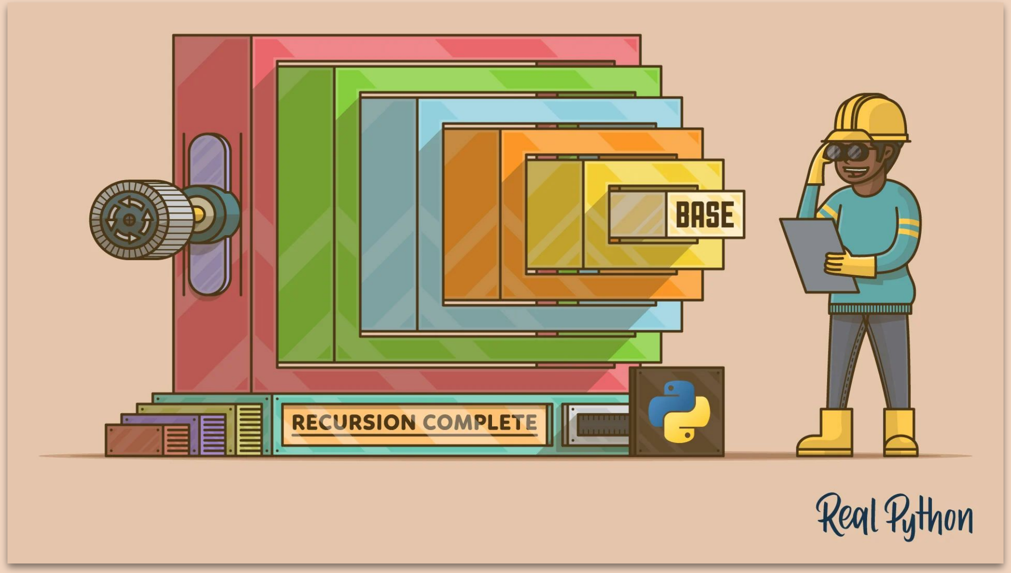
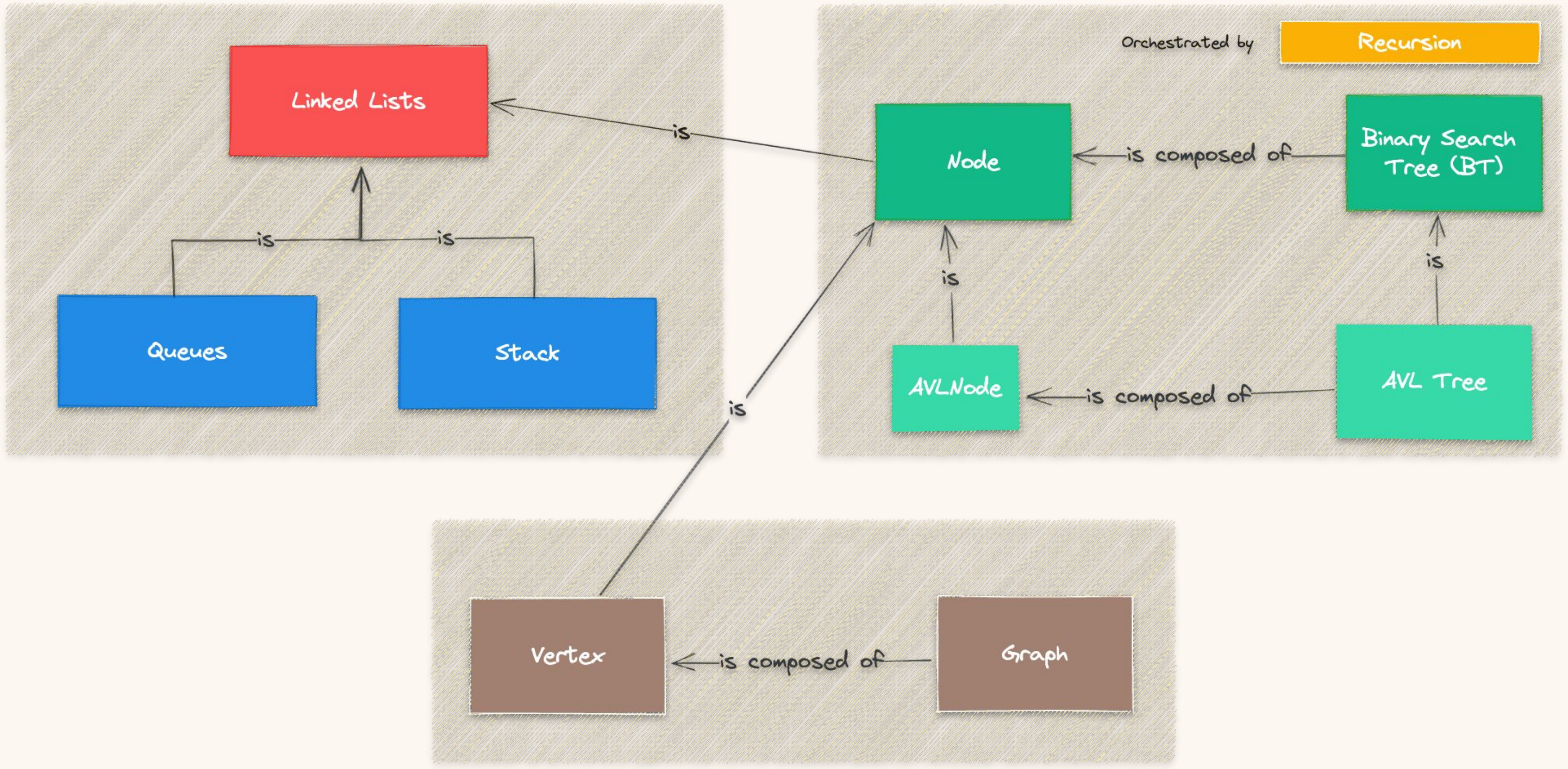
Week 02

Recursion
Binary Search
AVL Trees



Ivanovitch Silva
ivanovitch.silva@ufrn.br


Linked Lists
Queues
Stack
is
is
is
Orchestrated by
Recursion
Node
is composed of
Binary Search Tree (BT)
is
is
AVLNode
is composed of
AVL Tree
is
Vertex
is composed of
Graph

Developer skills

become a better developer by reading source code

methodology for this week

Data Structure Review

Recursion

The Importance of Studying Recursion

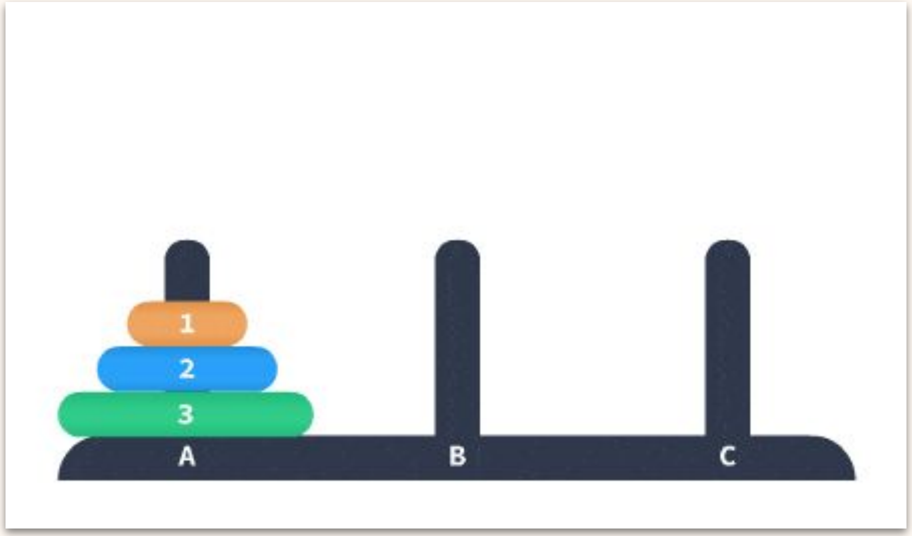
```python
def iterative_sum(values):
    total = 0
    for value in values:
        total += value
    return total

result = iterative_sum([1, 2, 3, 4, 5,
                        6, 7, 8, 9, 10])
```

```python
def recursive_sum(values):
    # Base case: the list is empty
    if not values:
        return 0
    # General case: the list is not empty
    return values[0] + recursive_sum(values[1:])

result = recursive_sum([1, 2, 3, 4, 5,
                        6, 7, 8, 9, 10])
```

