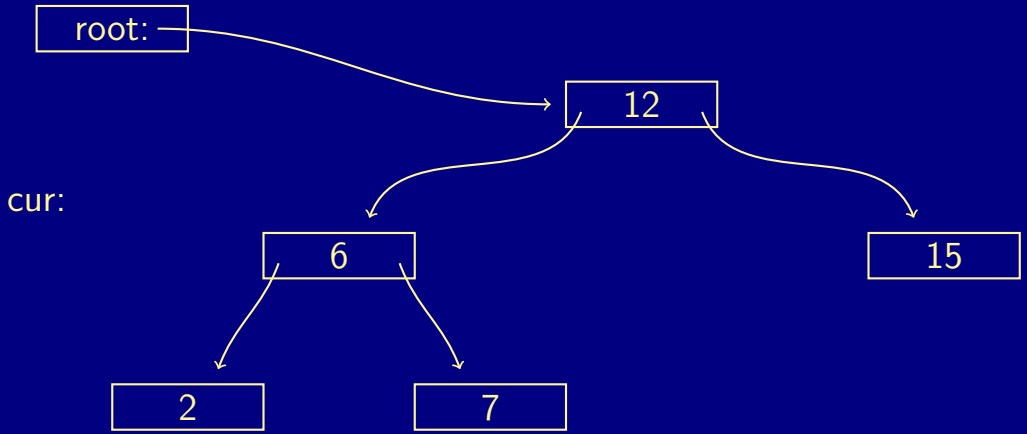

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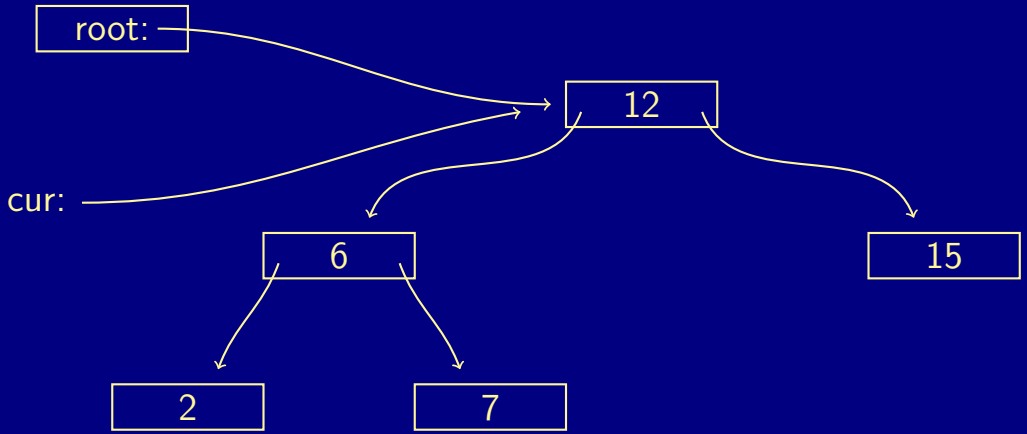

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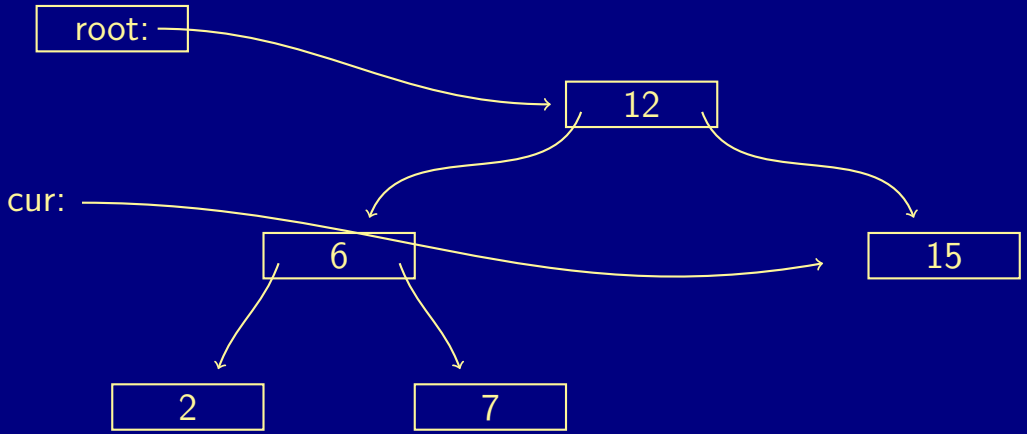

