Mutable Functions

A Function with Behavior That Varies Over Time

Let's model a bank account that has a balance of $100

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Argument: amount to withdraw

Return value: remaining balance

Different return value!

Where's this balance stored?

Persistent Local State Using Environments

All calls to the same function have the same parent

The parent frame contains the balance, the local state of the withdraw function

Every call decreases the same balance by (a possibly different) amount

Interactive Diagram

Reminder: Local Assignment

Execution rule for assignment statements:

1. Evaluate all expressions right of =, from left to right
2. Bind the names on the left to the resulting values in the current frame

Interactive Diagram

Non-Local Assignment & Persistent Local State

def make_withdraw(balance):
    """Return a withdraw function with a starting balance."""
    def withdraw(amount):
        nonlocal balance
        if amount > balance:
            return 'Insufficient funds'
        balance = balance - amount
        return balance
    return withdraw

(Demo)
The Effect of Nonlocal Statements

nonlocal <name>, <name>, ...

Effect: Future assignments to that name change its pre-existing binding in the first non-local frame of the current environment in which that name is bound.

From the Python 3 language reference:
Names listed in a nonlocal statement must refer to pre-existing bindings in an enclosing scope.
Names listed in a nonlocal statement must not collide with pre-existing bindings in the local scope.

Effect: Future assignments to that name change its pre-existing binding in the first non-local frame of the current environment in which that name is bound.

Python Docs: an "enclosing scope"

The Many Meanings of Assignment Statements

Status          Effect

• No nonlocal statement    Create a new binding from name "x" to object 2 in the first frame of the current environment

• No nonlocal statement    Re-bind name "x" to object 2 in the first non-local frame of the current environment

• nonlocal x
• "x" is bound locally     Re-bind "x" to 2 in the first non-local frame of the current environment in which "x" is bound

• nonlocal x
• "x" is not bound locally  SyntaxError: no binding for nonlocal 'x' found

• nonlocal x
• "x" is bound in a non-local frame    SyntaxError: name 'x' is parameter and nonlocal

Python Particulars

Python pre-computes which frame contains each name before executing the body of a function.
Within the body of a function, all instances of a name must refer to the same frame.

Multiple Mutable Functions

Interactive Diagram

Mutable Values & Persistent Local State

Interactive Diagram

Referential Transparency, Lost

Expressions are referentially transparent if substituting an expression with its value does not change the meaning of a program.

Interactive Diagram