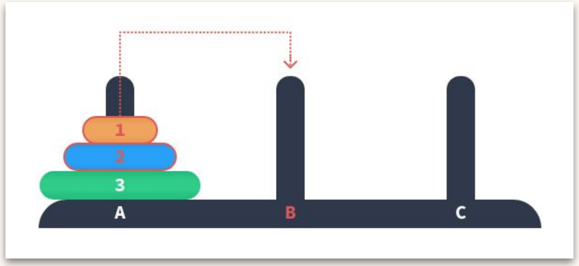
⚠ #stack_overflow

Some Problems are Naturally Recursive

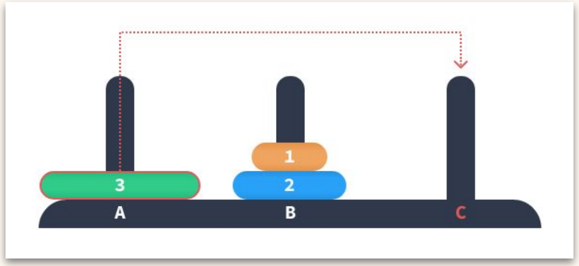
hanoi(N,origin, temp, dest)



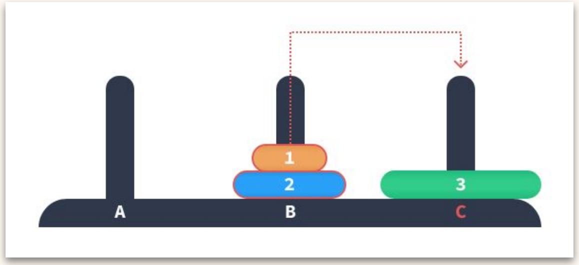
hanoi(N - 1, A, C, B)



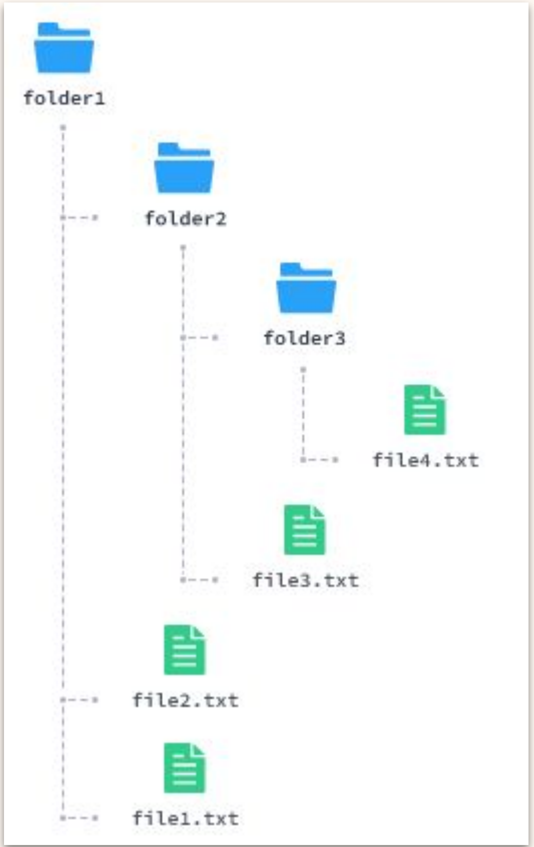
hanoi(1, A, - , C)



hanoi(N - 1, B, A, C)



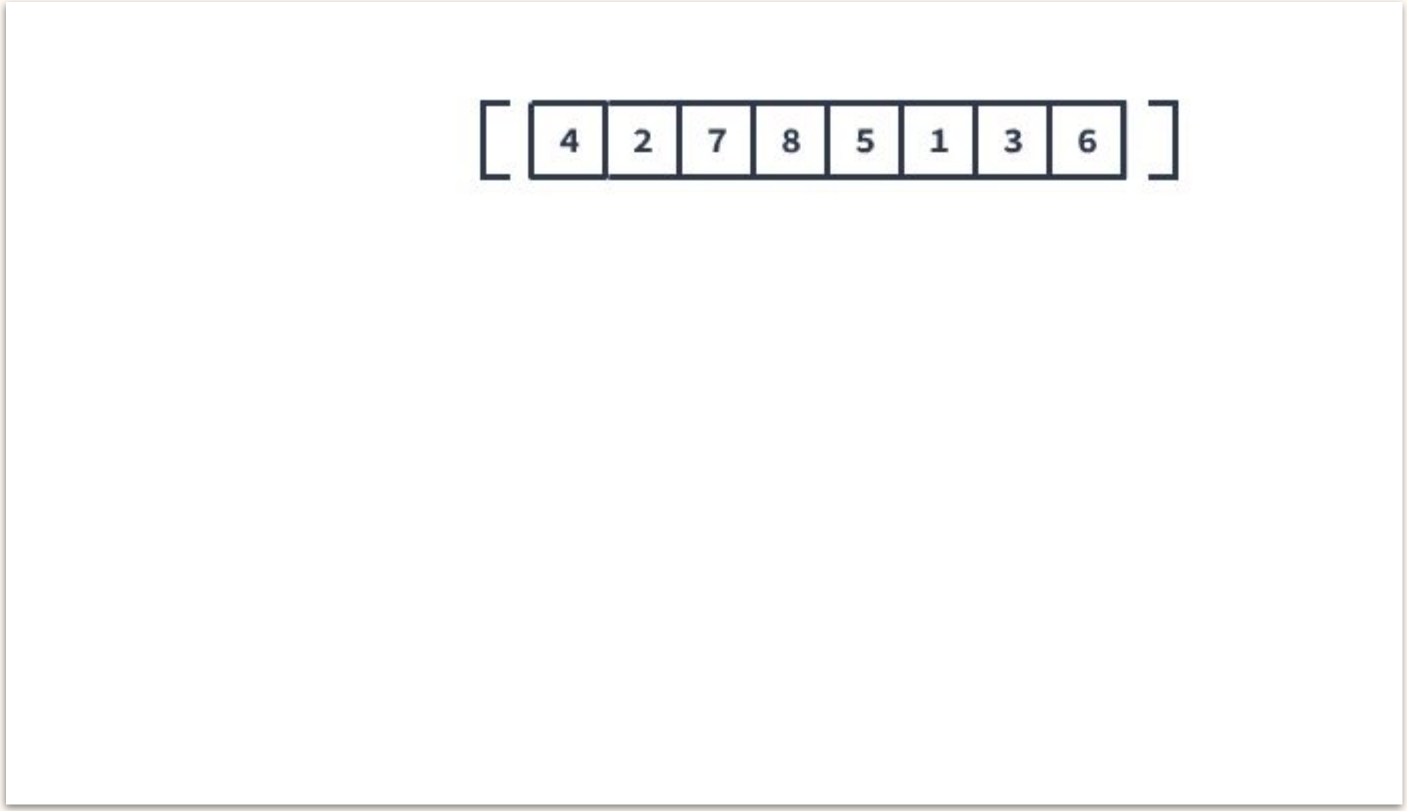
Some Problems are Naturally Recursive



```
import os
def list_files(current_path):
   #Base case
   if not os.path.isdir(current_path):
       print(current_path)
   else:
       # General case
       for name in os.listdir(current_path):
           file_path = os.path.join(current_path, name)
           list_files(file_path)

list_files("folder1")
```

