NONLOCAL AND ITERATORS Solutions

COMPUTER SCIENCE MENTORS

October 12 to October 15, 2020

1 Nonlocal

To evaluate a variable name, we find its value from the first frame (current frame, parent, parent's parent, ...) the variable is defined. The first time we assign (bind) a value to a variable, we declare a new variable in the current frame and bind to the respective value.

The `nonlocal` keyword introduces more control over this process. The first time we assign a value to a `nonlocal` variable, rather than declare a new variable in the current frame, we bind the value to the variable of the same name found in the first parent frame that contains such a variable. This means that this variable does not exist in the current frame. Note: you cannot declare variables in the global frame as `nonlocal`.

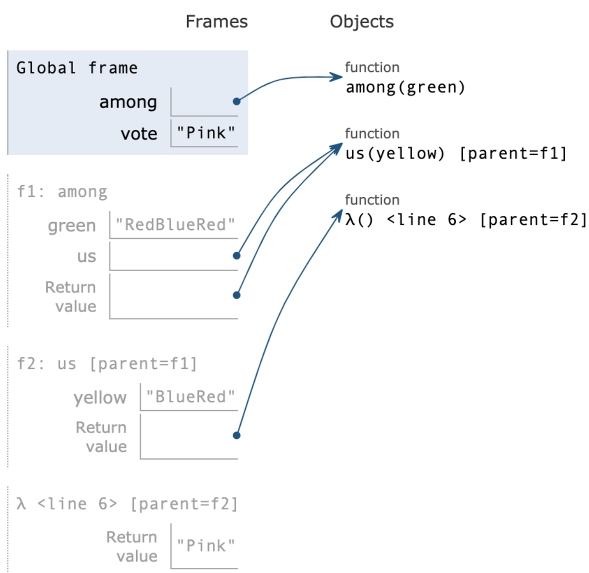
```
def example_without_nonlocal():
    grade = 1.0
    def gpa_boost():
        grade = 4.0 # creates a variable named grade in the
                    # gpa_boost frame
    gpa_boost()
    print(grade)
>>> example_without_nonlocal()
1.0
```

```
def example_with_nonlocal():
    grade = 1.0
    def gpa_boost():
        nonlocal grade
        grade = 4.0 # modifies the variable in the
                    # example_with_nonlocal frame instead
                    # of creating a new variable
    gpa_boost()
    print(grade)
>>> example_with_nonlocal()
4.0
```

1. **among us**
   Fill in each blank in the code example below so that its environment diagram is the following. You do not need to use all the blanks.

```
def among(green):
    def us(yellow):
        _______________________

        yellow += ___________
        green += ____________
        _____________________
        return ______________
    return ______________
vote = among('Red')('Blue')()
```




```
def among(green):
    def us(yellow):
        nonlocal green
        yellow += green
        green += yellow
        return lambda : 'Pink'
    return us
vote = among('Red')('Blue')()
```

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2. **Pingpong again...**

Time for some more ping-pong! Remember, the ping-pong sequence counts up starting from 1 and is always either counting up or counting down. At element k, the direction switches if k is a multiple of 7 or contains the digit 7.

The first 20 elements of the ping-pong sequence are listed below, with direction swaps marked using brackets at the 7th, 14th, and 17th elements

