

61A Lecture 13

Monday, February 23

Announcements

- Homework 4 due Monday 2/23 @ 11:59pm (small)
- Project 2 due Thursday 2/26 @ 11:59pm (BIG!)
 - Office hours on Monday 2/23 3pm–5pm are relocated to 310 Soda
 - Project party on Tuesday 2/24 5pm–6:30pm in 2050 VLSB
 - Extra office hours on Wednesday 2/25 4pm–6pm in Bechtel (Garbarini Lounge)
 - Bonus point for early submission by Wednesday 2/25 @ 11:59pm!
 - Thursday office hours will be held in...

Mutable Functions

A Function with Behavior That Varies Over Time

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

Return value:
remaining balance

Different
return value!

```
>>> withdraw(25)  
75
```

```
>>> withdraw(25)  
50
```

```
>>> withdraw(60)  
'Insufficient funds'
```

```
>>> withdraw(15)  
35
```

Argument:
amount to withdraw

Second withdrawal of
the same amount

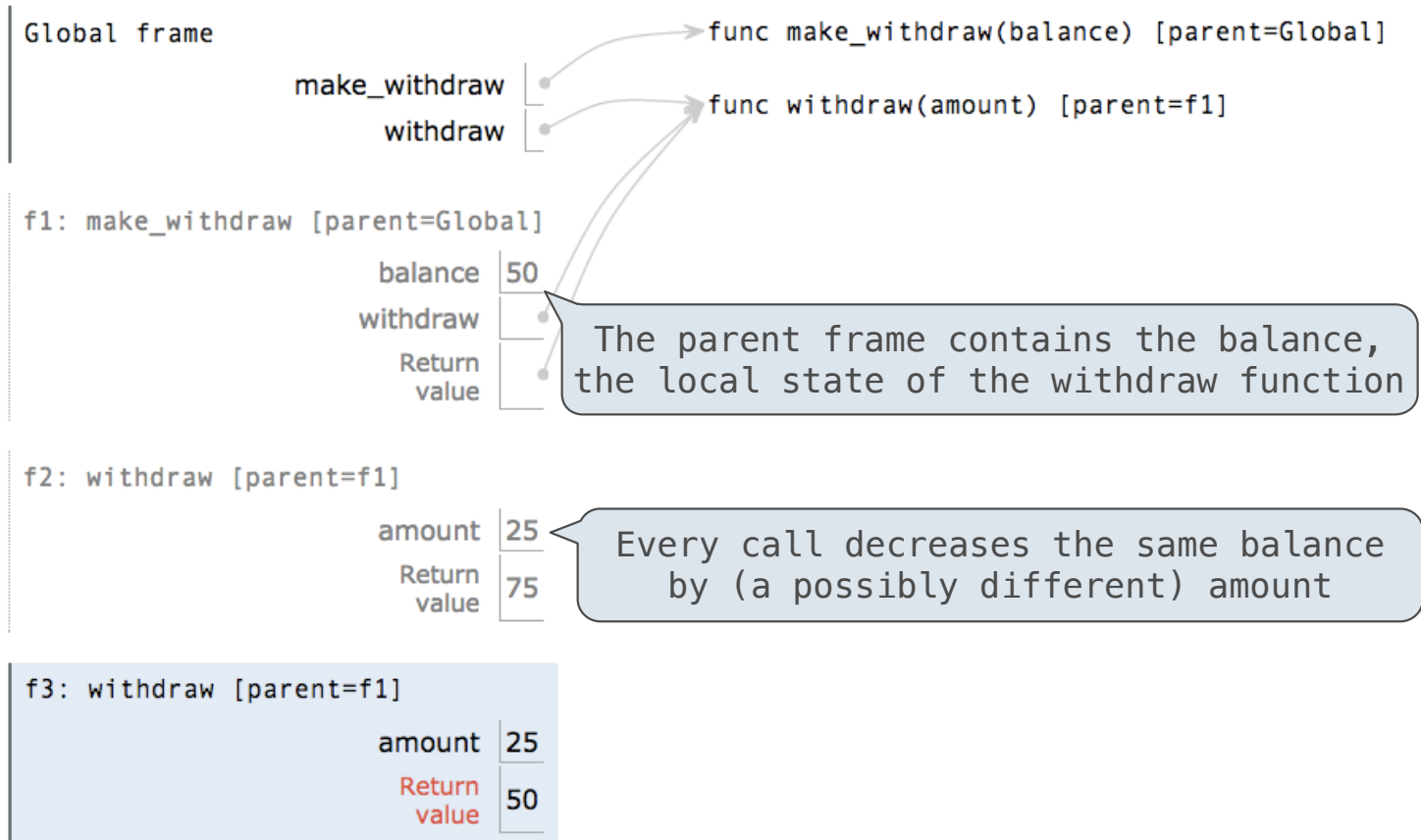
Where's this balance
stored?

```
>>> withdraw = make_withdraw(100)
```

Within the parent frame
of the function!