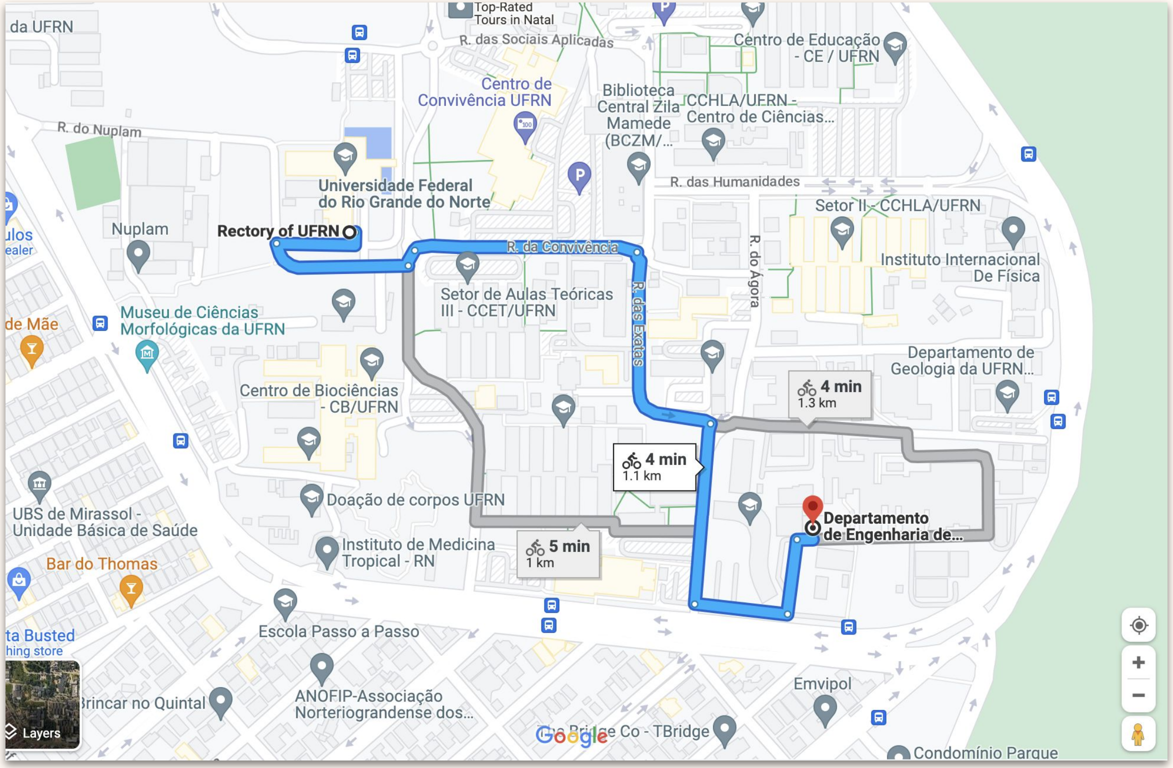
```
for file_name in os.listdir("folder1"):
    print(os.path.join("folder1", file_name))

folder1/file1.txt
folder1/file2.txt
folder1/folder2
```

Some Problems are Naturally Recursive



merge-sort

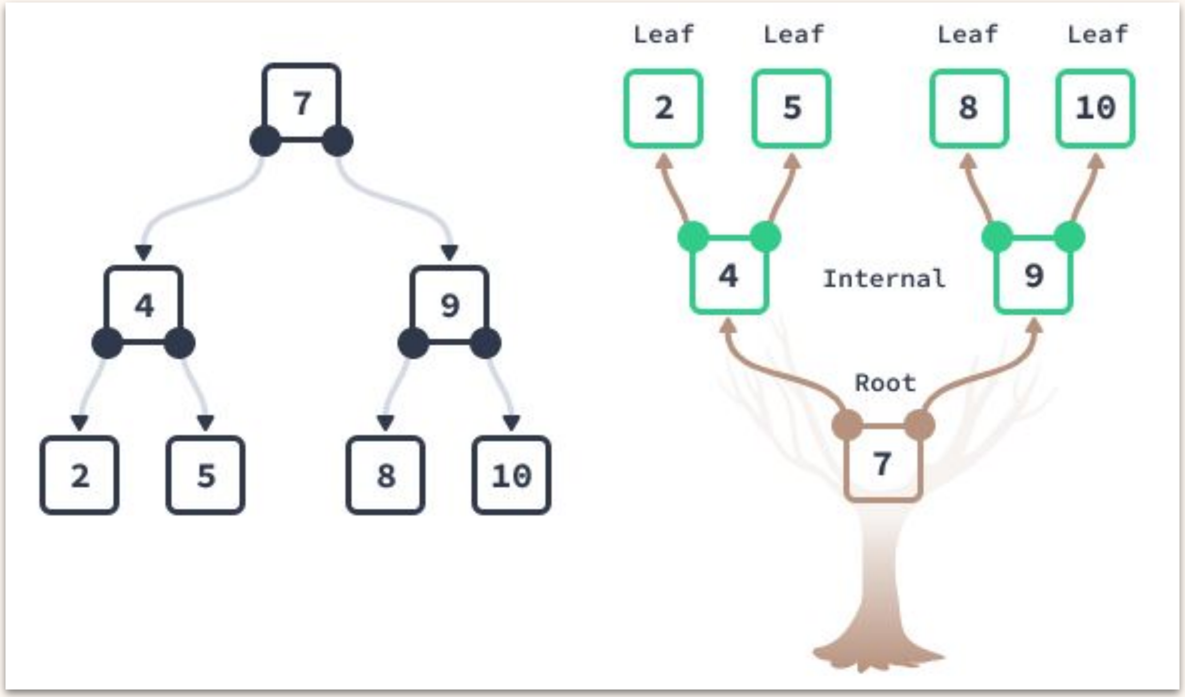
Some Problems are Naturally Recursive


Rectory of UFRN
Departamento de Engenharia de...
4 min
1.1 km
4 min
1.3 km
5 min
1 km
R. da Convivência
R. das Exatas
Universidade Federal do Rio Grande do Norte
Setor de Aulas Teóricas III - CCET/UFRN
Centro de Biociências - CB/UFRN
Departamento de Geologia da UFRN...
Instituto Internacional De Física
Setor II - CCHLA/UFRN
Biblioteca Central Zila Mamede (BCZM/...
Centro de Convivência UFRN
R. do Nuplam
Nuplam
Museu de Ciências Morfológicas da UFRN
Doação de corpos UFRN
Instituto de Medicina Tropical - RN
R. das Humanidades
R. do Ágora
Centro de Educação - CE / UFRN
CCHLA/UFRN - Centro de Ciências...
Layers

