

COMP 250

Assignment Project Exam Help

INTRODUC TER SCIENCE

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Week 11-1: Ro
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Giulia Alberini, Fall 2020

Slides adapted from Michael Langer's

WHAT ARE WE GOING TO DO IN THIS VIDEO?



- **Rooted Trees** Assignment Project Exam Help

- Terminology

- Implementation

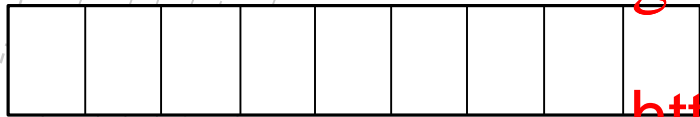
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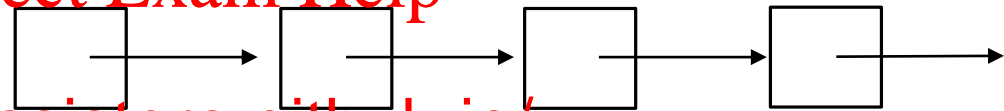
DATA STRUCTURES

- Linear

array



Linked list

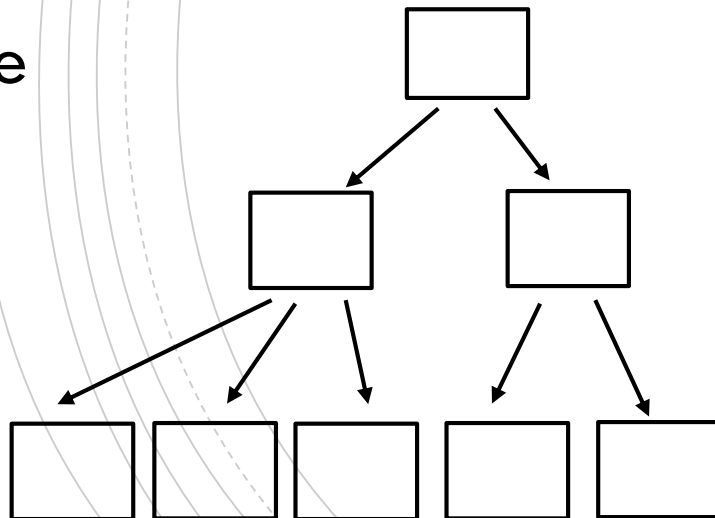


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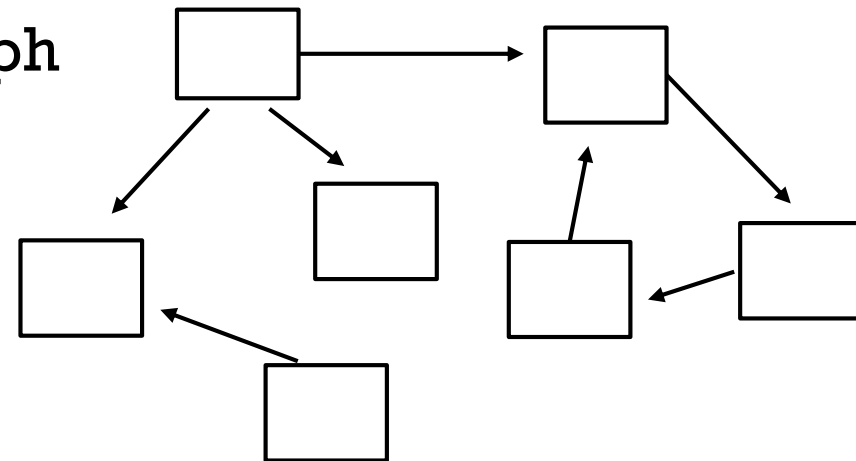
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- Non-linear

tree



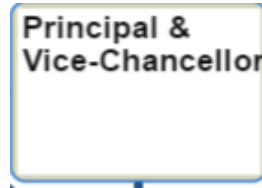
graph



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TREE - EXAMPLE

- Organizational Hierarchy
(McGill)

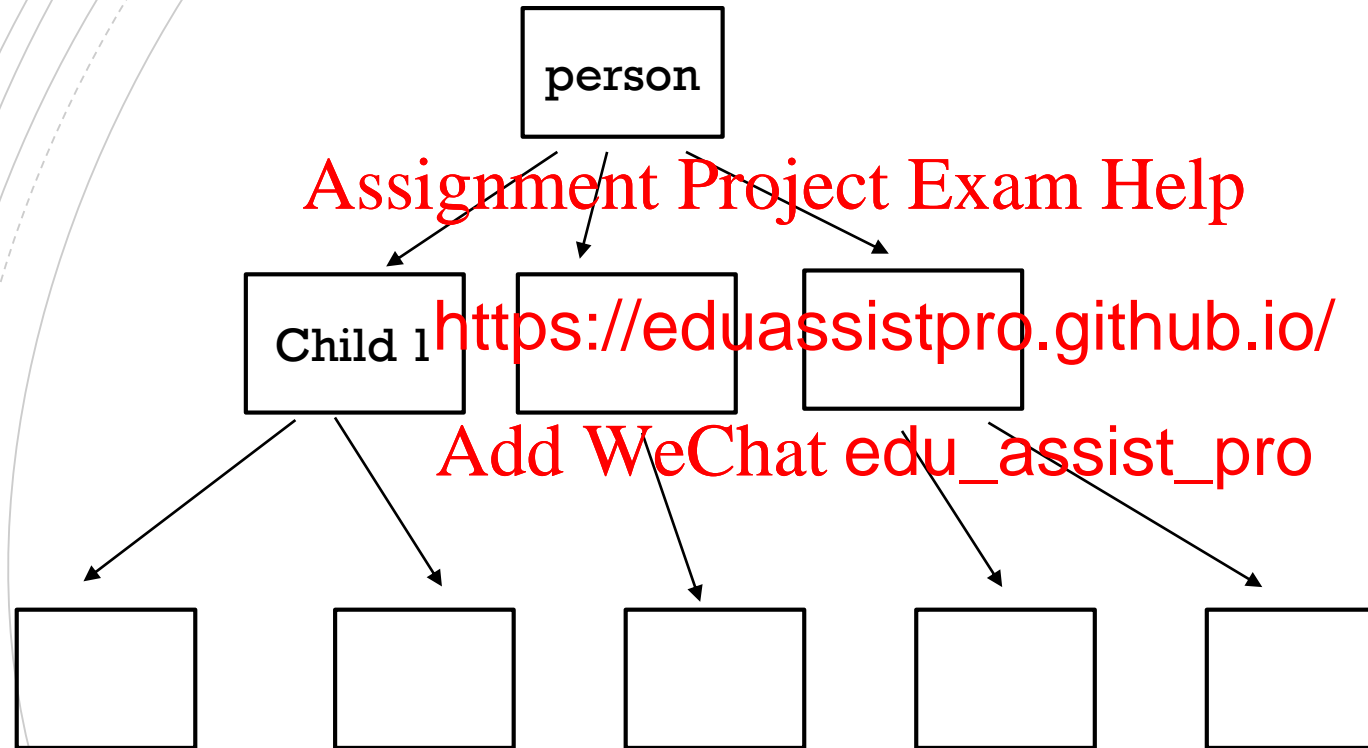


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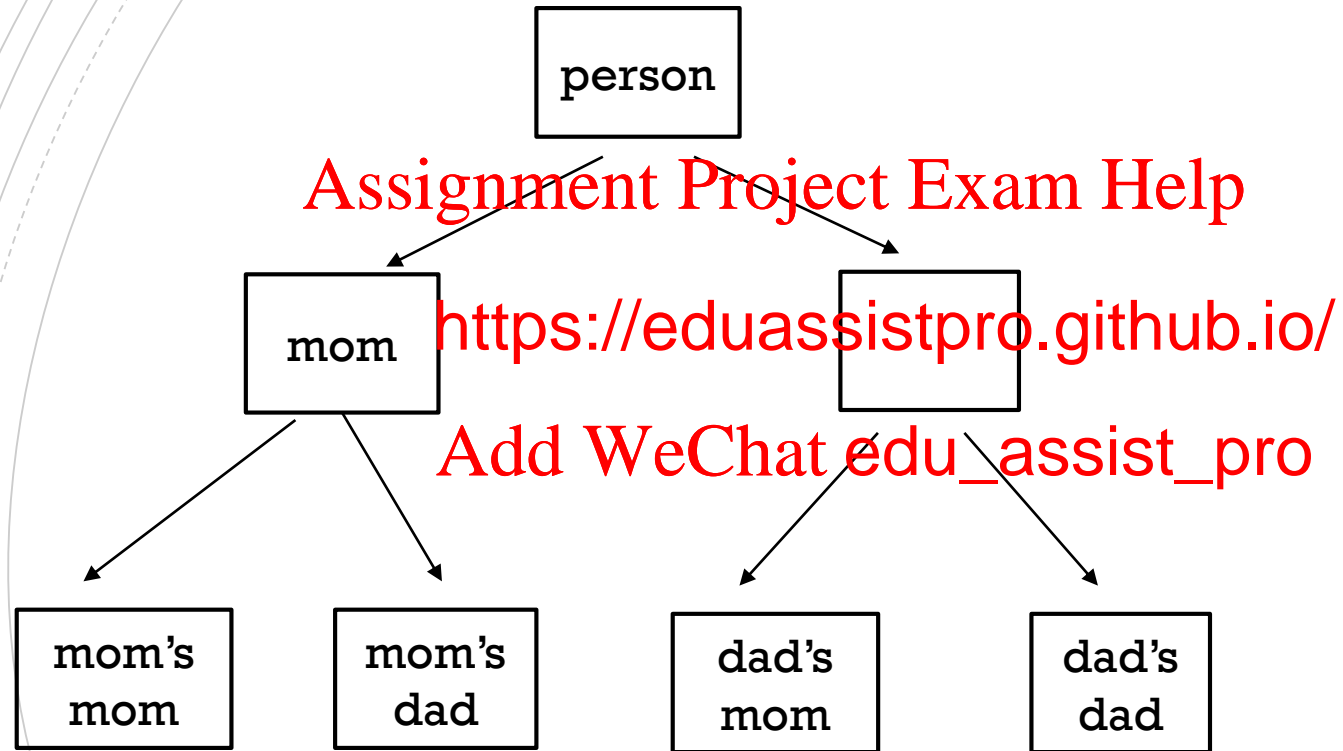
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EXAMPLE 2: FAMILY TREE (DESCENDANTS)



Here we ignore spouses (partner).

EXAMPLE 3: FAMILY TREE (ANCESTORS)



This is an example of a binary tree.

EXAMPLE 4: UNIX FILE SYSTEM

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EXAMPLE 5: JAVA CLASSES E.G. GUI

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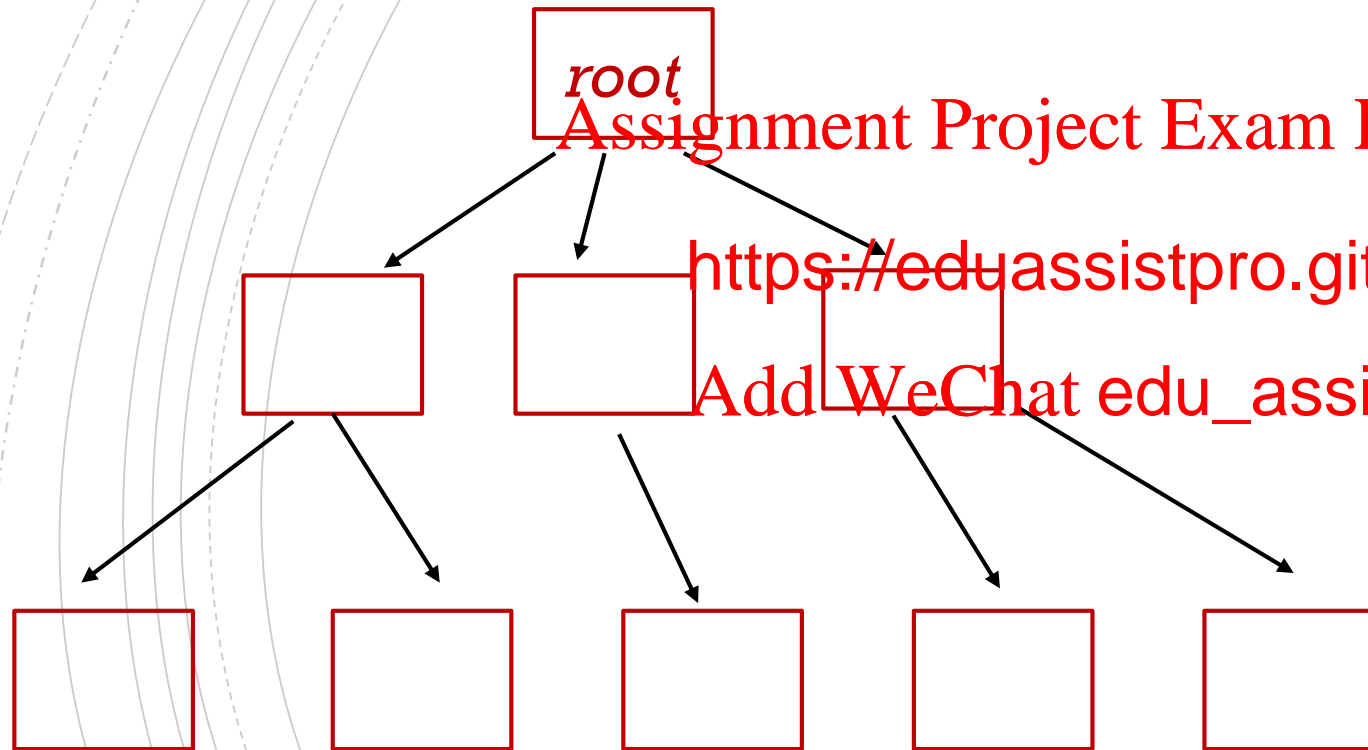
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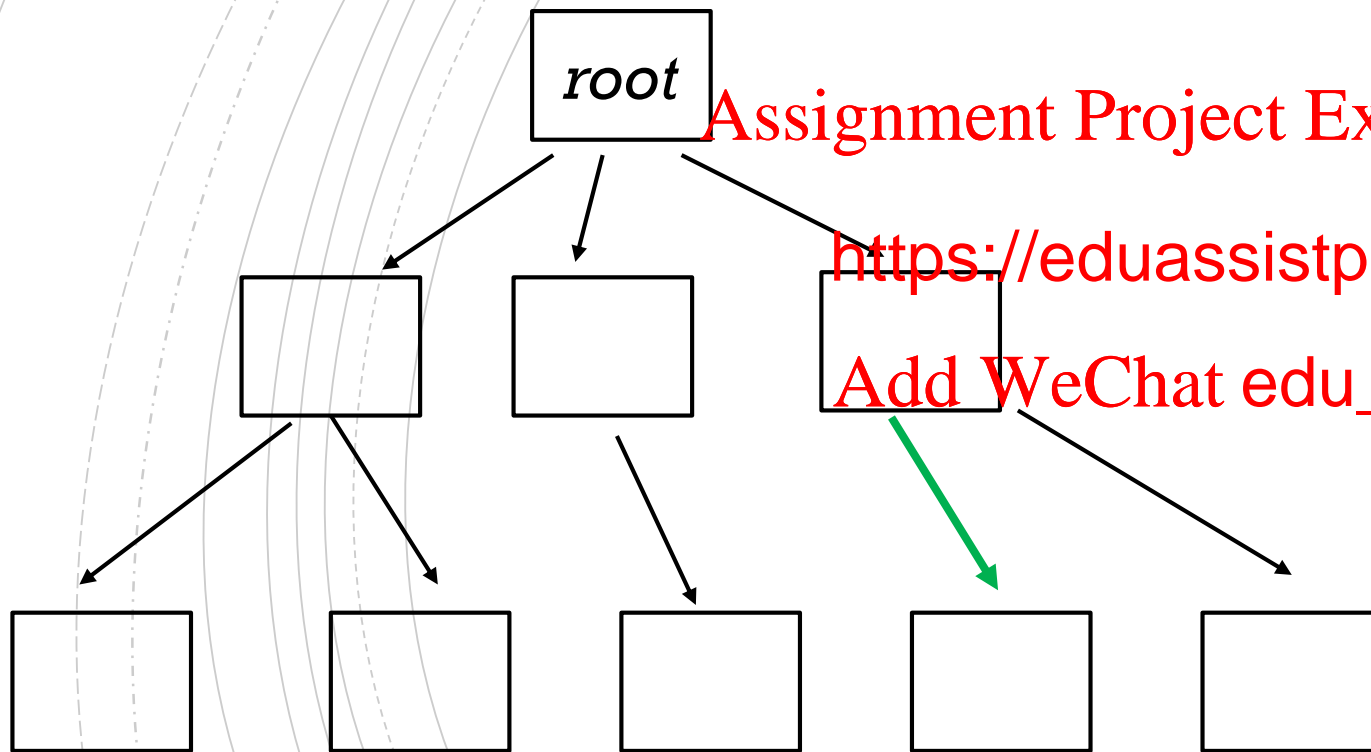
(ROOTED) TREE TERMINOLOGY



