03 traverse_a_tree_bfs_solution

May 4, 2020

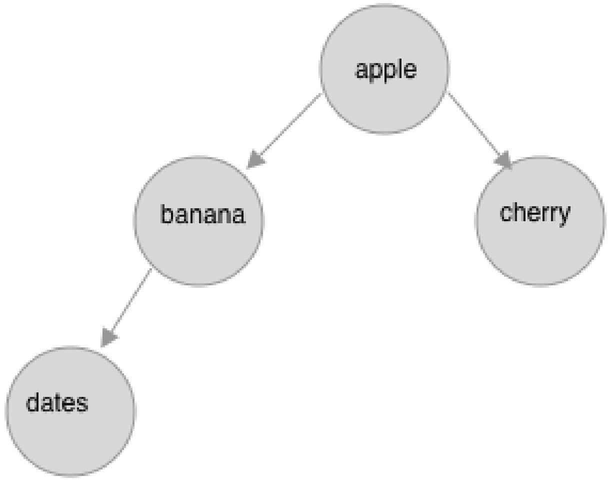
0.1 Traverse a tree (breadth first search)

We'll now practice implementing breadth first search (BFS). You'll see breadth first search again when we learn about graph data structures, so BFS is very useful to know.

0.2 Creating a sample tree

We'll create a tree that looks like the following:

```
In [1]: # this code makes the tree that we'll traverse

        class Node(object):

            def __init__(self,value = None):
                self.value = value
                self.left = None
                self.right = None

            def set_value(self,value):
                self.value = value

            def get_value(self):
                return self.value

            def set_left_child(self,left):
                self.left = left

            def set_right_child(self, right):
                self.right = right

            def get_left_child(self):
                return self.left

            def get_right_child(self):
                return self.right

            def has_left_child(self):
                return self.left != None
```



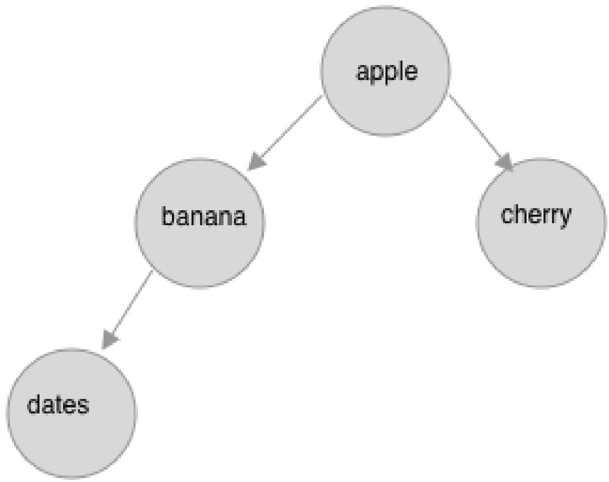
tree image

```
    def has_right_child(self):
        return self.right != None

    # define __repr_ to decide what a print statement displays for a Node object
    def __repr__(self):
        return f"Node({self.get_value()})"

    def __str__(self):
        return f"Node({self.get_value()})"


class Tree():
    def __init__(self, value=None):
        self.root = Node(value)

    def get_root(self):
        return self.root

tree = Tree("apple")
tree.get_root().set_left_child(Node("banana"))
tree.get_root().set_right_child(Node("cherry"))
tree.get_root().get_left_child().set_left_child(Node("dates"))
```

0.3 Breadth first search

Breadth first traversal of the tree would visit the nodes in this order:
apple, banana, cherry, dates

Think through the algorithm We are walking down the tree one level at a time. So we start with apple at the root, and next are banana and cherry, and next is dates.



tree image

1) start at the root node

2) visit the root node's left child (banana), then right child (cherry)

3) visit the left and right children of (banana) and (cherry).

0.4 Queue

Notice that we're waiting until we visit "cherry" before visiting "dates". It's like they're waiting in line. We can use a queue to keep track of the order.

0.5 Define a queue class

```
In [2]: from collections import deque
        q = deque()
        q.appendleft
        q.pop
        q.appendleft("apple")
        q.appendleft("banana")
        print(q)

deque(['banana', 'apple'])
```

```
In [3]: q.pop()

Out[3]: 'apple'

In [4]: len(q)

Out[4]: 1
```

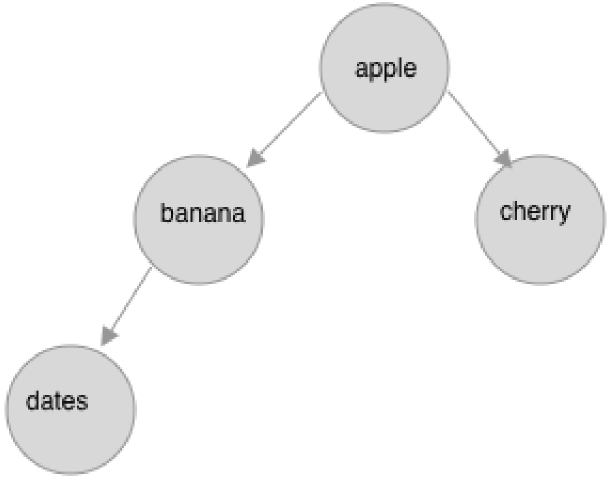
In [5]:
```python
from collections import deque
class Queue():
    def __init__(self):
        self.q = deque()

    def enq(self,value):
        self.q.appendleft(value)

    def deq(self):
        if len(self.q) > 0:
            return self.q.pop()
        else:
            return None

    def __len__(self):
        return len(self.q)

    def __repr__(self):
        if len(self.q) > 0:
            s = "<enqueue here>\n_________________\n"
            s += "\n_________________\n".join([str(item) for item in self.q])
            s += "\n_________________\n<dequeue here>"
            return s
        else:
            return "<queue is empty>"
```