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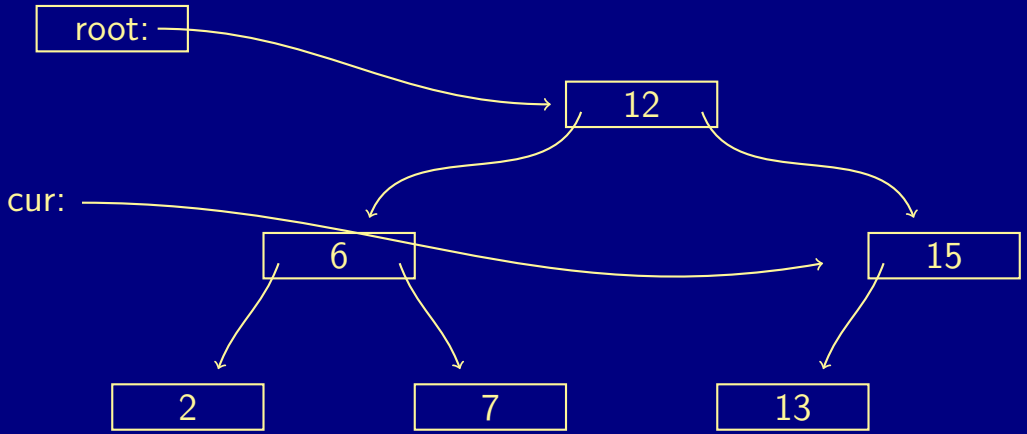


BinaryTree add(Integer key, Integer value)

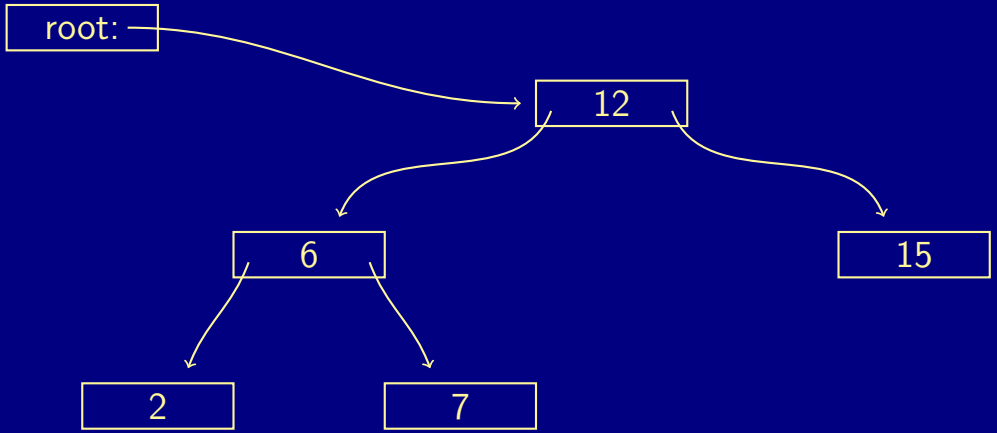
```
public void add(Integer key, Integer value) {
    if (root == null)
        root = new Node(key, value);
    else
        root.add(key, value);
}
```

Node add(Integer key, Integer value)

```
private void add(Integer key, Integer value) {

    if (this.key  == key) {
        this.value = value;
        return;
    }
    if (this.key > key)
        if (this.left != null)
            this.left.add(key, value);
        else
            this.left = new Node(key,value);
    else
        :
 }
```

lookup - find the value of a key



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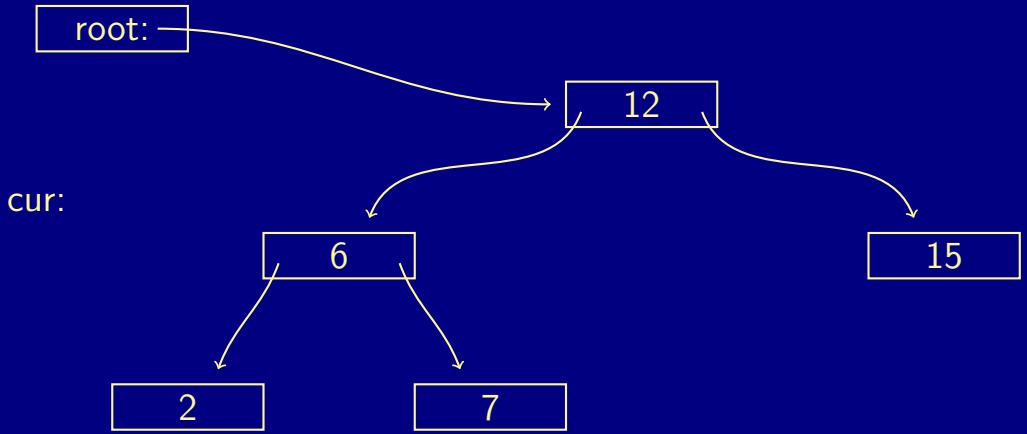