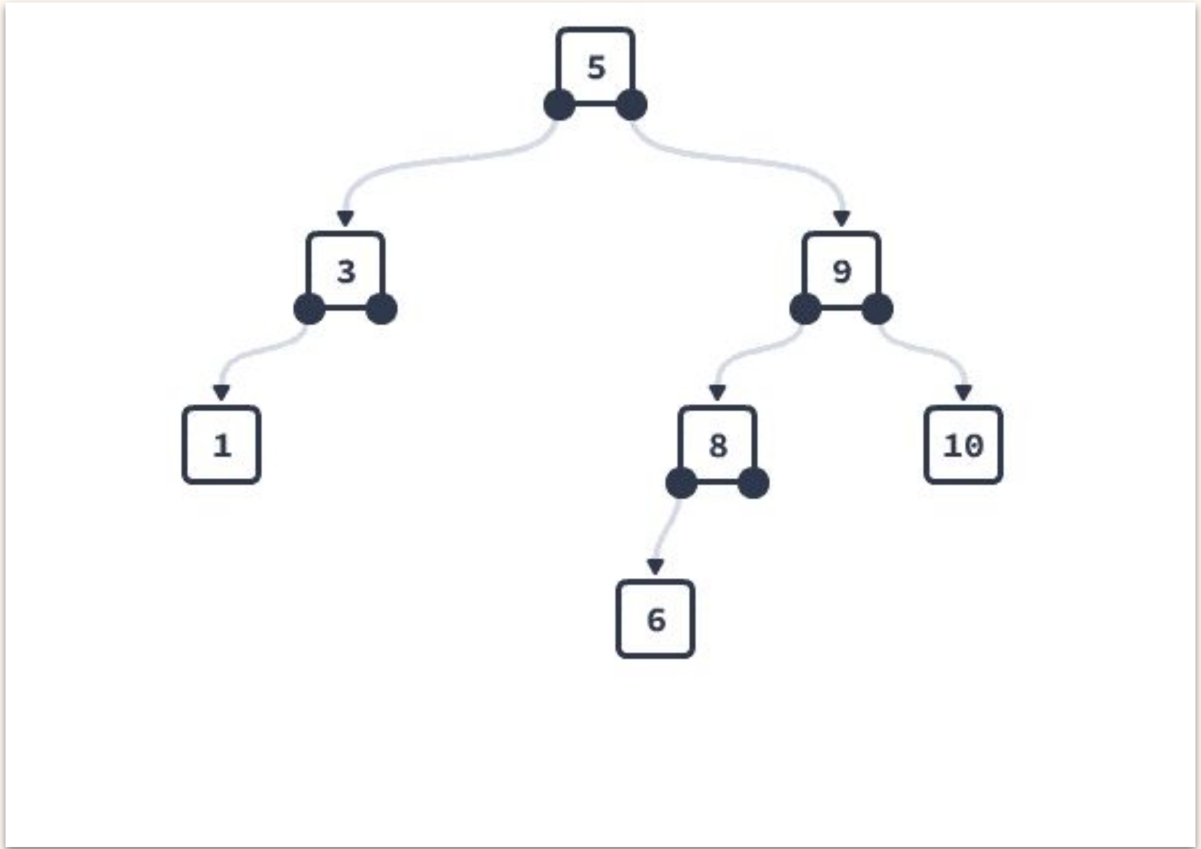
Data Structure Review

Binary Tree

Studying binary trees is important for several reasons

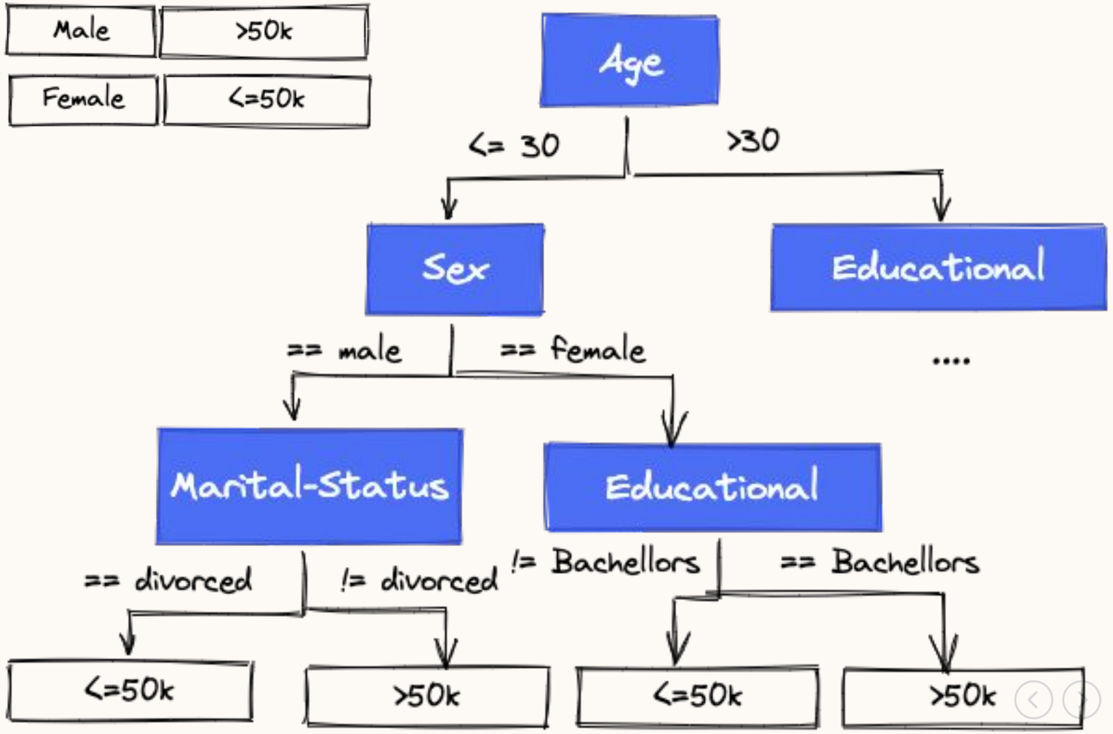


Efficient search, insertion, and deletion: Binary Search Tree (BST)

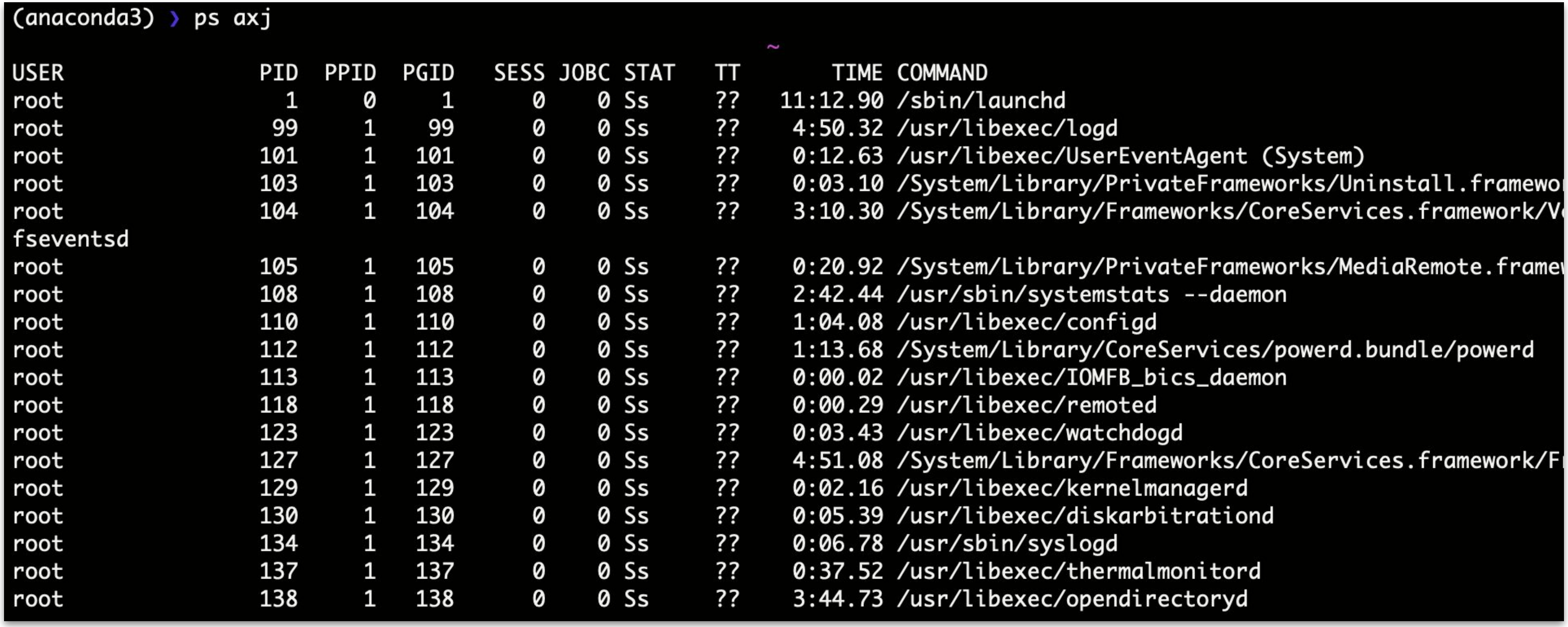


Age	Marital-Status	Educational	Sex	High-Income
28	Never-Married	Bachelors	Female	<=50k
46	Never-Married	Assoc-acdm	Female	<=50k
35	Married-civ-spouse	Some-college	Male	<=50k
27	Married-civ-spouse	Bachelors	Male	>50k
59	Divorced	Some-college	Female	<=50k