`1 2 3 4 5 6 [7] 6 5 4 3 2 1 [0] 1 2 [3] 2 1 0`

Implement a function `make_pingpong_tracker` that returns the next value in the pingpong sequence each time it is called. You may use assignment statements.

```
def has_seven(k): # Use this function for your answer below
    if k % 10 == 7:
        return True
    elif k < 10:
        return False
    else:
        return has_seven(k // 10)

def make_pingpong_tracker():
    """ Returns a function that returns the next value in the
    pingpong sequence each time it is called.
    >>> output = []
    >>> x = make_pingpong_tracker()
    >>> for _ in range(9):
    ... output += [x()]
    >>> output
    [1, 2, 3, 4, 5, 6, 7, 6, 5]
    """
    index, current, add = 1, 0, True
    def pingpong_tracker():
        ___________________________
        if add:
            ________________________
        else:
            ________________________
        if _______________________:
            add = not add
        __________________________
        __________________________
    return _______________________
```

```
def make_pingpong_tracker():
    index, current, add = 1, 0, True
    def pingpong_tracker():
        nonlocal index, current, add
        if add:
            current = current + 1
        else:
            current = current - 1
        if has_seven(index) or index % 7 == 0:
            add = not add
        index += 1
        return current
    return pingpong_tracker
```

2 Iterators and Generators

An **iterable** is any container that can be processed sequentially. Think of an iterable as anything you can loop over, such as lists or strings. You can see this in **for** loops, which sequentially loop through each element of a sequence. The anatomy of the for loop can be described as:

```
for some_var in iterable:
    <do something with some_var>
```

An **iterator** remembers where it is during its iteration. Though an iterator is an iterable, the reverse is not necessarily true. Think of an iterable as a book whereas an iterator is a bookmark.

Generators, which are a specific type of **iterators**, are created using the traditional function definition syntax in Python (**def**) with the body of the function containing one or more `yield` statements. When a generator (a function that has `yield` in the body) is called, it returns a generator object. When we call the generator object, we evaluate the body of the function until we have yielded a value. The `yield` statement pauses the function, yields the value, saves the local state so that evaluation can be resumed right where it left off. `yield` operates similarly to a return statement.

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1. Given the following code block, what is outputted by the lines that follow?

```
def foo():
    a = 0
    if a == 0:
        print("Hello")
        yield a
        print("World")
```

```
>>> foo()
```

```
<generator object>
```

```
>>> foo_gen = foo()
>>> next(foo_gen)
```

```
Hello
0
```

```
>>> next(foo_gen)
```

```
World
StopIteration
```

```
>>> for i in foo():
...    print(i)
```

```
Hello
0
World
```

2. How can we modify `foo` so that it satisfies the following doctests?

```
>>> a = list(foo())
>>> a
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
```

Change the **if** to a **while** statement, and make sure to increment `a`. This looks like:

```
def foo():
    a = 0
    while a < 10:
        a += 1
        yield a
```

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3. Define `filter_gen`, a generator that takes in iterable `s` and one-argument function `f` and yields every value from `s` for which `f` returns `True`

```
def filter_gen(s, f):
    """
    >>> list(filter_gen([1, 2, 3, 4, 5],
                                lambda x: x % 2 == 0))
    [2, 4]
    >>> list(filter_gen((1, 2, 3, 4, 5), lambda x: x < 3))
    [1, 2]
    """

for x in s:
    if f(x):
        yield x
```

4. Define `tree_sequence`, a generator that iterates through a tree by first yielding the root value and then yielding the values from each branch.

```
def tree_sequence(t):
    """
    >>> t = tree(1, [tree(2, [tree(5)]), tree(3, [tree(4)])])
    >>> print(list(tree_sequence(t)))
    [1, 2, 5, 3, 4]
    """
```

```
def tree_sequence(t):
    yield label(t)
    for branch in branches(t):
        for value in tree_sequence(branch):
            yield value
```

Alternate solution:

```
def tree_sequence(t):
    yield label(t)
    for branch in branches(t):
        yield from tree_sequence(branch)
```

Thinking about the solution in terms of the recursive leap of faith: assume that each call to `tree_sequence(branch)` yields the values in that branch in the proper order. Then all we have to do is yield each value from that branch for each branch in order after yielding the root value.

This question has a very similar logic in `sum_of_nodes` from last week; namely performing an action on the current node's value, and then using tree recursion to repeat this action for each branch of the list of branches.

In the alternate solution, `yield from` allows us to yield a list of values, aka the list of all results from recursively calling `tree_sequence`. This is equivalent to yielding each element through a for loop.

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