A tree is a collection of nodes (*vertexes*)

The *root* is the top node in a tree

(ROOTED) TREE TERMINOLOGY



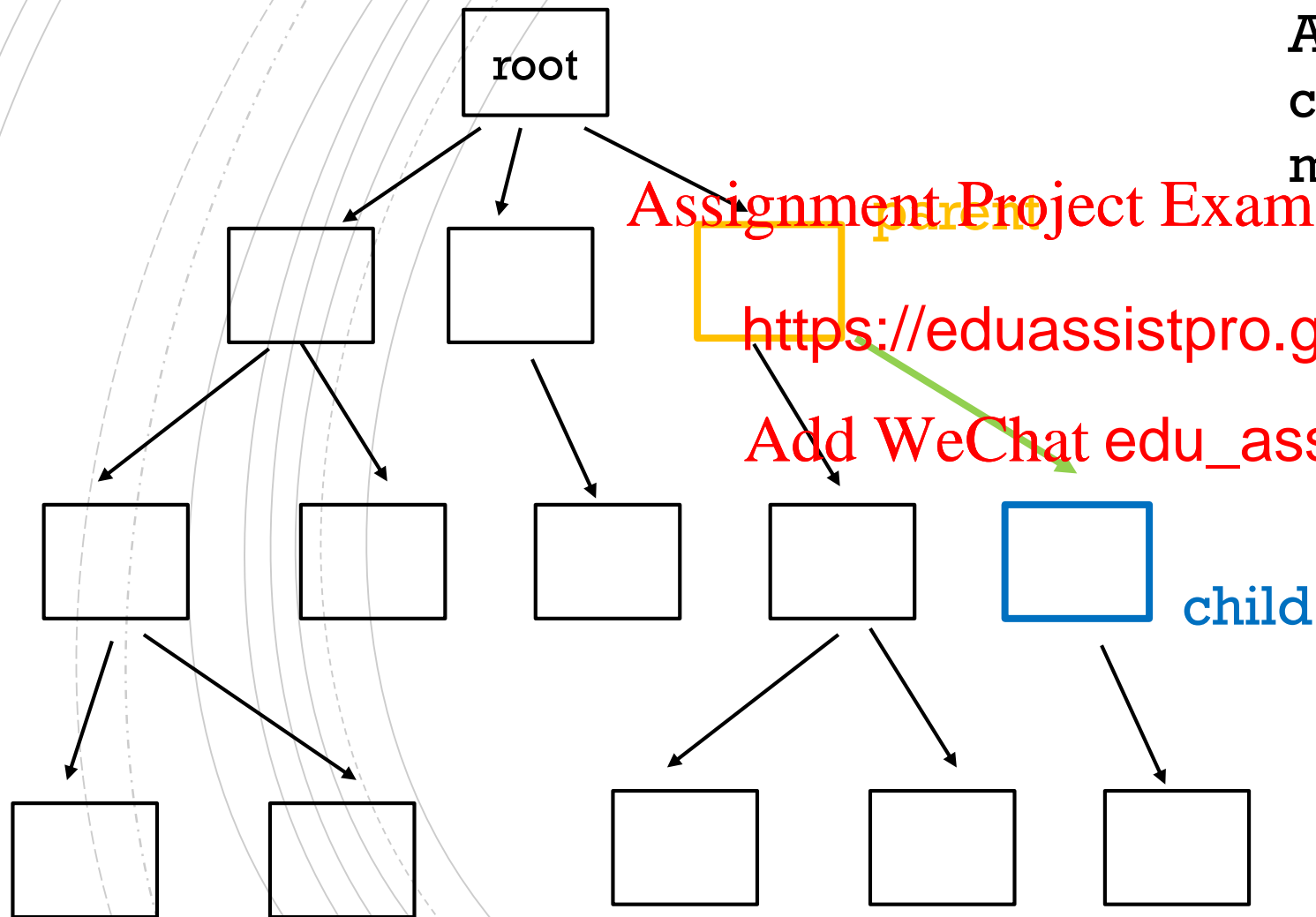
A **directed edge** is ordered pair of nodes (v_i, v_j) (from, to).

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Trees can be *undirected* or *directed*. If directed, the edges are either all pointing away from the root or all pointing towards the root.

(ROOTED) TREE TERMINOLOGY



A *child* is a node directly connected to another node when moving away from the root.

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A *parent* is a node directly connected to another node when moving towards the root.

Every node except the root is a *child*, and has exactly one *parent*.

EDGE DIRECTION

For some trees,

- edges are directed from parent to child
- edges are directed
- edges are directed both from child and child to parent.
- edge direction is ignored e.g. common with non-rooted trees (see next slide)

Most of definitions today will assume edges are from parent to child.

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ASIDE: NON-ROOTED TREES

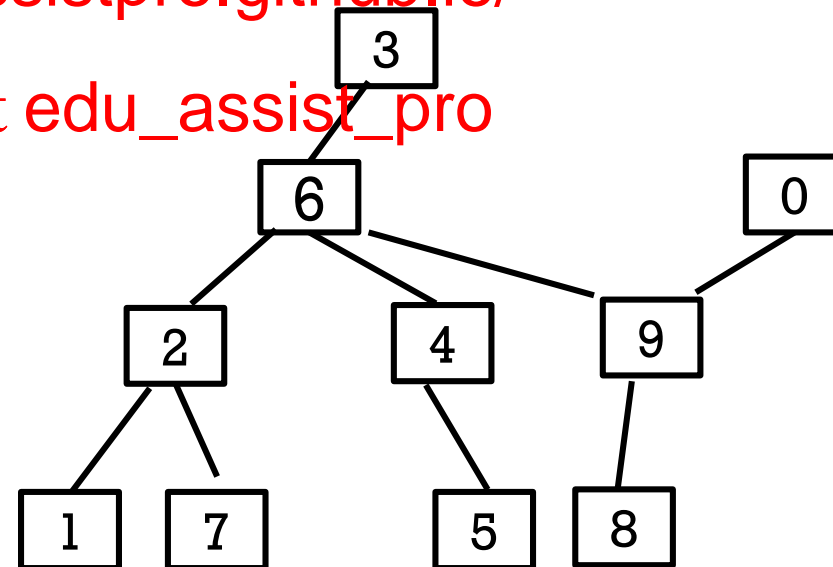
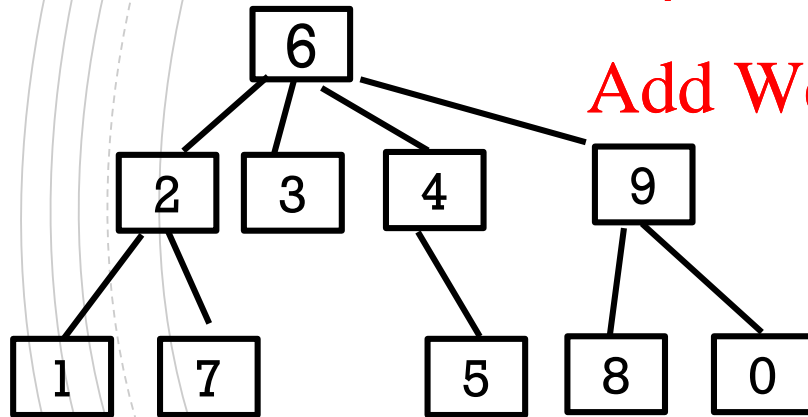
You will see non-rooted trees most commonly when edges are undirected, and there is no natural way to define the 'root'.

You will see examples in COMP 251.

e.g. the tree on the left is only rooted because I drew it that way. It is actually the same (no matter which node you choose) as the tree on the right.

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NUMBER OF EDGES

- Q: If a (rooted) tree has n nodes, then how many edges does it have?

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NUMBER OF EDGES

- Q: If a (rooted) tree has n nodes, then how many edges does it have?

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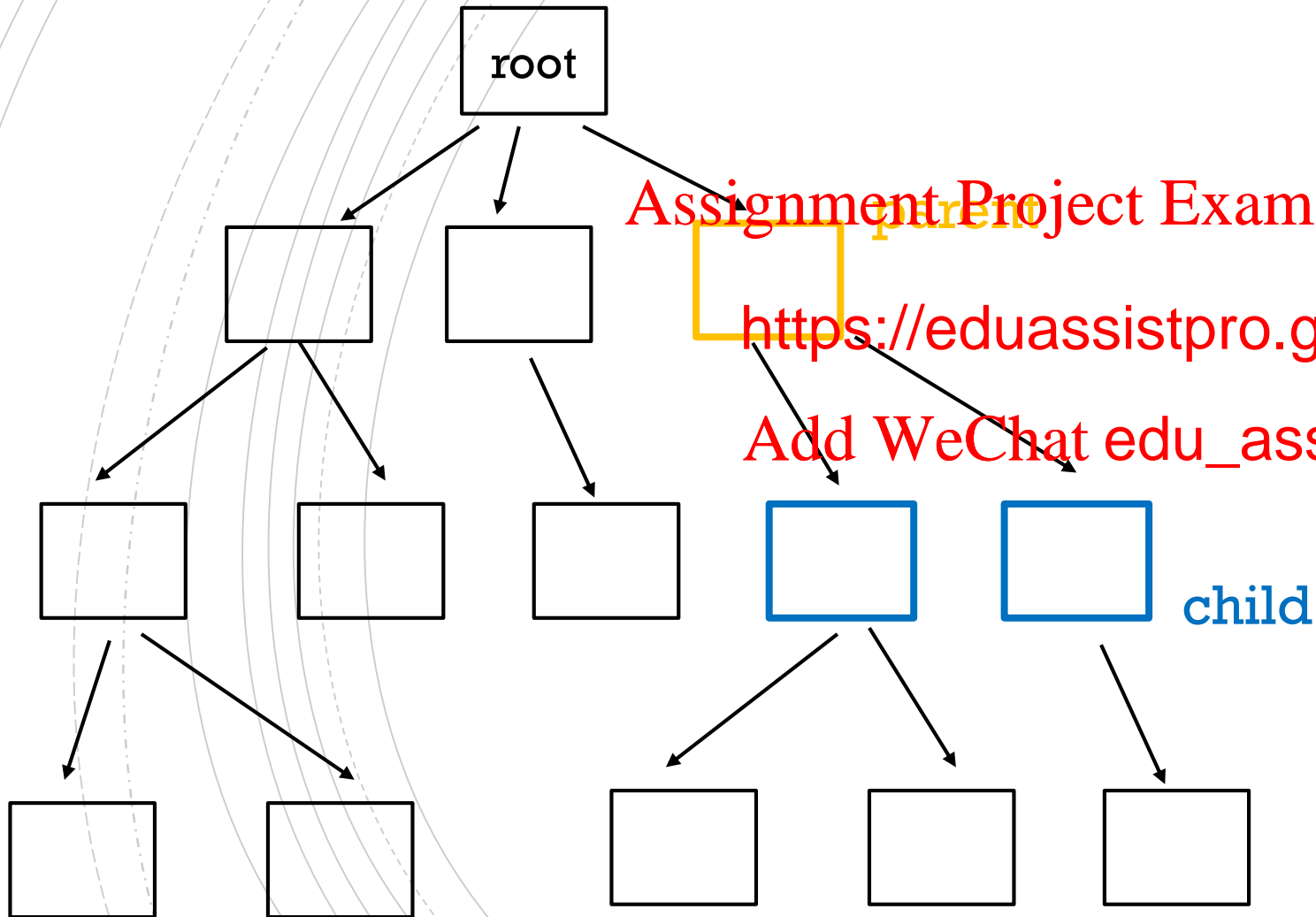
- A: $n - 1$

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Since every edge is of the form (parent, child) and each node except the root is a child and each child has exactly one parent.

