# Week8: Binary Trees

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# Announcements

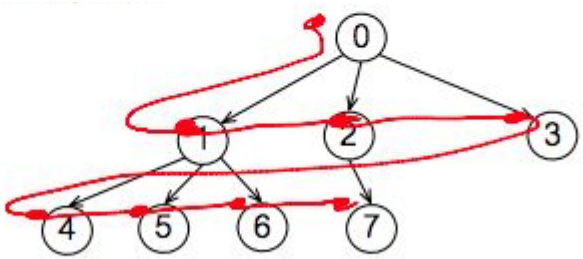
1. Extra extra hours has been allocated for A2.  Today, Monday and Tuesday (TAs, Professors)
2. Implement minimax in 2 ways (not 4 ways, not 10 ways)
3. Your Minimax should work for any game:
    a. Use the notion that each game is a subclass from **Game** and state is subclass of **GameState**
    b. Use hooks (get_possible_moves, is_over, who won? etc.)
    c. **DO NOT** use game specific assumptions
    d. Should work on any game

# Agenda

1. Binary trees
2. BinaryTree Class (NOT a subclass of *Tree*)
3. Work on an exercise (handout)
4. How to implement contains as a module level *function* vs class level *method*

# Recap

Tree level_order_visit




1. Using queue (no recursion)
2. Using recursion (no additional data structure)

# Recursive level_order_visit

Idea:

1. Visit the root
2. Visit nodes at each level until there are no children
3. While visiting a level, use recursion to traverse from root until that level

# Take home message

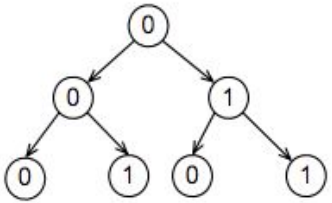
1. Some data structures can be used to solve recursive problems (stack or queue)
2. When you do not use any, there is an implicit data structure used: *call stack*

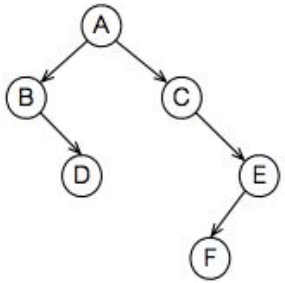
# Binary tree

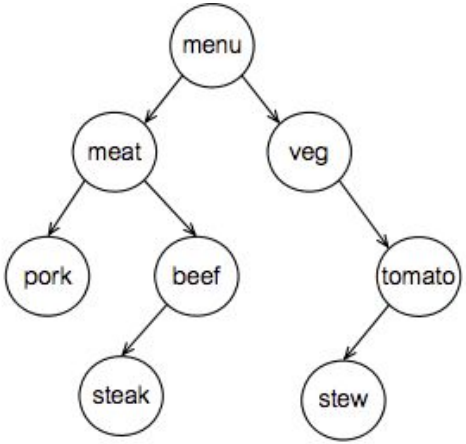
A tree with arity (maximum branching factor) 2

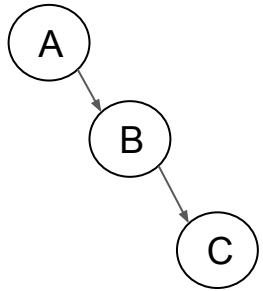
# Binary tree

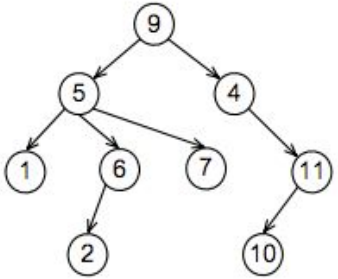
How many non-binary trees?

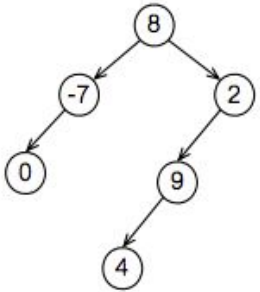


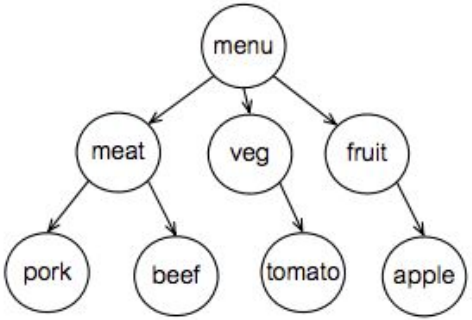




# Binary Tree Design

1. Think of a *special* General Tree
2. Not a good idea to make a subclass of Tree
    a. Keep checking if client code violates arity
3. If subclass, make children immutable
    a. Then make mutable in some subclasses (general trees)
    b. Complicated!!!!!
4. We will redesign a BinaryTree Class

# Binary Tree Class

```
class BinaryTree:
    """
    A Binary Tree, i.e. arity 2.
    """
    def __init__(self, value, left=None, right=None):
        """
        Create BinaryTree self with value and children left and right.
        @param BinaryTree self: this binary tree
        @param object value: value of this node
        @param BinaryTree|None left: left child
        @param BinaryTree|None right: right child
        @rtype: None
        """
        self.value, self.left, self.right = value, left, right
```

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```

General Tree:

```
self._value, self._children = value, children[:] if children is not None else []
```

# Creating a Binary Tree

Same bottom up design:

```
>>> childTree1 = BinaryTree(2,BinaryTree(3))
>>> childTree2 = BinaryTree(4)
>>> b = BinaryTree(1,childTree1, childTree2)
```

# Special methods

__eq__

__repr__

__str__

# Exercise 1

Handout

Design a function contains(tree, value)

# Exercise 2

Designing this function as a class level method -- what modifications necessary?