FINAL REVIEW 12

DATA C88C

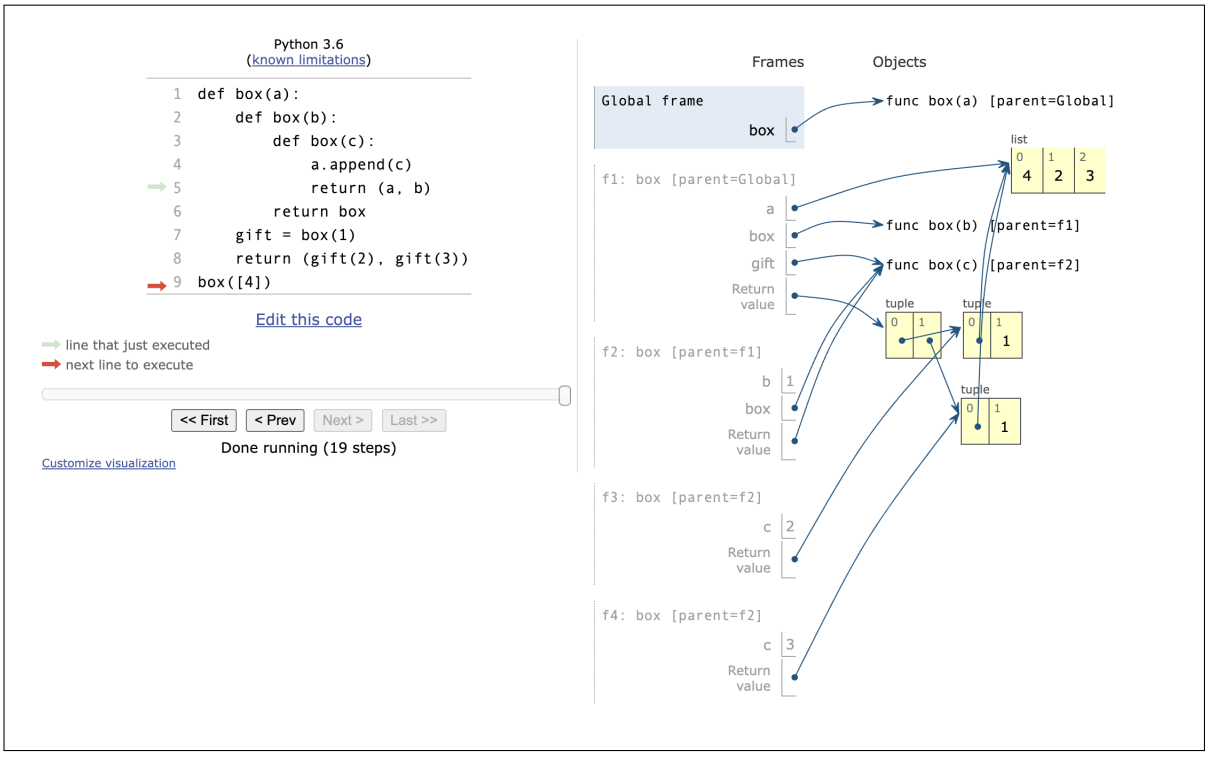
August 1, 2024

0.1 Environment Diagram

1. (Fall 2012) Draw the environment diagram.

```
def box(a):
    def box(b):
        def box(c):
            a.append(c)
            return (a, b)
        return box
    gift = box(1)
    return (gift(2), gift(3))
box([4])
```

> **Solution:** https://bitly.ws/33PRn


Python 3.6
(known limitations)
1 def box(a):
2 def box(b):
3 def box(c):
4 a.append(c)
5 return (a, b)
6 return box
7 gift = box(1)
8 return (gift(2), gift(3))
9 box([4])
Edit this code
line that just executed
next line to execute
<< First
< Prev
Next >
Last >>
Done running (19 steps)
Customize visualization
Frames
Objects
Global frame
box
func box(a) [parent=Global]
list
0 1 2
4 2 3
f1: box [parent=Global]
a
box
gift
Return value
func box(b) [parent=f1]
func box(c) [parent=f2]
tuple
tuple
tuple
f2: box [parent=f1]
b 1
box
Return value
f3: box [parent=f2]
c 2
Return value
f4: box [parent=f2]
c 3
Return value

0.2 OOP

1. (Summer 2015 Final) The TAs are building a social networking website called CS61A+. The TAs plan to represent the network in a class called `Network` that supports the following method:

   - `add_friend(user1, user2)` adds `user1` and `user2` to each other's friends lists. If `user1` or `user2` are not in the `Network`, add them to the dictionary of friends.