(ROOTED) TREE TERMINOLOGY



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nodes are said to be **siblings**

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child

RECURSIVE DEFINITION OF ROOTED TREE

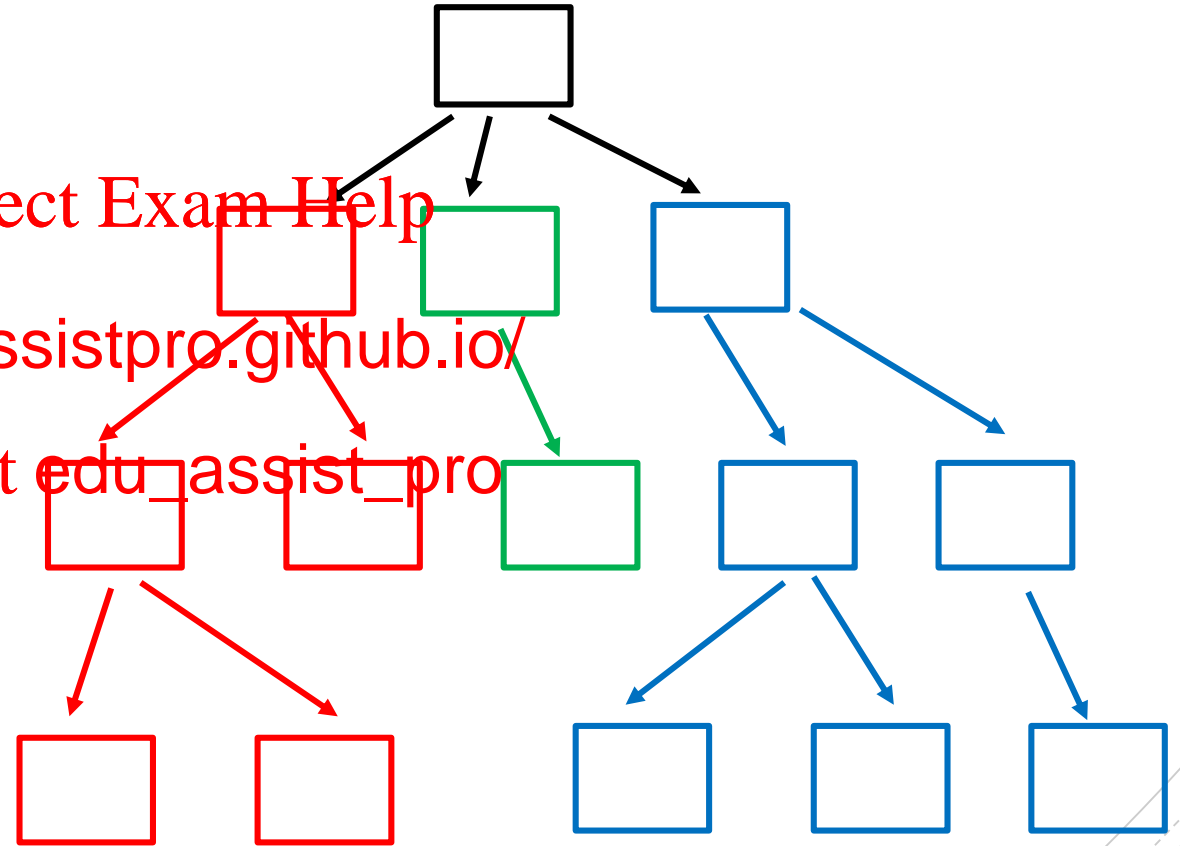
A tree T is a finite (& possibly empty) set of n nodes such that:

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?



RECURSIVE DEFINITION OF ROOTED TREE

A tree T is a finite (& possibly empty) set of n nodes such that:

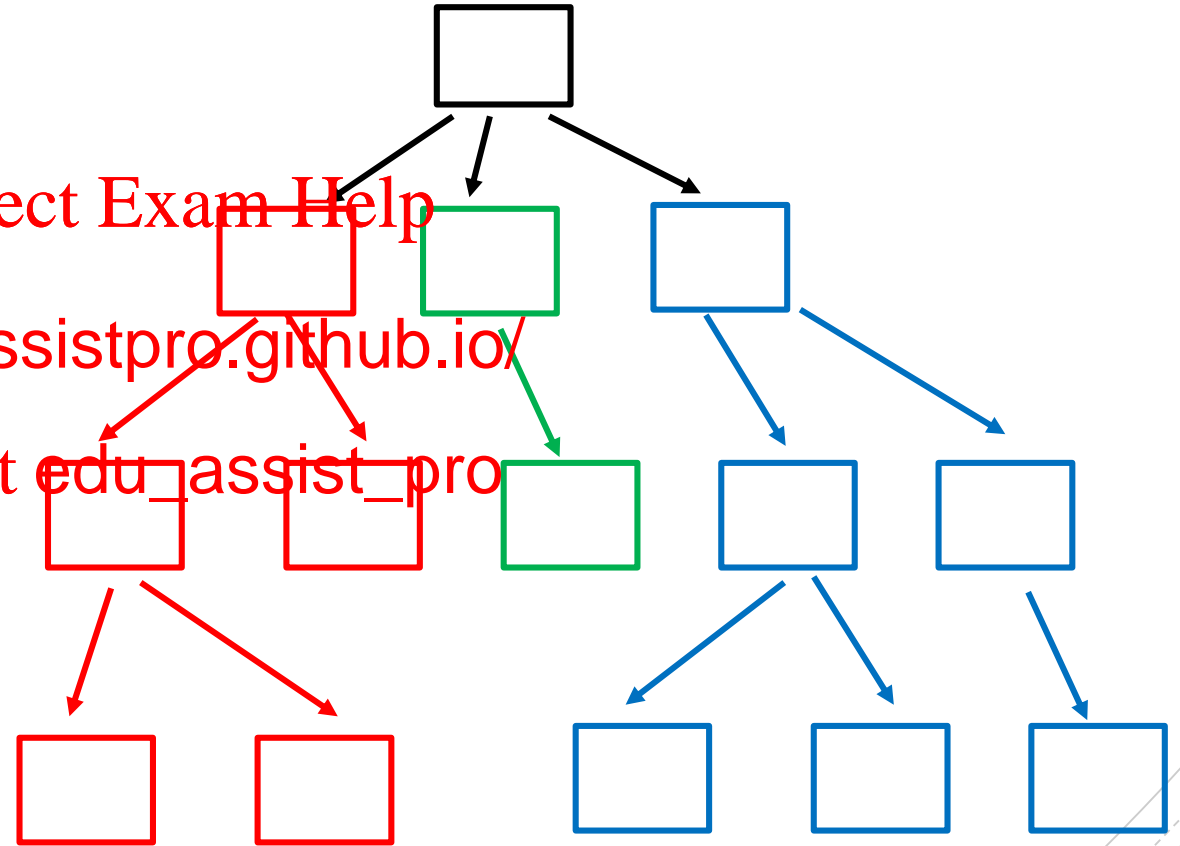
- if $n > 0$ then one of the node

?

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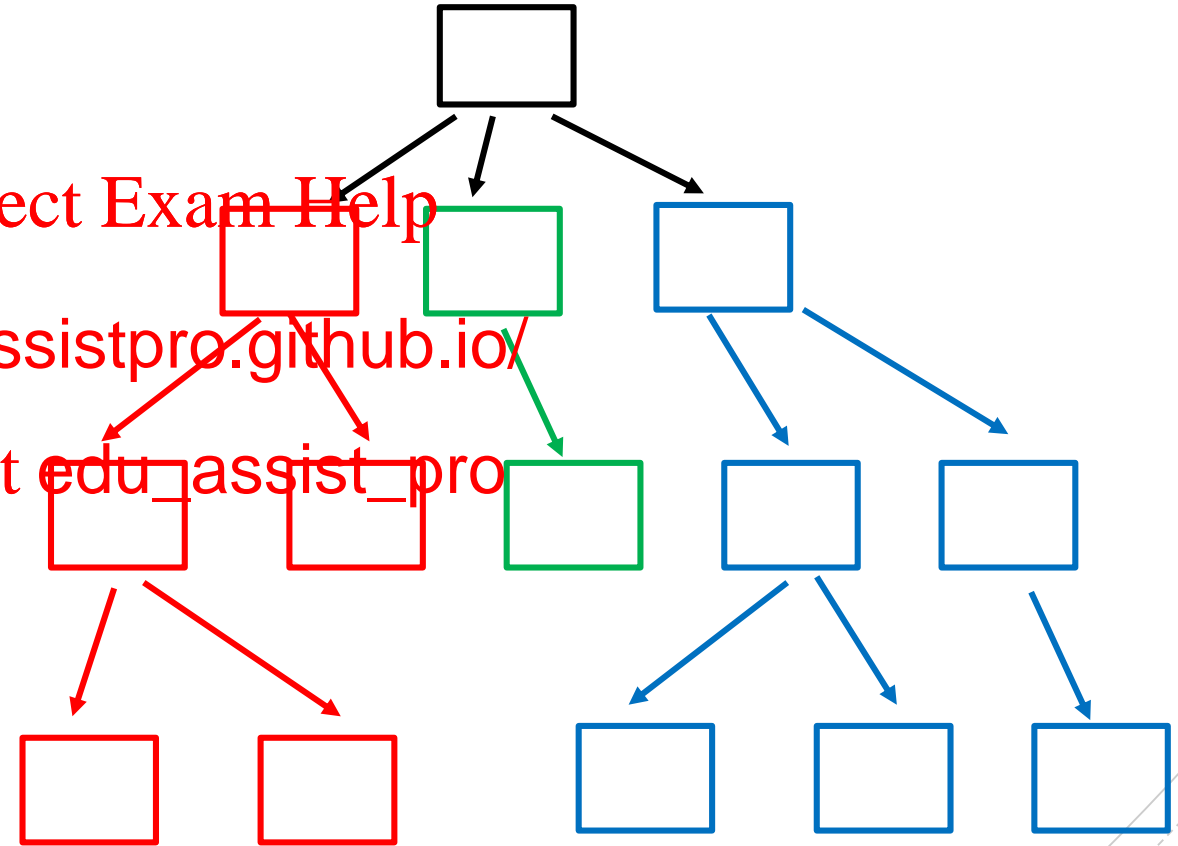
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RECURSIVE DEFINITION OF ROOTED TREE

A tree T is a finite (& possibly empty) set of n nodes such that:

- if $n > 0$ then one of the node
- if $n > 1$ then the $n - 1$ non-root nodes are partitioned into (non-empty) subsets T_1, T_2, \dots, T_k , each of which is a tree (called a “subtree”), and the roots of the subtrees are the children of root r .



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ANOTHER DEFINITION

A recursive definition for tree can also be given using lists as follows:

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```
tree      =  (root tOfSubTrees )  
listOfSubTrees = tree | listOfSubTrees
```

Note that `listOfSubTrees` cannot be empty.

TRY IT!

A recursive definition for tree can also be given using lists as follows:

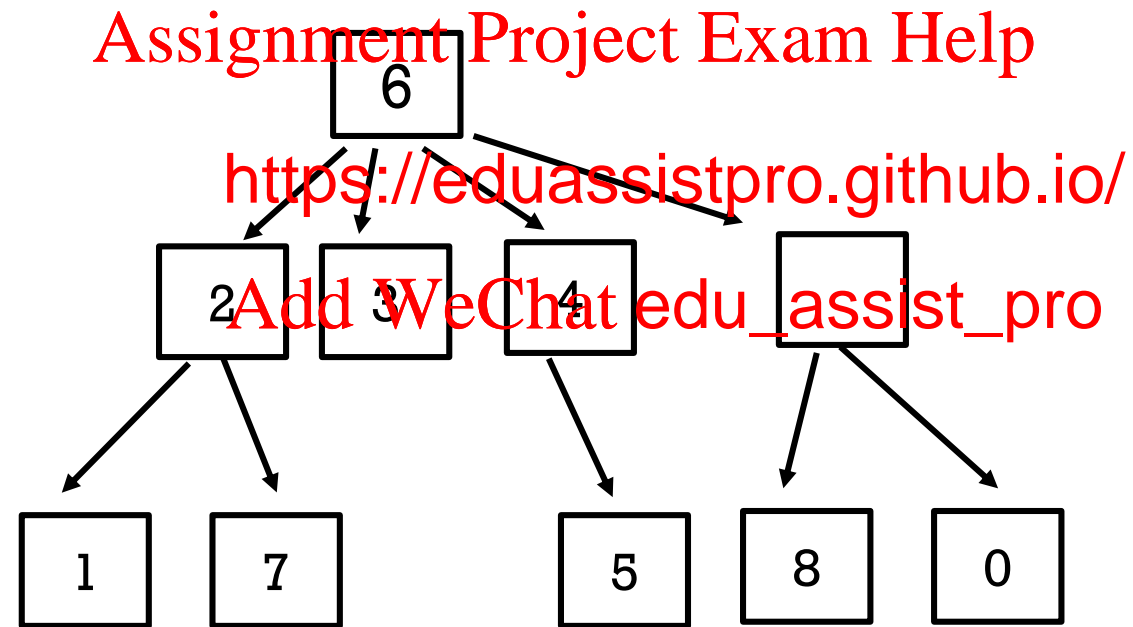
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`tree = (root listOfSubTrees)`
`listOfSubTrees = tree | listOfSubTrees`
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- Draw the tree that corresponds to the following list, where the root elements are single digits.

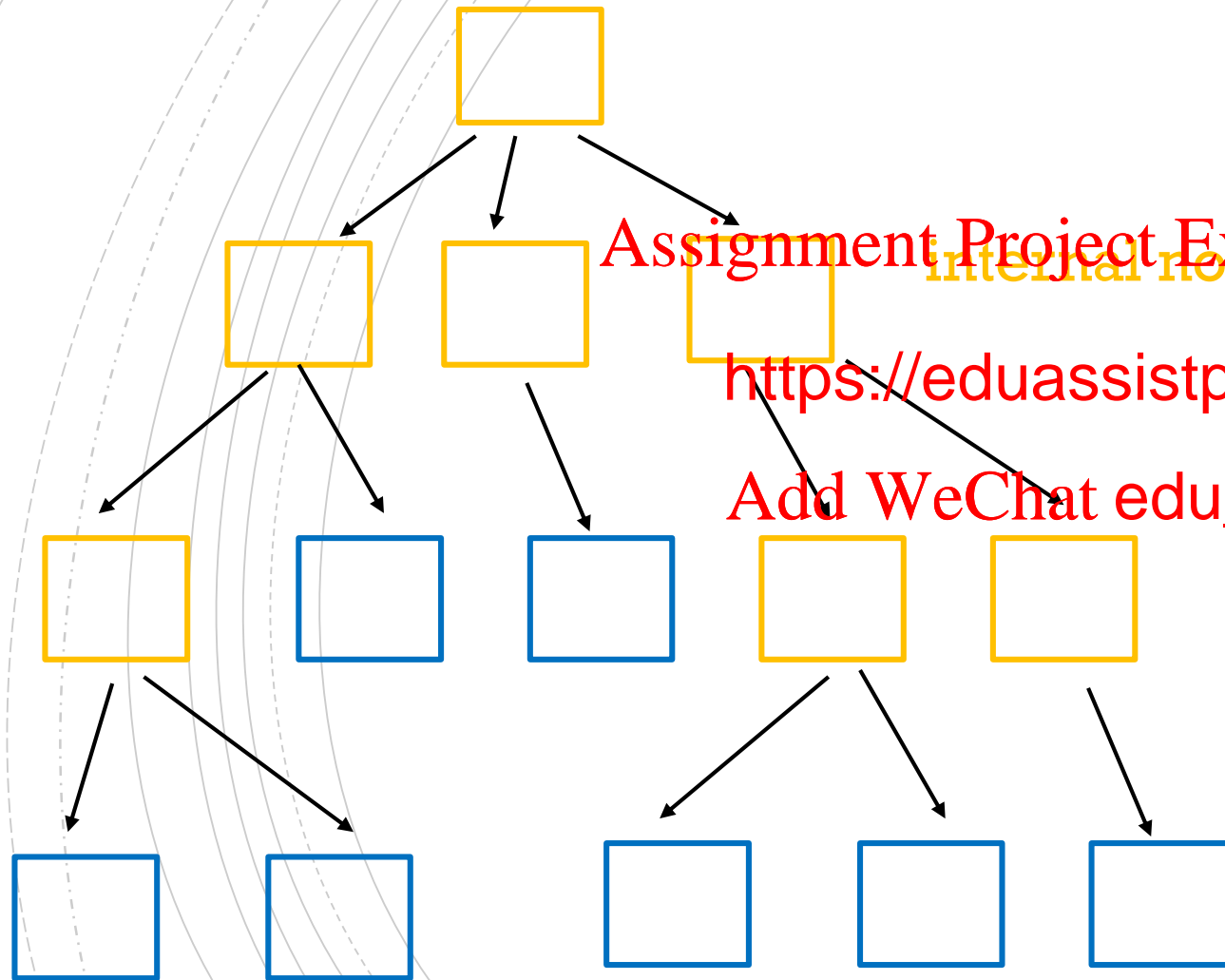
`(6 (2 1 7) 3 (4 5) (9 8 0))`

SOLUTION

$(6 \ (2 \ 1 \ 7) \ 3 \ (4 \ 5) \ (9 \ 8 \ 0))$ represents the following tree:



(ROOTED) TREE TERMINOLOGY



An *internal node* is a node with at least one child.

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Internal nodes

directories)

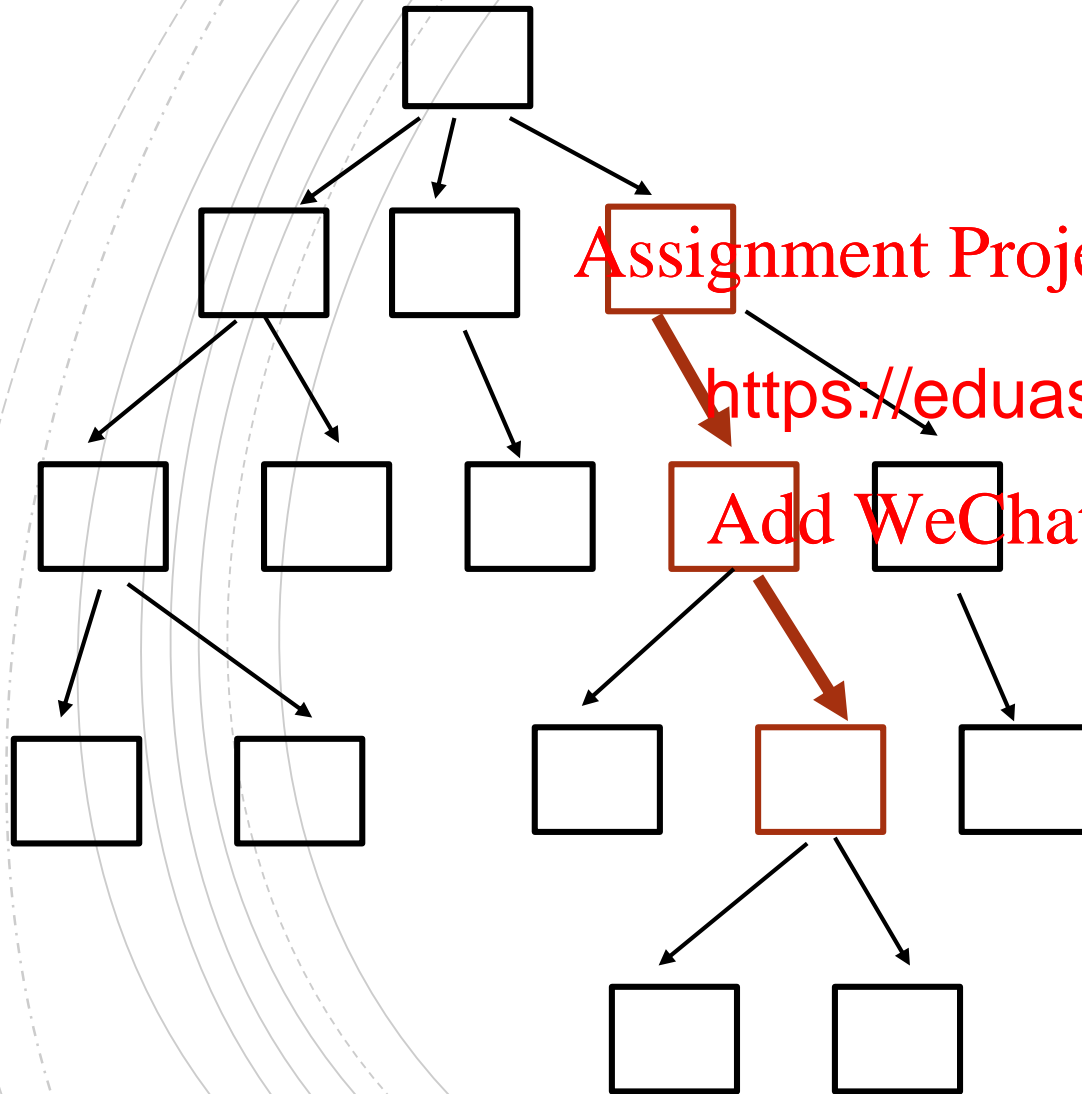
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An *leaf (or external node)* is a node with no children.

leaves (external nodes)
(e.g. files or empty directories)

TREE TERMINOLOGY



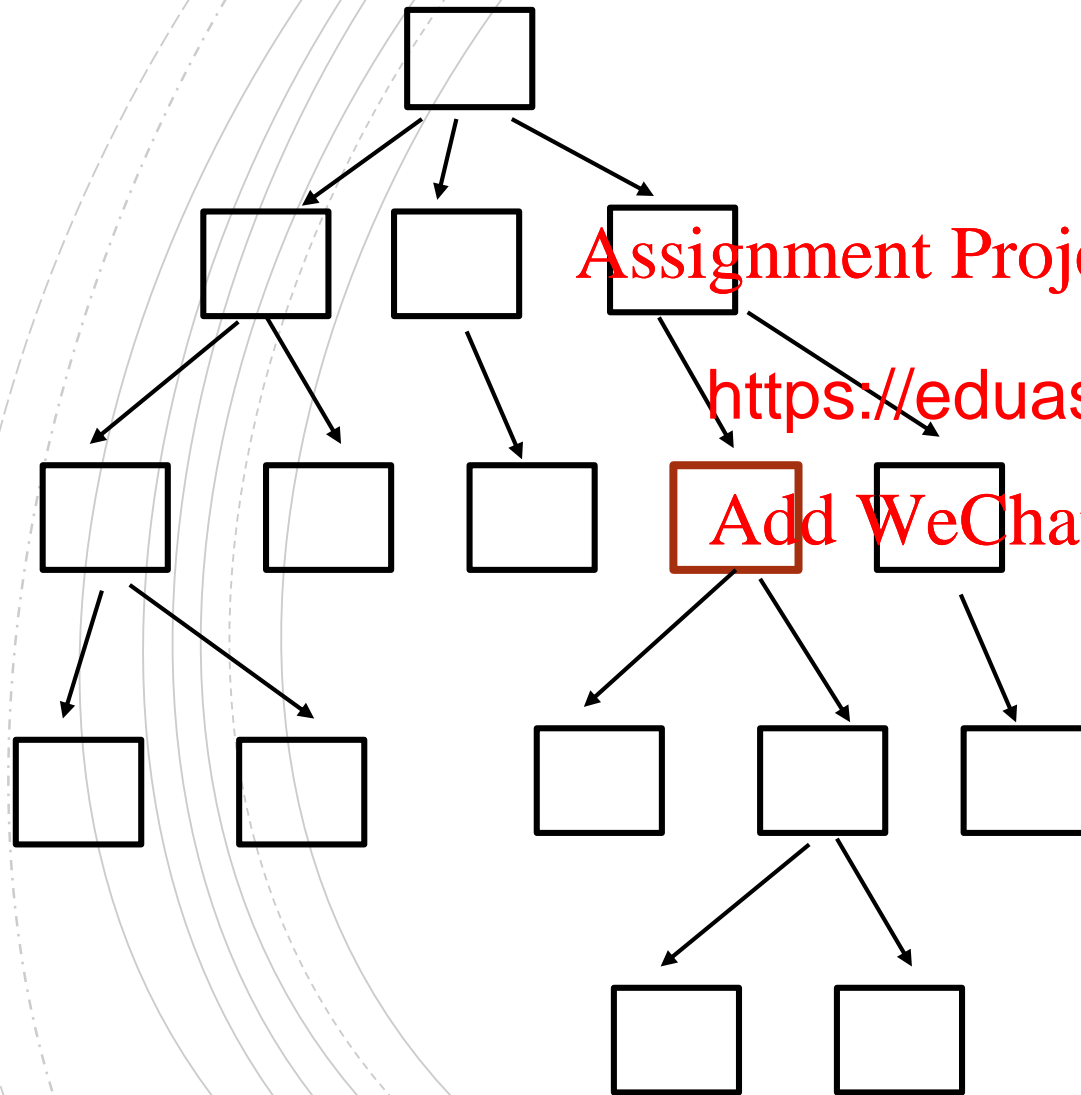
A **path** in a tree is a sequence of nodes (v_1, v_2, \dots, v_k) such that (v_i, v_{i+1}) is an edge.

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length of a path is *the number of edges in the path*
(number of nodes in the path – 1)

TREE TERMINOLOGY



