CSCI 232:

Data Structures and Algorithms

Binary Search Trees (Part 1)

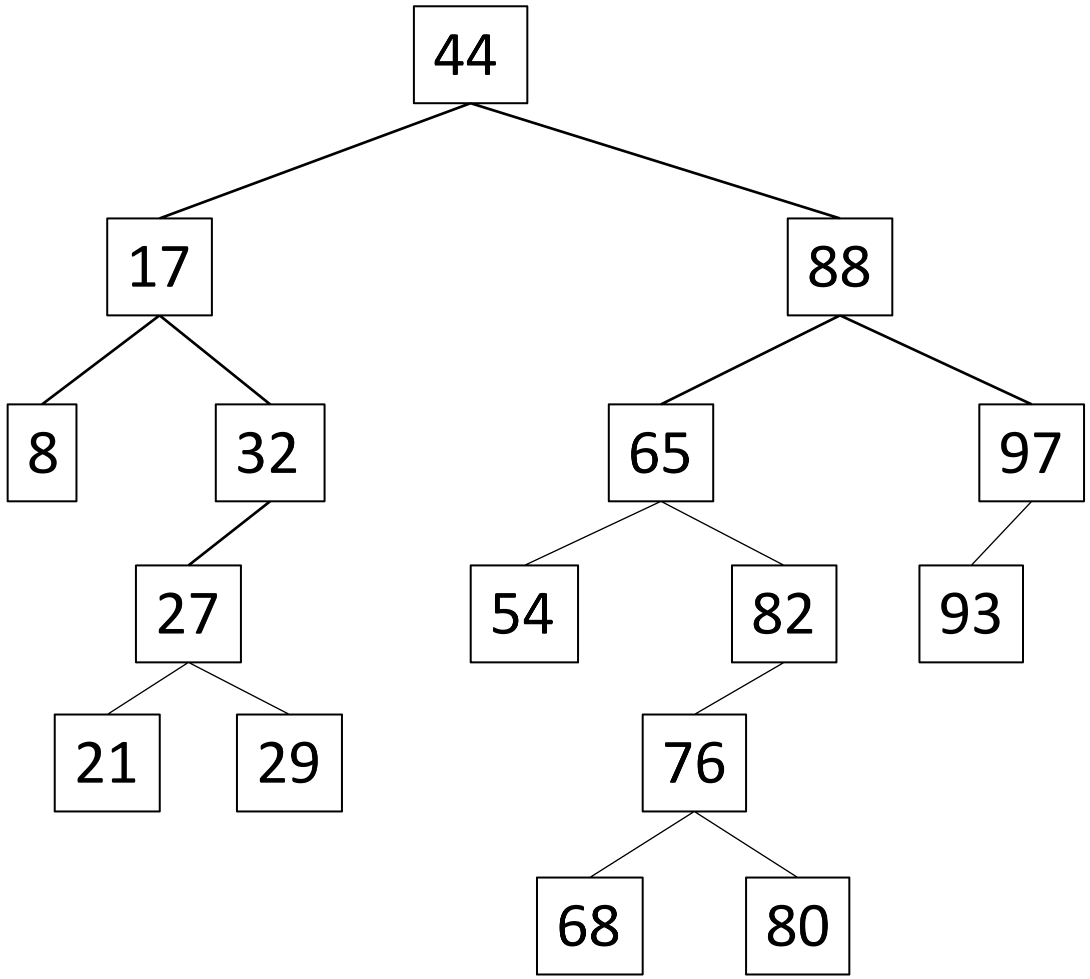
Reese Pearsall

Spring 2025

Announcements

Lab 2 due tomorrow

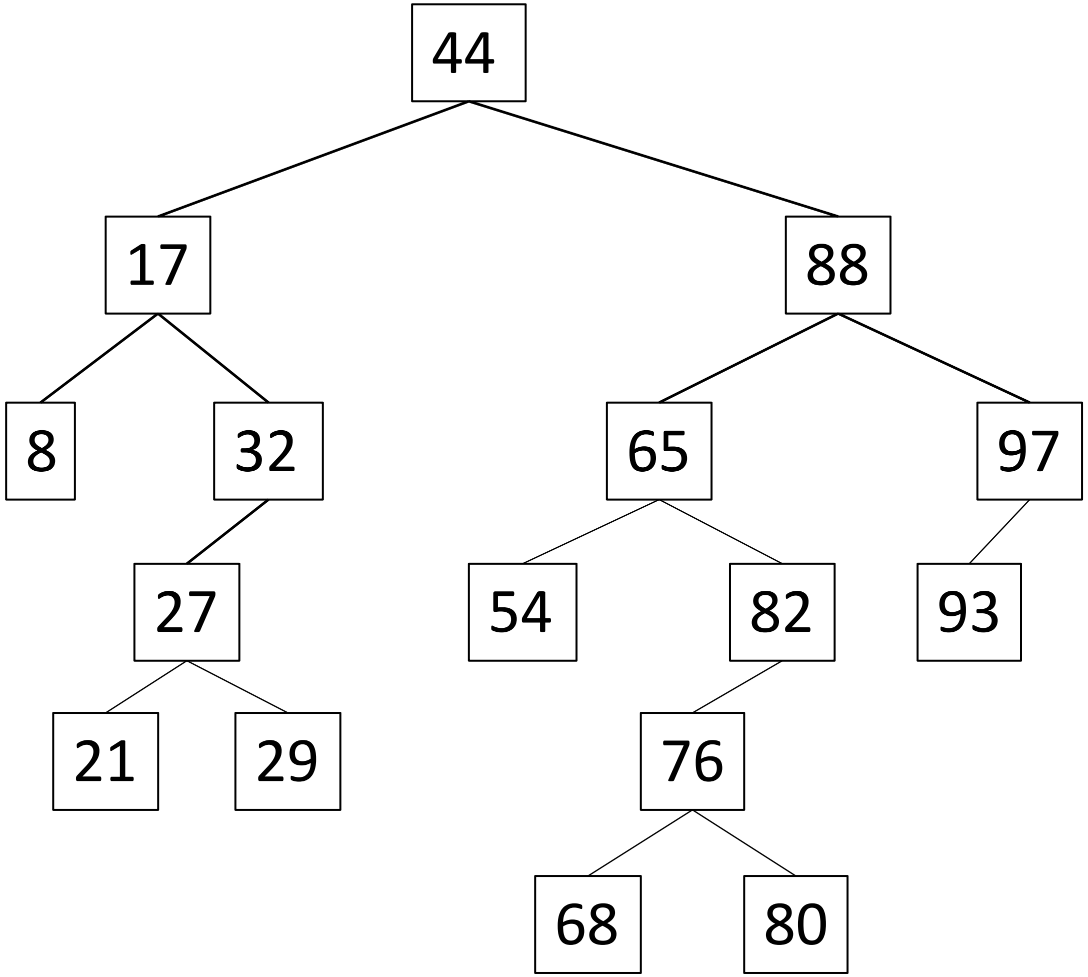
Binary Search Tree



Binary Search Tree

Binary Search Tree (BST) properties:

- A BST is composed of `Comparable` data elements.



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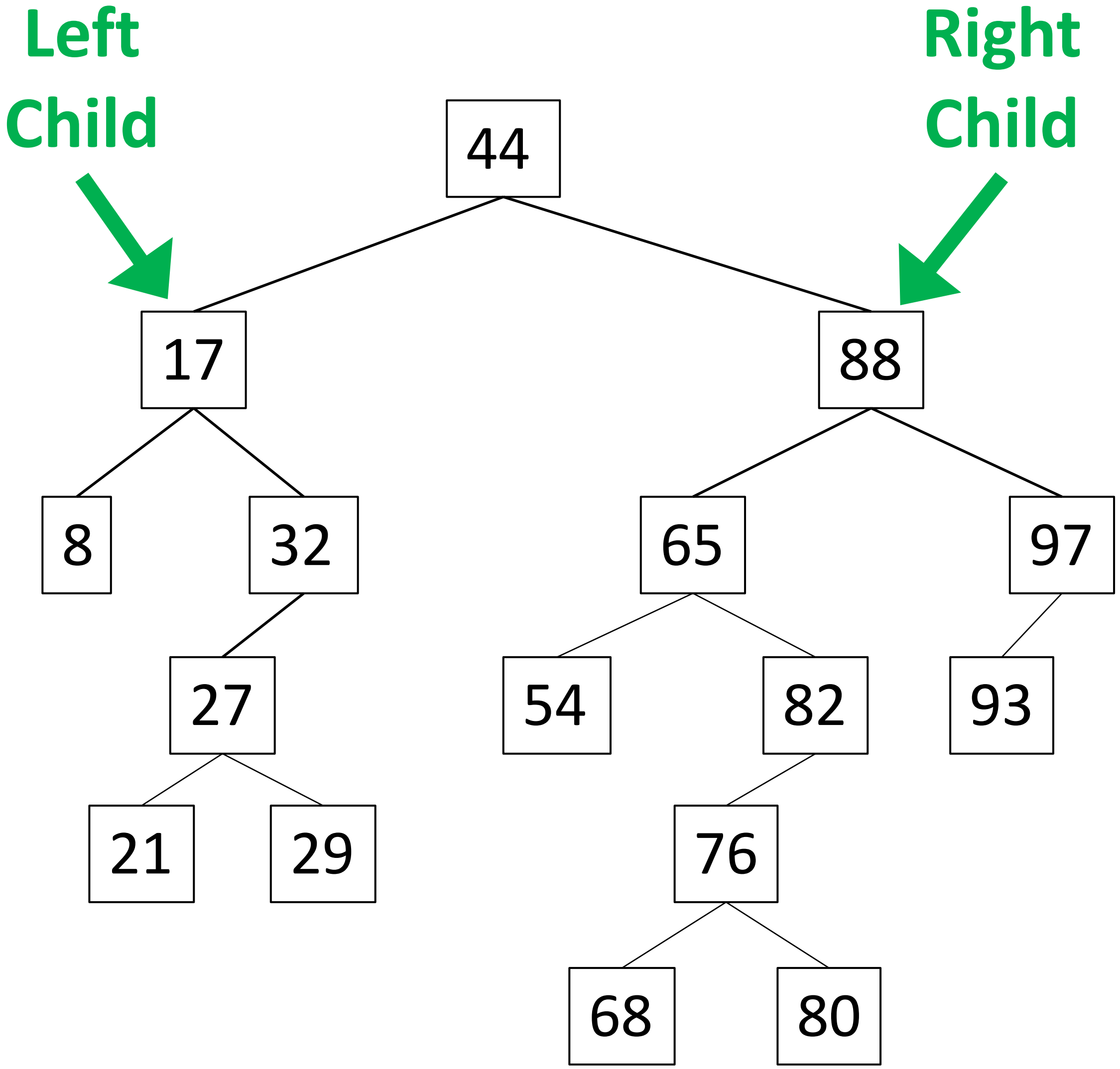

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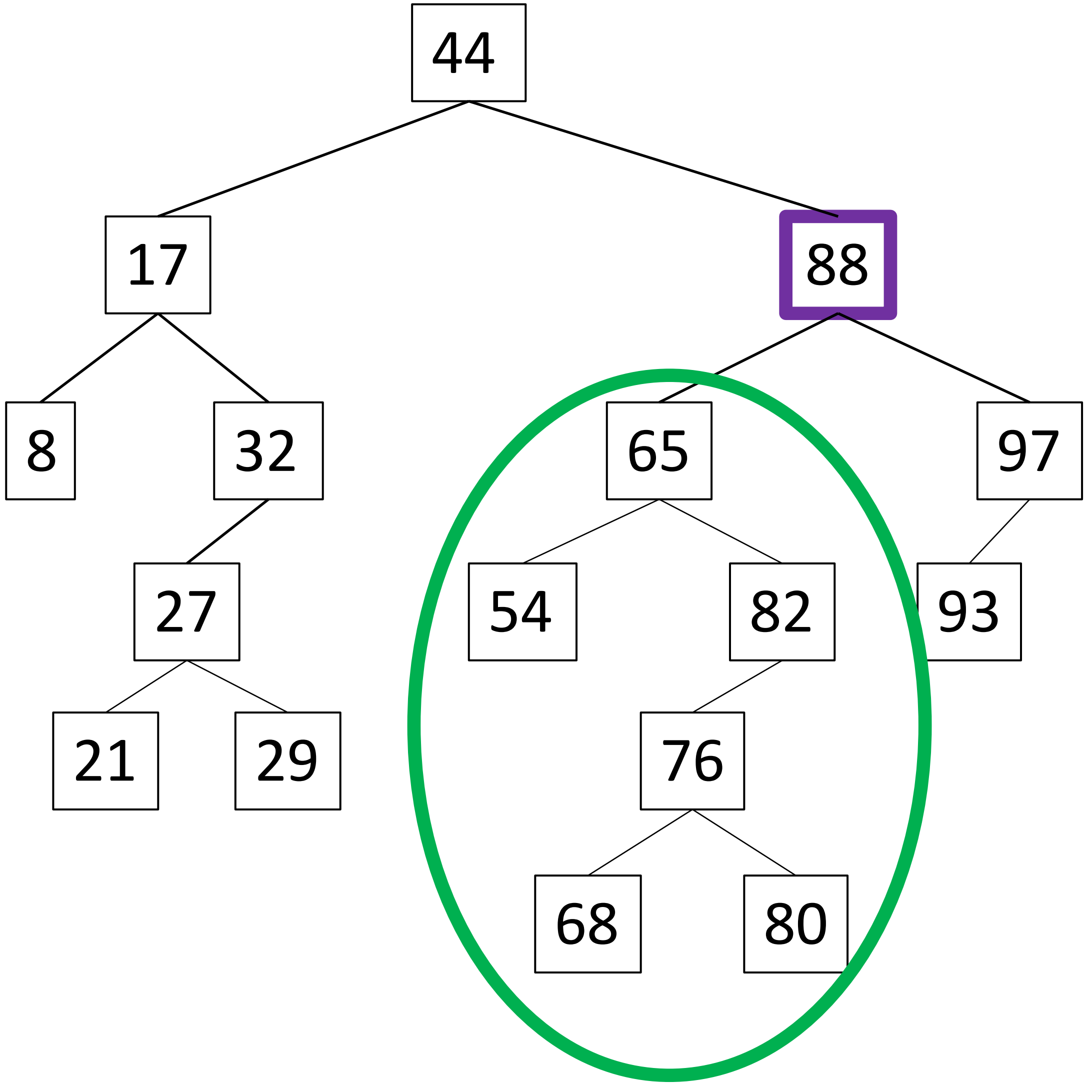

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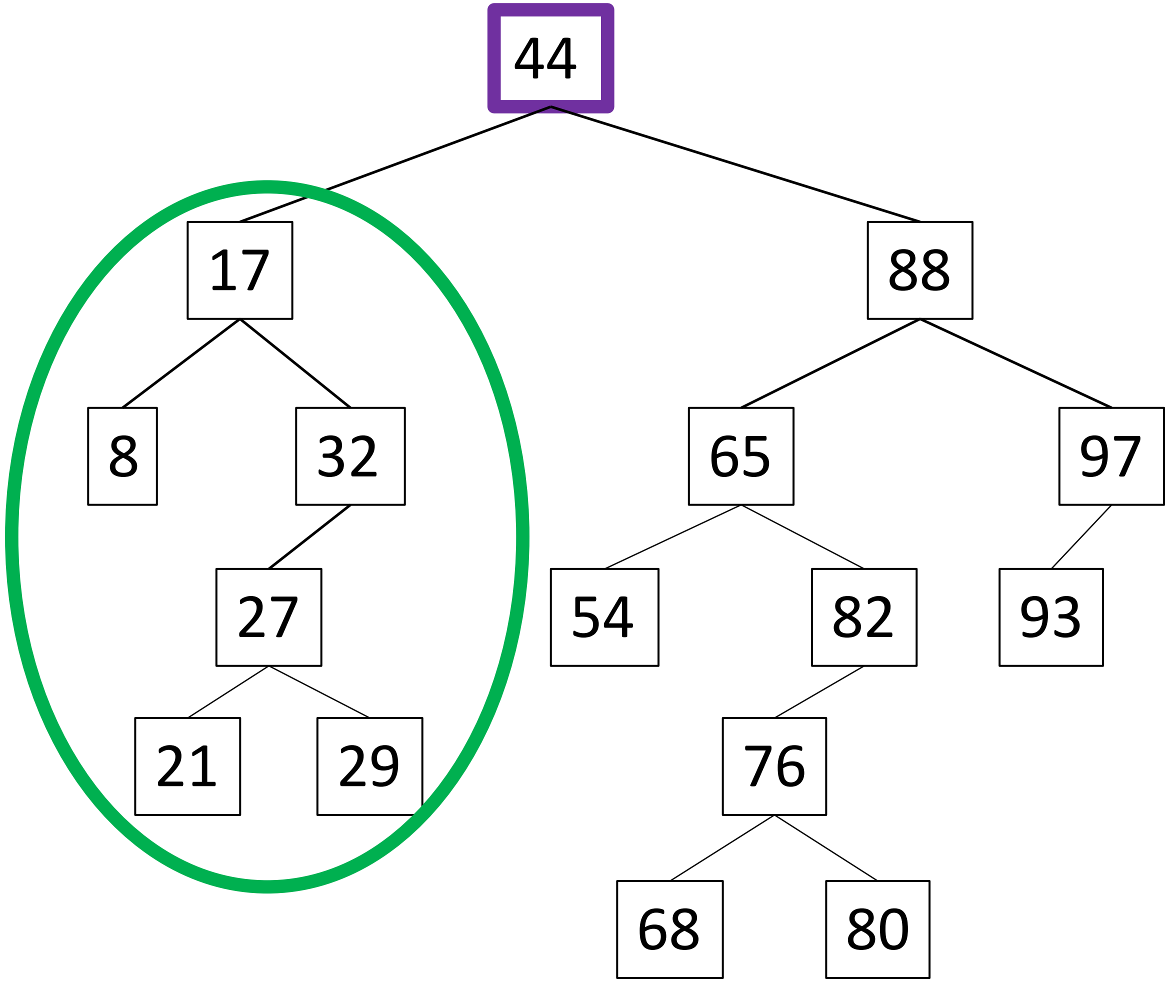

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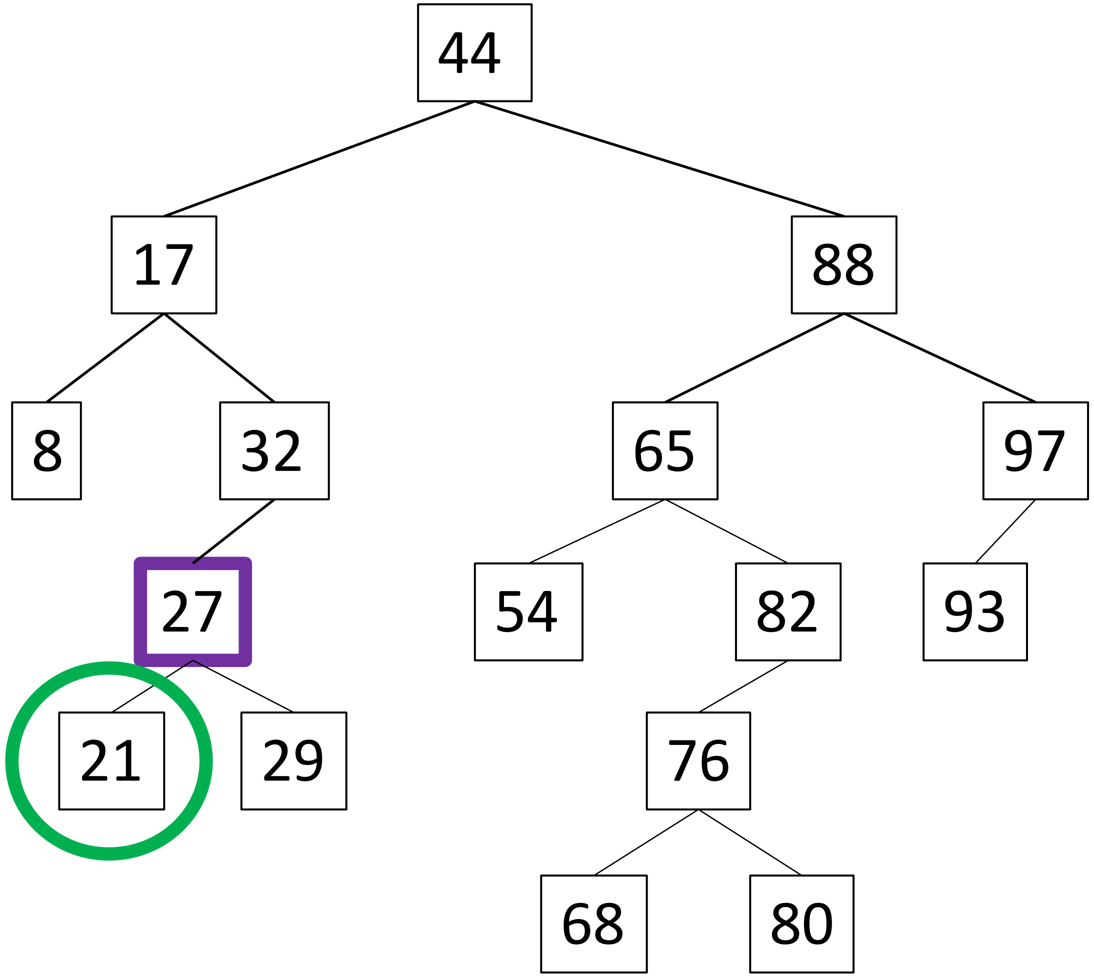

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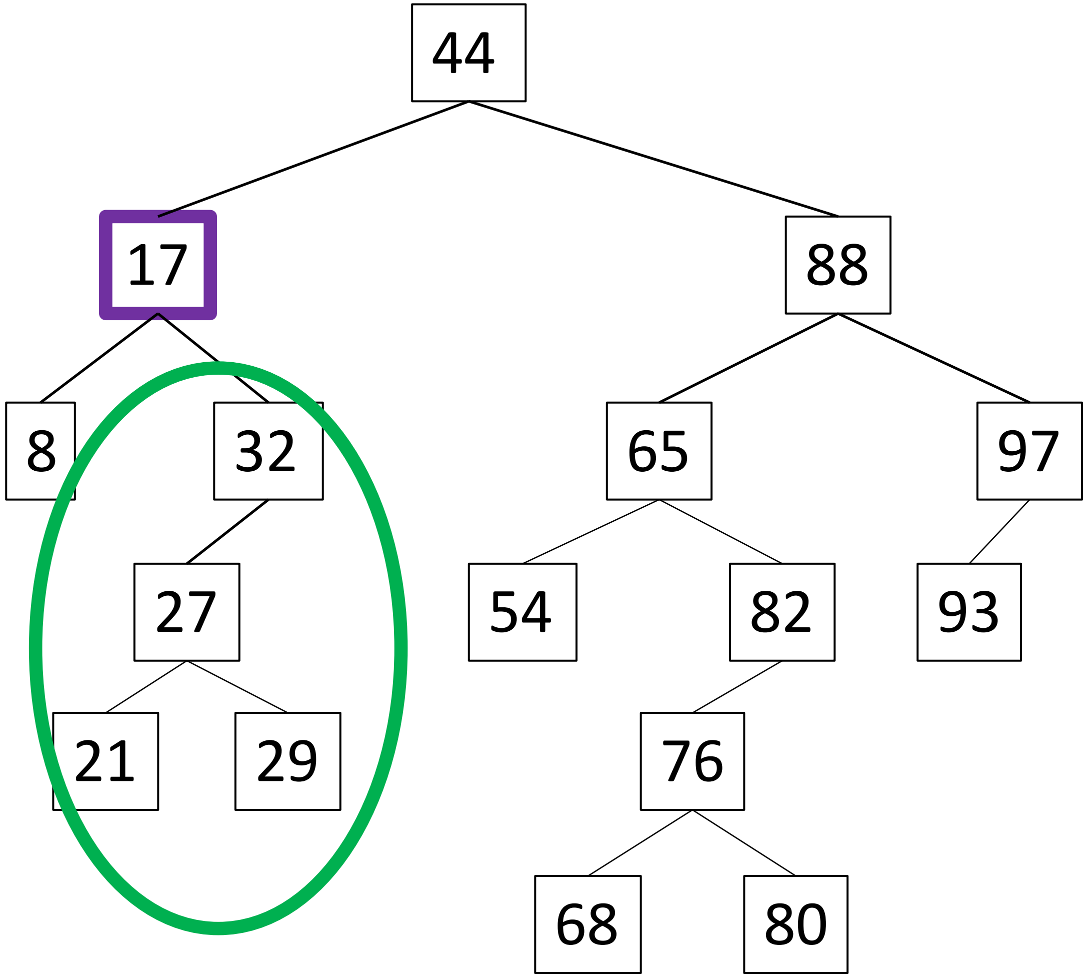

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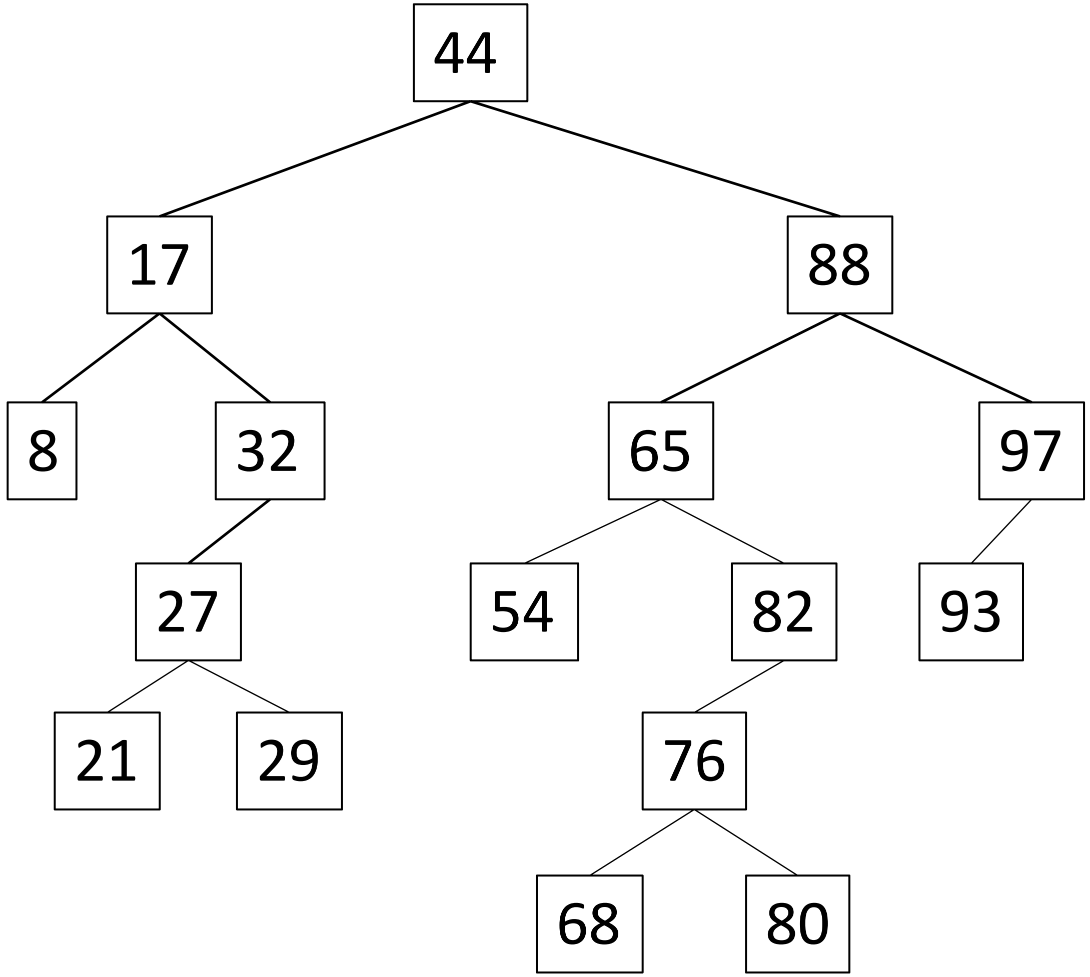

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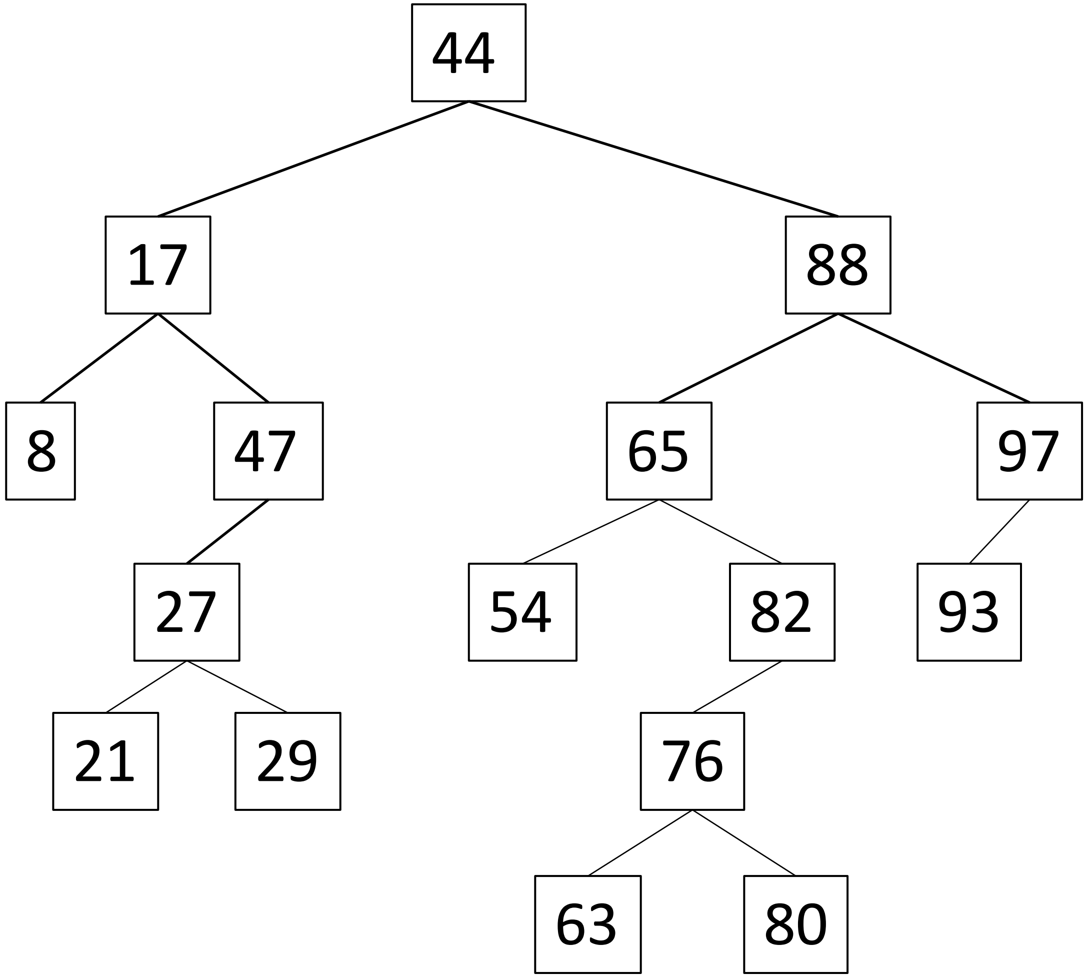

Is it a BST?

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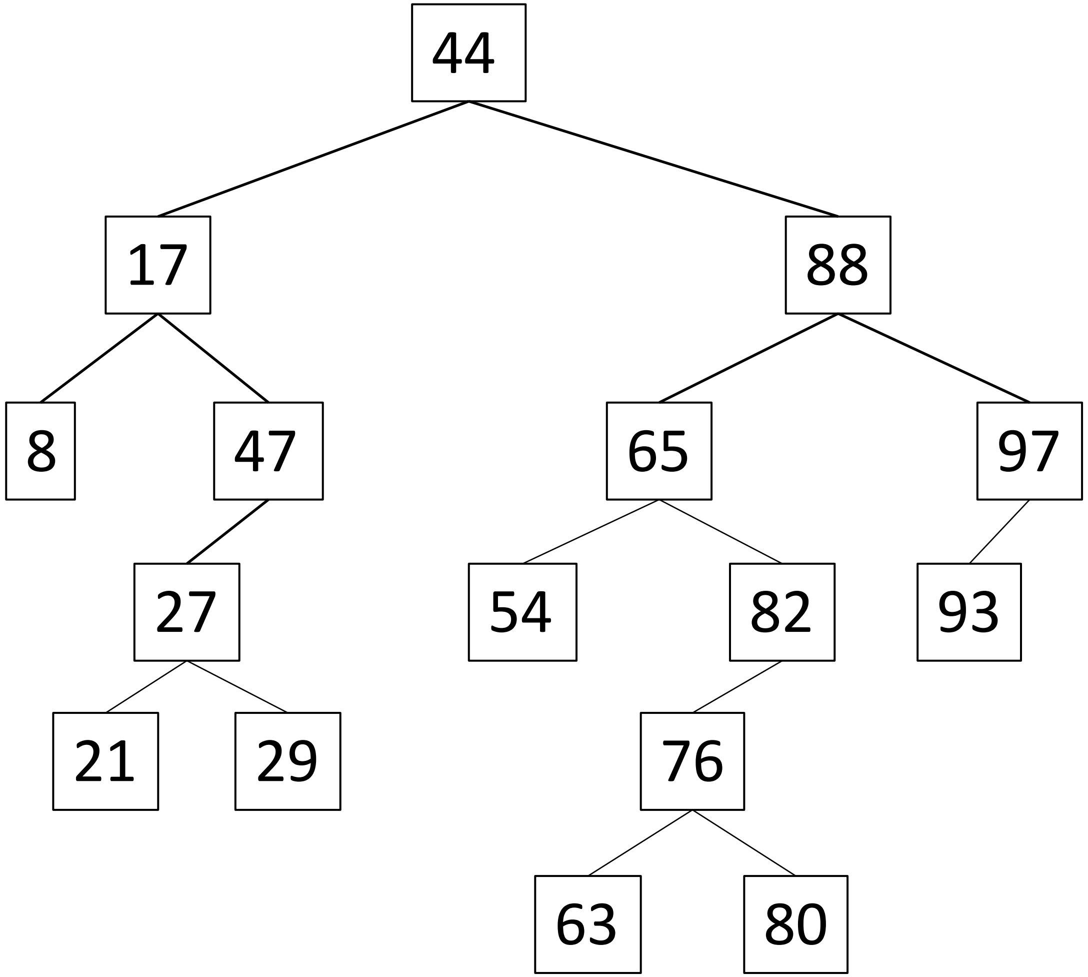

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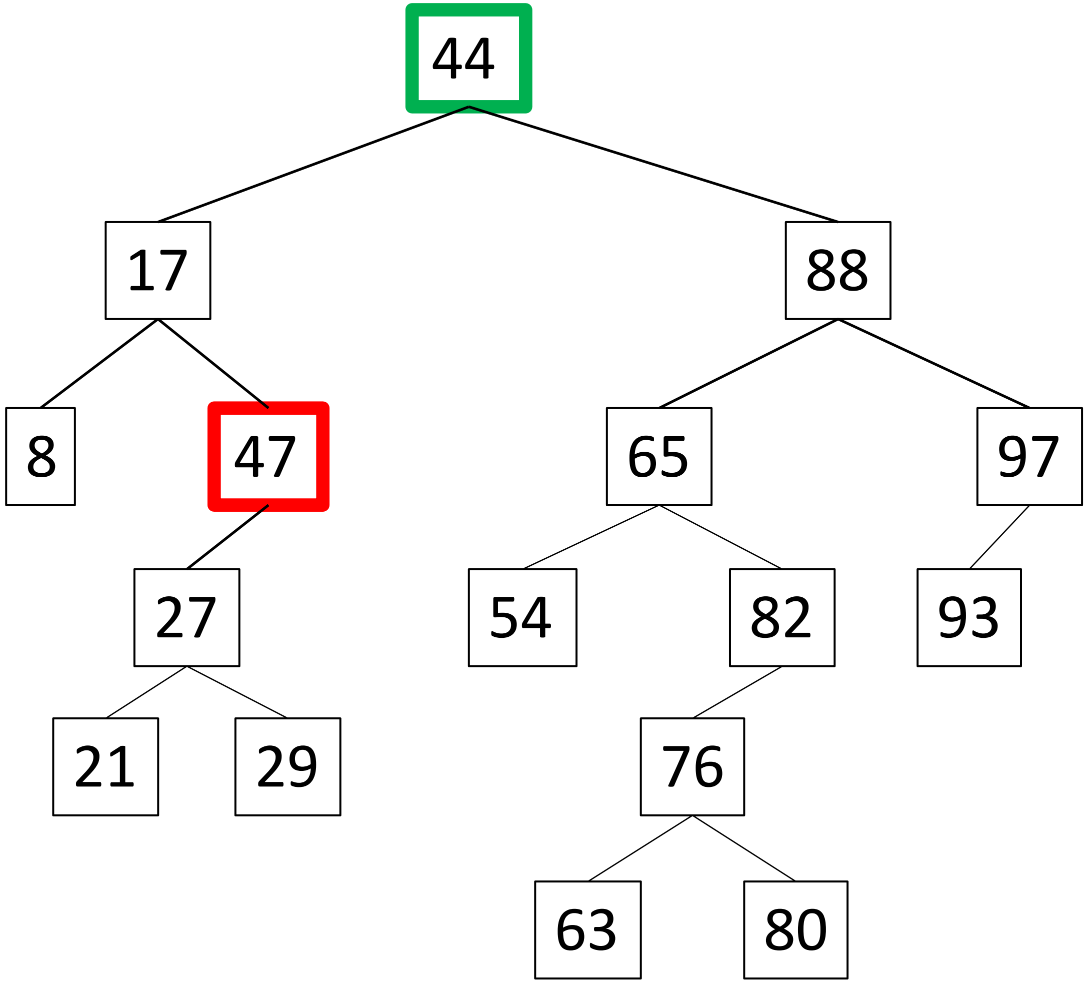

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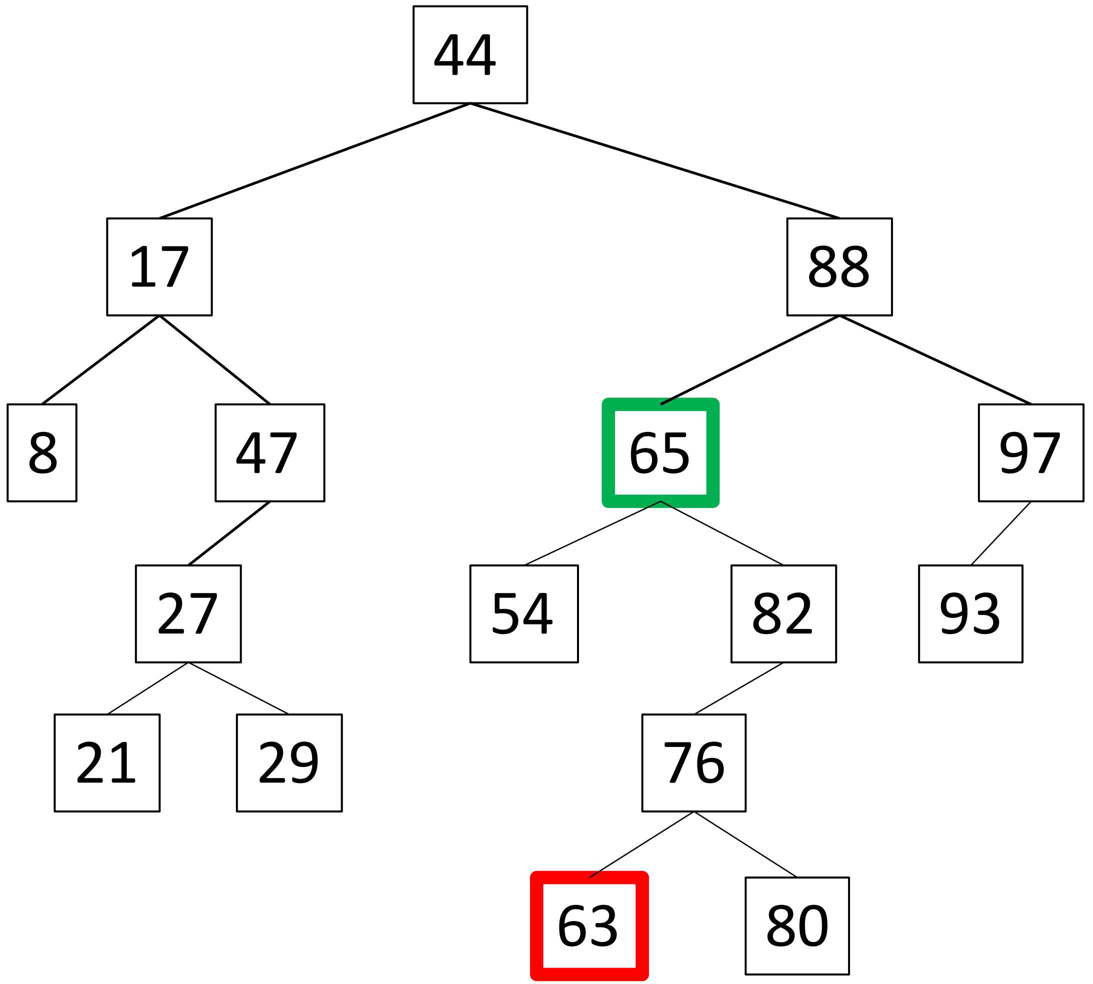

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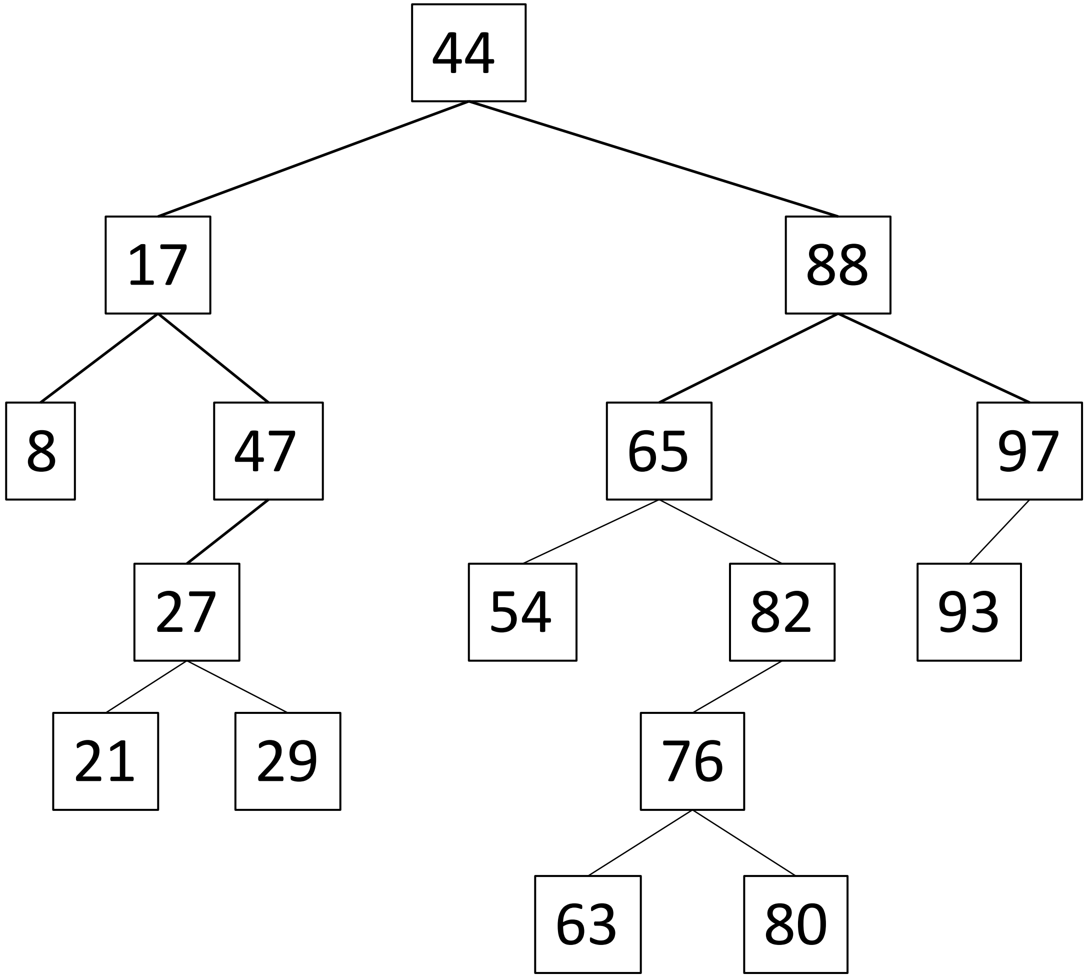

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Binary Search Tree

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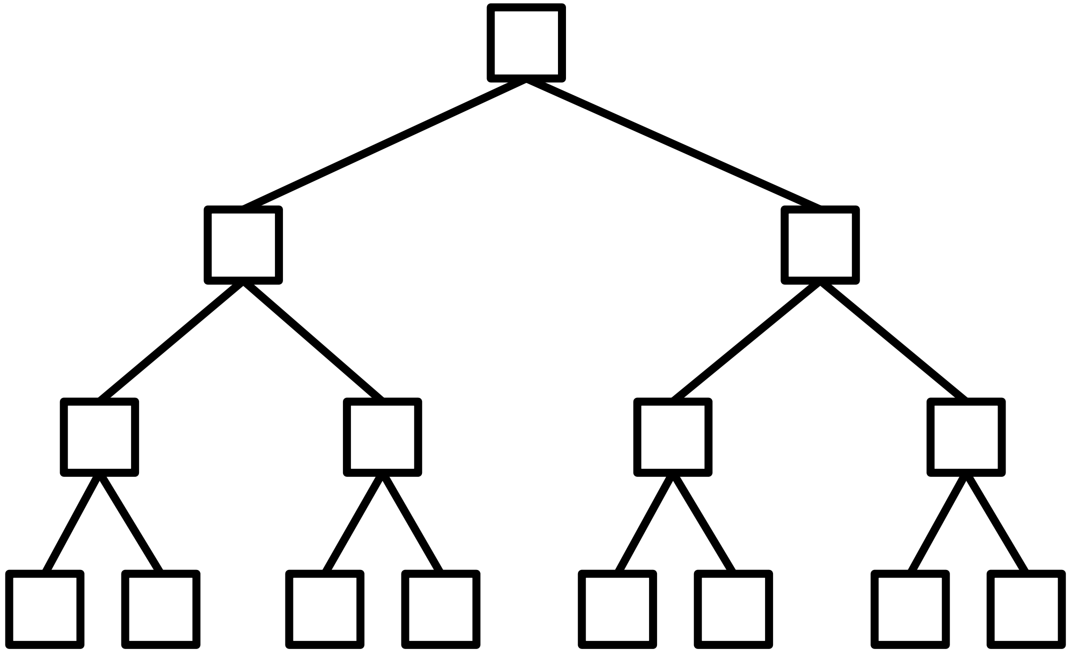

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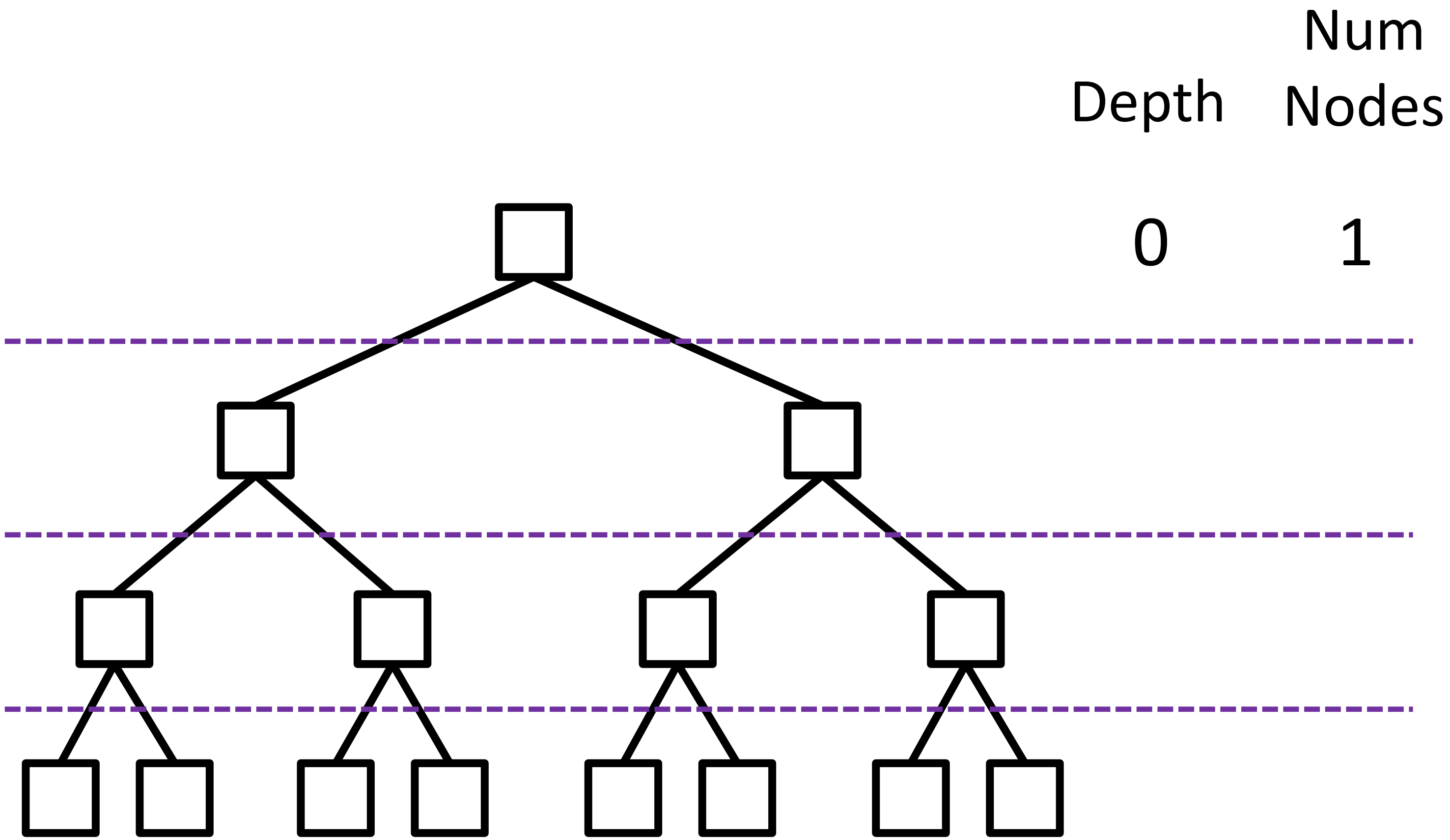