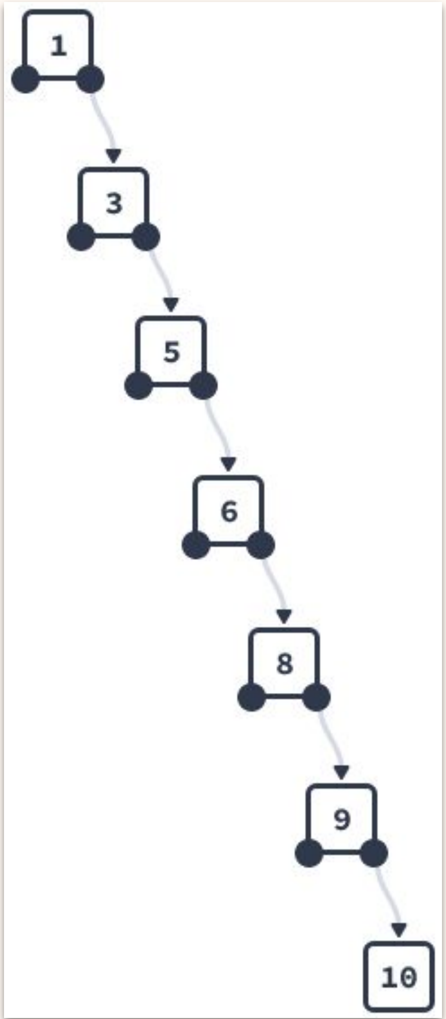
Decision Tree (classification)



ps axj

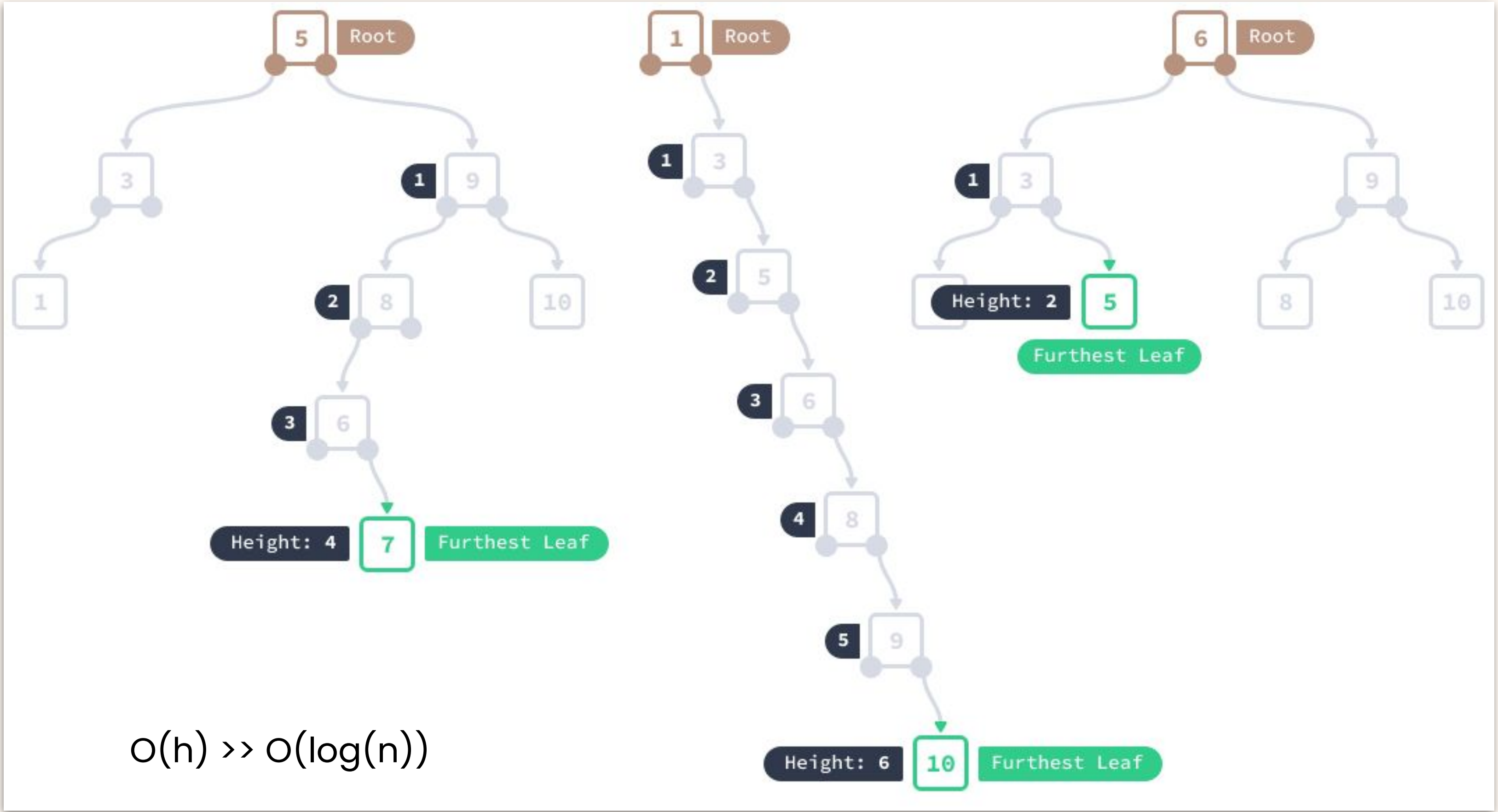


```
(anaconda3) ❯ ps axj
                                                                                       ~
USER                PID  PPID  PGID    SESS JOBC STAT    TT       TIME COMMAND
root                  1     0     1      0    0 Ss      ??   11:12.90 /sbin/launchd
root                 99     1    99      0    0 Ss      ??    4:50.32 /usr/libexec/logd
root                101     1   101      0    0 Ss      ??    0:12.63 /usr/libexec/UserEventAgent (System)
root                103     1   103      0    0 Ss      ??    0:03.10 /System/Library/PrivateFrameworks/Uninstall.framewo
root                104     1   104      0    0 Ss      ??    3:10.30 /System/Library/Frameworks/CoreServices.framework/V
fseventsd
root                105     1   105      0    0 Ss      ??    0:20.92 /System/Library/PrivateFrameworks/MediaRemote.frame
root                108     1   108      0    0 Ss      ??    2:42.44 /usr/sbin/systemstats --daemon
root                110     1   110      0    0 Ss      ??    1:04.08 /usr/libexec/configd
root                112     1   112      0    0 Ss      ??    1:13.68 /System/Library/CoreServices/powerd.bundle/powerd
root                113     1   113      0    0 Ss      ??    0:00.02 /usr/libexec/IOMFB_bics_daemon
root                118     1   118      0    0 Ss      ??    0:00.29 /usr/libexec/remoted
root                123     1   123      0    0 Ss      ??    0:03.43 /usr/libexec/watchdogd
root                127     1   127      0    0 Ss      ??    4:51.08 /System/Library/Frameworks/CoreServices.framework/F
root                129     1   129      0    0 Ss      ??    0:02.16 /usr/libexec/kernelmanagerd
root                130     1   130      0    0 Ss      ??    0:05.39 /usr/libexec/diskarbitrationd
root                134     1   134      0    0 Ss      ??    0:06.78 /usr/sbin/syslogd
root                137     1   137      0    0 Ss      ??    0:37.52 /usr/libexec/thermalmonitord
root                138     1   138      0    0 Ss      ??    3:44.73 /usr/libexec/opendirectoryd
```



What if we add the values in increasing order [1, 3, 5, 6, 8, 9, 10]?

