CSC148 winter 2014

linked structures

week 8

Danny Heap
heap@cs.toronto.edu
BA4270 (behind elevators)
http://www.cdf.toronto.edu/~heap/148/W14/
416-978-5899

March 4, 2014

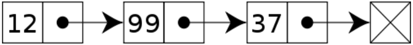
Outline

linked lists, two concepts

There are two useful, but different, ways of thinking of linked list structures

1. as lists made up of an item (value) and the remaining list (rest)

2. as objects (nodes) with a value and a reference to other similar objects



a node class

```
class LListNode:
    """Node to be used in linked list"""

    def __init__(self: 'LListNode', value: object,
                 nxt: 'LListNode' =None) -> None:
        """Create a new LListNode containing value
        referring to next node nxt

        nxt --- None if and only if we are on the last node
        value --- always a Python object, there are no empty nodes
        """
        self.value, self.nxt = value, nxt
```

a wrapper class for list

The list class keeps track of information about the entire list — such as its front.

```
class LinkedList:
    """Collection of LListNodes"""

    def __init__(self: 'LinkedList') -> None:
        """Create an empty LinkedList"""
        self.front = None
        self.size = 0
```

insertion

```
def insert(self: ’LinkedList’, value: object) -> None:
    """Insert LListNode with value at front of self

    >>> lnk = LinkedList()
    >>> lnk.insert(0)
    >>> lnk.insert(1)
    >>> lnk.insert(2)
    >>> str(lnk.front)
    ’2 -> 1 -> 0 -> None’
    >>> lnk.size
    3
    """
```

deletion

```
"""Delete front LListNode from self

self must not be None

>>> lnk = LinkedList()
>>> lnk.insert(0)
>>> lnk.insert(1)
>>> lnk.insert(2)
>>> lnk.delete_front()
>>> str(lnk.front)
’1 -> 0 -> None’
>>> lnk.size
2
"""
```

reversing

```
def reverse(ln: LListNode) -> LListNode:
    """Return the linked list starting
    at ln in reverse order

    ln is not None

    >>> ln = LListNode(0)
    >>> ln1 = LListNode(1, ln)
    >>> ln2 = LListNode(2, ln1)
    >>> ln3 = LListNode(3, ln2)
    >>> lnr = reverse(ln3)
    >>> str(lnr)
    ’0 -> 1 -> 2 -> 3 -> None’
    """
```

wrapper/node binary tree

instead of single tree class, separate node and bst classes:

```
class BTNode:
    """Binary Tree node."""

    def __init__(self: ’BTNode’, data: object,
                 left: ’BTNode’=None,
                 right: ’BTNode’=None) -> None:
        """Create BT node with data, children left and right."""
        self.data, self.left, self.right = data, left, right
```

string representation

Python __str__ method is more informal than __repr__. I had to start with a helper function (why?)

```
def _str(b: BTNode, i: str) -> str:
    """Return a string representing self inorder
    indent by i"""
    return ((bt_str(b.right, i + '    ') if b.left else '') +
            i + str(b.data) + '\n' +
            (bt_str(b.left, i + '    ') if b.right else ''))
```

...now the __str__ method is easy

```
def __str__(self: ’BTNode’) -> str:
    """Return a string representing self inorder"""
    return _str(self, ’’)
```

binary search tree

Add a condition: data in left subtree is less than that in the root, which in turn is less than that in right subtree. Now search is more efficient...

```
class BST:
    """Binary search tree."""

    def __init__(self: 'BST', root: BTNode=None) -> None:
        """Create BST with BTNode root."""
        self._root = root
```

insert must obey condition

Careful reading of the example show that we expect **insert** to ensure this is a binary **search** tree:

```
   def insert(self: 'BST', data: object) -> None:
       """Insert data, if necessary, into this tree.

       >>> b = BST()
       >>> b.insert(8)
       >>> b.insert(4)
       >>> b.insert(2)
       >>> b.insert(6)
       >>> b.insert(12)
       >>> b.insert(14)
       >>> b.insert(10)
       >>> b
       BST(BTNode(8, BTNode(4, BTNode(2, None, None), BTNode(6, None,
BTNode(12, BTNode(10, None, None), BTNode(14, None, None))))
   """
       self._root = _insert(self._root, data)
```

helper function...

the wrapper/node design means that the recursive structures are **BTNodes** rather than **BST**, so write a module-level function as a helper:

```
def _insert(node: BTNode, data: object) -> BTNode:
    """Insert data starting at node, and return root."""
    return_node = node
    if not node:
        return_node = BTNode(data)
    elif data < node.data:
        node.left = _insert(node.left, data)
    elif data > node.data:
        node.right = _insert(node.right, data)
    else:  # nothing to do
        pass
    return return_node
```