   Help the TAs implement these two methods to make their social networking website popular!

```
class Network:
    """
    >>> cs61a_plus = Network()
    >>> cs61a_plus.add_friend('Robert', 'Jeffrey')
    >>> cs61a_plus.friends['Robert']
    ['Jeffrey']
    >>> cs61a_plus.friends['Jeffrey']
    ['Robert']
    >>> cs61a_plus.add_friend('Jessica', 'Robert')
    >>> cs61a_plus.friends['Robert']
    ['Jeffrey', 'Jessica']
    """
    def __init__(self):
        self.friends = {}       # Maps users to a list of their friends

    def add_friend(self, user1, user2):


        if ____________________________________________________:

            ____________________________________________________

        if ____________________________________________________:

            ____________________________________________________

        ____________________________________________________

        ____________________________________________________
```

Solution:

```
    def add_friend(self, user1, user2):
        if user1 not in self.friends:
            self.friends[user1] = []
        if user2 not in self.friends:
            self.friends[user2] = []
        self.friends[user1].append(user2)
        self.friends[user2].append(user1)
```

CS61A+ turns out to be unpopular. To attract more users, the TAs want to implement a feature that checks if two users have at most `n` degrees of separation. Consider the following CS61A+ `Network`:

```
self.friends = {
    'Robert':  ['Jeffrey', 'Jessica'],
    'Jeffrey': ['Robert', 'Jessica', 'Yulin'],
    'Jessica': ['Robert', 'Jeffrey', 'Yulin'],
    'Yulin':   ['Jeffrey', 'Jessica'],
    'Albert':  []
}
```

- There is 1 degree of separation between Robert and Jeffrey, because they are direct friends.
- There are 2 degrees of separation between Robert and Yulin (Robert → Jessica → Yulin)
- The degree of separation between Albert and anyone else is undefined, since Albert has no friends.

```
class Network:
    # Code from previous question

    def degrees(self, user1, user2, n):
        """In these doctests, assume cs61a_plus is a Network with the
        dictionary of friends described in the example.

        >>> cs61a_plus.degrees('Robert', 'Yulin', 2)    # Exactly 2 degrees
        True
        >>> cs61a_plus.degrees('Robert', 'Jessica', 2)  # Less than 2
            degrees
        True
        >>> cs61a_plus.degrees('Yulin', 'Robert', 1)    # More than 1
            degree
        False
        >>> cs61a_plus.degrees('Albert', 'Jessica', 10) # No friends!
        False
        """
        if _____________________________________:
            return True
        elif _____________________________________:
            return False
        for friend in _____________________________________:

            if _____________________________________:
                return True
        return _____________________________________
```

Solution:

```
class Network:
    # Code from previous question

    def degrees(self, user1, user2, n):
        """
        >>> cs61a_plus = Network()
        >>> cs61a_plus.friends = {
        ...     'Robert': ['Jeffrey', 'Jessica'],
```

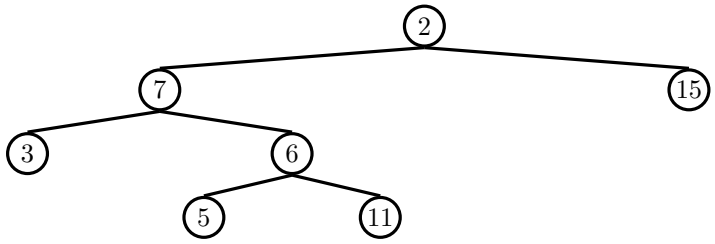
```
...     'Jeffrey': ['Robert', 'Jessica', 'Yulin'],
...     'Jessica': ['Robert', 'Jeffrey', 'Yulin'],
...     'Yulin': ['Jeffrey', 'Jessica'],
...     'Albert': []
... }
>>> cs61a_plus.degrees('Robert', 'Yulin', 2)    # Exactly 2
   degrees
True
>>> cs61a_plus.degrees('Robert', 'Jessica', 2)  # Less than 2
   degrees
True
>>> cs61a_plus.degrees('Yulin', 'Robert', 1)    # More than 1
   degree
False
>>> cs61a_plus.degrees('Albert', 'Jessica', 10) # No friends!
False
"""

if user1 == user2:

    return True

elif n <= 0:

    return False

for friend in self.friends[user1]:

    if self.degrees(friend, user2, n - 1):

        return True

return False
```

0.3 Trees

1. Write a function that takes in a tree and a value `x` and returns a list containing the nodes along the path required to get from the root of the tree to a node containing `x`.

   If `x` is not present in the tree, return `None`. Assume that the entries of the tree are unique.