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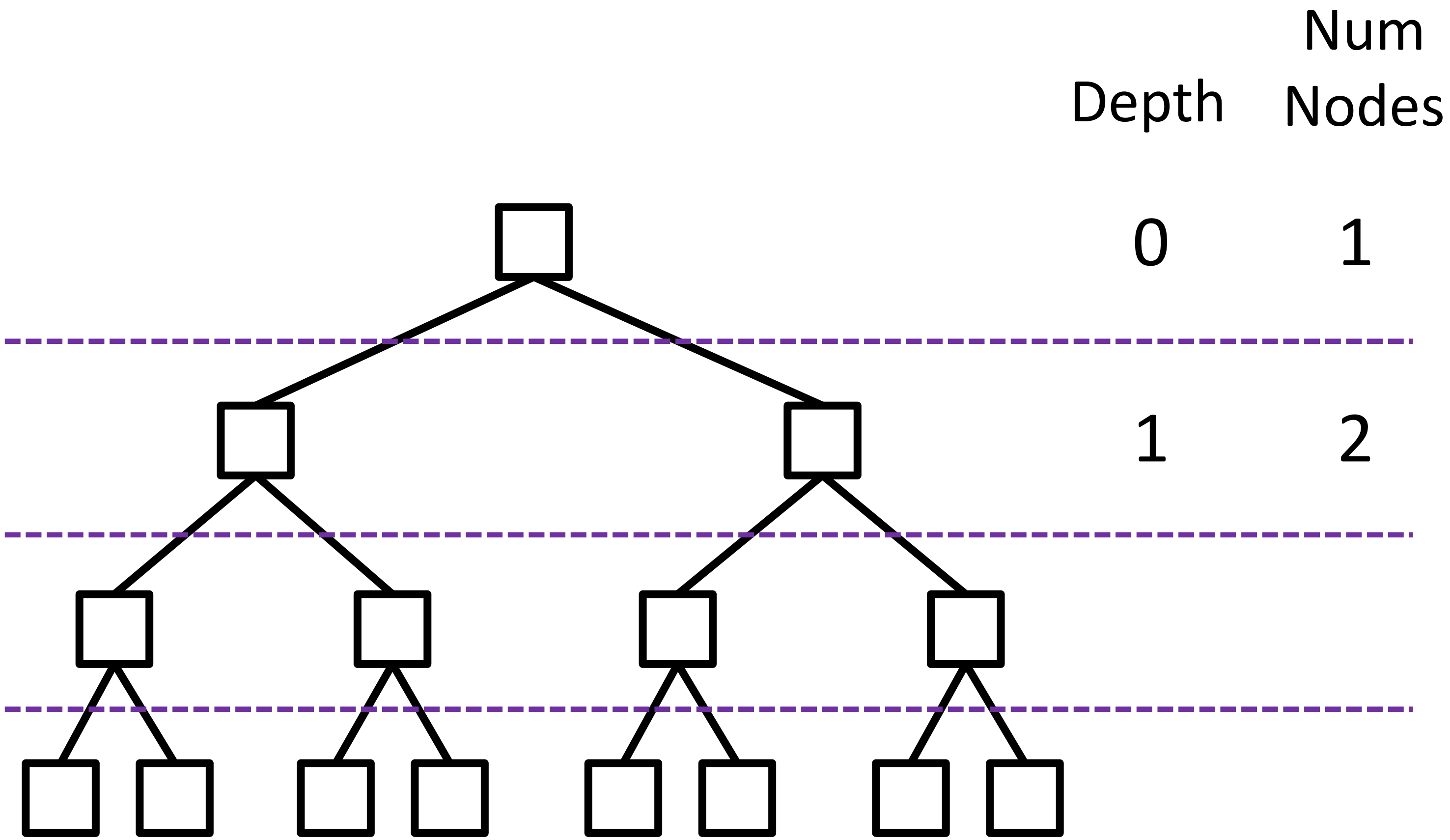

Depth	Num Nodes
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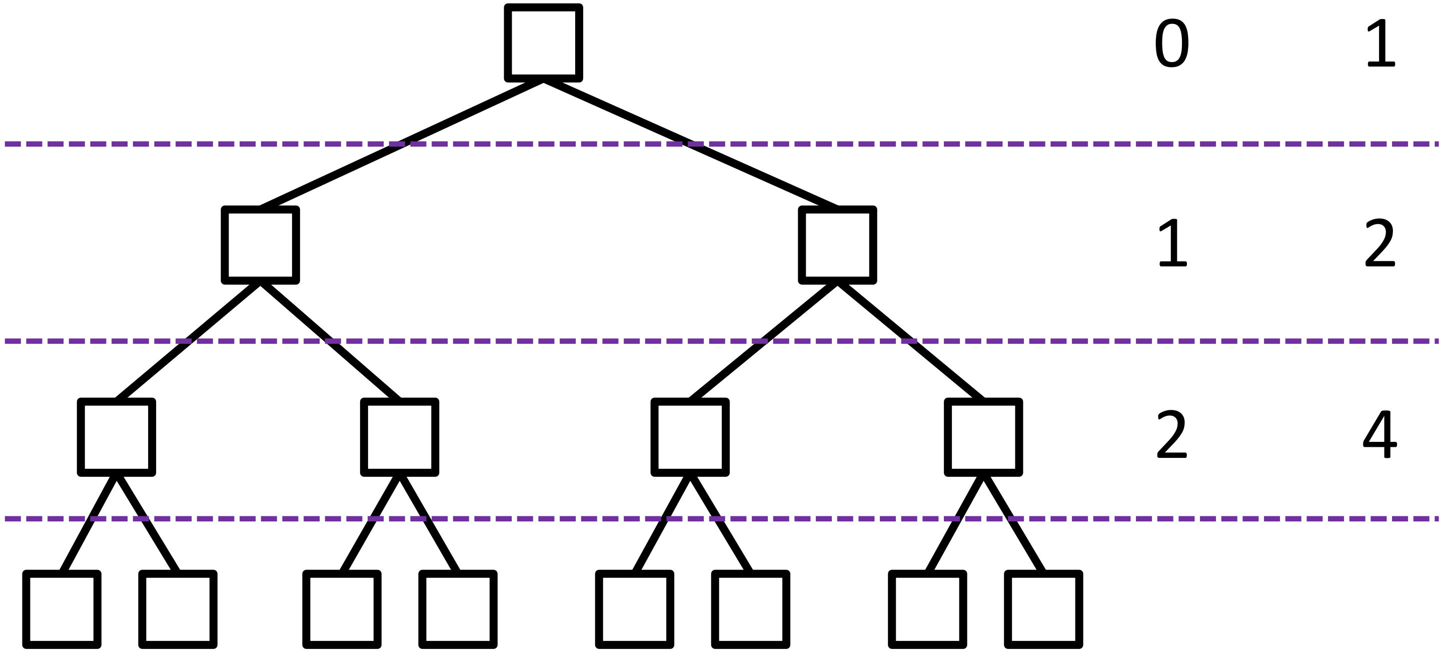

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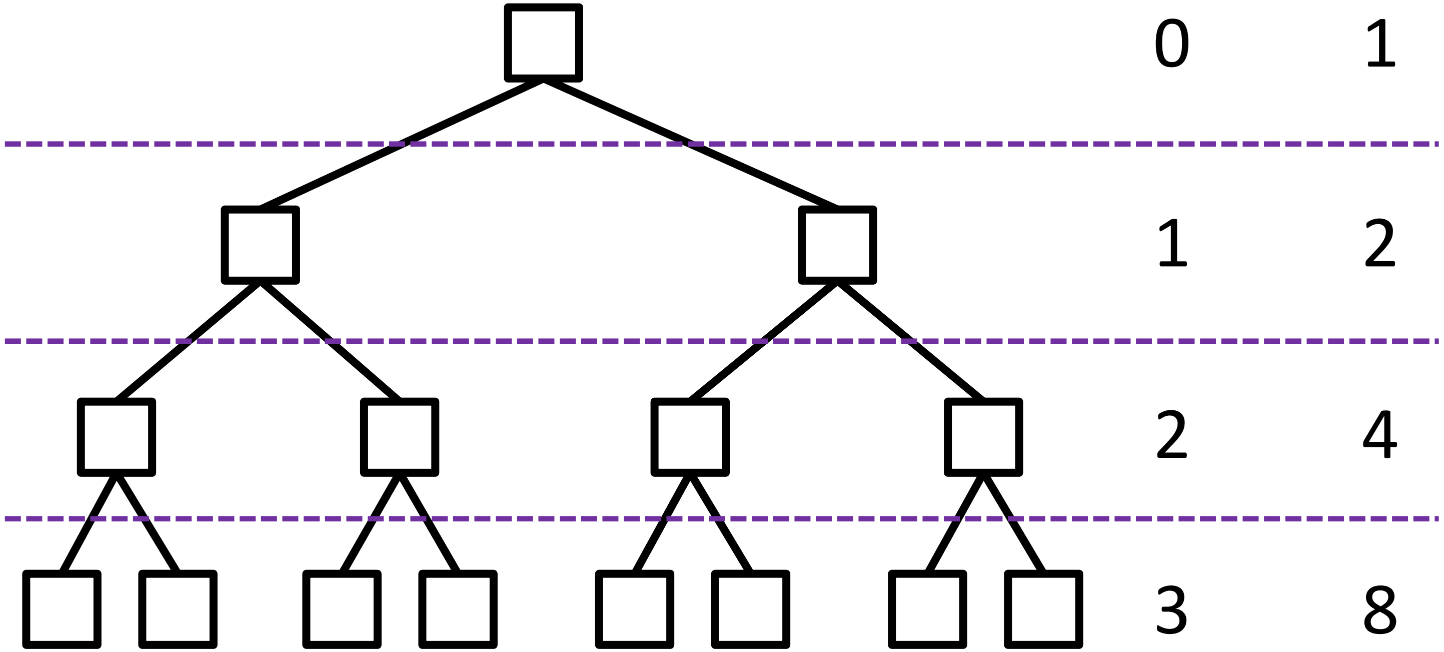

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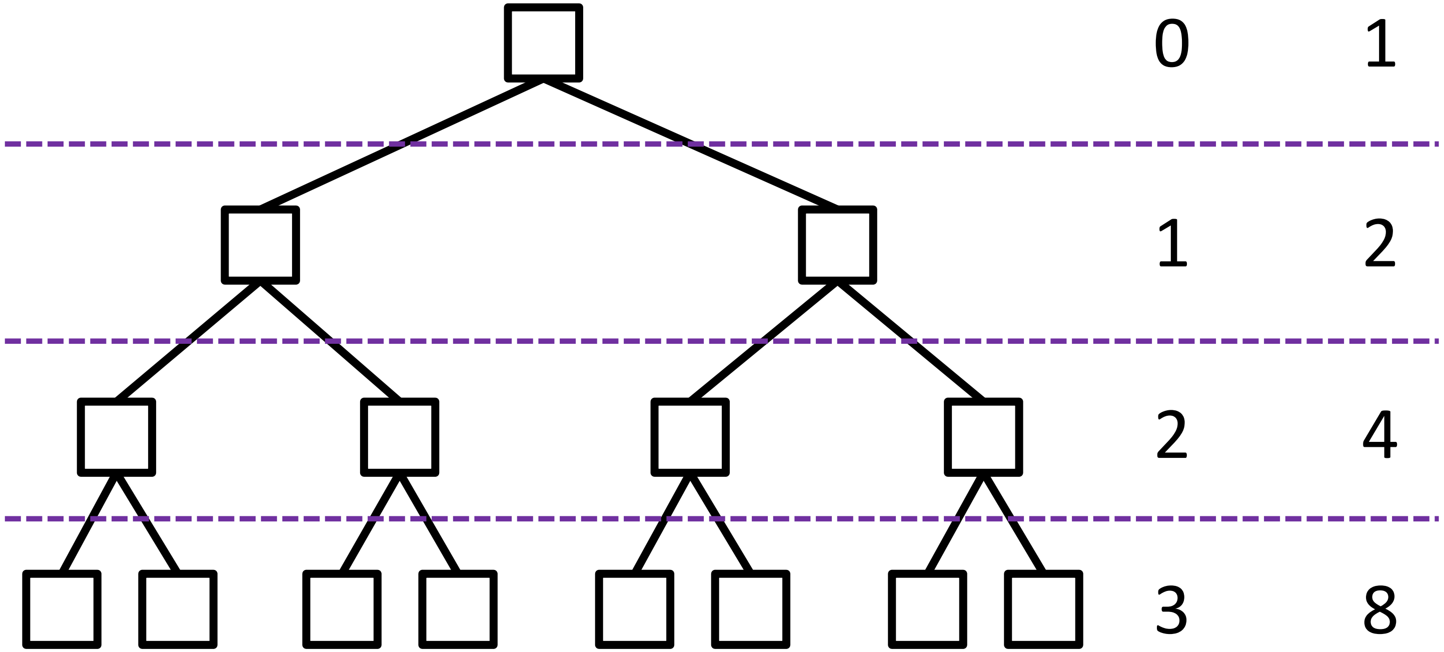
Binary Search Tree

What is the point? Why use a BST?

In general, at depth d, there are at most $??$ nodes.



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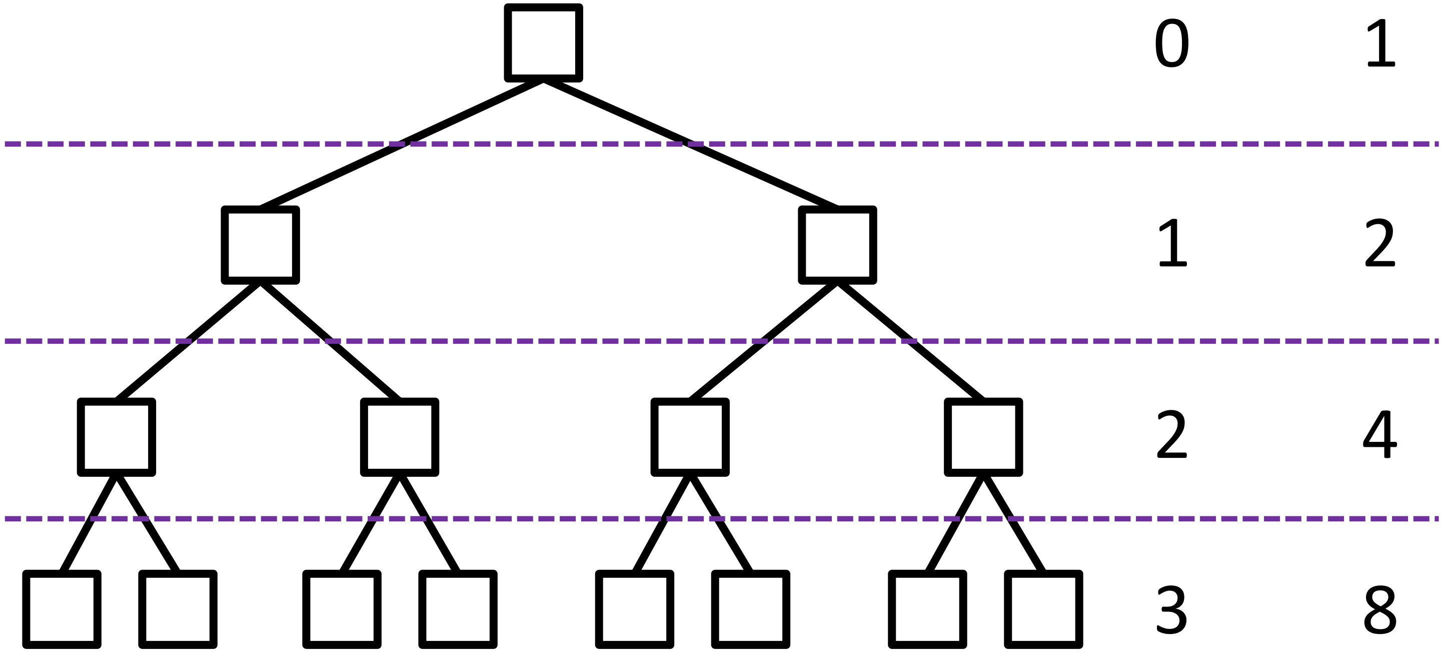

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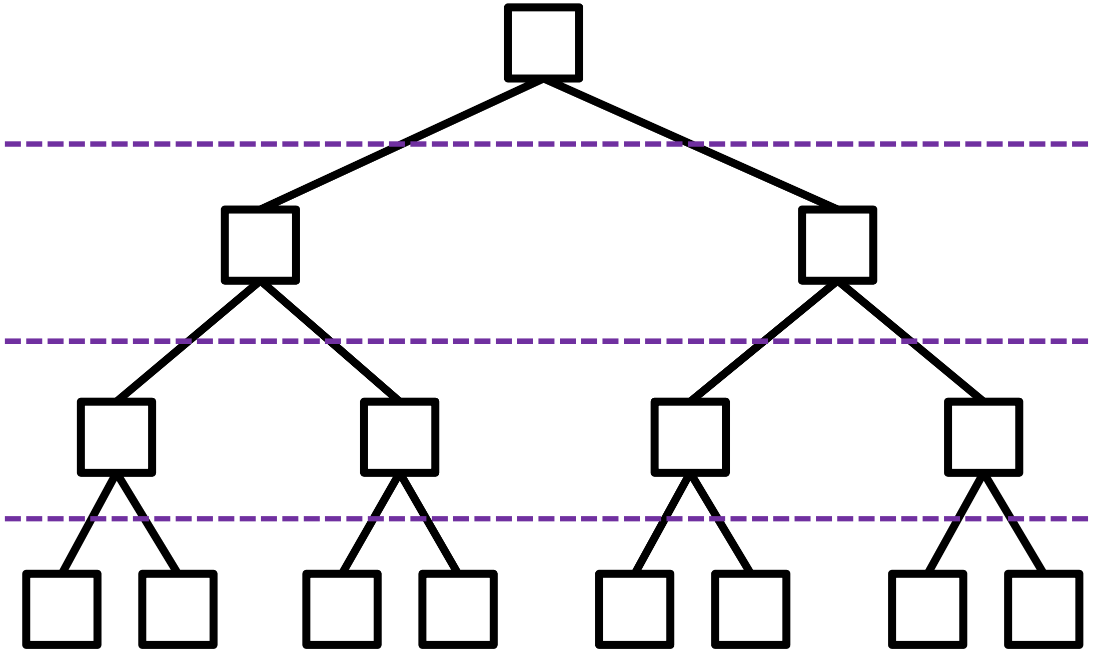

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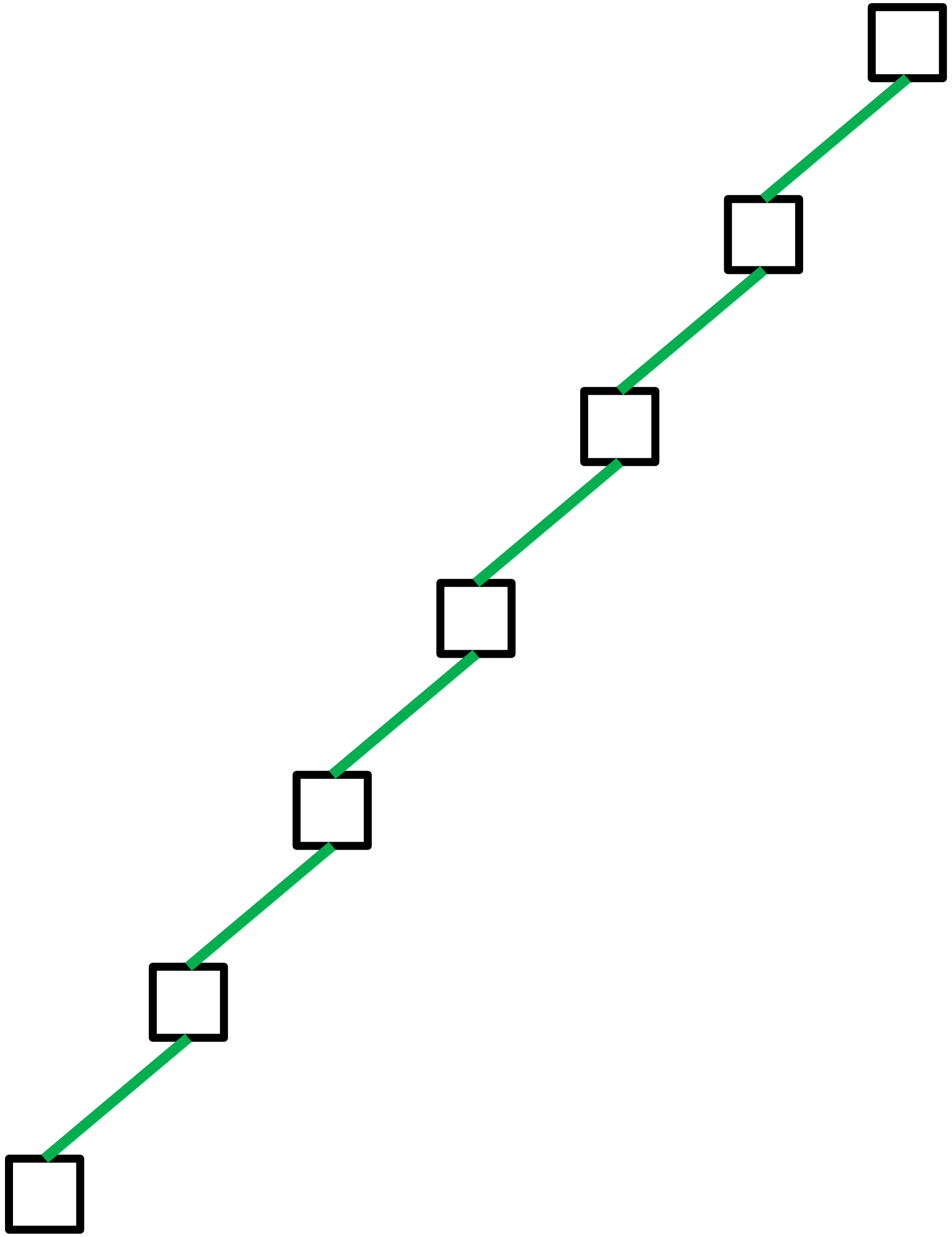

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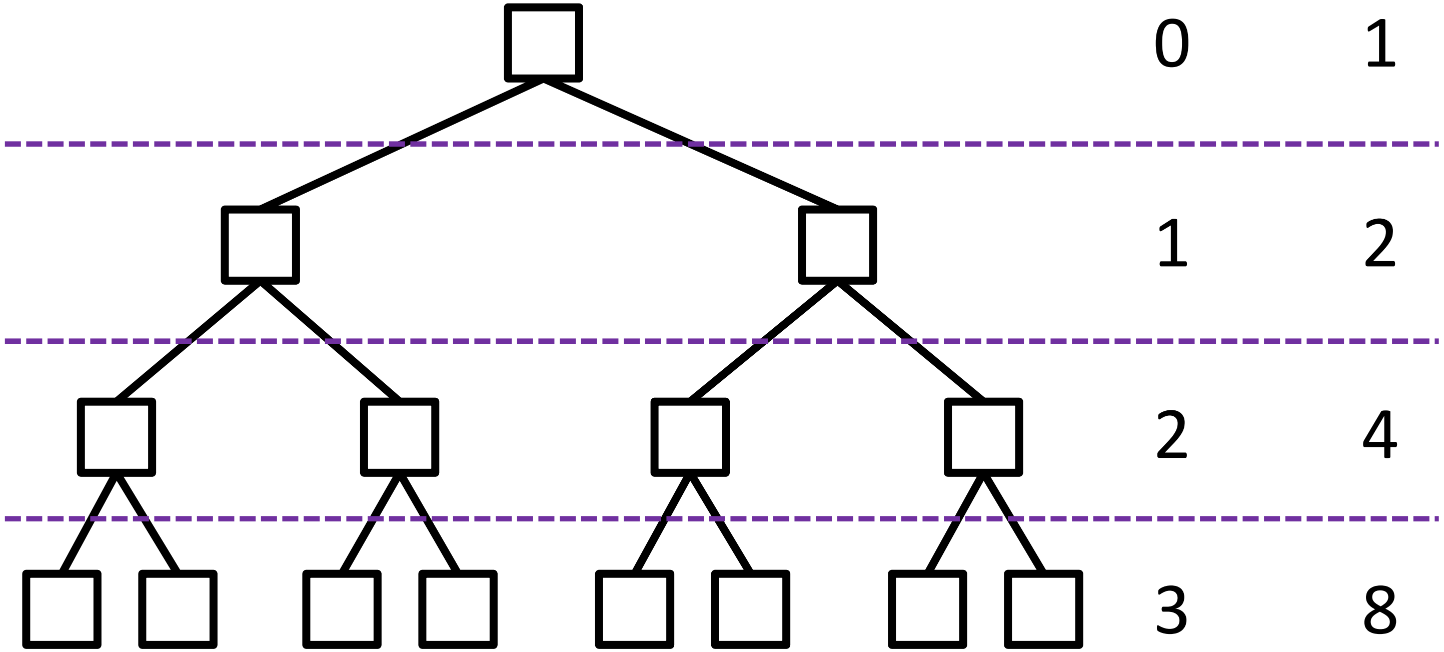

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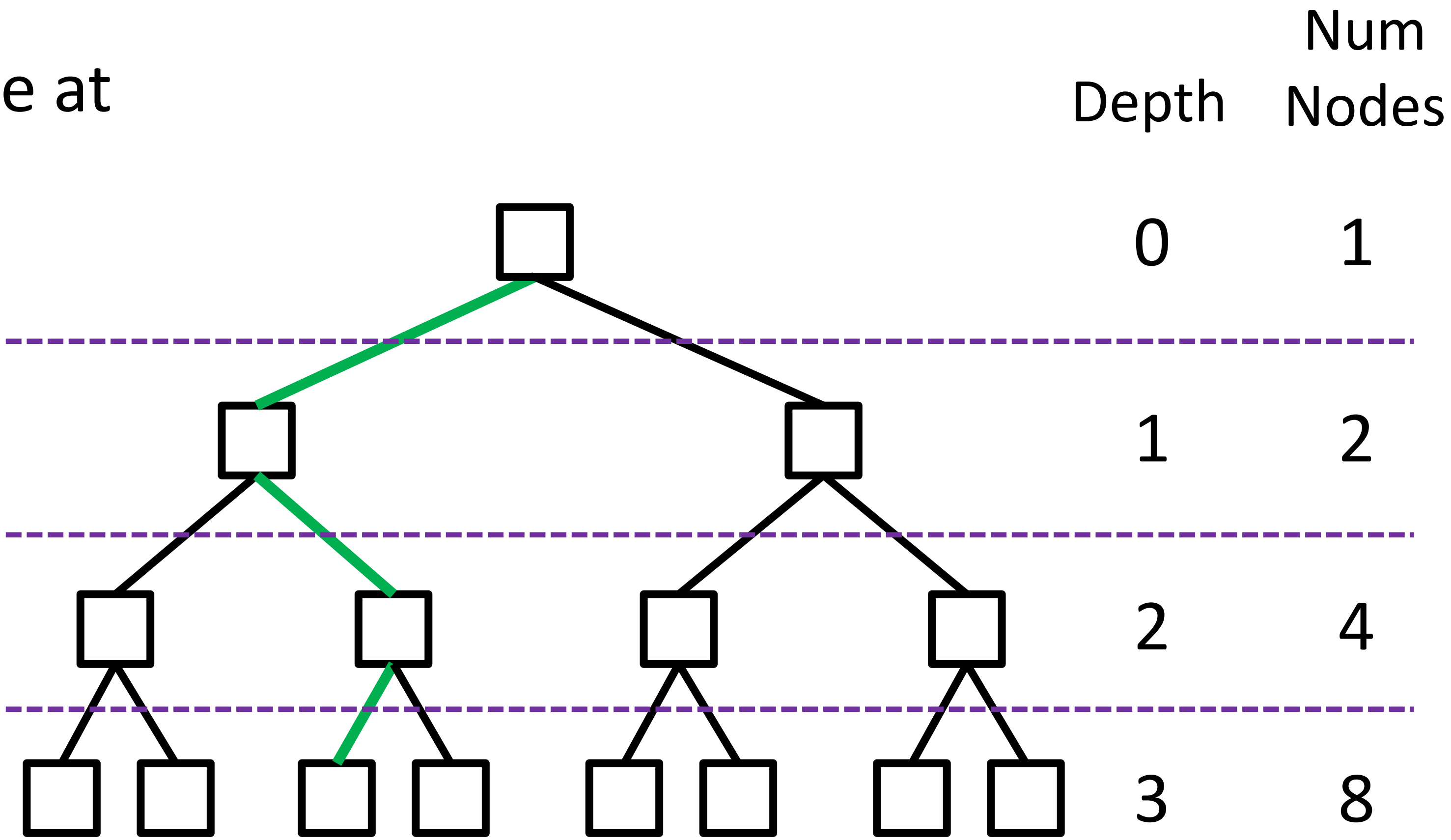

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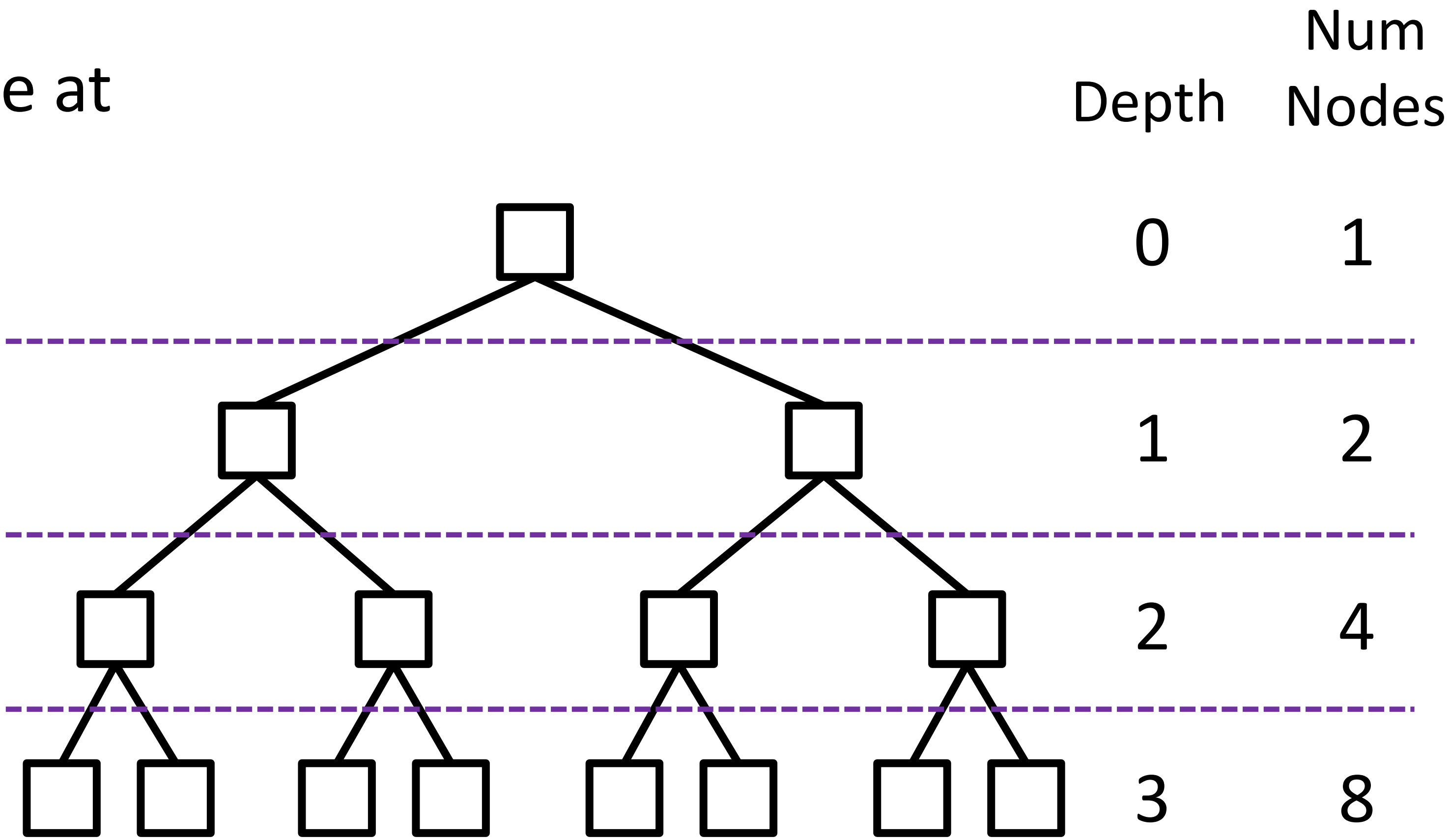
Given n nodes, what is the smallest height (h) of the BST?



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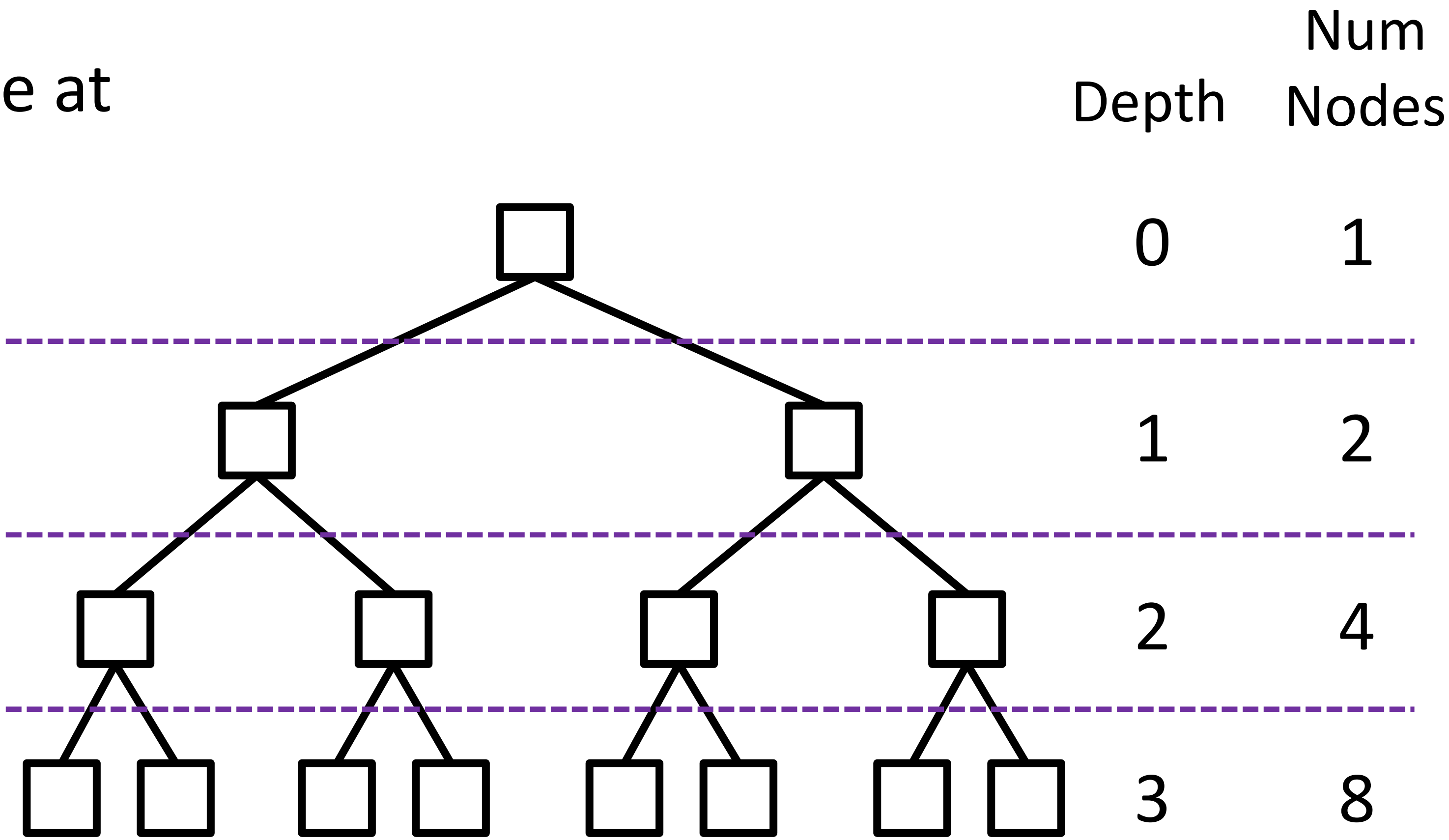

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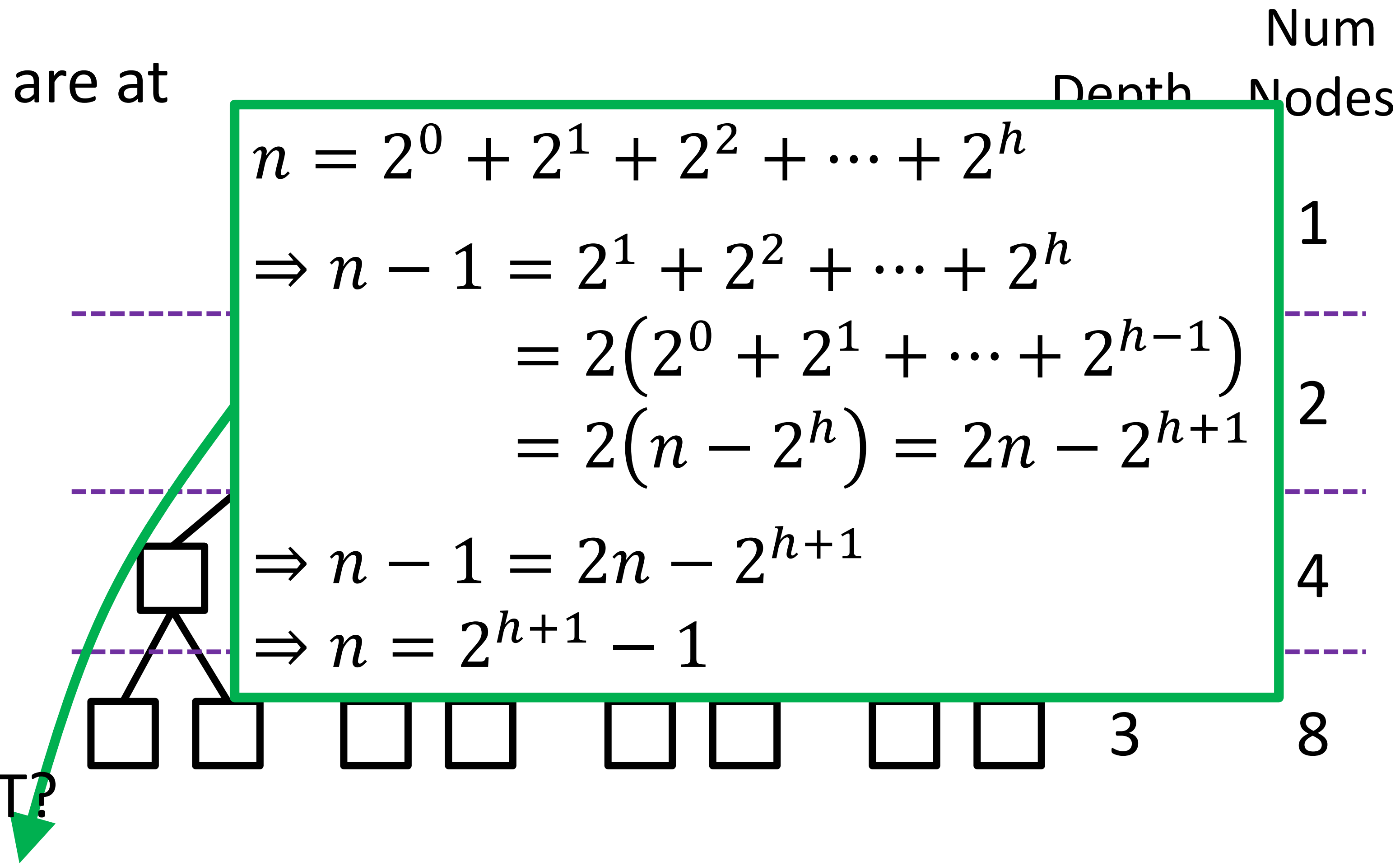

$$n = 2^0 + 2^1 + 2^2 + \cdots + 2^h$$

$$\Rightarrow n - 1 = 2^1 + 2^2 + \cdots + 2^h$$

$$= 2\left(2^0 + 2^1 + \cdots + 2^{h-1}\right)$$

$$= 2\left(n - 2^h\right) = 2n - 2^{h+1}$$

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$$\Rightarrow n = 2^{h+1} - 1$$

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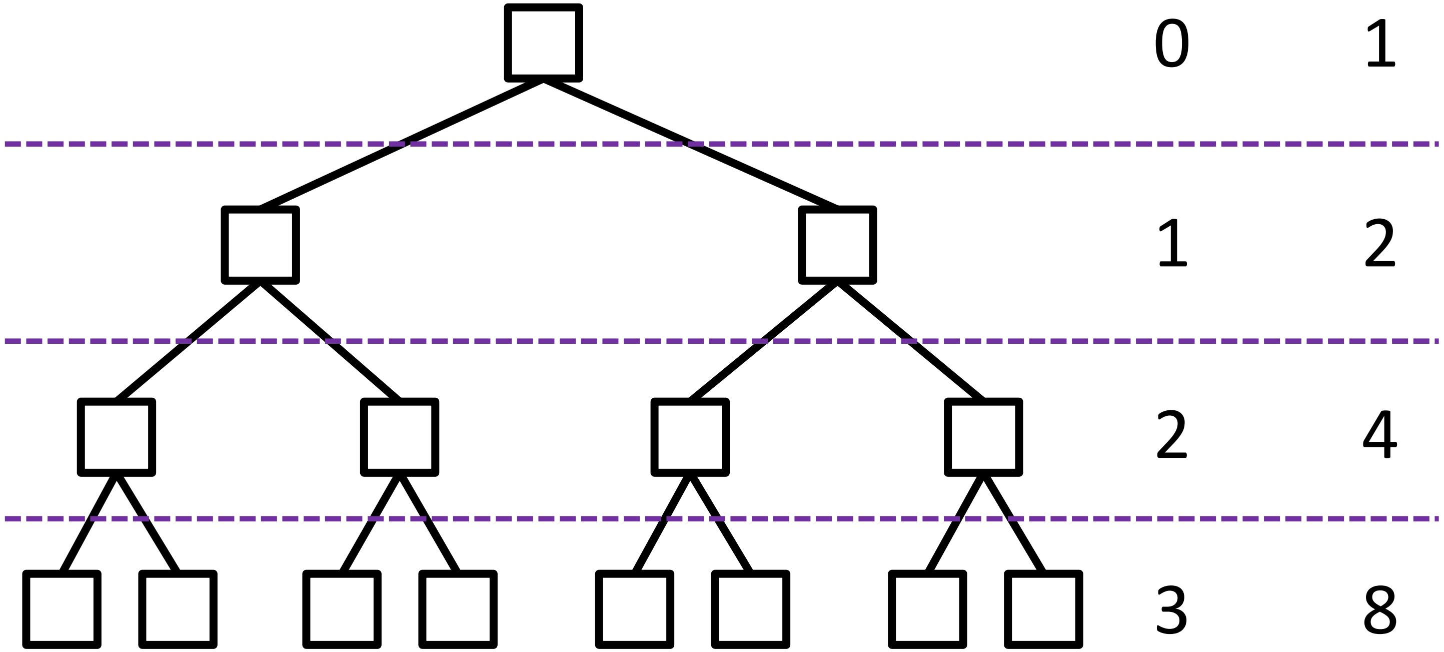

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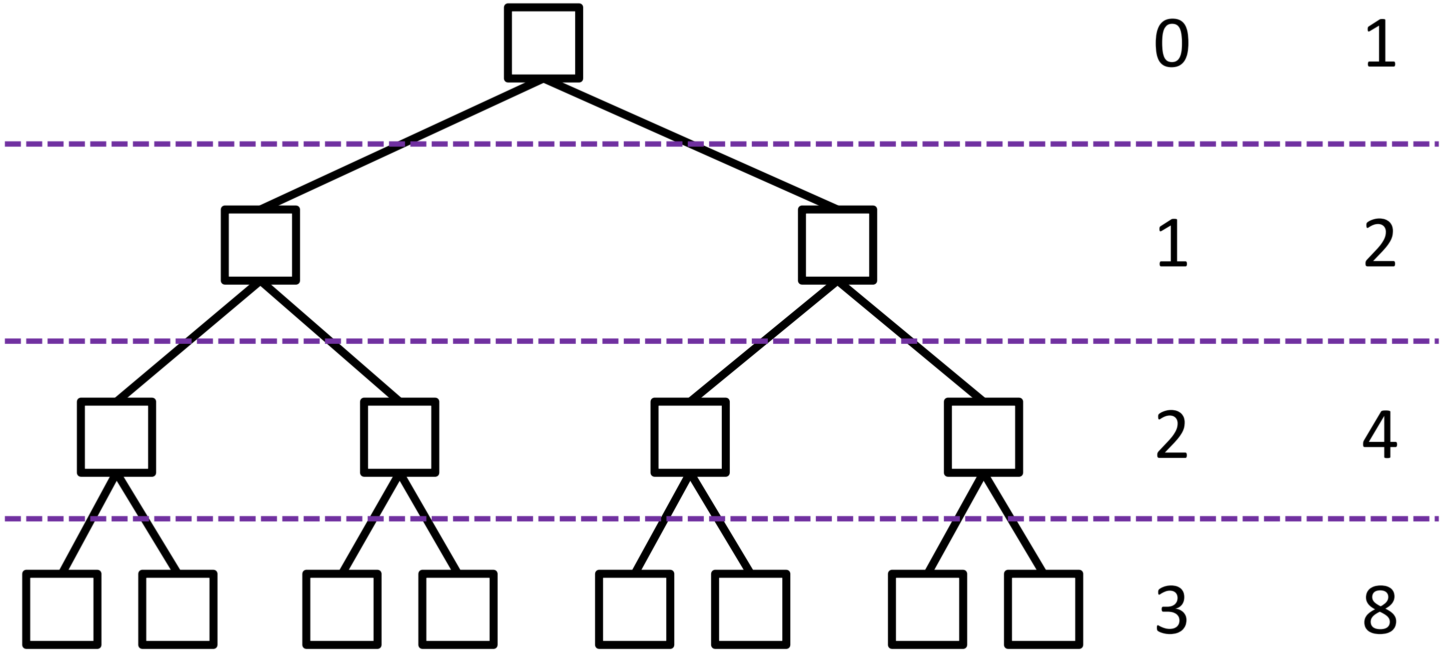

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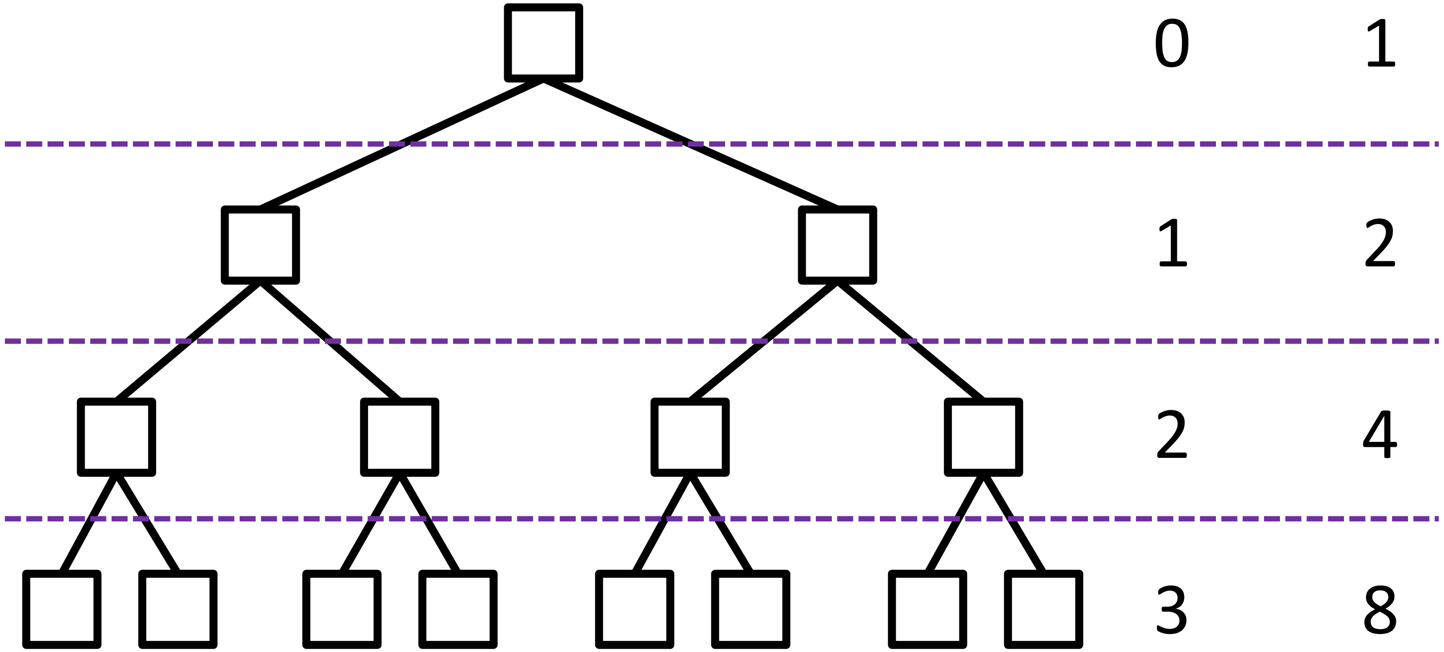

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$$n = 2^0 + 2^1 + 2^2 + \cdots + 2^h = 2^{h+1} - 1 \Rightarrow \begin{matrix} n + 1 = 2^{h+1} \\ \log_2(n+1) = h + 1 \end{matrix} \Rightarrow \boldsymbol{h \in O(\log n)}$$

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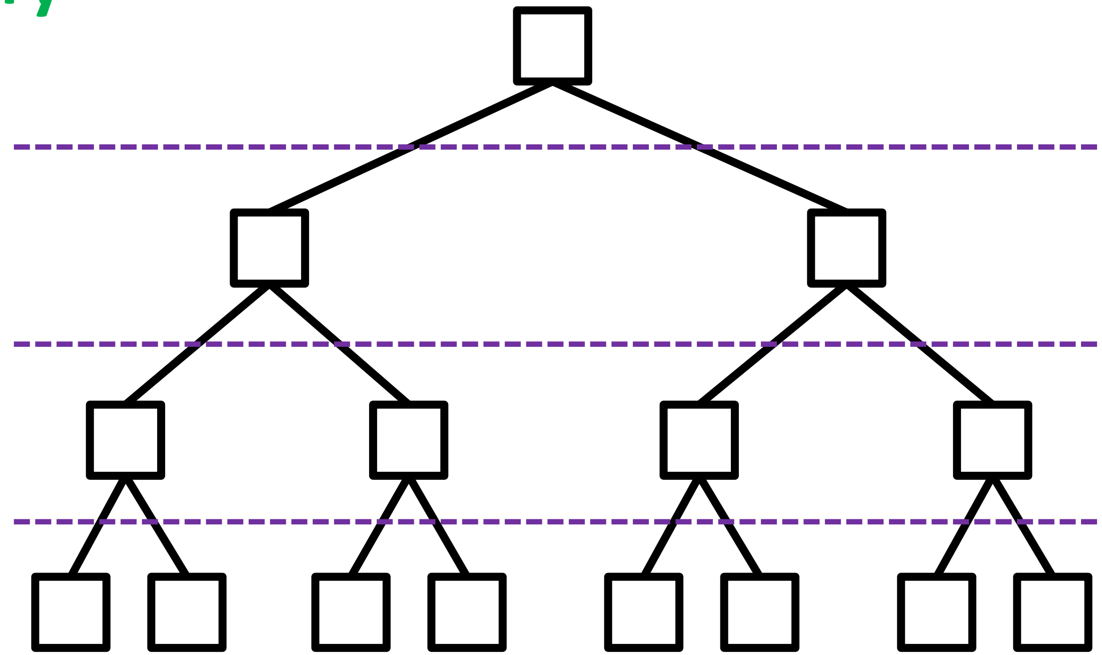
What is the point? Why use a BST?