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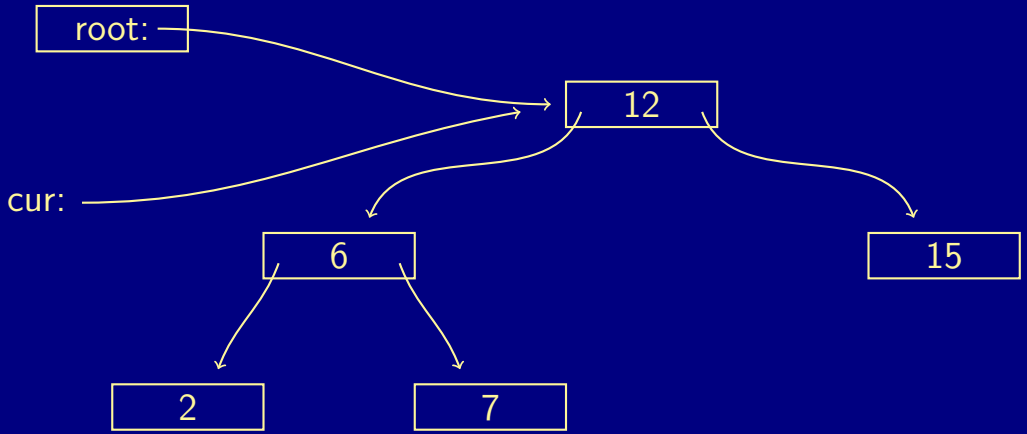
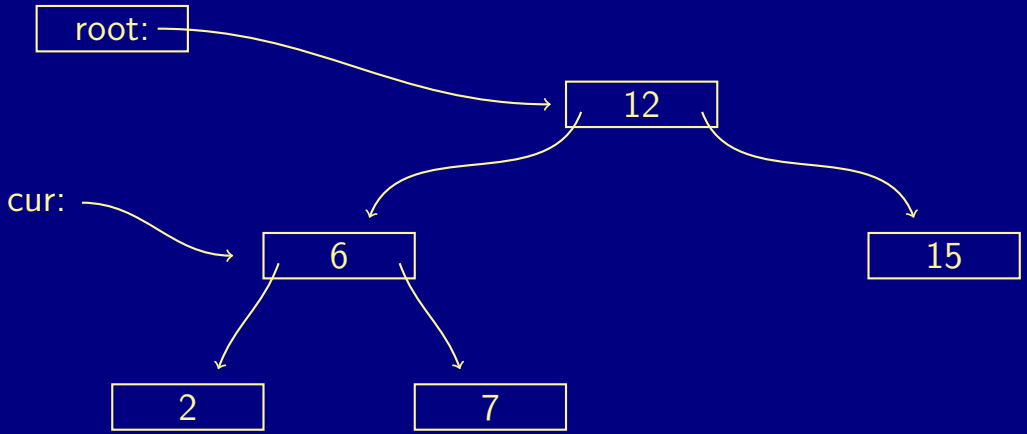
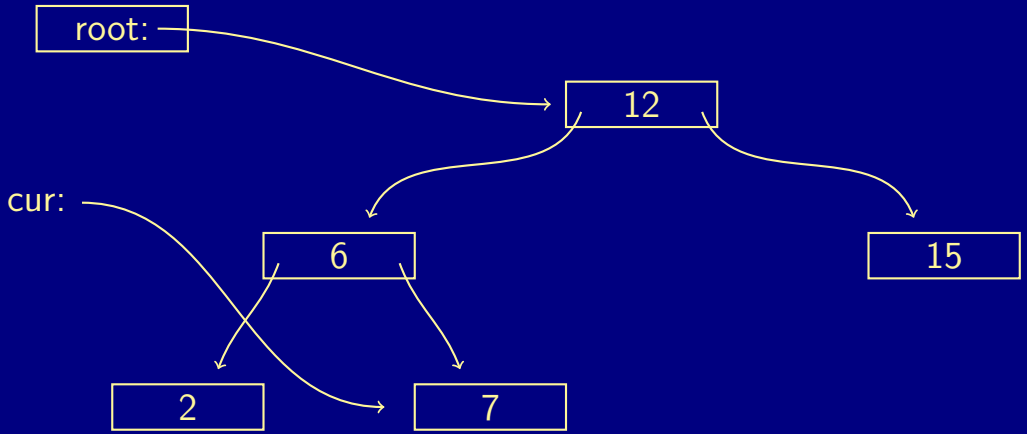


lookup - find the value of a key



lookup - find the value of a key



lookup(Integer key)

```
public class BinaryTree {
   :
  public int lookup(Integer key) {
    Node cur = this.root;
    while (cur != null) {
      if (cur.key == key)
        return cur.value;
      if (cur.key < key)
        cur = cur.right;
      else
        cur = cur.left;
    }
    return null;
  }
   :
}
```

asymptotic complexity

- What is the run time complexity of lookup()?