A function has a body and
a parent environment

Persistent Local State Using Environments



All calls to the same function have the same parent

Interactive Diagram

Reminder: Local Assignment

```
def percent_difference(x, y):  
    difference = abs(x-y)  
    return 100 * difference / x  
diff = percent_difference(40, 50)
```

Assignment binds name(s) to value(s) in the first frame of the current environment

Global frame

percent_difference

func percent_difference(x, y) [parent=Global]

f1: percent_difference [parent=Global]

x 40

y 50

→ difference 10

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
```

Declare the name "balance" nonlocal at the top of the body of the function in which it is re-assigned

Re-bind balance in the first non-local frame in which it was bound previously

(Demo)

Non-Local Assignment

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.

Python Docs: an
"enclosing scope"

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**.

Current frame

http://docs.python.org/release/3.1.3/reference/simple_stmts.html#the-nonlocal-statement

<http://www.python.org/dev/peps/pep-3104/>

The Many Meanings of Assignment Statements

`x = 2`

Status

Effect

- No nonlocal statement
- "x" **is not** bound locally

Create a new binding from name "x" to object 2 in the first frame of the current environment

-
- No nonlocal statement
 - "x" **is** bound locally

Re-bind name "x" to object 2 in the first frame of the current environment

-
- nonlocal x
 - "x" **is** bound in a non-local frame

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 in a non-local frame

SyntaxError: no binding for nonlocal 'x' found

-
- nonlocal x
 - "x" **is** bound in a non-local frame
 - "x" also bound locally

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.

```
def make_withdraw(balance):  
    def withdraw(amount):  
        if amount > balance:  
            return 'Insufficient funds'  
            balance = balance - amount  
        return balance  
    return withdraw
```

Local assignment

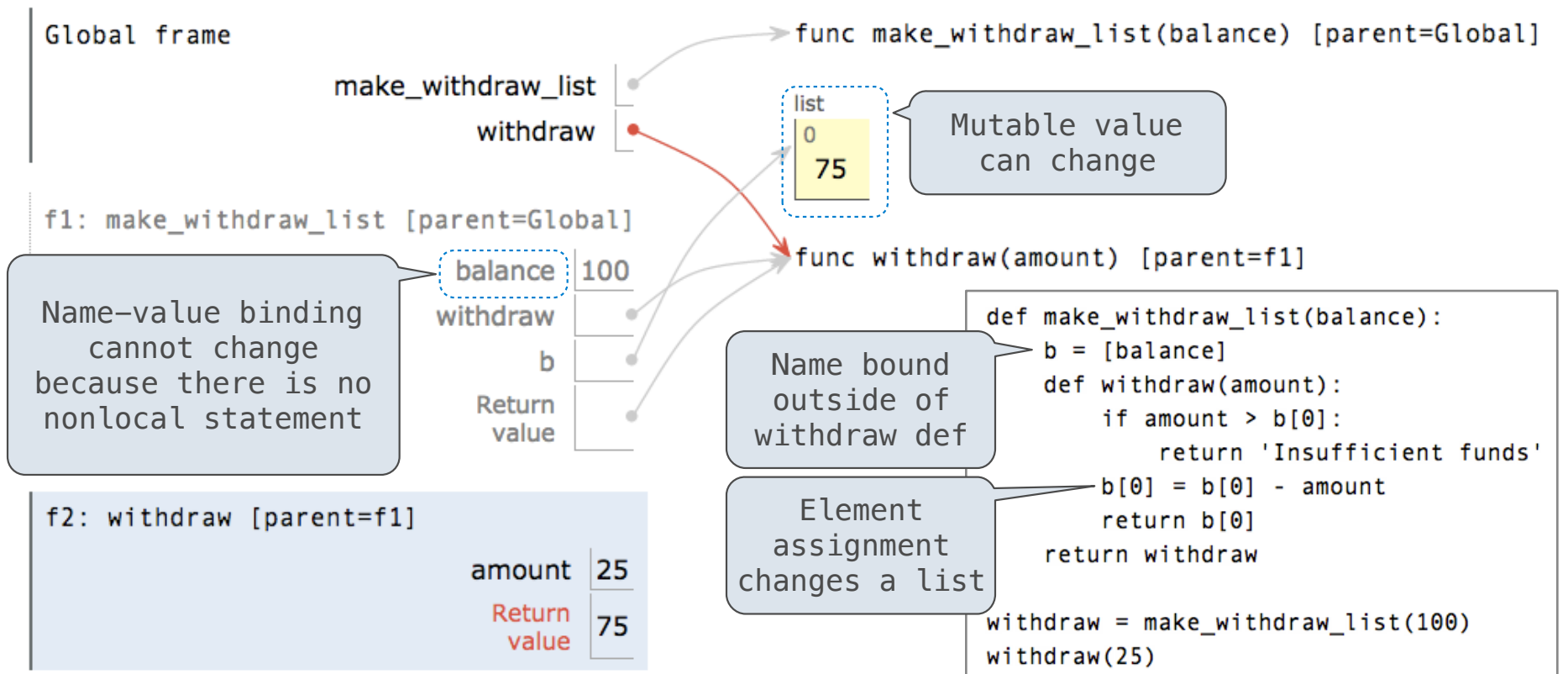
```
wd = make_withdraw(20)  
wd(5)
```

UnboundLocalError: local variable 'balance' referenced before assignment

[Interactive Diagram](#)

Mutable Values & Persistent Local State

Mutable values can be changed *without* a nonlocal statement.



Interactive Diagram

Multiple Mutable Functions

(Demo)

Referential Transparency, Lost

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



```
mul(add(2, mul(4, 6)), add(3, 5))
```

```
mul(add(2, 24), add(3, 5))
```

```
mul(26, add(3, 5))
```



- Mutation operations violate the condition of referential transparency because they do more than just return a value; **they change the environment.**

[Interactive Diagram](#)