This means we can access any node in a specific type of binary tree in $\log n$ time.



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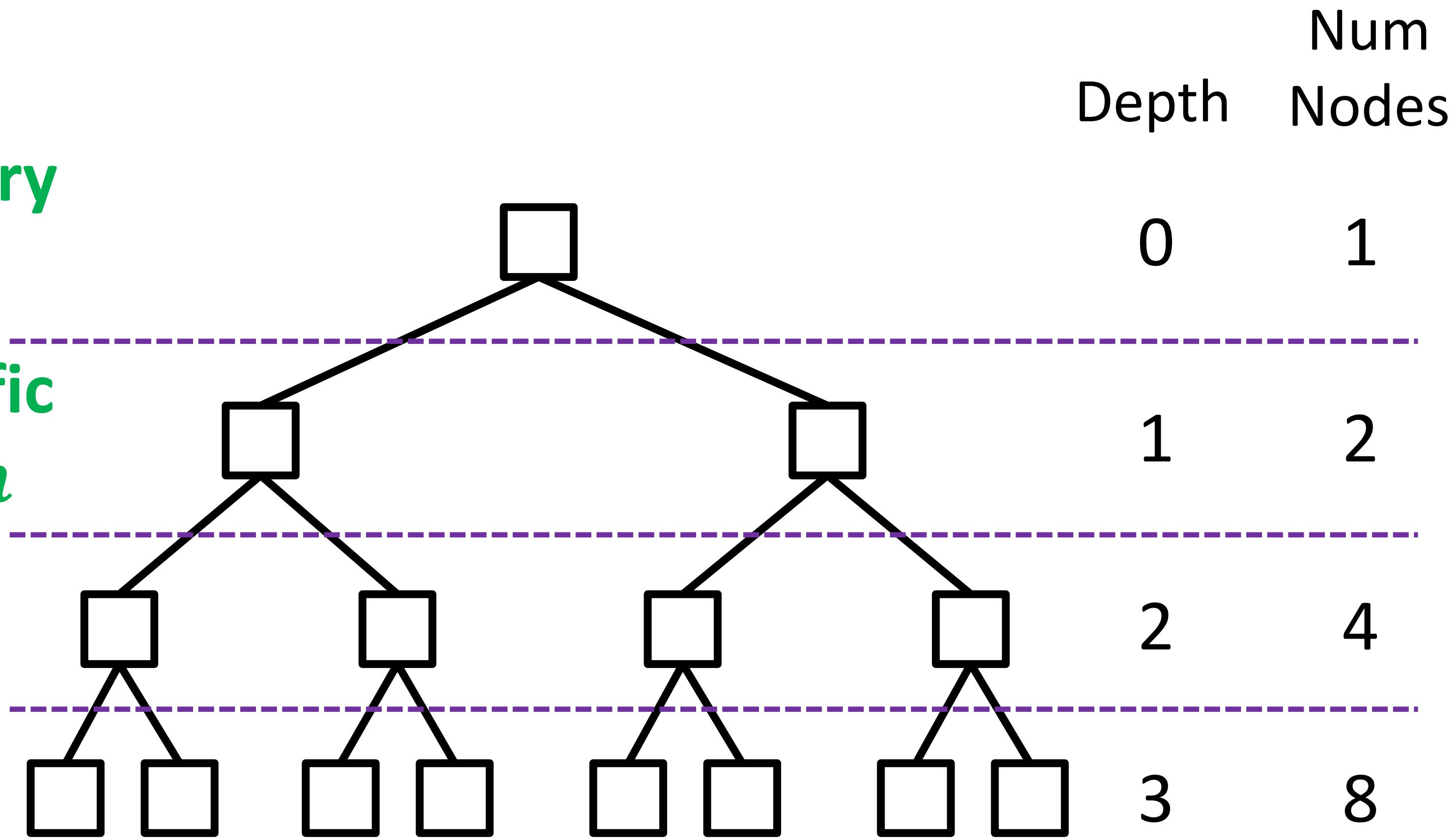

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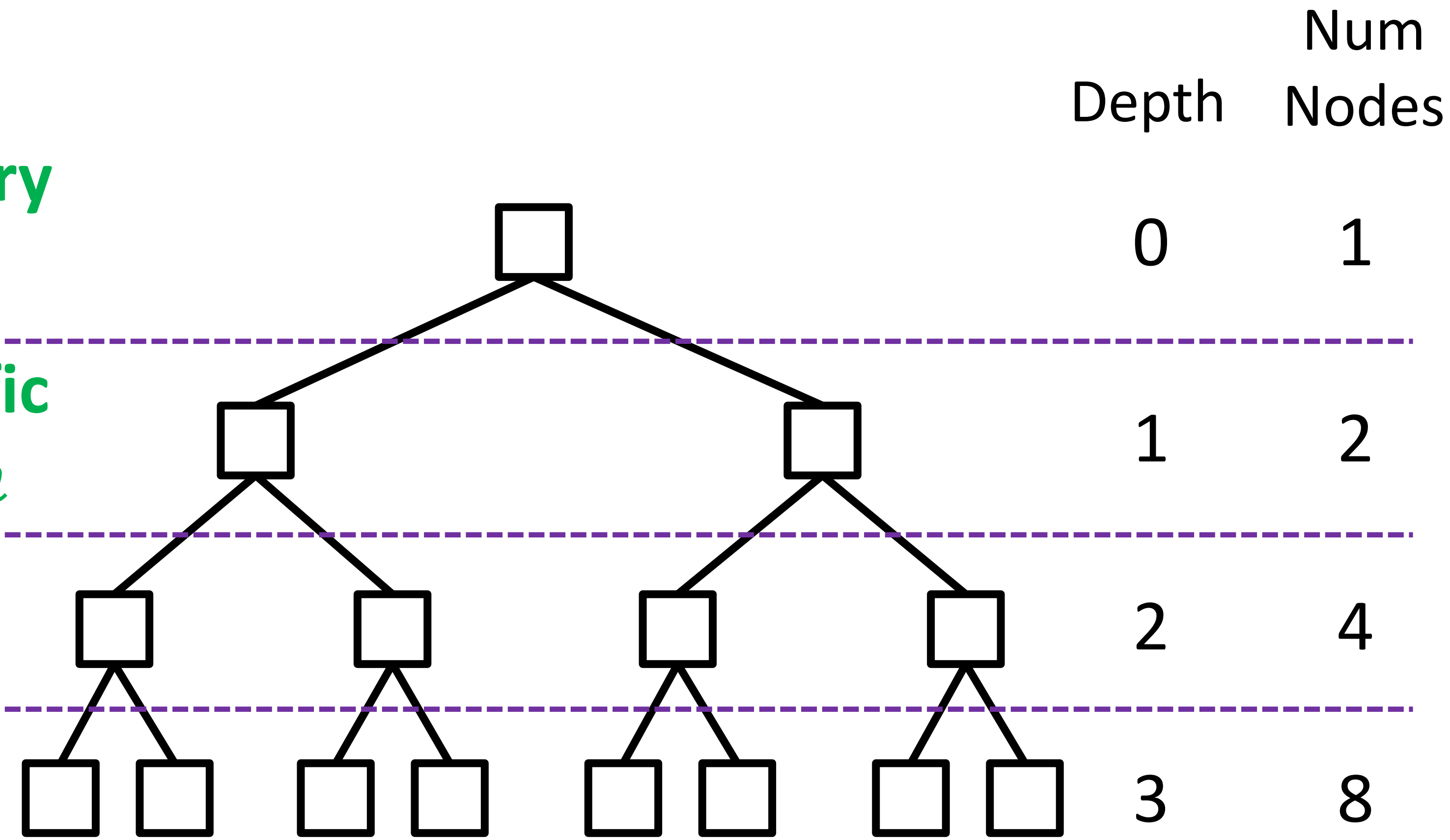

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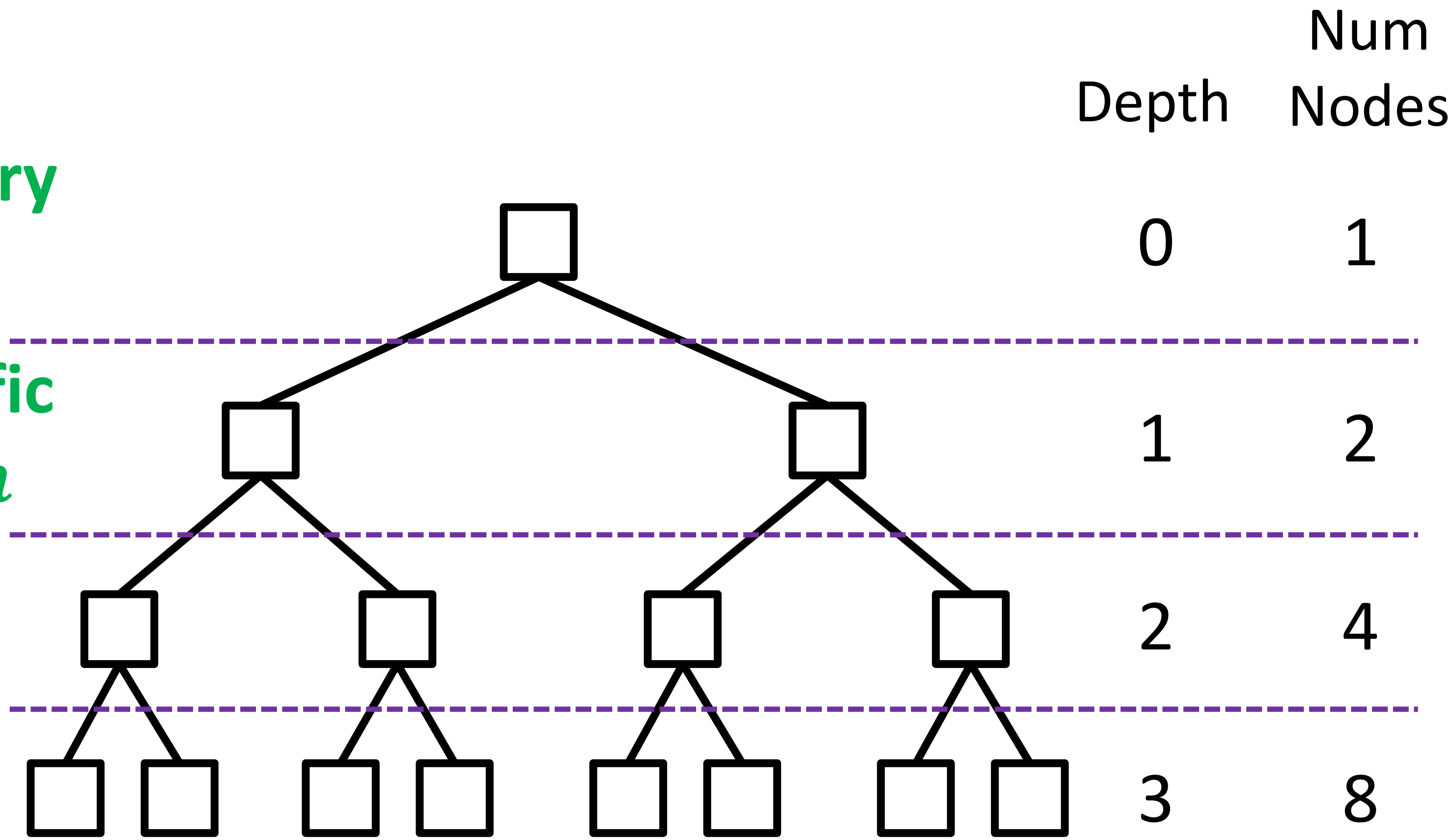

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Perhaps managing a BST is more efficient than managing an array.

Binary Search Tree - Insertion

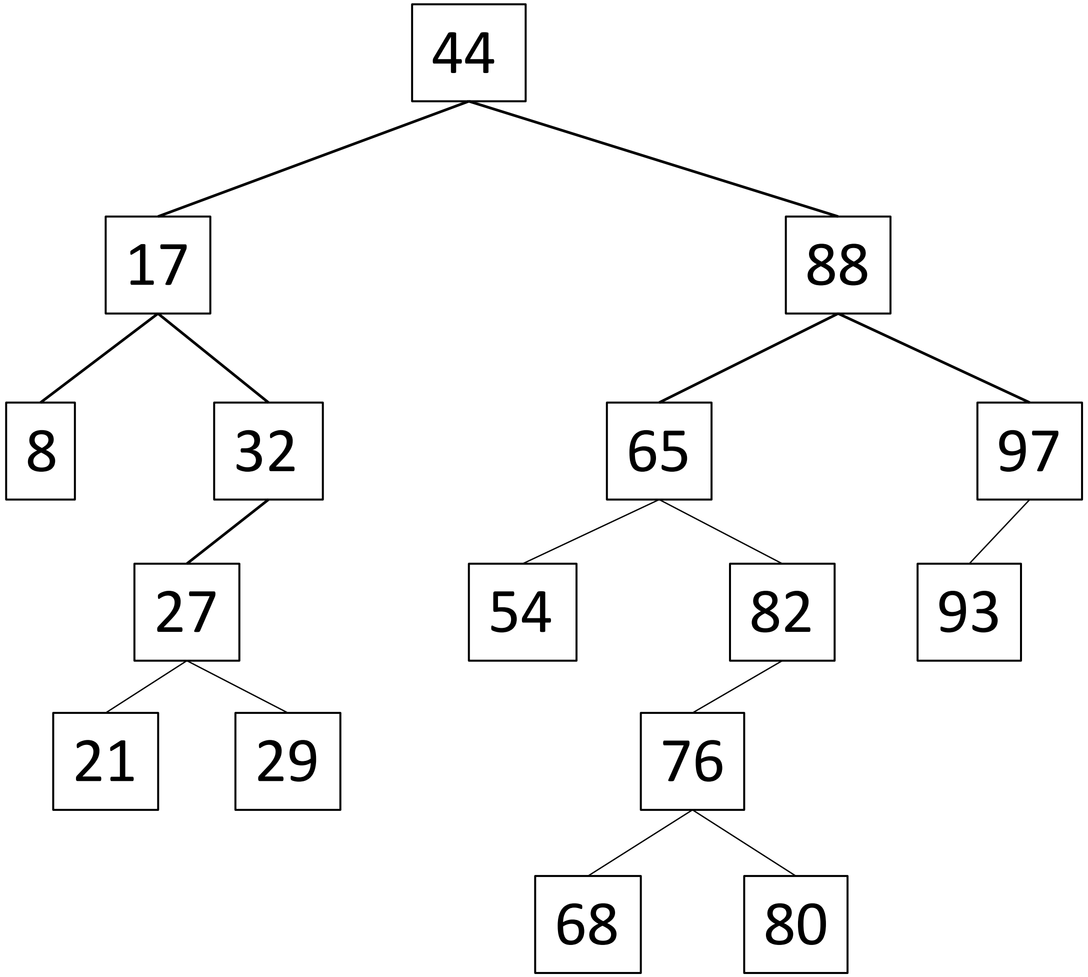
```
public class Node {

    private int value;
    private Node left;
    private Node right;
    private Node parent;

    public Node(int value) {
        this.value = value;
    }

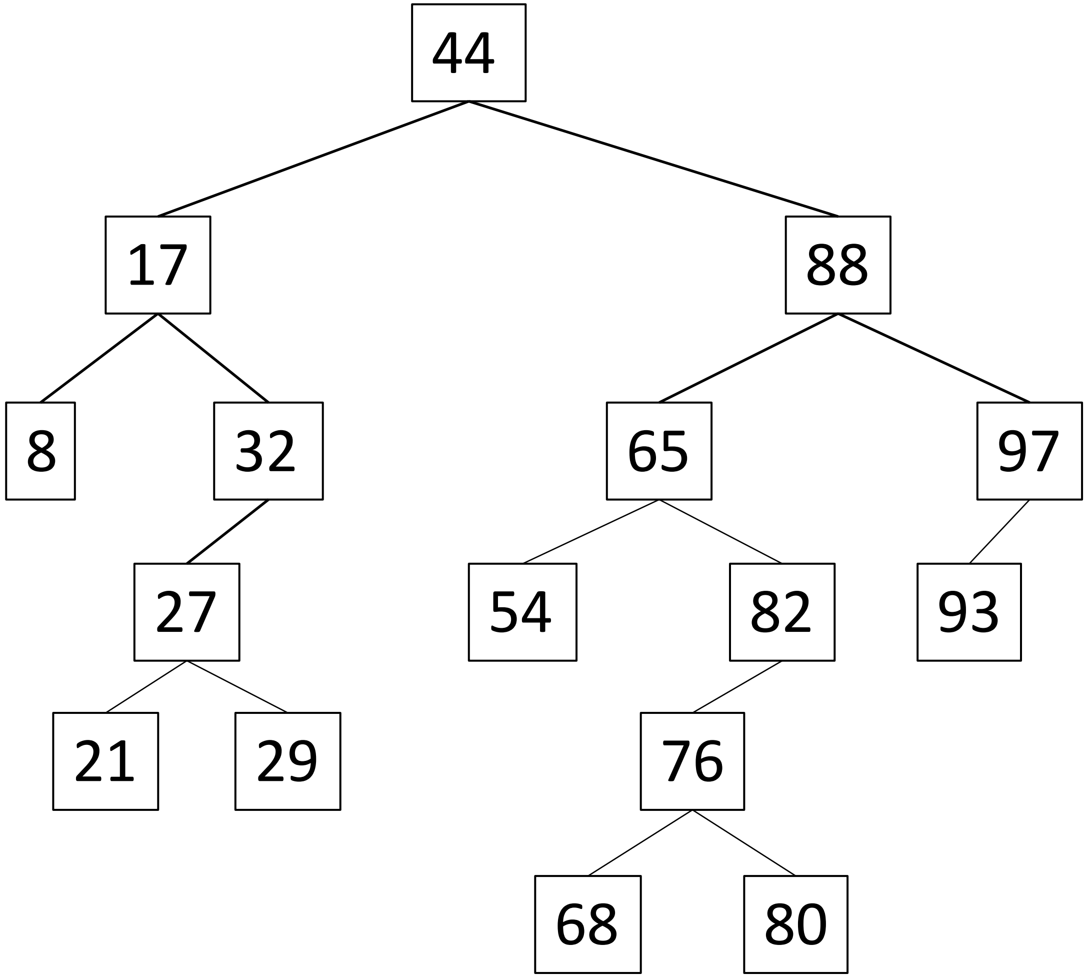
    // getValue()
    // getLeft(), getRight()
    // getParent()

    // setLeft(), setRight()
    // setParent()
}
```



Binary Search Tree - Insertion

```
insert(31);
```



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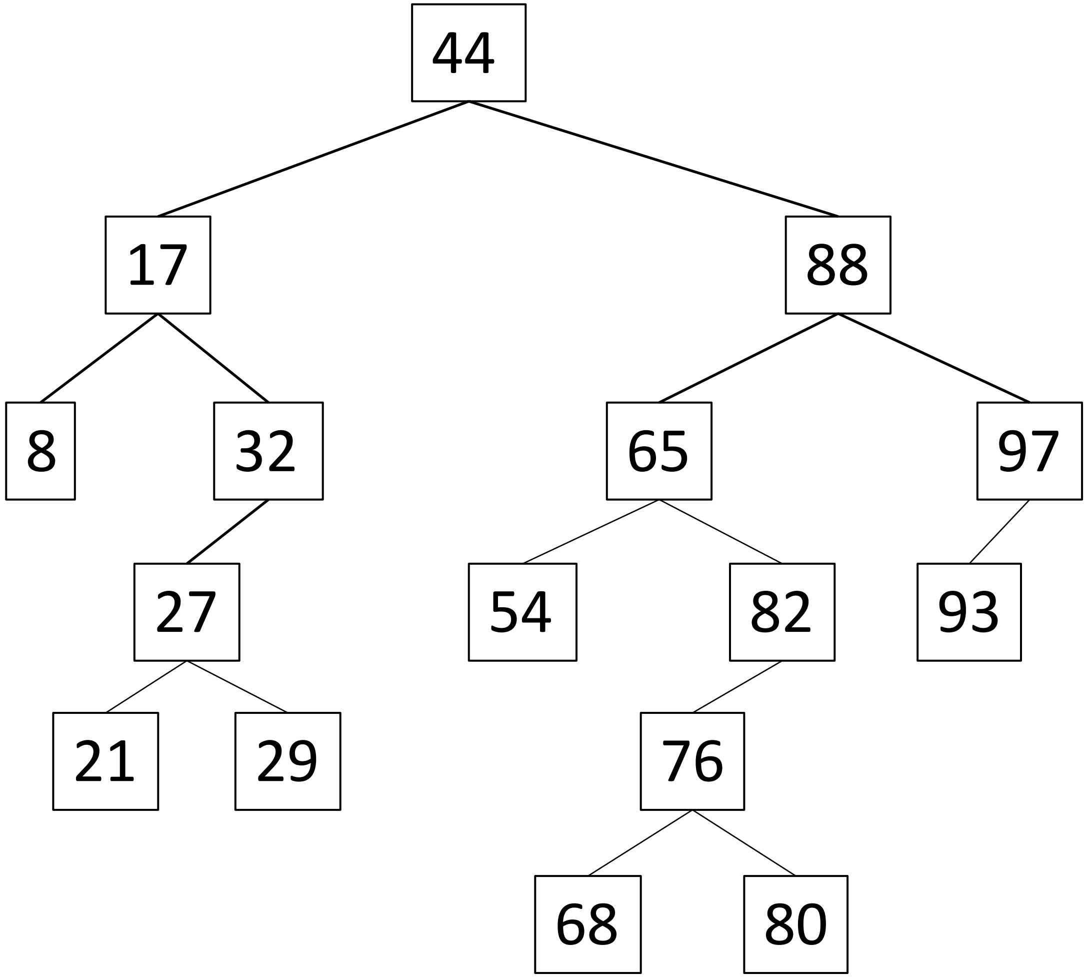
Step 1: Find where it should go.

Step 2: Modify pointers.



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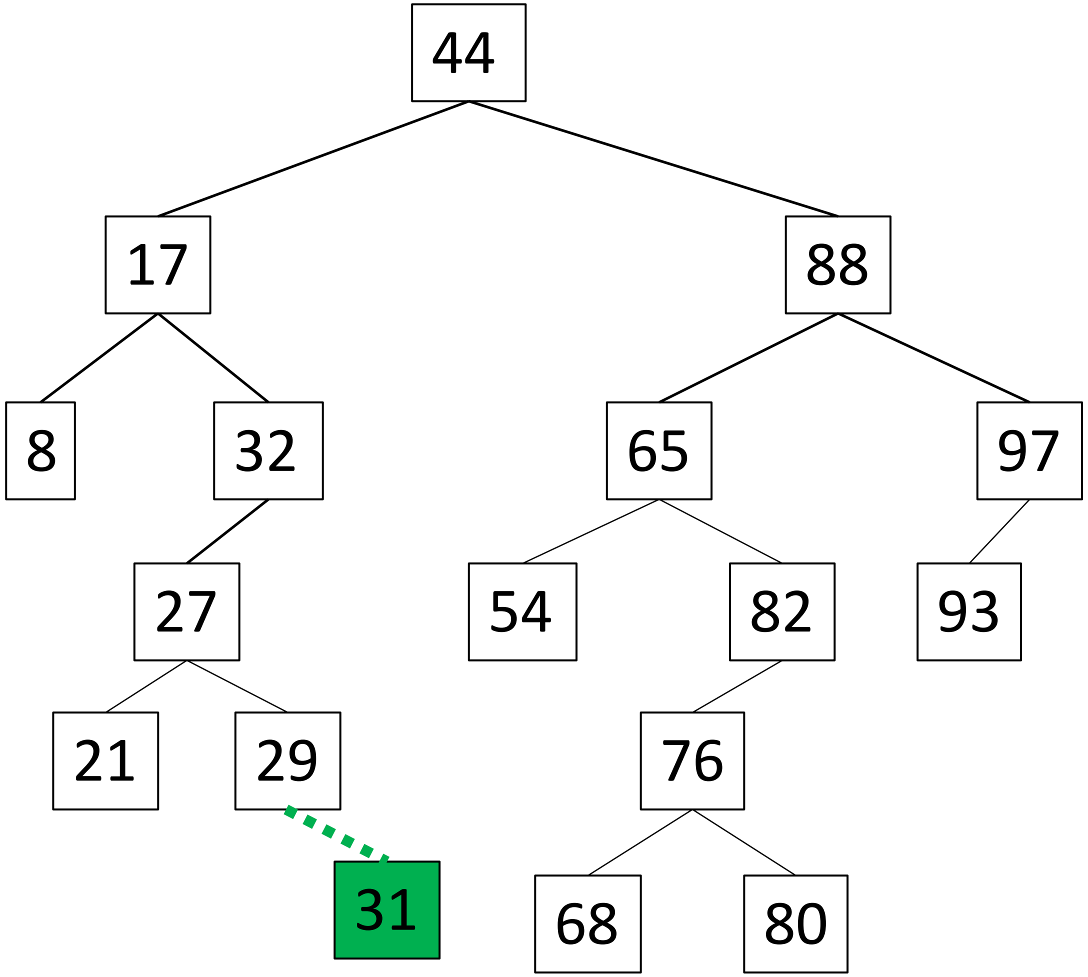

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```
insert(95);
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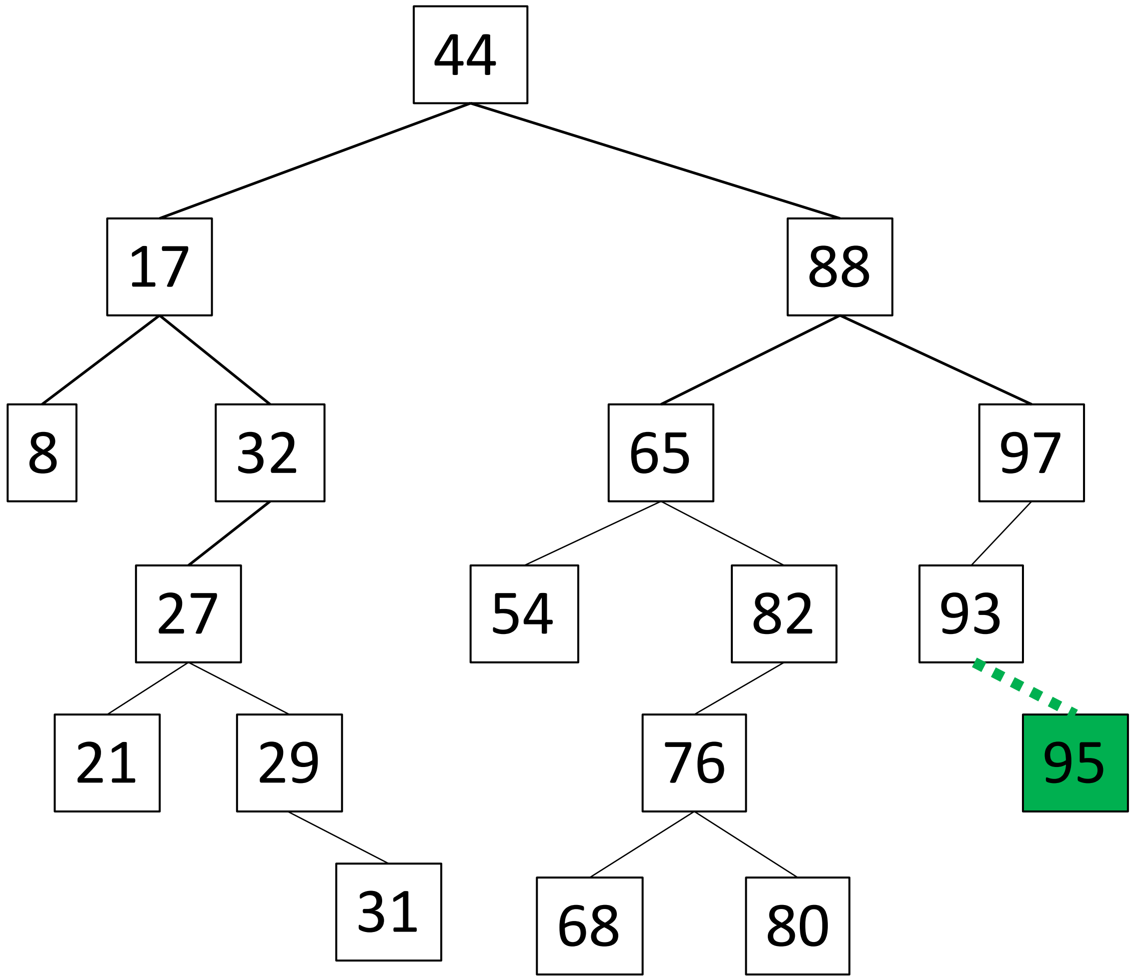

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```
insert(95);
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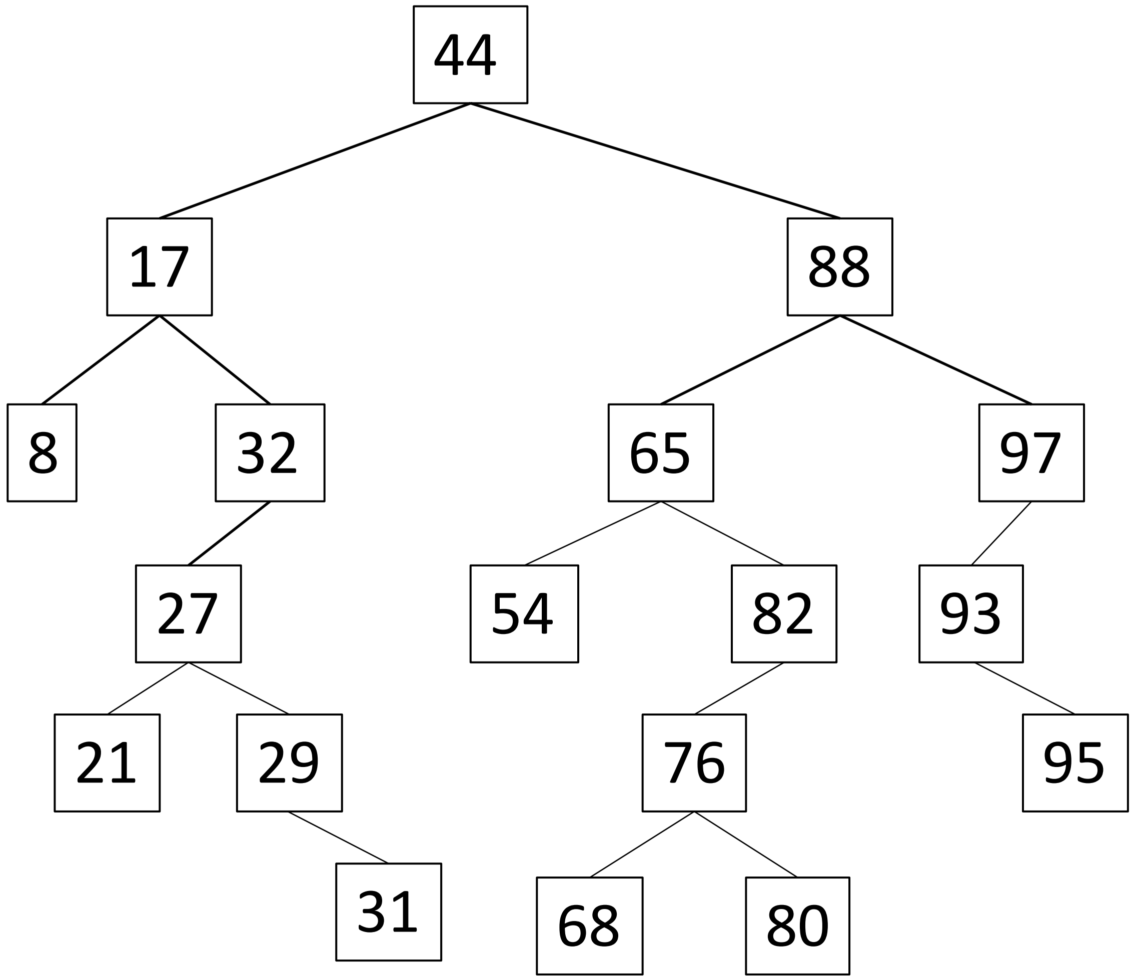
Step 1: Find where it should go.

Step 2: Modify pointers.

Any trends??



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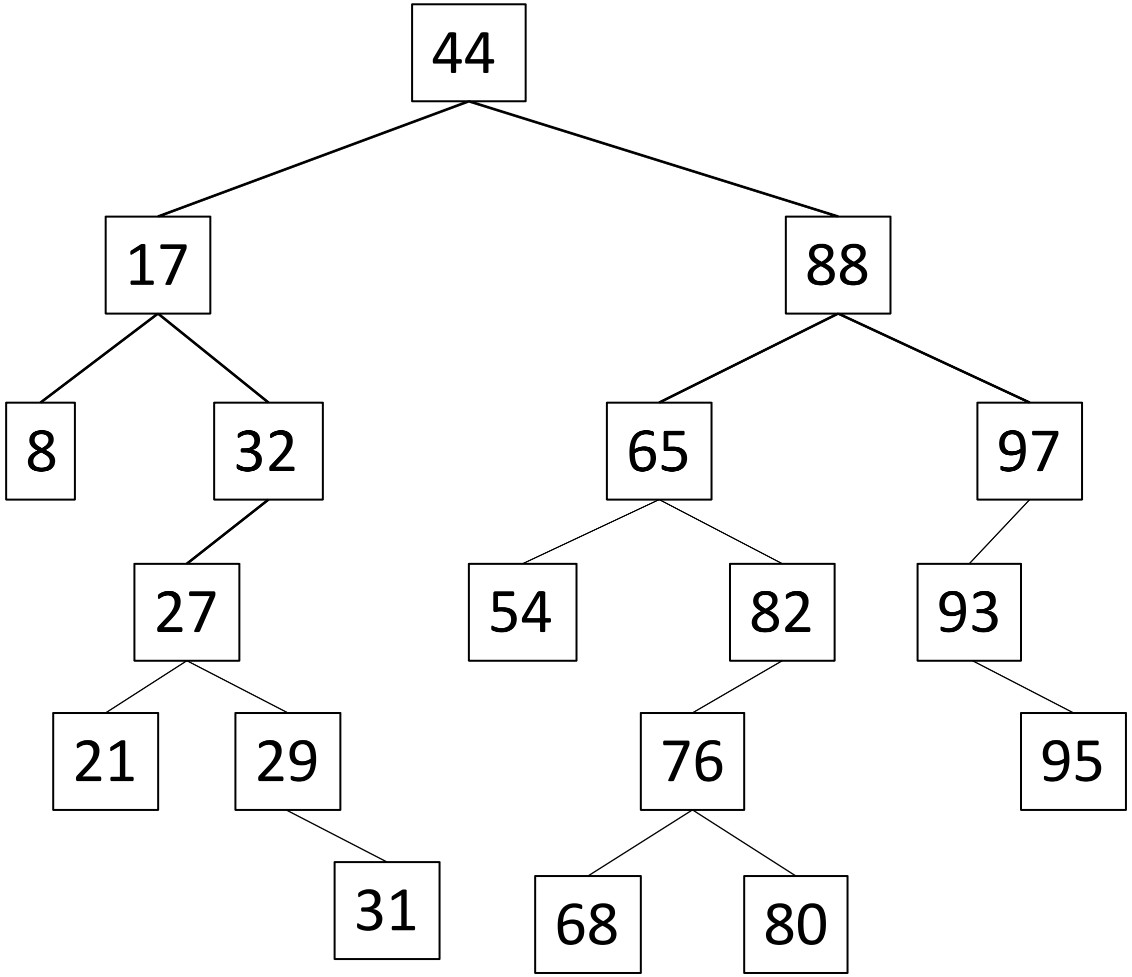
insert(95);
```

Step 1: Find where it should go.

Step 2: Modify pointers.

Any trends??

Always insert a new leaf!



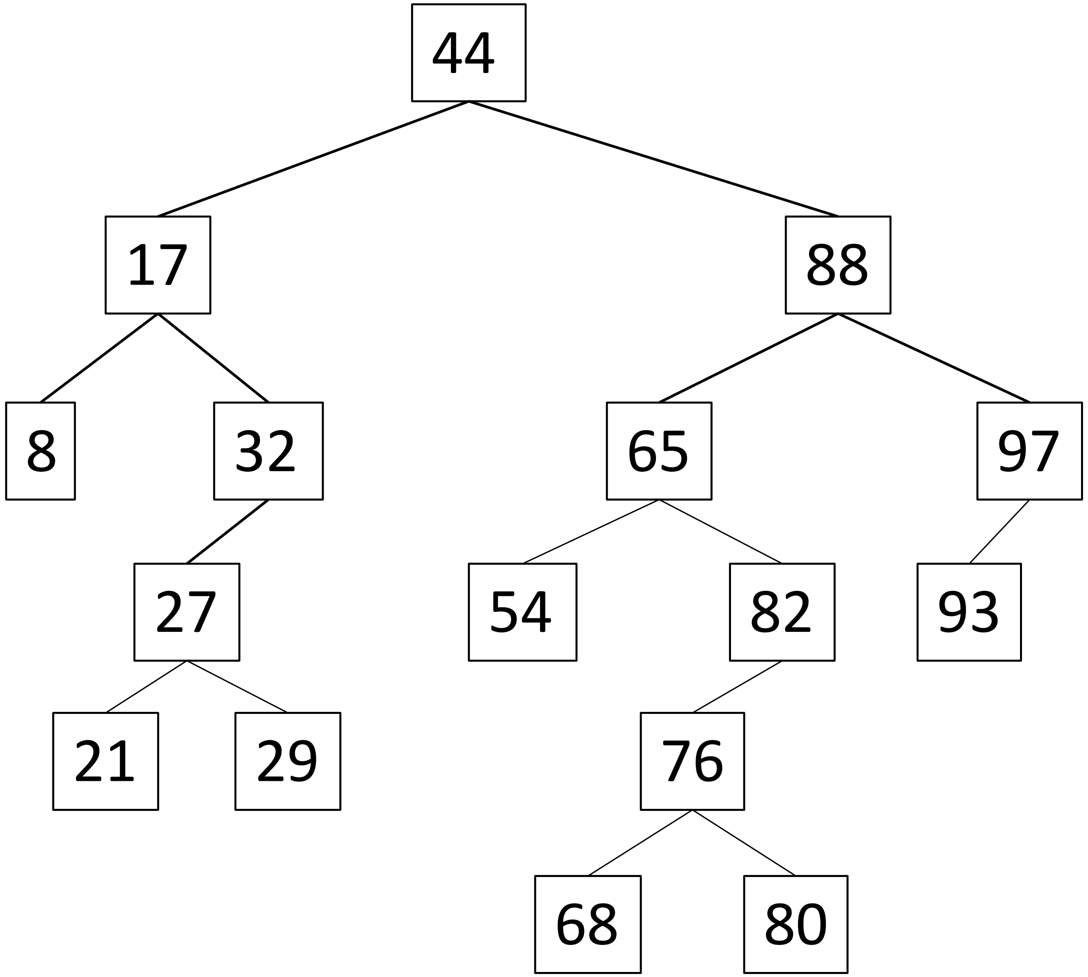
Binary Search Tree - Insertion

insert(28);

```
public void insert(int newValue) {




}
```



Binary Search Tree - Insertion

insert(28);

```
public void insert(int newValue) {
  if (root == null) {

  } else {











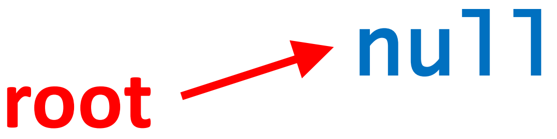









}
```



Binary Search Tree - Insertion

insert(28);

```
public void insert(int newValue) {
  if (root == null) {
    root = new Node(newValue);
  } else {











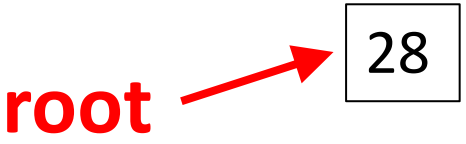









}
```



Binary Search Tree - Insertion

insert(28);

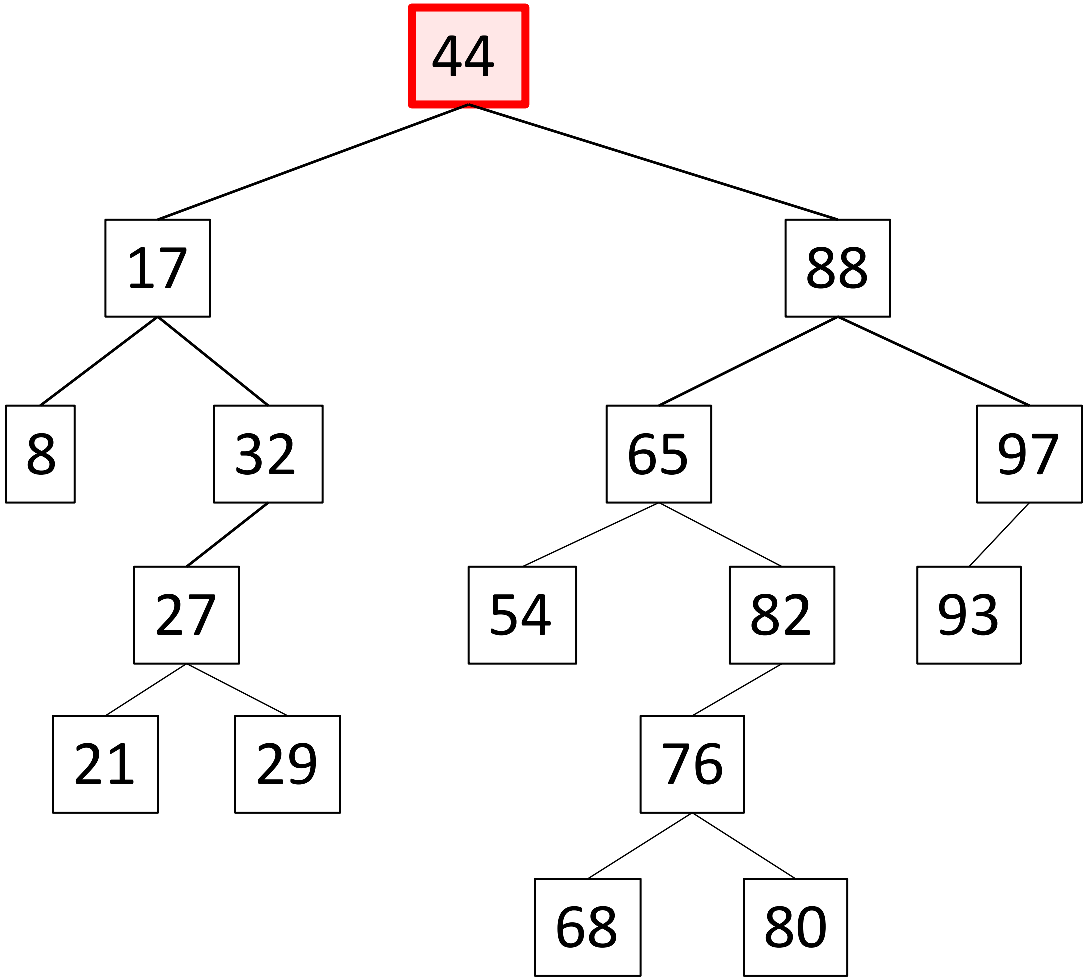
```
public void insert(int newValue) {
  if (root == null) {
    root = new Node(newValue);
  } else {
    Node currentNode = root;