   For the following tree, `find_path(t, 5)` should return `[2, 7, 6, 5]`




```
def find_path(tree, x):
    """
    >>> t = Tree(2, [Tree(7, [Tree(3), Tree(6, [Tree(5), Tree(11)])] ),
        Tree(15)])
    >>> t.value
    2
    >>> find_path(t, 5)
    [2, 7, 6, 5]
    >>> find_path(t, 10)  # returns None
    """

    if _____________________________________:

        return _____________________________________

    _____________________________________:

        path = _____________________________________

        if _____________________________________:

            return _____________________________________
```

Solution:

```
def find_path(tree, x):
    if tree.value == x:
        return [tree.value]
    for b in tree.branches:
        path = find_path(b, x)
        if path:
            return [tree.value] + path
```

Video walkthrough

0.4 Recursion

1. (Fall 2013) Fill in the blanks in the implementation of `paths`, which takes as input two positive integers `x` and `y`. It returns the number of ways of reaching y from x by repeatedly incrementing or doubling. For instance, we can reach 9 from 3 by incrementing to 4, doubling to 8, then incrementing again to 9.

```
def inc(x):
    return x + 1

def double(x):
    return x * 2

def paths(x, y):
    """Return the number of ways to reach y from x by repeated
    incrementing or doubling.
    >>> paths(3, 5) # inc(inc(3))
    1
    >>> paths(3, 6) # double(3), inc(inc(inc(3)))
    2
    >>> paths(3, 9) # E.g. inc(double(inc(3)))
    3
    >>> paths(3, 3) # No calls is a valid path
    1
    """
    if x > y:
        return _____________________________________________

    elif x == y:
        return _____________________________________________

    else:
        return _____________________________________________
```

Solution:

```
def paths(x, y):
    if x > y:
        return 0
    elif x == y:
        return 1
    else:
        return paths(inc(x), y) + paths(double(x), y)
```

0.5 Linked List

1. You are trying to communicate with your project partner but Evil Eve is attempting to intercept your messages. Write a function `insert_secret` that takes a LinkedList, `lnk`, and a string `secret` and mutates `lnk` by interleaving the secret message into the linked list. Look at the doctests for details. (You can assume that the length of the secret message is less than or equal to the length of the linked list)

```
def insert_secret(lnk, secret):
    """
    >>> two_link = Link(1, Link(2))
    >>> insert_secret(two_link, 'f')
    >>> two_link
    Link(1, Link('f', Link(2)))
    >>> surprise = Link(8, Link(8))
    >>> insert_secret(surprise, 'CS')
    >>> surprise
    Link(8, Link('C', Link(8, Link('S'))))
    """
```

Solution:

```
if secret == '':
  return
new_link = Link(secret[0])
new_link.rest = lnk.rest
lnk.rest = new_link
insert_secret(lnk.rest.rest, secret[1:])
```

0.6 Iterator/Generator

1. Write a generator function `generate_subsets` that returns all subsets of the positive integers from 1 to `n`. Each call to this generator's **`next`** method will return a list of subsets of the set `[1, 2, ..., n]`, where `n` is the number of previous calls to `next`.

```
def generate_subsets():
    """
    >>> subsets = generate_subsets()
    >>> for _ in range(3):
    ...     print(next(subsets))
    ...
    [[]]
    [[], [1]]
    [[], [1], [2], [1, 2]]
    """
```

Solution:

```
    subsets = [[]]
    n = 1
    while True:
        yield subsets
        subsets = subsets + [s + [n] for s in subsets]
        n += 1
```

We start with a base list of subsets. To get the next sequence of subsets, we need two things:

- All current subsets will continue to be valid subsets in the future.
- We take all the subsets we currently have, and add the next number. These are also valid subsets.

0.7 SQL

1. Write a query that outputs all divisions for which there is more than one employee, and all pairs of employees within that division have a salary less than 100,000.

   Reminder: we are using a table named `records` that stores information about the employees at a small company[1]. Each of the eight rows represents an employee.

Name	Division	Title	Salary	Supervisor
Ben Bitdiddle	Computer	Wizard	60000	Oliver Warbucks
Alyssa P Hacker	Computer	Programmer	40000	Ben Bitdiddle
Cy D Fect	Computer	Programmer	35000	Ben Bitdiddle
Lem E Tweakit	Computer	Technician	25000	Ben Bitdiddle
Louis Reasoner	Computer	Programmer Trainee	30000	Alyssa P Hacker
Oliver Warbucks	Administration	Big Wheel	150000	Oliver Warbucks
Eben Scrooge	Accounting	Chief Accountant	75000	Oliver Warbucks
Robert Cratchet	Accounting	Scrivener	18000	Eben Scrooge

Solution:

```
SELECT e1.division FROM records AS e1, records AS e2
   WHERE e1.name < e2.name AND e1.division = e2.division
   GROUP BY e1.division HAVING MAX(e1.salary + e2.salary) < 100000;
```

[1] Example adapted from Structure and Interpretation of Computer Programs