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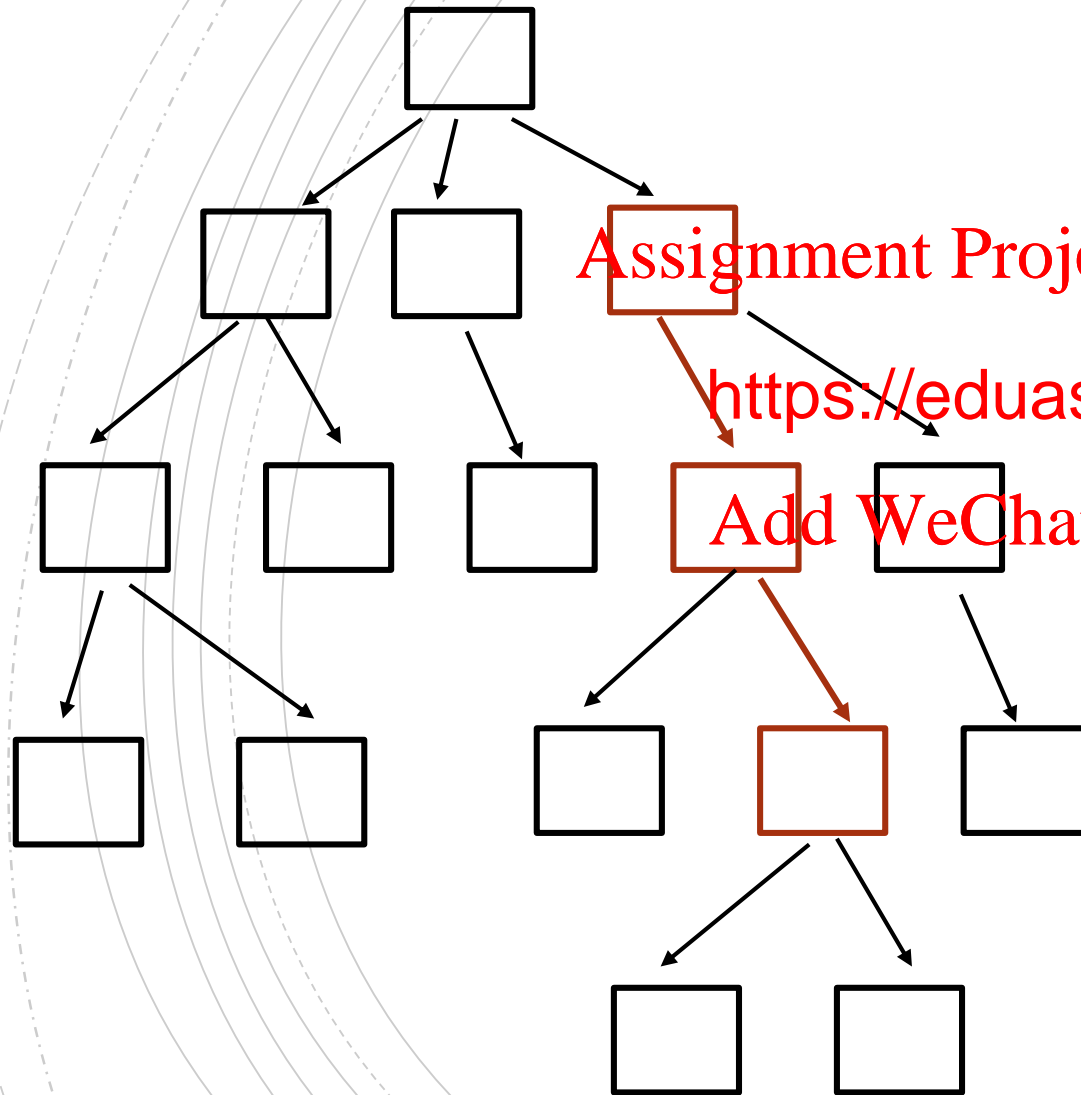
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path with just one node (v_1)
length = 0, since it has no

es.

QUICK QUESTION



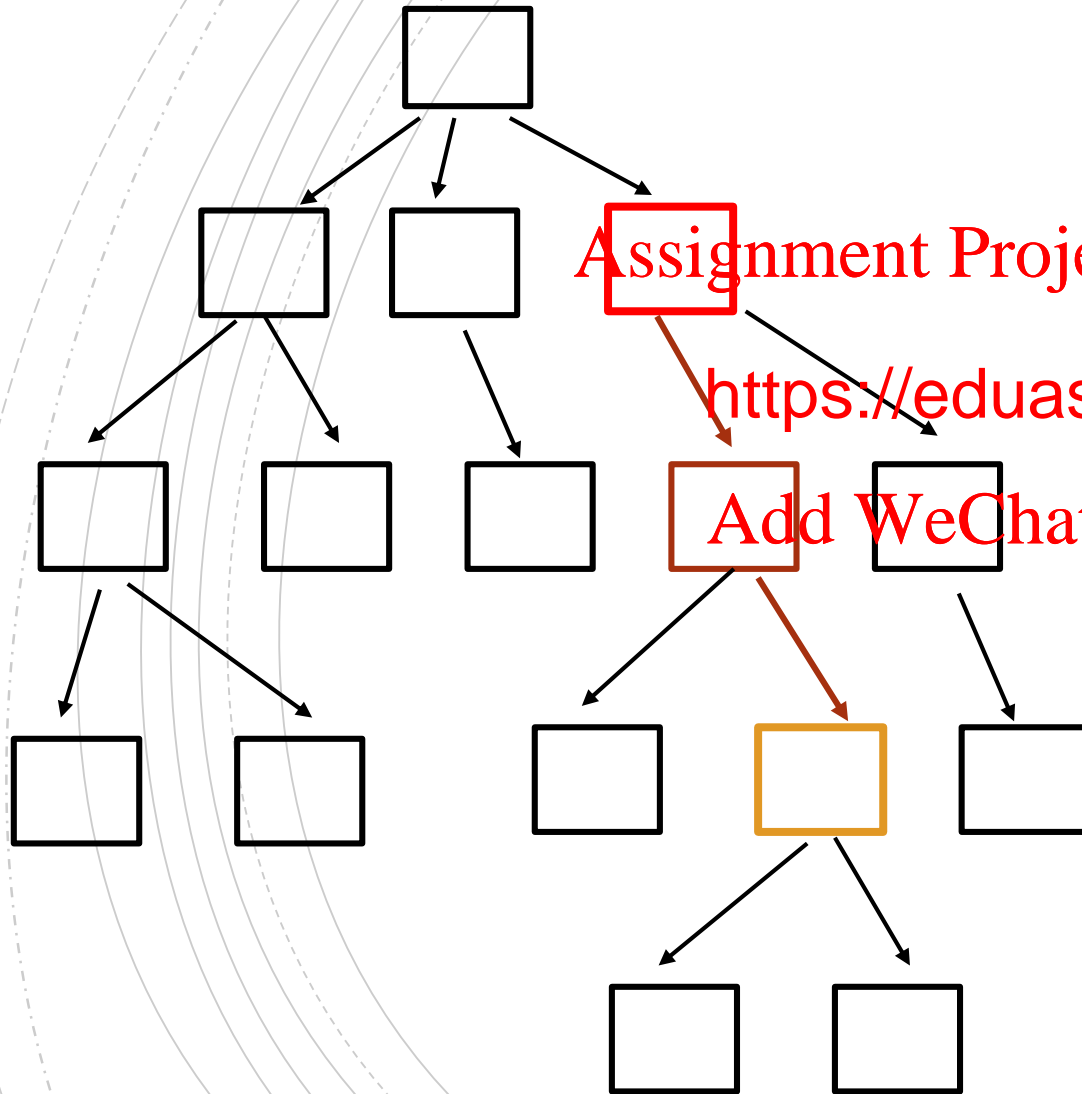
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What is the path length?

TREE TERMINOLOGY



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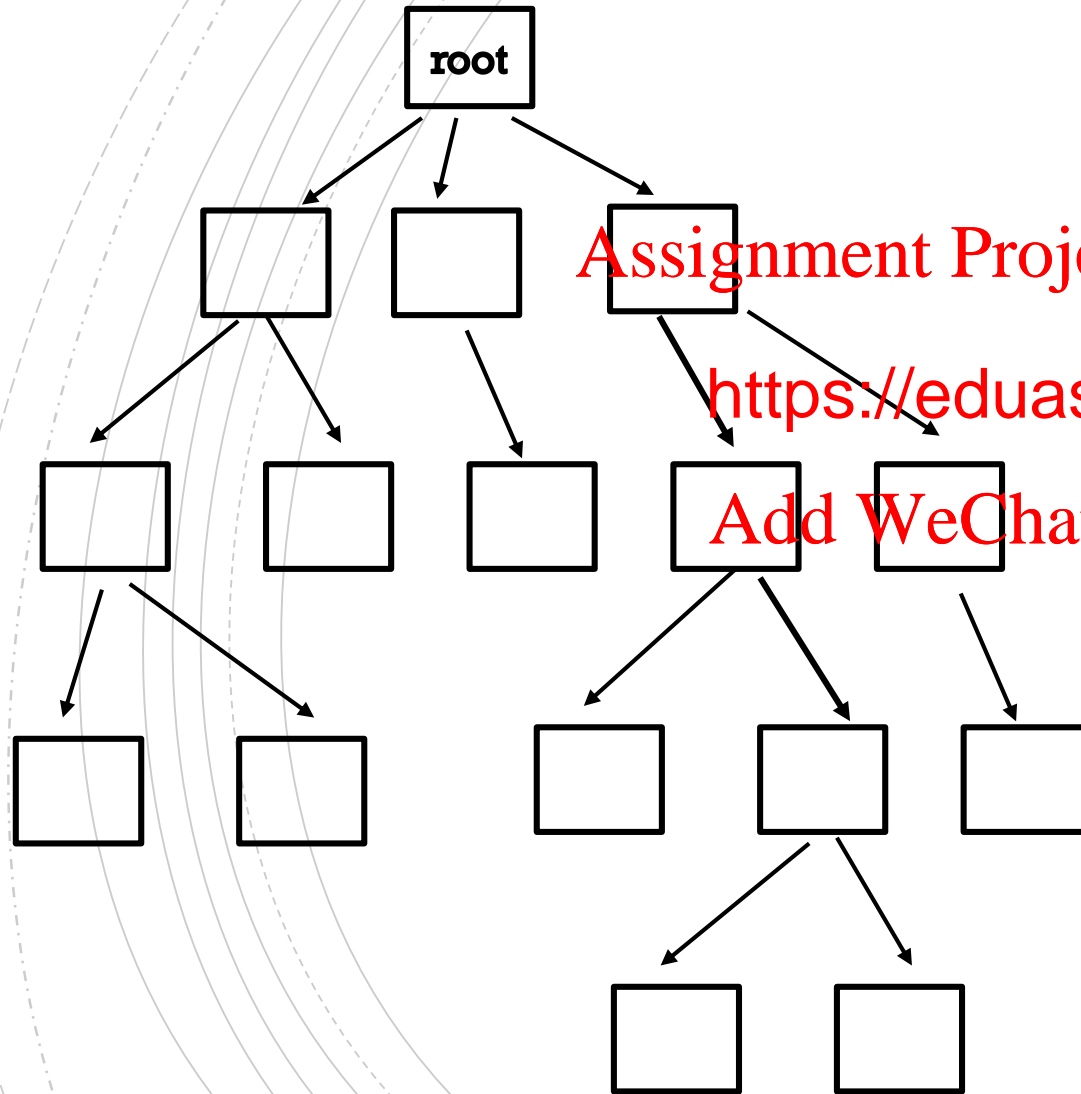
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node v is an *ancestor* of node w if and only if
there is a path from v to w .
In each case, we also say that
 w is a *descendant* of node v .

(ROOTED) TREE TERMINOLOGY

depth (level)
0



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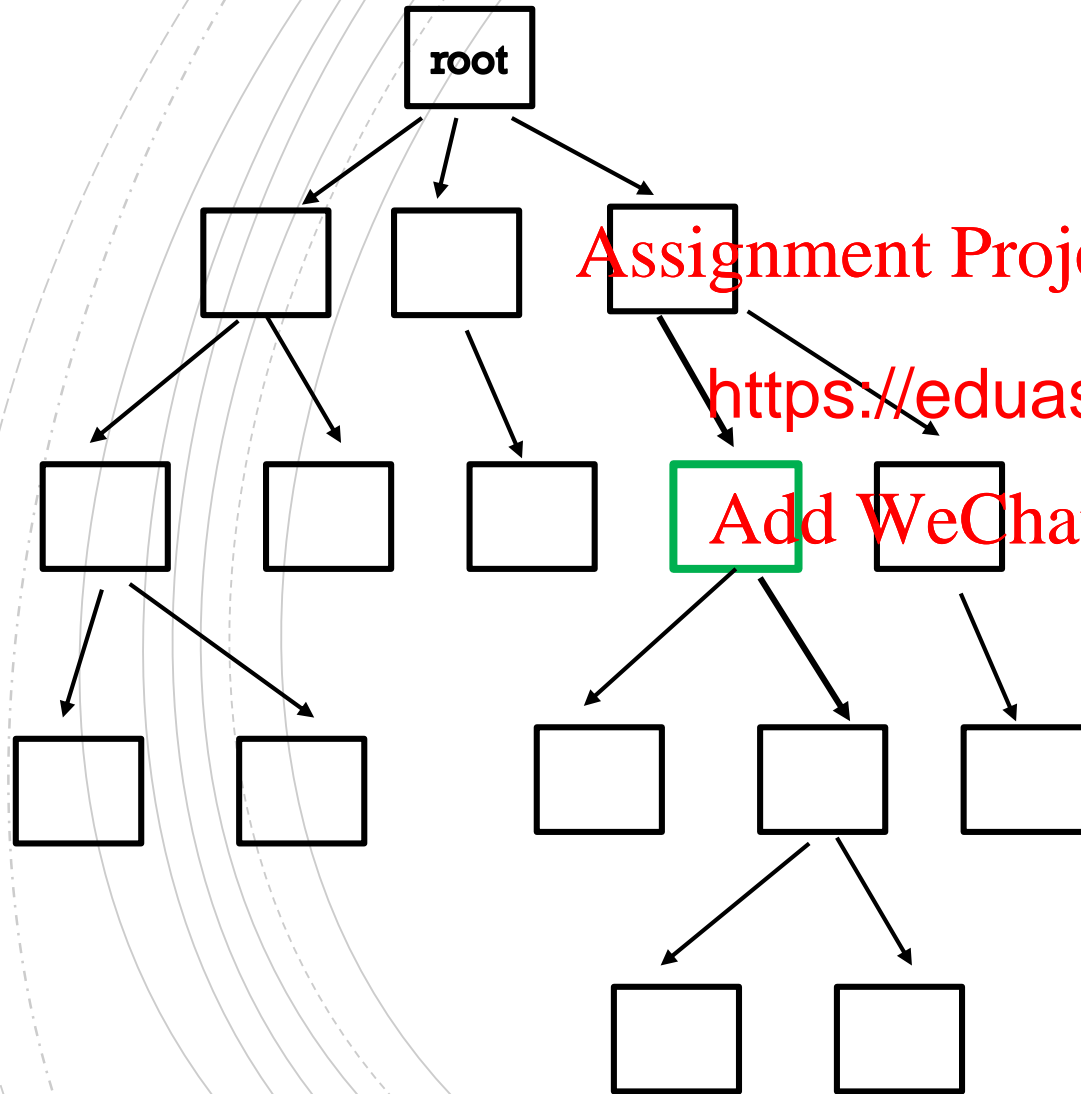
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The *depth* (or *level*) of a node is the length of the path *from the root to the node*.

3

4

(ROOTED) TREE TERMINOLOGY



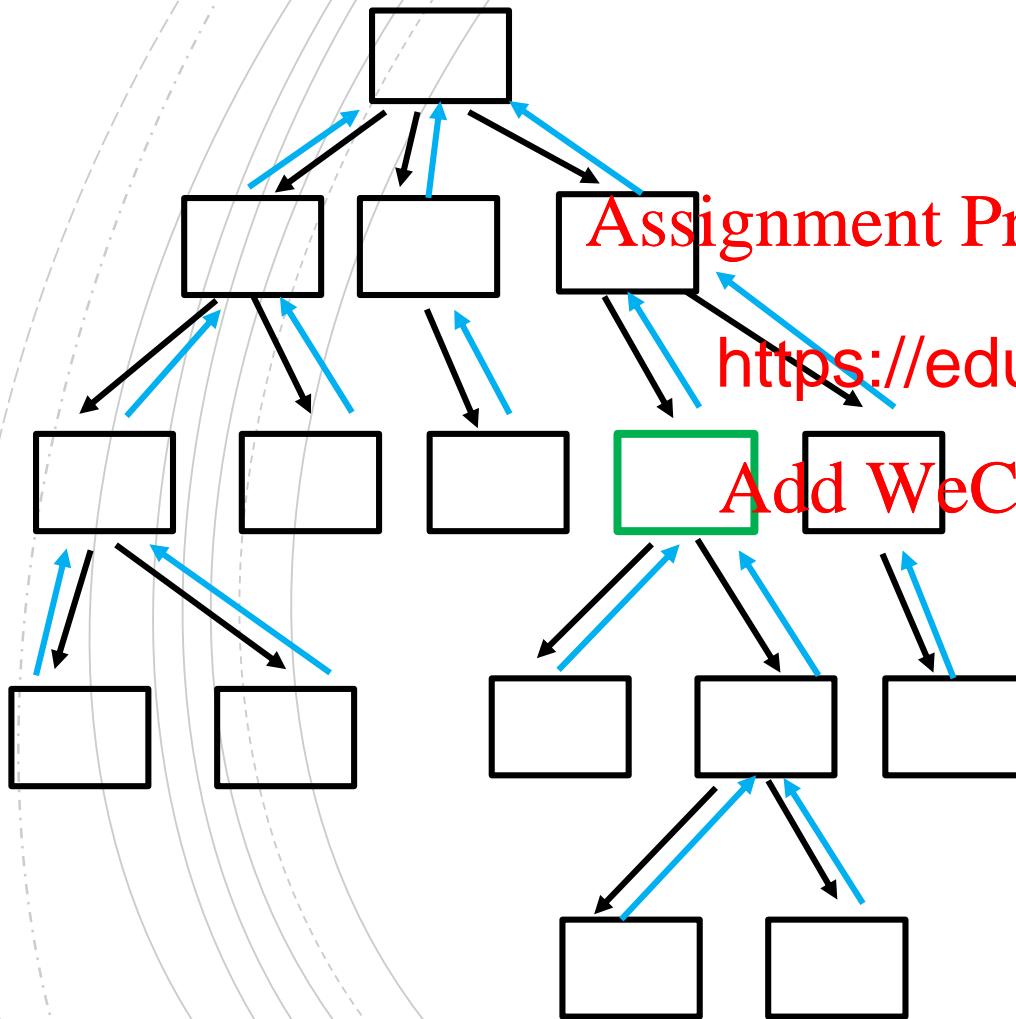
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How can we compute
the depth of a node v ?

depth(v)



To do this efficiently we require nodes to have a **parent link**. This is analogous to a 'prev' link in a doubly linked list.

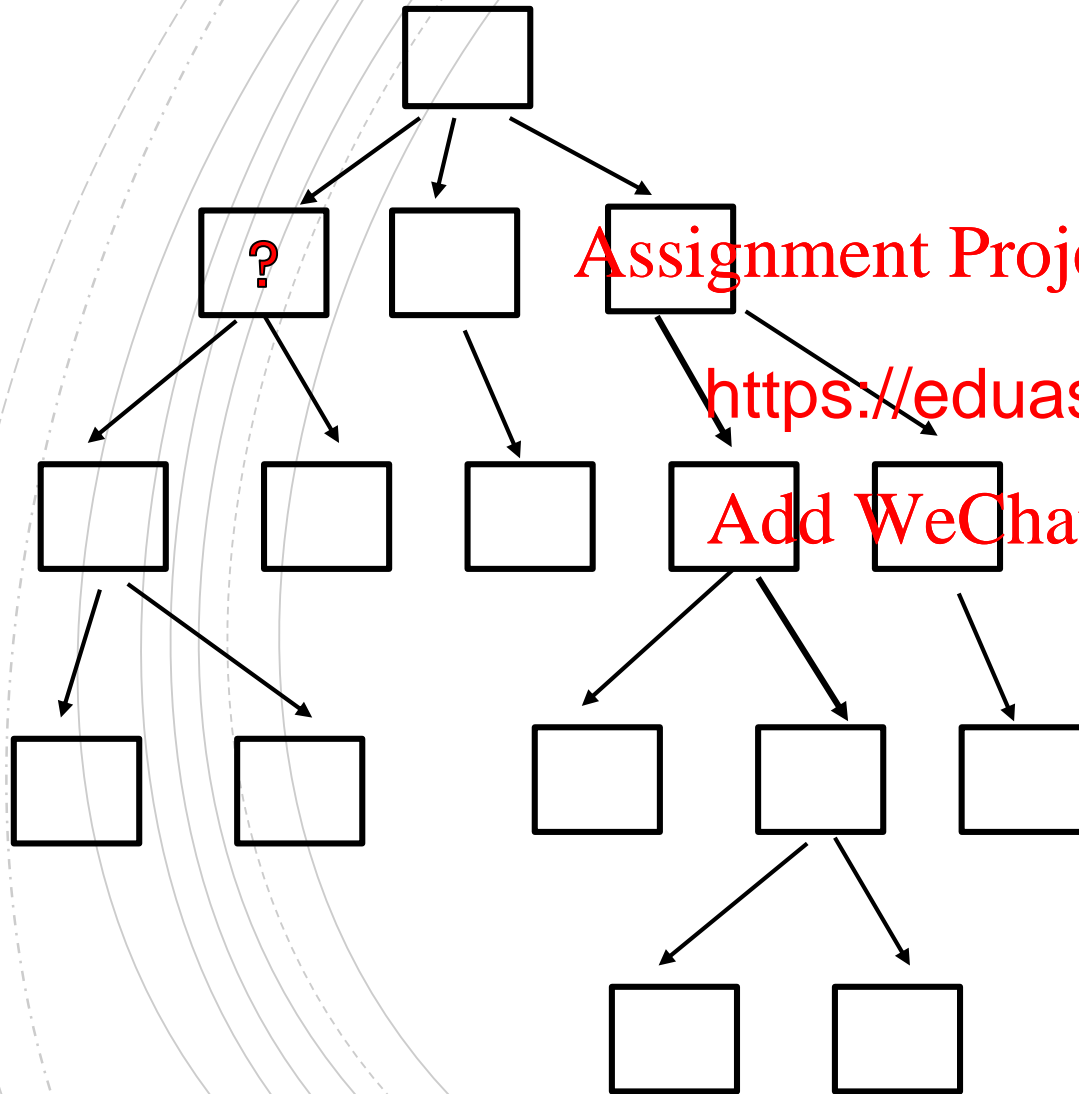
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```
} {  
    if(v.parent == null) //root  
        return 0  
    else  
        return 1 + depth(v.parent)  
}
```