}
```



Binary Search Tree - Insertion

insert(28);

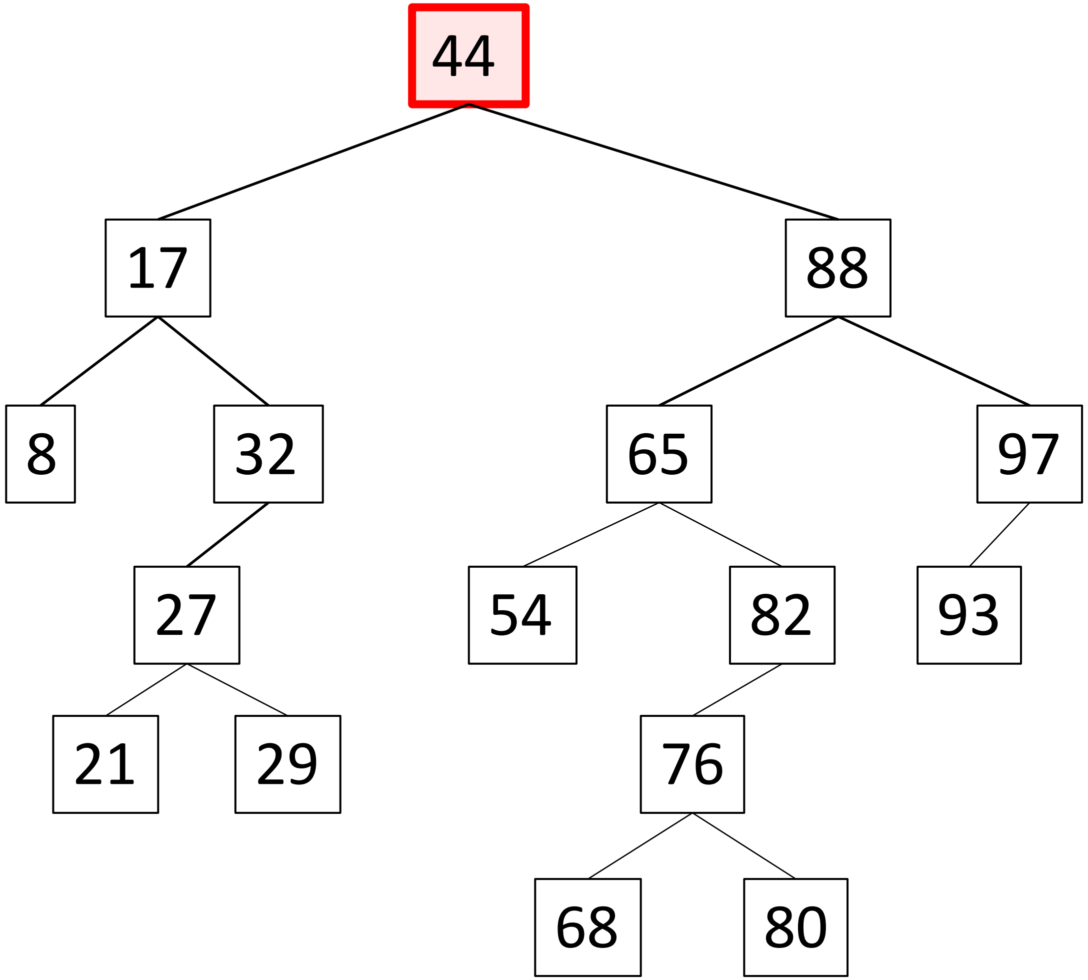
```
public void insert(int newValue) {
  if (root == null) {
    root = new Node(newValue);
  } else {
    Node currentNode = root;
    boolean placed = false;







}
```



Binary Search Tree - Insertion

insert(28);

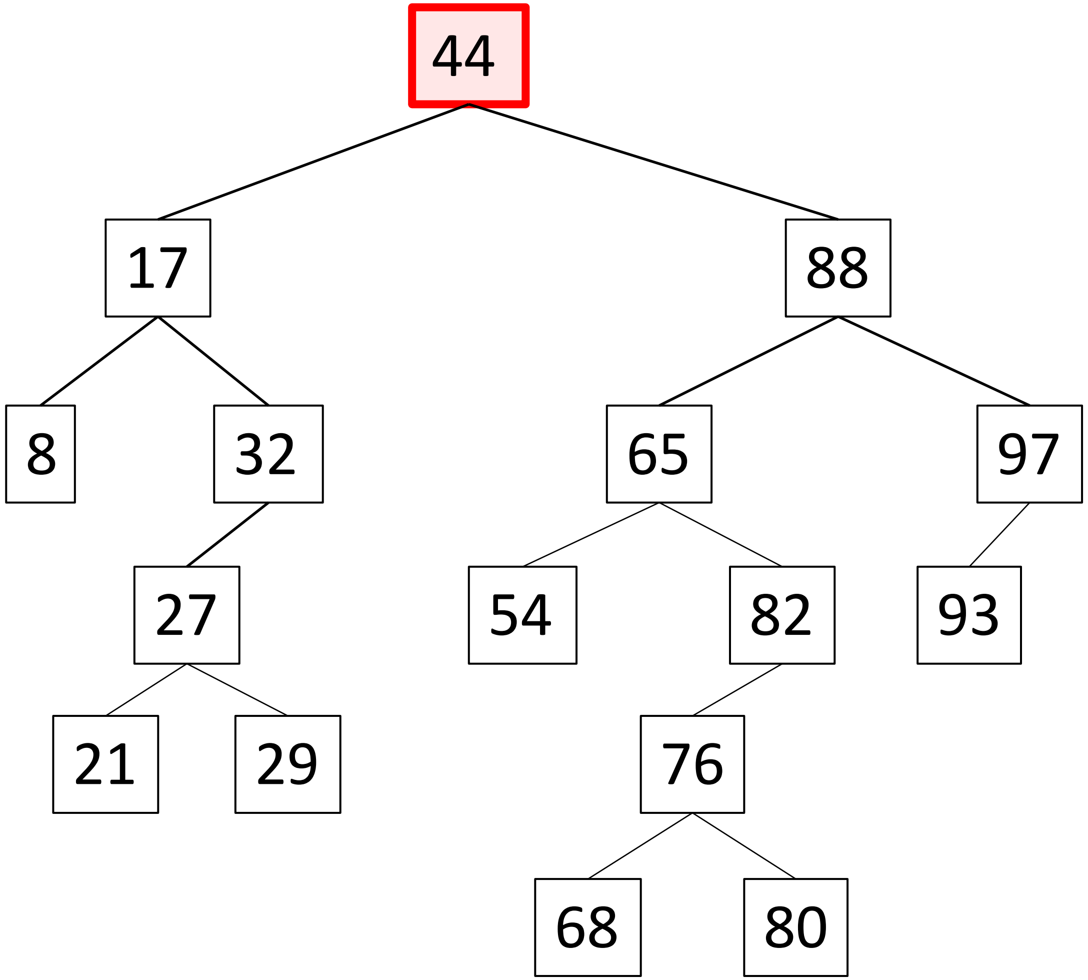
```
public void insert(int newValue) {
  if (root == null) {
    root = new Node(newValue);
  } else {
    Node currentNode = root;
    boolean placed = false;
    while (!placed) {








}
```



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public void insert(int newValue) {
  if (root == null) {
    root = new Node(newValue);
  } else {
    Node currentNode = root;
    boolean placed = false;
    while (!placed) {
      if (newValue < currentNode.getValue()) {







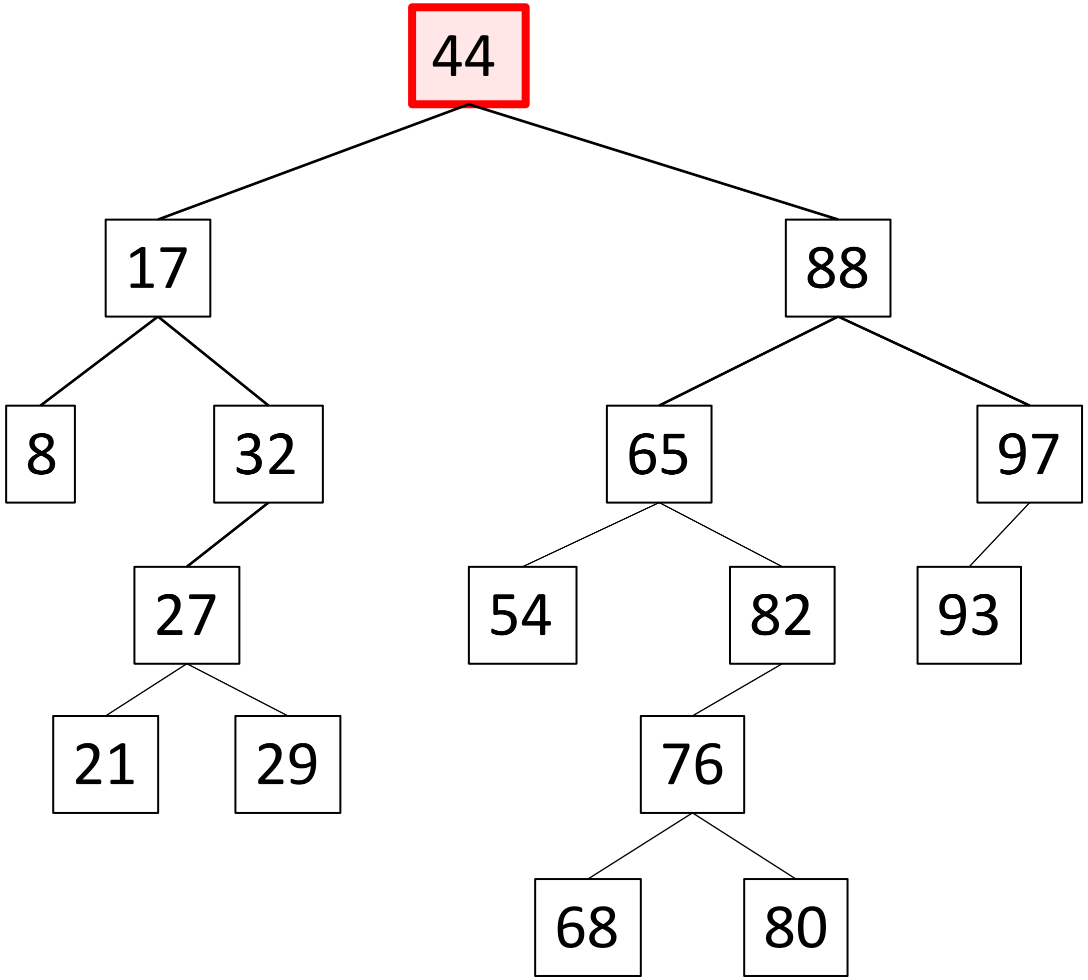
      } else {







}
```



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    while (!placed) {
      if (newValue < currentNode.getValue()) {
        if (currentNode.getLeft() != null) {

        } else {



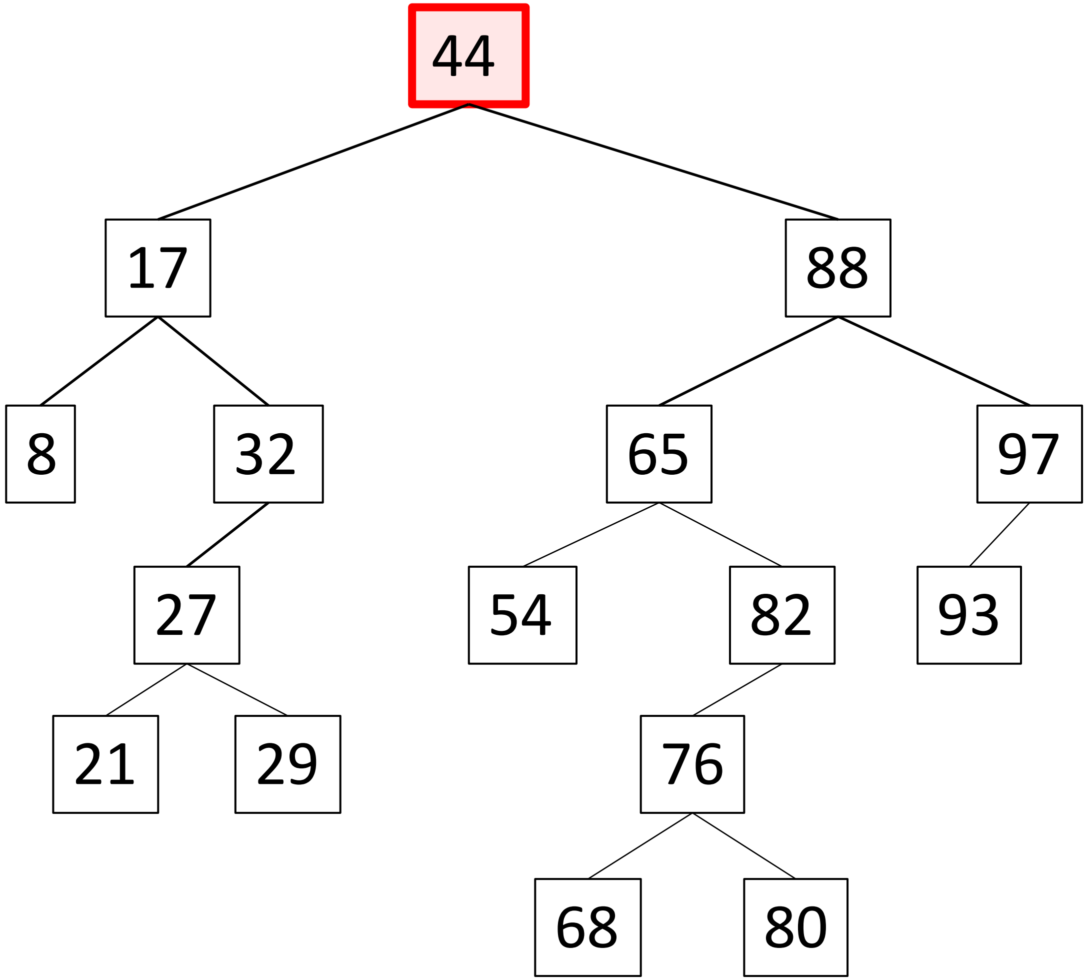
        }
      } else {







}
```



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}
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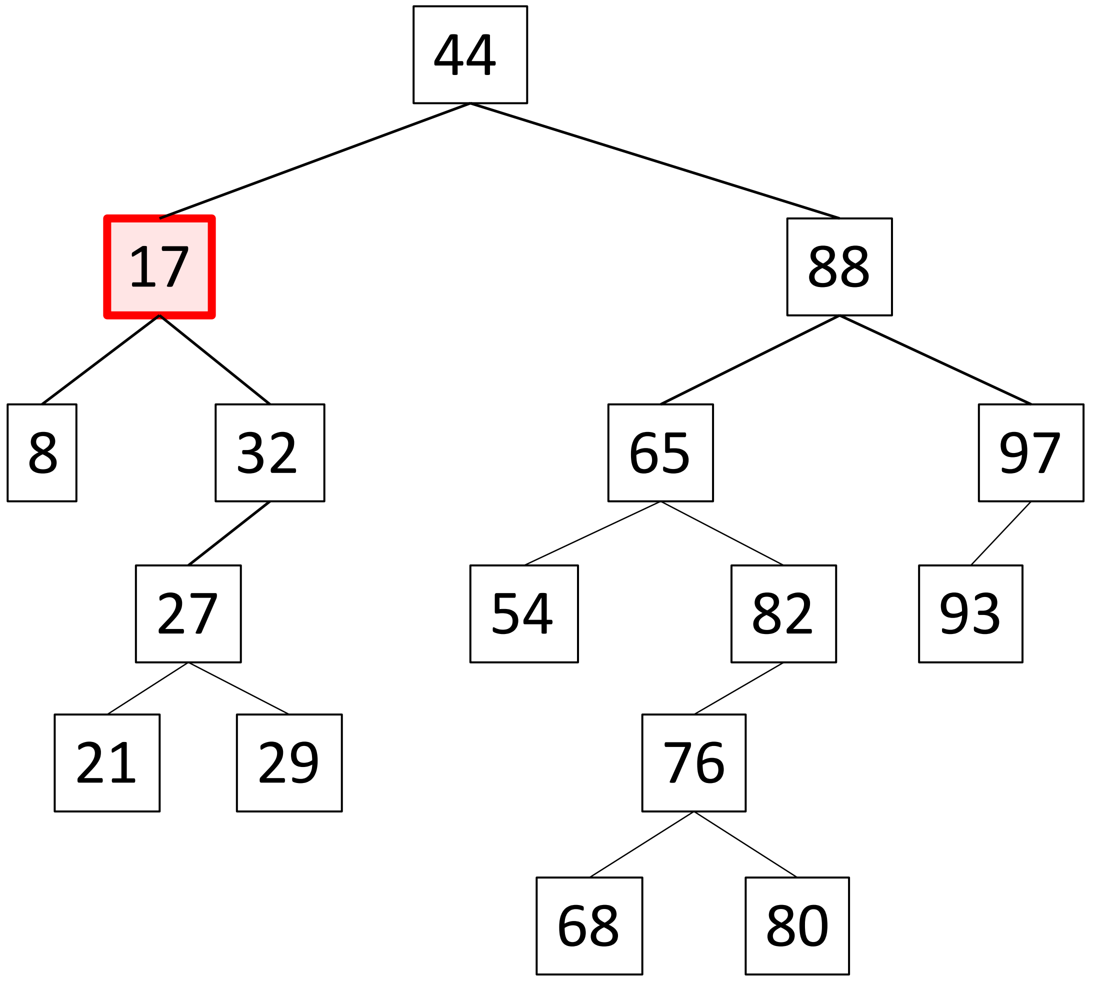

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          currentNode = currentNode.getLeft();
        } else {

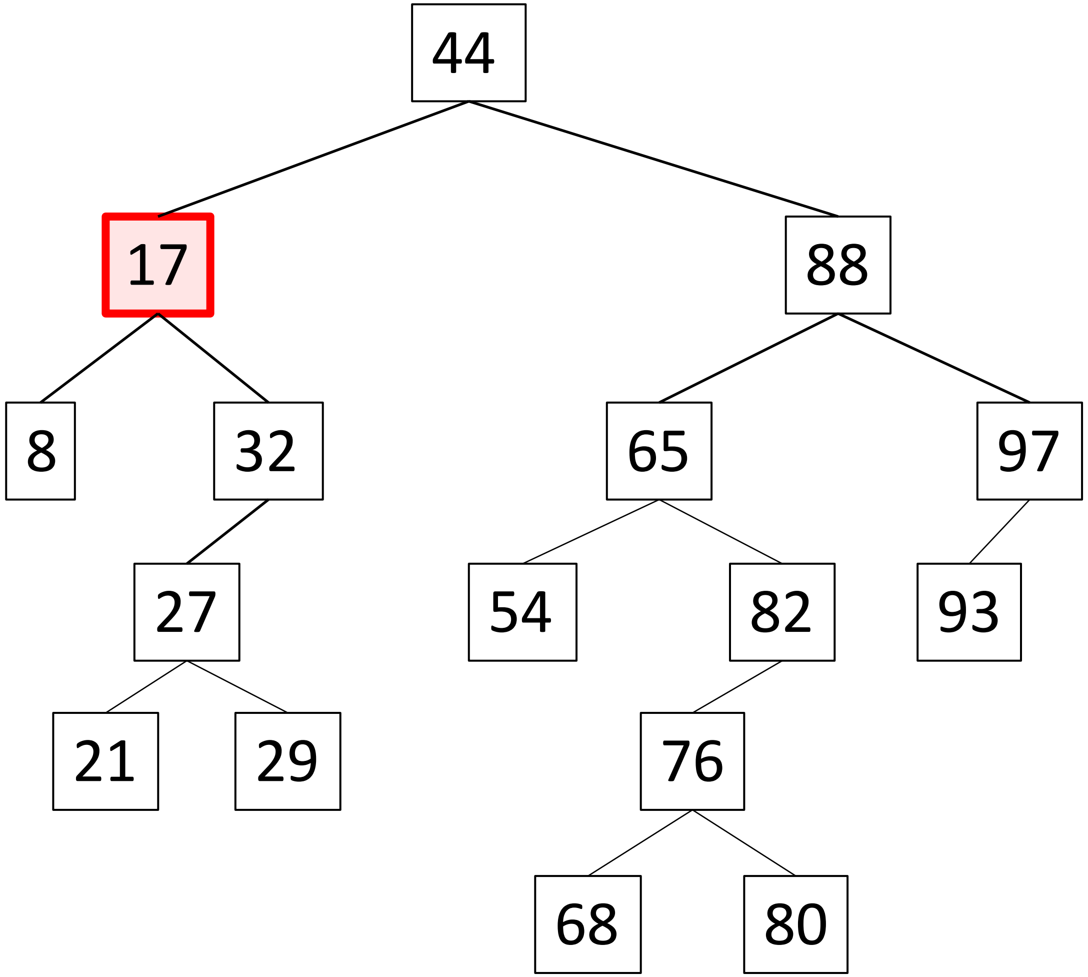


        }
      } else {






}
```



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          currentNode = currentNode.getLeft();
        } else {

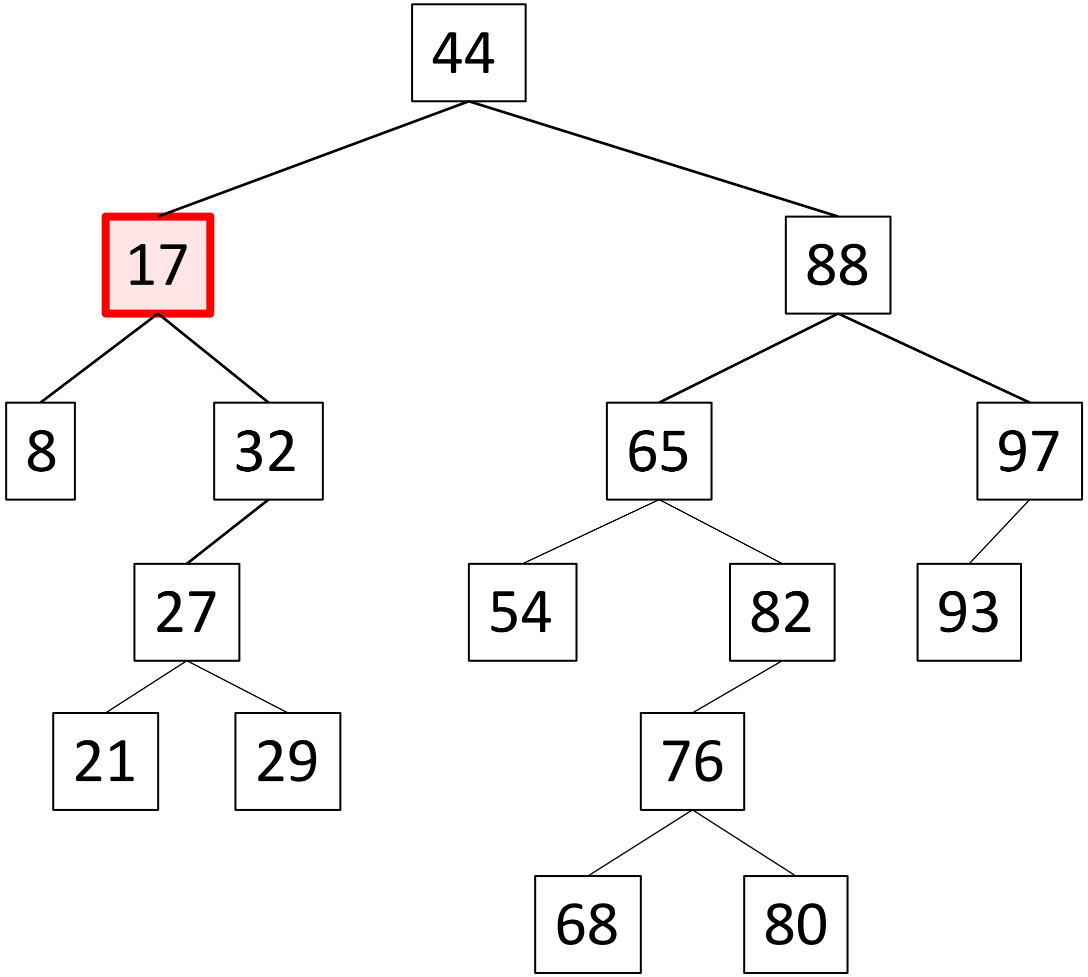


        }
      } else {






}
```



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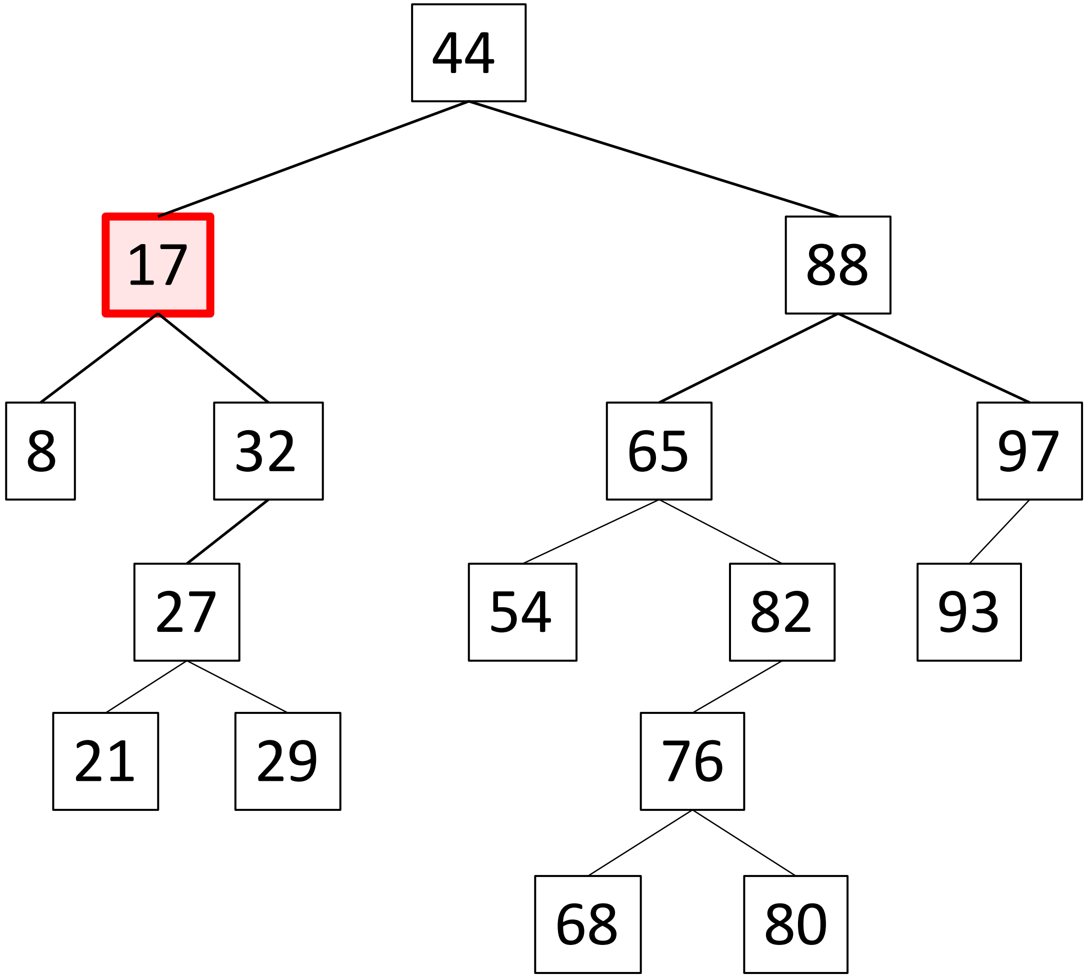
          currentNode = currentNode.getLeft();
        } else {



        }
      } else {




}
```



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    while (!placed) {
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          currentNode = currentNode.getLeft();
        } else {

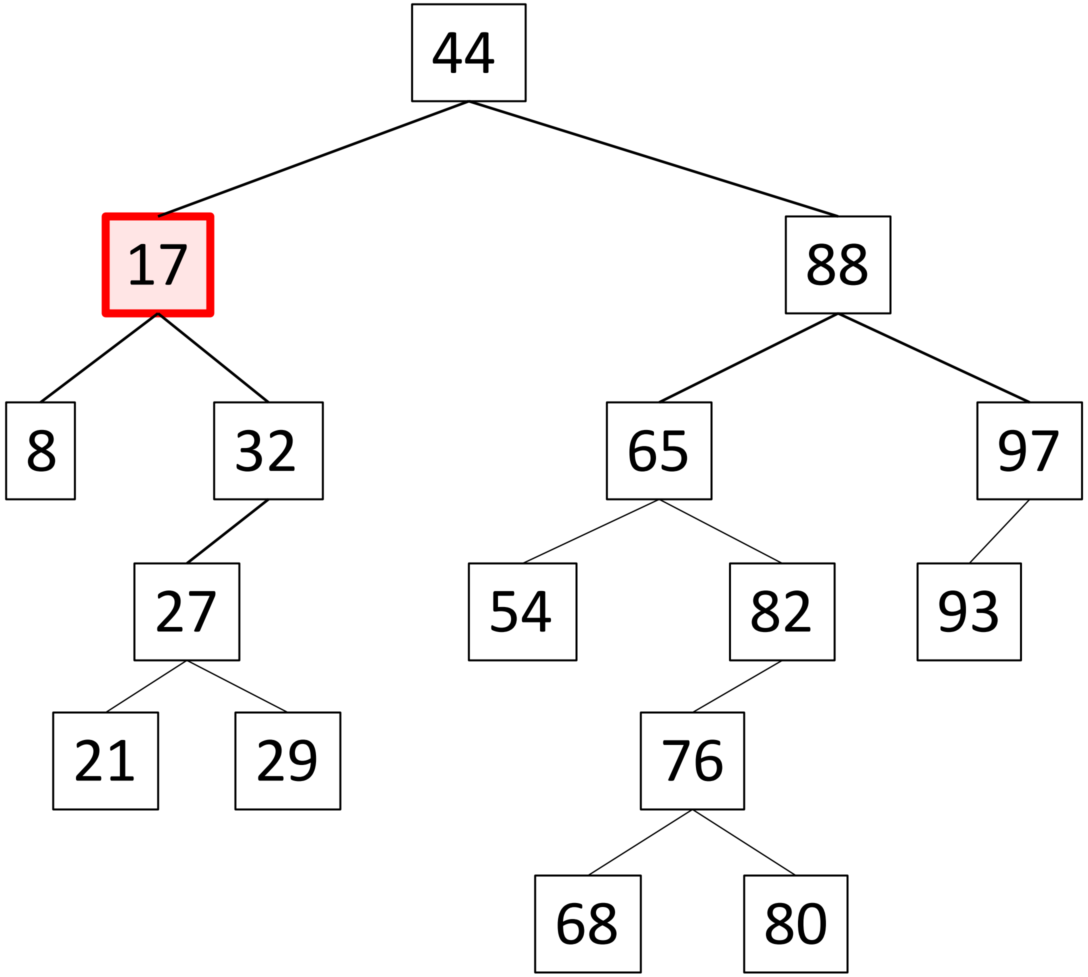


        }
      } else {
        if (currentNode.getRight() != null) {

        } else {



}
```



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        } else {




}
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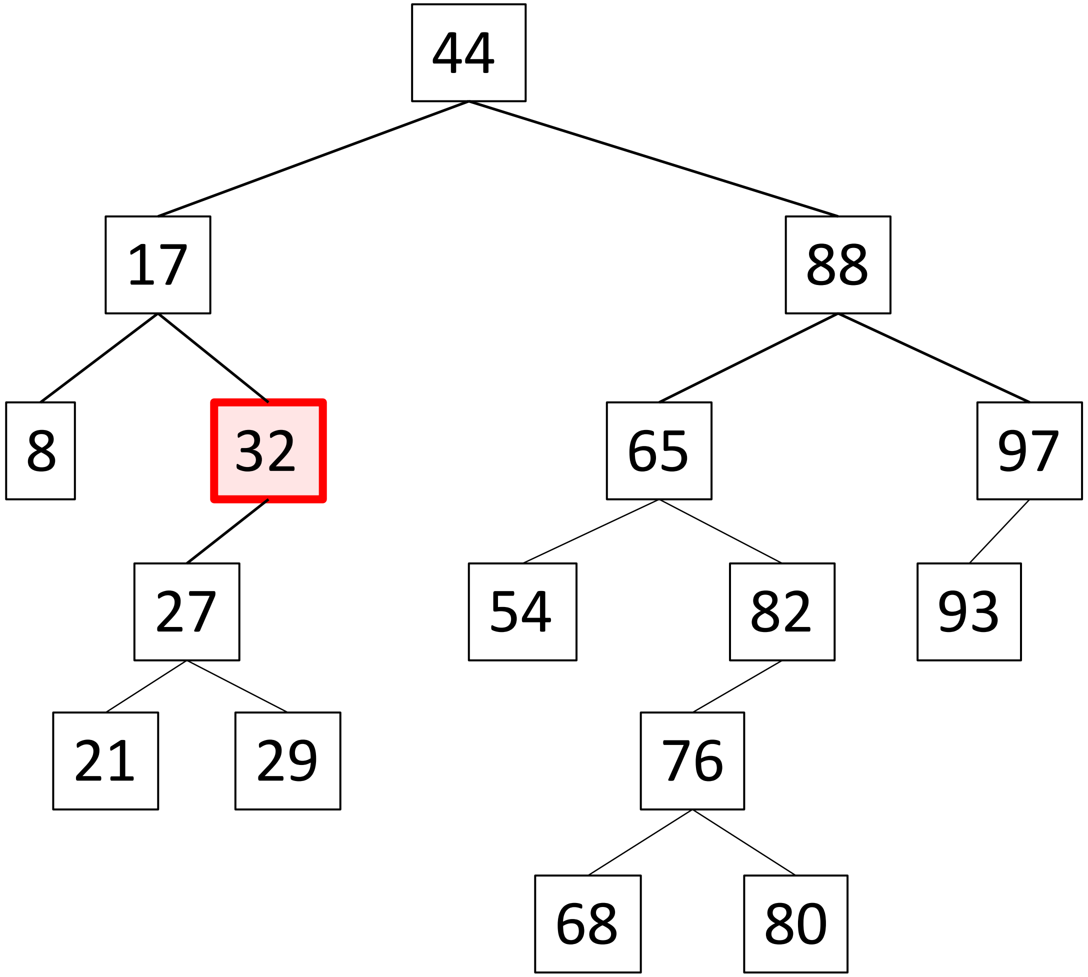

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        }
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        if (currentNode.getRight() != null) {
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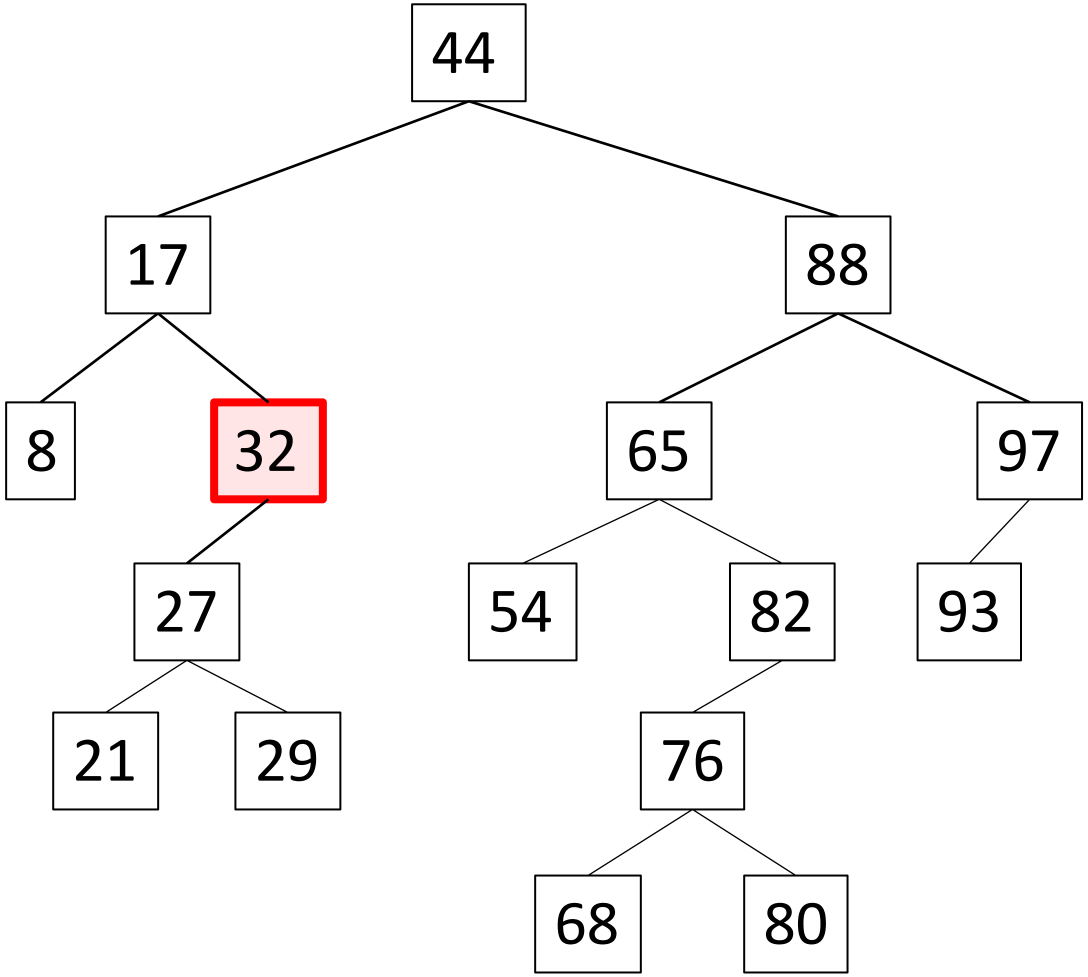
        } else {




}
```



Binary Search Tree - Insertion

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        }
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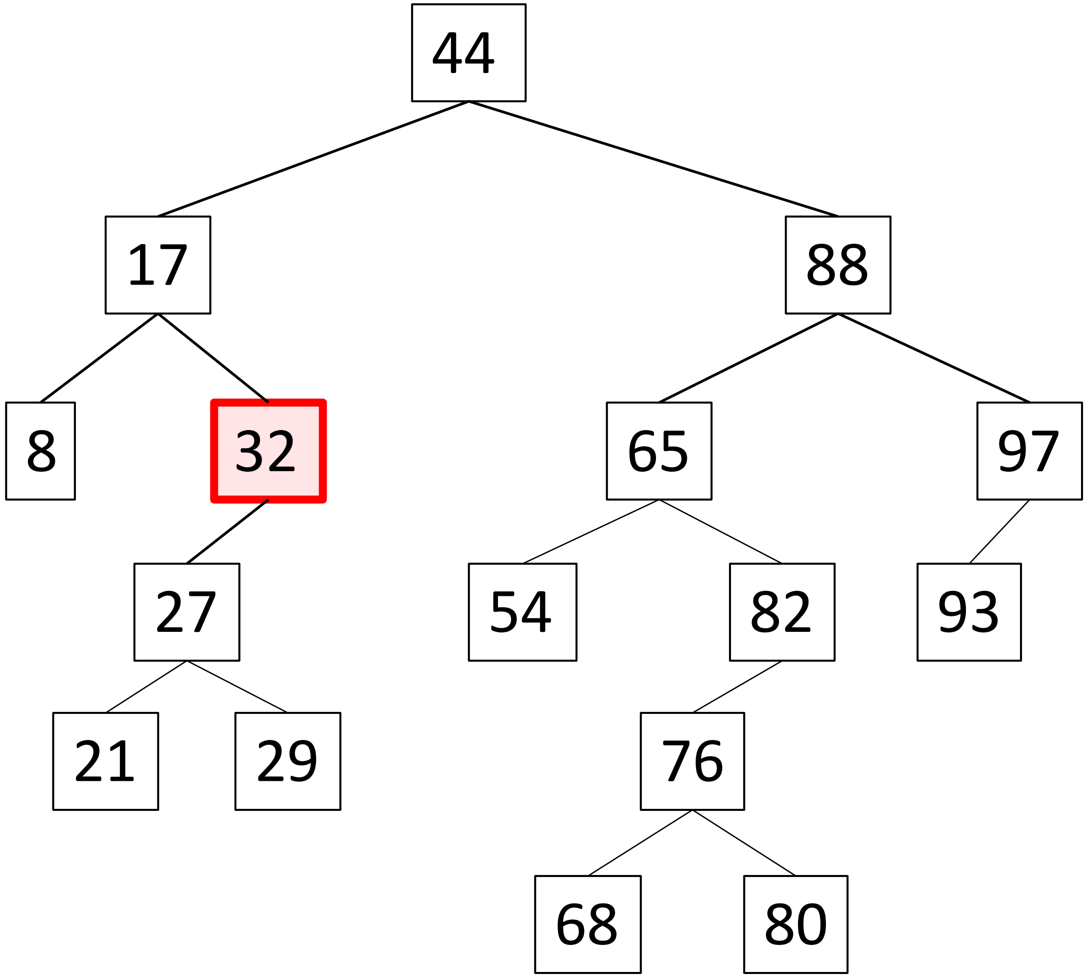
        if (currentNode.getRight() != null) {
          currentNode = currentNode.getRight();
        } else {




