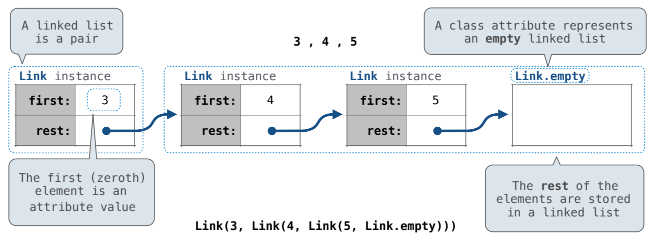
Composition

Announcements

Linked Lists

Linked List Structure

A linked list is either empty **or** a first value and the rest of the linked list


A linked list is a pair
3 , 4 , 5
A class attribute represents an **empty** linked list
Link instance
first: 3
rest:
Link instance
first: 4
rest:
Link instance
first: 5
rest:
Link.empty
The first (zeroth) element is an attribute value
The **rest** of the elements are stored in a linked list
Link(3, Link(4, Link(5, Link.empty)))

Linked List Structure

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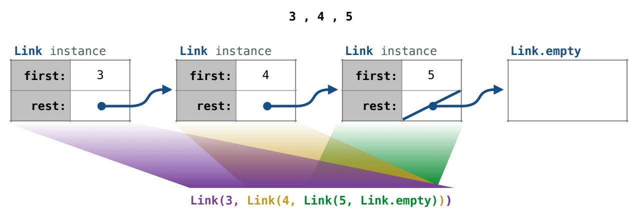


Linked List Class

Linked list class: attributes are passed to `__init__`

```
class Link:
    empty = ()
    def __init__(self, first, rest=empty):
        assert rest is Link.empty or isinstance(rest, Link)
        self.first = first
        self.rest = rest
```

Some zero-length sequence

Returns whether rest is a Link

help(isinstance): Return whether an object is an instance of a class or of a subclass thereof.

Link(3, Link(4, Link(5)))

(Demo)

Property Methods

Property Methods

In some cases, we want the value of instance attributes to be computed on demand

For example, if we want to access the second element of a linked list

```
>>> s = Link(3, Link(4, Link(5)))
>>> s.second
4
>>> s.second = 6
>>> s.second
6
>>> s
Link(3, Link(6, Link(5)))
```

No method calls!

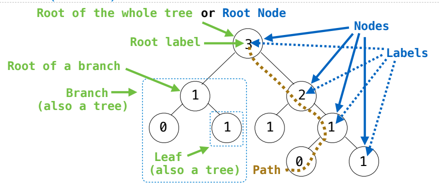
The @property decorator on a method designates that it will be called whenever it is looked up on an instance

A @<attribute>.setter decorator on a method designates that it will be called whenever that attribute is assigned. <attribute> must be an existing property method.

(Demo)

Tree Class

Tree Abstraction (Review)



Recursive description (wooden trees):

A **tree** has a **root label** and a list of **branches**

Each **branch** is a **tree**

A **tree** with zero **branches** is called a **leaf**

A **tree** starts at the **root**

Relative description (family trees):

Each location in a tree is called a **node**

Each **node** has a **label** that can be any value

One node can be the **parent/child** of another

The top node is the **root node**

People often refer to labels by their locations: "each parent is the sum of its children"

Tree Class

A Tree has a label and a list of branches; each branch is a Tree

```
class Tree:
    def __init__(self, label, branches=[]):
        self.label = label
        for branch in branches:
            assert isinstance(branch, Tree)
        self.branches = list(branches)
```

```
def tree(label, branches=[]):
    for branch in branches:
        assert is_tree(branch)
    return [label] + list(branches)
def label(tree):
    return tree[0]
def branches(tree):
    return tree[1:]
```

```
def fib_tree(n):
    if n == 0 or n == 1:
        return Tree(n)
    else:
        left = fib_tree(n-2)
        right = fib_tree(n-1)
        fib_n = left.label + right.label
        return Tree(fib_n, [left, right])
```

```
def fib_tree(n):
    if n == 0 or n == 1:
        return tree(n)
    else:
        left = fib_tree(n-2)
        right = fib_tree(n-1)
        fib_n = label(left) + label(right)
        return tree(fib_n, [left, right])
```

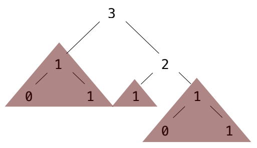
(Demo)

Tree Mutation

Example: Pruning Trees

Removing subtrees from a
tree is called *pruning*

Prune branches before
recursive processing



```
def prune(t, n):
    """Prune sub-trees whose label value is n."""
    t.branches = [_______b_______ for b in t.branches if _____b.label != n_____]
    for b in t.branches:
        prune(_______________b_______________, _______________n_______________)
```

(Demo)

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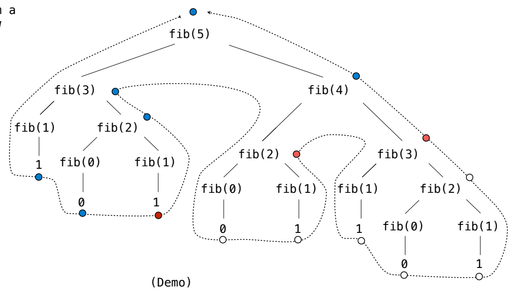

Memoization:

● Returned by fib

● Found in cache

○ Skipped

(Demo)