Trees

Part 3
March 26

Interface

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

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) {
  … }
```

insert

```
public void insertAlt(E element) {
        if (root==null) {
            root=new Node(element);
            size = 1;
        } else
            iInsertAlt(root, element);
    }
```

insert (alternative)

```
private void iInsertAlt(Node treepart, E toBeAdded) {
    int cmp = treepart.payload.compareTo(toBeAdded);
    if (cmp==0) return; // the item is in the tree
    if (cmp<0) {
        if (treepart.left==null) {
            size++;
            treepart.left=new Node(toBeAdded);
        } else {
            iInsertAlt(treepart.left, toBeAdded);
        }
    } else {// cmp>0
        if (treepart.right==null) {
            size++;
            treepart.right=new Node(toBeAdded);
        } else {
            iInsertAlt(treepart.right, toBeAdded);
        }}}
```

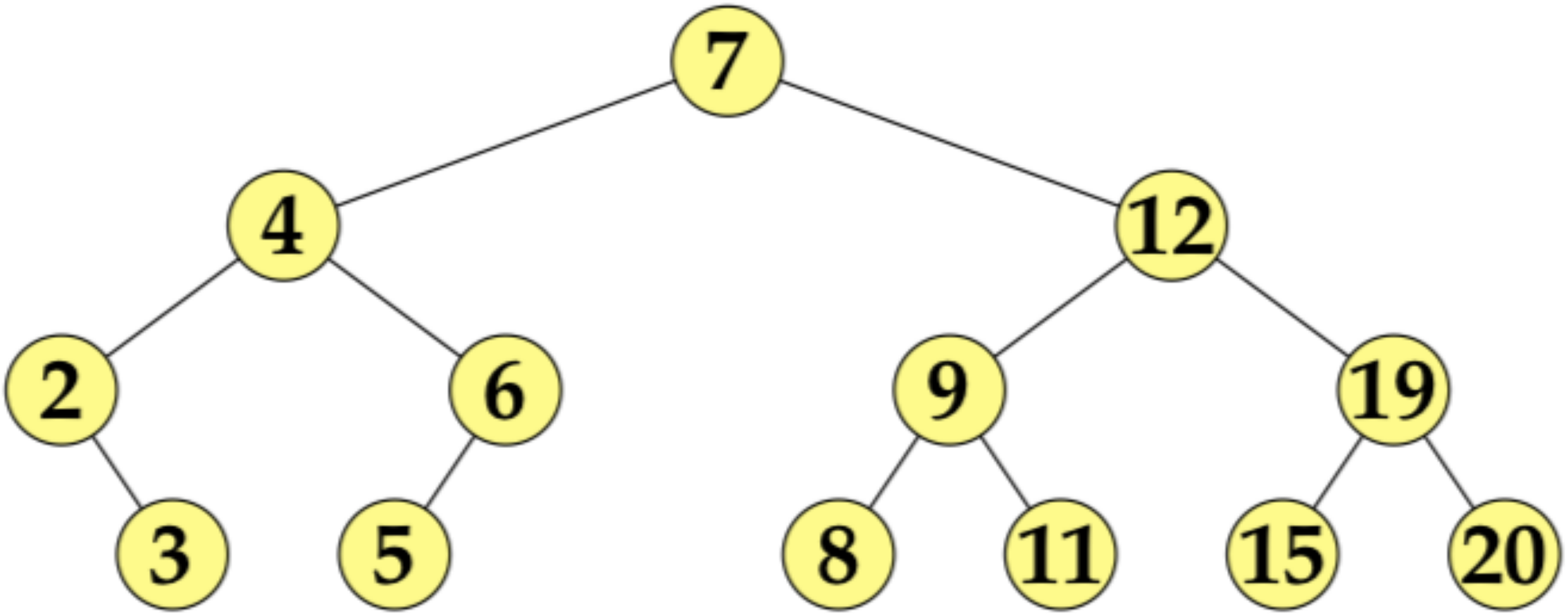
height()

```
public int height()
    {
        return iMaxDepth(root)-1;
    }
private int iMaxDepth(Node node)
    {
        if (node==null) return 0;
        int rd=iMaxDepth(node.right)+1;
        int ld=iMaxDepth(node.left)+1;
        if (rd>ld)
            return rd;
        else