}
```



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}
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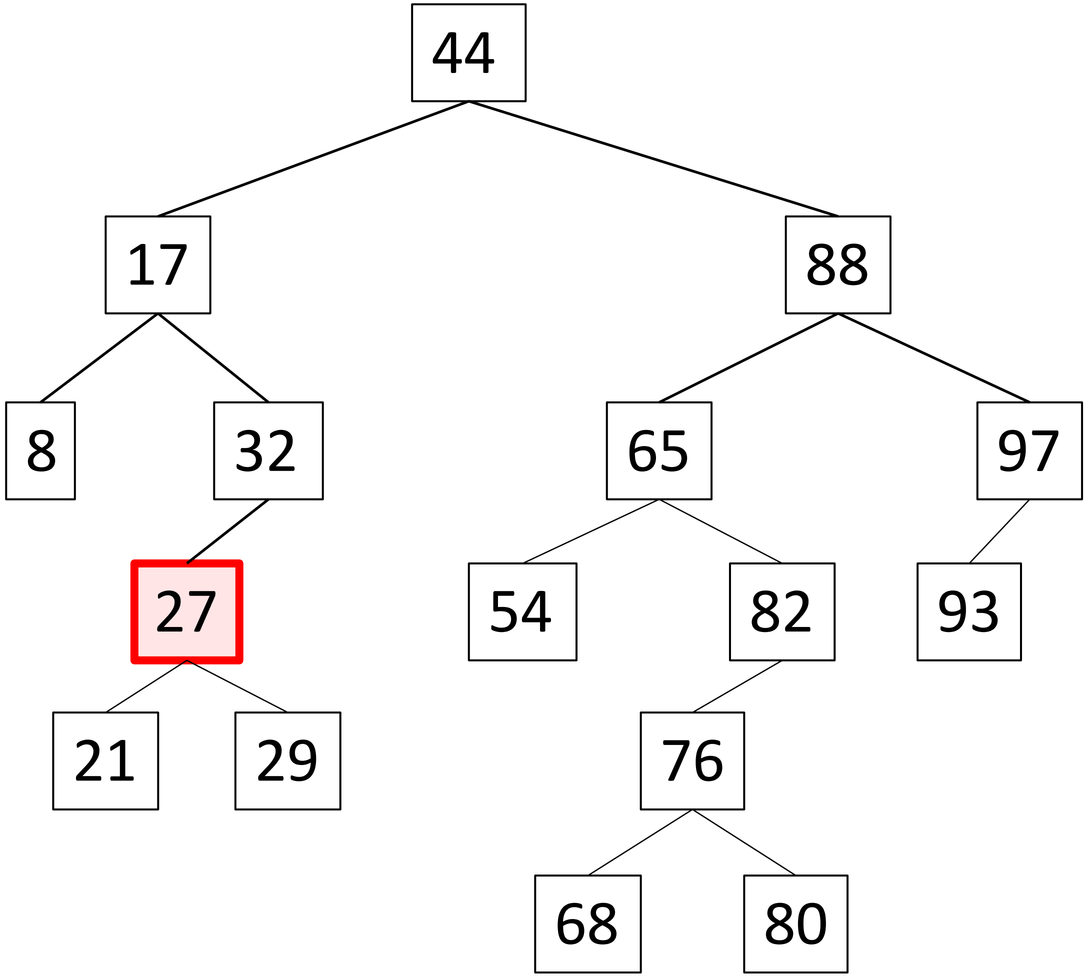

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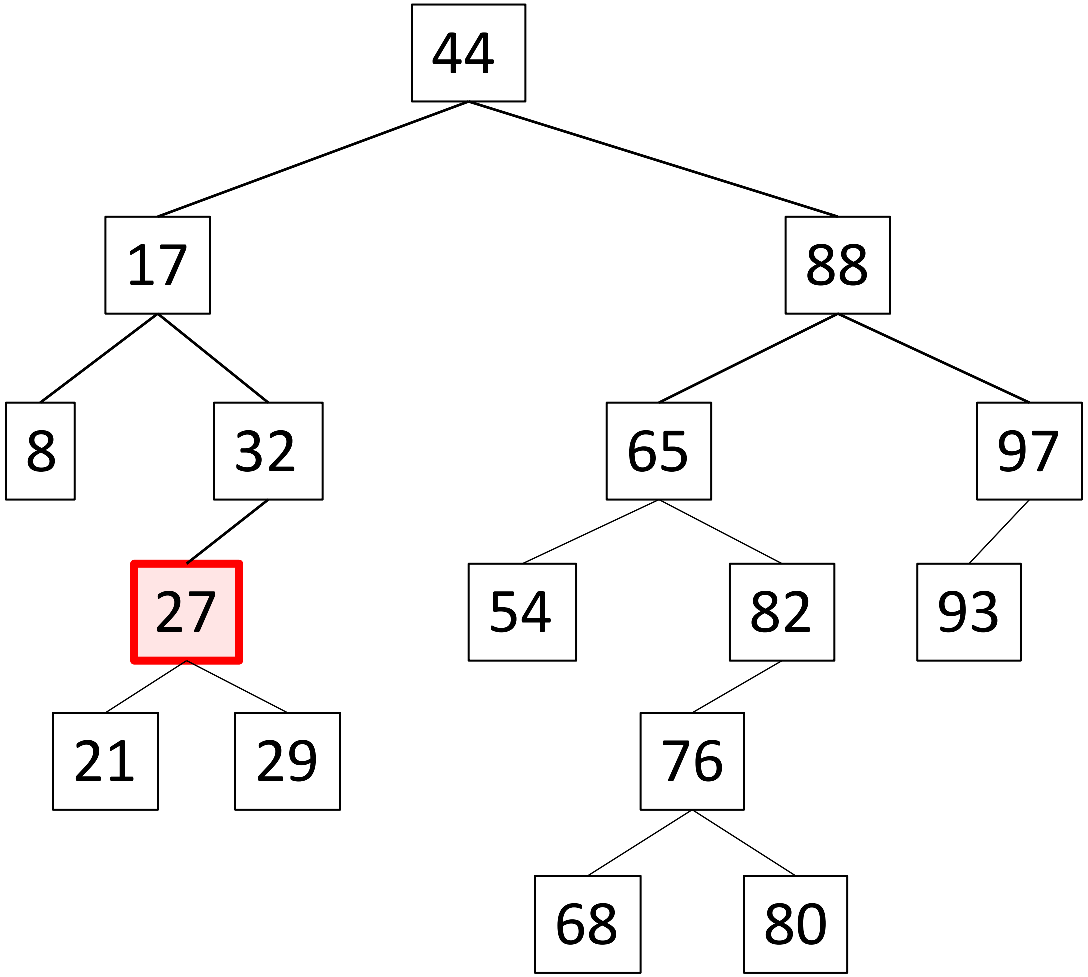

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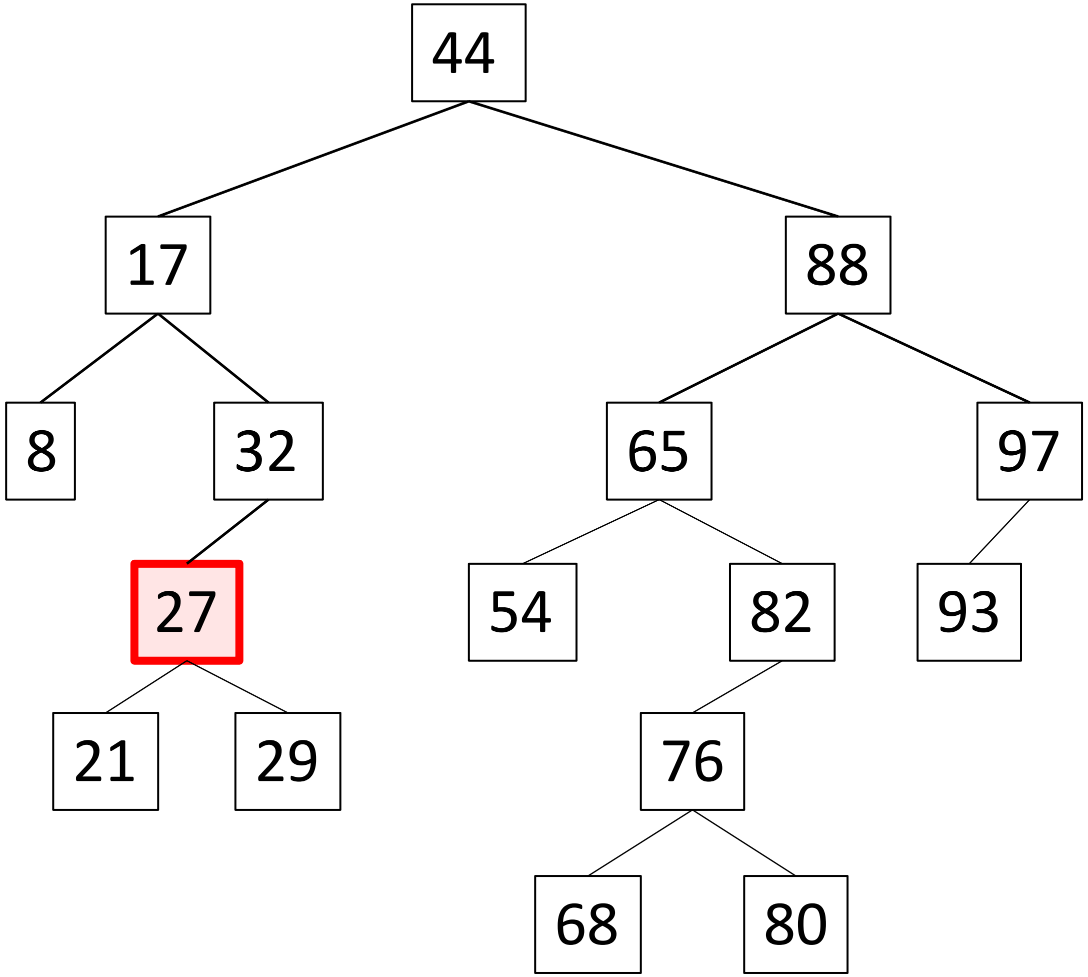

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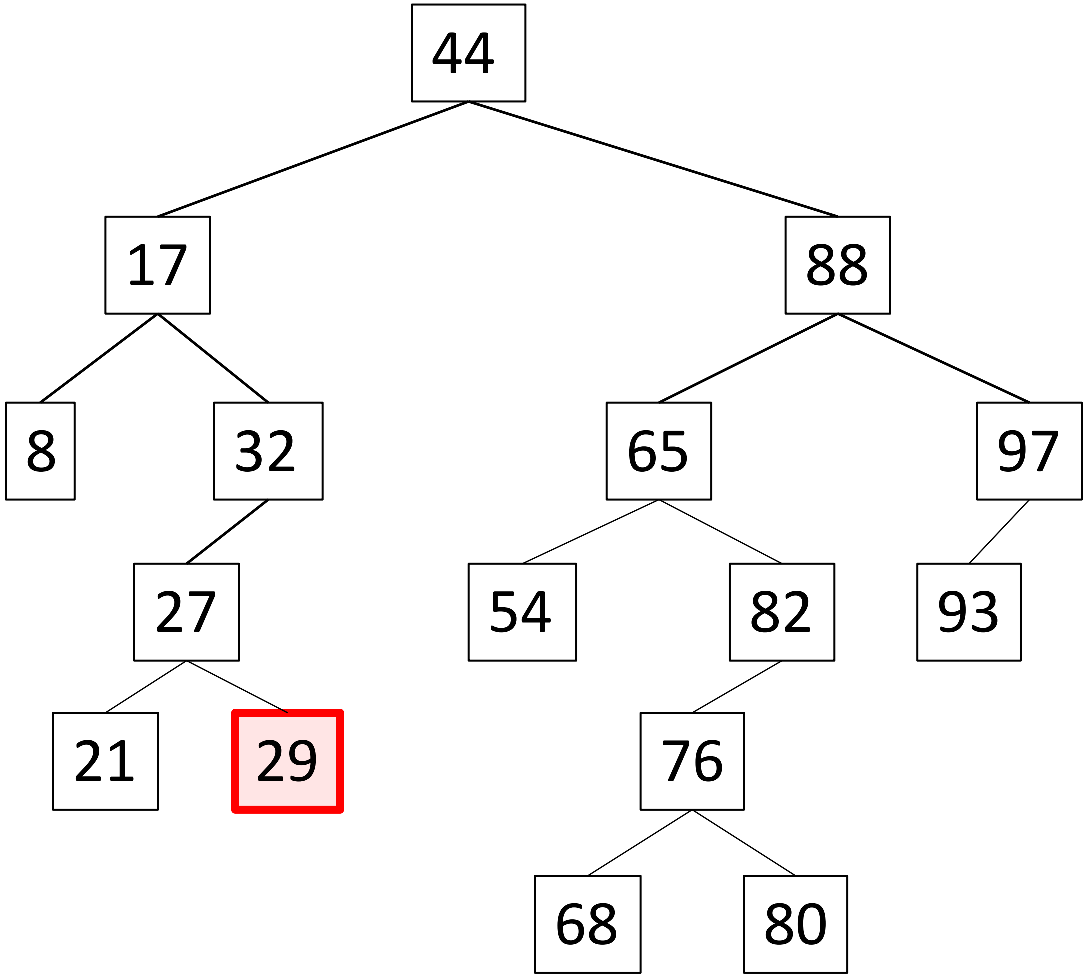

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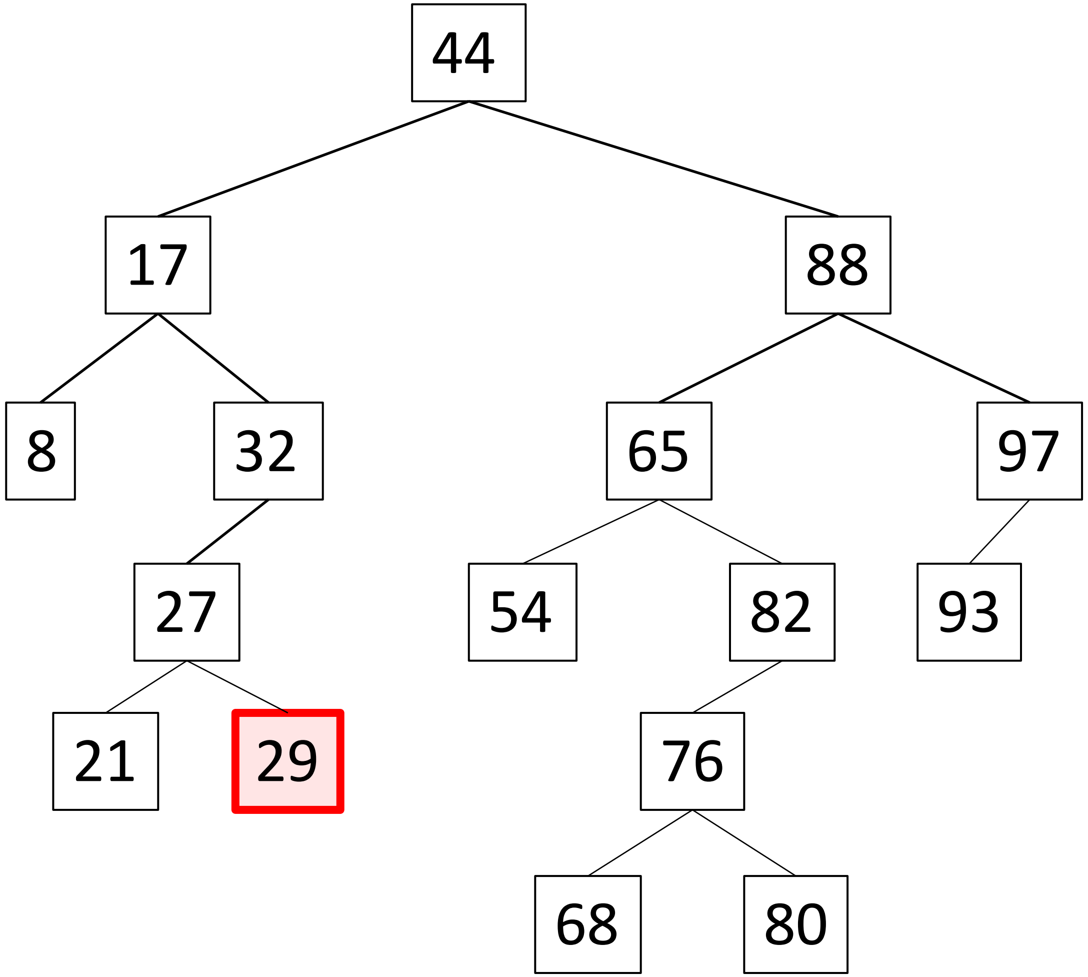

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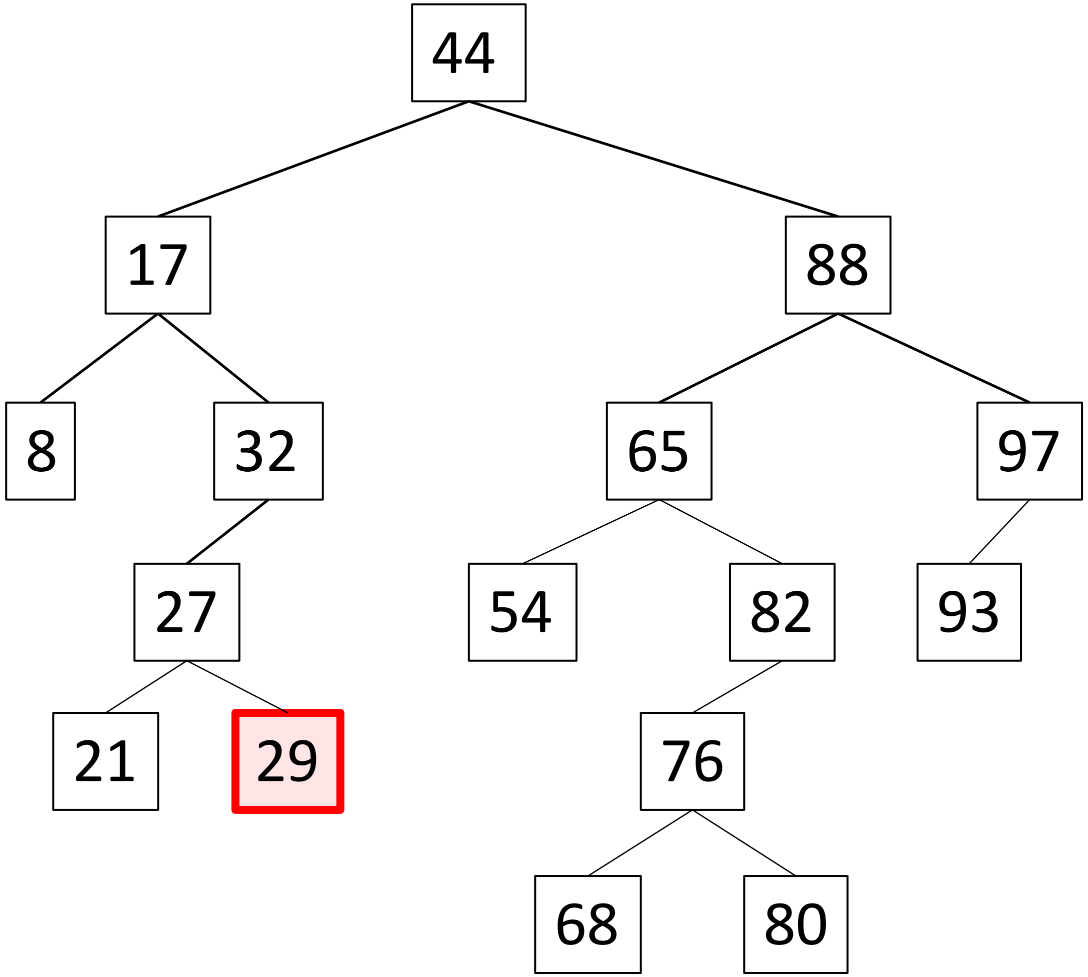

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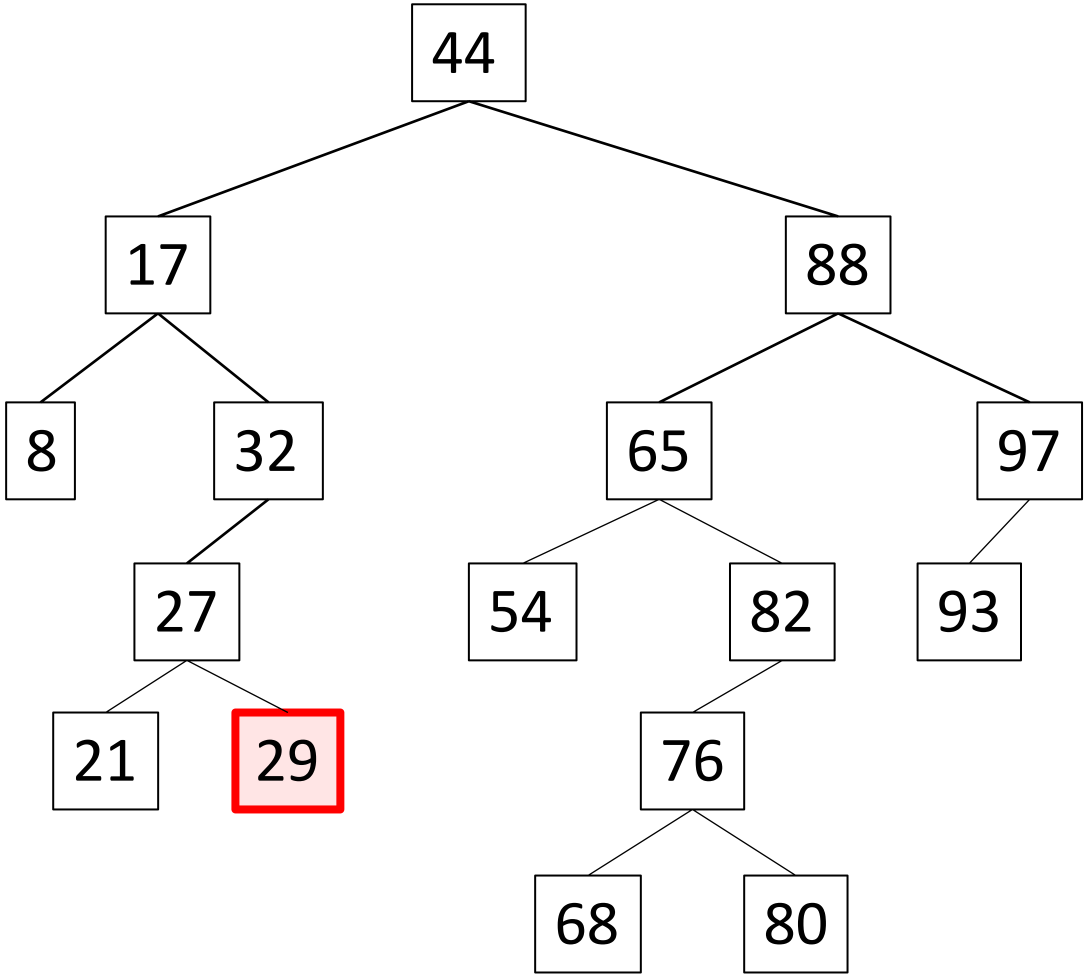

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        if (currentNode.getLeft() != null) {
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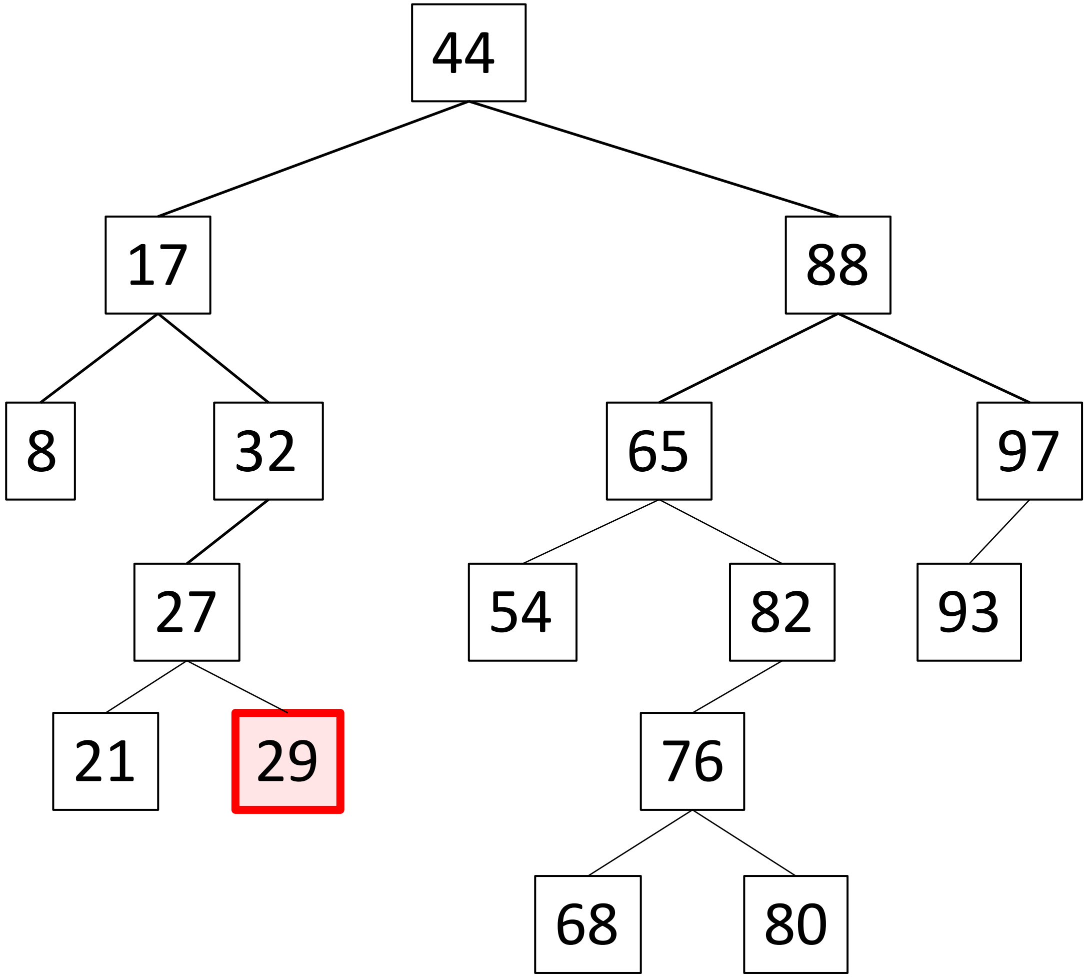

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        if (currentNode.getLeft() != null) {
          currentNode = currentNode.getLeft();
        } else {
          currentNode.setLeft(new Node(newValue));


        }
      } else {
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          currentNode = currentNode.getRight();
        } else {




}
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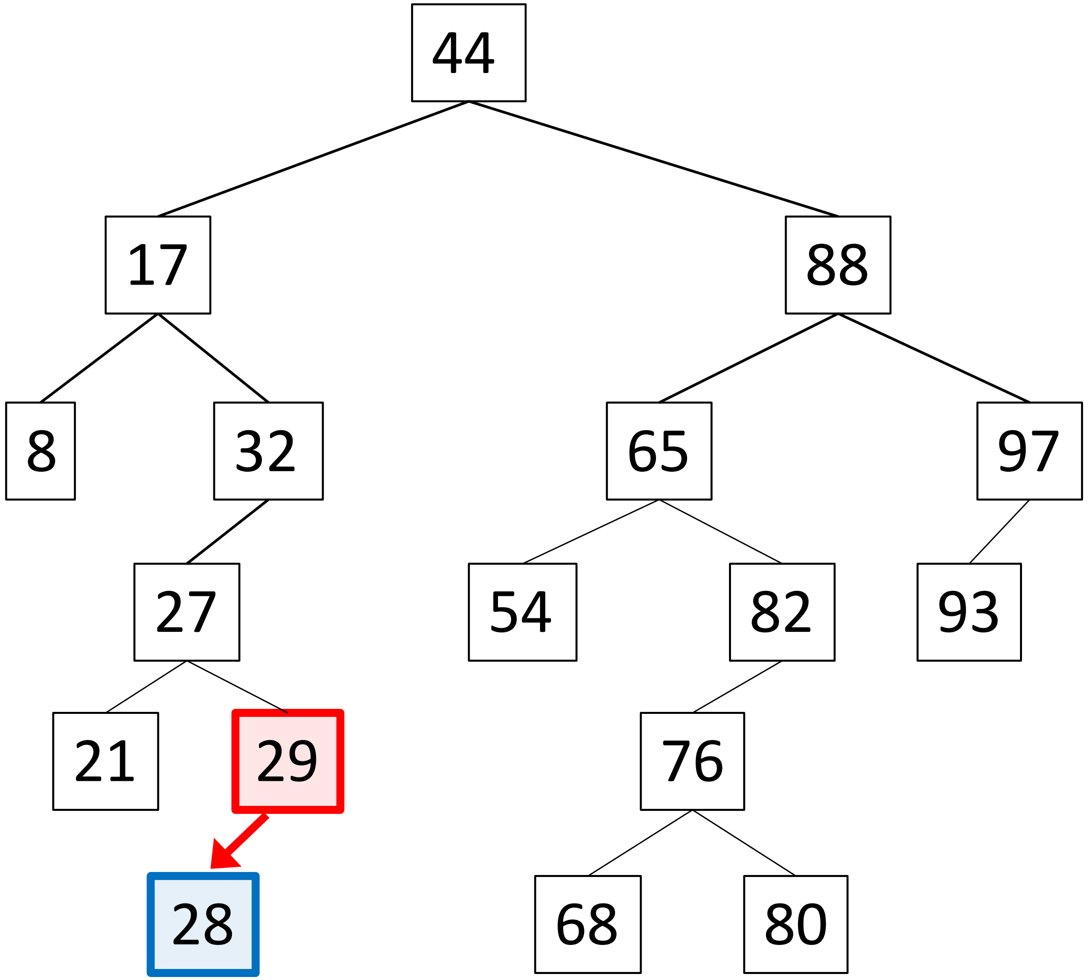

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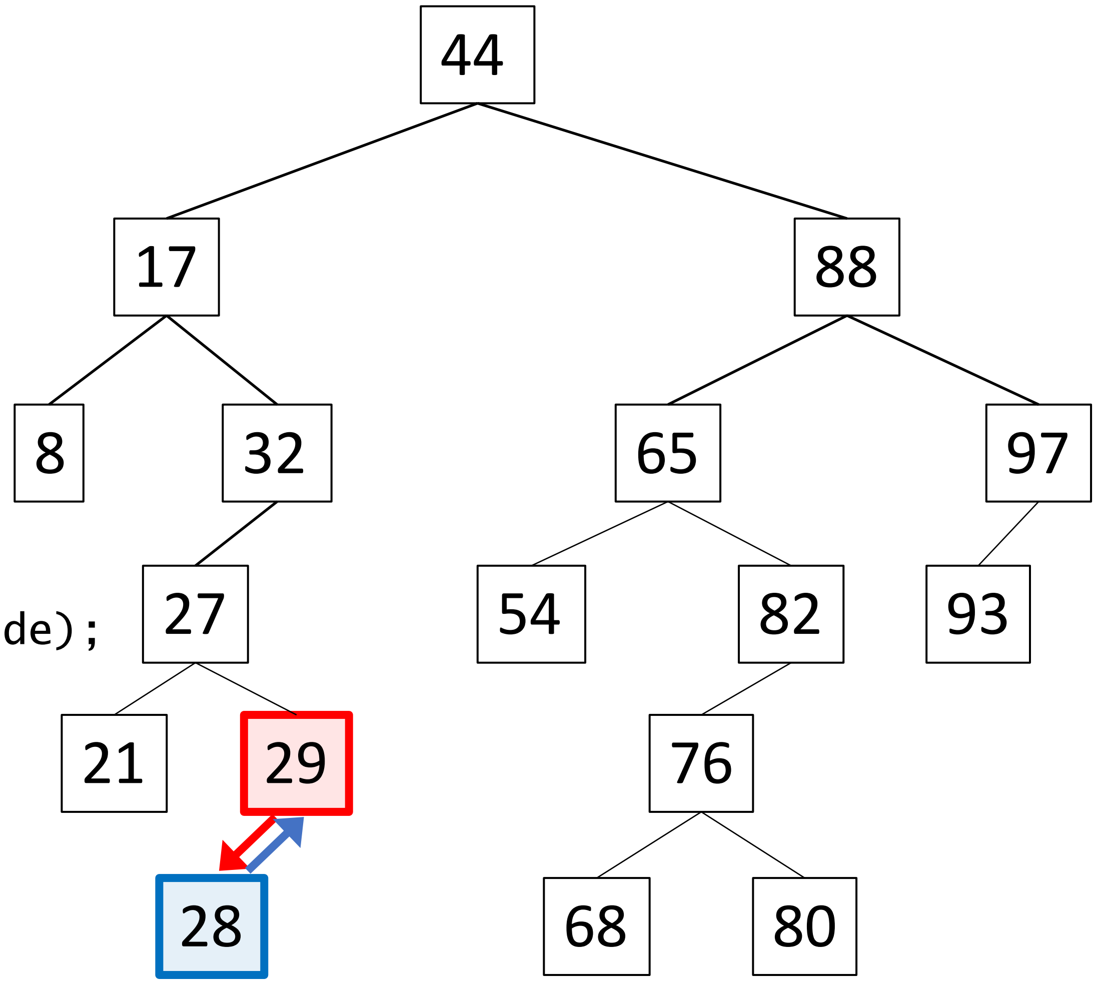

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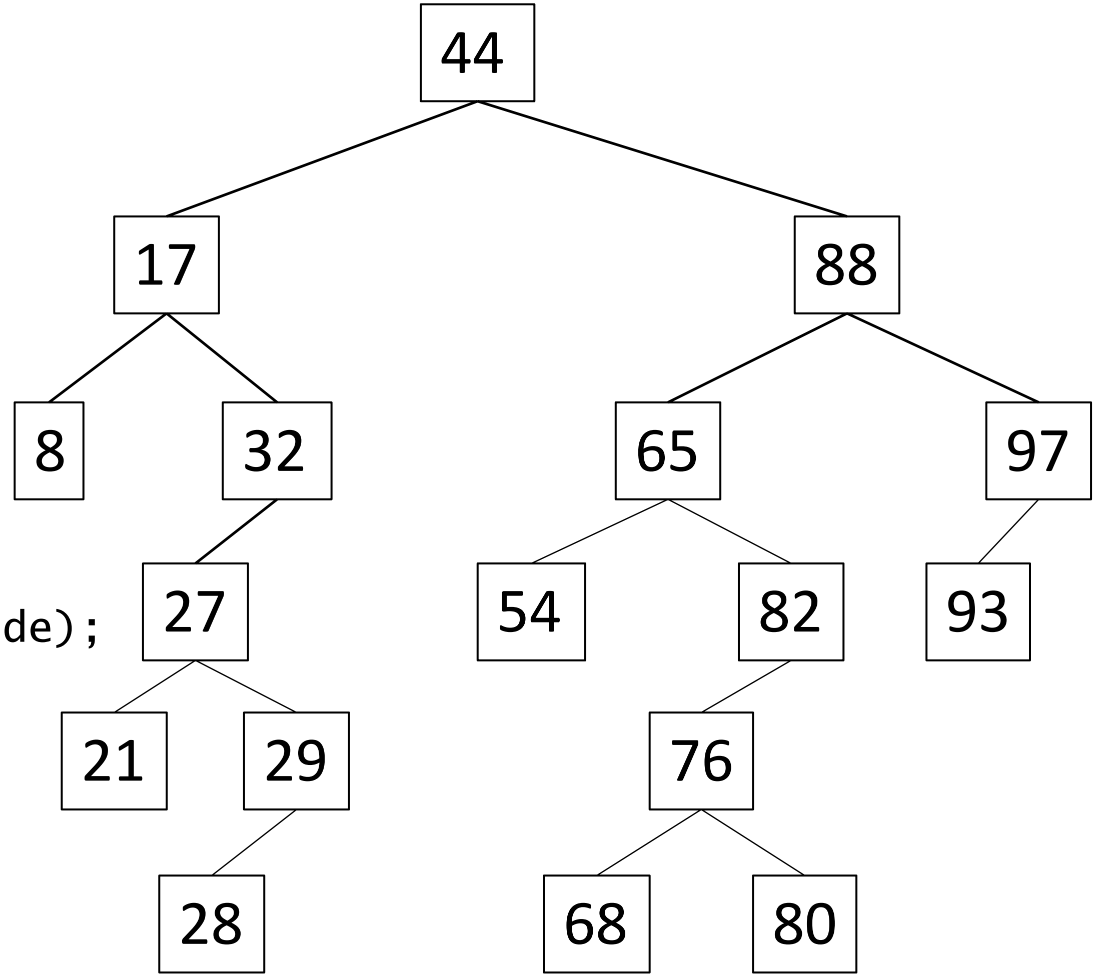

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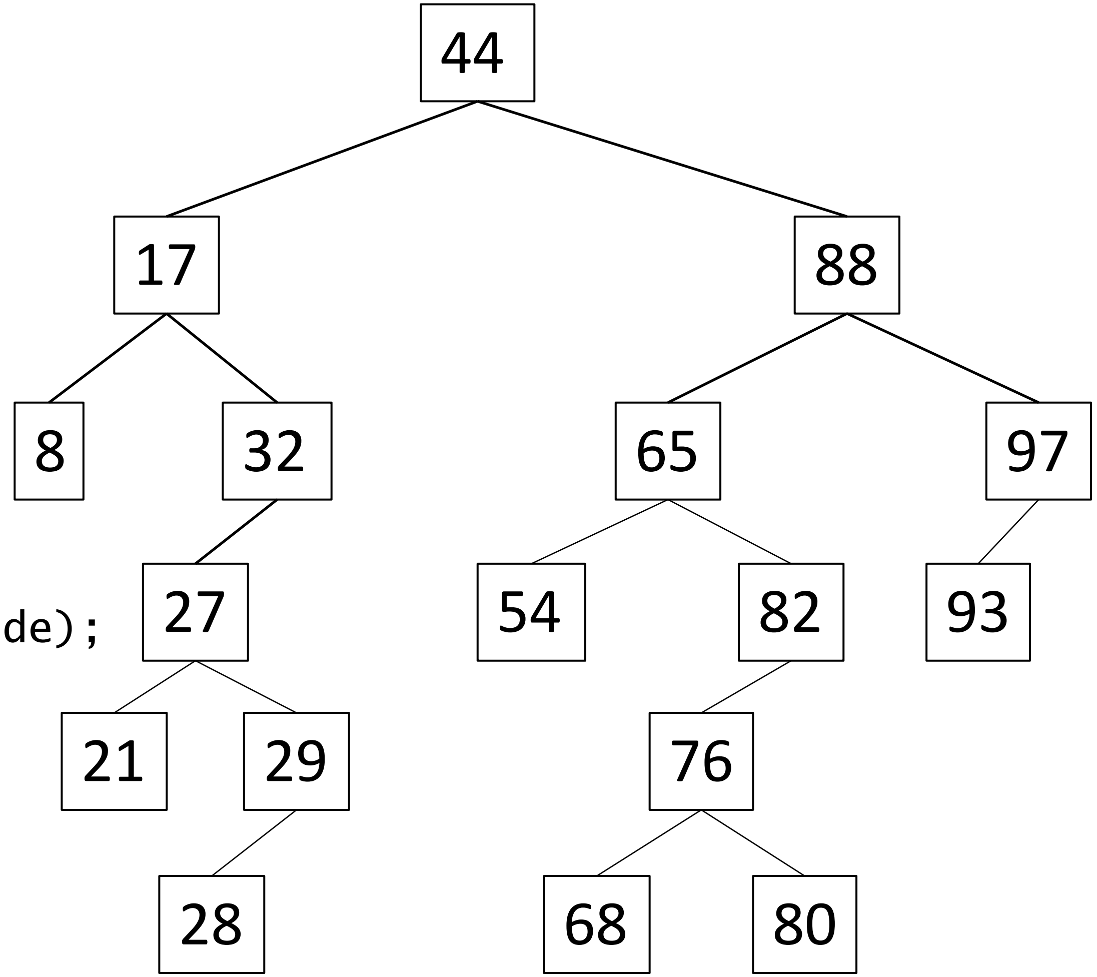

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        }
      } else {
        if (currentNode.getRight() != null) {
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        } else {
          currentNode.setRight(new Node(newValue));


}
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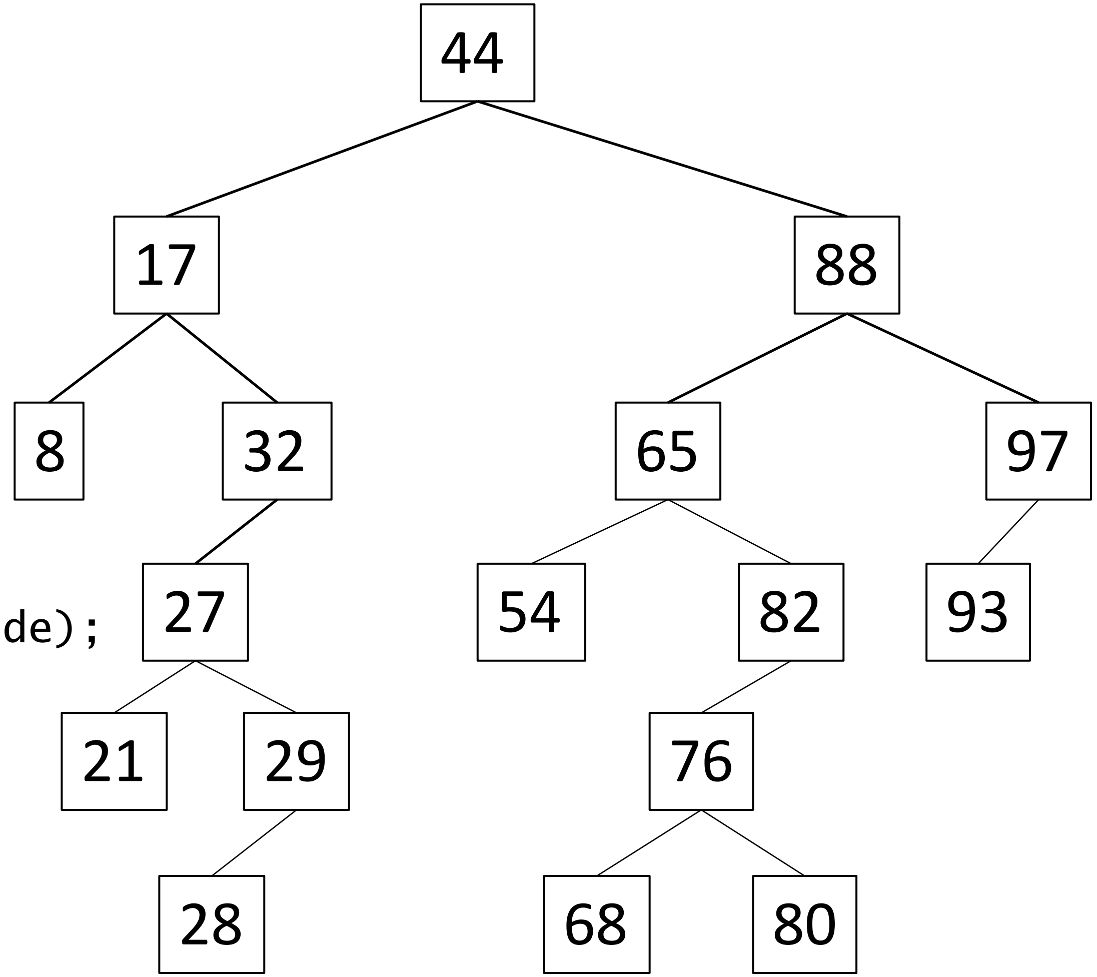

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}
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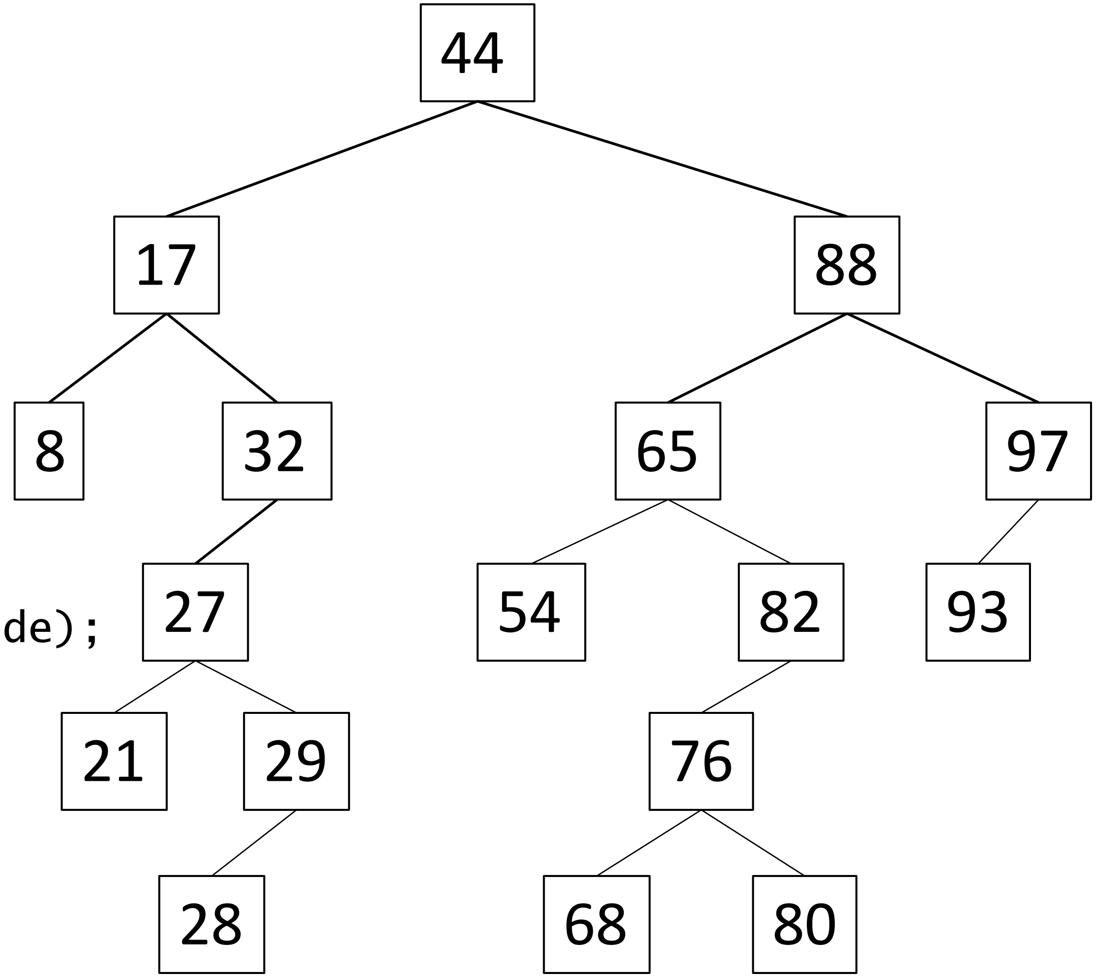

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        }
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        } else {
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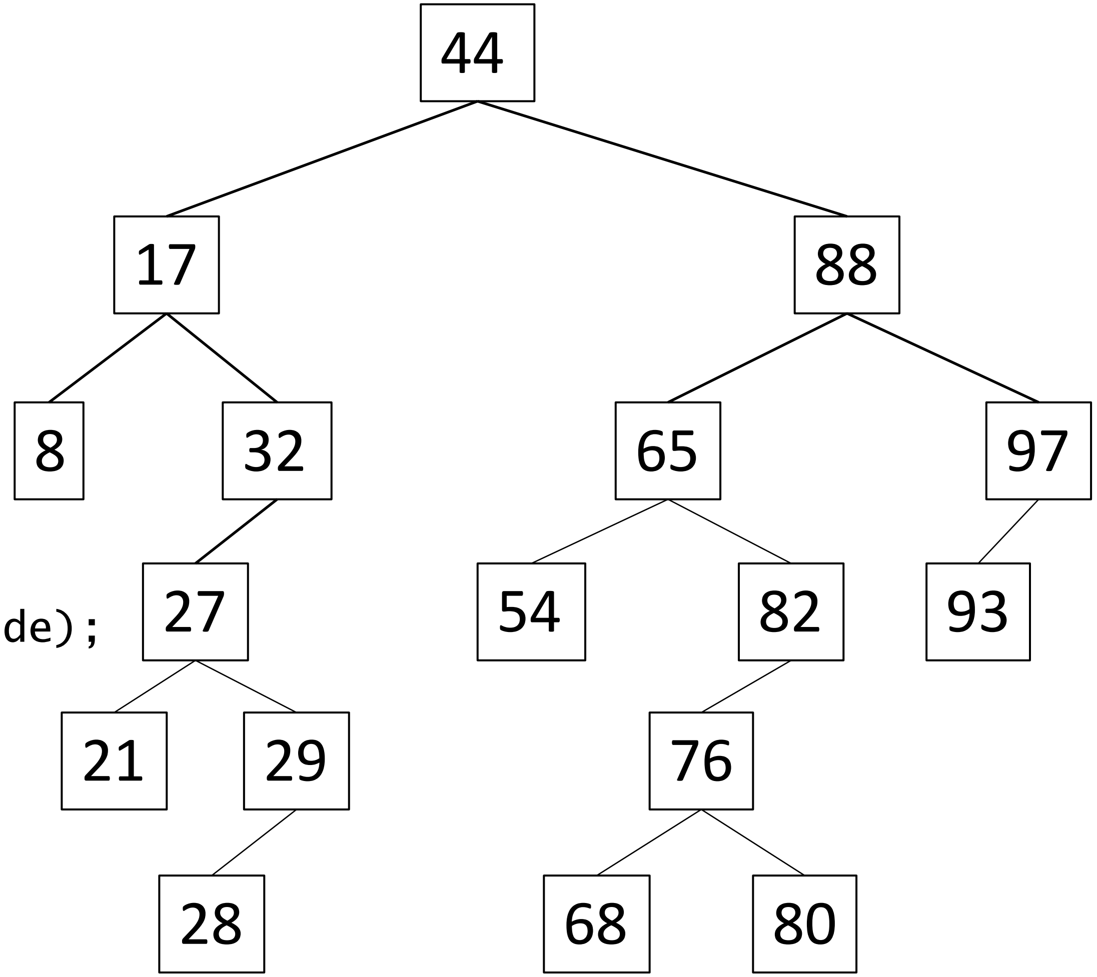
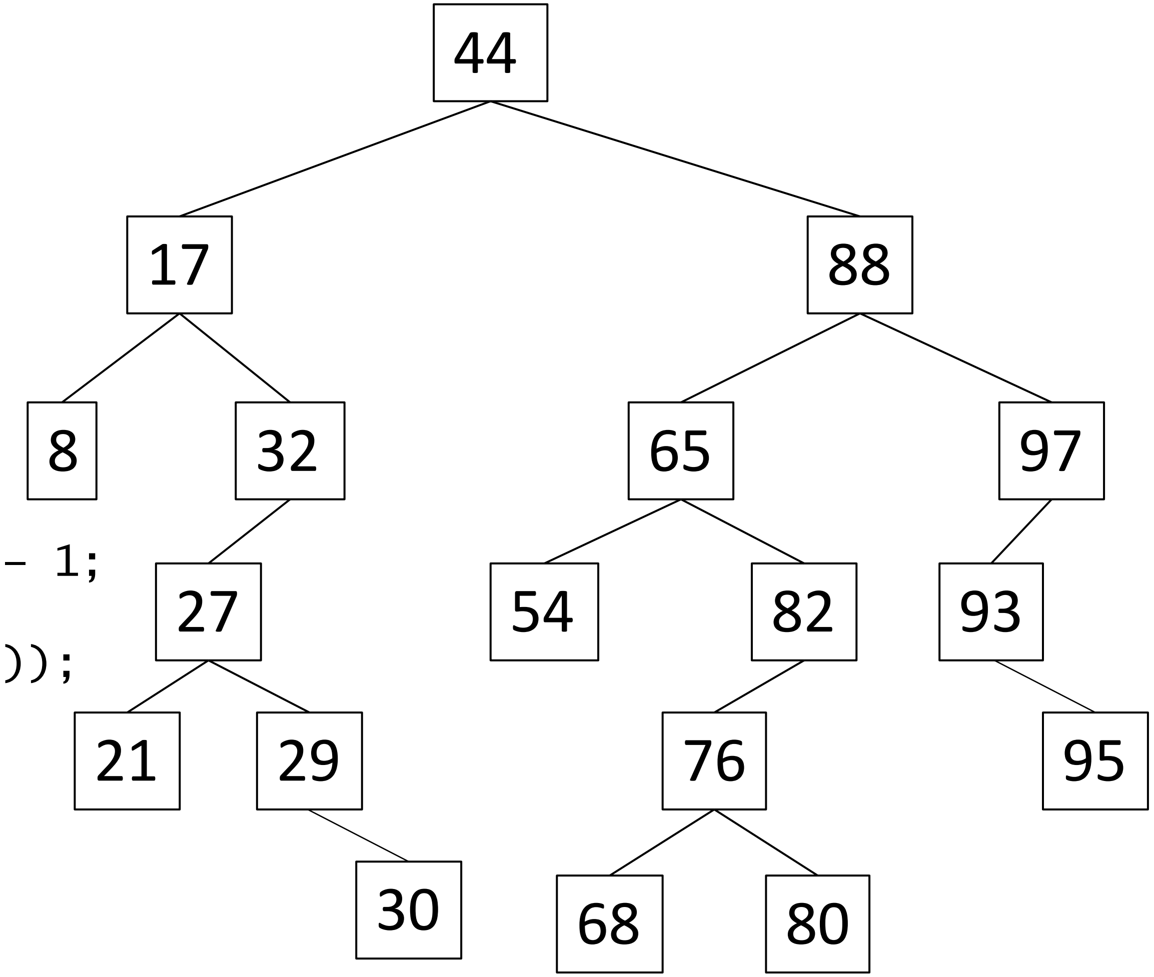
          placed = true;
}
```



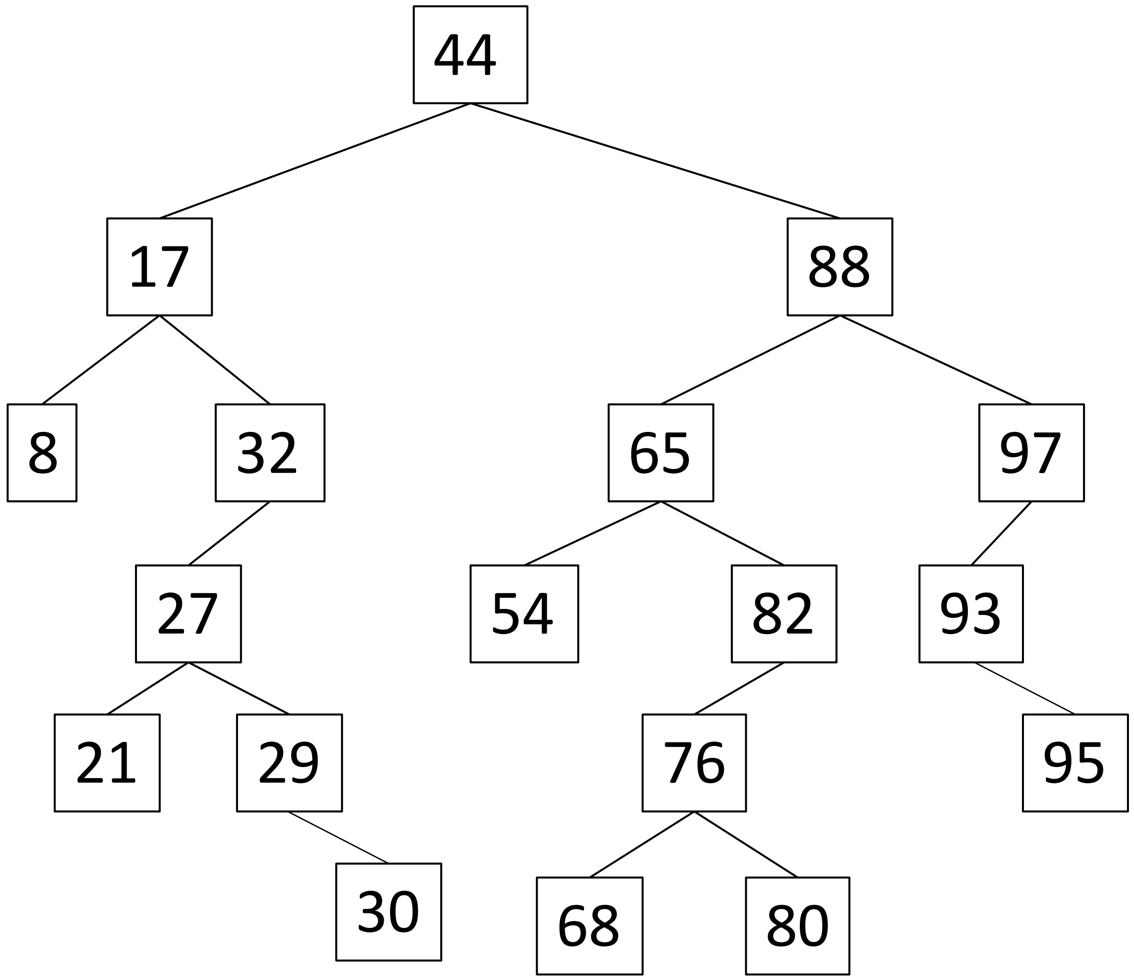
Binary Search Tree - Traversal

```
public void depthFirst() {
    Stack<Node> stack = new Stack<>();
    if (root != null) {
        stack.add(root);
        while(!stack.isEmpty()) {
            Node node = stack.pop();
            System.out.println(node.getName());
            for (int i = node.getChildren().size() – 1;
                 i >= 0; i--) {
                stack.push(node.getChildren().get(i));
            }
        }
    }
}
```