asymptotic complexity

- What is the run time complexity of lookup()?
- Depending on what?

asymptotic complexity

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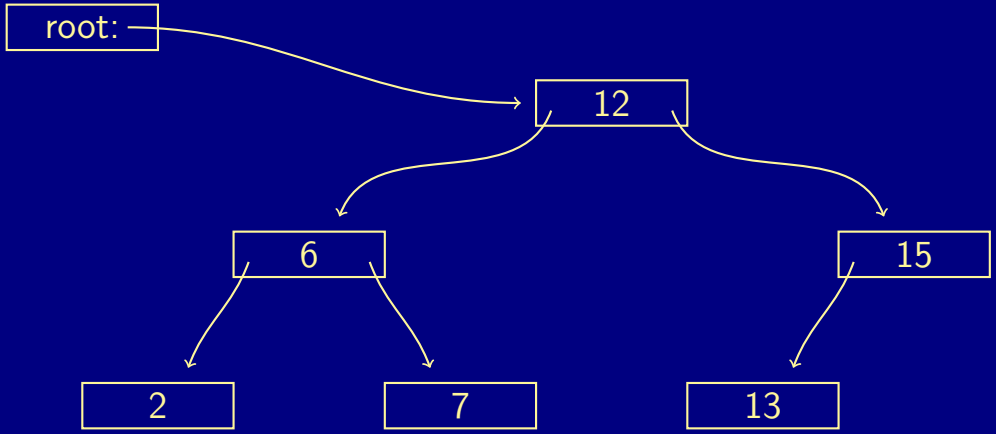
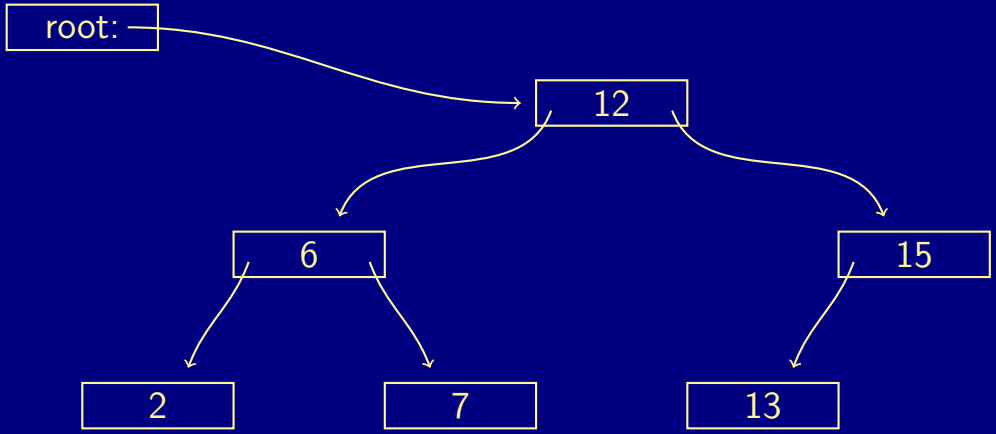
- Depending on what?

Not all trees are balanced :-(

delete 2, 7 or 13



delete 2, 7 or 13



Deleting a leaf is simple.

BinaryTree delete(Integer key)

```
public void delete(Integer key) {

    if (root == null)
        return;

    root = root.delete(key);
}
```

BinaryTree delete(Integer key)

```
public void delete(Integer key) {

    if (root == null)
        return;

    root = root.delete(key);
}
```

Node delete(key) should return a new root where the key-value node is deleted.

Node delete(Integer key)

```
private Node delete(Integer k) {
    if (this.key == k) {
      // what do we do?
    }
    if (this.key < k && this.right != null)  {
        Node deleted = this.right.delete(k);
        this.right = deleted;
        return this;
    }
    if (this.key > k && this.left != null)  {
        :
    }
    return this;
}
```

Node delete(Integer key)