(ROOTED) TREE TERMINOLOGY



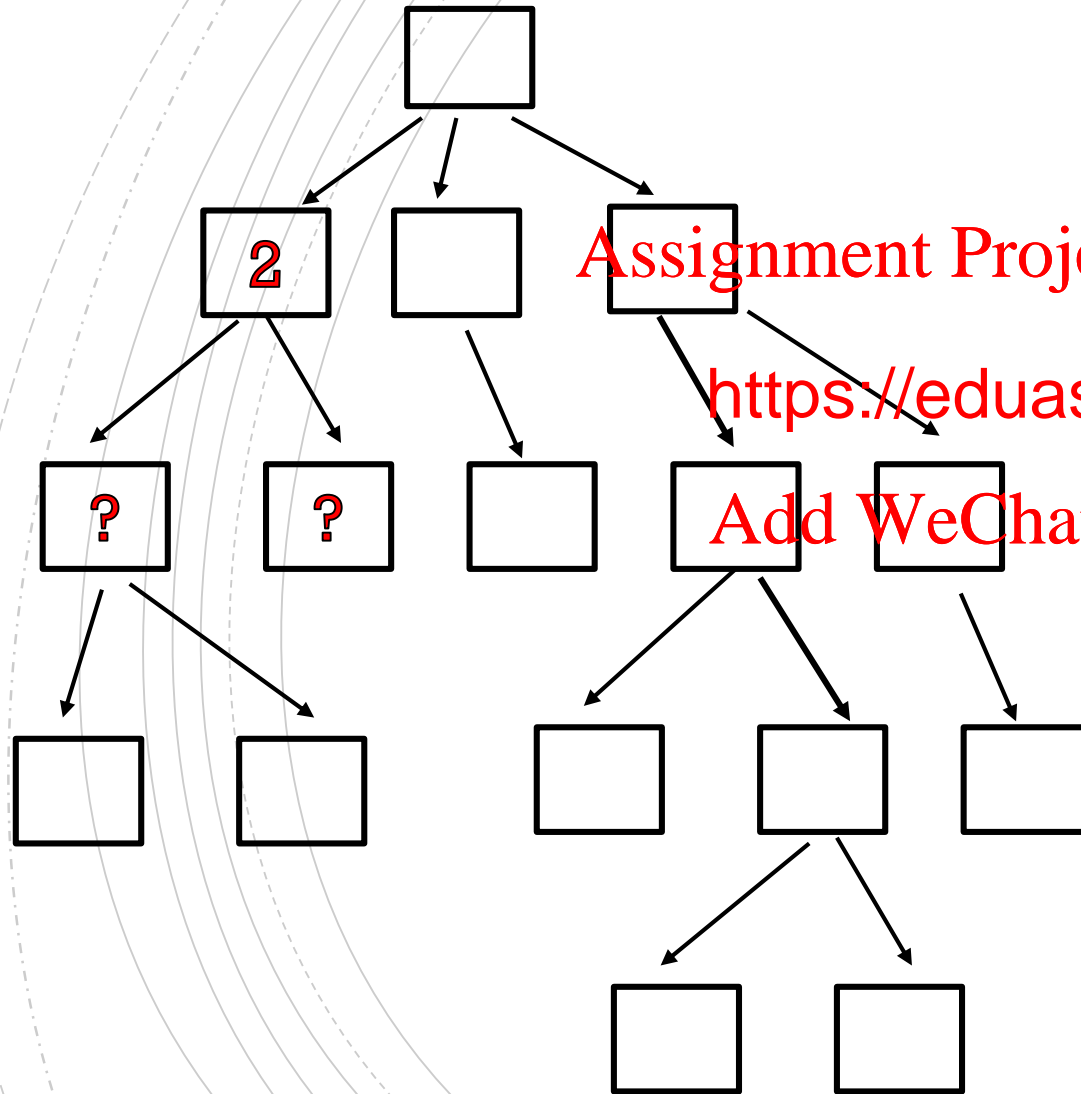
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The *height* of a node is the minimum length of a path from that node to a leaf.

TREE TERMINOLOGY



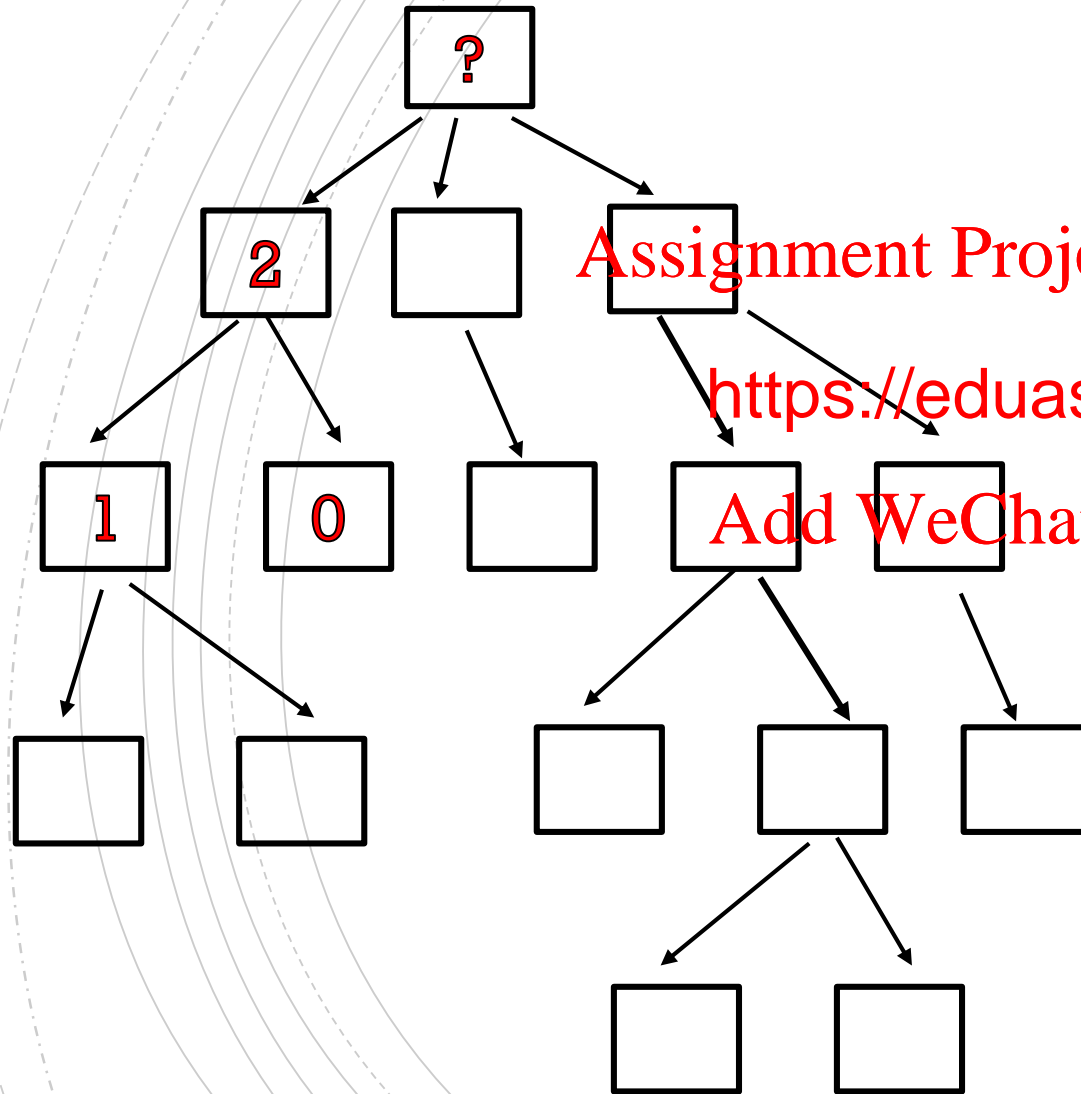
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TREE TERMINOLOGY