Binary Search Tree - Traversal

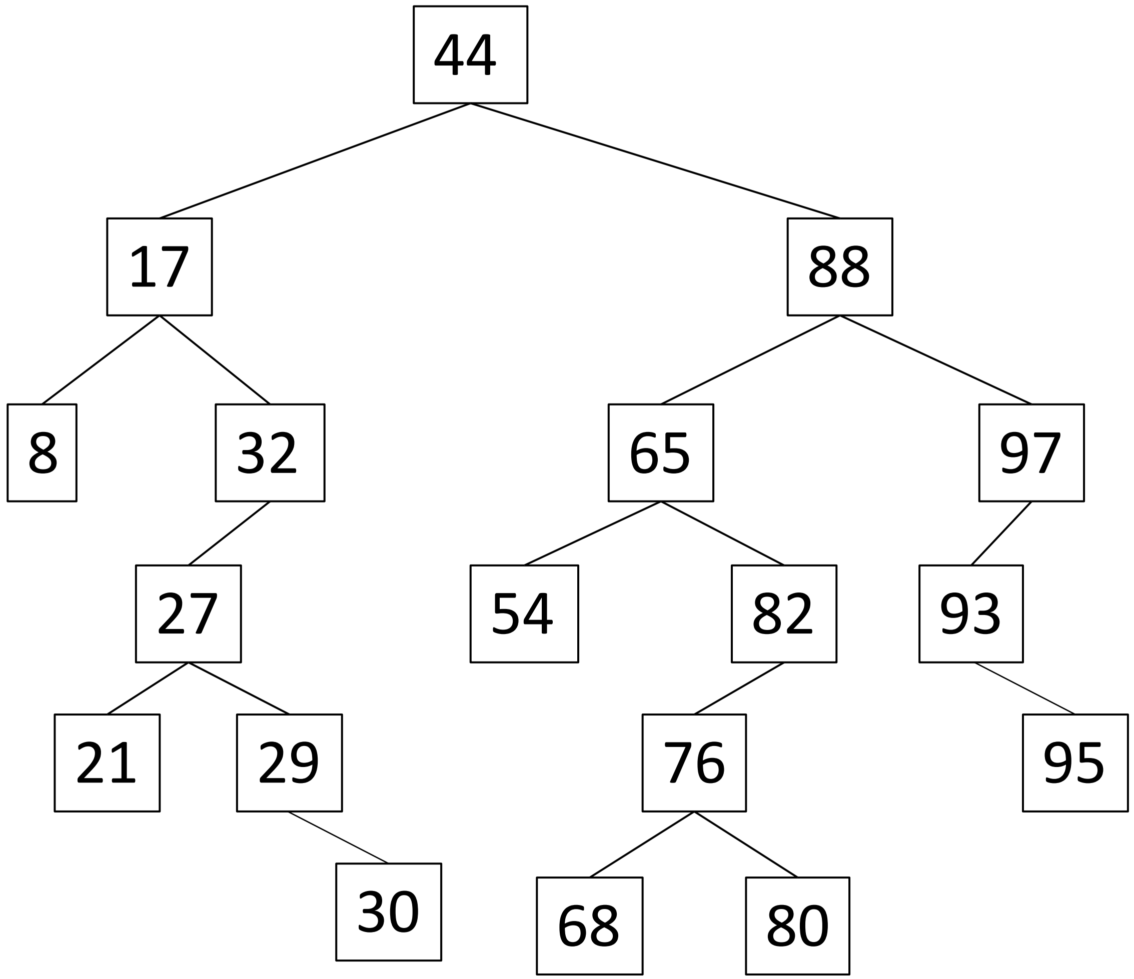
Recursion:



Binary Search Tree - Traversal

Recursion:

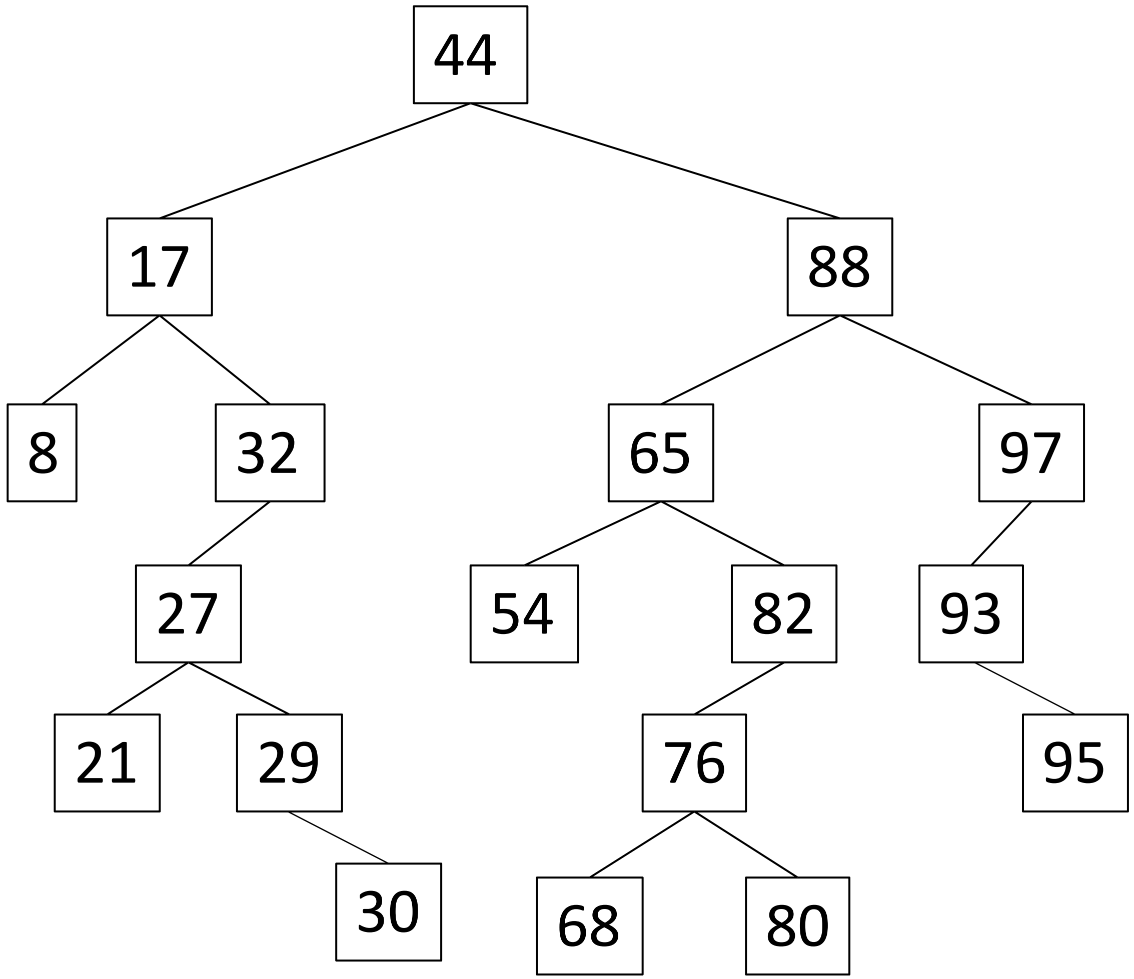
- **Calling a method from inside itself.**



Binary Search Tree - Traversal

Recursion:

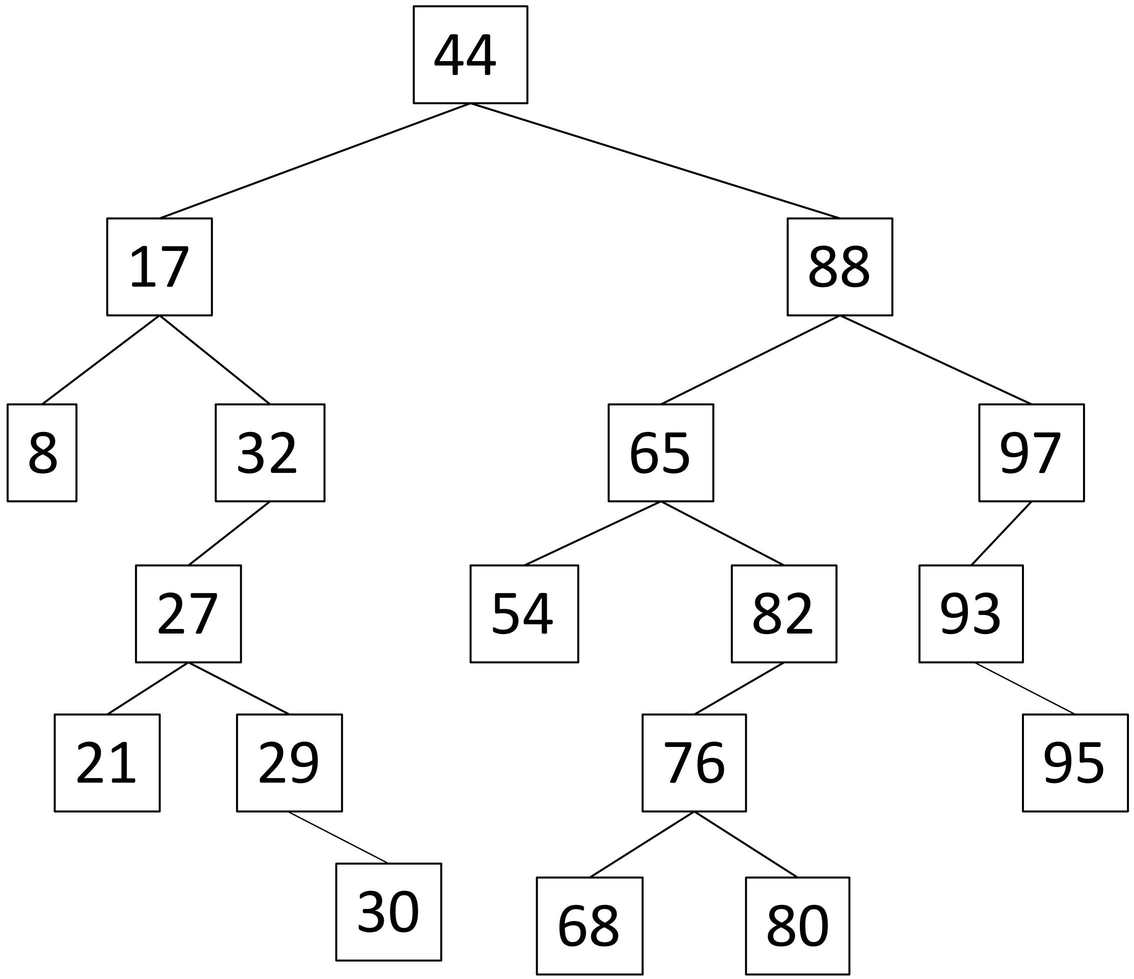
- **Calling a method from inside itself.**
- **Solve the problem by solving identical smaller problems.**



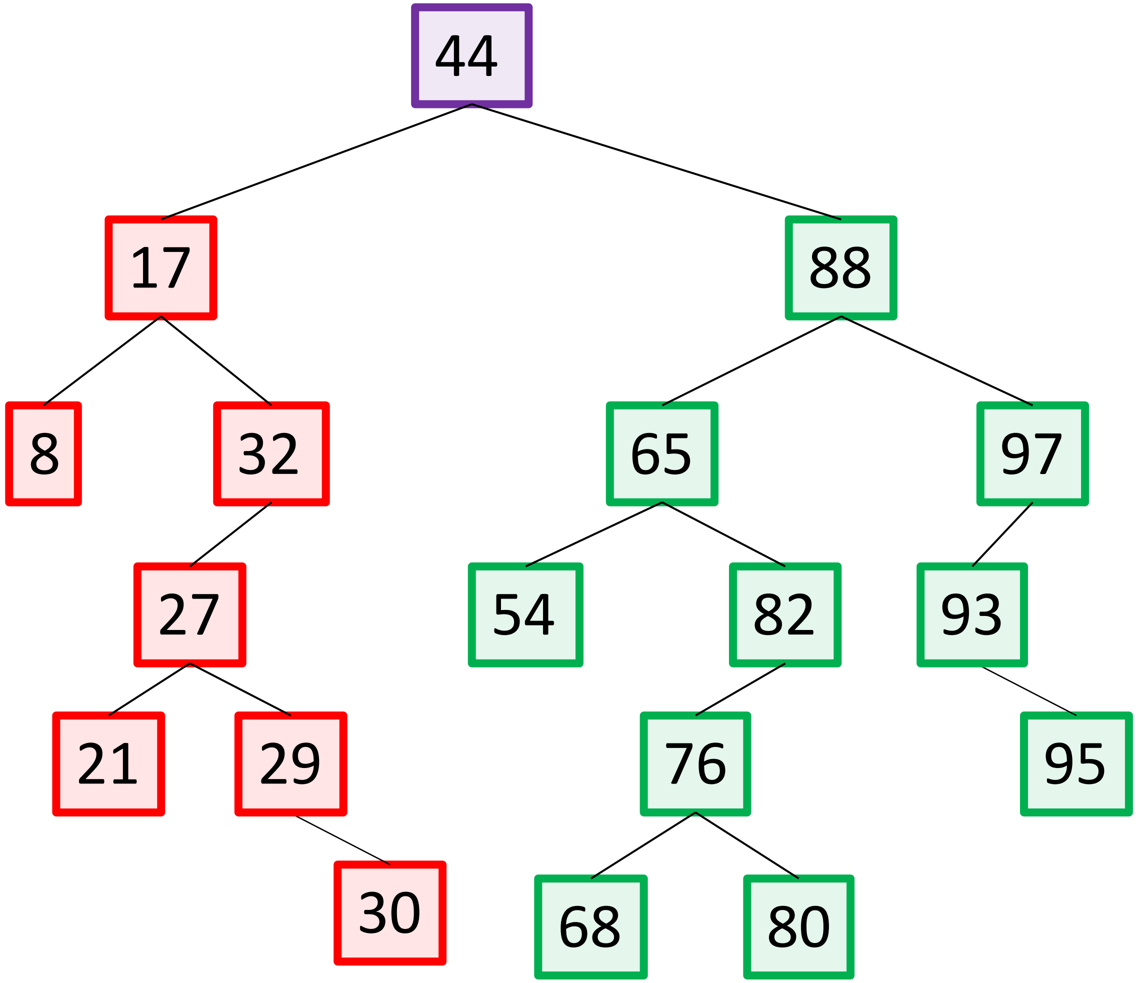
Binary Search Tree - Traversal

Recursion:

- **Calling a method from inside itself.**
- **Solve the problem by solving identical smaller problems.**
- **What is the "smaller problem"?**



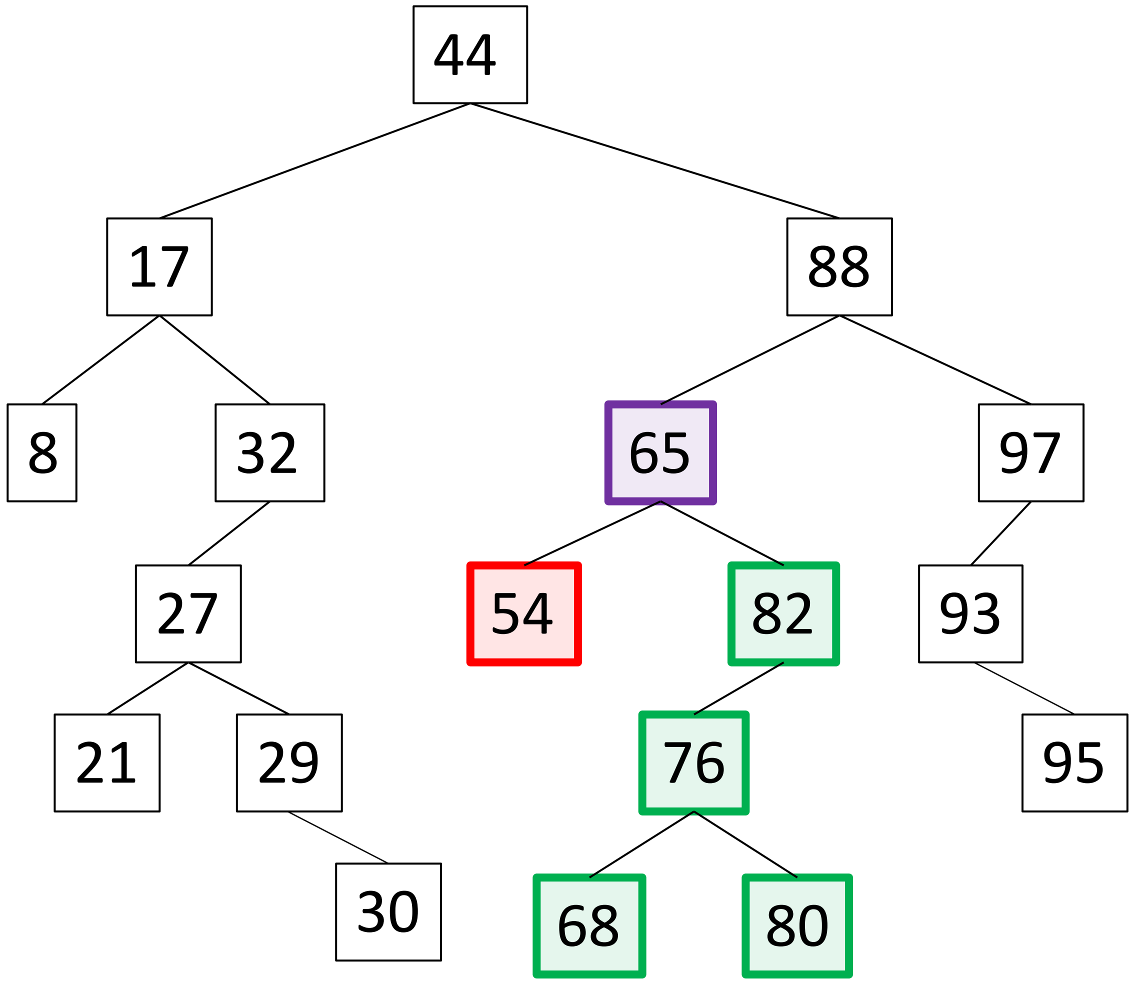
Binary Search Tree - Traversal



Recursion:

- **Calling a method from inside itself.**
- **Solve the problem by solving identical smaller problems.**
- **What is the "smaller problem"?**
  - **Process the left side, then process the right side.**

Binary Search Tree - Traversal

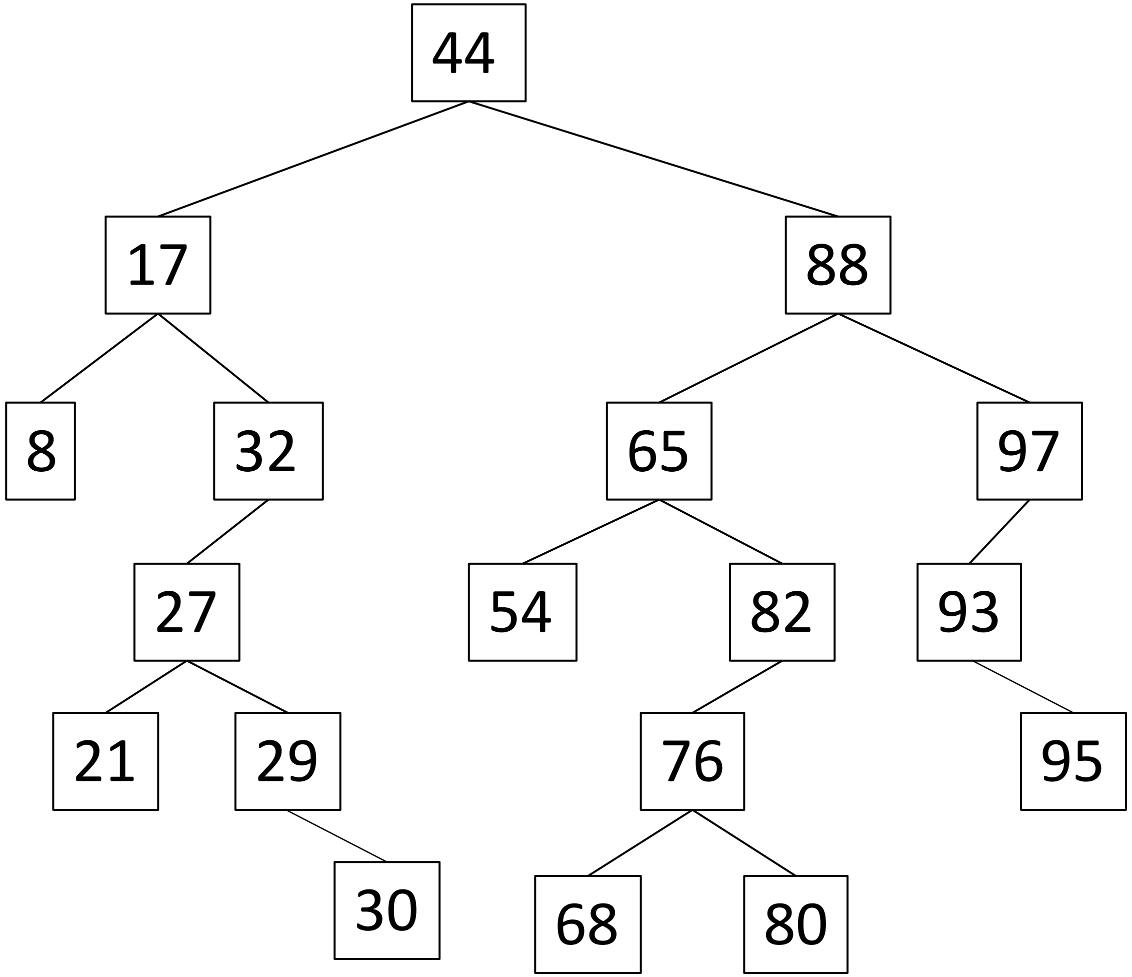


Recursion:

- **Calling a method from inside itself.**
- **Solve the problem by solving identical smaller problems.**
- **What is the "smaller problem"?**
  - **Process the left side, then process the right side.**

Binary Search Tree - Traversal

```
public void depthFirst(Node n) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



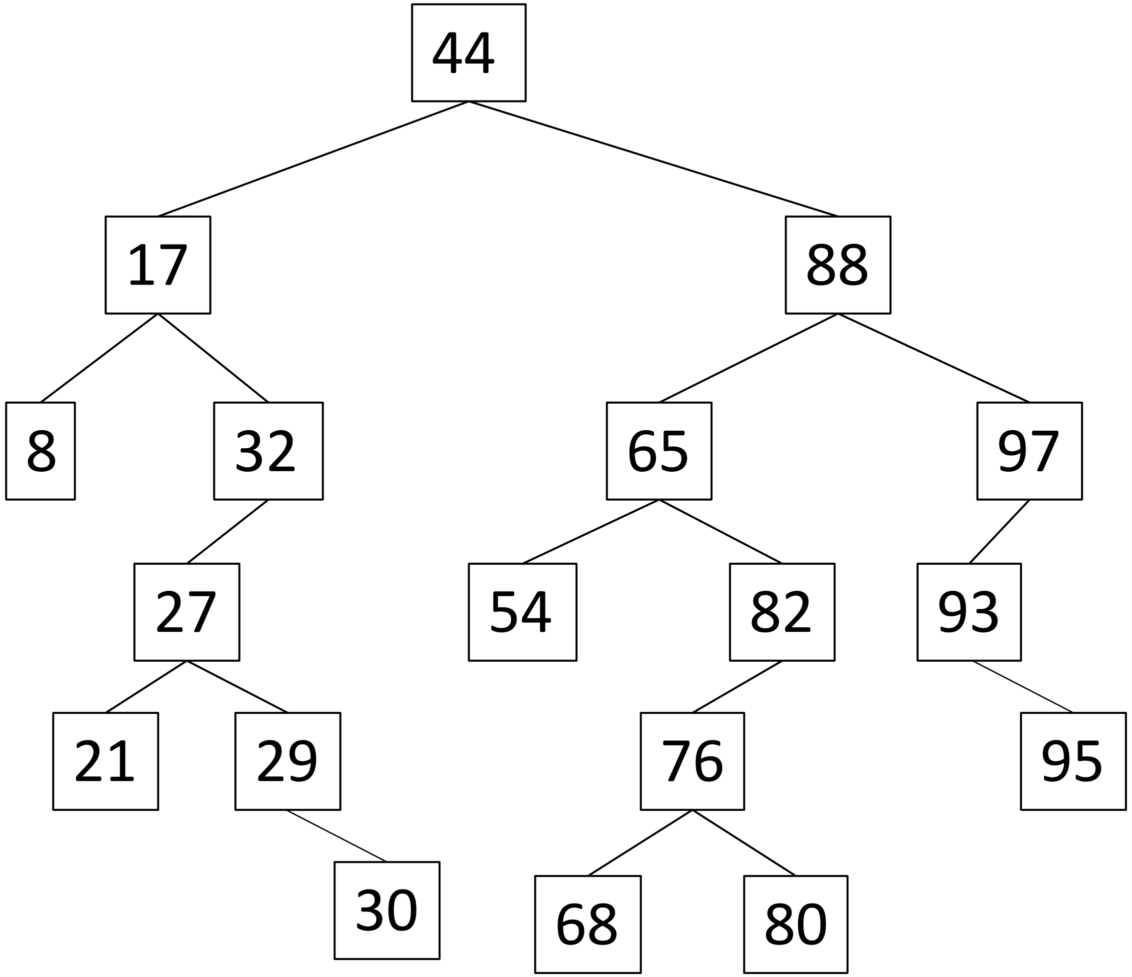
Recursion:

- **Calling a method from inside itself.**
- **Solve the problem by solving identical smaller problems.**
- **What is the "smaller problem"?**
  - **Process the left side, then process the right side.**

Output:

Binary Search Tree - Traversal

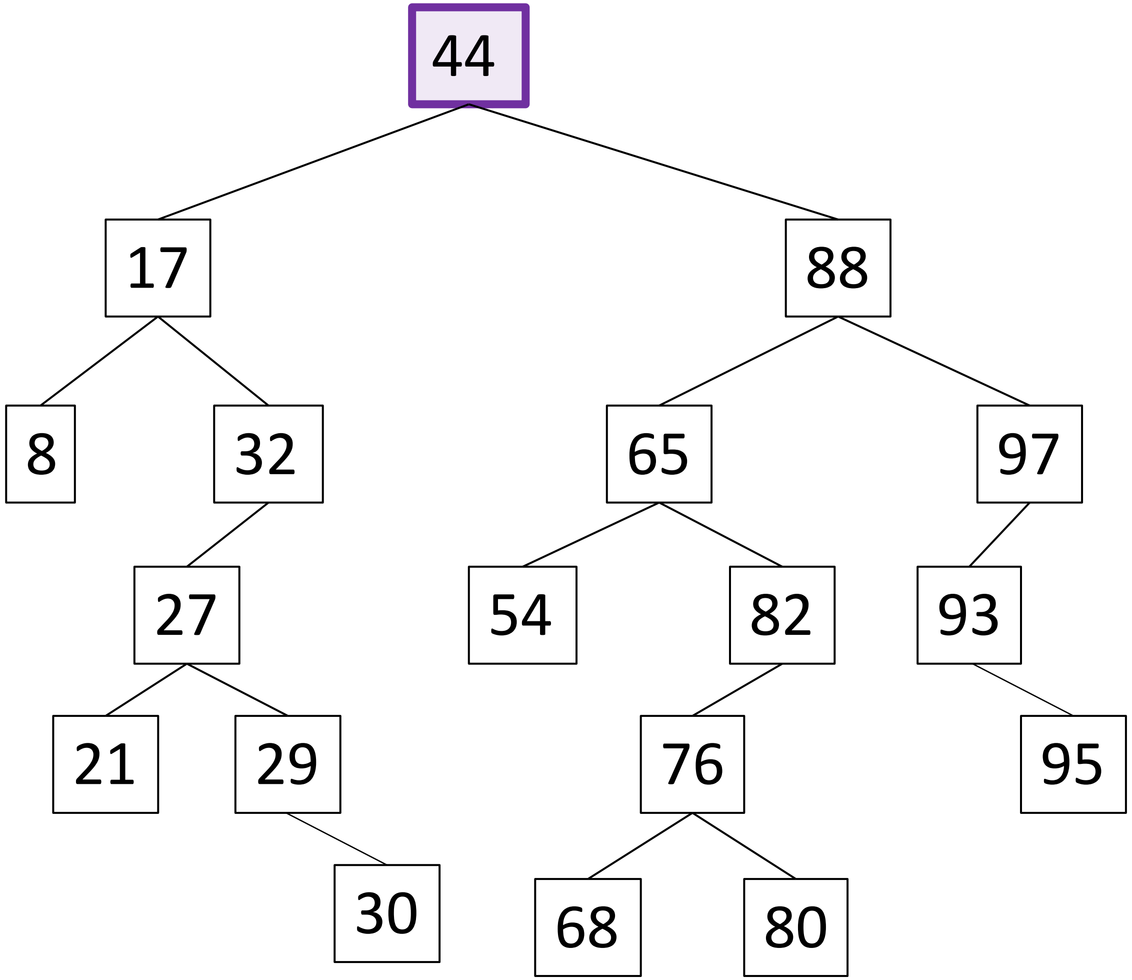
```
public void depthFirst(Node n) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

Binary Search Tree - Traversal

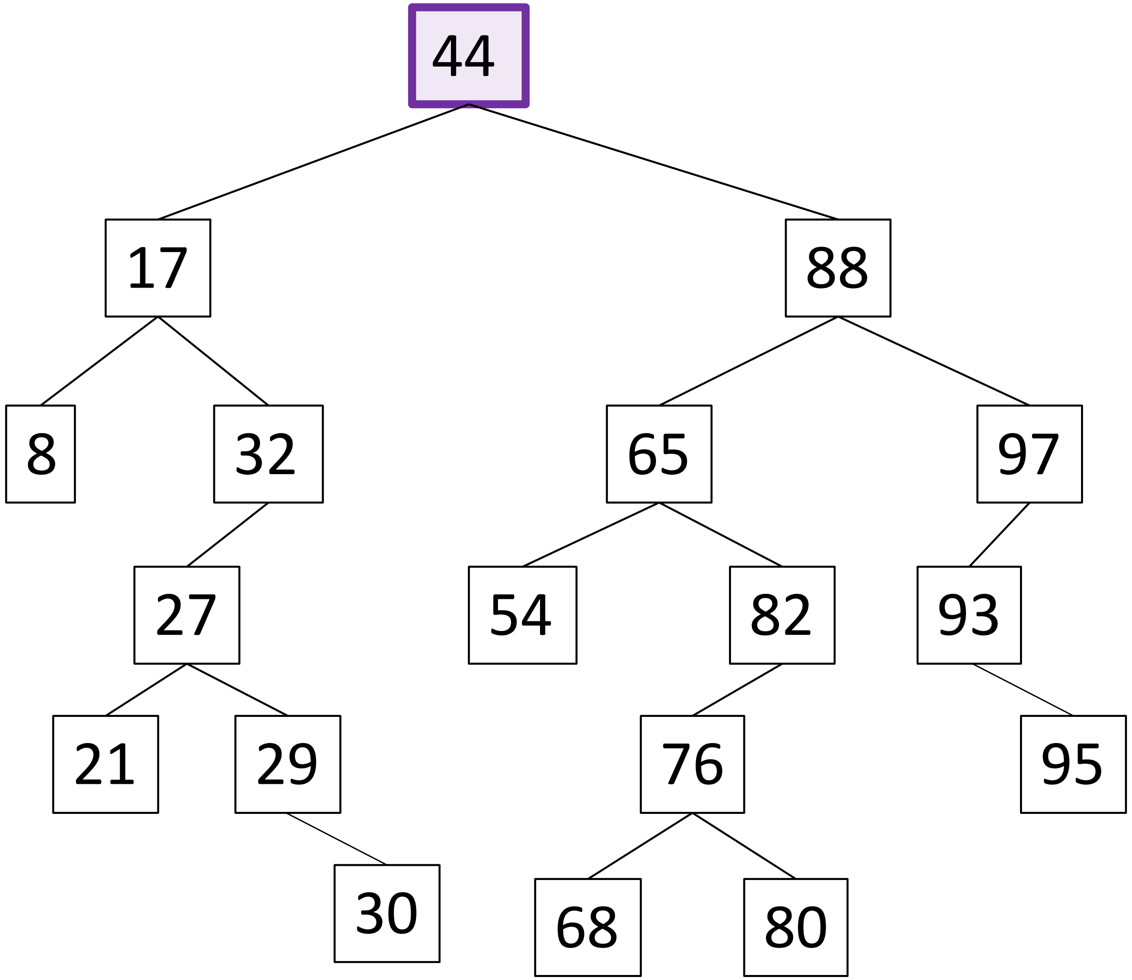
```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:
44

Binary Search Tree - Traversal

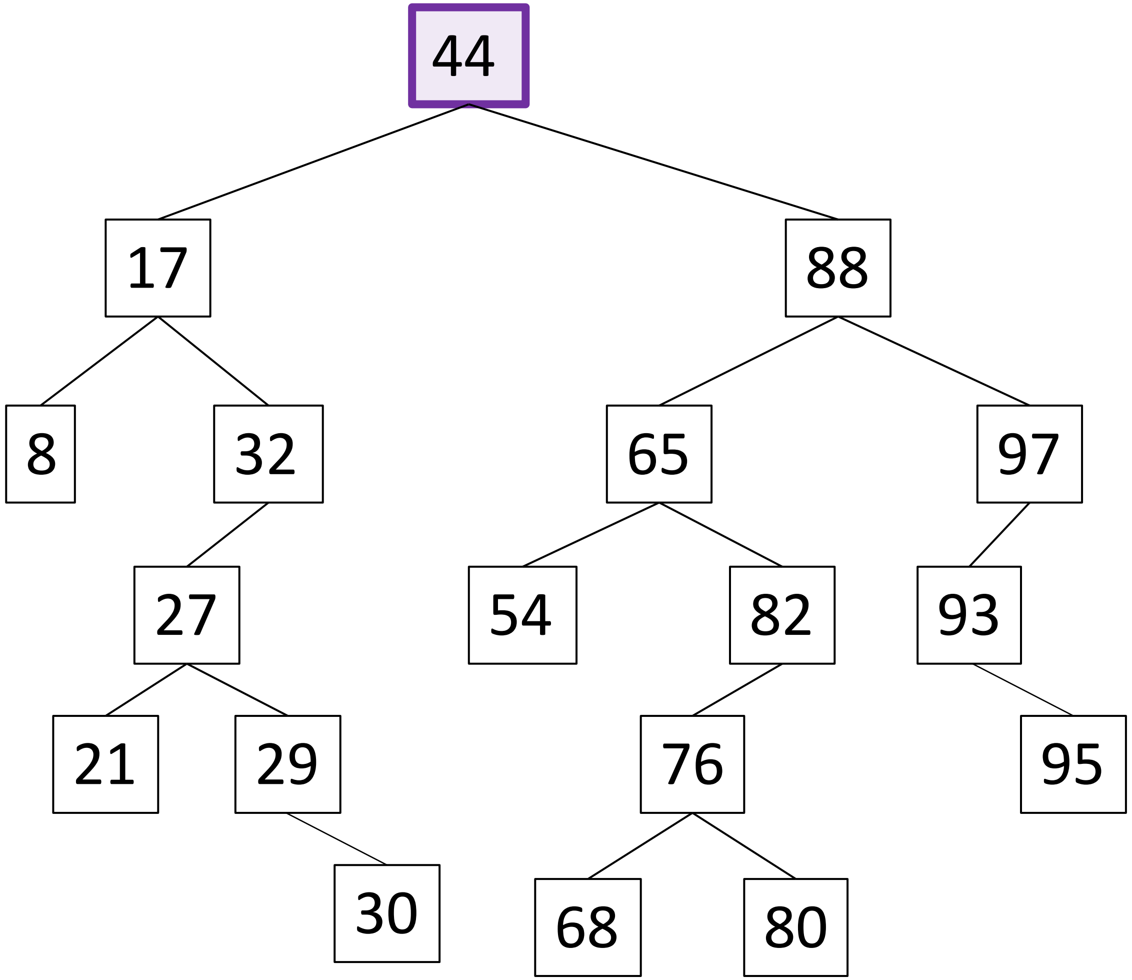
```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:
44