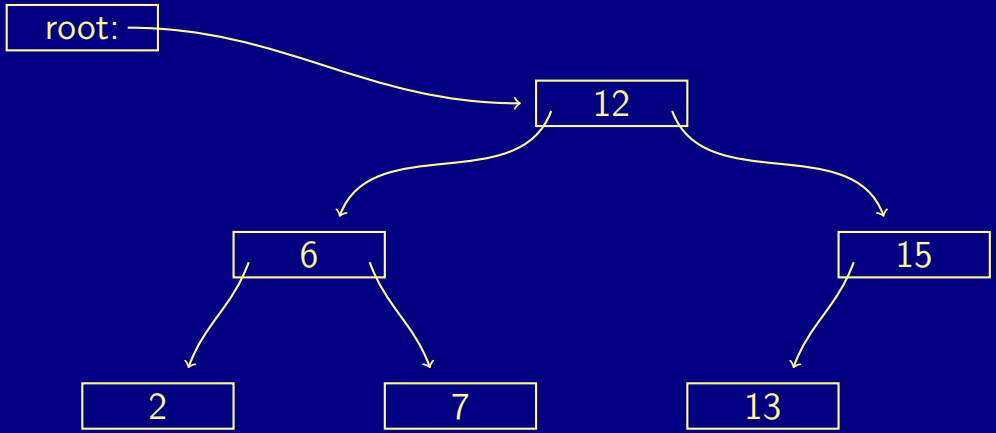
```
if (this.key == k) {
  if (this.left == null)
     return this.right;
  if (this.right == null)
     return this.left;
  :
  :
}
```

Node delete(Integer key)

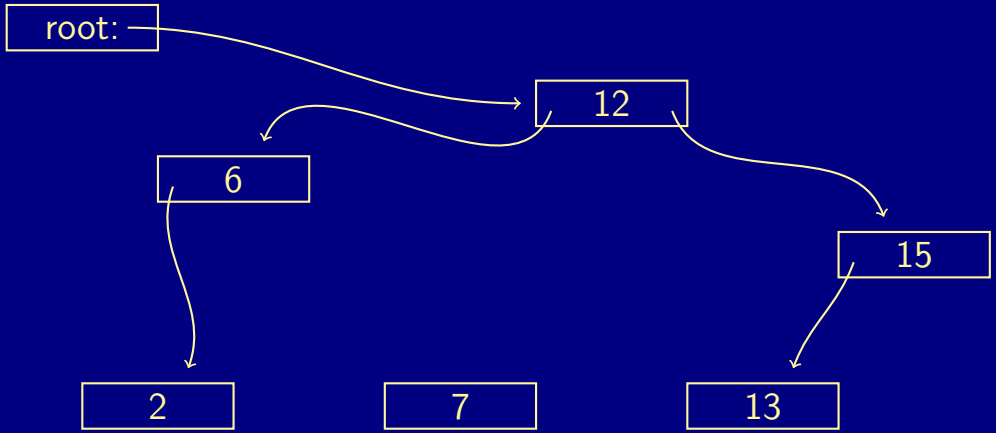
```
if (this.key == k) {
  if (this.left == null)
     return this.right;
  if (this.right == null)
     return this.left;
  :
  :
}
```

This takes care of all the simple cases.

