Discussion 02

HOF, Environment Diagrams (for days)

6/28

1.2 (last part)

Walking through how to execute function calls

What will the following output?

```
def negate(f, x):
     return -f(x)
def square(n):
     return n * n
def double(n):
     return 2 * n
>>> negate(double, negate(square, -4))
```

Evaluate Operators and Operands

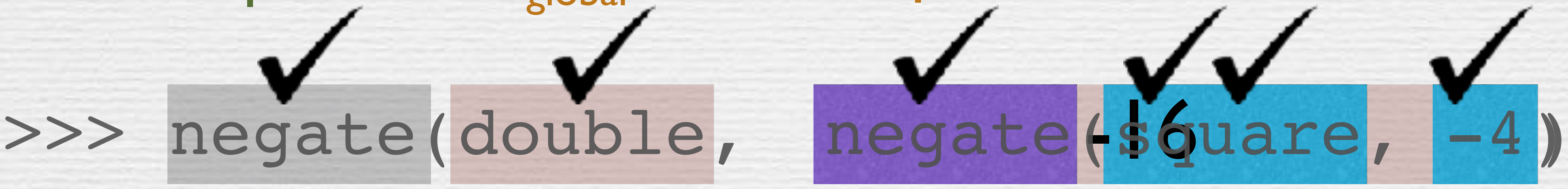
We have defined the function with the name **negate** in global

Evaluate the operator

We have defined the function with the name **double** in global

Evaluate the operands

square and -4 are both primitive



```
>>> negate(double, negate(square, -4))
```

The function call returned 16, so we can replace the complicated looking operand with the value 16

Evaluate the operator

Evaluate the operands

We evaluated the operator, evaluated the operands. We are now ready for our first function call to negate. Note that this function call comes before the call to the negate on the outside of all the parenthesis (gray)

Execute the function call:

f1: negate [P = G]
f: square
x: -4
RV: -16

f2: square [P = G]
x: -4
RV: 16

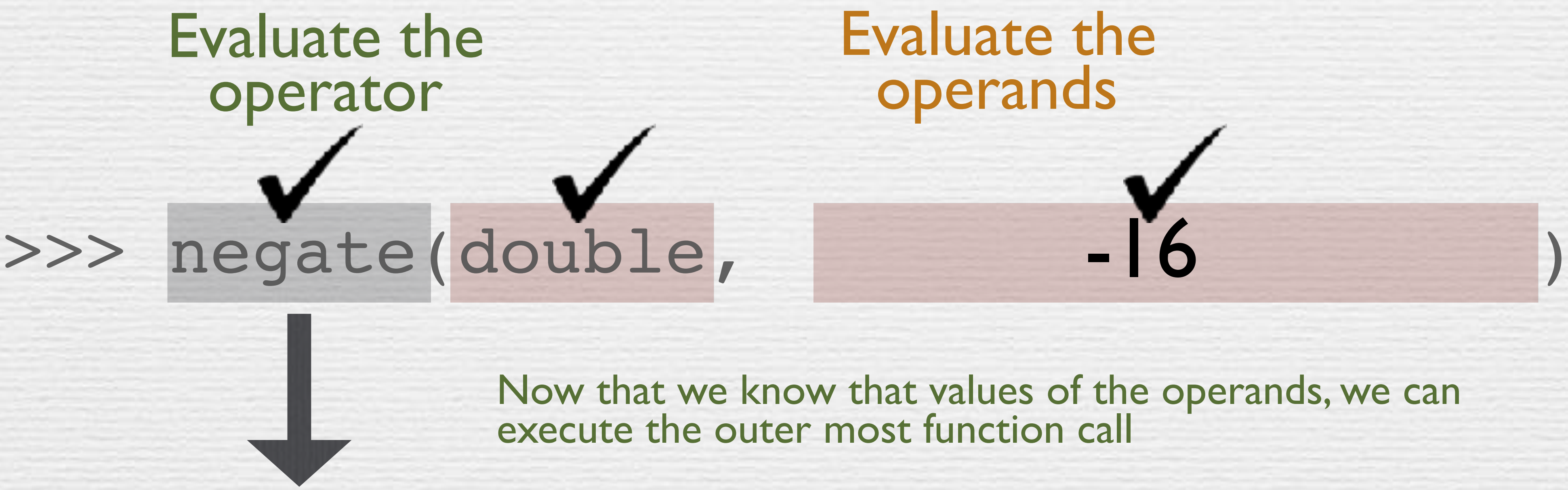
Note: this is not a fully complete environment diagram (there are missing components)

The rules for executing a function call are:

1. Evaluate the operator
2. Evaluate the operands
3. Execute the body of the function

Note that these rules can be interrupted. In this example we were preparing to execute the first negate, but were interrupted in the process of evaluating it's operands. Sometimes it is necessary to complete another function call before completing the one we initially started

Execute the Function Call



Evaluate the operator

Evaluate the operands

```
>>> negate(double, -16)
```

Now that we know that values of the operands, we can execute the outer most function call

Execute the function call:

f1: negate [P = G]
f: double
x: -16
RV: 32

f2: double [P = G]
x: -16
RV: -32

Solution: 32

What’s different with HOF?

What’s different between the code on the left and the code on the right? What will be printed when the code on the left is executed? What about the code on the right?

```
t = “surprise!”
def outer(t):
    def inner():
        print(t)
    return inner
outer(“boo!”)()
```

```
t = “surprise!”
def inner():
    print(t)
def outer(t):
    return inner
outer(“boo!”)()
```

```
t = “surprise!”
def outer(t):
    def inner():
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outer(“boo!”)()
```
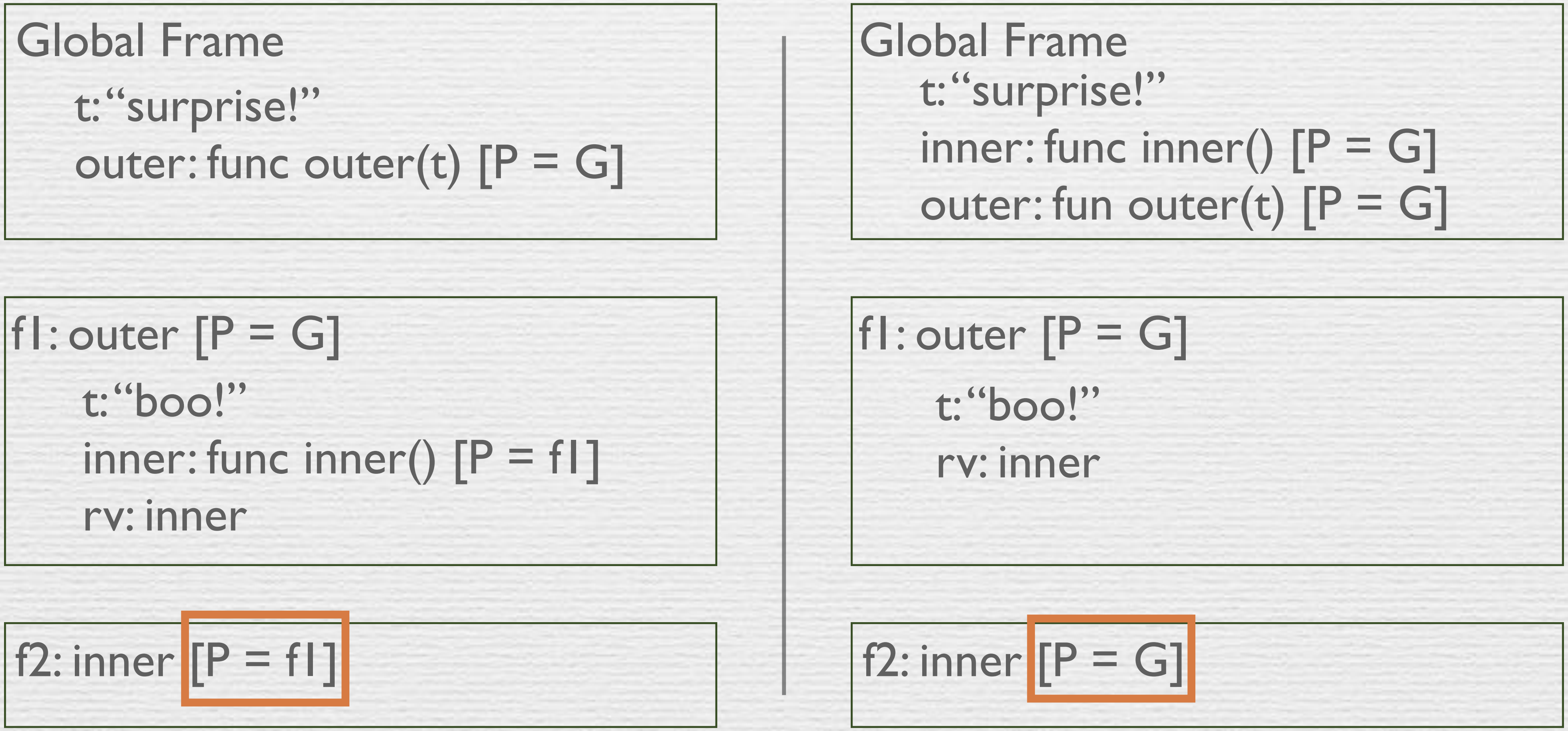

```
t = “surprise!”
def inner():
    print(t)
def outer(t):
    return inner
outer(“boo!”)()
```

Draw environment diagrams to see what’s different



Global Frame
t: “surprise!”
outer: func outer(t) [P = G]

f1: outer [P = G]
t: “boo!”
inner: func inner() [P = f1]
rv: inner

f2: inner [P = f1]

Global Frame
t: “surprise!”
inner: func inner() [P = G]
outer: fun outer(t) [P = G]

f1: outer [P = G]
t: “boo!”
rv: inner

f2: inner [P = G]

All inner does is print(t). Since t is not defined in the **local** frame, where does inner find **t**?

Python prints: boo!

Python prints: surprise!

Environment Diagrams

Know the rules!

1. **Def** statements:
   1. create a new function whose parent is the current frame
   2. skip the body of the function
   3. bind the function to it’s name in the current frame
2. **Assignment** statements:
   1. evaluate the RHS
   2. bind the value of the RHS to the name on the LHS
   3. NOTE: names can only have one value per frame
3. **Function** calls:
   1. evaluate the operator
   2. evaluate the operands
   3. execute the body of the function

1.5 #1

```
def curry2(h):
    def f(x):
        def g(y):
            return h(x, y)
        return g
    return f
make_adder = curry2(lambda x, y: x + y)

add_three = make_adder(3)

five = add_three(2)
```

function call

assignment

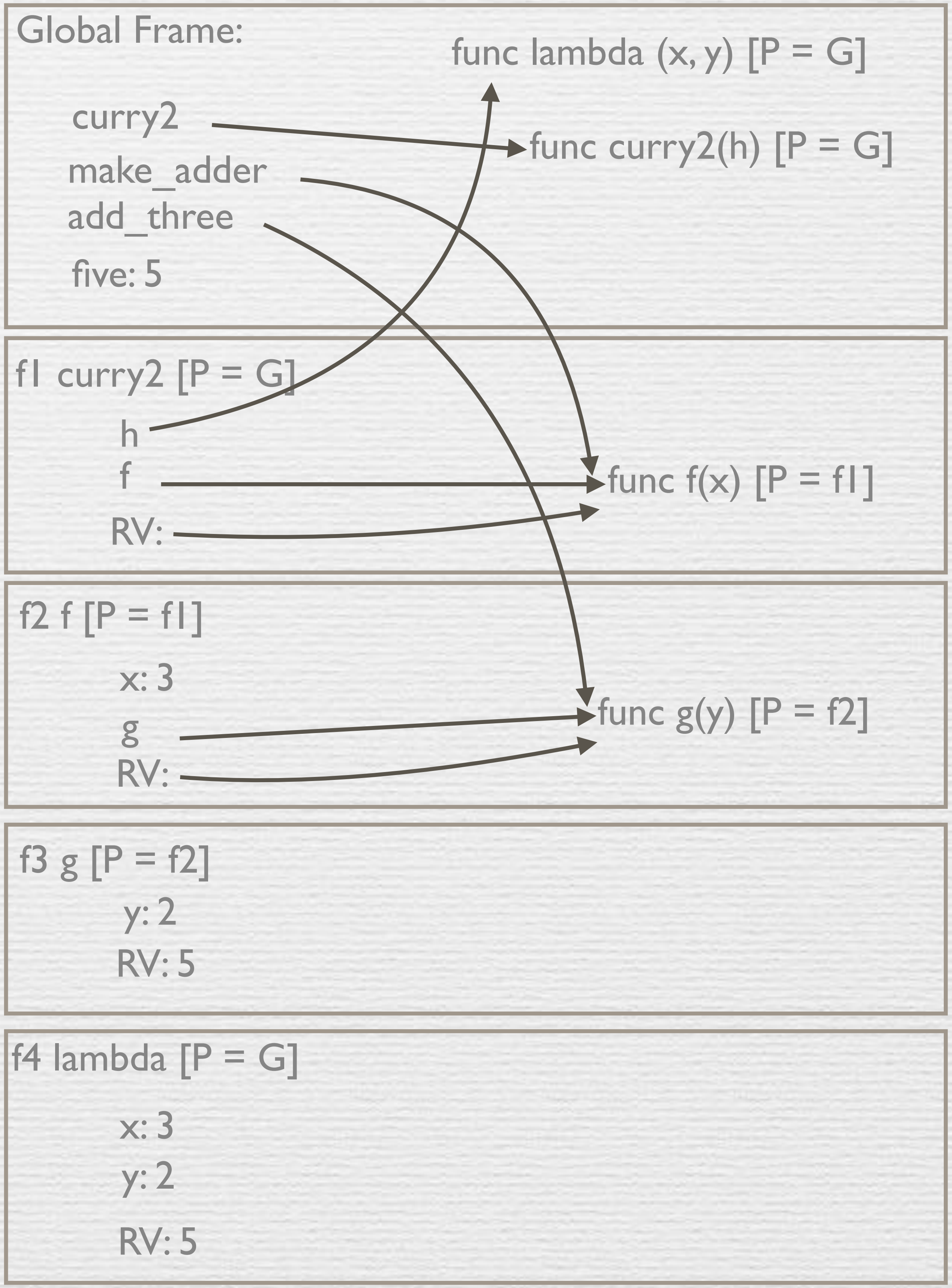
function call

assignment

function call

assignment

function call



Global Frame:

curry2

make_adder

add_three

five: 5

func lambda (x, y) [P = G]

func curry2(h) [P = G]

f1 curry2 [P = G]

h

f

RV:

func f(x) [P = f1]

f2 f [P = f1]

x: 3

g

RV:

func g(y) [P = f2]

f3 g [P = f2]

y: 2

RV: 5

f4 lambda [P = G]

x: 3

y: 2

RV: 5

tip: when you start doing a function call, mark where you were before so that you know which line to go back to

1.5 #2

```
n = 7
def f(x):
    n = 8
    return x + 1
def g(x):
    n = 9
    def h():
        return x + 1
    return h
def f(f, x):
    return f(x + n)
```

function call

```
f = f(g, n)
```

assignment

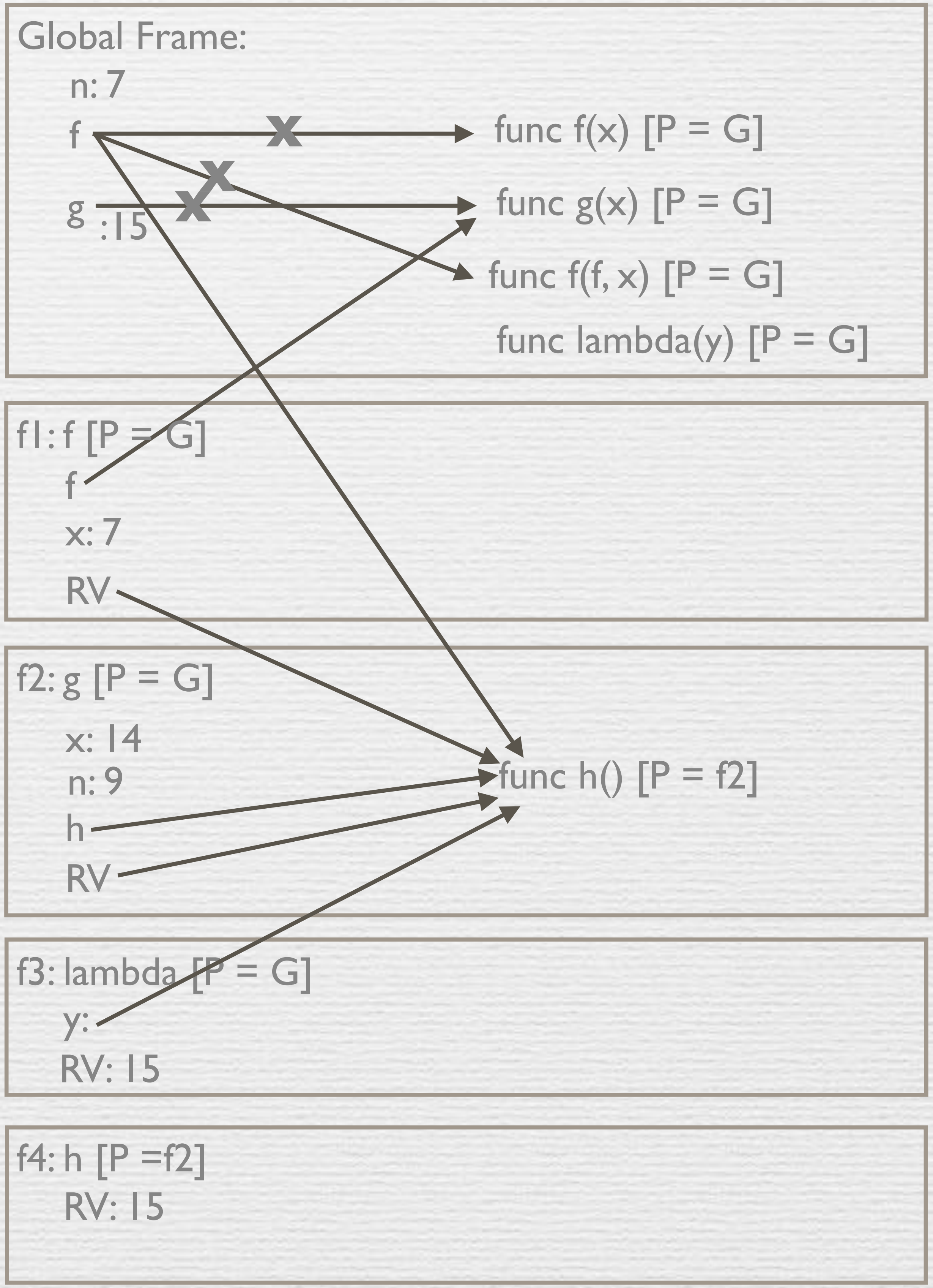
function call

```
g = (lambda y: y())(f)
```

assignment

function call

function call



Global Frame:

n: 7

f

g :15

func f(x) [P = G]

func g(x) [P = G]

func f(f, x) [P = G]

func lambda(y) [P = G]

f1: f [P = G]

f

x: 7

RV

f2: g [P = G]

x: 14

n: 9

h

RV

func h() [P = f2]

f3: lambda [P = G]

y:

RV: 15

f4: h [P =f2]

RV: 15

Challenge Problem

1.5 #3

```
y = "y"

h = y

def y(y):

    h = "h"

    if y == h:

        return y + "i"

    y = lambda y: y(h)

    return lambda h: y(h)

y = y(y)(y)
```

~~func y~~

“h”

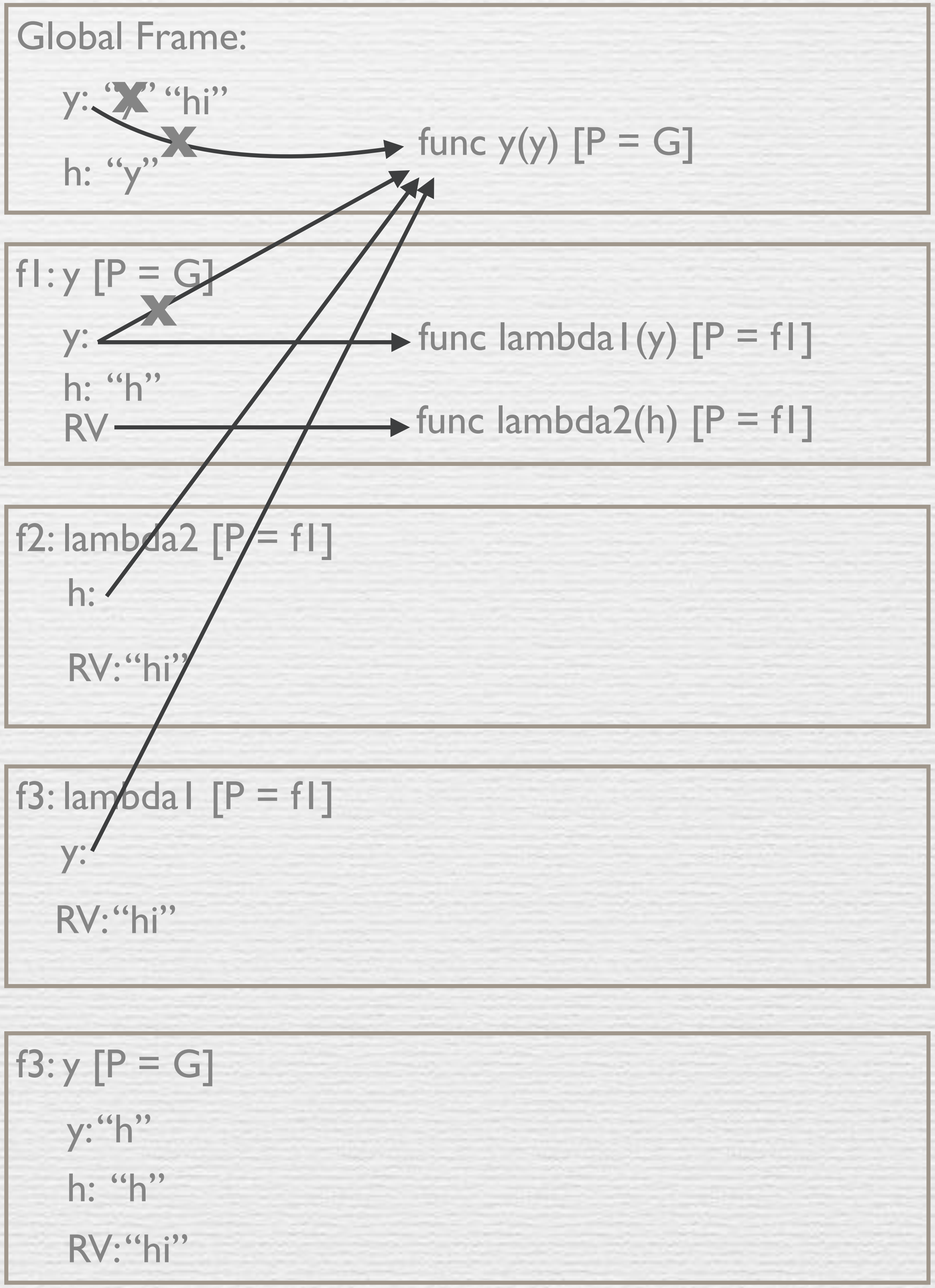
“h”

The return value of lambda1 is the result of calling y (which is what we passed in) on h. Since h is not defined in this frame, we must look at the **parent** frames

assignment

y is not defined here, we must look for it in the **parent** frames h was passed in; in this case h is the function y (check f2)

We just completed the first y(y) function call: now we know what the **operator** is for the second function call



Global Frame:

y: ~~“y”~~ “hi”

h: “y”

func y(y) [P = G]

f1: y [P = G]

y:

h: “h”

RV

func lambda1(y) [P = f1]

func lambda2(h) [P = f1]

f2: lambda2 [P = f1]

h:

RV: “hi”

f3: lambda1 [P = f1]

y:

RV: “hi”

f3: y [P = G]

y: “h”

h: “h”

RV: “hi”