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

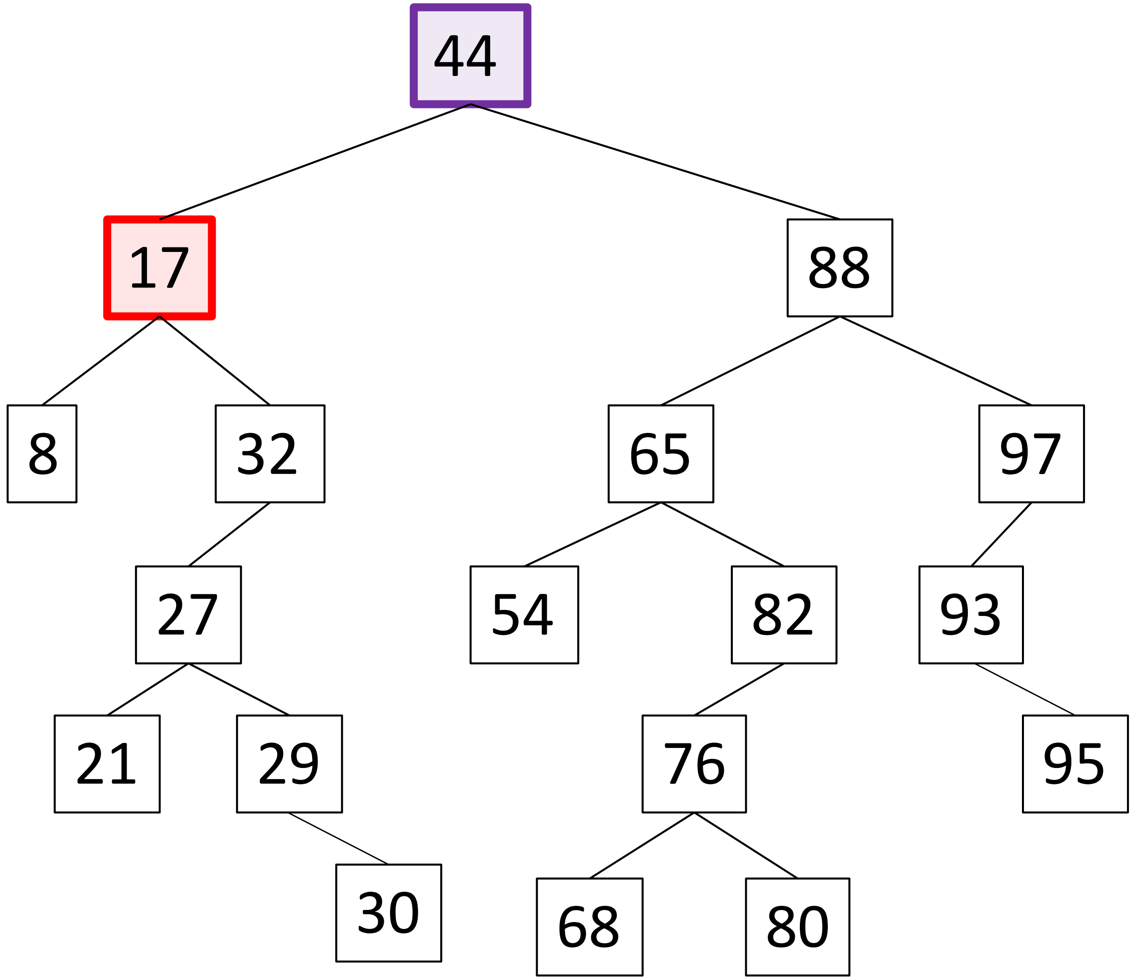


Output:
44

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

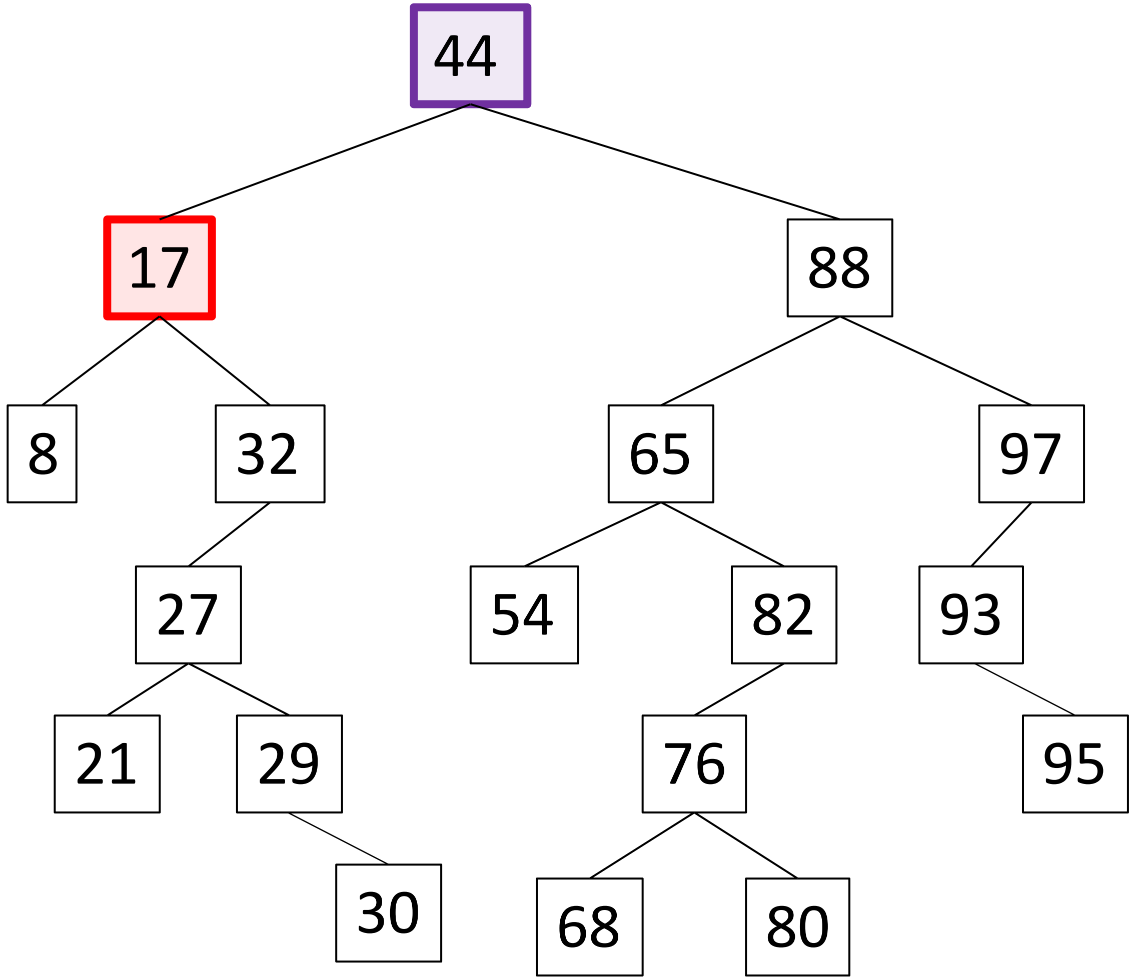
44

17

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

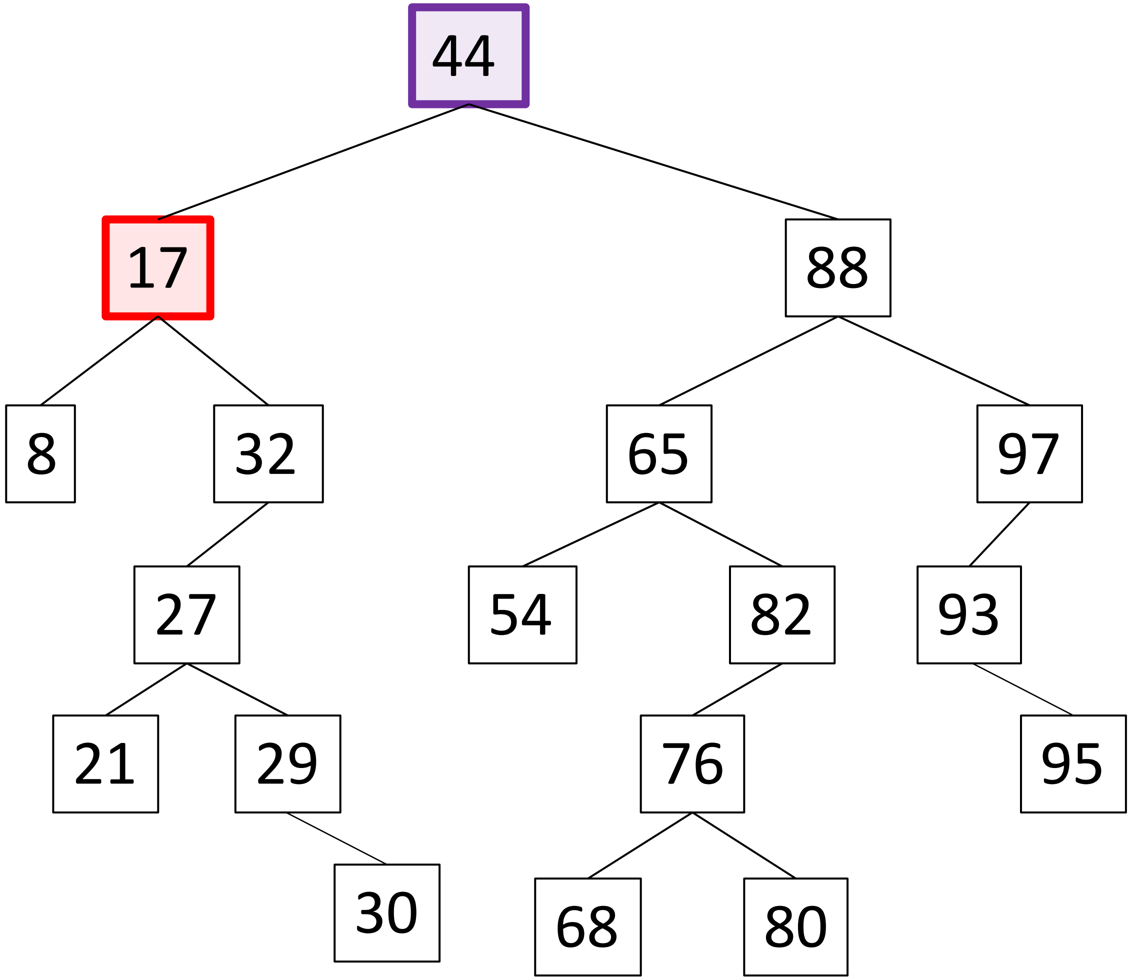
```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

44

17

Output:

44

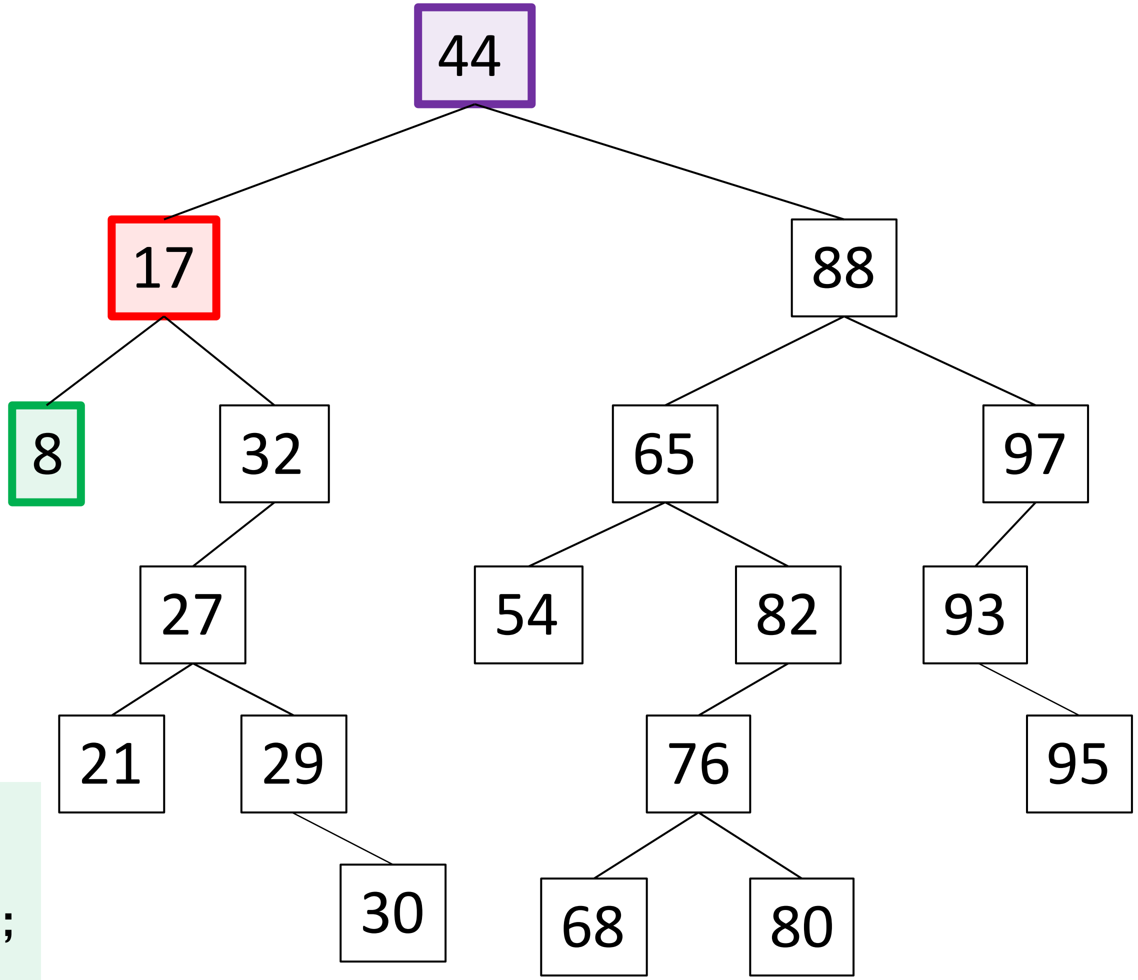
17

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(8) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



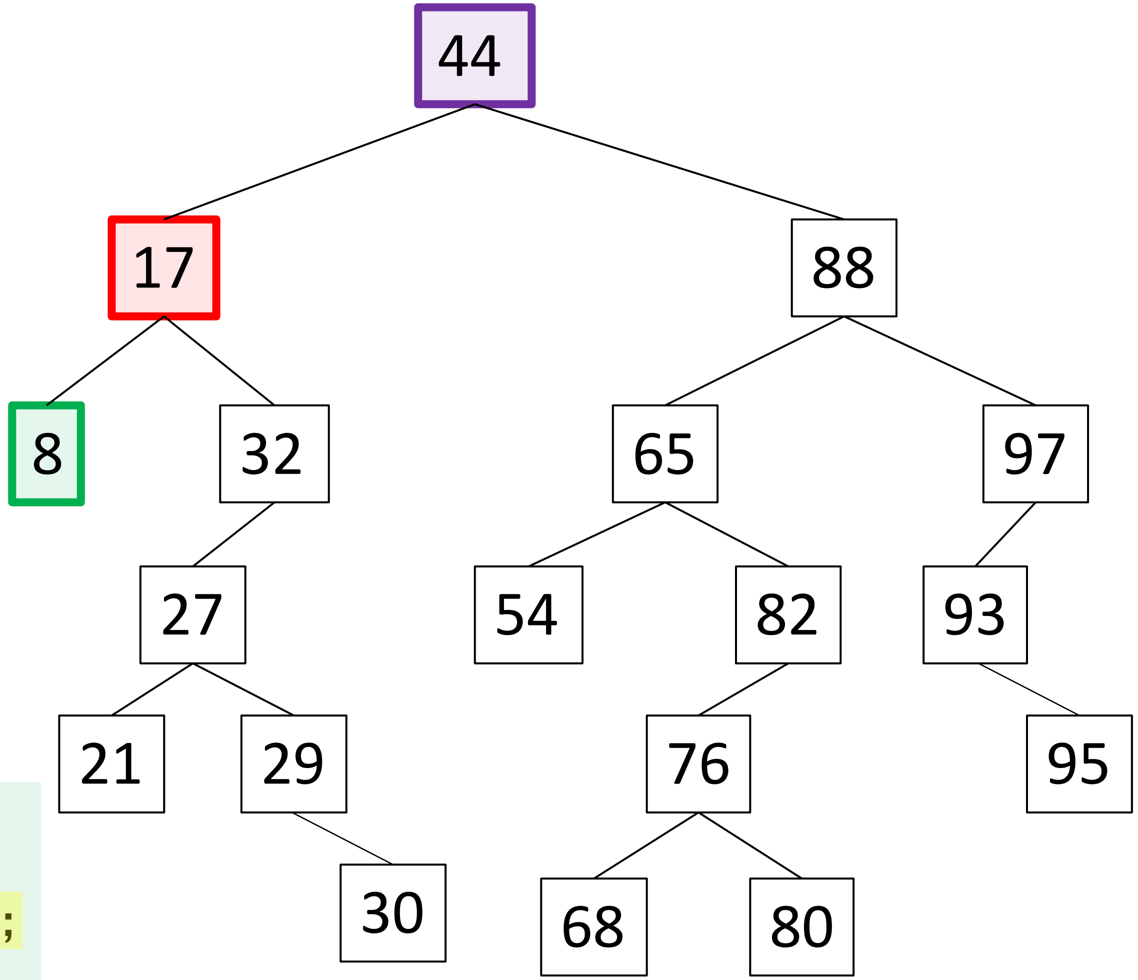
Output:
44
17
8

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(8) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Binary Search Tree - Traversal

Output:

44

17

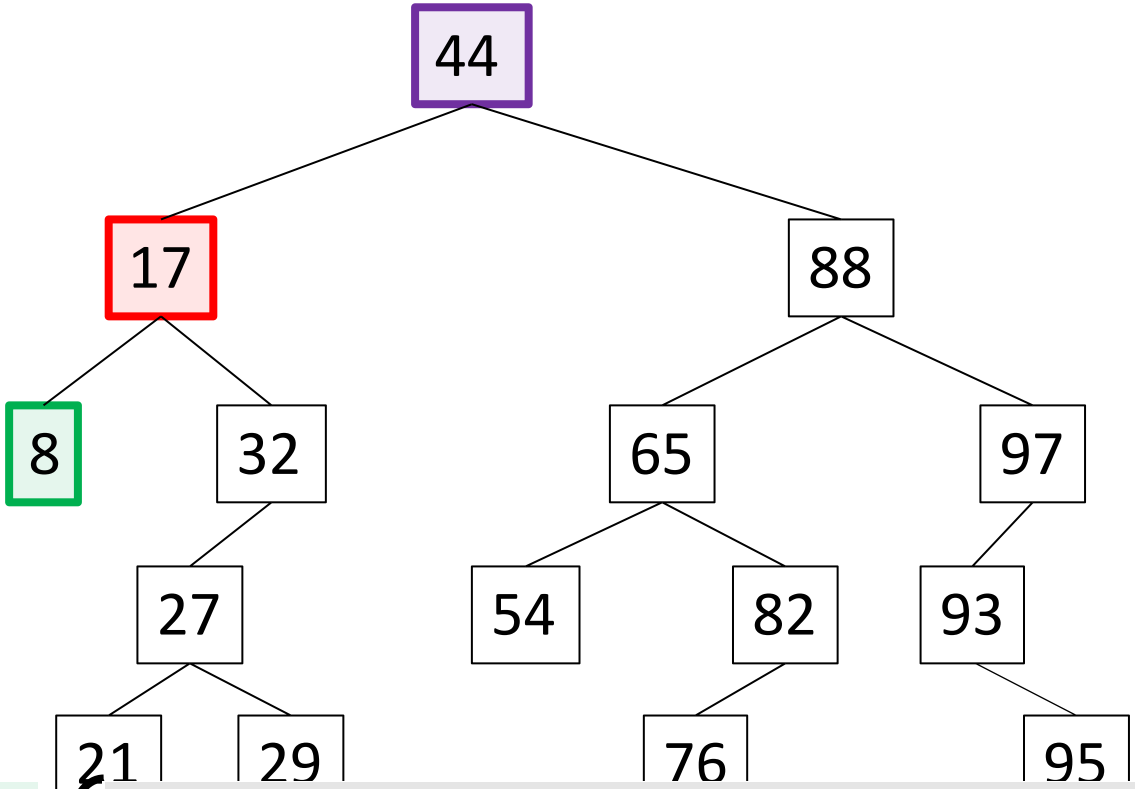
8

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(8) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(null) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

44

17

8

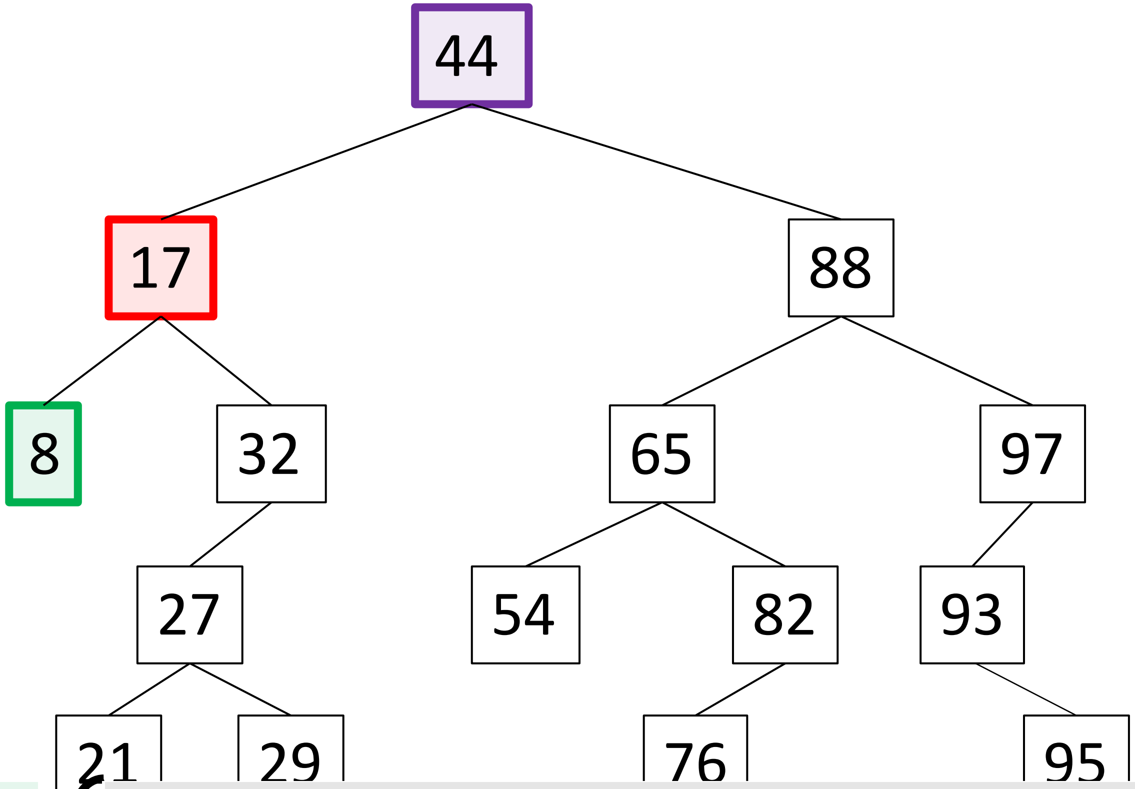
Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(8) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(null) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

44

17

8

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
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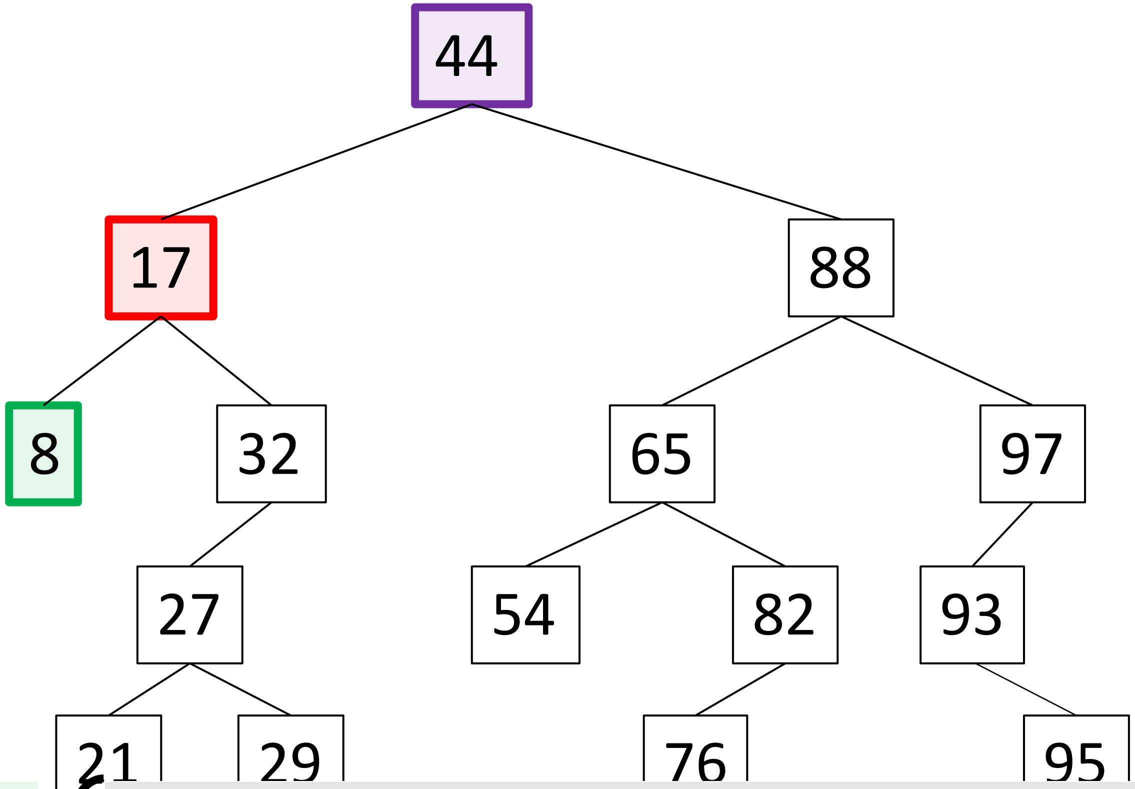
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(8) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(null) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

44

17

8

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

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public void depthFirst(17) {
    if (n != null) {
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public void depthFirst(8) {
    if (n != null) {
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        depthFirst(n.getLeft());
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    }
}
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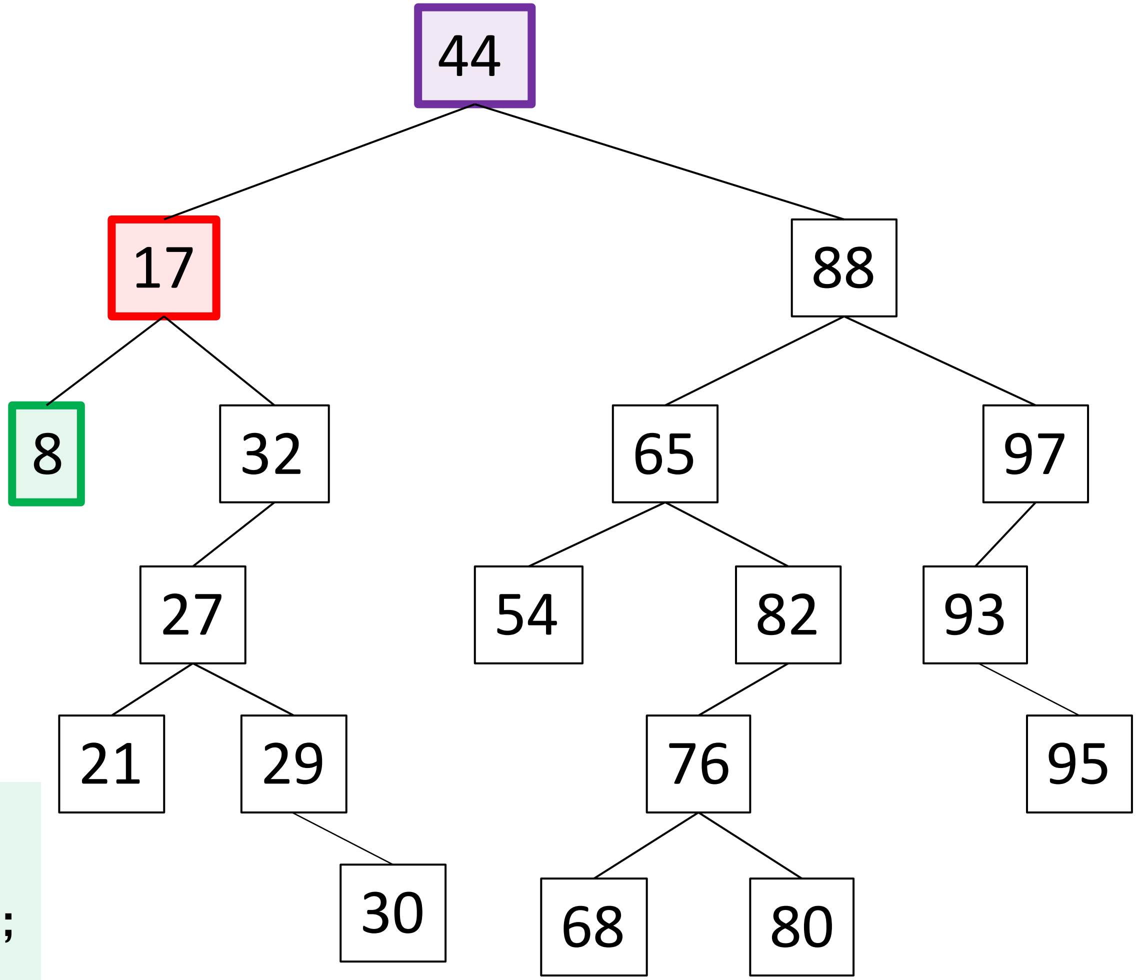

Output:

44

17

8

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
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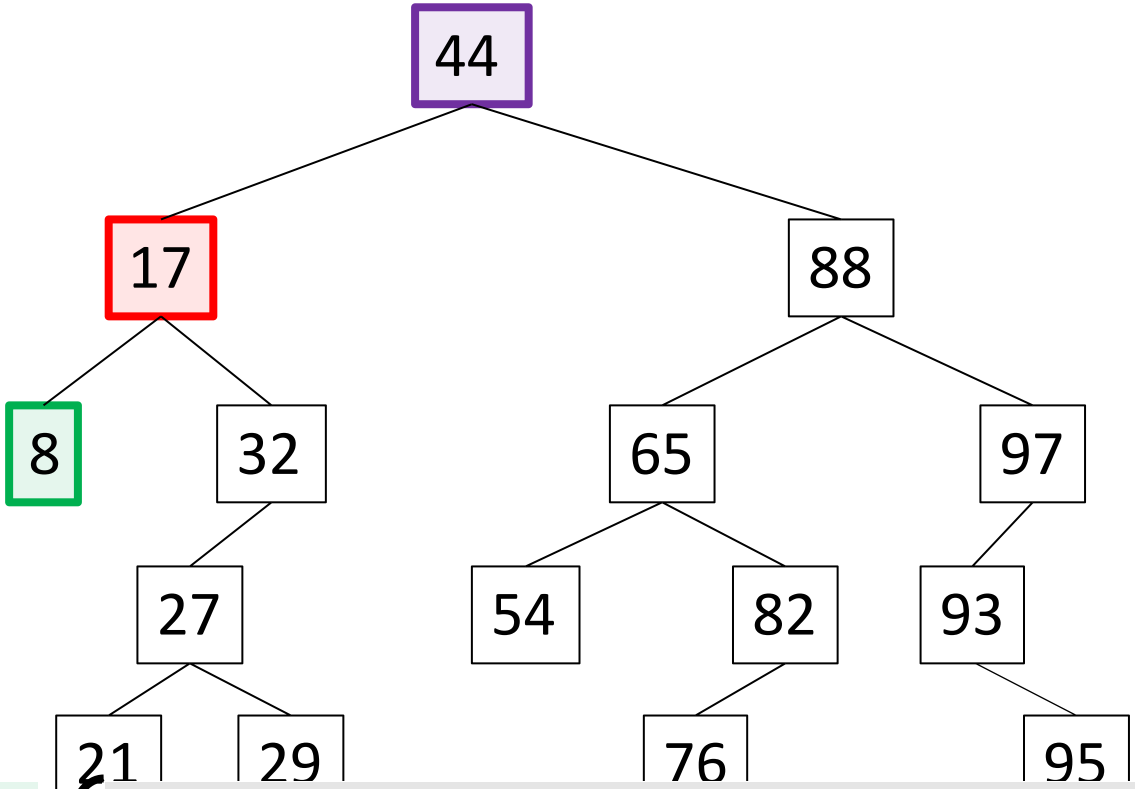
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(null) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

44

17

8

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
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public void depthFirst(null) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
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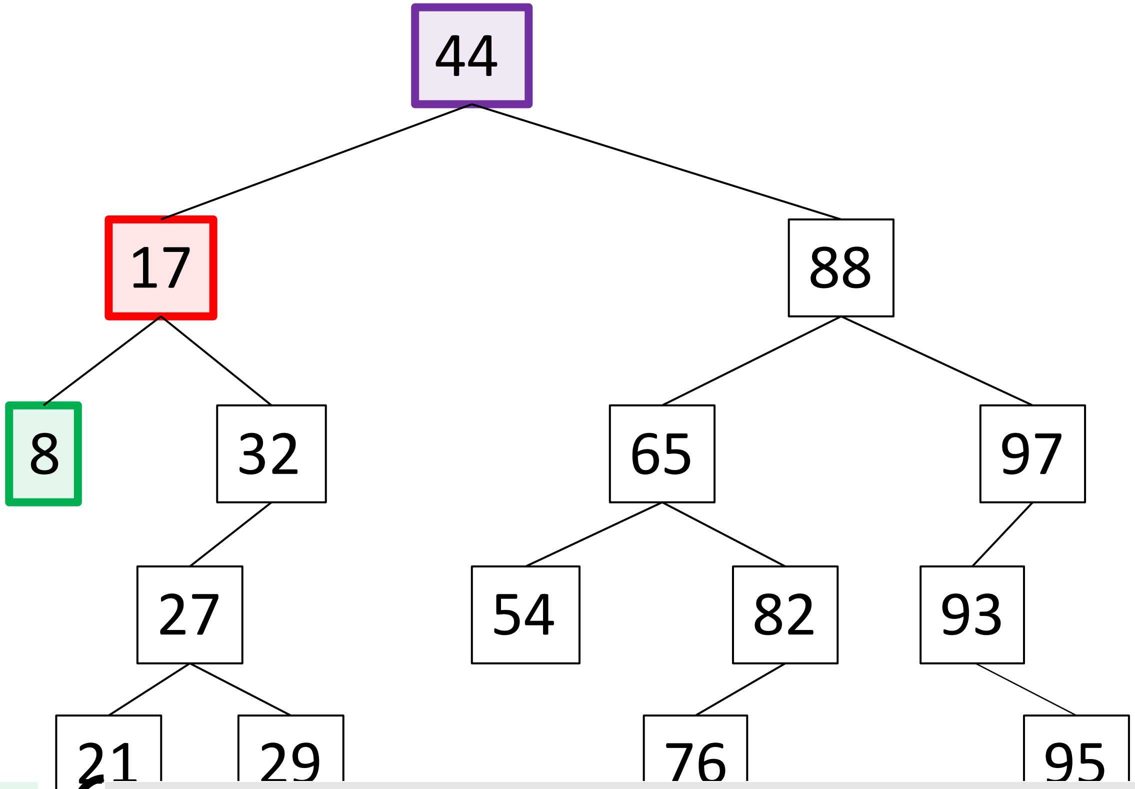

Output:

44

17

8

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
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    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
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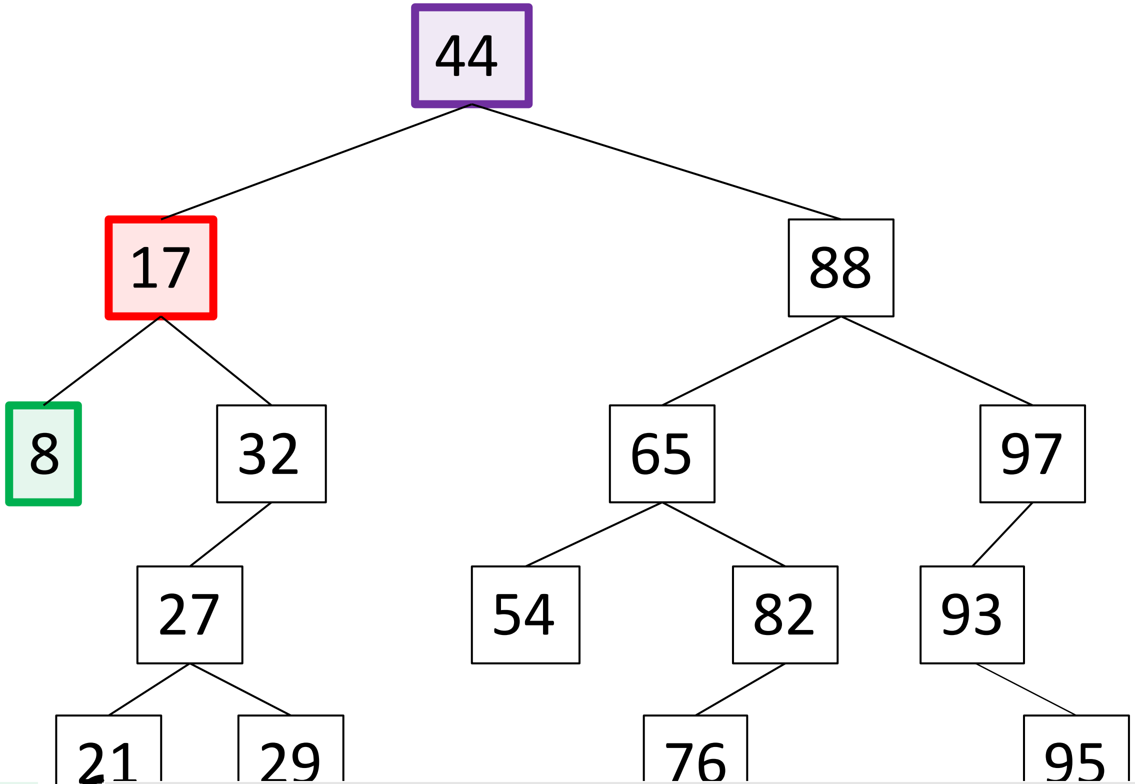
}
```

```
public void depthFirst(8) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(null) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

44

17

8

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
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```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(8) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
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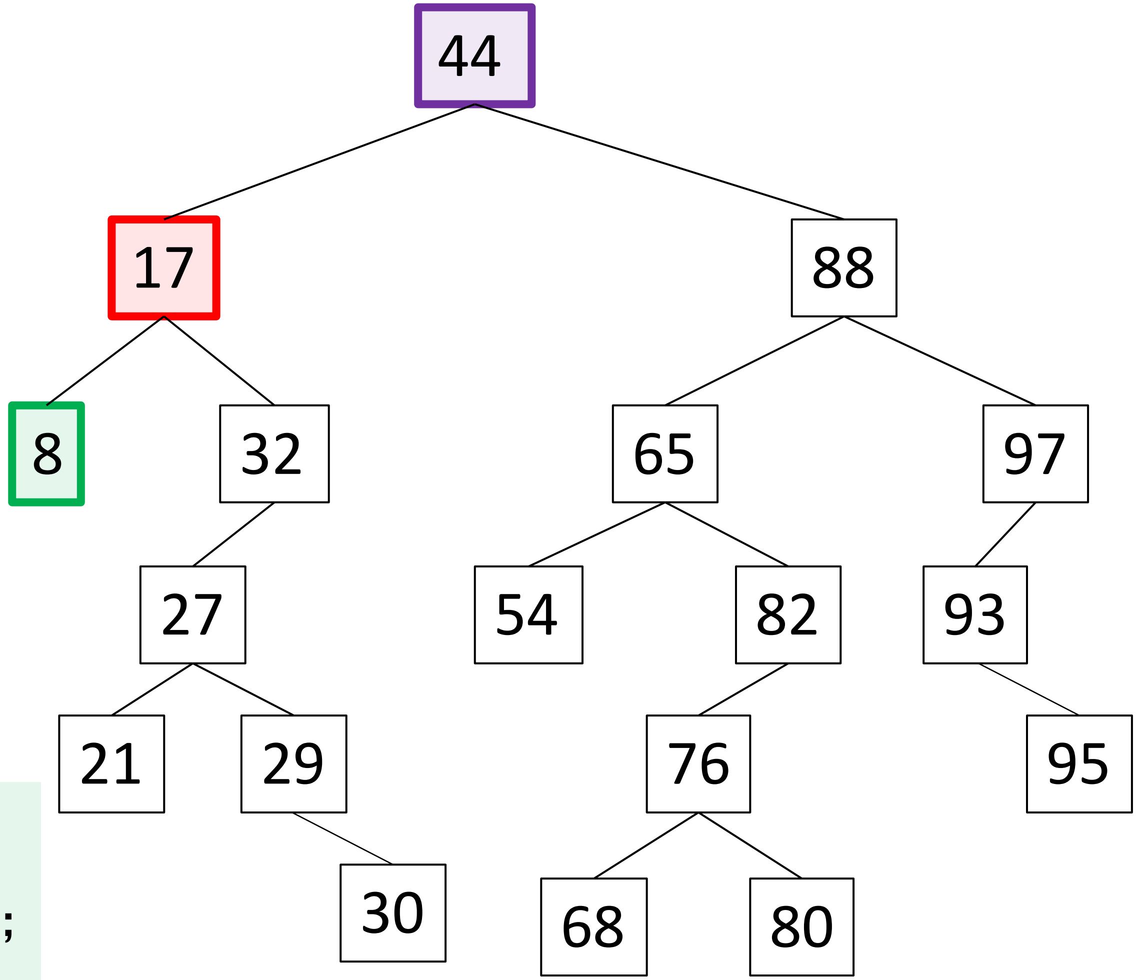

Output:
44
17
8

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
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    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
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}
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```
public void depthFirst(8) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
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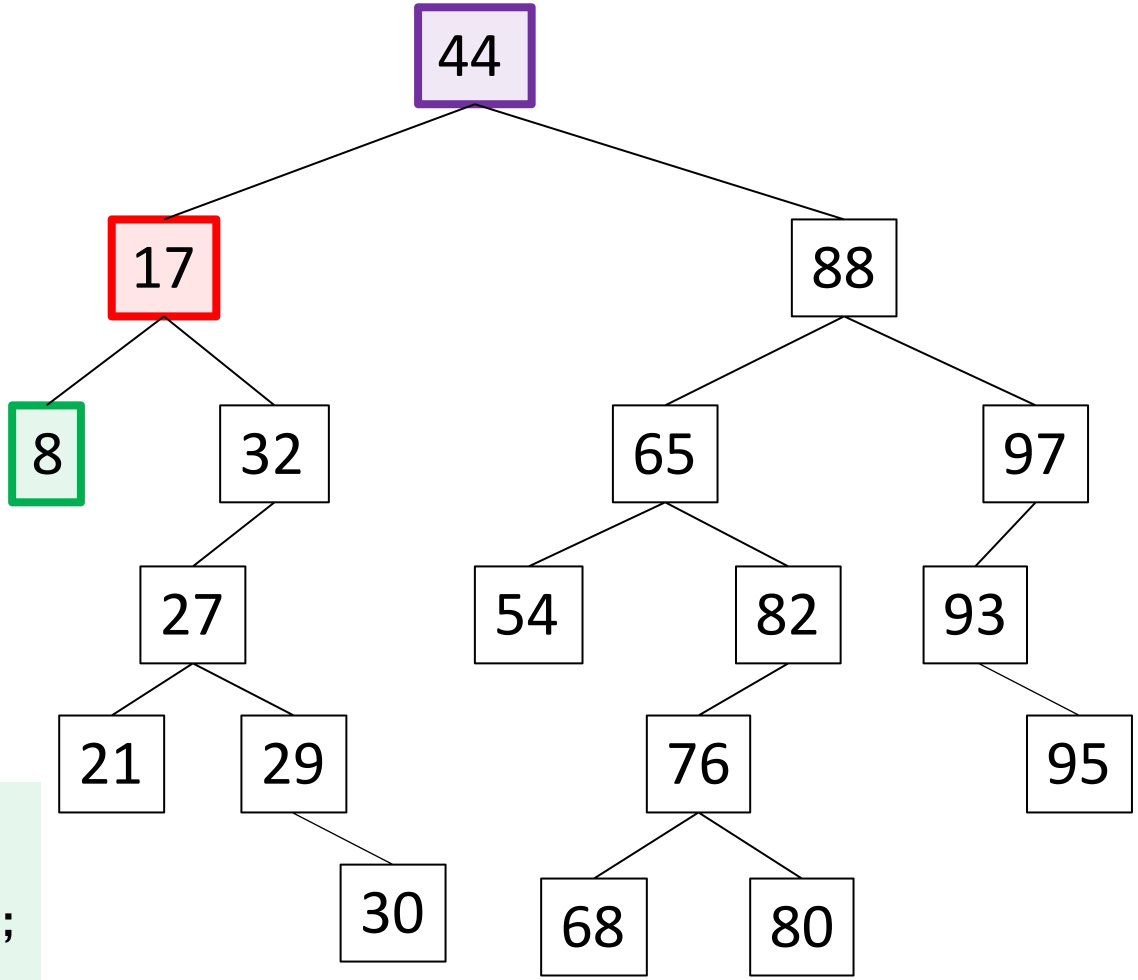

Binary Search Tree - Traversal

Output:

44

17

8

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
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    }
}
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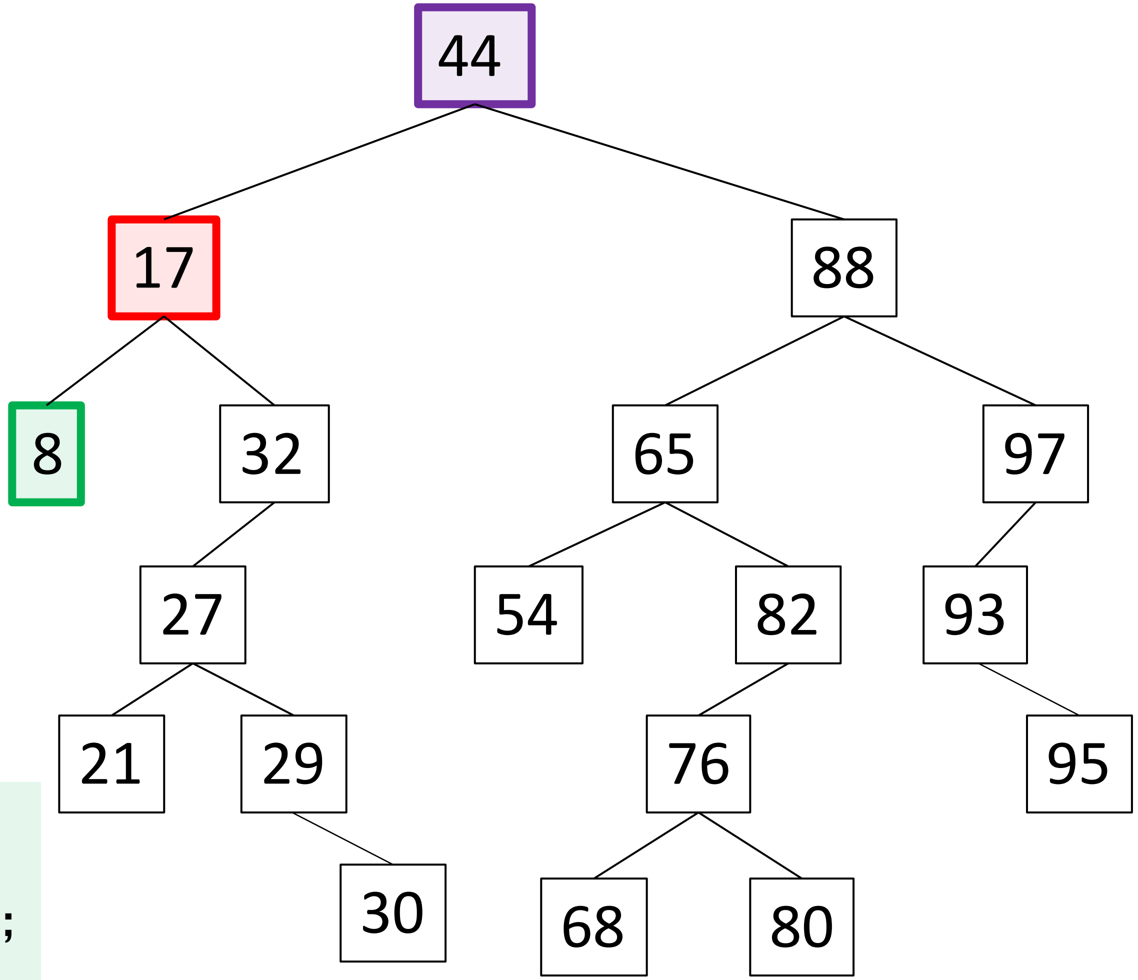
```
public void depthFirst(8) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

44

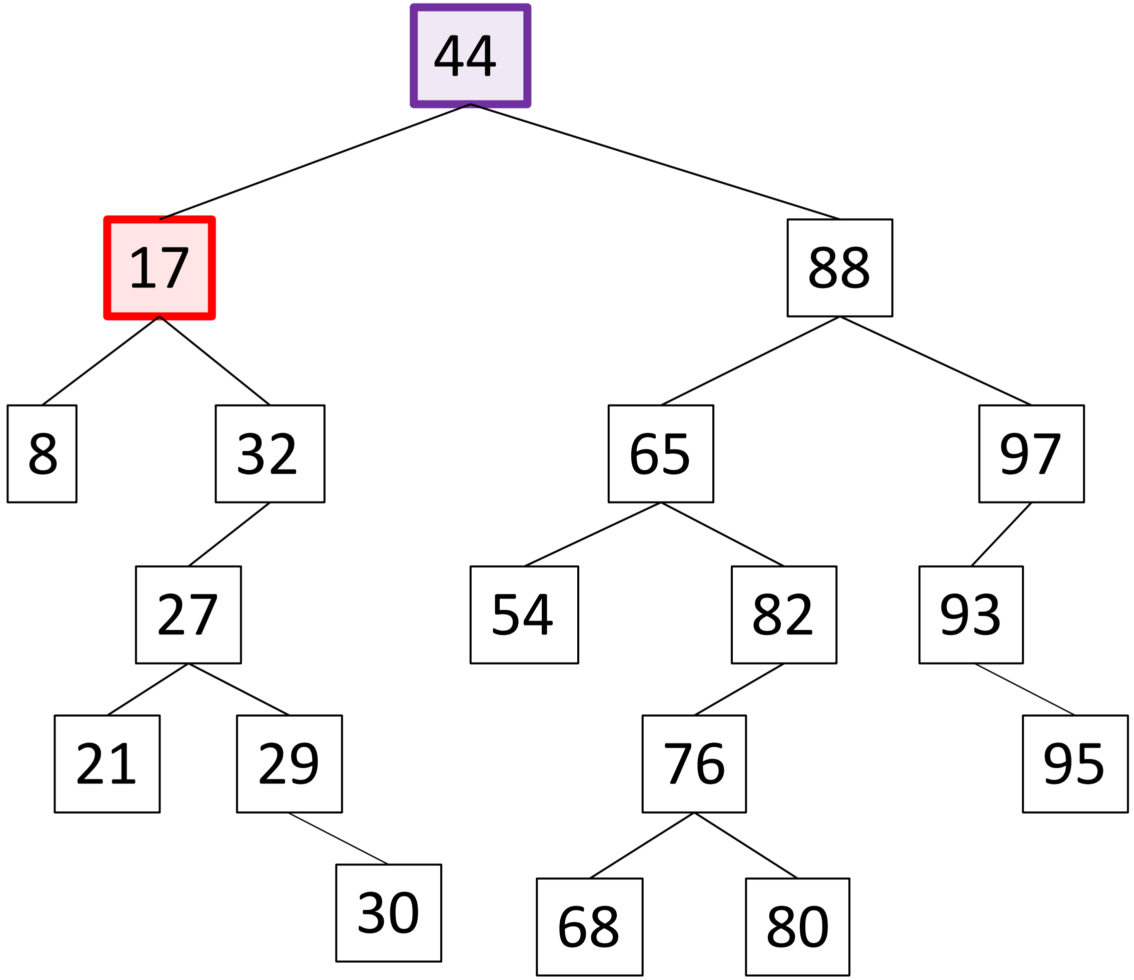
17

8

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

44

17

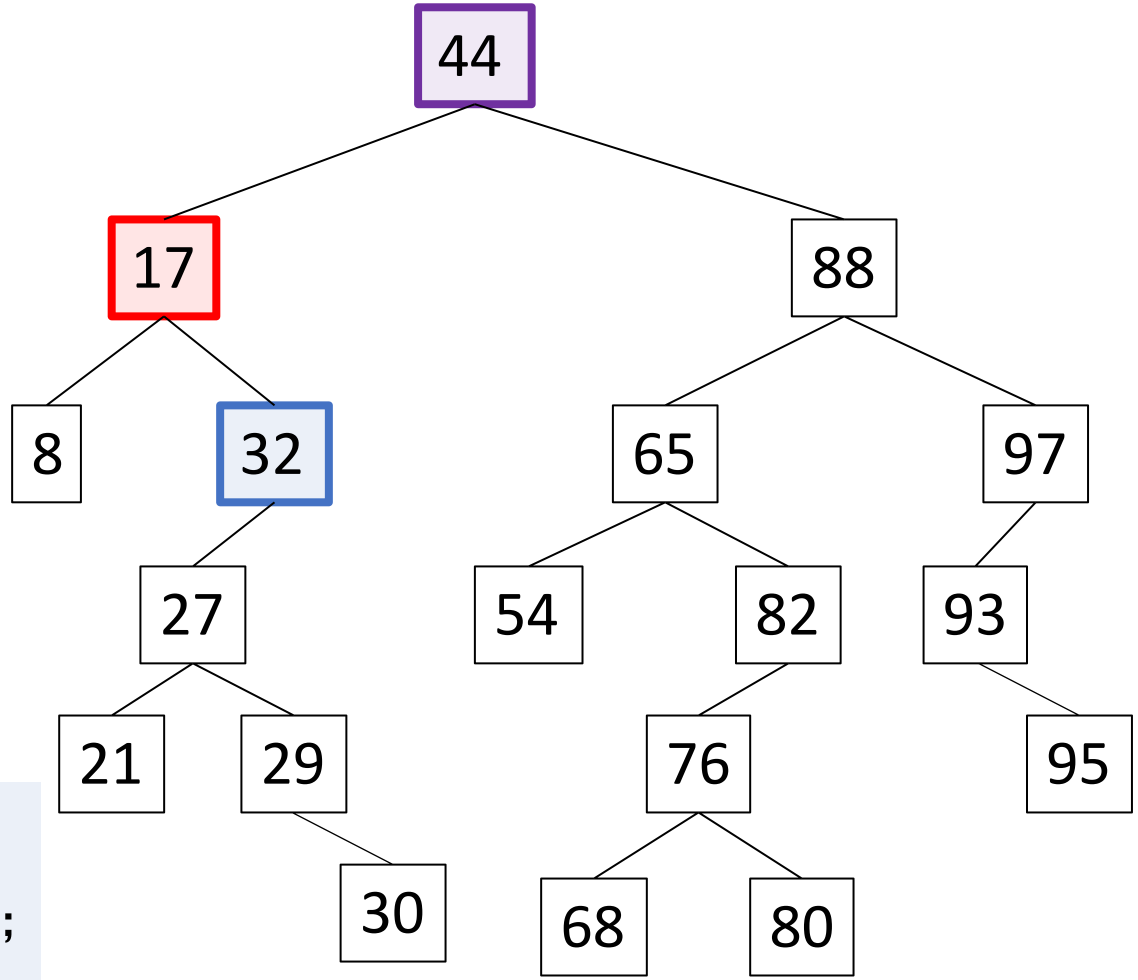
8

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(32) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

44

17

8

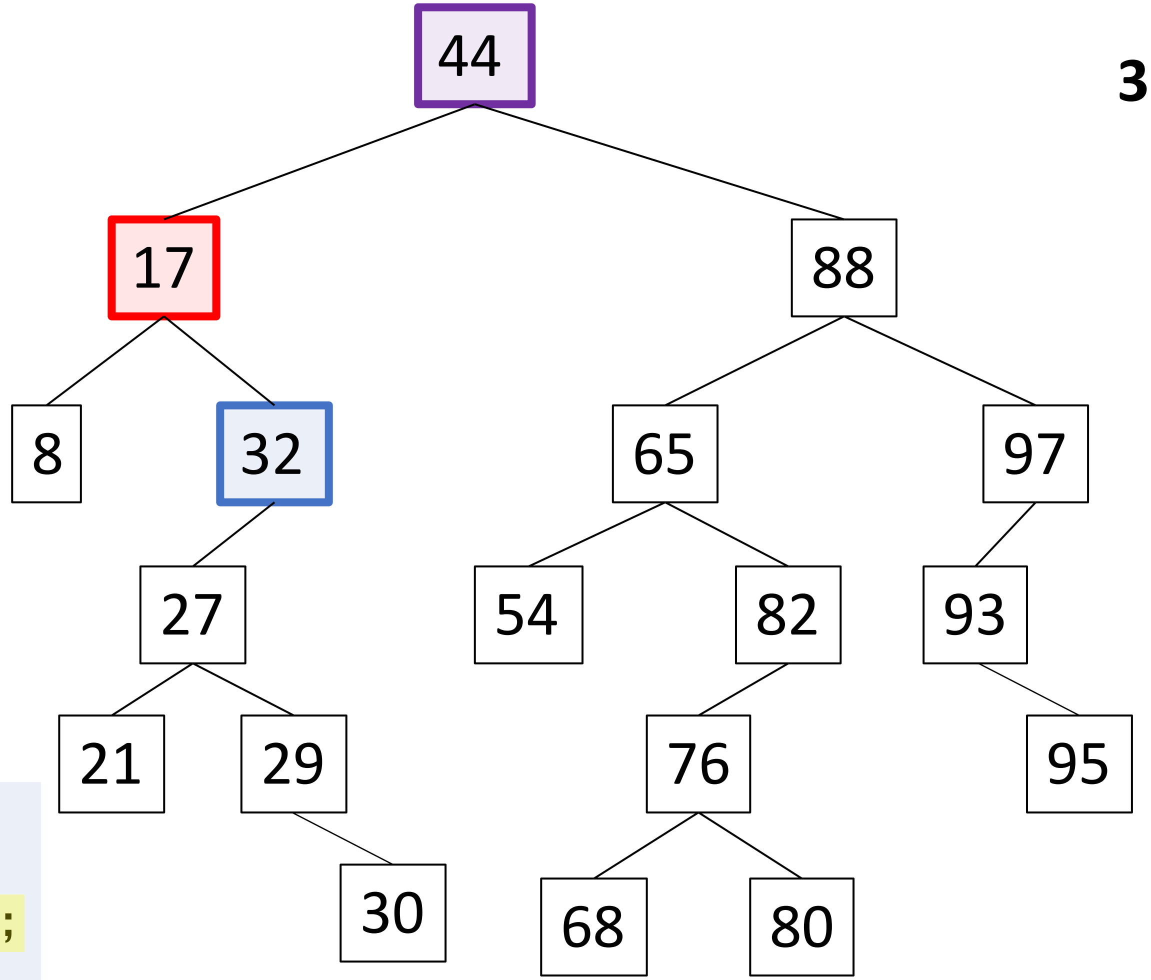
32

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(32) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

44

17

8

32

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
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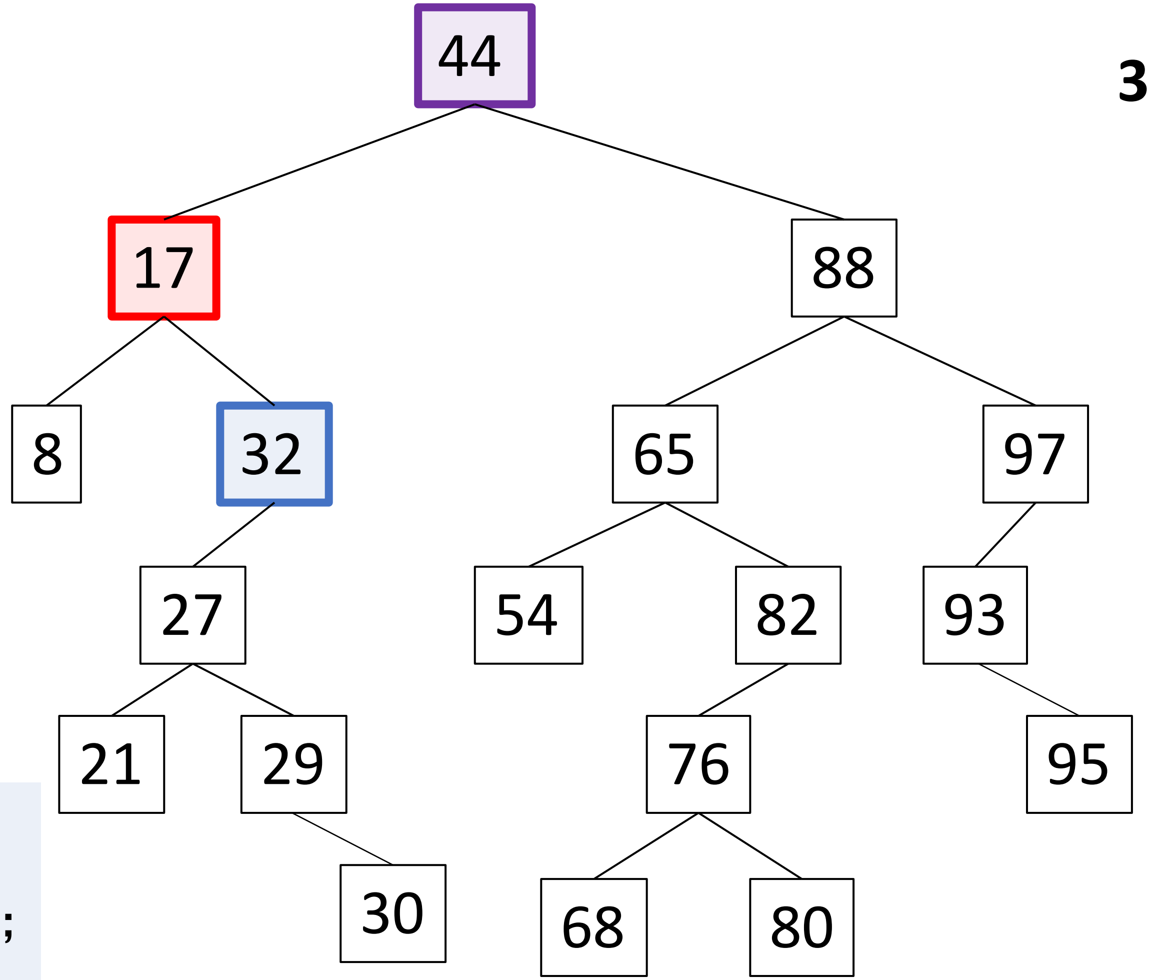


Binary Search Tree - Traversal

Output:

44

17

8

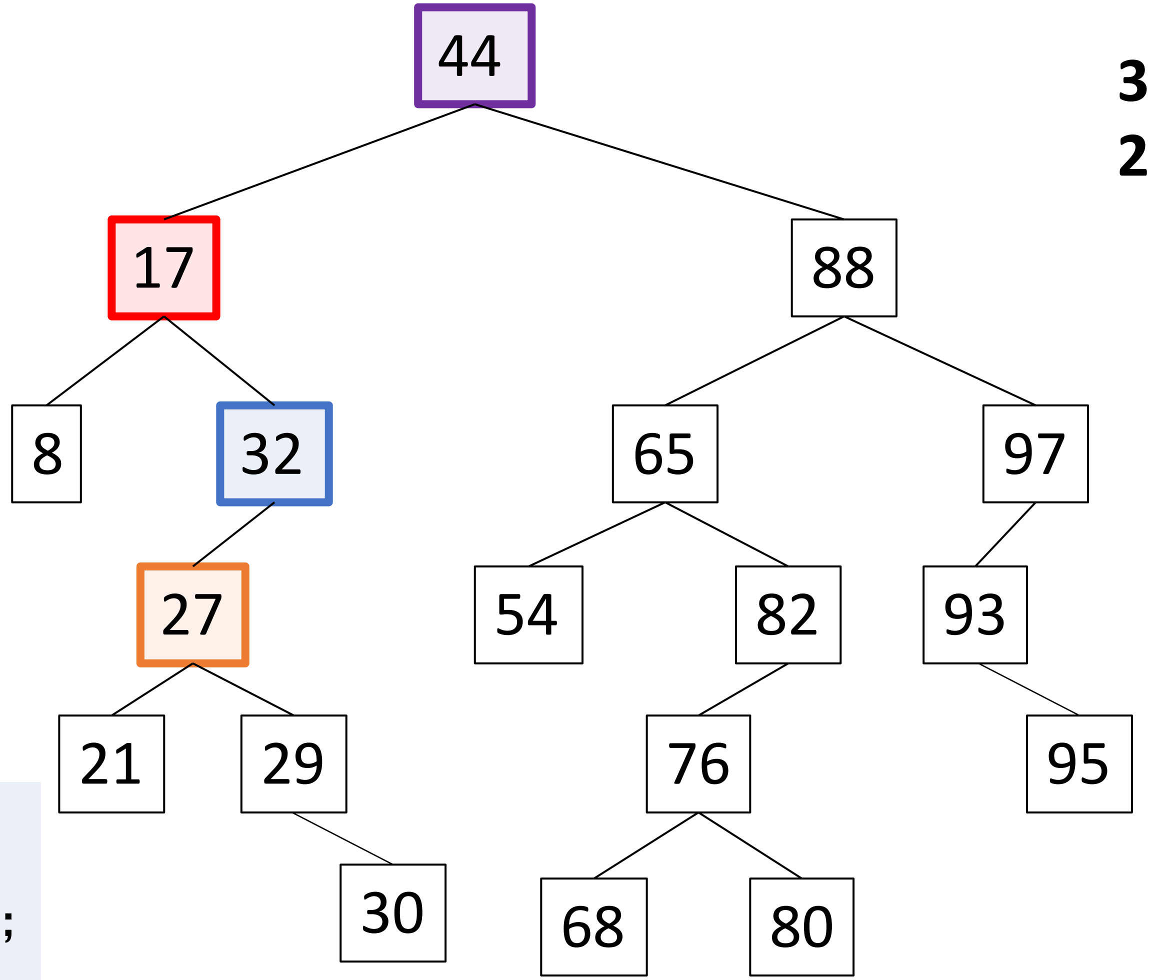
32

27

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(32) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



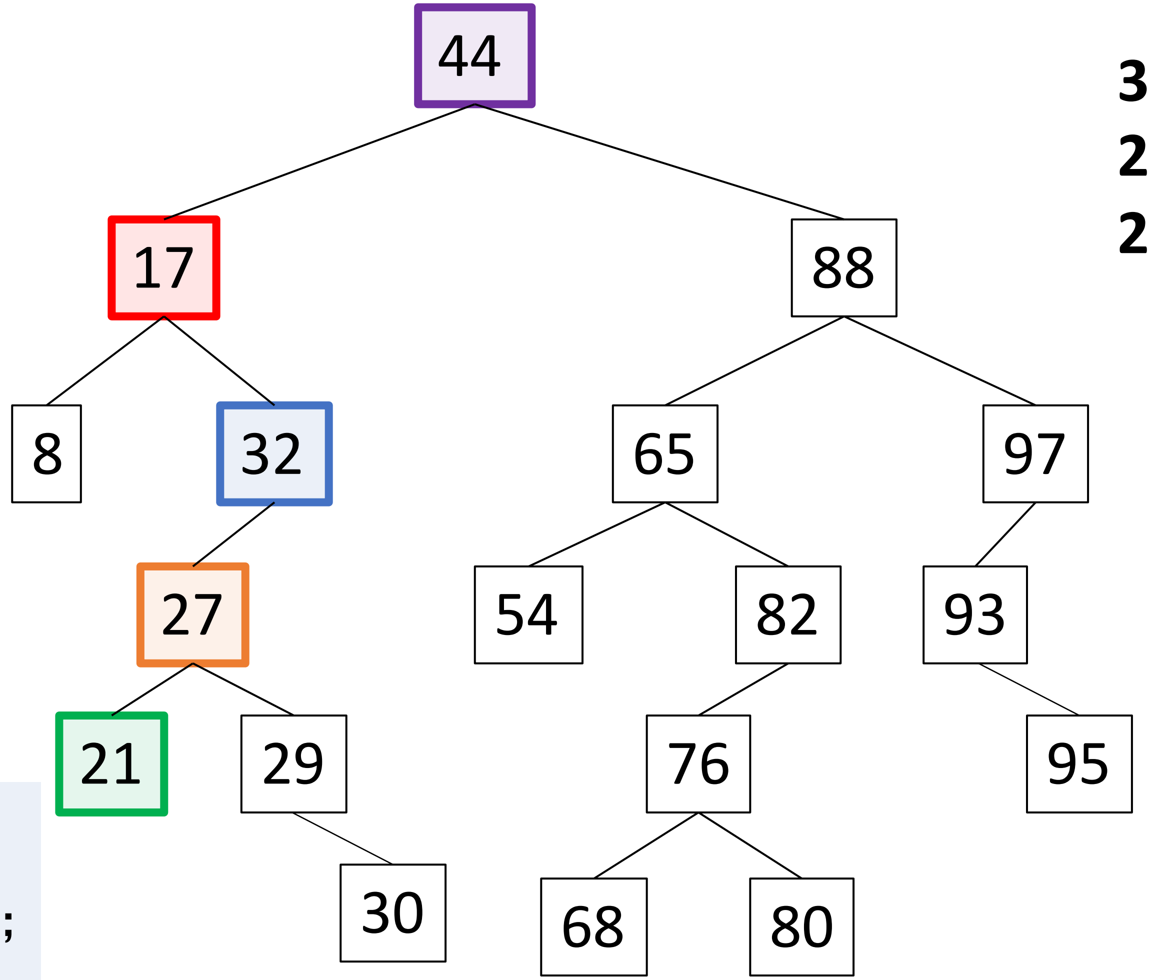
Output:
44
17
8
32
27
21

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(32) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());

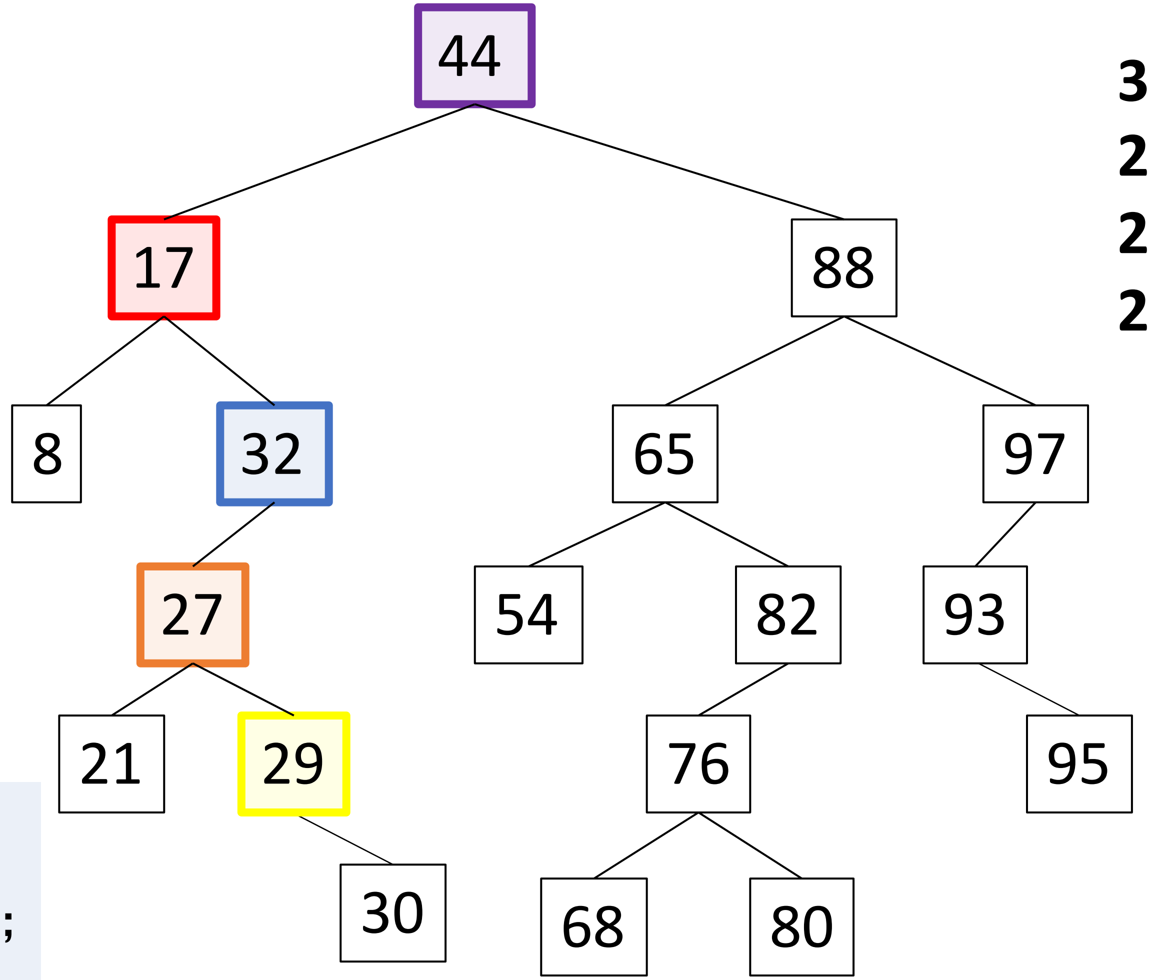
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());

        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(32) {
    if (n != null) {
        System.out.println(n.getValue());

        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

44

17

8

32

27

21

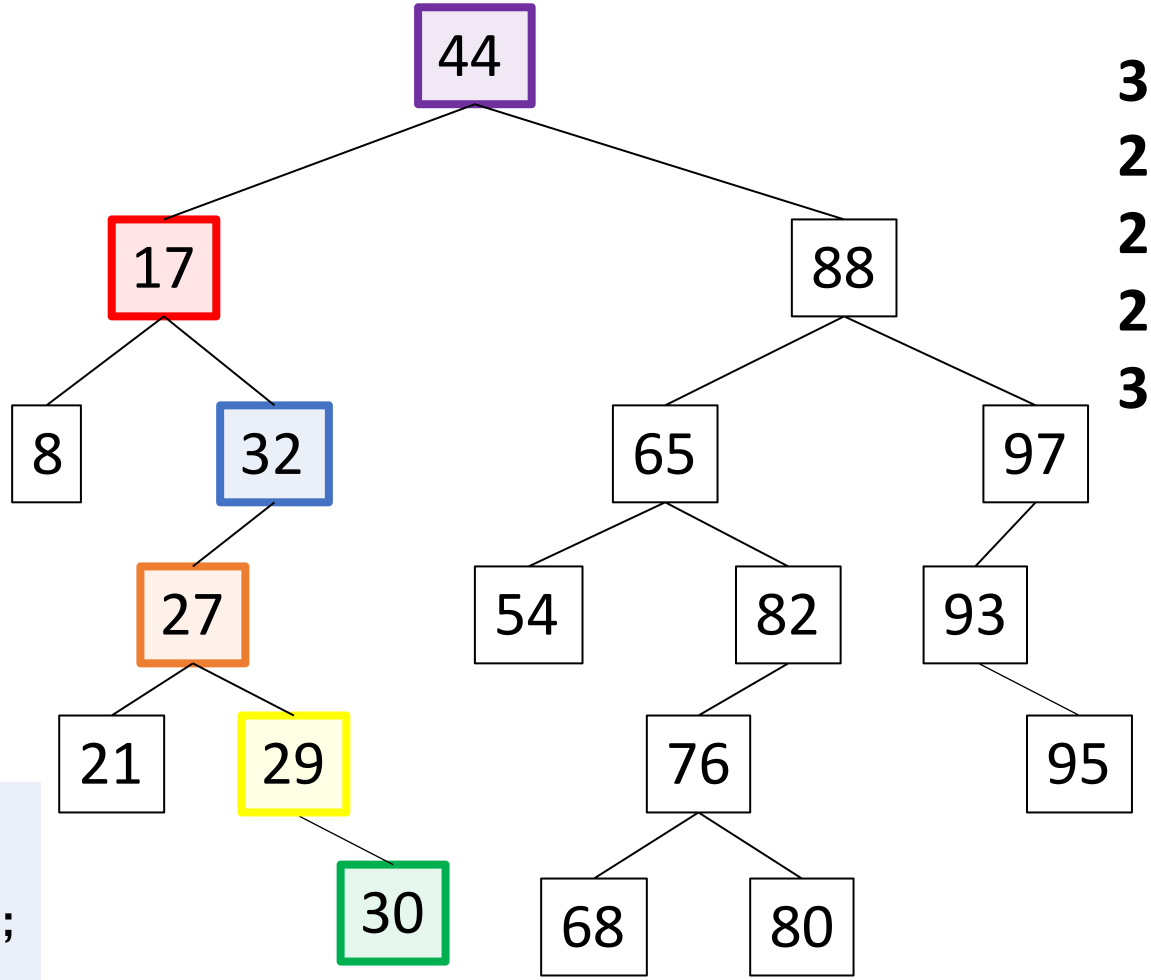
29

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(32) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

```
44
17
8
32
27
21
29
30
```

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());

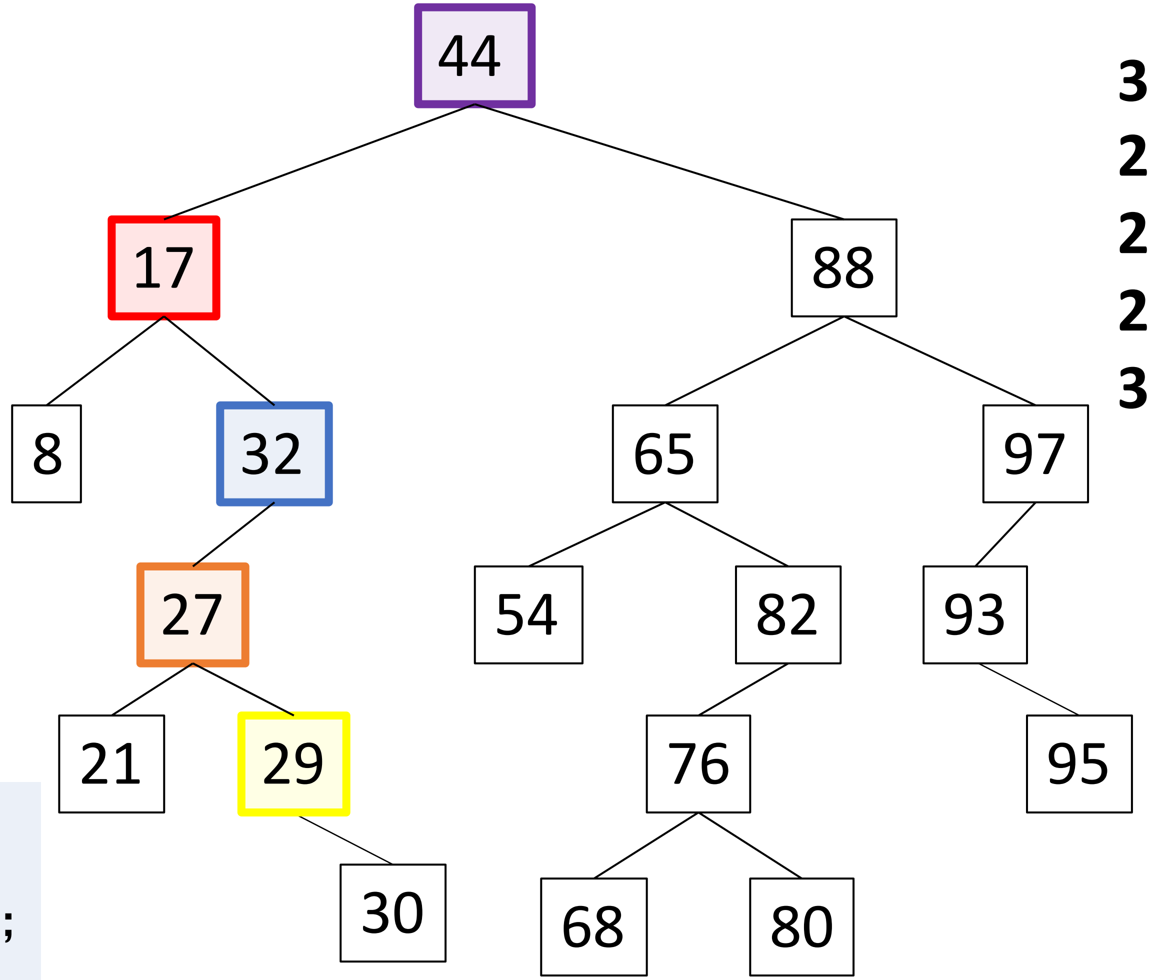
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());

        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(32) {
    if (n != null) {
        System.out.println(n.getValue());

        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

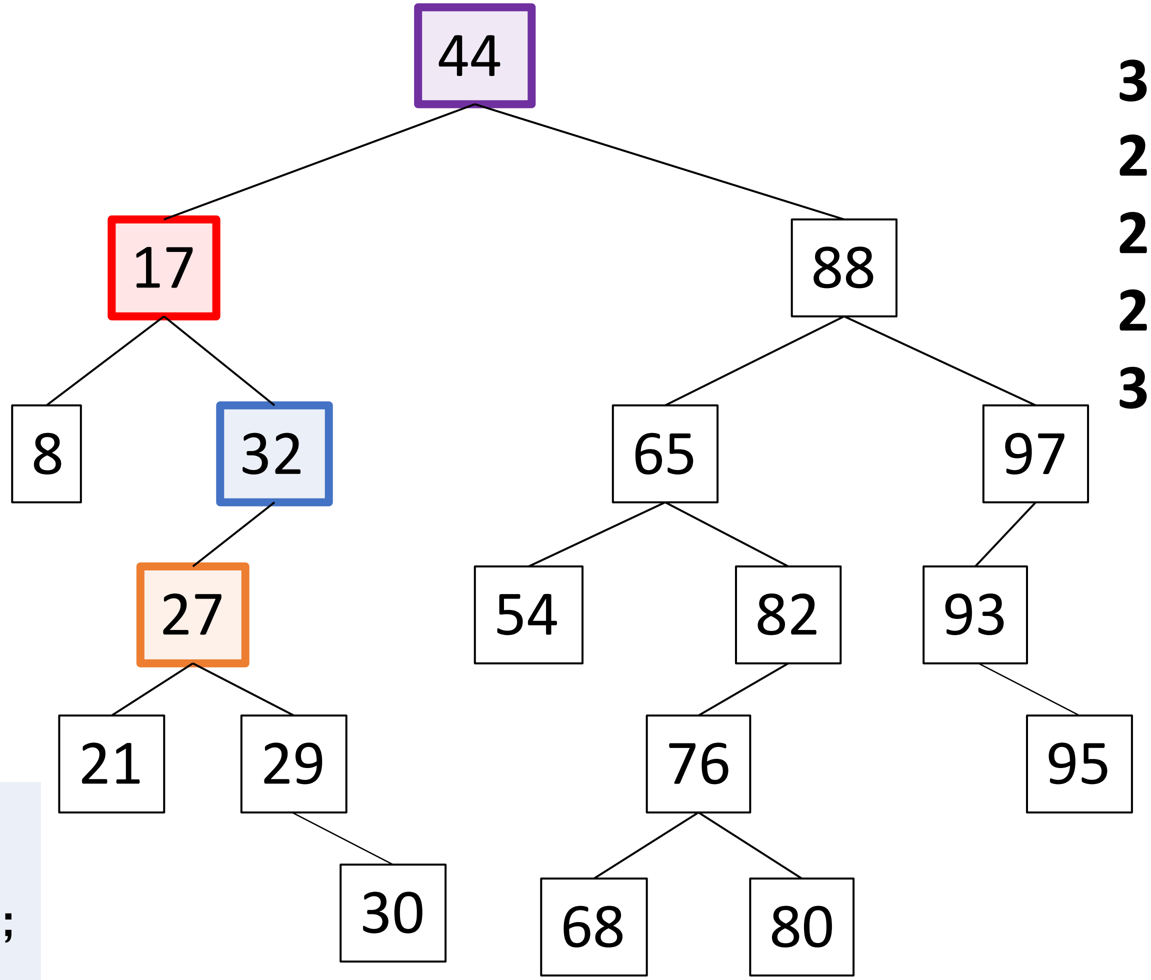
44
17
8
32
27
21
29
30

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(32) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

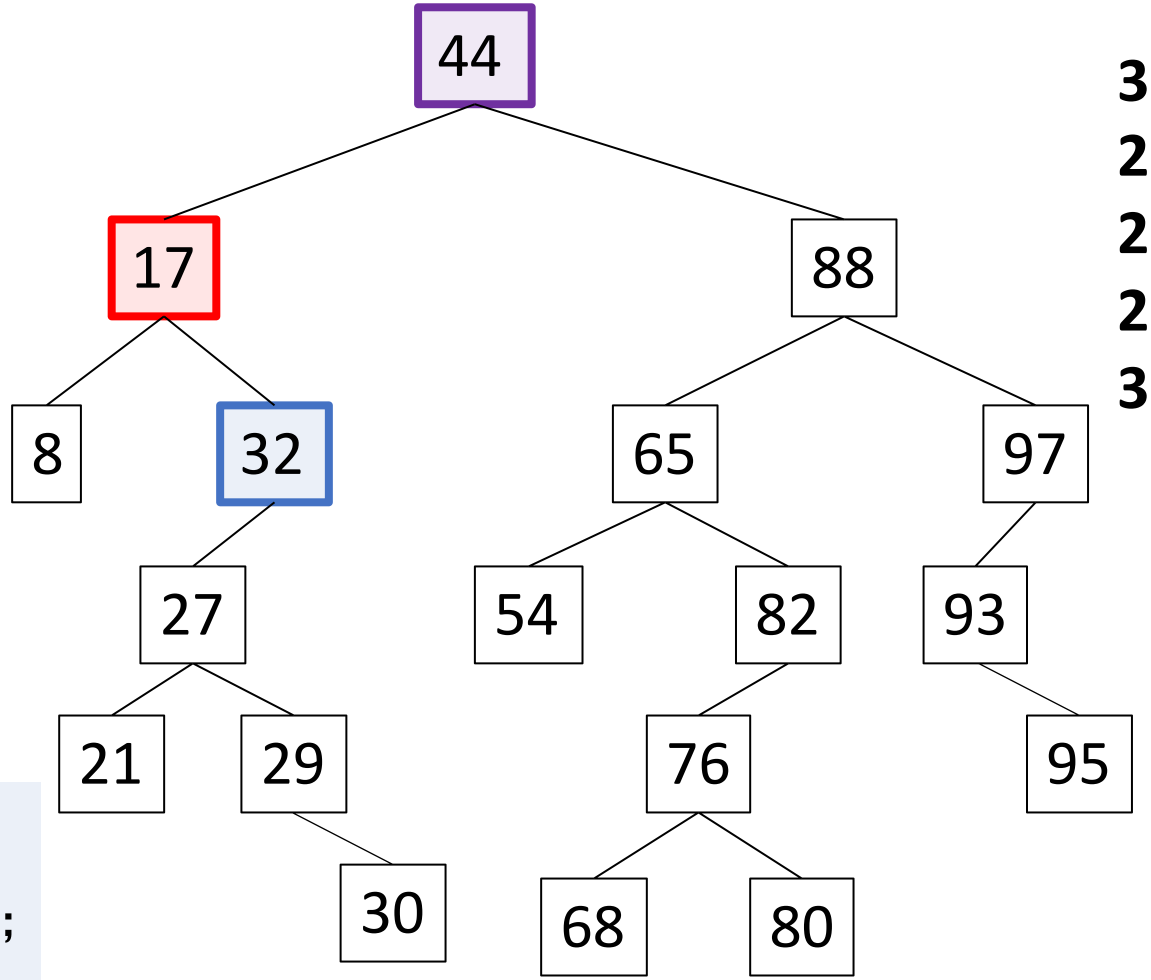
```
44
17
 8
32
27
21
29
30
```

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(32) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



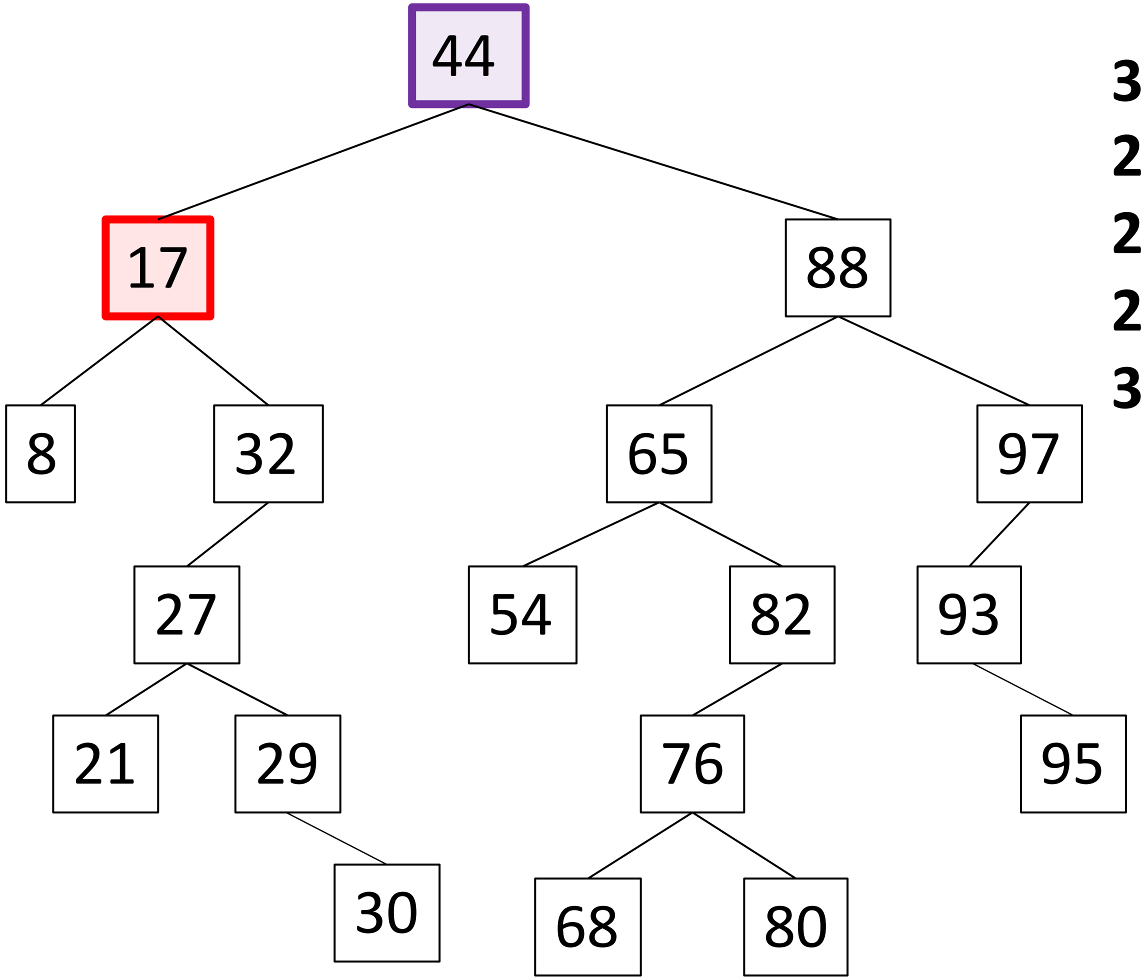
Output:

```
44
17
 8
32
27
21
29
30
```

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

44

17

8

32

27

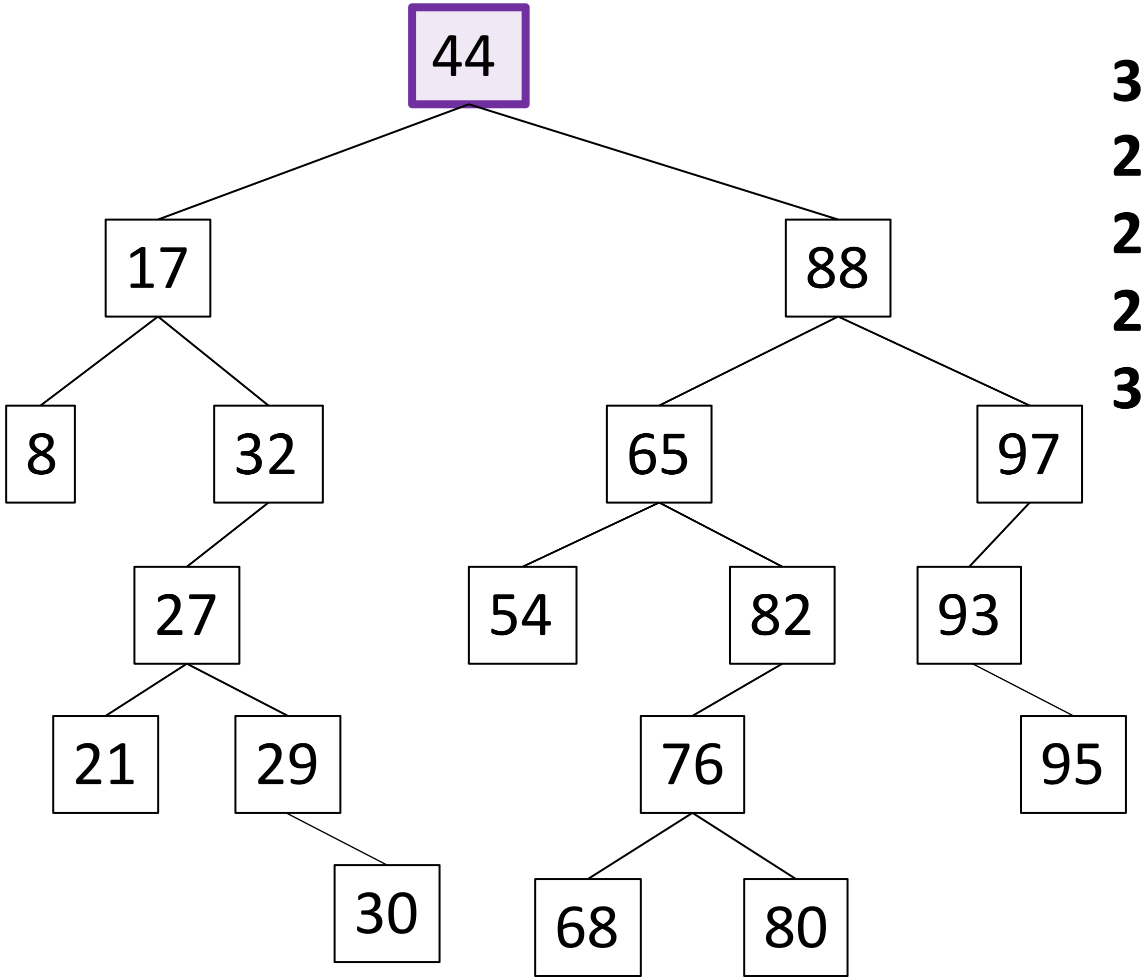
21

29

30

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

44

17

8

32

27

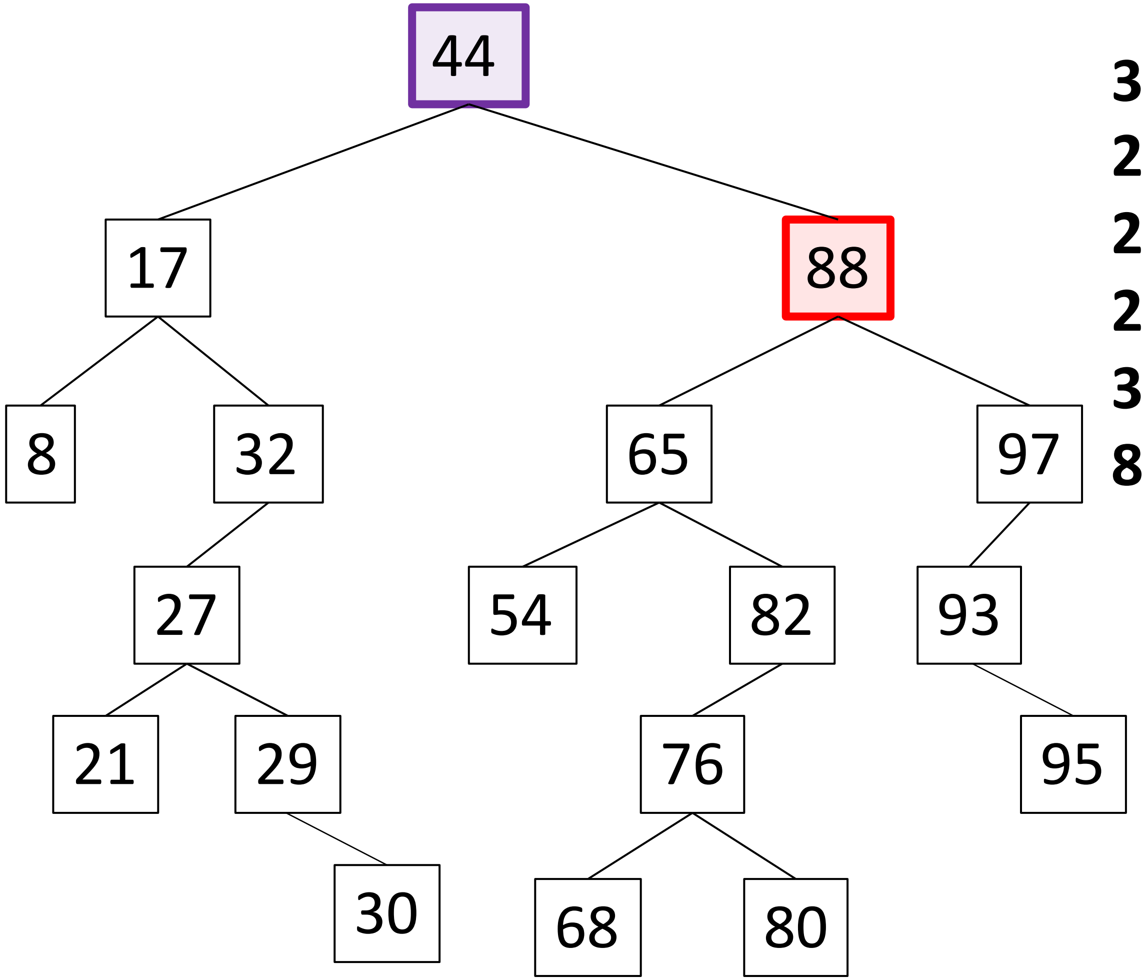
21

29

30

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

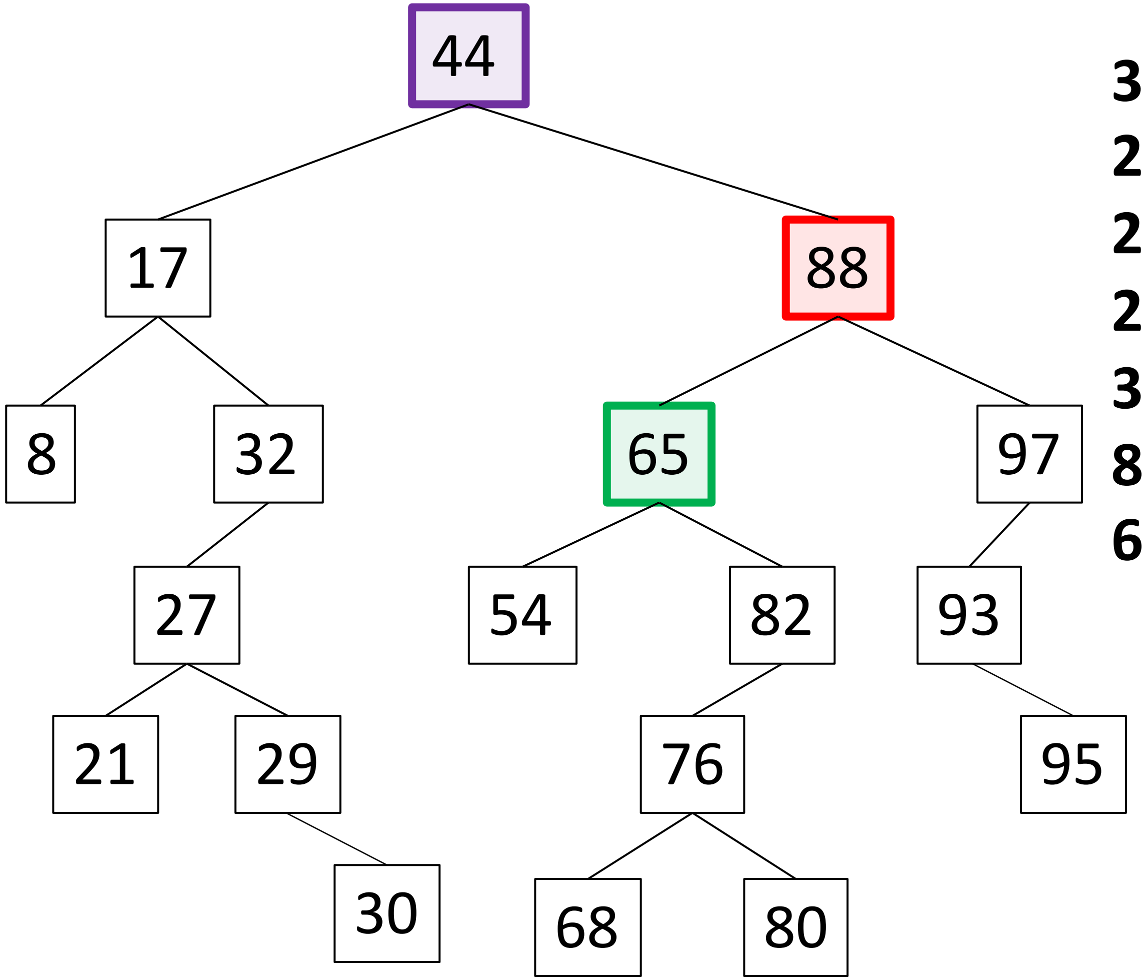


Output:

```
44
17
 8
32
27
21
29
30
88
```

Binary Search Tree - Traversal

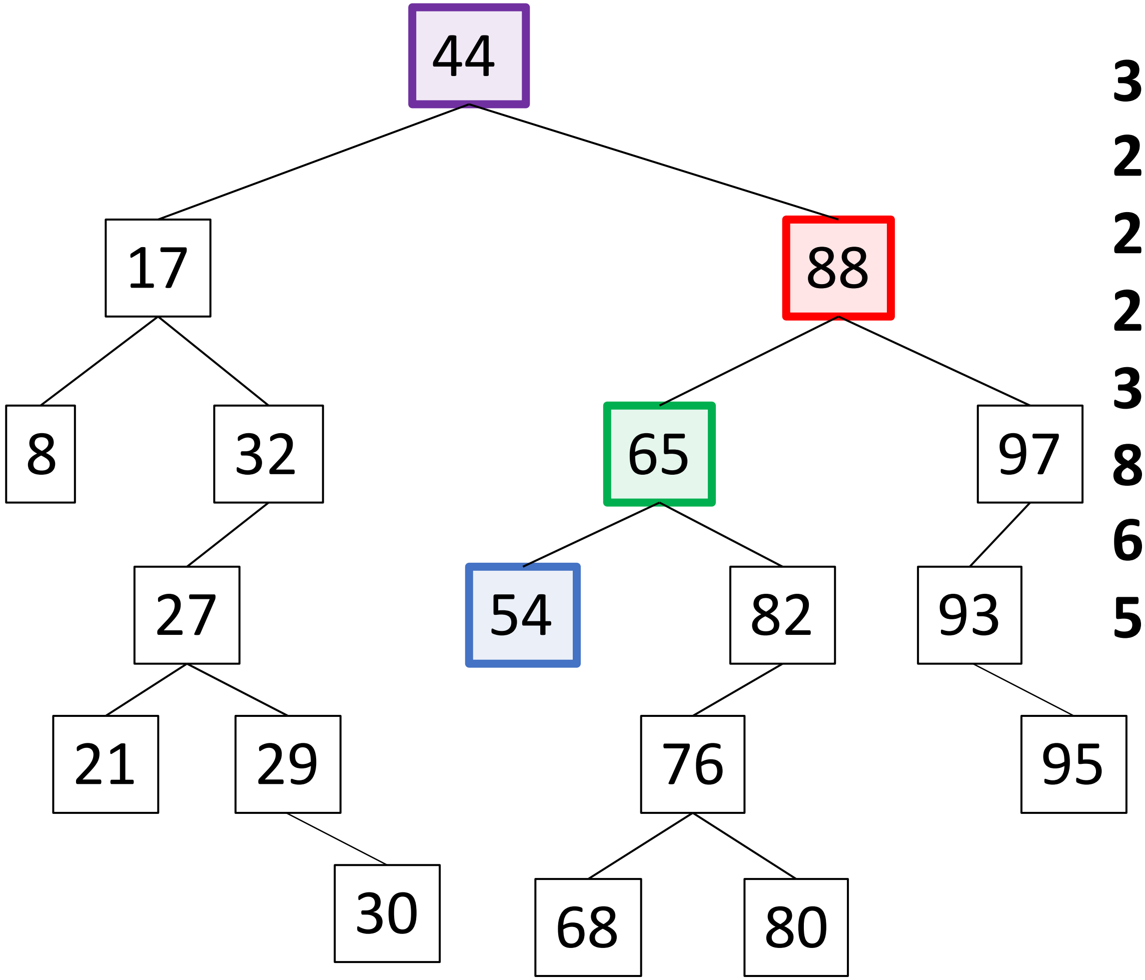
```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:
44
17
8
32
27
21
29
30
88
65

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

```
44
17
 8
32
27
21
29
30
88
65
54
```

Output:

44

17

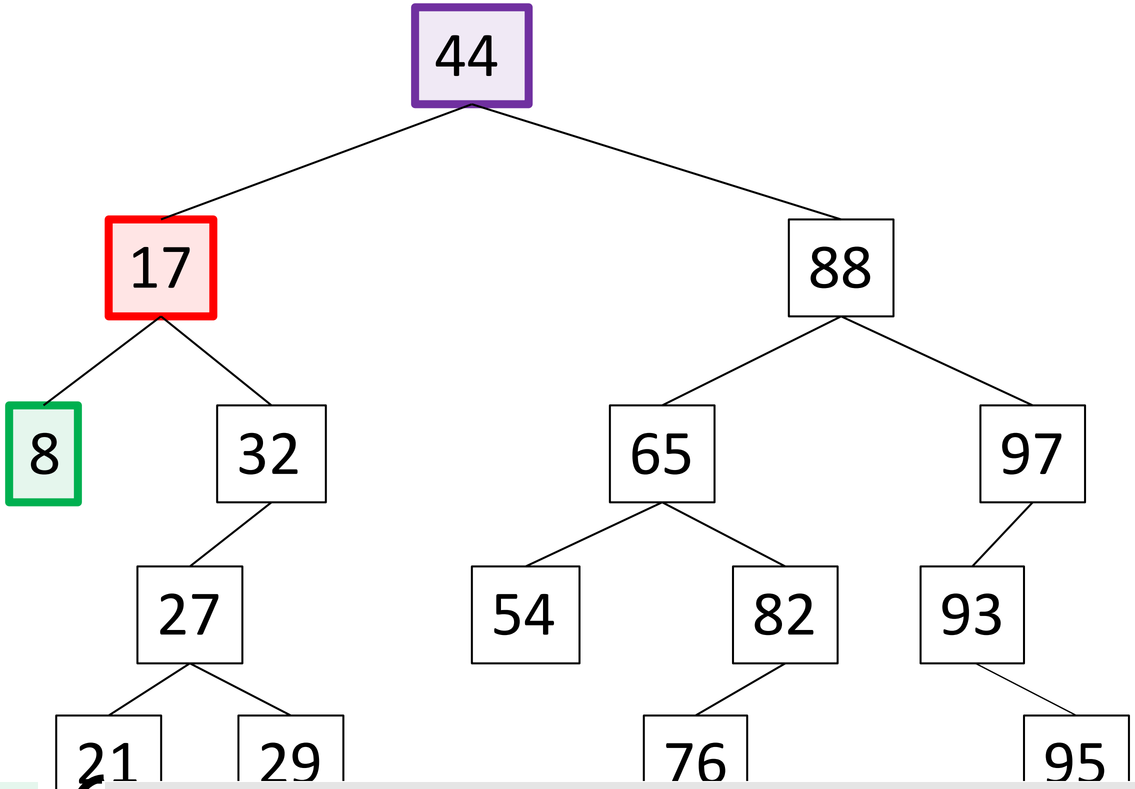
8

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

```
public void depthFirst(17) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

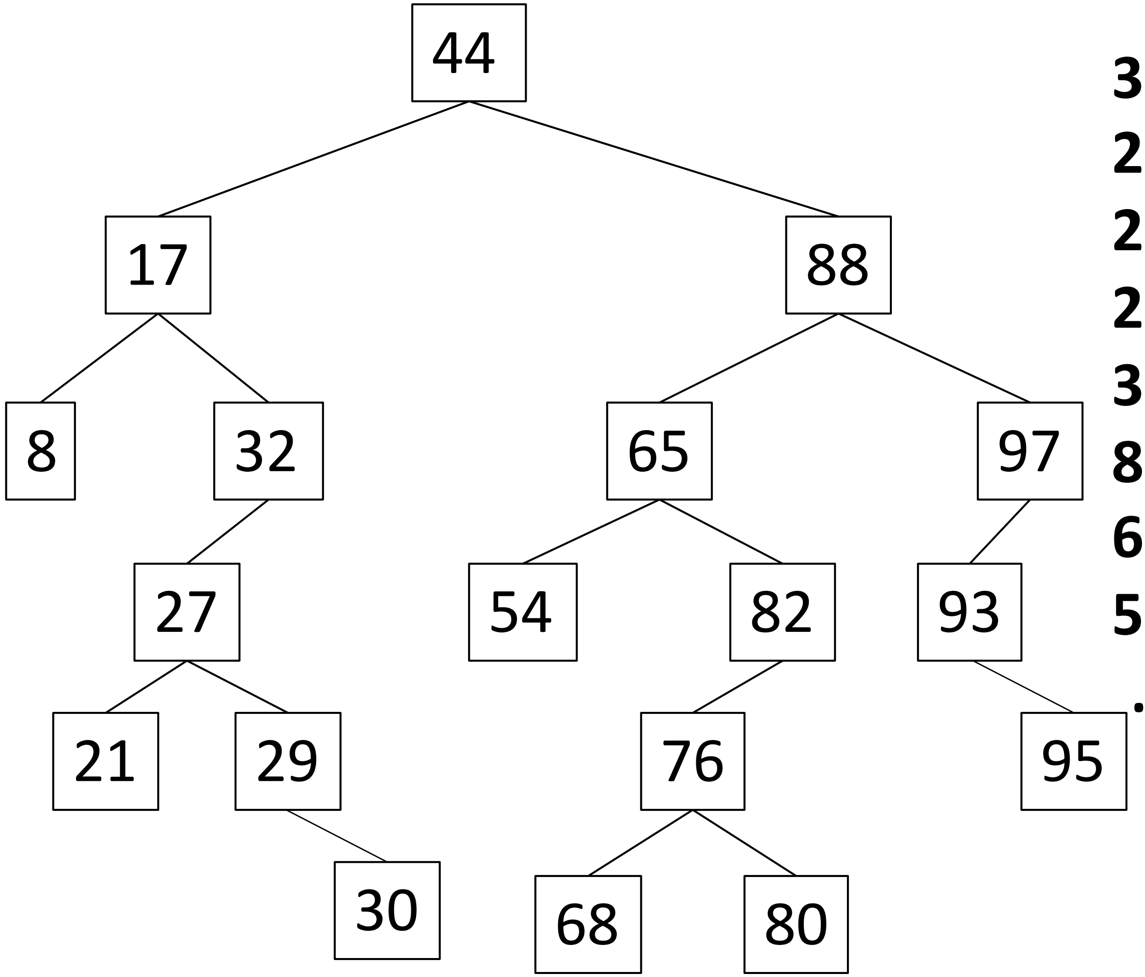
```
public void depthFirst(8) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



```
public void depthFirst(null) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```

Binary Search Tree - Traversal

```
public void depthFirst(44) {
    if (n != null) {
        System.out.println(n.getValue());
        depthFirst(n.getLeft());
        depthFirst(n.getRight());
    }
}
```



Output:

44

17

8

32

27

21

29

30

88

65

54

…