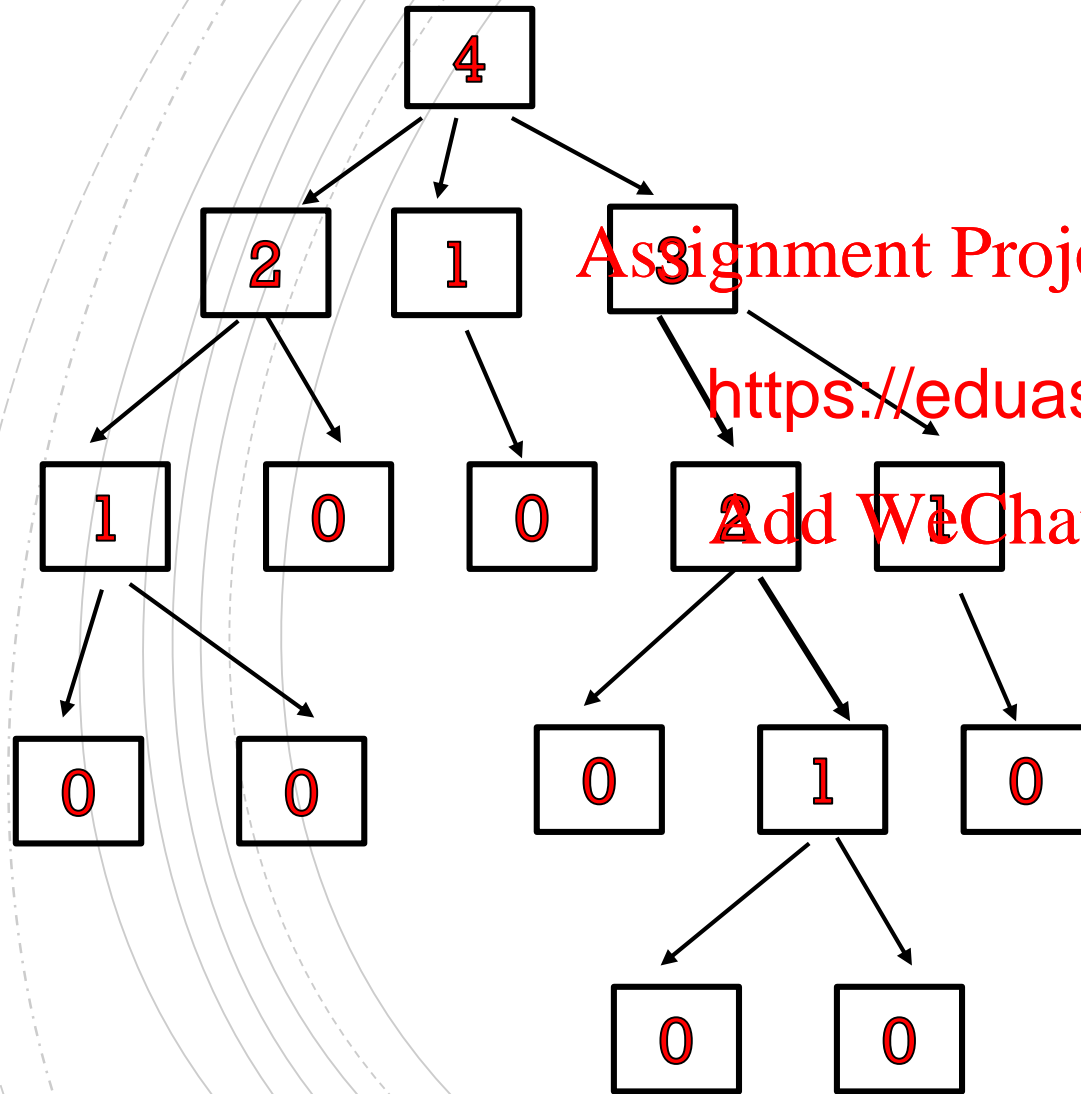
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TREE TERMINOLOGY



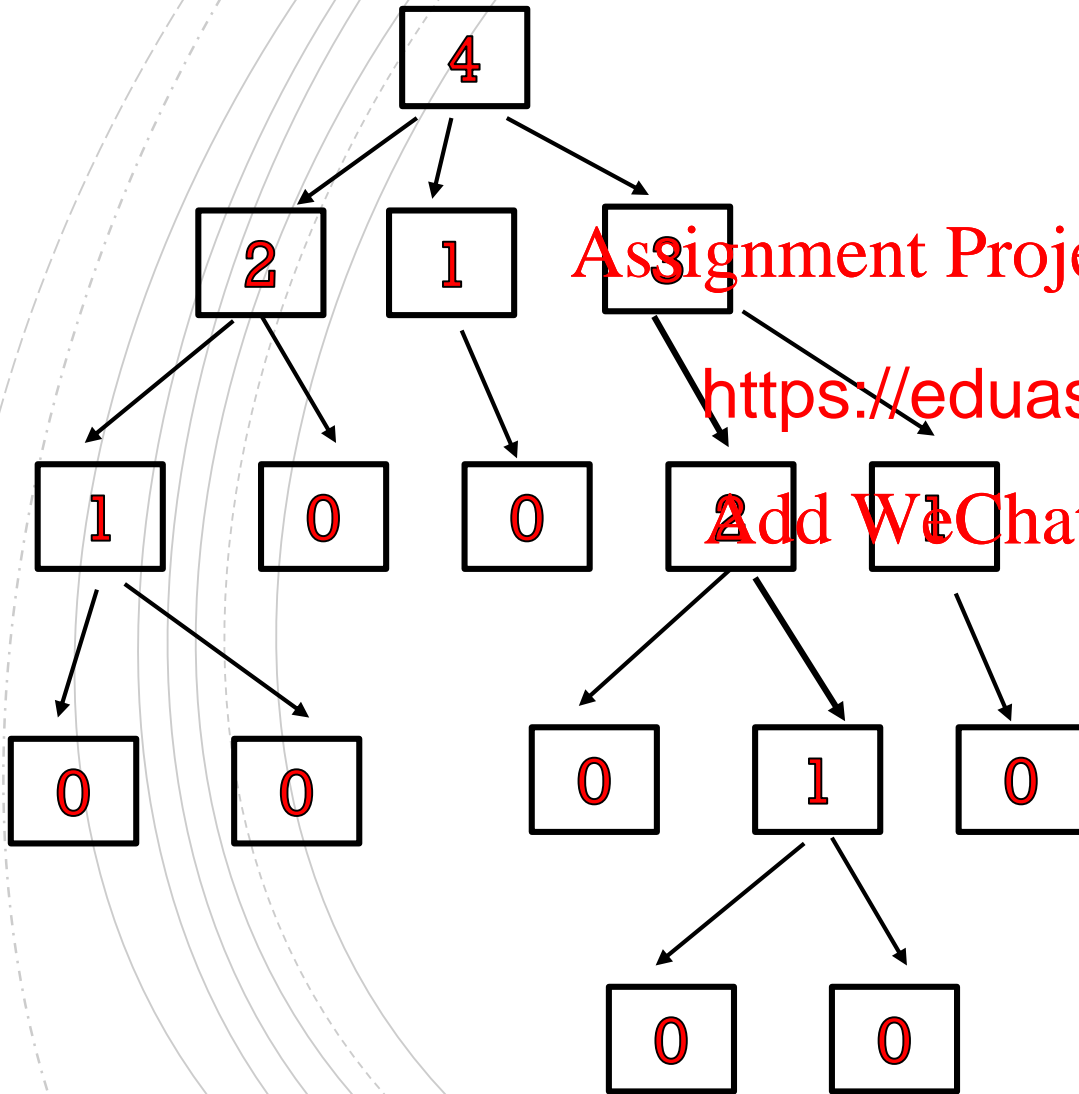
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we can compute the
ht of a node v?

height(v)



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```
height(v) {
    if (v is a leaf)
        return 0
    h = 0
    for each child w of v
        h = max(h, height(w))
    return 1 + h
}
```

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IM

ONS

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HOW TO IMPLEMENT A TREE IN JAVA?

Same idea as with linked lists:

- Create a data type to represent tree nodes.
- Represent a tree with a pointer to the root node.

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class TreeNode<T> {

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}

HOW TO IMPLEMENT A TREE IN JAVA?

Same idea as with linked lists:

- Create a data type to represent tree nodes.
- Represent a tree with a pointer to the root node.

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```
class TreeNode<T> {  
    All TreeNode<T>> children;  
  
    TreeNode<T> parent; // optional  
  
}
```

HOW TO IMPLEMENT A TREE IN JAVA?

Same idea as with linked lists:

- Create a data type to represent tree nodes.
- Represent a tree with a pointer to the root node.

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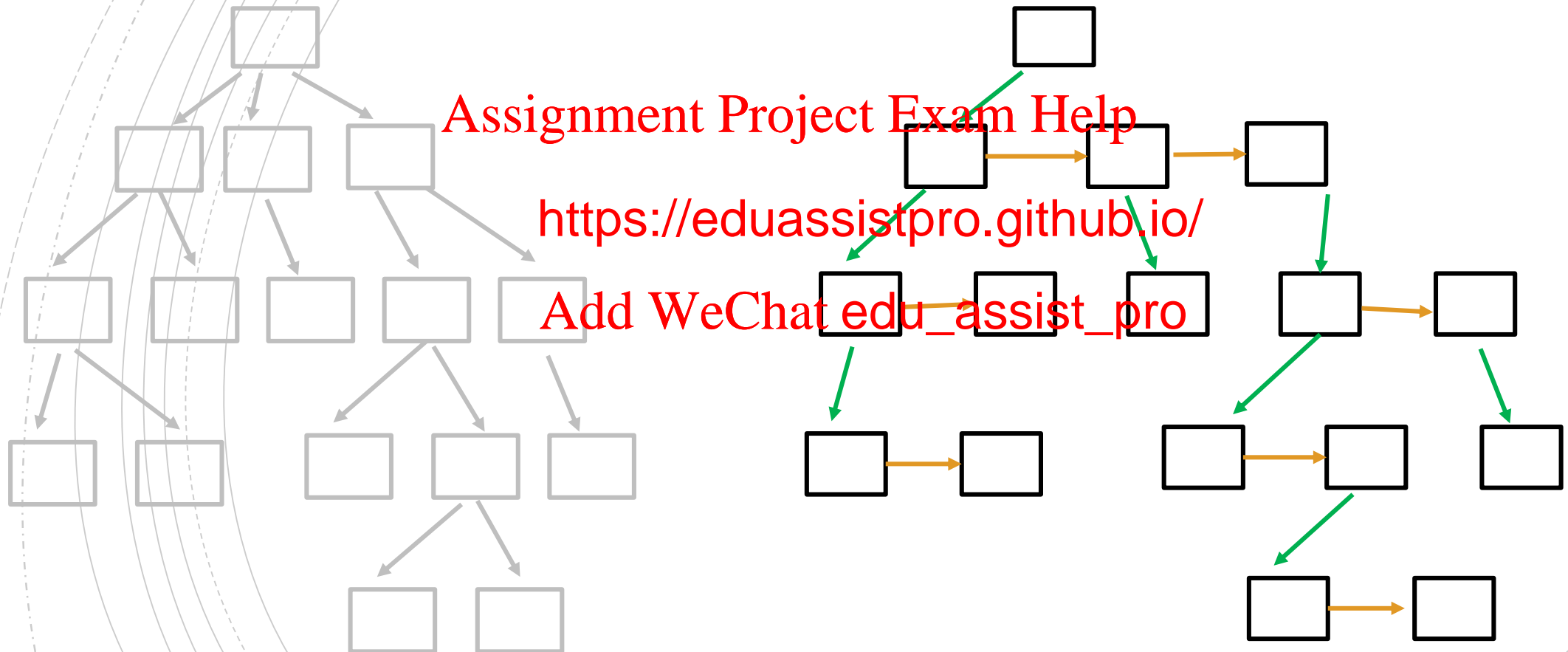
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```
class Tree<T>{
    T root;