delete 6



delete 6



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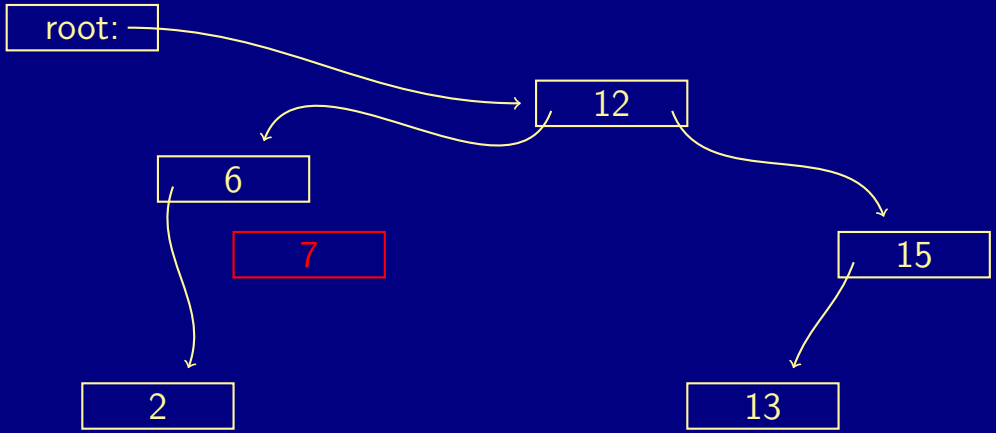
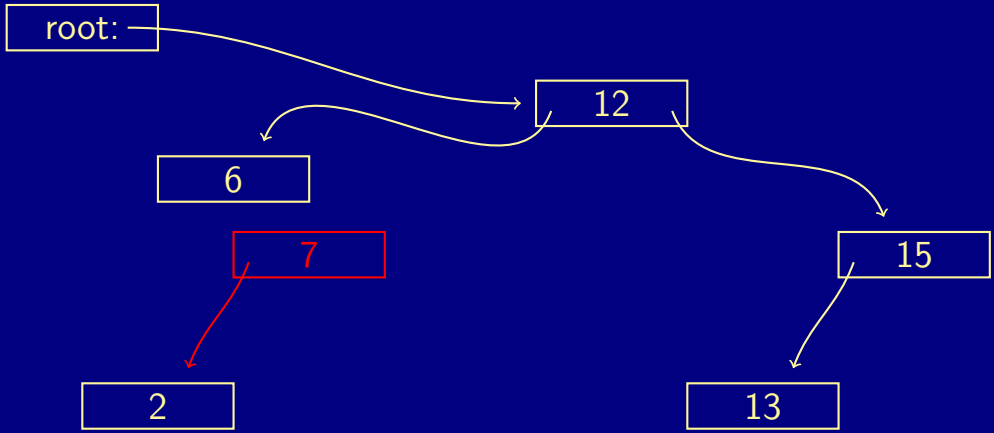
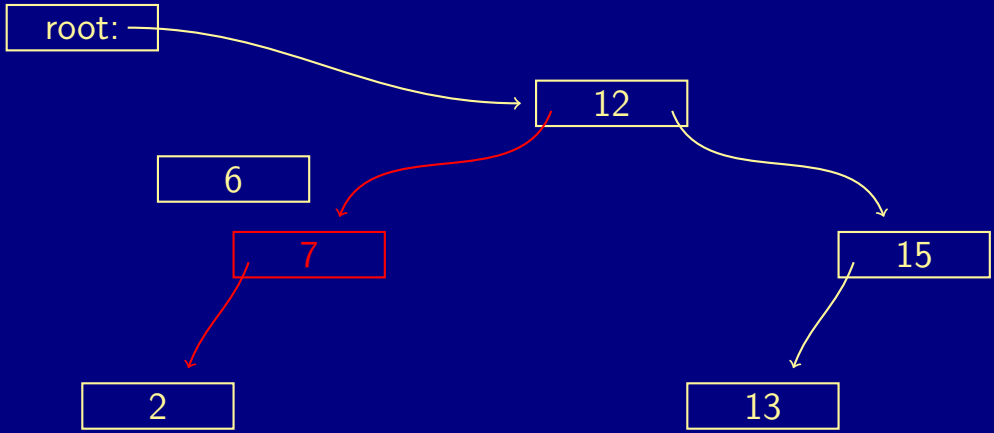


delete 6



delete 6



Node delete(Integer key)

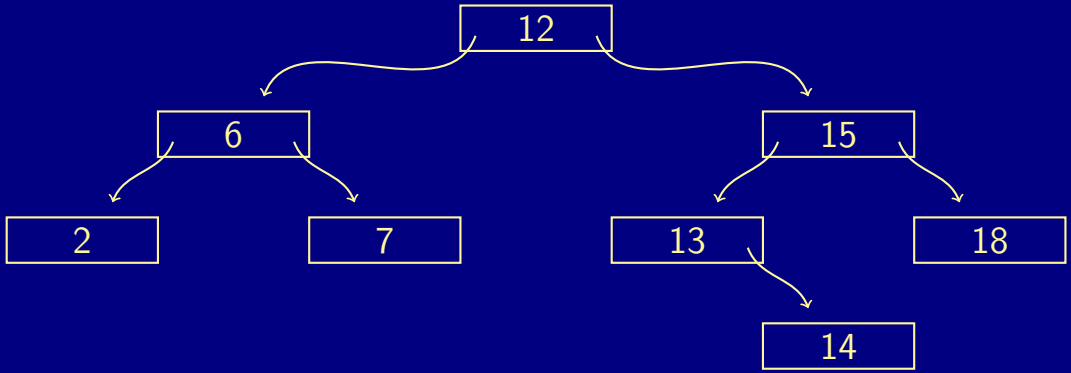
```
if (this.key == k) {
  if (this.left == null)
     return this.right;
  if (this.right == null)
     return this.left;
  Node promoted = this.right.promote();
  promoted.left = this.left;
  return promoted;
}
  :
```

Node delete(Integer key)