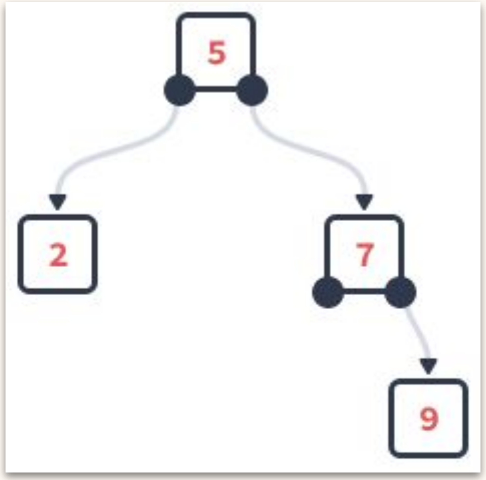
BST Complexity



O(h) >> O(log(n))

BST Implementation

```python
class Node:
   """
   A class representing a node in a binary search tree.

   Attributes:
   - value: the value of the node
   - left_child: the left child of the node
   - right_child: the right child of the node
   """

   def __init__(self, value):
       """
       Initializes a new instance of the Node class.

       Args:
       - value: the value of the node
       """
       self.value = value
       self.left_child = None
       self.right_child = None
```



```python
class BST:

    def __init__(self):
        """
        Initializes a new instance of the BST class.
        """
        self.root = None

    def add(self, value):
        """
        Adds a new node with the given value
Args:
        - value: the value of the node to add
        """
        if self.root is None:
            # The root does exist yet, create it
            self.root = Node(value)
        else:
            # Find the right place and insert value
            self._add_recursive(self.root, value)
```

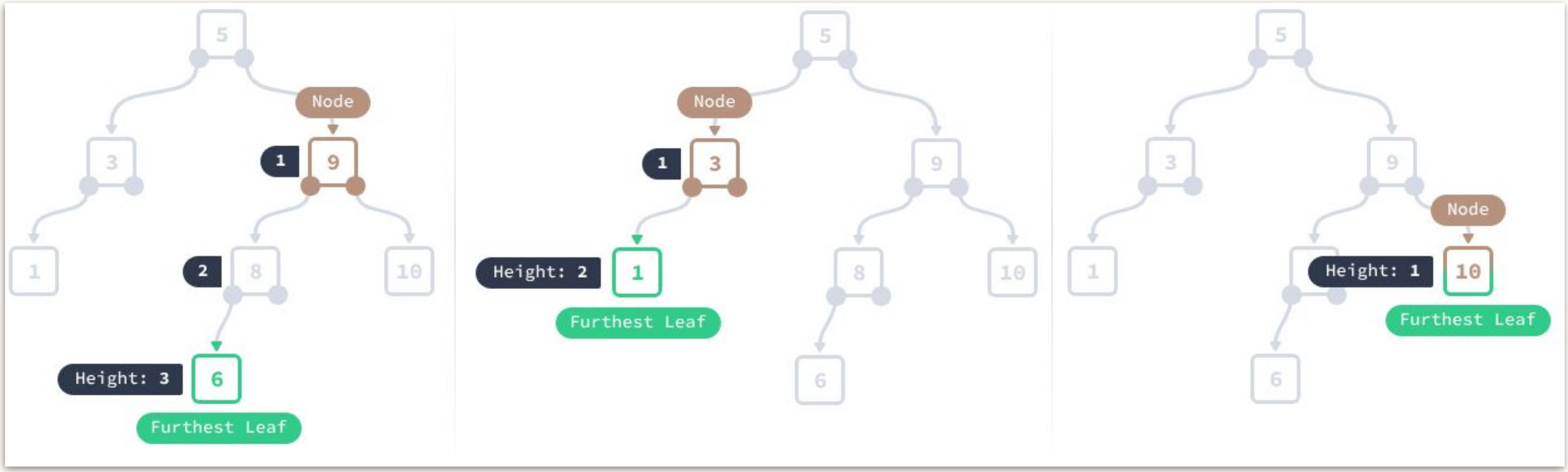
```python
def _add_recursive(self, current_node, value):
 """
 A helper method to recursively traverse the tree and find the
correct position to add the new node.

 Args:
 - current_node: the current node to traverse
 - value: the value of the node to add
 """
 if value <= current_node.value:
     # Go to the left
     if current_node.left_child is None:
         current_node.left_child = Node(value)
     else:
         self._add_recursive(current_node.left_child, value)
 else:
     # Go to the right
     if current_node.right_child is None:
         current_node.right_child = Node(value)
     else:
         self._add_recursive(current_node.right_child, value)
```

```python
def contains(self, value):
       """
       Checks whether a node with the given
value is present in the tree.

       Args:
       - value: the value to search for

       Returns:
       - True if a node with the given value is
found, False otherwise
       """
       return self._contains(self.root, value)
```

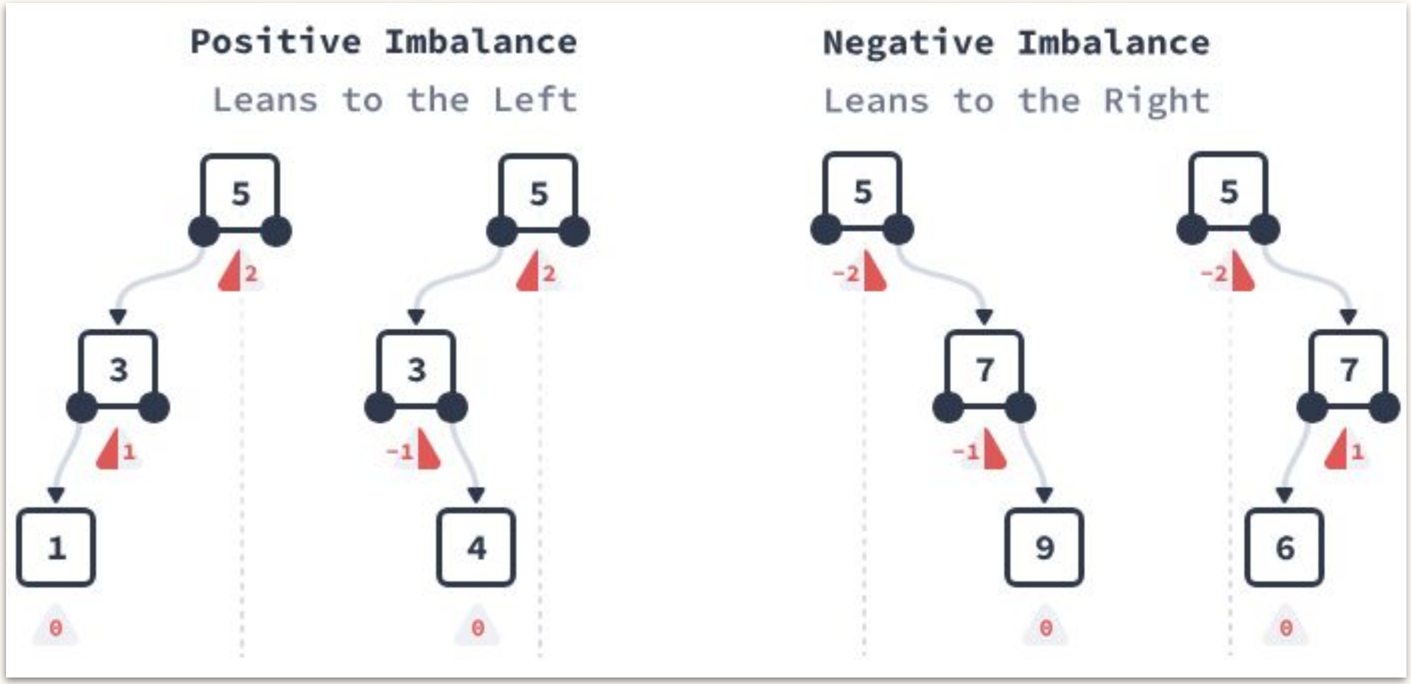
```python
   def _contains(self, current_node, value):
       """
       A helper method to recursively traverse the tree and find
the node with the given value.

       Args:
       - current_node: the current node to traverse
       - value: the value to search for

       Returns:
       - True if a node with the given value is found, False
otherwise
       """
       if current_node is None:
           return False
       if current_node.value == value:
           return True
       if value < current_node.value:
           return self._contains(current_node.left_child, value)
       return self._contains(current_node.right_child, value)
```