    class TreeNode<T>{
        T
        ArrayList<TreeNode<T>> children;
        TreeNode<T> parent; // optional
    }
}
```


ANOTHER COMMON IMPLEMENTATION: 'first child, next sibling'

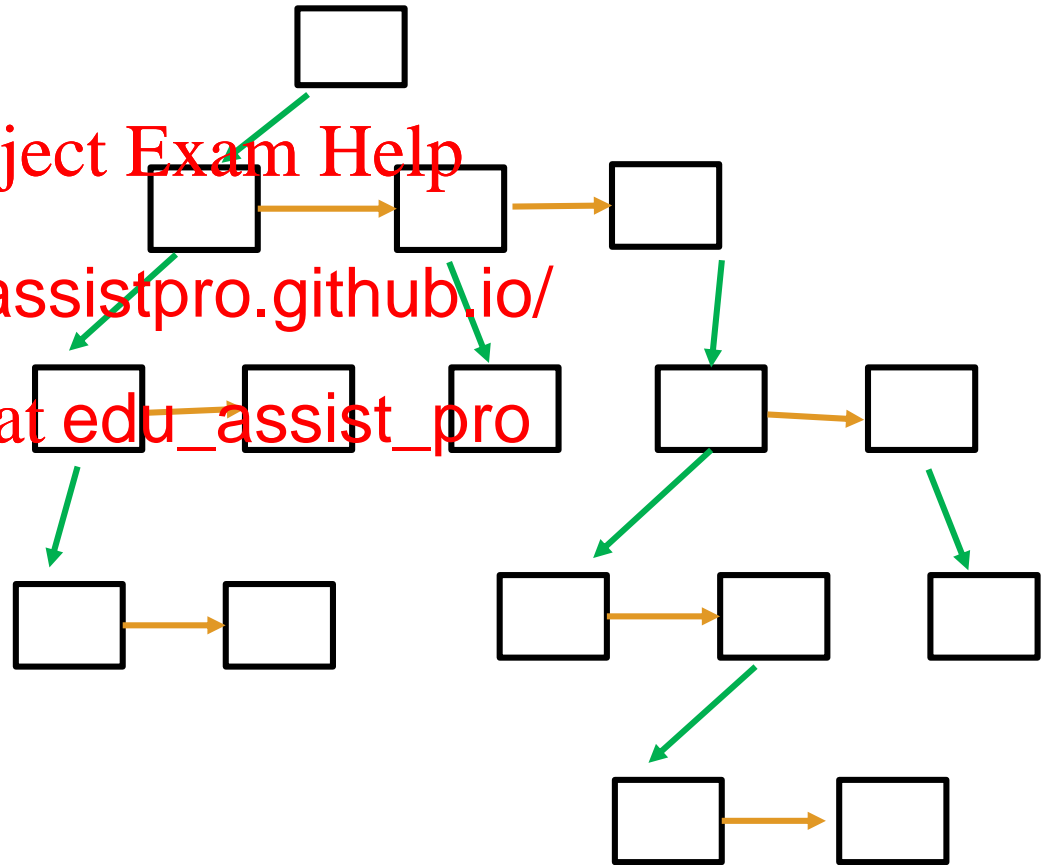


(similar to singly linked lists)

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ANOTHER COMMON IMPLEMENTATION: 'first child, next sibling'

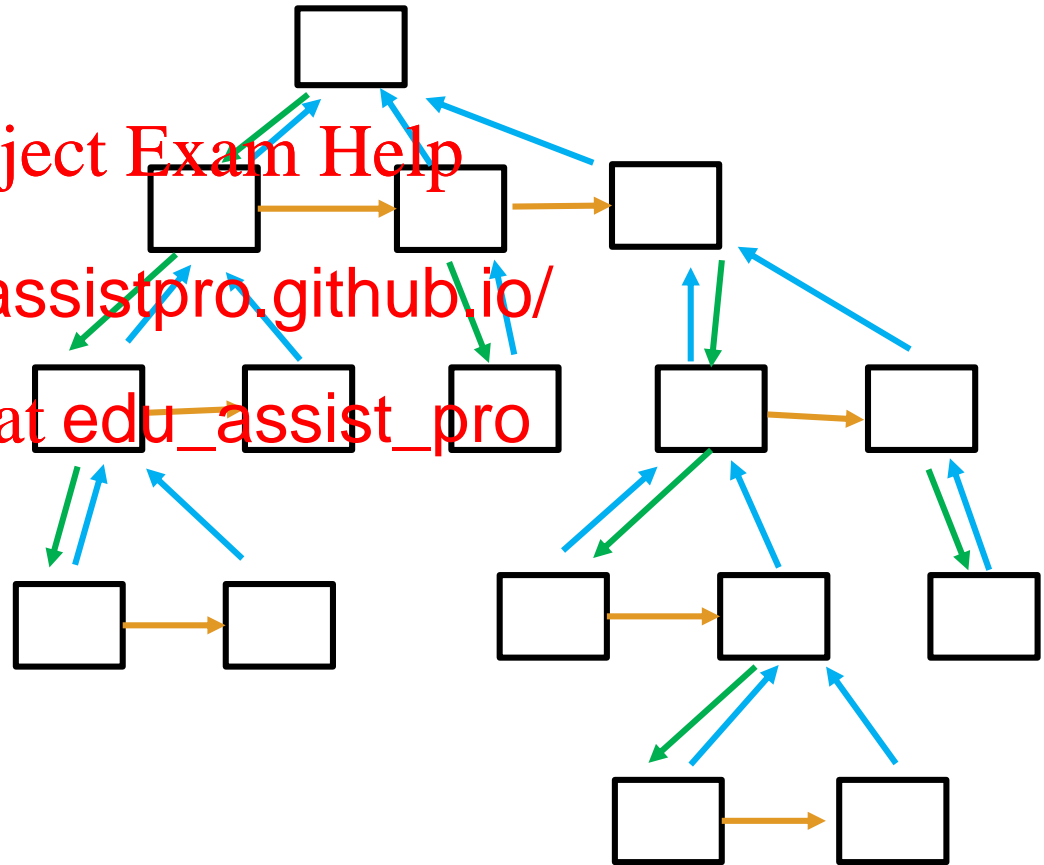
(similar to singly linked lists)

```
class Tree<T>{
    TreeNode<T> root;
    :
    class TreeNode<T>{
        T element;
        TreeNode<T> firstChild;
        TreeNode<T> nextSibling;
        TreeNode<T> parent;
    }
}
```

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A TREE OF WHAT? EACH NODE HAS AN ELEMENT!

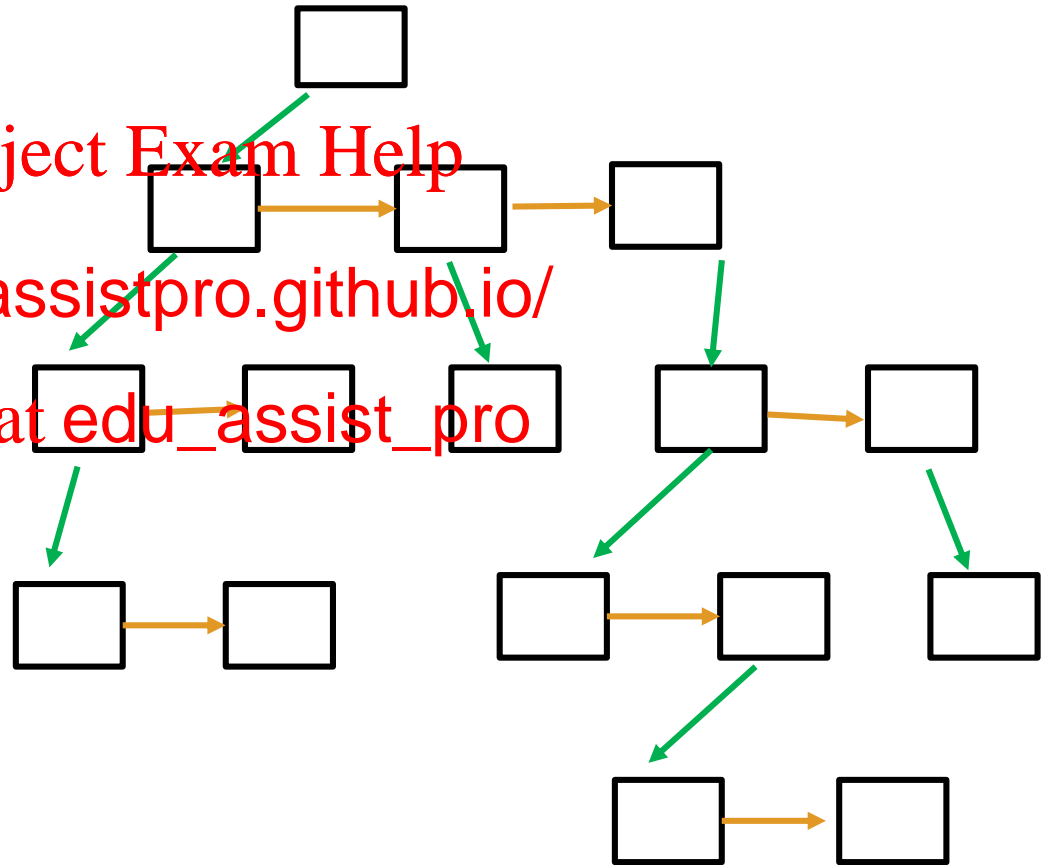
(NOT ILLUSTRATED ON THE RIGHT)

```
class Tree<T>{
    TreeNode<T> root;
    :
    class TreeNode<T>{
        T element;
        TreeNode<T> firstChild;
        TreeNode<T> nextSibling;
        :
    }
}
```

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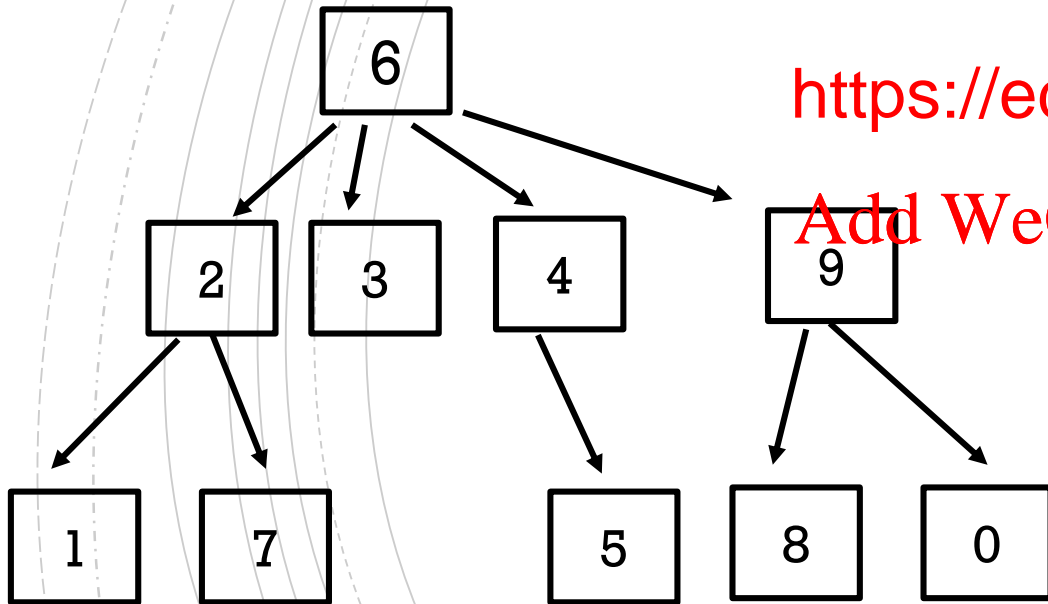
ANOTHER EXERCISES

Write this tree using the first child, next sibling representation.

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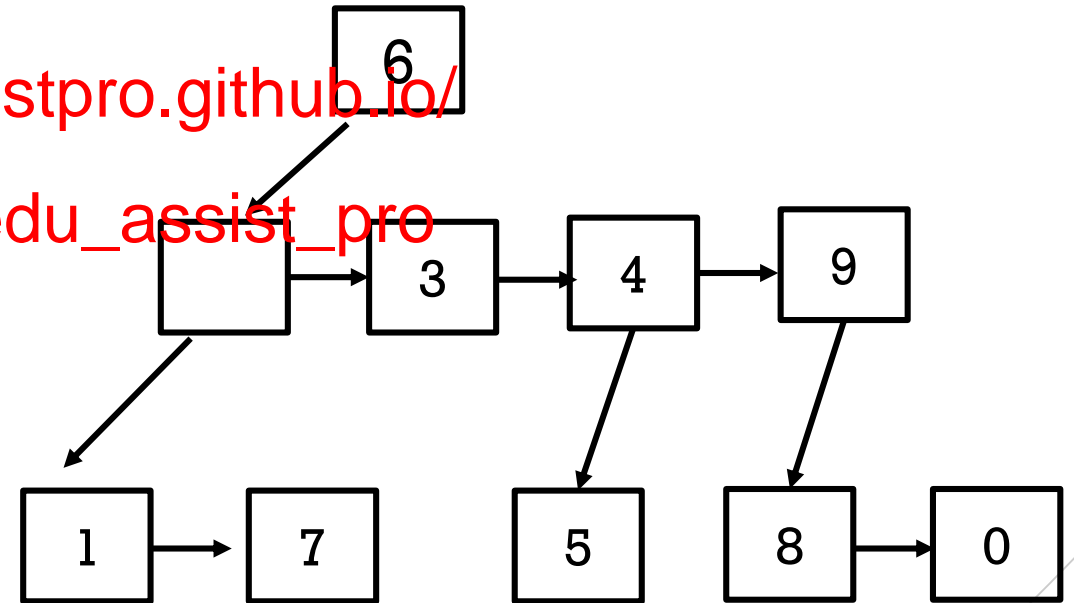
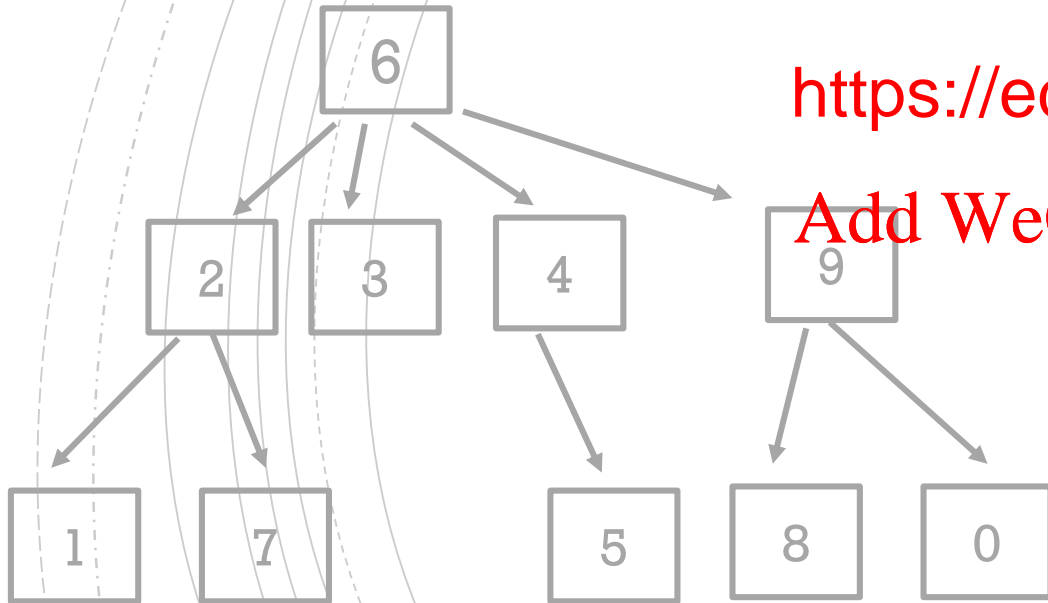
SOLUTION

Write this tree using the first child, next sibling representation.

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An orange paint roller with a red handle, positioned horizontally. The roller is partially covered in orange paint, which is dripping down the left side. The text "Coming Soon" is written in white on the orange surface of the roller.

Coming Soon

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In the next

- Tree Tra <https://eduassistpro.github.io/>
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