CSC148-Section:L0301 Week#8-Friday

Instructed by

AbdulAziz Al-Helali

a.alhelali@mail.utoronto.ca

Office hours: Wednesday 11-1, BA2230.

Slides adapted from Professor Danny Heap course material winter17

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Announcement

- In addition to regularly-scheduled office hours we have:
  - ~~Thursday March 1, 11-noon, 1-2, Anujan~~
  - ~~Friday March 2, 9-11, 12-1, Anujan~~
  - Monday March 5, 10 a.m. - 8 p.m., Ali
  - Monday March 5, 10 a.m. - 4 p.m., Shahin
  - Monday March 5, 4 p.m. - 8 p.m., Mingjie

Outline

- Tree
  - Levelorder visit
- Binary Trees

levelorder

```
def levelorder_visit(t: Tree, act: Callable[[Tree], Any]) -> None:
    """
    Visit every node in Tree t in level order and act on the node
    as you visit it.

    >>> t = descendants_from_list(Tree(0),
                                  [1, 2, 3, 4, 5, 6, 7], 3)
    >>> def act(node): print(node.value)
    >>> levelorder_visit(t, act)
    0
    1
    2
    3
    4
    5
    6
    7
    """
```

```
def levelorder_visit(t: Tree, act: Callable[[Tree], Any]) -> None:
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    >>> t = descendants_from_list(Tree(0),[1, 2, 3, 4, 5, 6, 7], 3)
    >>> def act(node): print(node.value)
    >>> levelorder_visit(t, act)
    0
    1
    2
    3
    4
    5
    6
    7
    """
    q = Queue()
    q.add(t)
    while not q.is_empty():
        curr_tree = q.remove()
        act(curr_tree)
        for x in curr_tree.children:
            q.add(x)
```
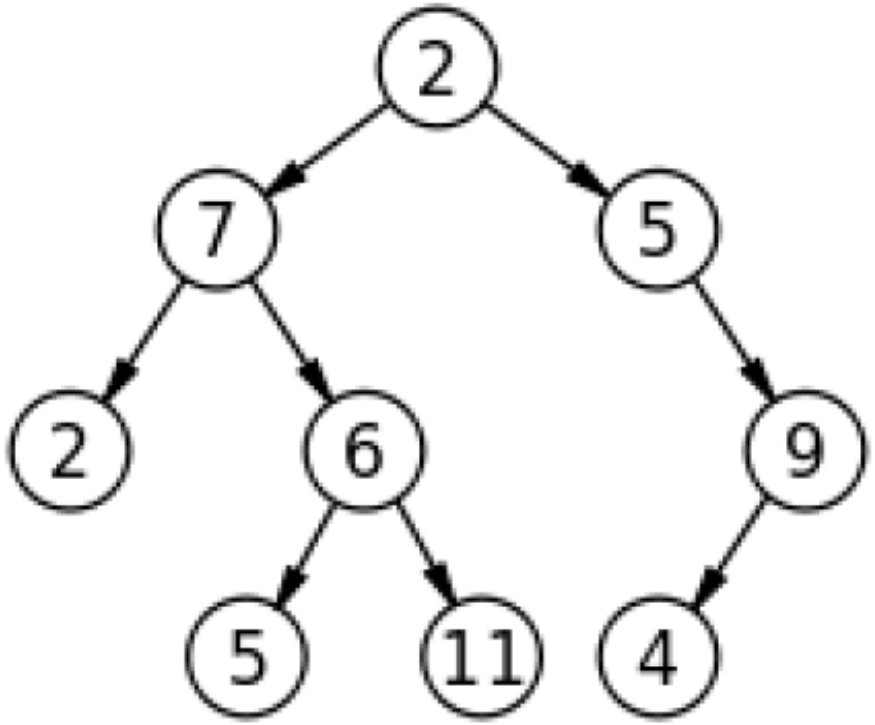

Binary Trees

- Each node: has at most two children
- Called: ***left child*** and the ***right child***



- ***Applications:***
  - Search algorithms
  - compression algorithms used in jpeg and .mp3
  - Compilers

tree inheritance issues

- one approach to **BinaryTree** would be to make it a subclass of **Tree**, but there are some design considerations
  - any client code that uses **Tree** would be required not to violate the branching factor (2) of **BinaryTree**
  - one way to achieve this would be to make **Tree** immutable: make sure there is no way to change **children** or **value**, and then have subclasses that might be mutable
- we will take a different approach: a completely separate **BinaryTree** class

BinaryTree

```
class BinaryTree:
    """
    A Binary Tree, i.e. arity 2.
    """

    def __init__(self, value: object, left: Union['BinaryTree', None]=None,
                 right: Union['BinaryTree', None]=None) -> None:
        """
        Create BinaryTree self with value and children left and right.

        """
        self.value, self.left, self.right = value, left, right
```

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special methods...