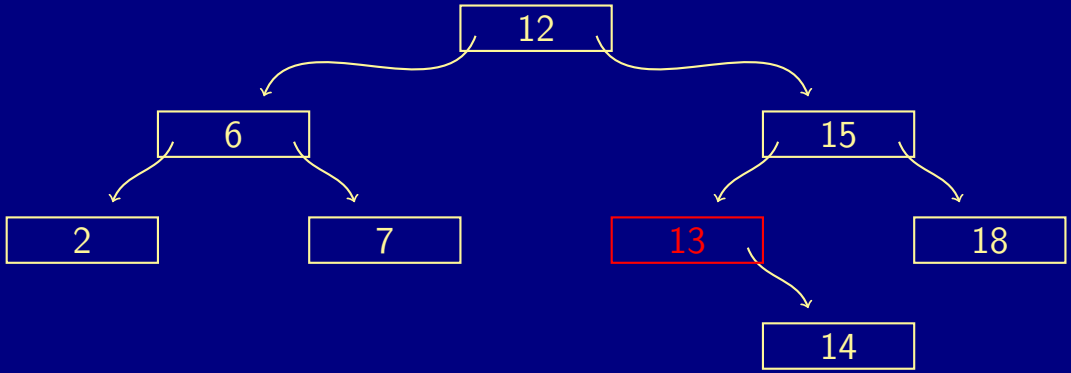
```
if (this.key == k) {
  if (this.left == null)
     return this.right;
  if (this.right == null)
     return this.left;
  Node promoted = this.right.promote();
  promoted.left = this.left;
  return promoted;
}
  :
```

What should promote() do?.

delete 12 by promoting 13



delete 12 by promoting 13



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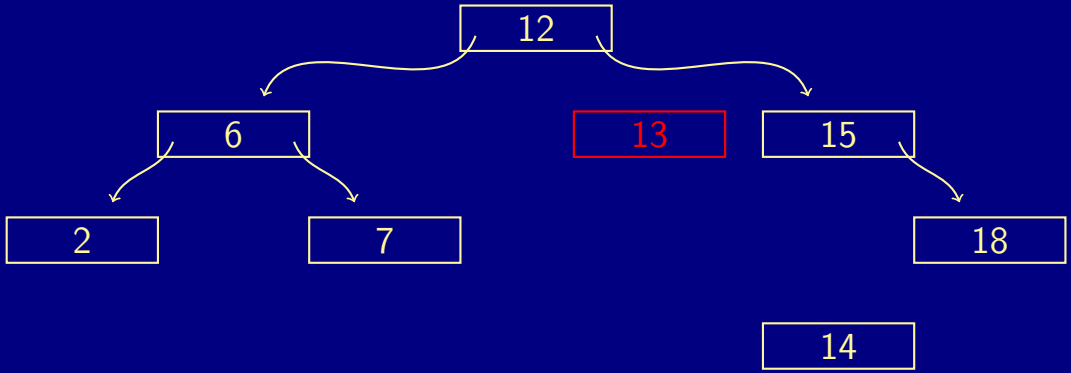

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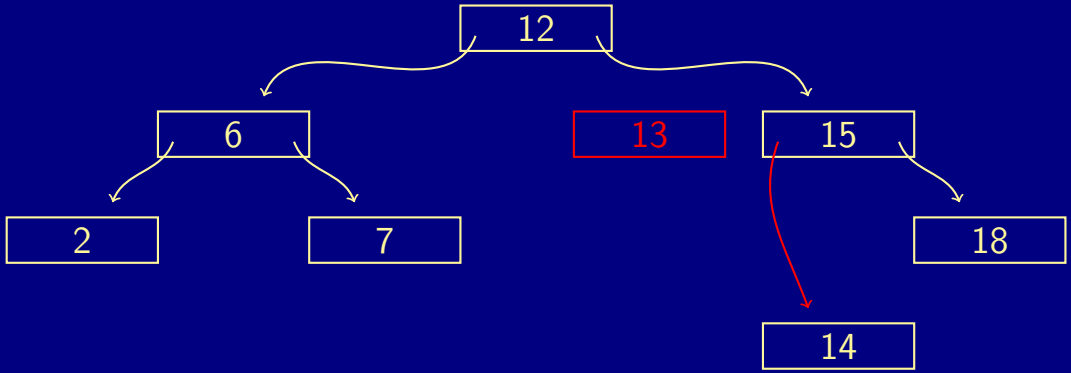

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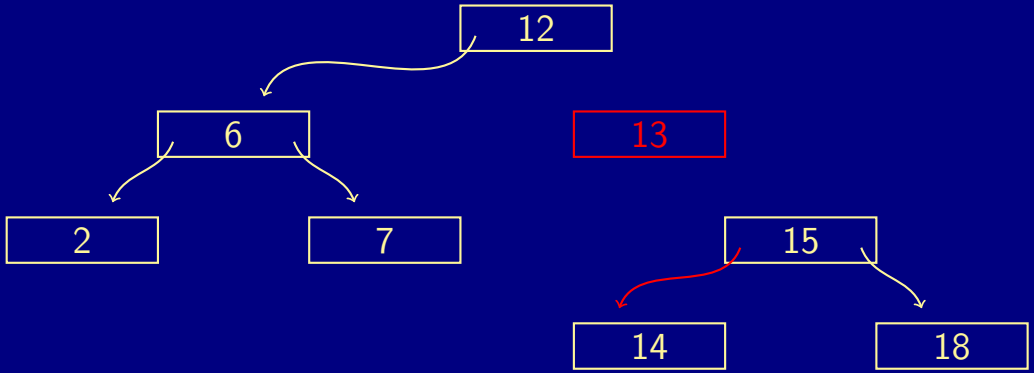