Data Structure Review

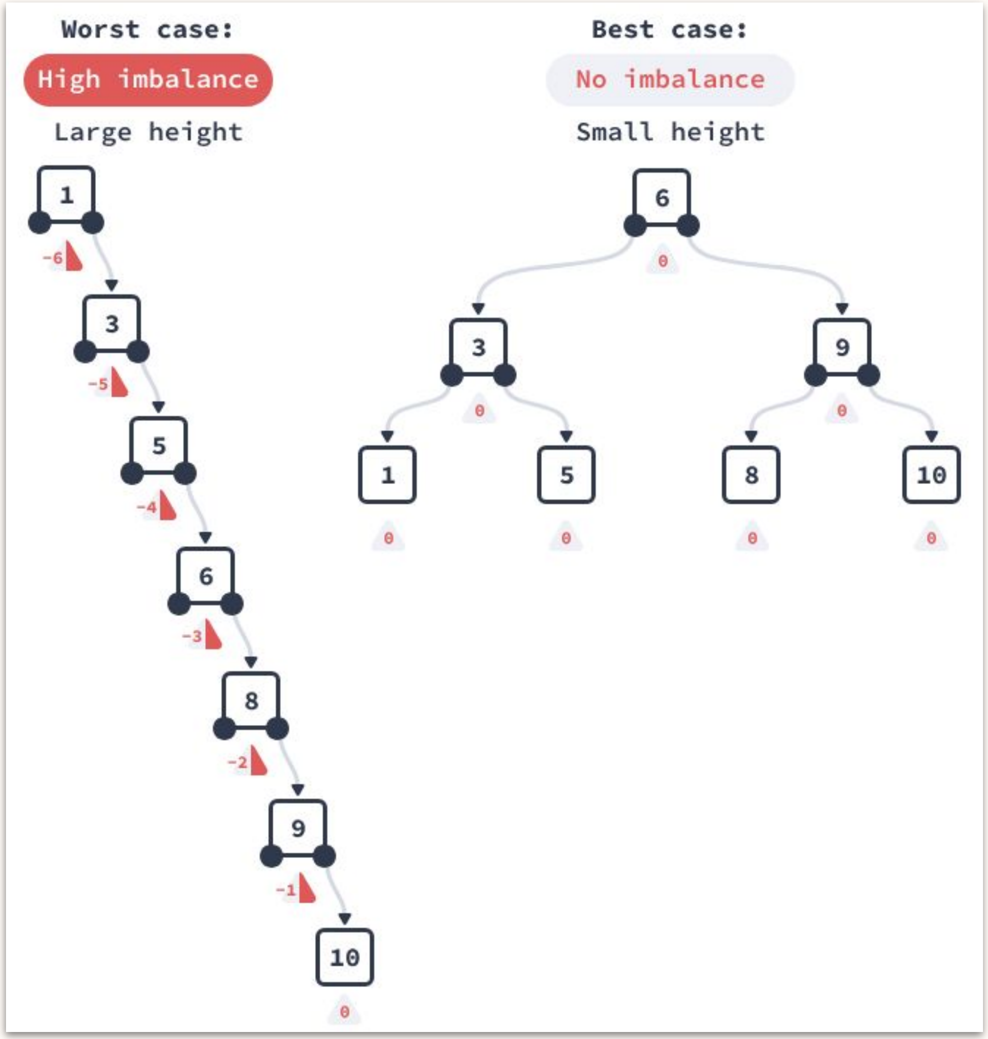
AVL Tree



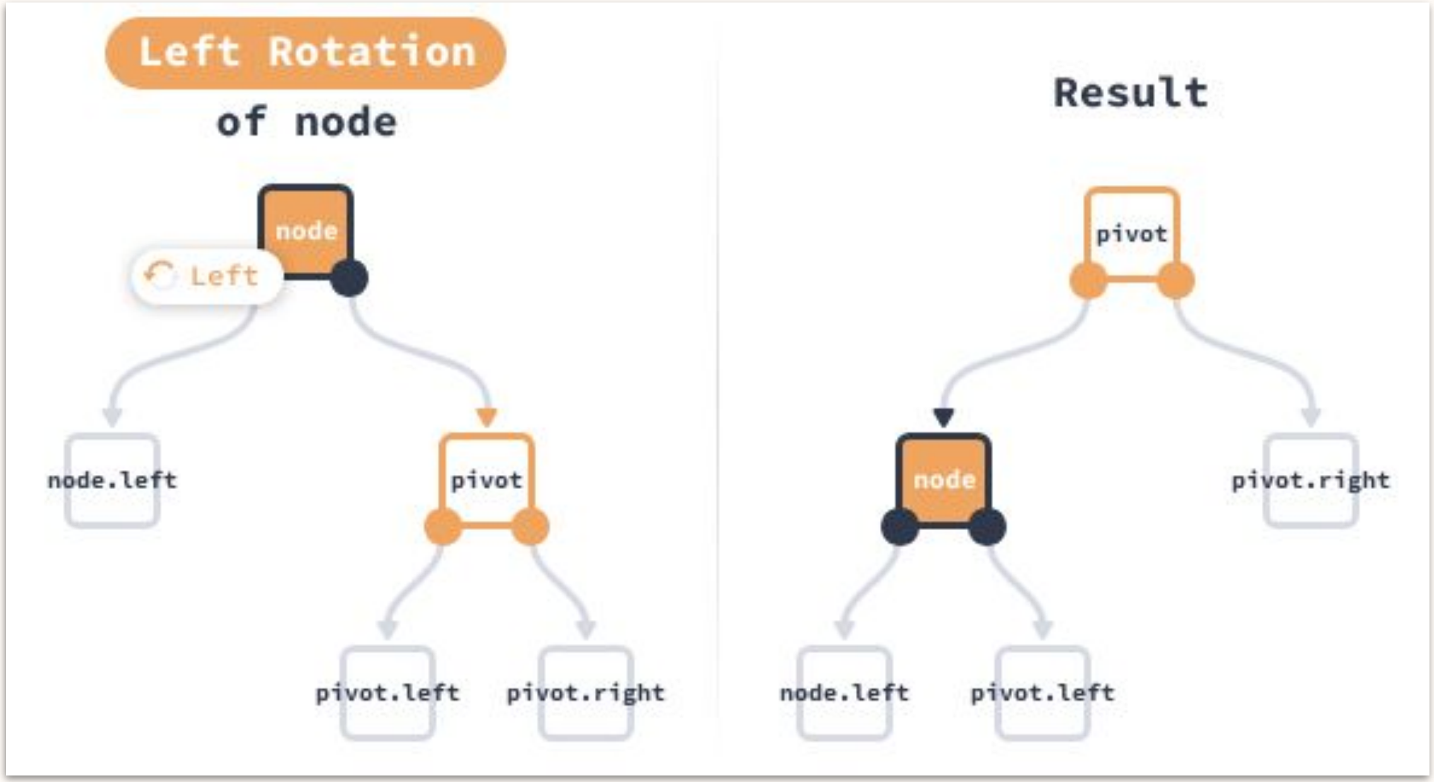
Node Height and Imbalance

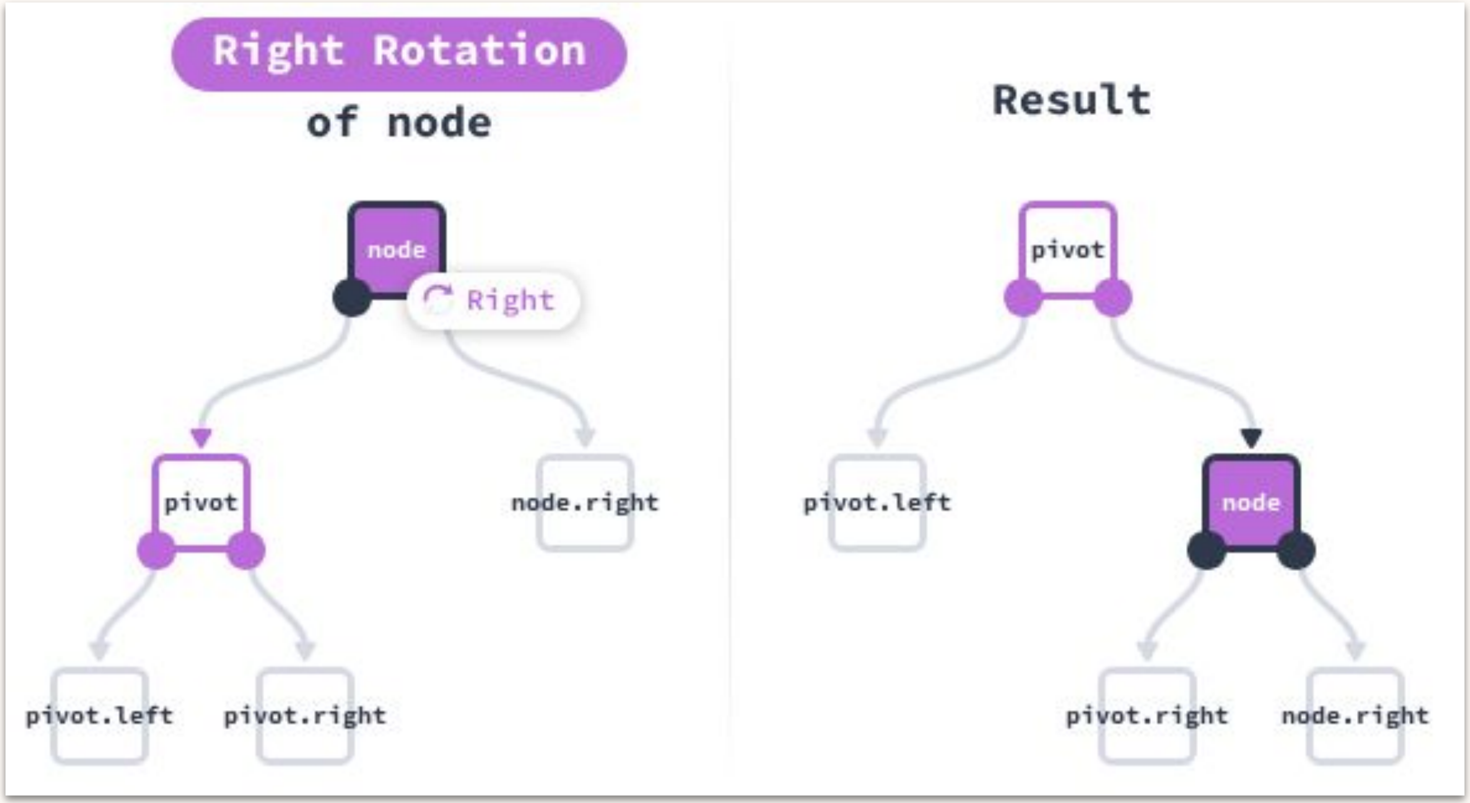


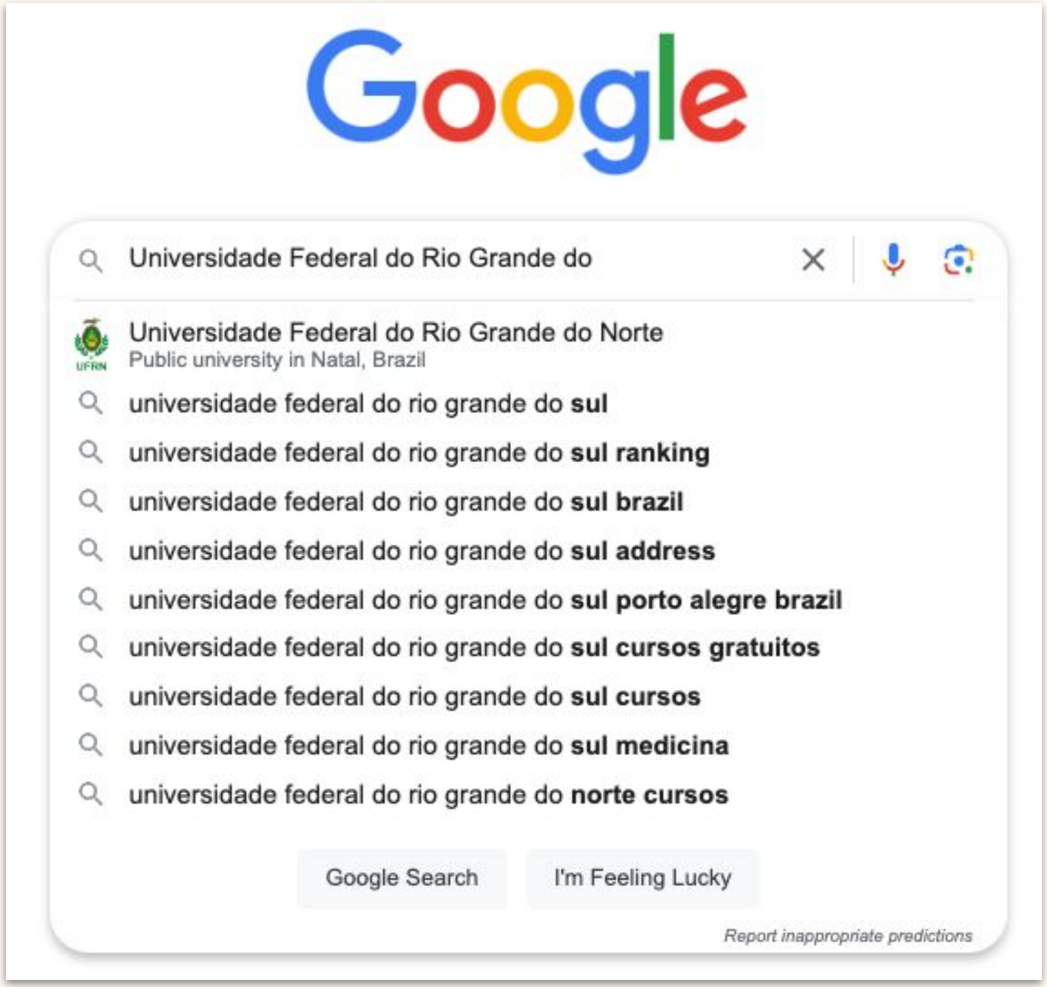
Height and Imbalance Relation



Height and Imbalance Relation


Left Rotation
of node
node
Left
node.left
pivot
pivot.left
pivot.right
Result
pivot
node
pivot.right
node.left
pivot.left


Right Rotation
of node
node
Right
pivot
node.right
pivot.left
pivot.right
Result
pivot
pivot.left
node
pivot.right
node.right


Universidade Federal do Rio Grande do

Universidade Federal do Rio Grande do Norte
Public university in Natal, Brazil

universidade federal do rio grande do **sul**

universidade federal do rio grande do **sul ranking**

universidade federal do rio grande do **sul brazil**

universidade federal do rio grande do **sul address**

universidade federal do rio grande do **sul porto alegre brazil**

universidade federal do rio grande do **sul cursos gratuitos**

universidade federal do rio grande do **sul cursos**

universidade federal do rio grande do **sul medicina**

universidade federal do rio grande do **norte cursos**

Challenge for Programming AVL Trees