            return ld;
    }
```

Binary Tree Traversals

- Traversal visits all nodes in a tree in some order
- Inorder: left subtree, current, right subtree
- Preorder: current, left subtree, right subtree
- Postorder: left subtree, right subtree, current

Traversals / Printing



Postorder traversal

```
public void printPostOrder() {
    iPrintPostOrder(root, 0);
    System.out.println();
}
```

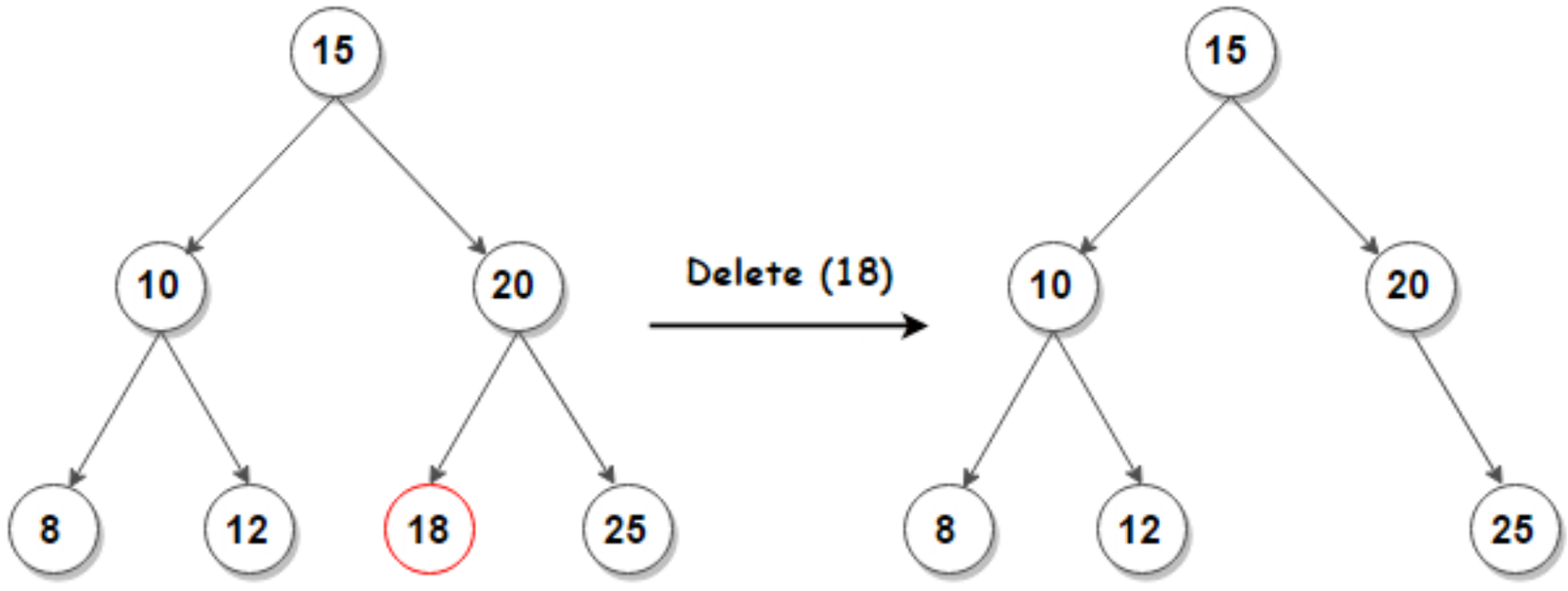
```
private void iPrintPostOrder(Node treePart, int depth) {
    if (treePart==null) return;
    iPrintPostOrder(treePart.left, depth+1);
    iPrintPostOrder(treePart.right, depth+1);