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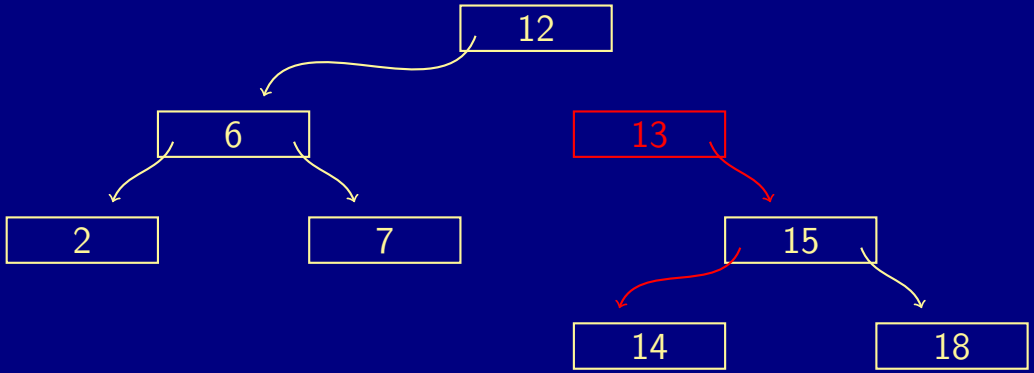

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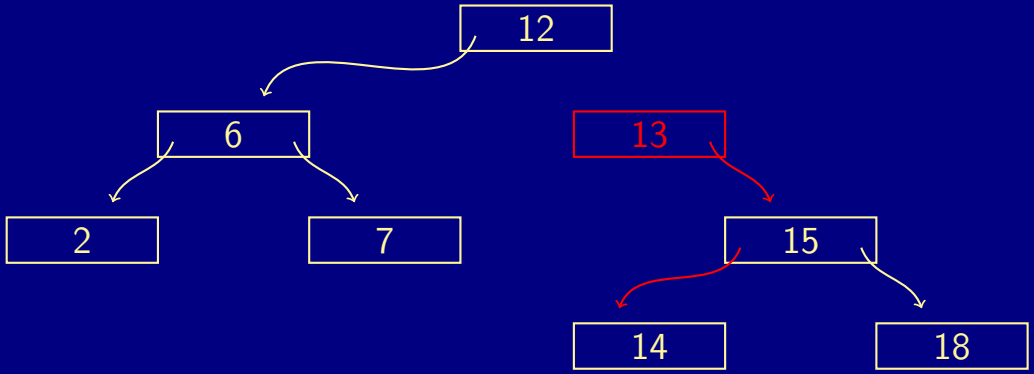
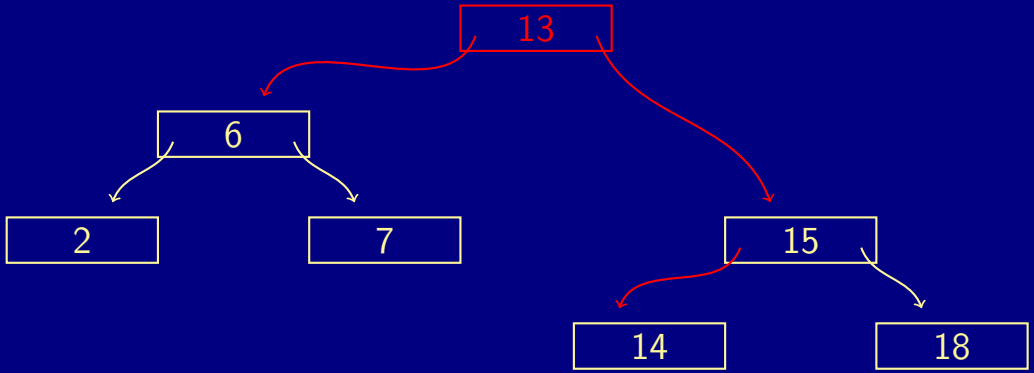


The method promote() should return the root of an ordered tree, with the left branch empty.

delete 12 by promoting 13



Node promote()

```
private Node promote() {
    if (this.left == null)
        return this;
    Node cur = this;
    while ( cur.left.left != null) {
        cur = cur.left;
    }
    Node ret = cur.left;
    cur.left = cur.left.right;
    ret.right = this;
    return ret;
}
```

nota bene

nota bene

The add() and delete() operatins that we have will not keep the tree well balanced.