- We'll want the standard special methods:
  - __eq__
  - __str__
  - __repr__

Contains – As Module Level functions

```
def contains(node: BinaryTree, value: object) -> bool:
    """
    Return whether tree rooted at self contains value.

    >>> t = BinaryTree(5, BinaryTree(7), BinaryTree(9))
    >>> contains(t,7)
    True
    """
```

Contains – As Module Level functions

```
def contains(node: BinaryTree, value: object) -> bool:
    """
    Return whether tree rooted at self contains value.

    >>> t = BinaryTree(5, BinaryTree(7), BinaryTree(9))
    >>> contains(t,7)
    True
    """
    if node.left is None and node.right is None:
        return node.value == value
    else:
        return (node.value == value
                or contains(node.left,value)
                or contains(node.right,value))
```

The code **will NOT work** if the BinaryTree has one child as None ?
No, we need to handle those cases see next slide

```
def contains(node: Union[BinaryTree, None], value: object) -> bool:
    """
    Return whether tree rooted at self contains value.

    >>> t = BinaryTree(5, BinaryTree(7), BinaryTree(9))
    >>> contains(t,5)
    True
    >>> contains(t,2)
    False
    >>> t1 = BinaryTree(5, BinaryTree(7,BinaryTree(3)), None)
    >>> contains(t1,1)
    False
    """
    if node.left is None and node.right is None:
        return node.value == value
    elif node.left is None:
        return node.value == value or contains(node.right, value)
    elif node.right is None:
        return node.value == value or contains(node.left, value)
    else:
        return (node.value == value
                or contains(node.left, value)
                or contains(node.right, value))
```

If either left or right nodes is None
We should not call contains on that branch of the tree

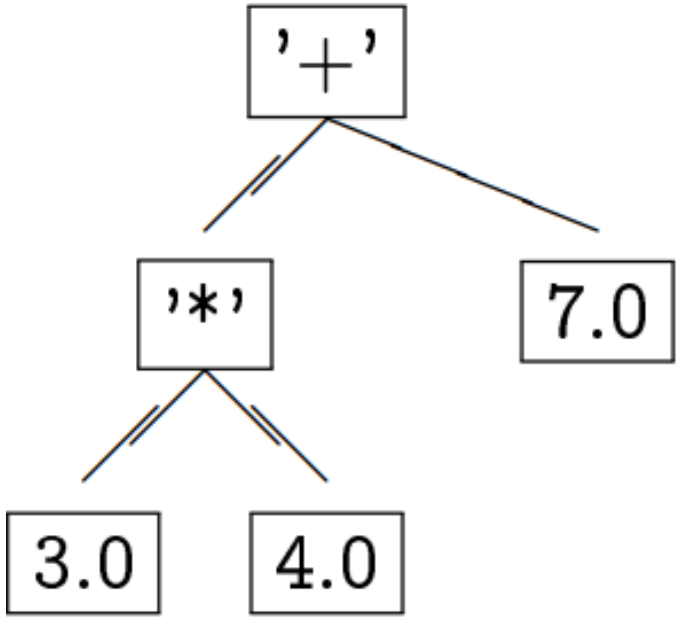
Contains – As BinaryTree class Method

```
def __contains__(self, value: object) -> bool:
    """
    Return whether tree rooted at self contains value.

    >>> t = BinaryTree(5, BinaryTree(7), BinaryTree(9))
    >>> 7 in t
    True
    >>> t = BinaryTree(5, BinaryTree(7), None)
    >>> 3 in t
    False
    """
    if self.left is None and self.right is None:
        return self.value == value
    elif self.left is None:
        return self.value == value or value in self.right
    elif self.right is None:
        return self.value == value or value in self.left
    else:
        return (self.value == value
                or value in self.left
                or value in self.right)
```

arithmetic expression trees

- Binary arithmetic expressions can be represented as binary trees:



evaluating a binary expression tree

- there are no empty expressions
- if it's a leaf, just return the value
- otherwise...
  - evaluate the left tree
  - evaluate the right tree
  - combine left and right with the binary operator
- Python built-in eval might be handy.

evaluating a binary expression tree

```
def evaluate(b: BinaryTree) -> Union[float, object]:
    """
    Evaluate the expression rooted at b.  If b is a leaf,
    return its float value.  Otherwise, evaluate b.left and
    b.right and combine them with b.value.

    Assume:  -- b is a non-empty binary tree
             -- interior nodes contain value in {"+", "-", "*", "/"}
             -- interior nodes always have two children
             -- leaves contain float value

    >>> b = BinaryTree(3.0)
    >>> evaluate(b)
    3.0
    >>> b = BinaryTree("*", BinaryTree(3.0), BinaryTree(4.0))
    >>> evaluate(b)
    12.0
    """
```

```
def evaluate(b: BinaryTree) -> Union[float, object]:
    """
    Evaluate the expression rooted at b.  If b is a leaf,
    return its float value.  Otherwise, evaluate b.left and
    b.right and combine them with b.value.

    Assume:  -- b is a non-empty binary tree
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    >>> b = BinaryTree(3.0)
    >>> evaluate(b)
    3.0
    >>> b = BinaryTree("*", BinaryTree(3.0), BinaryTree(4.0))
    >>> evaluate(b)
    12.0
    """
    if b.left is None and b.right is None:
        return b.value
    else:
        return eval("{} {} {}".format(evaluate(b.left),
                                      b.value,
                                      evaluate(b.right)))
```