    System.out.print("["+treePart.payload+","+depth+"]");
}
```

Remove

- `boolean remove(E element);`
- returns true if element existed and was removed and false otherwise
- Cases
  - element not in tree
  - element is a leaf
  - element has one child
  - element has two children

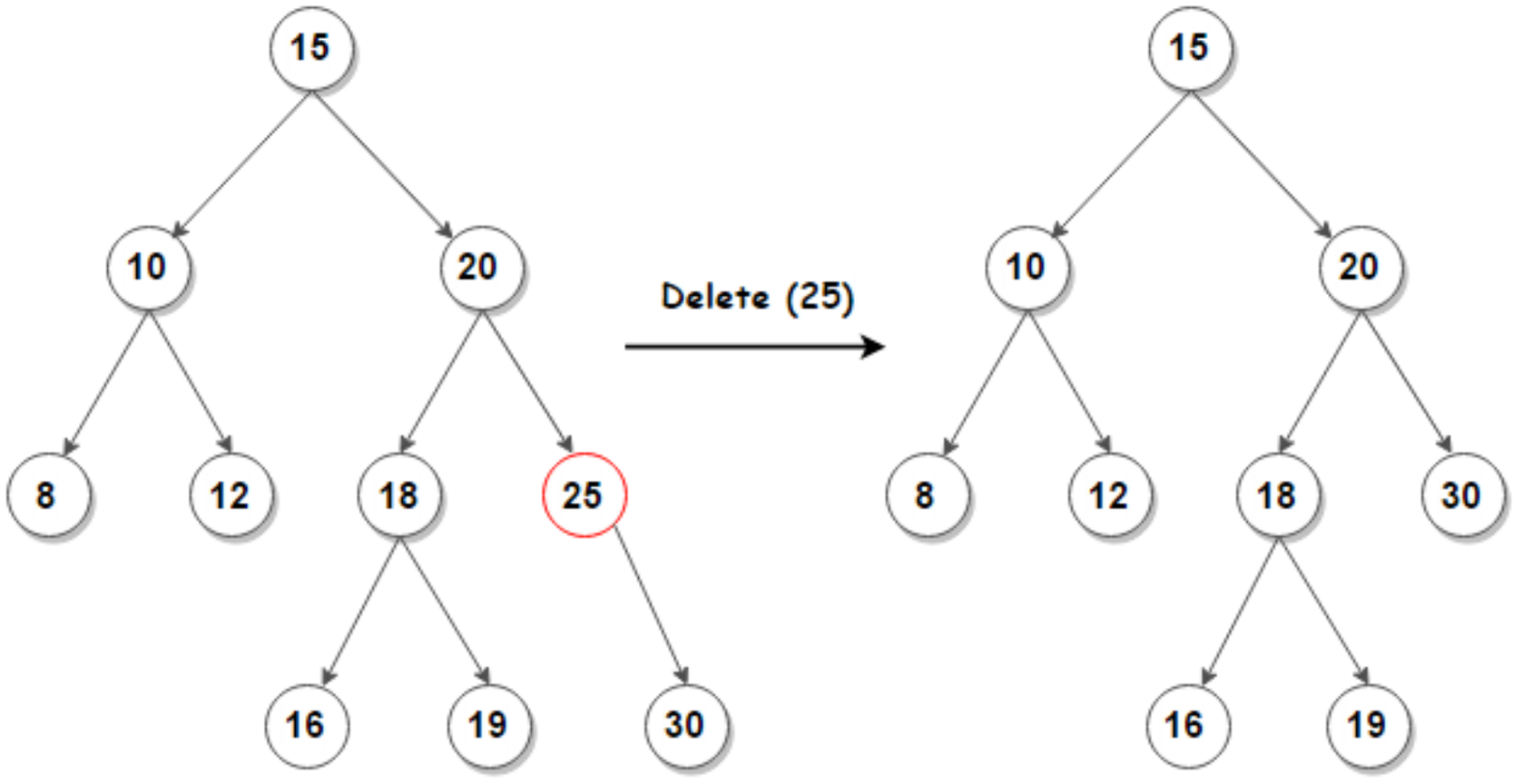
Leaf

- Just delete



One child

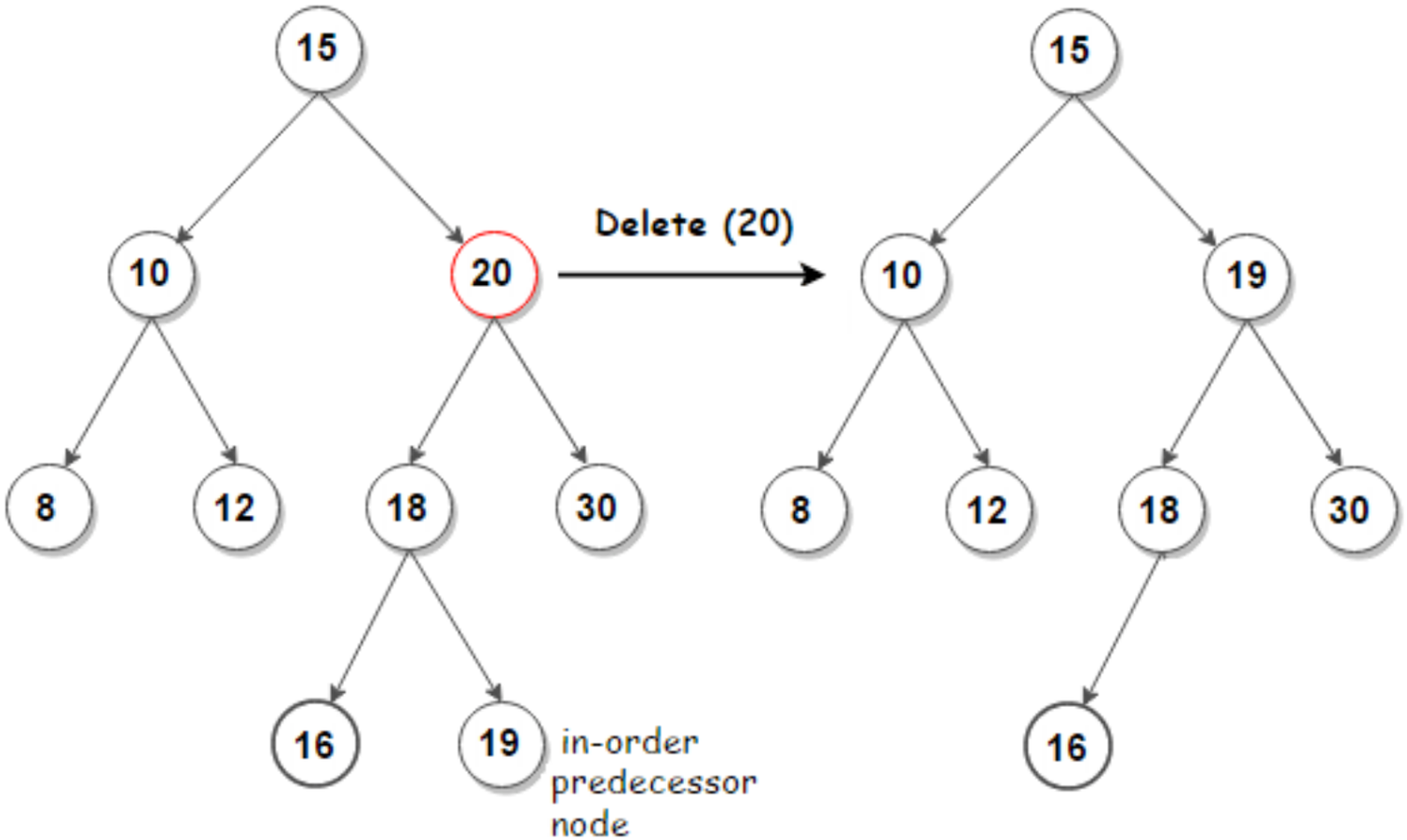
- Replace with child – skip over like in linked list



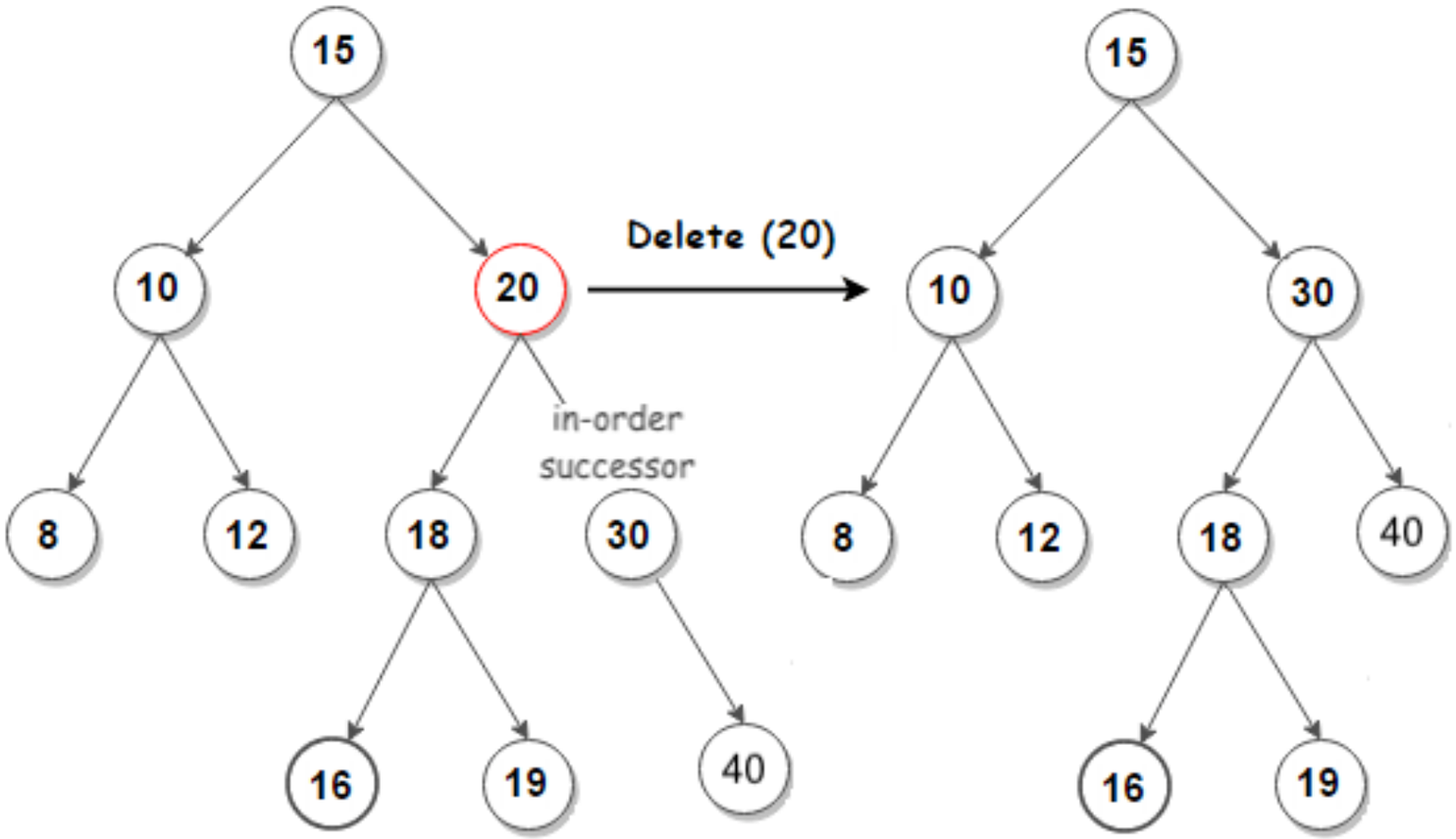
Two Children

- Replace with in-order predecessor or in-order successor
- in-order predecessor
  - rightmost child in left subtree
  - max-value child in left subtree
- in-order successor
  - leftmost child in right subtree
  - min-value child in right subtree

Replace with Predecessor



Replace with Successor



Mini-homework

Build tree with this list
104, 164, 139, 93, 132, 197, 167, 197, 113, 74, 17, 73, 124, 19, 181, 104, 1, 45, 88, 176

show the final tree

then remove and show tree after each removal for each of the following: numbers, (each removal follows from the previous). You need not redraw the entire tree after each deletion if you think the result is clear.

45
73
74
93
139
197
104

Send me a picture of your trees: gtowell206@cs.brynmawr.edu