In [6]:
```python
q = Queue()
q.enq("apple")
q.enq("banana")
q.enq("cherry")
print(q.deq())
print(q)
```

```
apple
<enqueue here>
_________________
cherry
_________________
banana
_________________
<dequeue here>
```

0.6 Walk through the steps with code

We're going to translate what we're doing by hand into code, one step at a time. This will help us check if our code is doing what we expect it to do.



tree image

```
In [7]: visit_order = list()
        q = Queue()

        # start at the root node and add it to the queue
        node = tree.get_root()
        q.enq(node)
        print(q)
```

```
<enqueue here>
------------------
Node(apple)
------------------
<dequeue here>
```

```
In [8]: # dequeue the next node in the queue.
        # "visit" that node
        # also add its children to the queue

        node = q.deq()
        visit_order.append(node)
        if node.has_left_child():
            q.enq(node.get_left_child())
        if node.has_right_child():
            q.enq(node.get_right_child())

        print(f"visit order: {visit_order}")
        print(q)
```

```
visit order: [Node(apple)]
<enqueue here>
------------------
```

```
Node(cherry)
------------------
Node(banana)
------------------
<dequeue here>
```

```
In [9]: # dequeue the next node (banana)
        # visit it, and add its children (dates) to the queue

        node = q.deq()
        visit_order.append(node)
        if node.has_left_child():
            q.enq(node.get_left_child())
        if node.has_right_child():
            q.enq(node.get_right_child())

        print(f"visit order: {visit_order}")
        print(q)
```

```
visit order: [Node(apple), Node(banana)]
<enqueue here>
------------------
Node(dates)
------------------
Node(cherry)
------------------
<dequeue here>
```

```
In [10]: # dequeue the next node (cherry)
         # visit it, and add its children (there are None) to the queue

         node = q.deq()
         visit_order.append(node)
         if node.has_left_child():
             q.enq(node.get_left_child())
         if node.has_right_child():
             q.enq(node.get_right_child())

         print(f"visit order: {visit_order}")
         print(q)
```

```
visit order: [Node(apple), Node(banana), Node(cherry)]
<enqueue here>
------------------
Node(dates)
------------------
```

```
<dequeue here>
```

```python
In [11]: # dequeue the next node (dates)
         # visit it, and add its children (there are None) to the queue

         node = q.deq()
         visit_order.append(node)
         if node.has_left_child():
             q.enq(node.get_left_child())
         if node.has_right_child():
             q.enq(node.get_right_child())

         print(f"visit order: {visit_order}")
         print(q)
```

```
visit order: [Node(apple), Node(banana), Node(cherry), Node(dates)]
<queue is empty>
```

0.7 Task: write the breadth first search algorithm

```python
In [18]: # Solution

         def bfs(tree):
             q = Queue()
             visit_order = list()
             node = tree.get_root()
             q.enq(node)
             while(len(q) > 0):
                 node = q.deq()
                 visit_order.append(node)
                 if node.has_left_child():
                     q.enq(node.get_left_child())
                 if node.has_right_child():
                     q.enq(node.get_right_child())

             return visit_order
```

```python
In [19]: # check solution: should be: apple, banana, cherry, dates
         bfs(tree)
```

```
Out[19]: [Node(apple), Node(banana), Node(cherry), Node(dates)]
```

0.8 Bonus Task: write a print function

Define the print function for the Tree class. Nodes on the same level are printed on the same line.
For example, the tree we've been using would print out like this:

```
Node(apple)
Node(banana) | Node(cherry)
Node(dates) | <empty> | <empty> | <empty>
<empty> | <empty>
```

We'll have `<empty>` be placeholders so that we can keep track of which node is a child or parent of the other nodes.

hint: use a variable to keep track of which level each node is on. For instance, the root node is on level 0, and its child nodes are on level 1.

```
In [16]: # solution

         class Tree():
             def __init__(self, value=None):
                 self.root = Node(value)

             def get_root(self):
                 return self.root

             def __repr__(self):
                 level = 0
                 q = Queue()
                 visit_order = list()
                 node = self.get_root()
                 q.enq( (node,level) )
                 while(len(q) > 0):
                     node, level = q.deq()
                     if node == None:
                         visit_order.append( ("<empty>", level))
                         continue
                     visit_order.append( (node, level) )
                     if node.has_left_child():
                         q.enq( (node.get_left_child(), level +1 ))
                     else:
                         q.enq( (None, level +1) )

                     if node.has_right_child():
                         q.enq( (node.get_right_child(), level +1 ))
                     else:
                         q.enq( (None, level +1) )

                 s = "Tree\n"
                 previous_level = -1
                 for i in range(len(visit_order)):
                     node, level = visit_order[i]
                     if level == previous_level:
                         s += " | " + str(node)
                     else:
```

```
                s += "\n" + str(node)
                previous_level = level

        return s
```

In [17]:
```
# check solution
tree = Tree("apple")
tree.get_root().set_left_child(Node("banana"))
tree.get_root().set_right_child(Node("cherry"))
tree.get_root().get_left_child().set_left_child(Node("dates"))
print(tree)
```

```
Tree

Node(apple)
Node(banana) | Node(cherry)
Node(dates) | <empty> | <empty> | <empty>
<empty> | <empty>
```

In [ ]: