Linked Lists Basics

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1 Types of Linked Lists

In this notebook we'll explore three versions of linked-lists: singly-linked lists, doubly-linked lists, and circular lists.

1.1 1. Singly Linked Lists

In this linked list, each node in the list is connected only to the next node in the list.

This connection is typically implemented by setting the `next` attribute on a node object itself.

```
In [ ]: class Node:
            def __init__(self, value):
                self.value = value
                self.next = None
```

```
In [ ]: # A small linked list:

        head = Node(1)
        head.next = Node(2)
```

Above we have a simple linked list with two elements, `[1, 2]`. Usually you'll want to create a `LinkedList` class as a wrapper for the nodes themselves and to provide common methods that operate on the list. For example you can implement an `append` method that adds a value to the end of the list. Note that if we're only tracking the head of the list, this runs in linear time - $O(N)$ - since you have to iterate through the entire list to get to the tail node. However, prepending (adding to the head of the list) can be done in constant $O(1)$ time. You'll implement this `prepend` method in the `Linked List Practice.ipynb` notebook.

Singly Linked List

```
In [ ]: class LinkedList:
            def __init__(self):
                self.head = None

            def append(self, value):
                if self.head is None:
                    self.head = Node(value)
                    return

                # Move to the tail (the last node)
                node = self.head
                while node.next:
                    node = node.next

                node.next = Node(value)
                return
```

```
In [ ]: linked_list = LinkedList()
        linked_list.append(1)
        linked_list.append(2)
        linked_list.append(4)

        node = linked_list.head
        while node:
            print(node.value)
            node = node.next
```

1.1.1 Exercise: Add a method `to_list()` to `LinkedList` that converts a linked list back into a Python list.

```
In [1]: class LinkedList:
            def __init__(self):
                self.head = None

            def append(self, value):
                if self.head is None:
                    self.head = Node(value)
                    return

                # Move to the tail (the last node)
                node = self.head
                while node.next:
                    node = node.next

                node.next = Node(value)
                return

            def to_list(self):
```

```
            # TODO: Write function to turn Linked List into Python List
            nodesList = []
            node = self.head
            while node:
                out_list.append(node.value)
                node = node.next
            return nodesList
            pass
```

In [ ]:
```
# Test your method here
linked_list = LinkedList()
linked_list.append(3)
linked_list.append(2)
linked_list.append(-1)
linked_list.append(0.2)

print ("Pass" if  (linked_list.to_list() == [3, 2, -1, 0.2]) else "Fail")
```

Hide Solution

In [ ]:
```
# Solution

class LinkedList:
    def __init__(self):
        self.head = None

    def append(self, value):
        if self.head is None:
            self.head = Node(value)
            return

        # Move to the tail (the last node)
        node = self.head
        while node.next:
            node = node.next

        node.next = Node(value)
        return

    def to_list(self):
        out_list = []

        node = self.head
        while node:
            out_list.append(node.value)
            node = node.next

        return out_list
```

Doubly Linked List

1.2 2. Doubly Linked Lists

This type of list has connections backwards and forwards through the list.

```
In [ ]: class DoubleNode:
            def __init__(self, value):
                self.value = value
                self.next = None
                self.previous = None
```

Now that we have backwards connections it makes sense to track the tail of the linked list as well as the head.

1.2.1 Exercise: Implement a doubly linked list that can append to the tail in constant time. Make sure to include forward and backward connections when adding a new node to the list.

```
In [ ]: class DoublyLinkedList:
            def __init__(self):
                self.head = None
                self.tail = None

            def append(self, value):

                # TODO: Implement this method to append to the tail of the list
                if self.head is None:
                    self.head = DoubleNode(value)
                    self.tail = self.head
                else:
                    self.tail.next = DoubleNode(value)
                    self.tail.next.previous = self.tail
                    self.tail = self.tail.next
                return
                pass
```

```
In [ ]: # Test your class here

        linked_list = DoublyLinkedList()
        linked_list.append(1)
```

```
linked_list.append(-2)
linked_list.append(4)

print("Going forward through the list, should print 1, -2, 4")
node = linked_list.head
while node:
    print(node.value)
    node = node.next

print("\nGoing backward through the list, should print 4, -2, 1")
node = linked_list.tail
while node:
    print(node.value)
    node = node.previous
```

Hide Solution

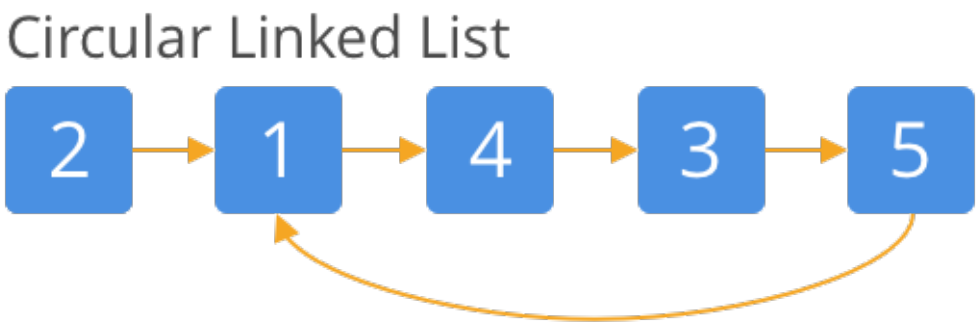
In [ ]:
```
# Solution

class DoublyLinkedList:
    def __init__(self):
        self.head = None
        self.tail = None

    def append(self, value):
        if self.head is None:
            self.head = DoubleNode(value)
            self.tail = self.head
            return

        self.tail.next = DoubleNode(value)
        self.tail.next.previous = self.tail
        self.tail = self.tail.next
        return
```

2 3. Circular Linked Lists

Circular linked lists occur when the chain of nodes links back to itself somewhere. For example `NodeA -> NodeB -> NodeC -> NodeD -> NodeB` is a circular list because `NodeD` points back to `NodeB` creating a loop `NodeB -> NodeC -> NodeD -> NodeB`.

A circular linked list is typically considered pathological because when you try to iterate through it, you'll never find the end. We usually want to detect if there is a loop in our linked lists to avoid these problems. You'll get a chance to implement a solution for detecting loops later in the lesson.

In [ ]:



Circular Linked List