61A Lecture 3

Wednesday, August 31

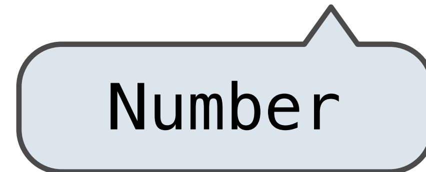
Lightning Review: Expressions

Primitive expressions:

Call expressions:

Lightning Review: Expressions

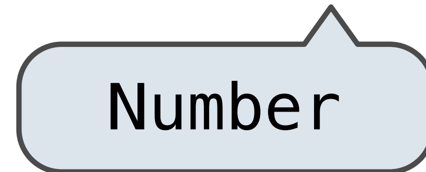
Primitive expressions: 2



Call expressions:

Lightning Review: Expressions

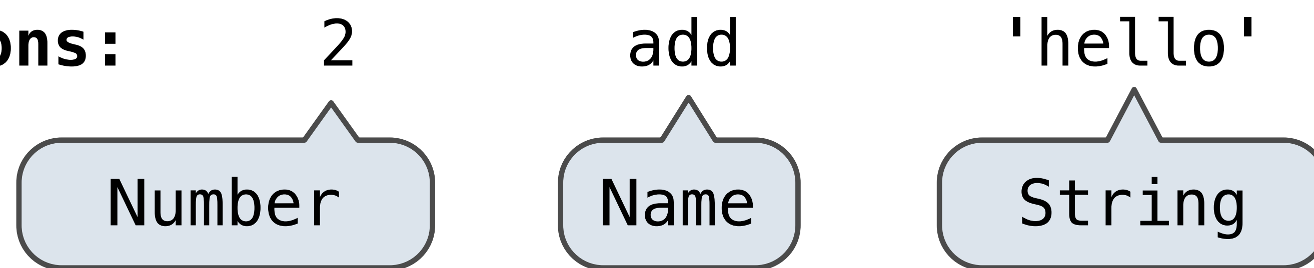
Primitive expressions: 2 add



Call expressions:

Lightning Review: Expressions

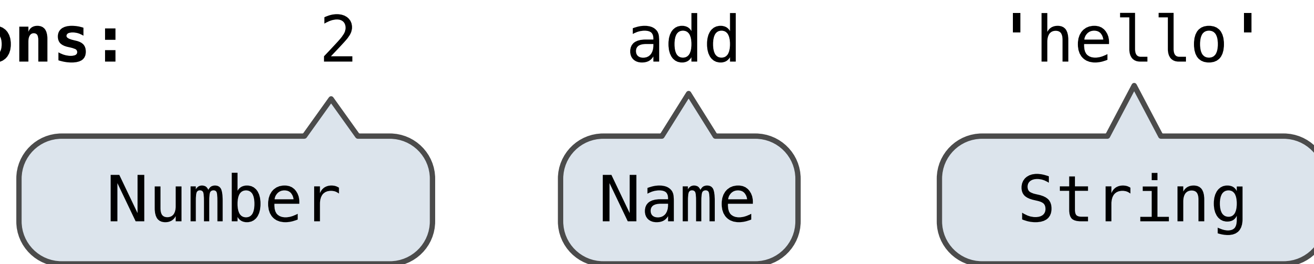
Primitive expressions:



Call expressions:

Lightning Review: Expressions

Primitive expressions:

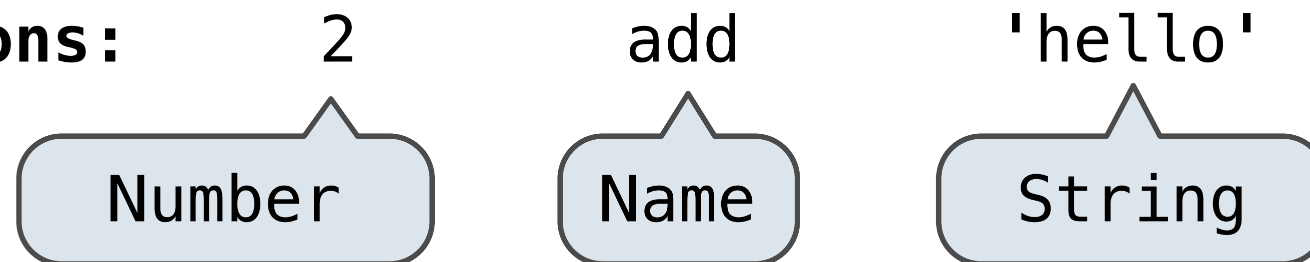


Call expressions:

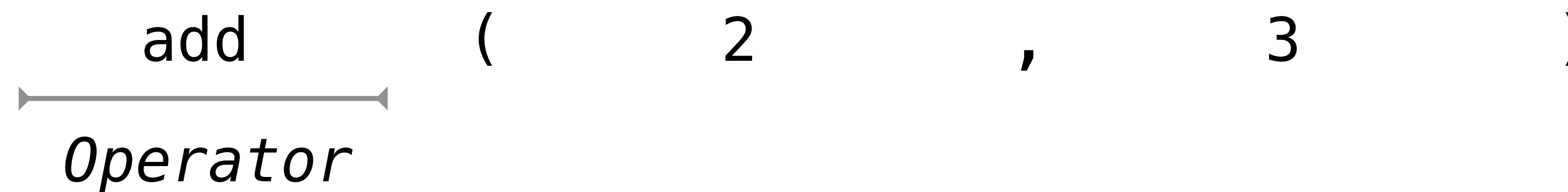
add (2 , 3)

Lightning Review: Expressions

Primitive expressions:

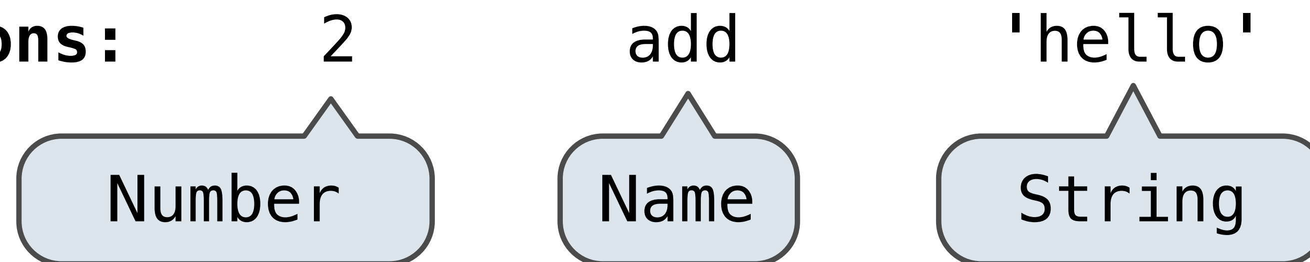


Call expressions:

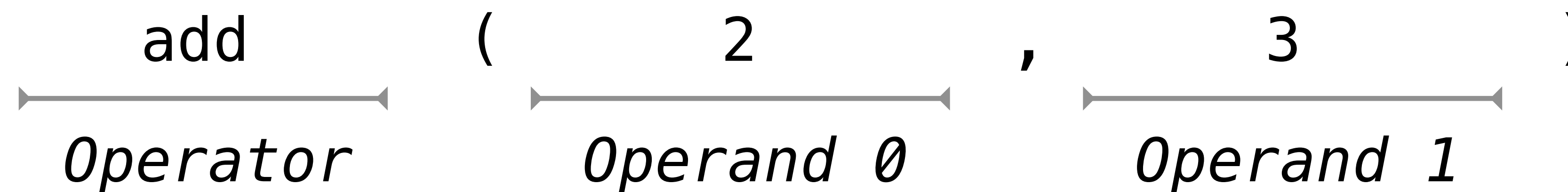


Lightning Review: Expressions

Primitive expressions:

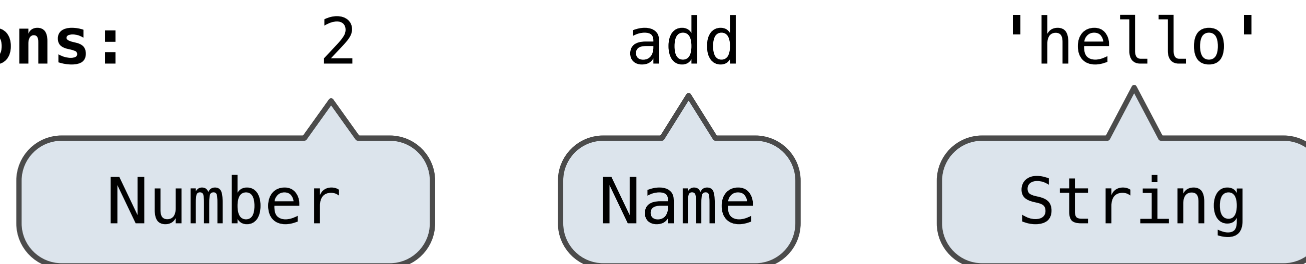


Call expressions:

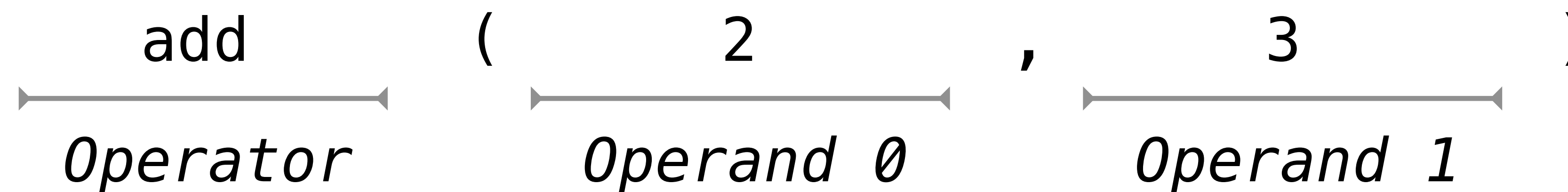


Lightning Review: Expressions

Primitive expressions:



Call expressions:



One big nested call expression

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

Life Cycle of a User-Defined Function

What happens?

Defining:

```
>>> def square( x ):
        return mul(x, x)
```

Call expression: `square(2+2)`

Calling/Applying:

```
square( x ):
    return mul(x, x)
```

Life Cycle of a User-Defined Function

What happens?

Defining:

```
>>> def square( x ):
        return mul(x, x)
```

Def statement

Call expression: square(2+2)

Calling/Applying:

```
square( x ):
    return mul(x, x)
```

Life Cycle of a User-Defined Function

What happens?

Defining:

Formal parameter

Def statement

```
>>> def square( x ):
        return mul(x, x)
```

Call expression: square(2+2)

Calling/Applying:

```
square( x ):
    return mul(x, x)
```

Life Cycle of a User-Defined Function

What happens?

Defining:

```
>>> def square( x ):
        return mul(x, x)
```

Formal parameter

Def statement

Body

Call expression: `square(2+2)`

Calling/Applying:

```
square( x ):
    return mul(x, x)
```

Life Cycle of a User-Defined Function

What happens?

Defining:

```
>>> def square( x ):
        return mul(x, x)
```

Formal parameter

Def statement

Body (*return statement*)

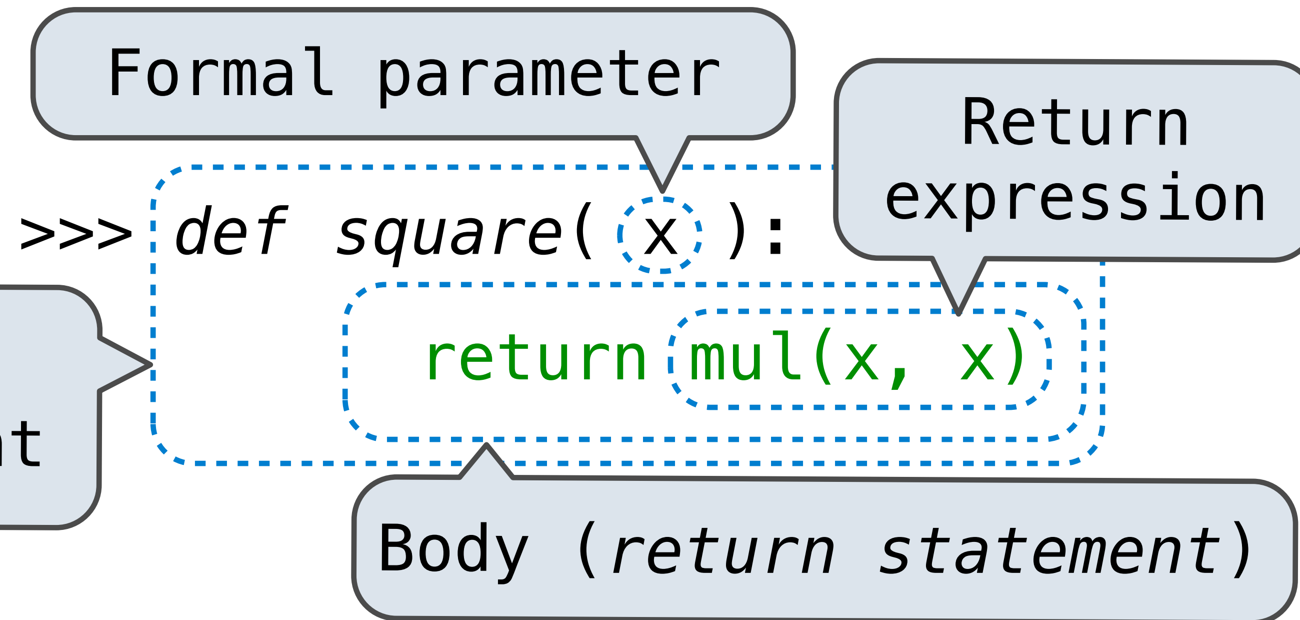
Call expression: `square(2+2)`

Calling/Applying:

```
square( x ):
    return mul(x, x)
```

Life Cycle of a User-Defined Function

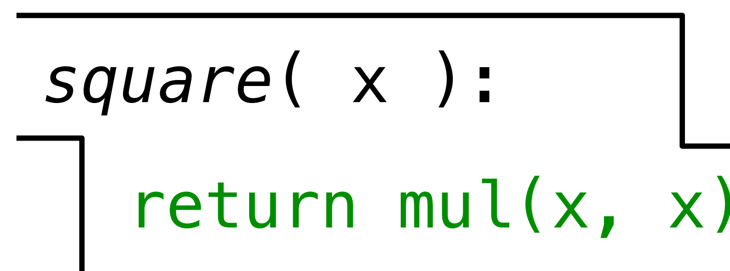
Defining:



What happens?

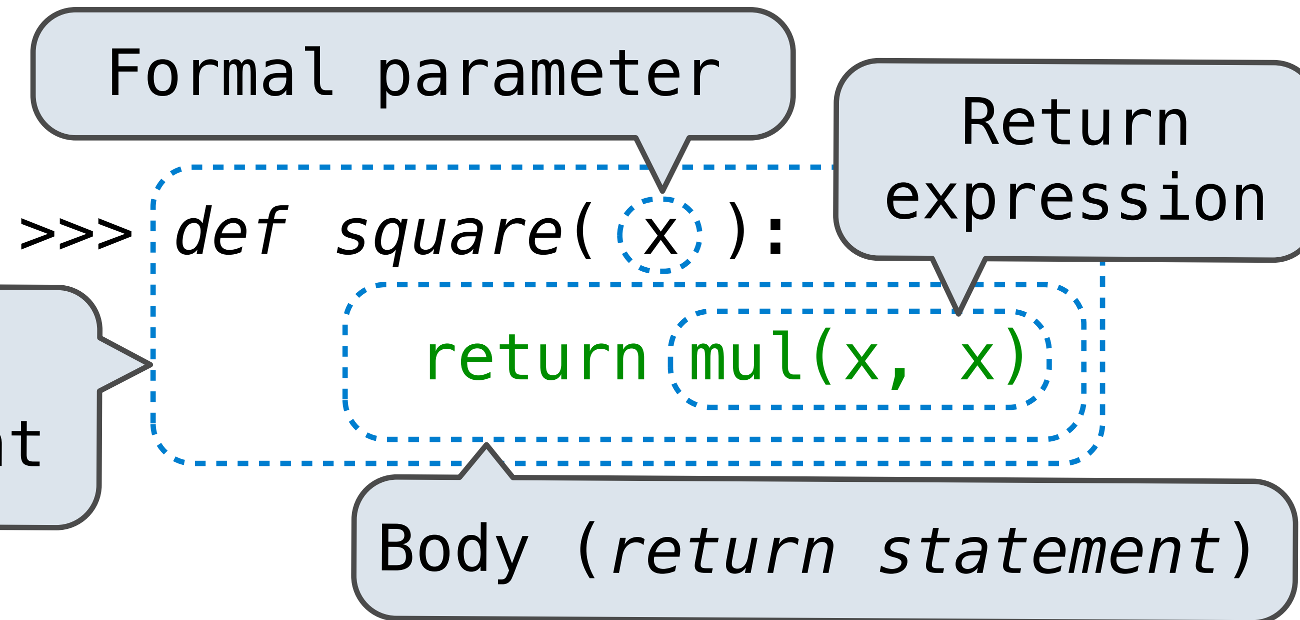
Call expression: square(2+2)

Calling/Applying:



Life Cycle of a User-Defined Function

Defining:

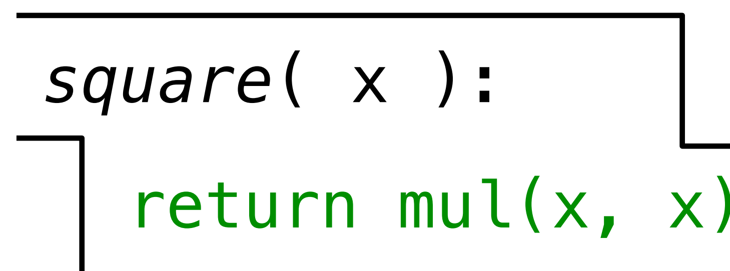


What happens?

Function created

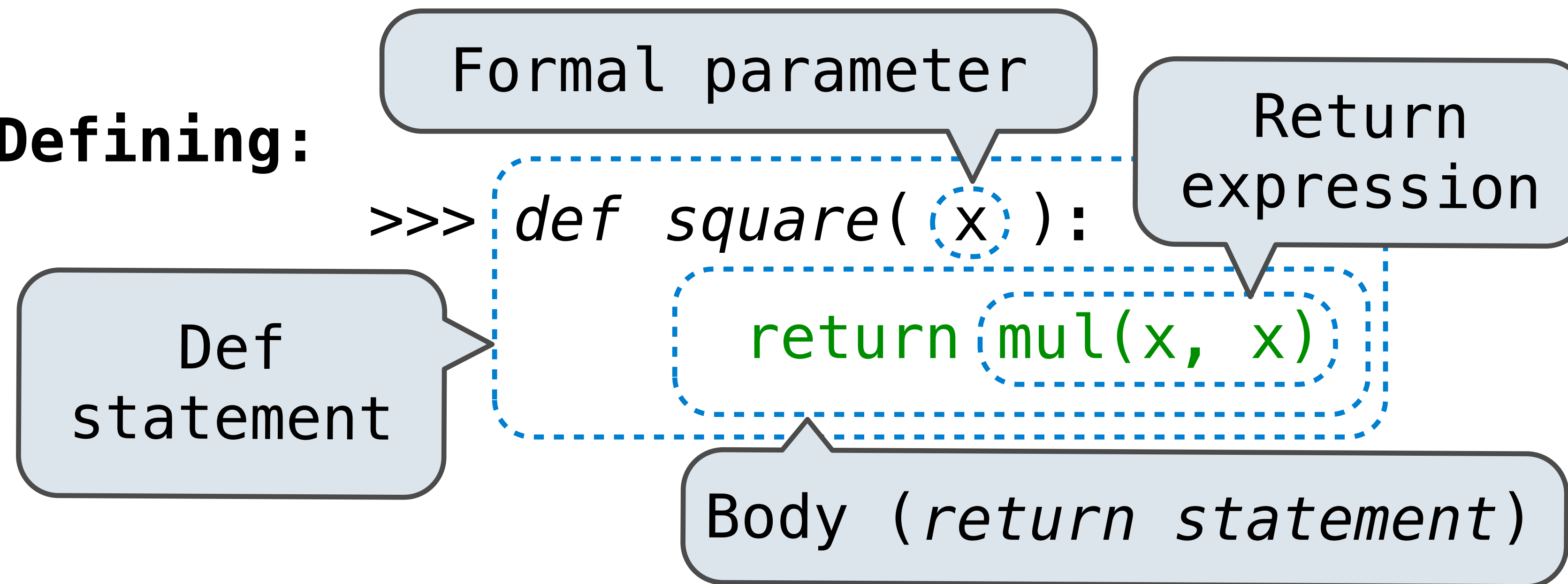
Call expression: square(2+2)

Calling/Applying:



Life Cycle of a User-Defined Function

Defining:



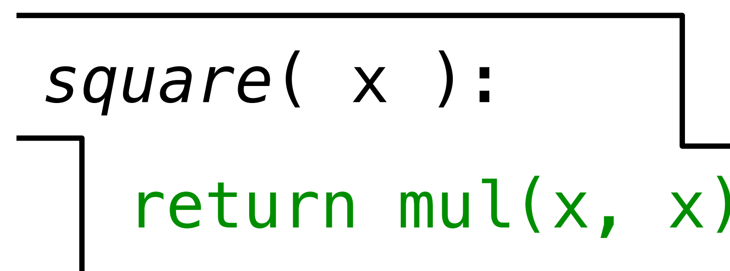
What happens?

Function created

Body stored

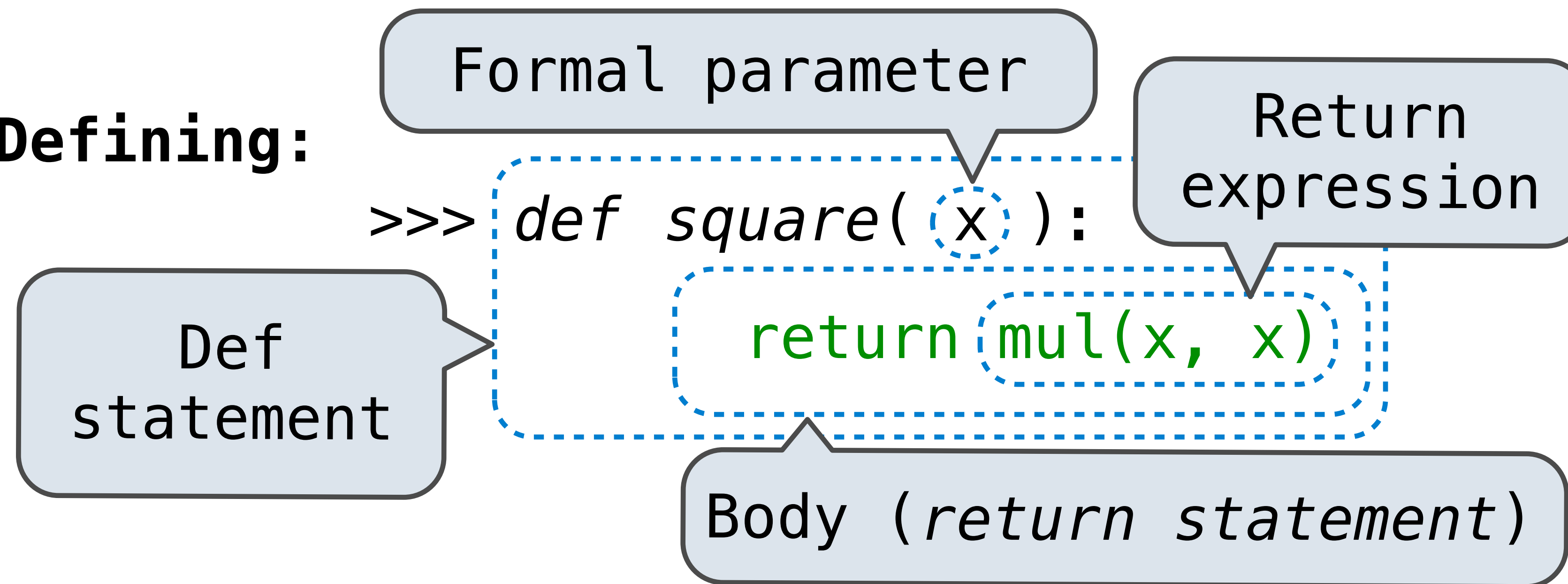
Call expression: square(2+2)

Calling/Applying:



Life Cycle of a User-Defined Function

Defining:



What happens?

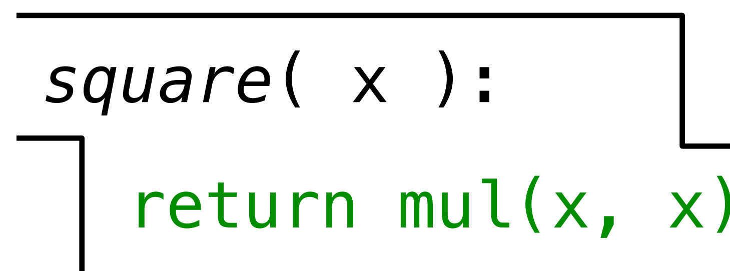
Function created

Body stored

Name bound

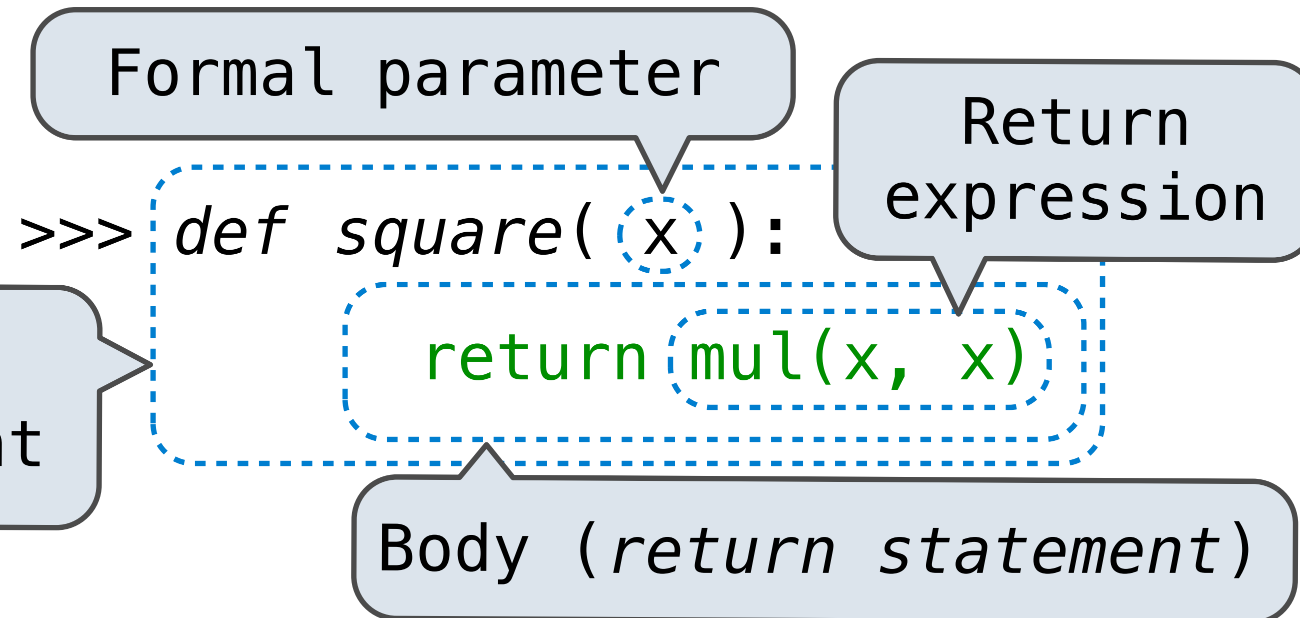
Call expression: square(2+2)

Calling/Applying:

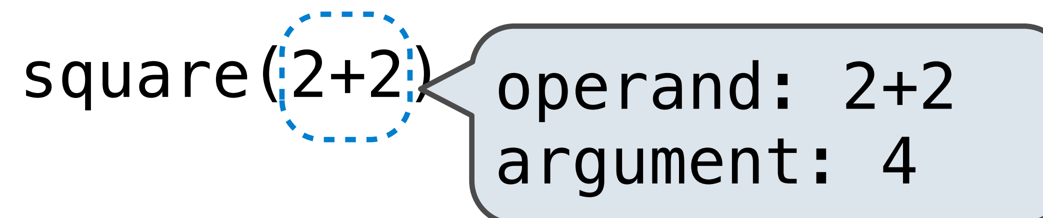


Life Cycle of a User-Defined Function

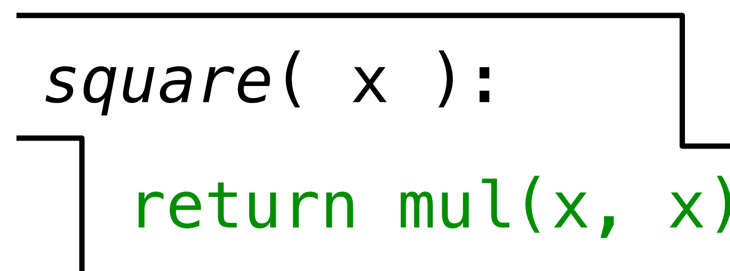
Defining:



Call expression:



Calling/Applying:



What happens?

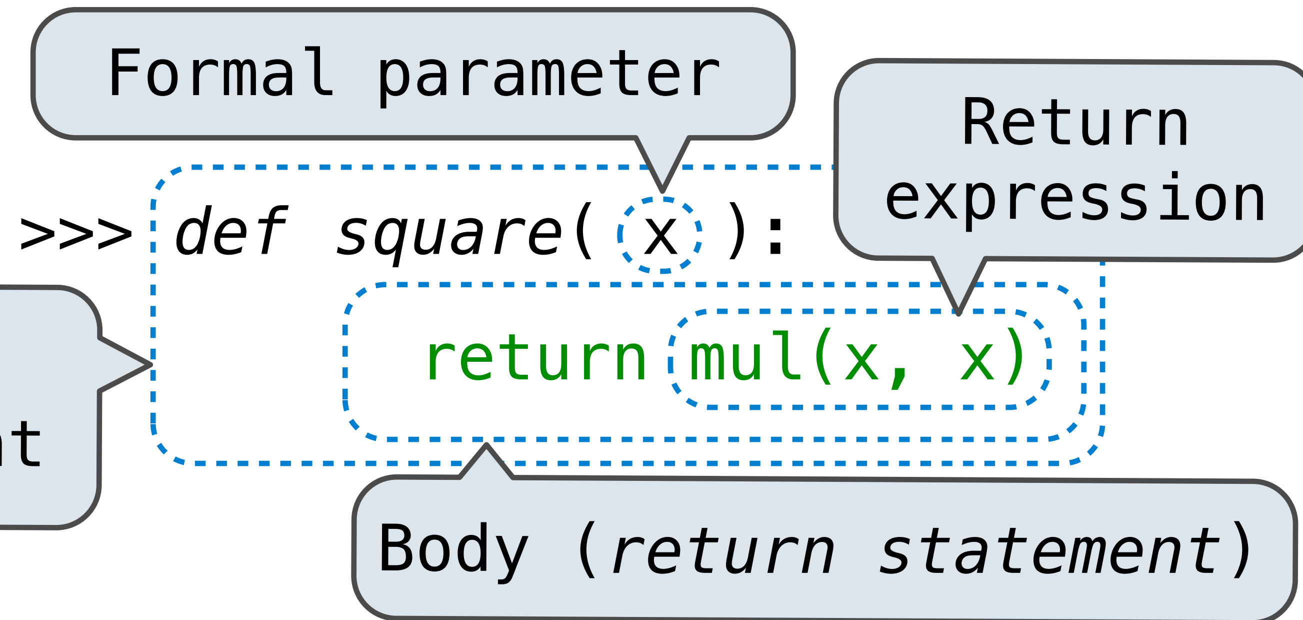
Function created

Body stored

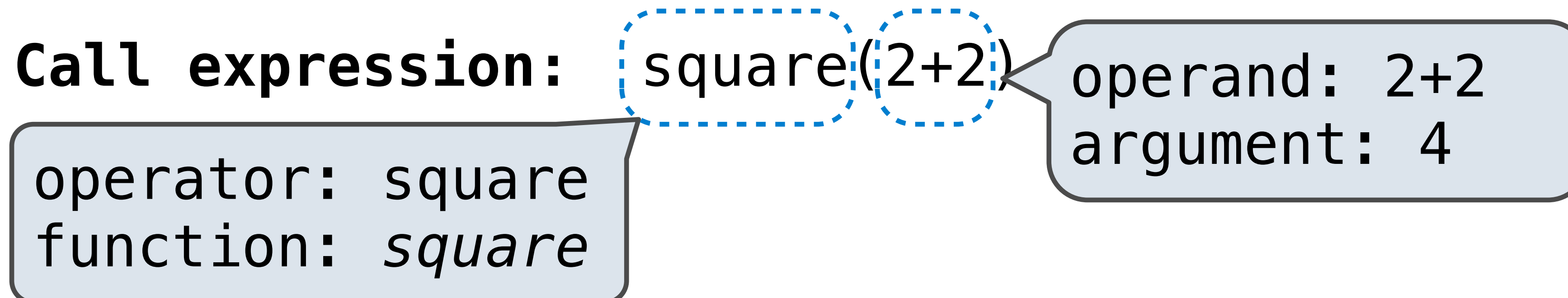
Name bound

Life Cycle of a User-Defined Function

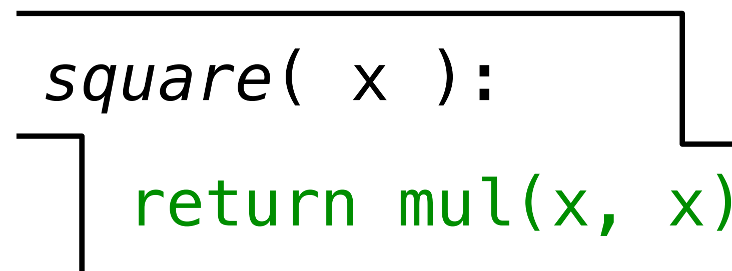
Defining:



Call expression:



Calling/Applying:



What happens?

Function created

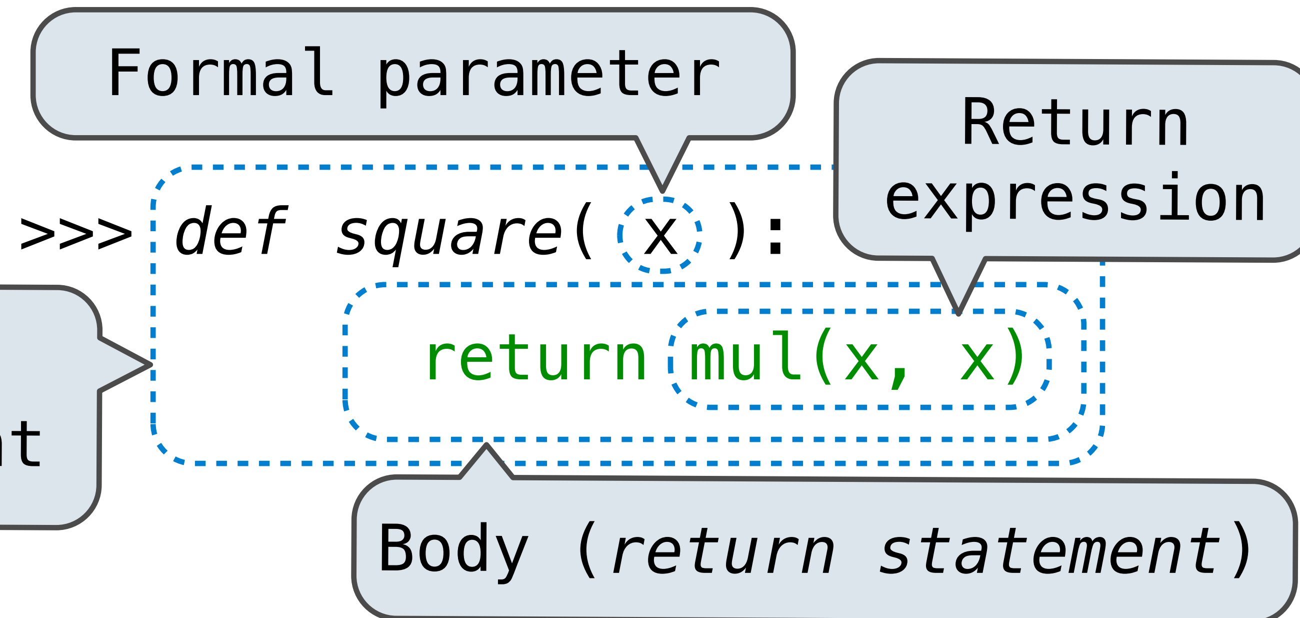
Body stored

Name bound

Life Cycle of a User-Defined Function

What happens?

Defining:

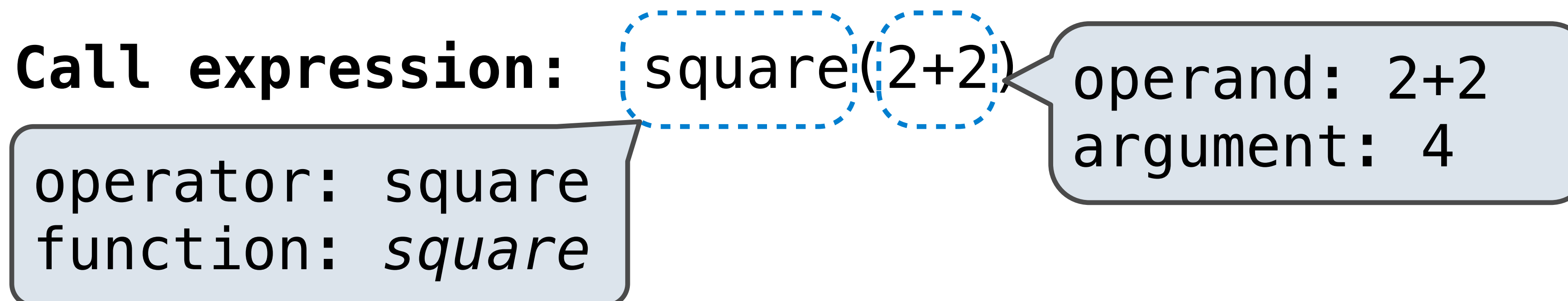


Function created

Body stored

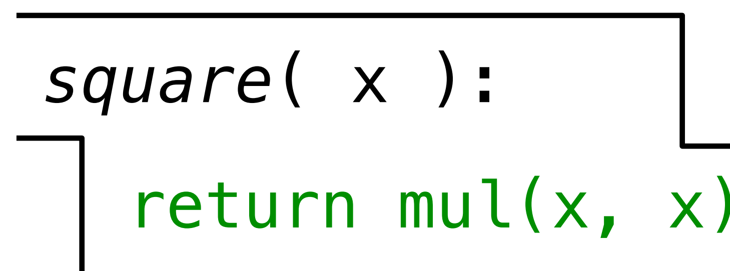
Name bound

Call expression:



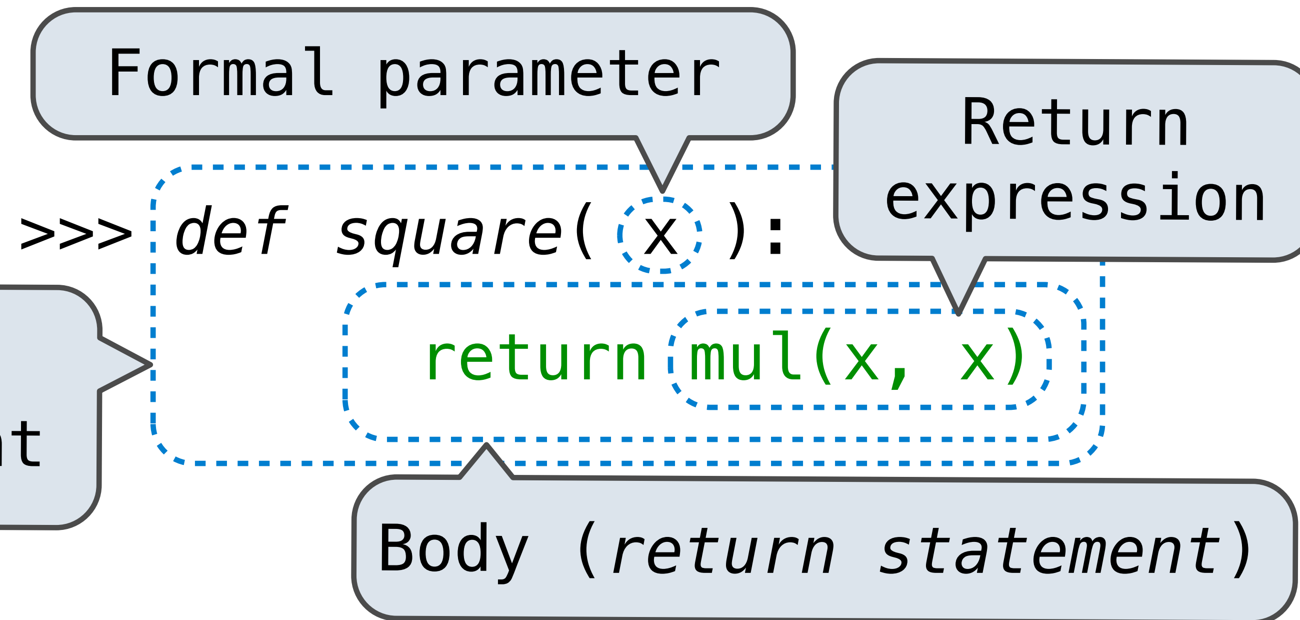
Op's evaluated

Calling/Applying:



Life Cycle of a User-Defined Function

Defining:



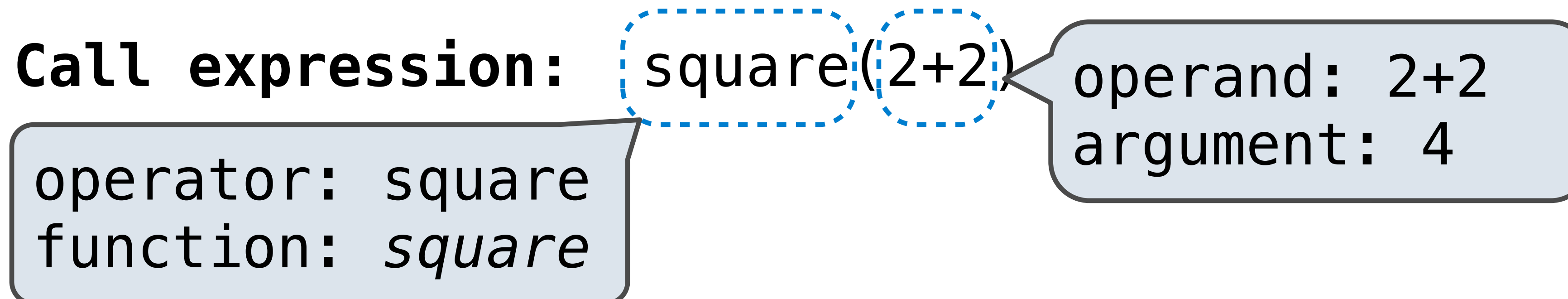
What happens?

Function created

Body stored

Name bound

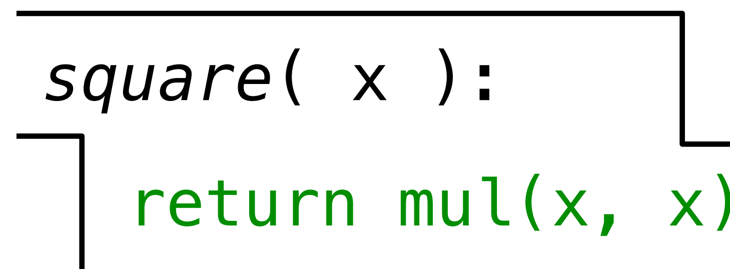
Call expression:



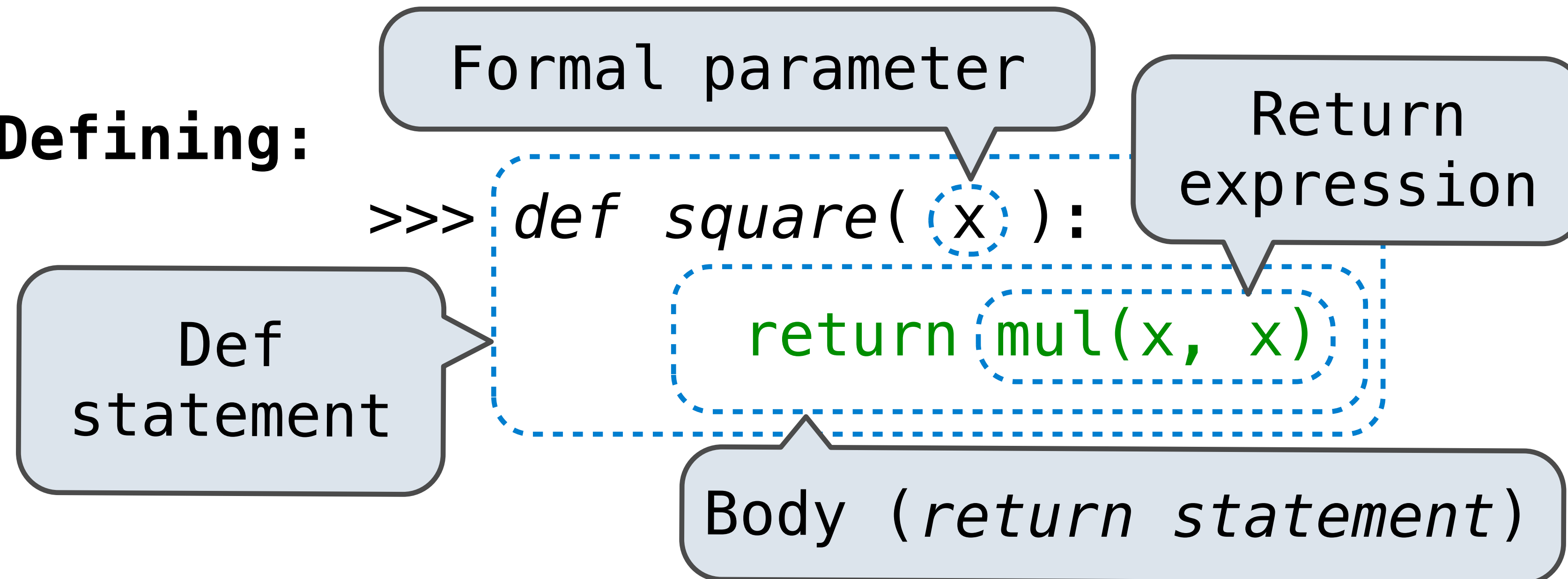
Op's evaluated

Function called

Calling/Applying:



Life Cycle of a User-Defined Function

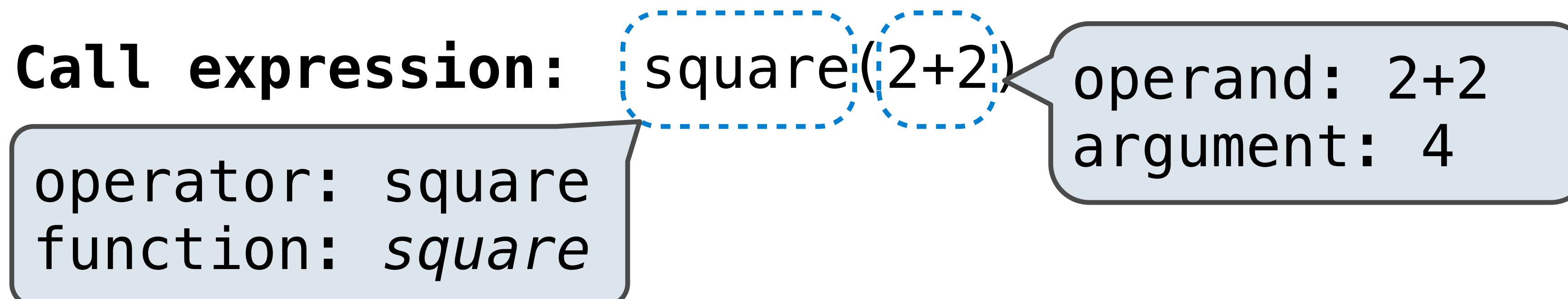


What happens?

Function created

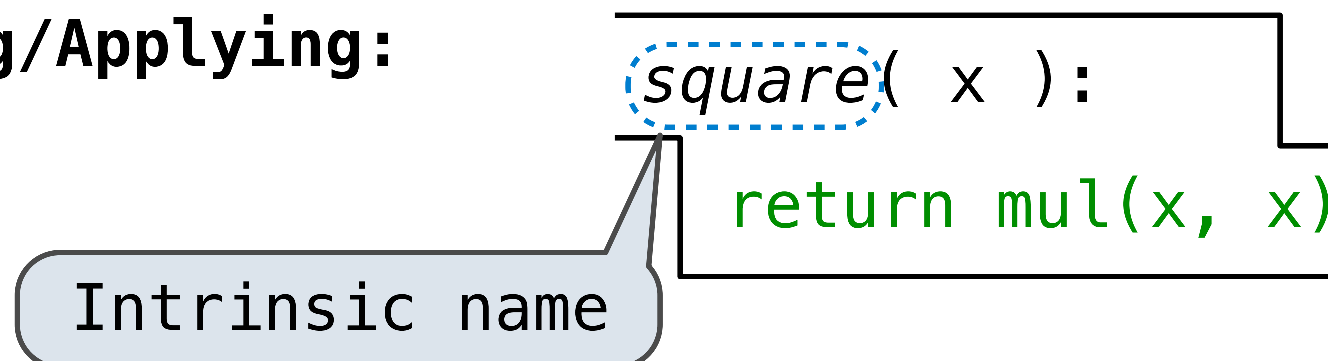
Body stored

Name bound

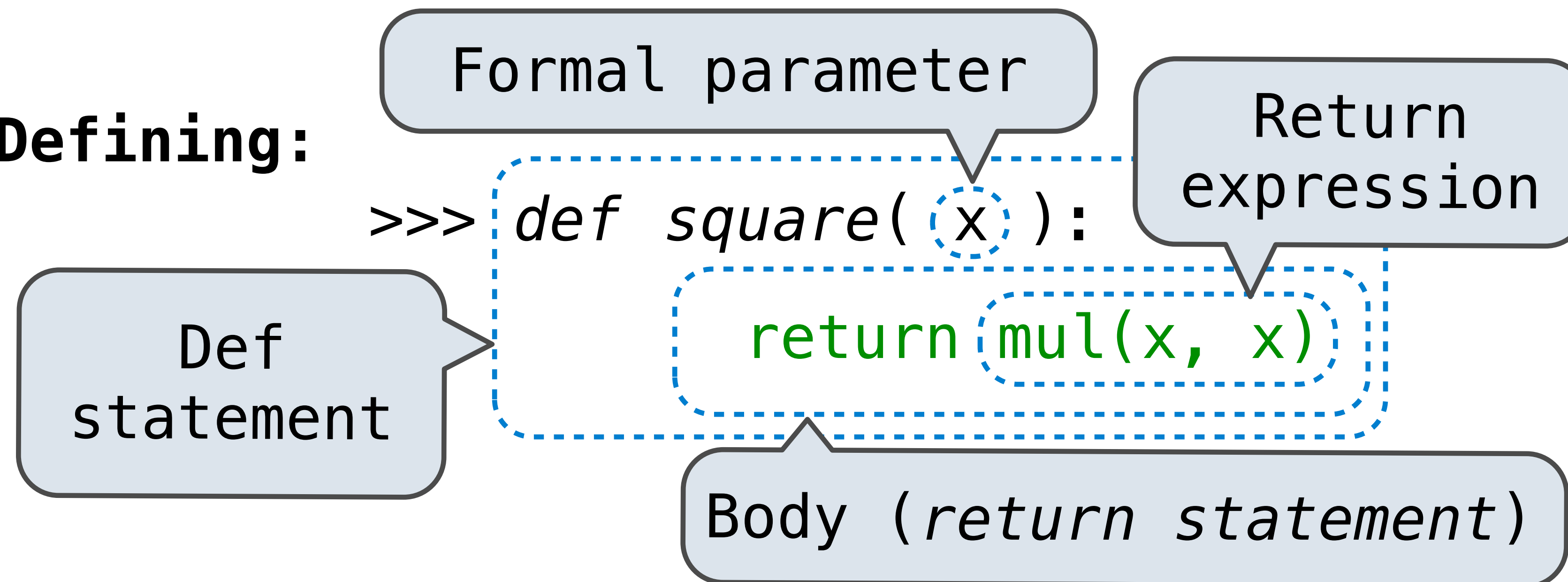


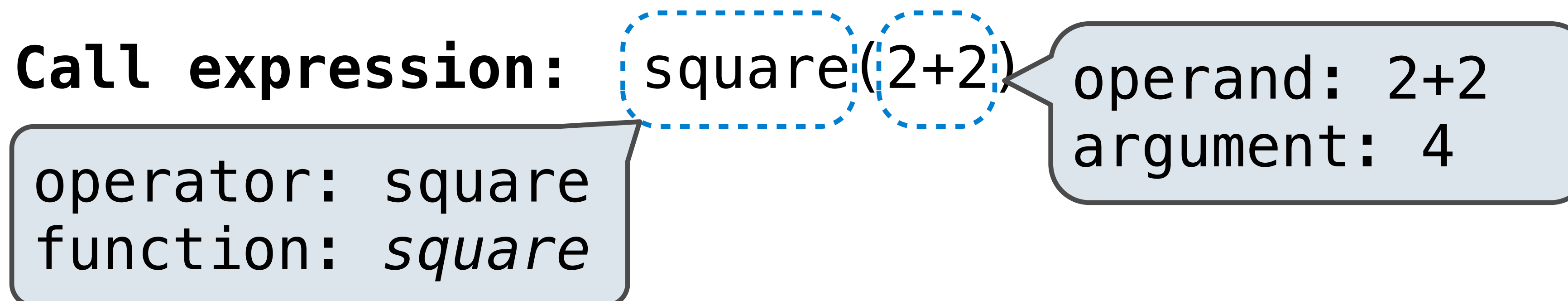
Op's evaluated

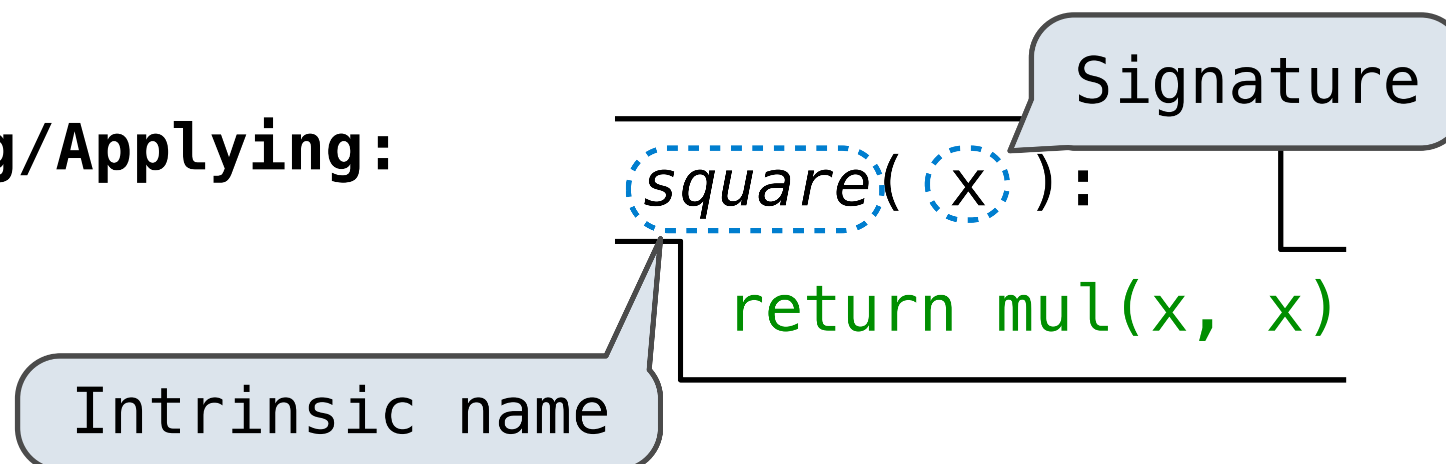
Function called



Life Cycle of a User-Defined Function







What happens?

Function created

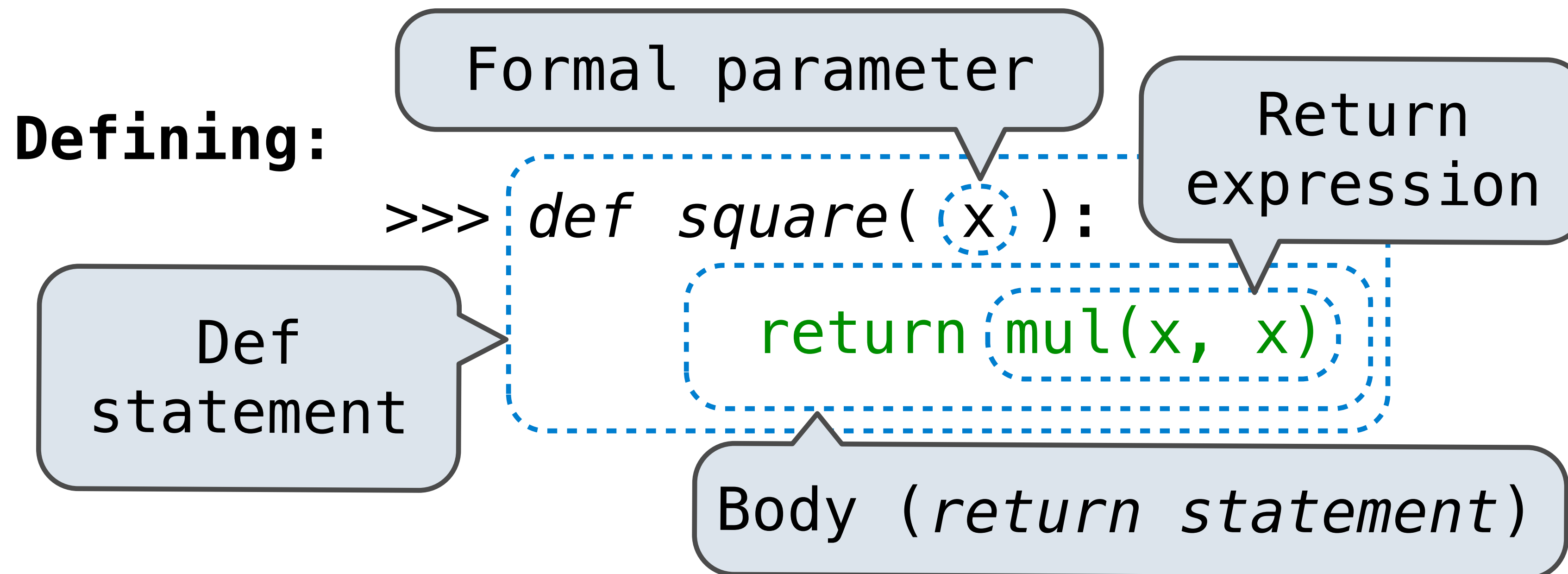
Body stored

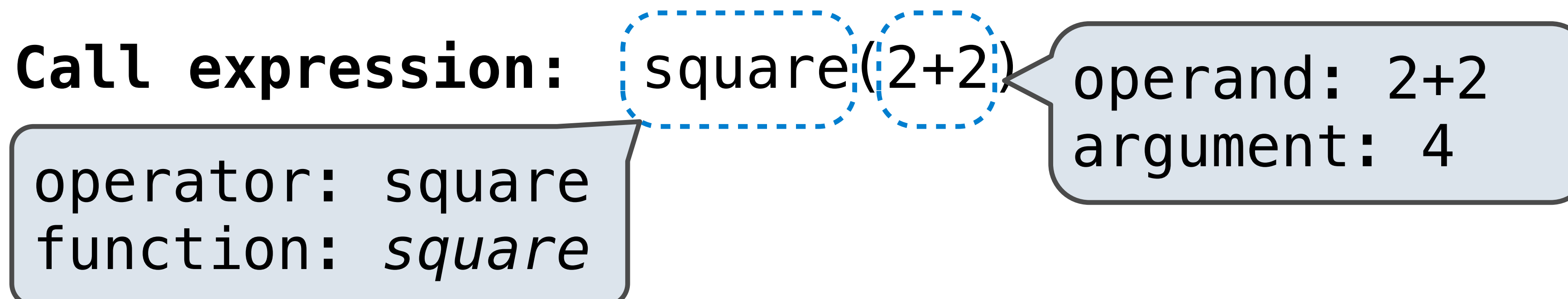
Name bound

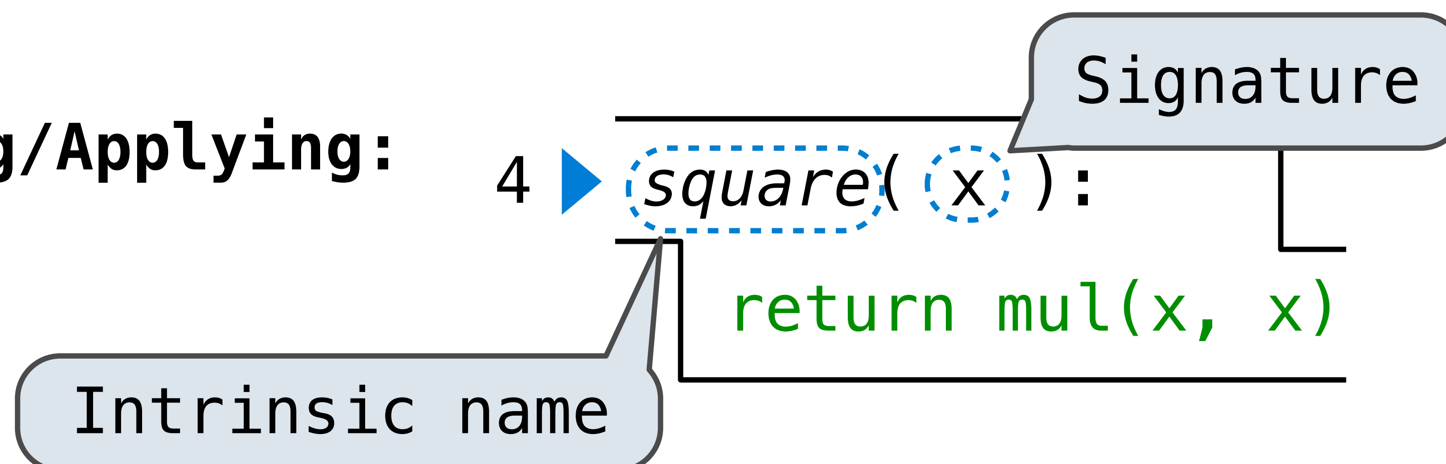
Op's evaluated

Function called

Life Cycle of a User-Defined Function







What happens?

Function created

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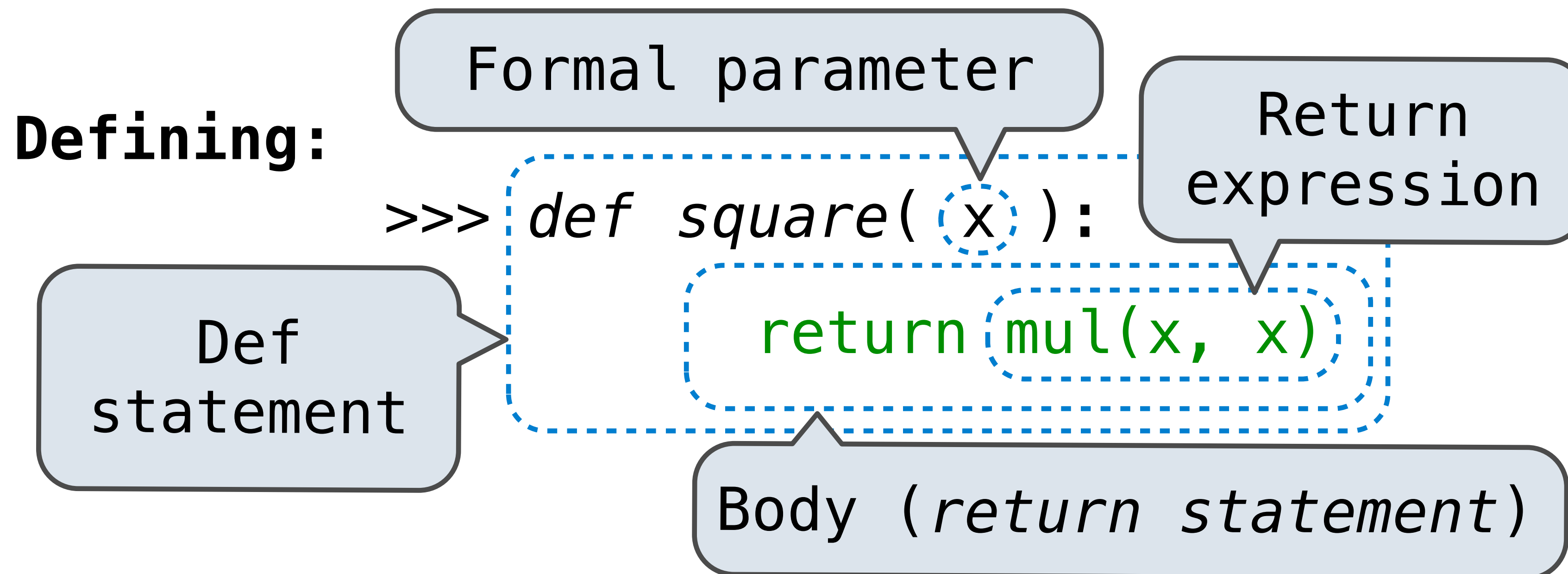
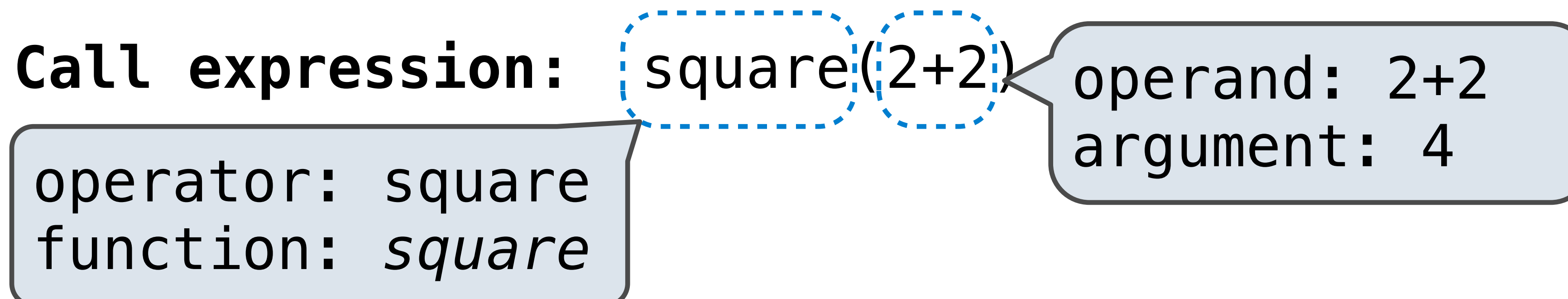
Name bound

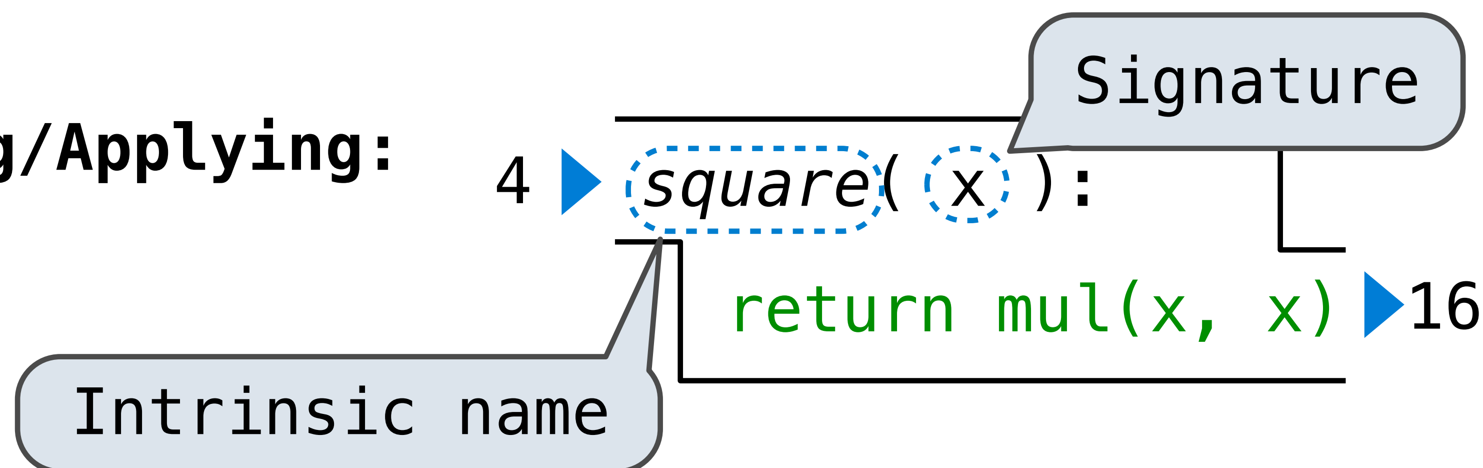
Op's evaluated

Function called

Life Cycle of a User-Defined Function







What happens?

Function created

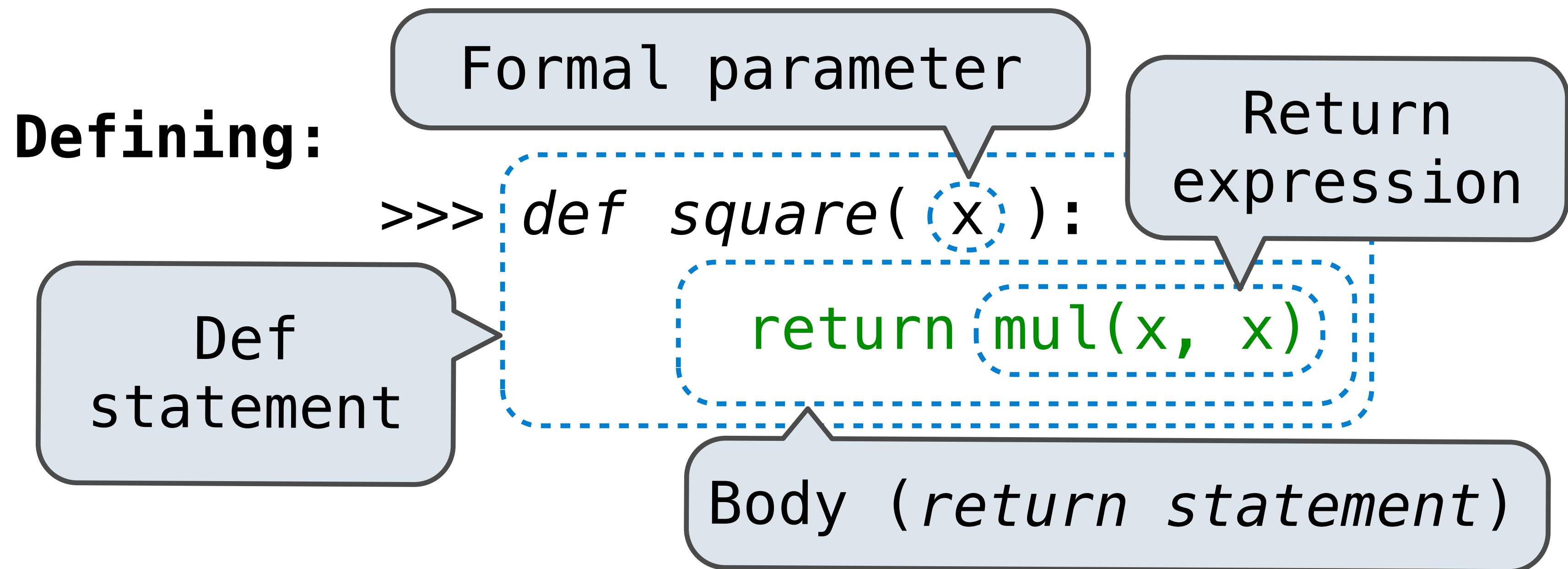
Body stored

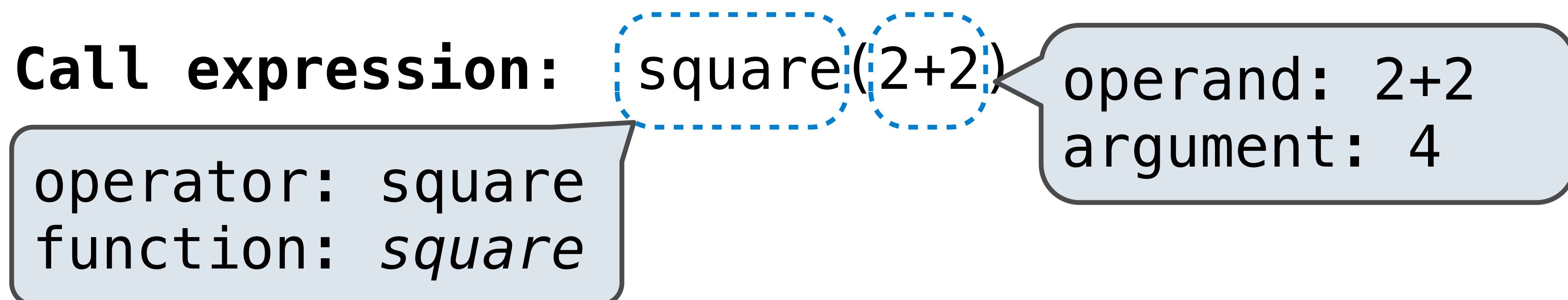
Name bound

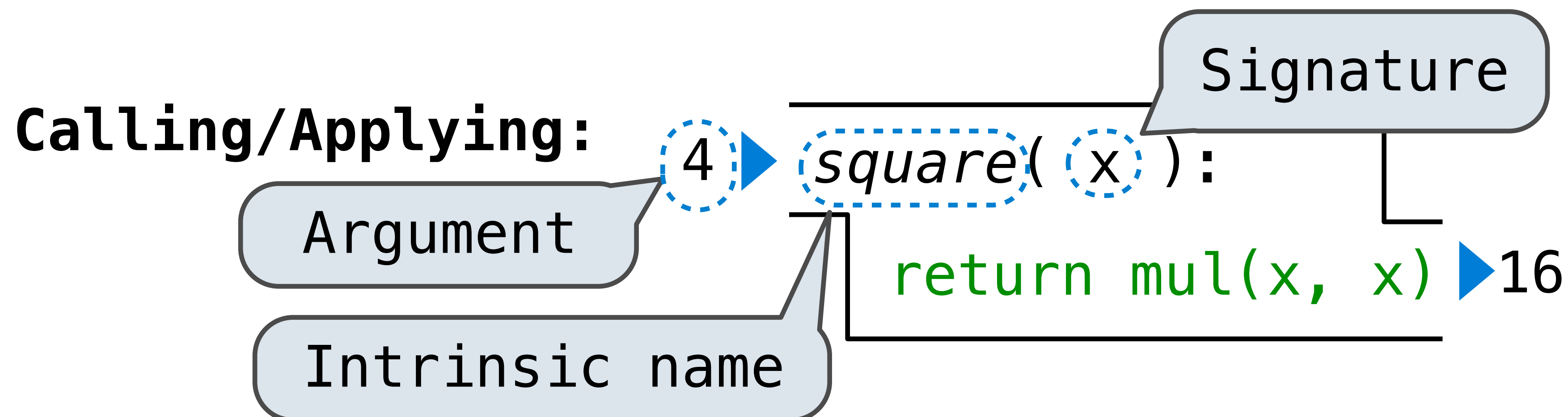
Op's evaluated

Function called

Life Cycle of a User-Defined Function







What happens?

Function created

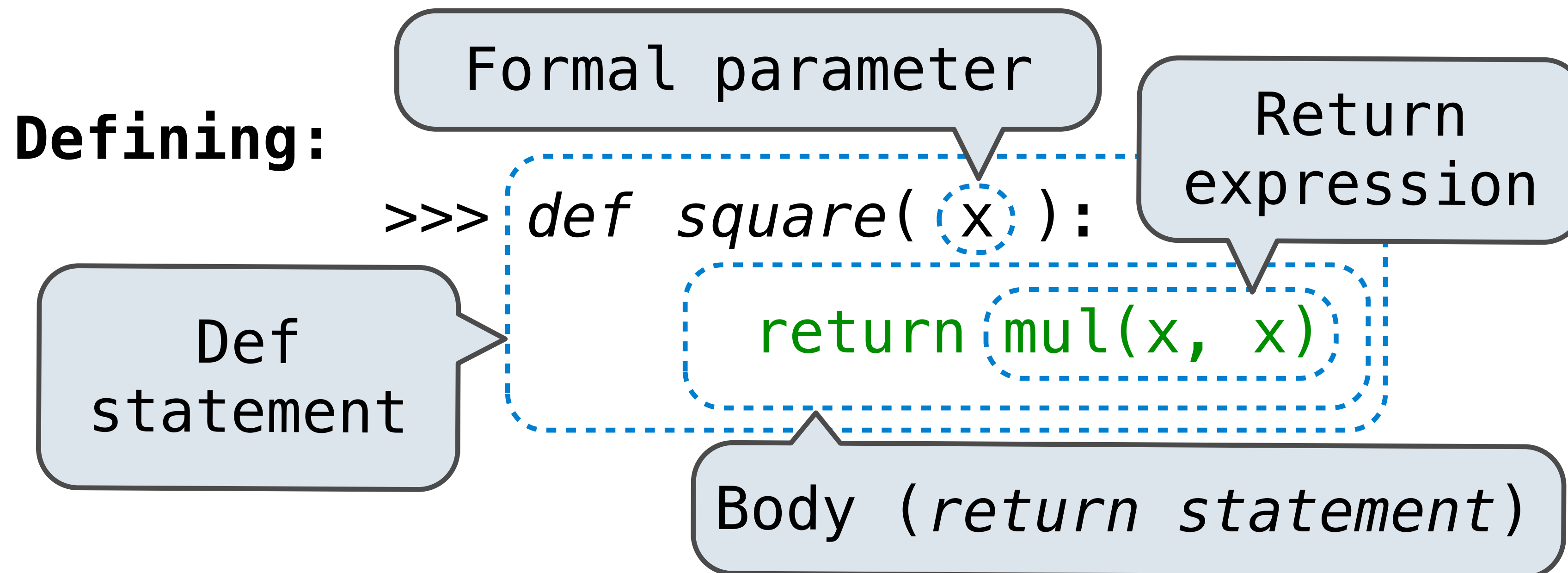
Body stored

Name bound

Op's evaluated

Function called

Life Cycle of a User-Defined Function

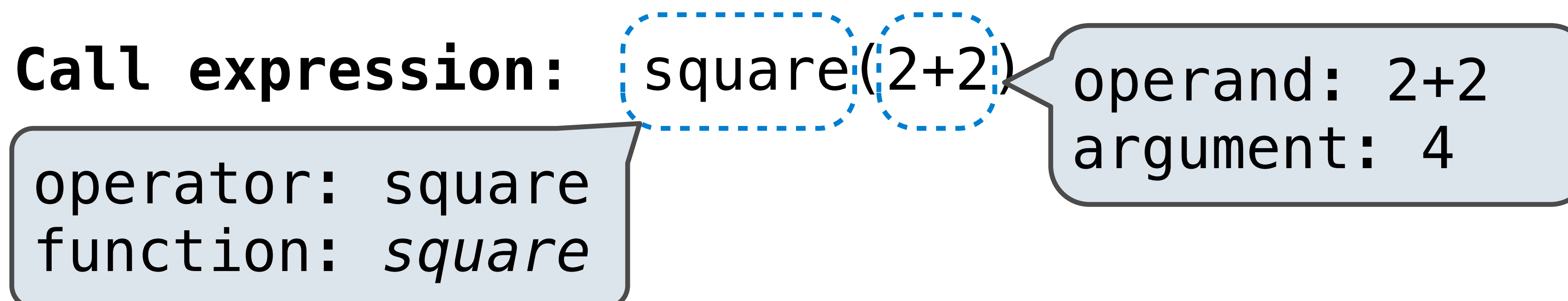


What happens?

Function created

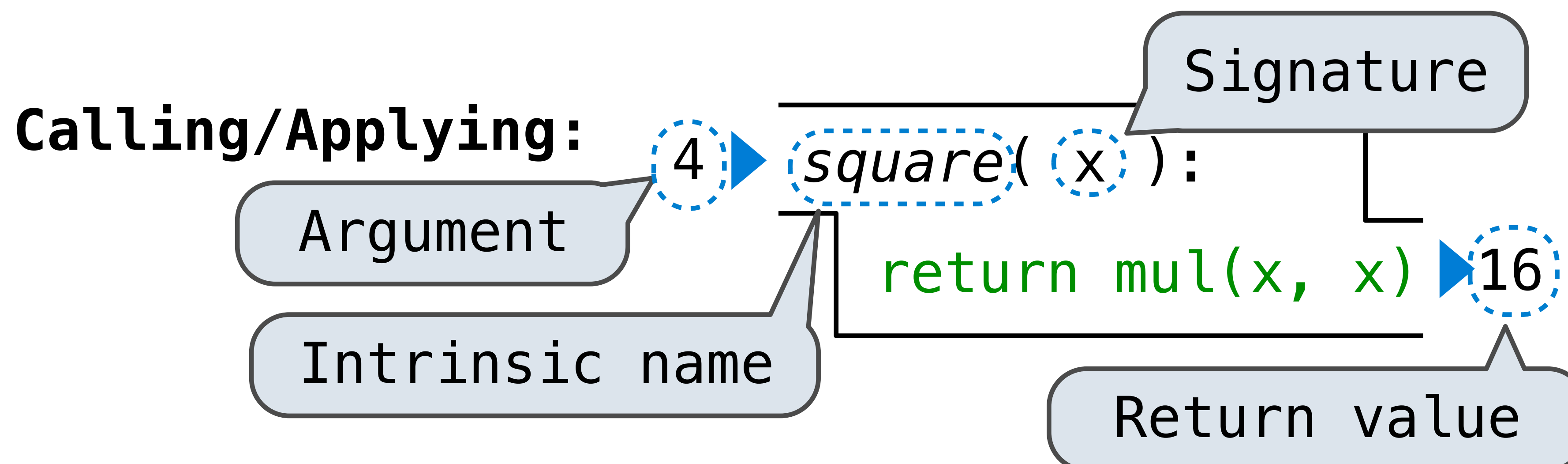
Body stored

Name bound

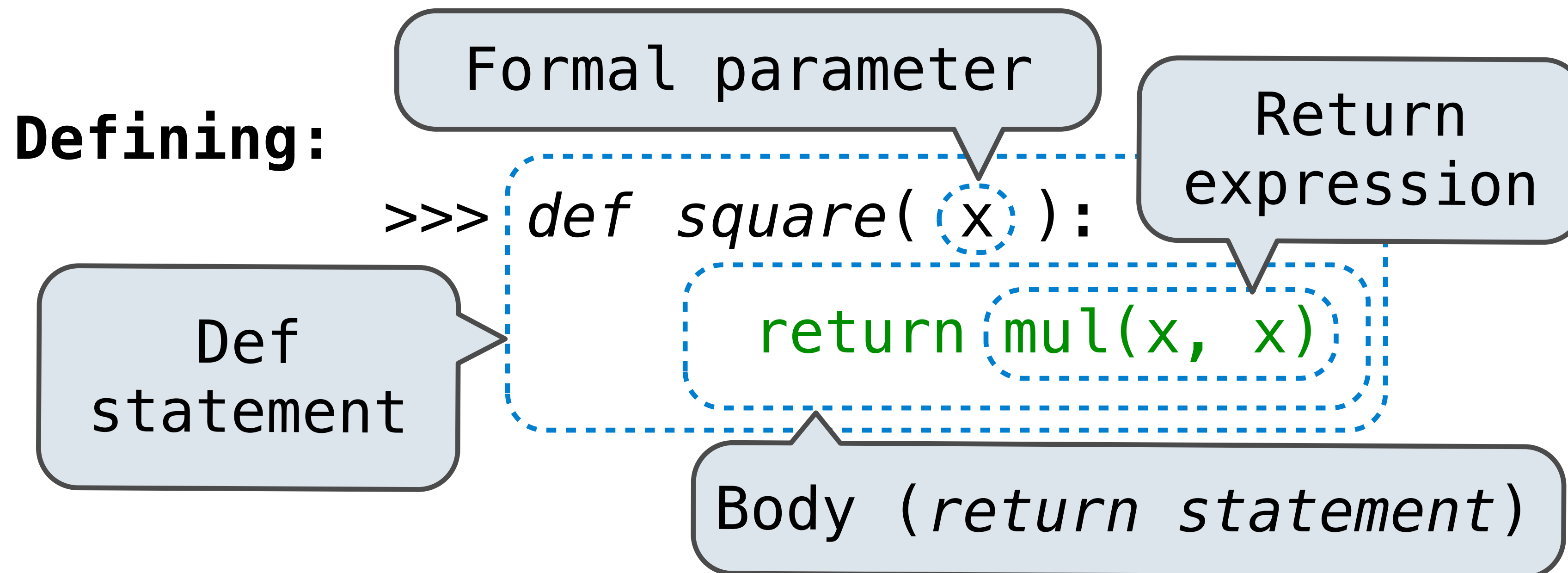


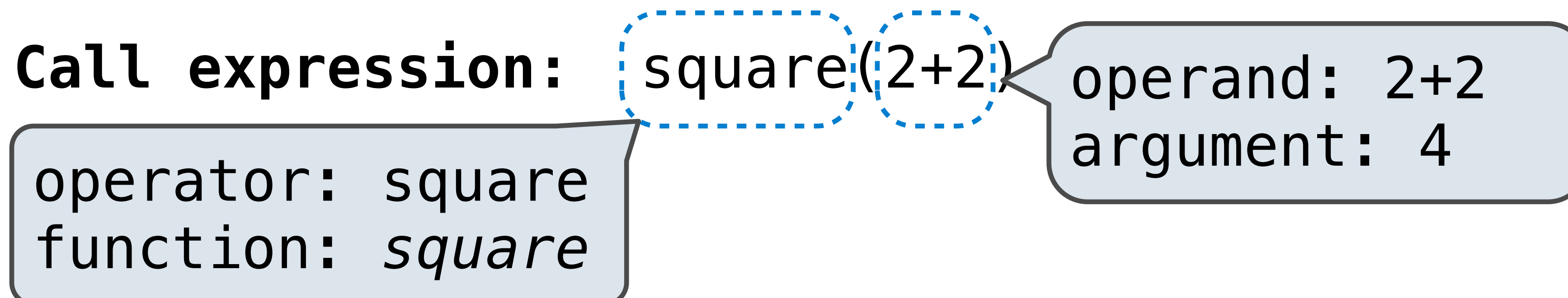
Op's evaluated

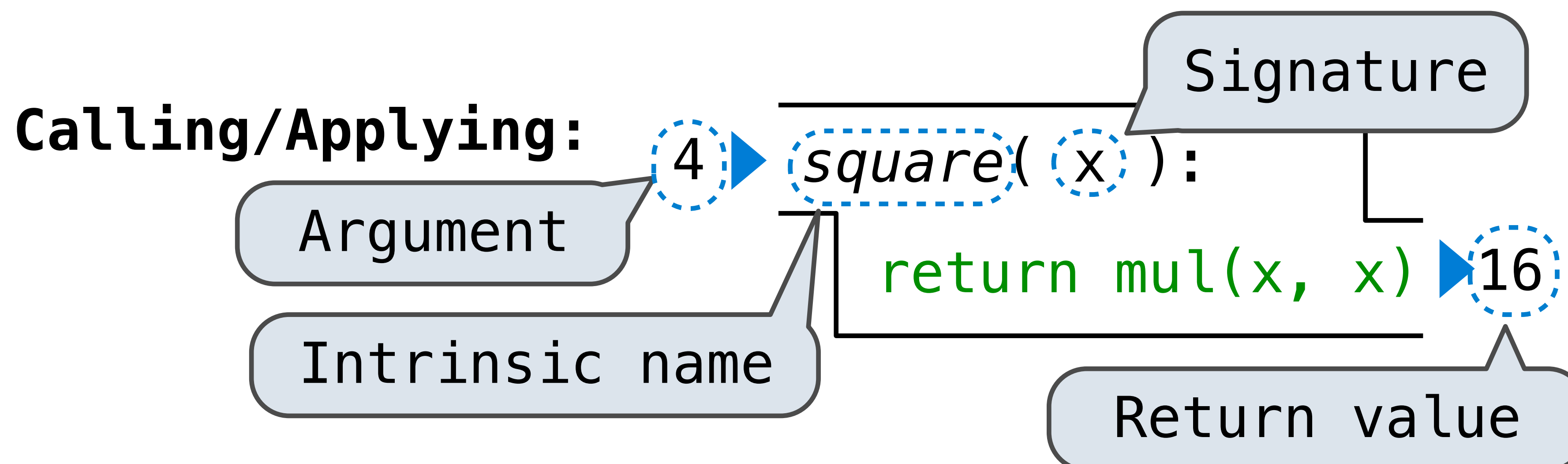
Function called



Life Cycle of a User-Defined Function







What happens?

Function created

Body stored

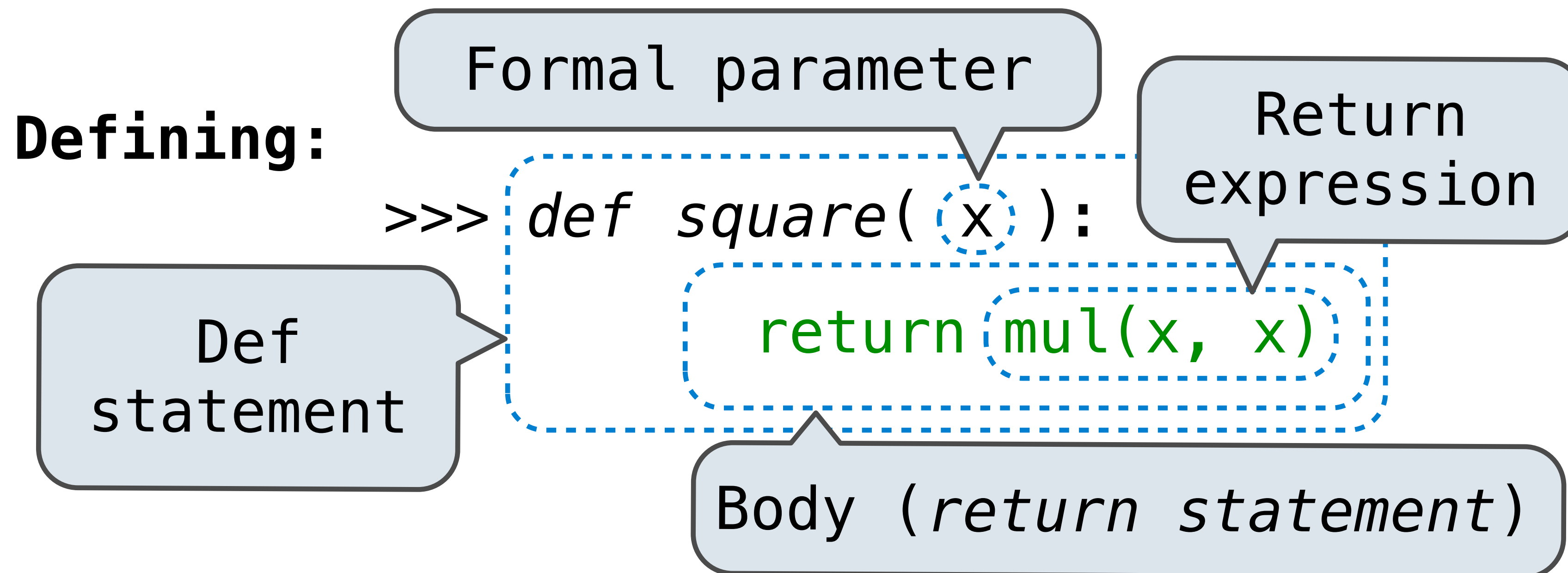
Name bound

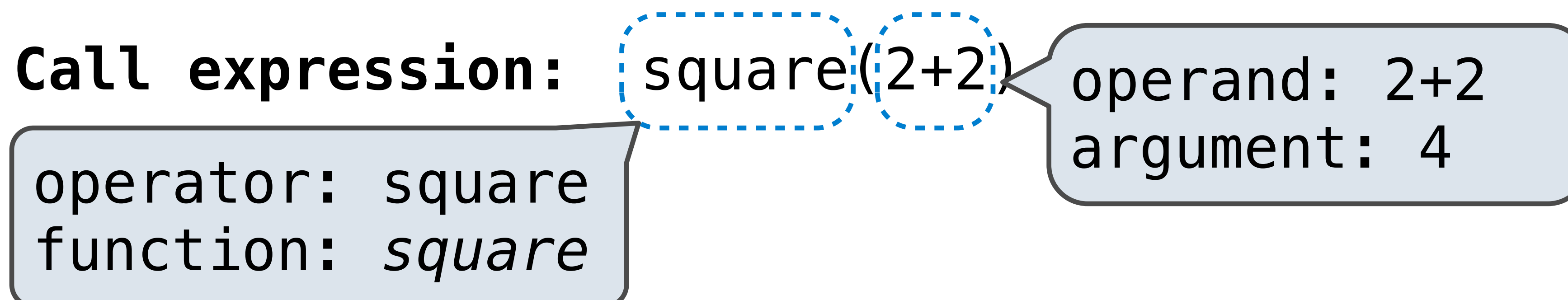
Op's evaluated

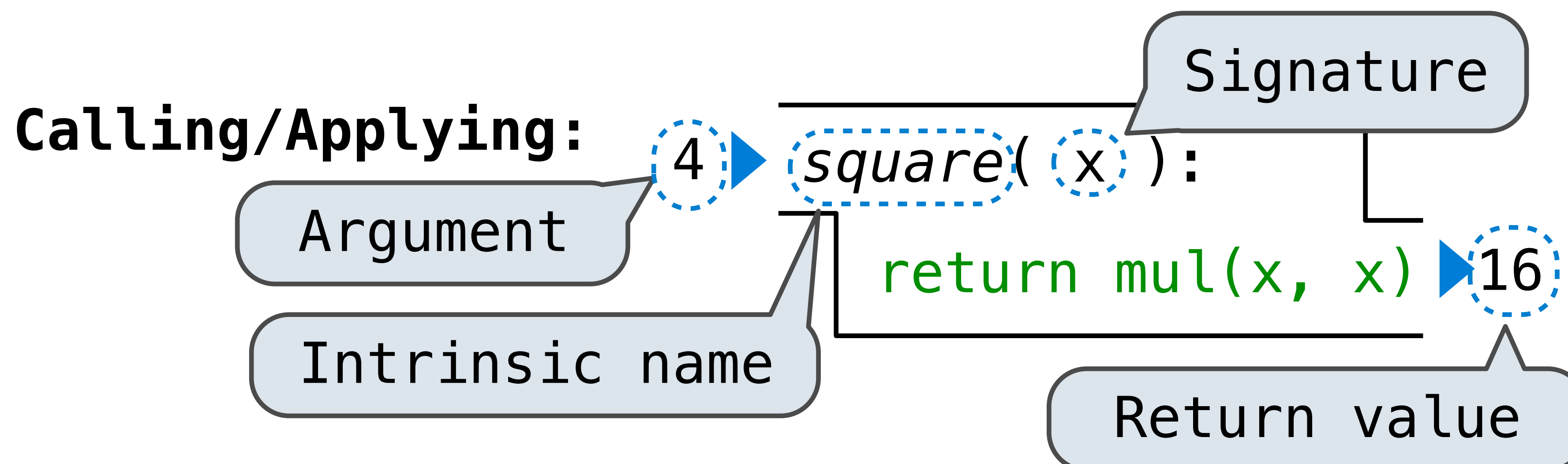
Function called

New frame!

Life Cycle of a User-Defined Function







What happens?

Function created

Body stored

Name bound

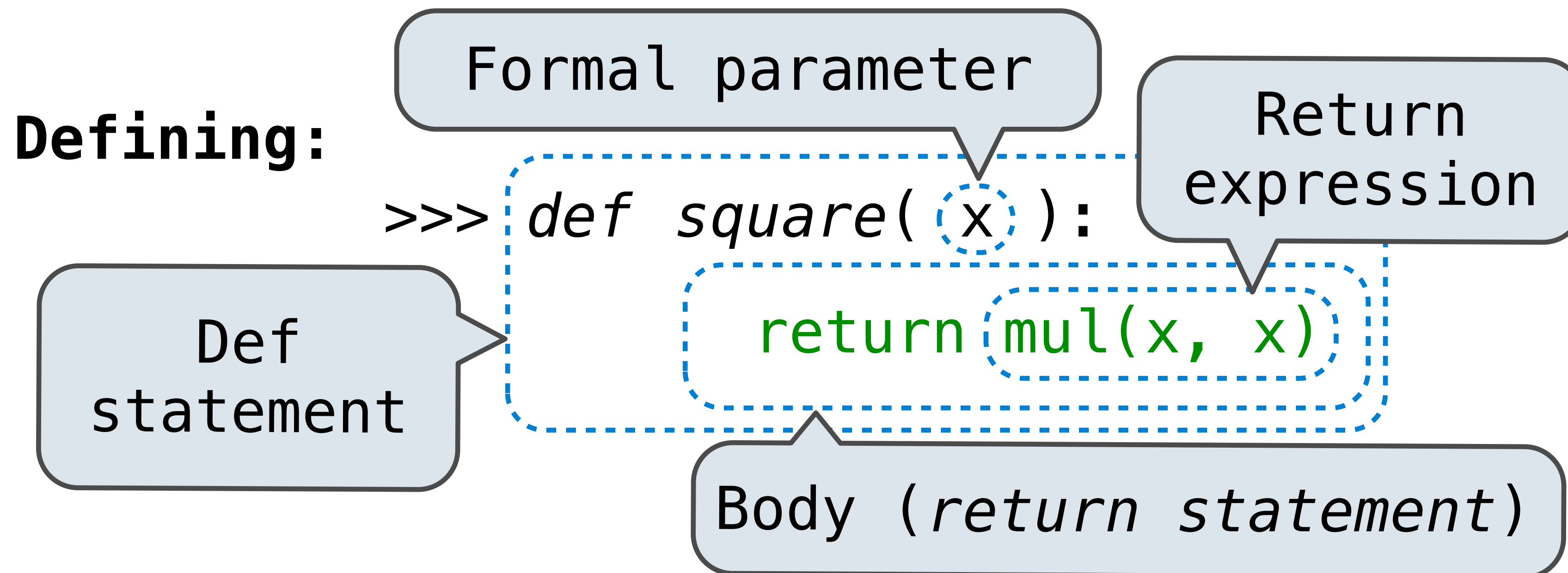
Op's evaluated

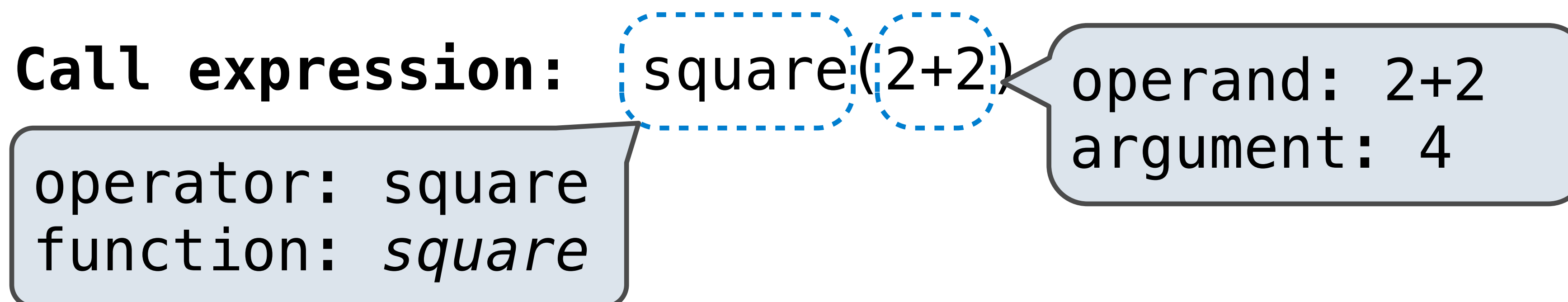
Function called

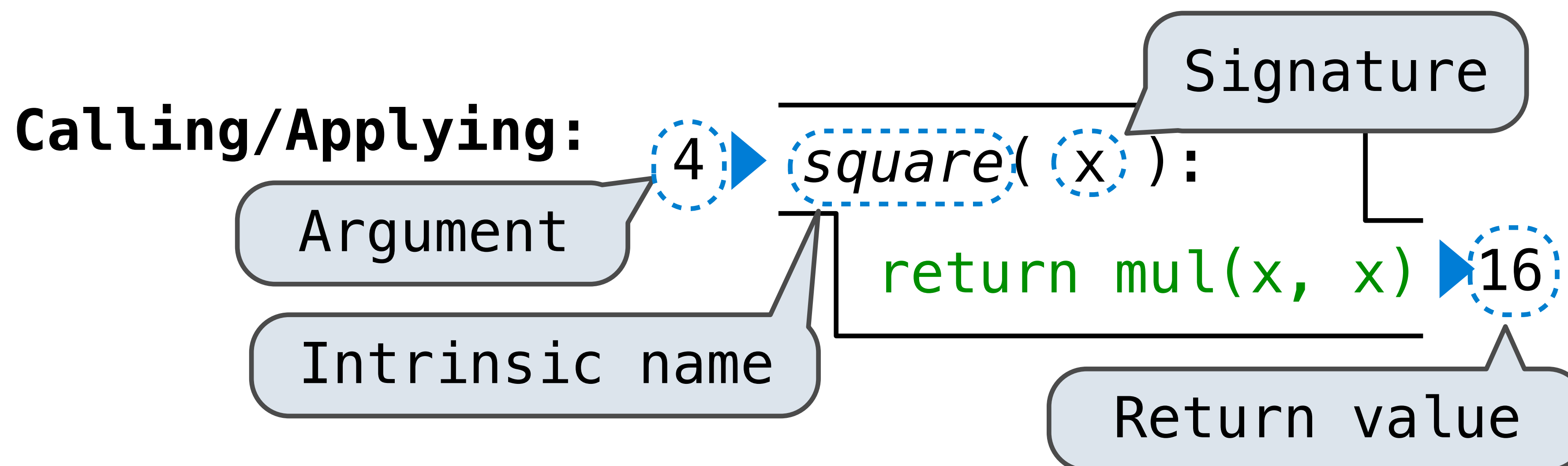
New frame!

Params bound

Life Cycle of a User-Defined Function







What happens?

Function created

Body stored

Name bound

Op's evaluated

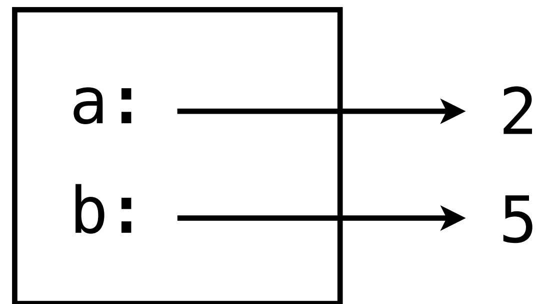
Function called

New frame!

Params bound

Body evaluated

Cast of Characters: Environment Diagrams

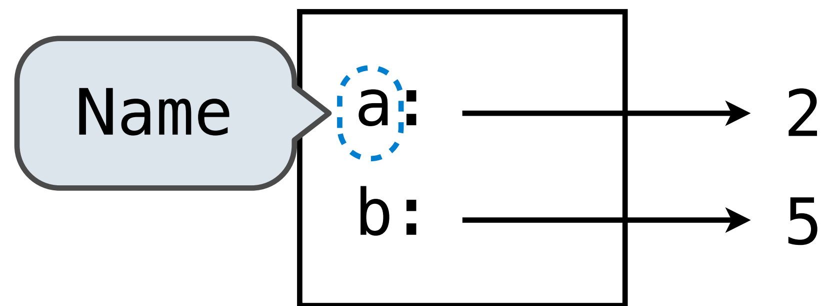


Frames:

Environments:

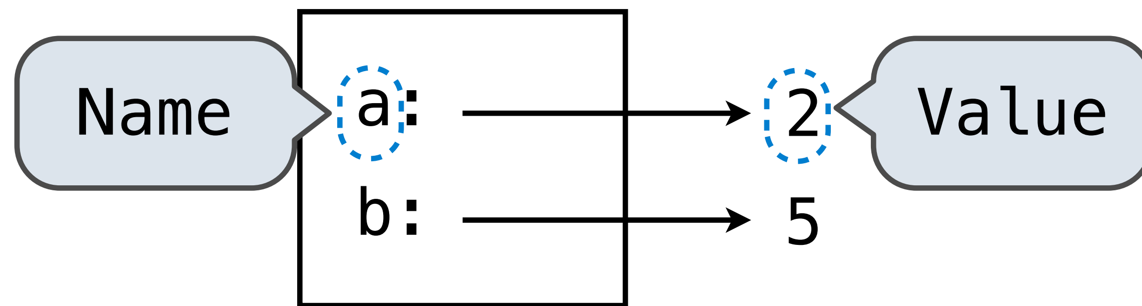
Cast of Characters: Environment Diagrams

Frames:



Environments:

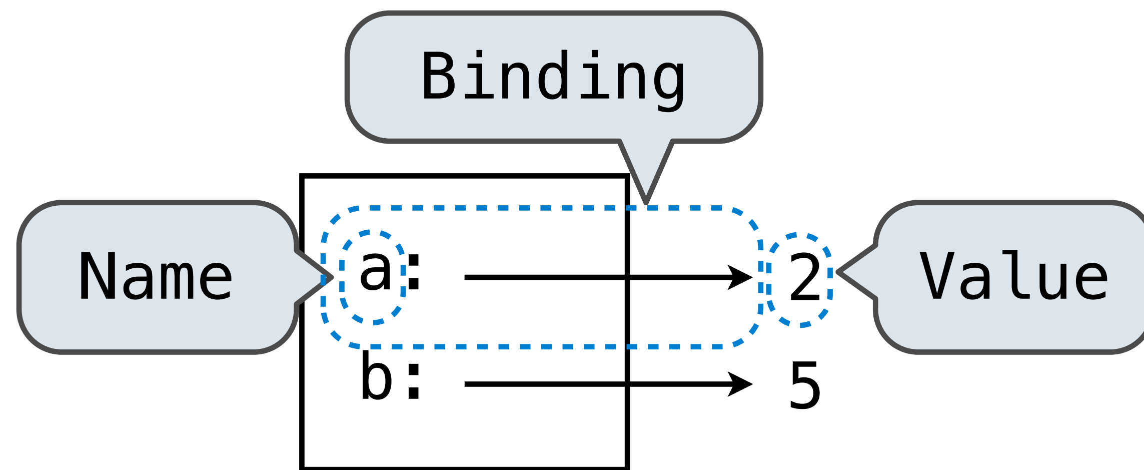
Cast of Characters: Environment Diagrams



Frames:

Environments:

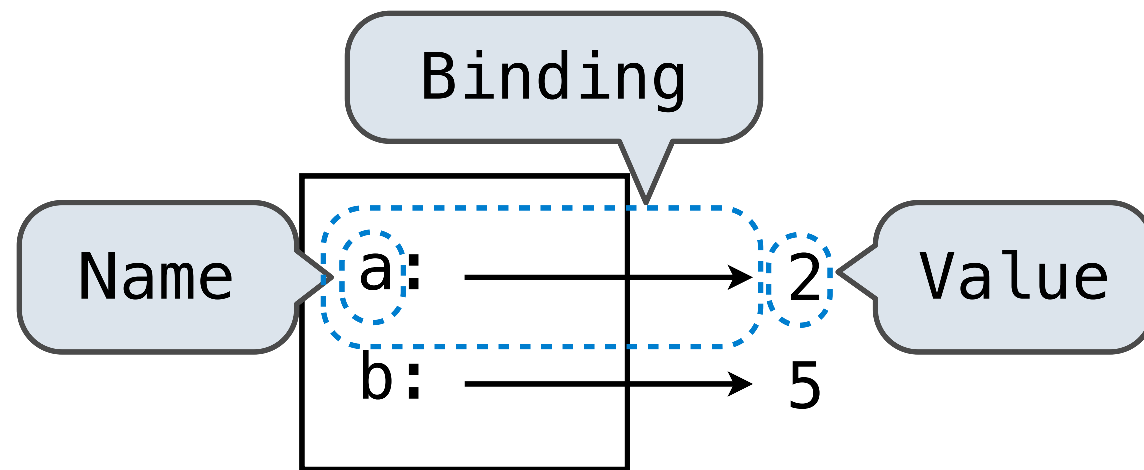
Cast of Characters: Environment Diagrams



Frames:

Environments:

Cast of Characters: Environment Diagrams

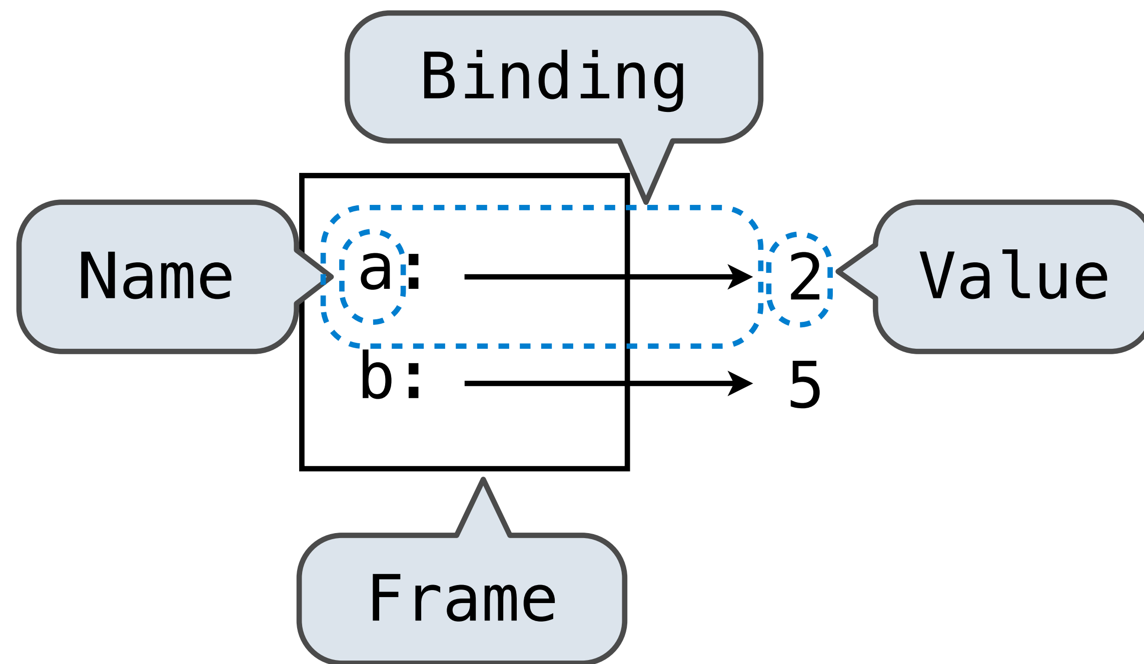


Frames:

A name is bound to a value

Environments:

Cast of Characters: Environment Diagrams

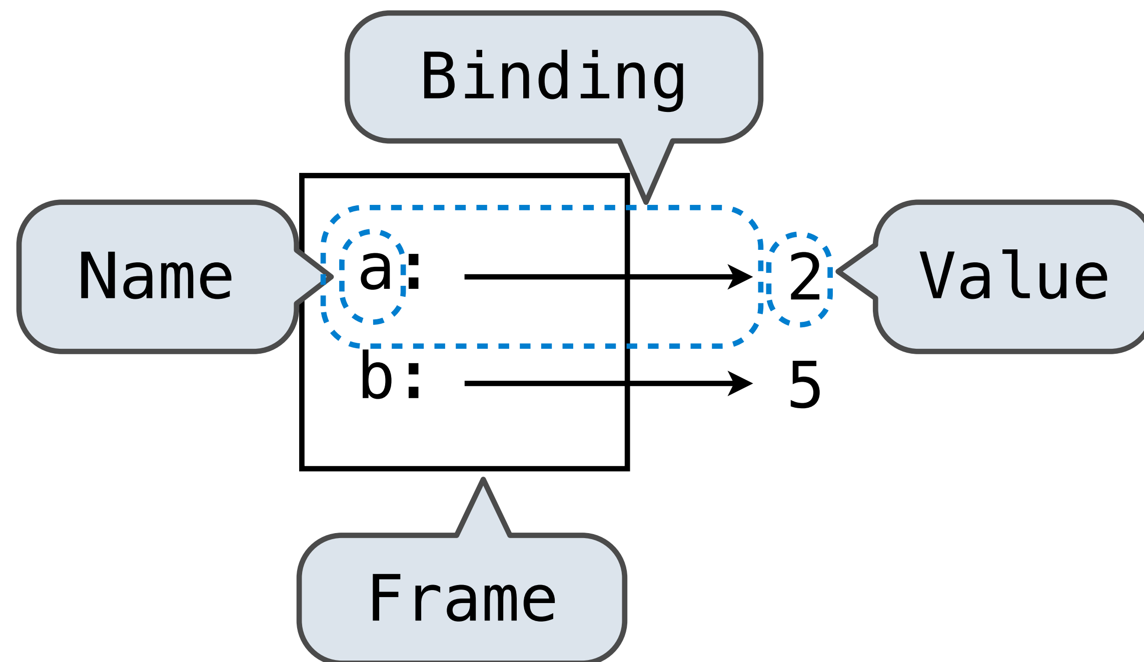


Frames:

A name is bound to a value

Environments:

Cast of Characters: Environment Diagrams



Frames:

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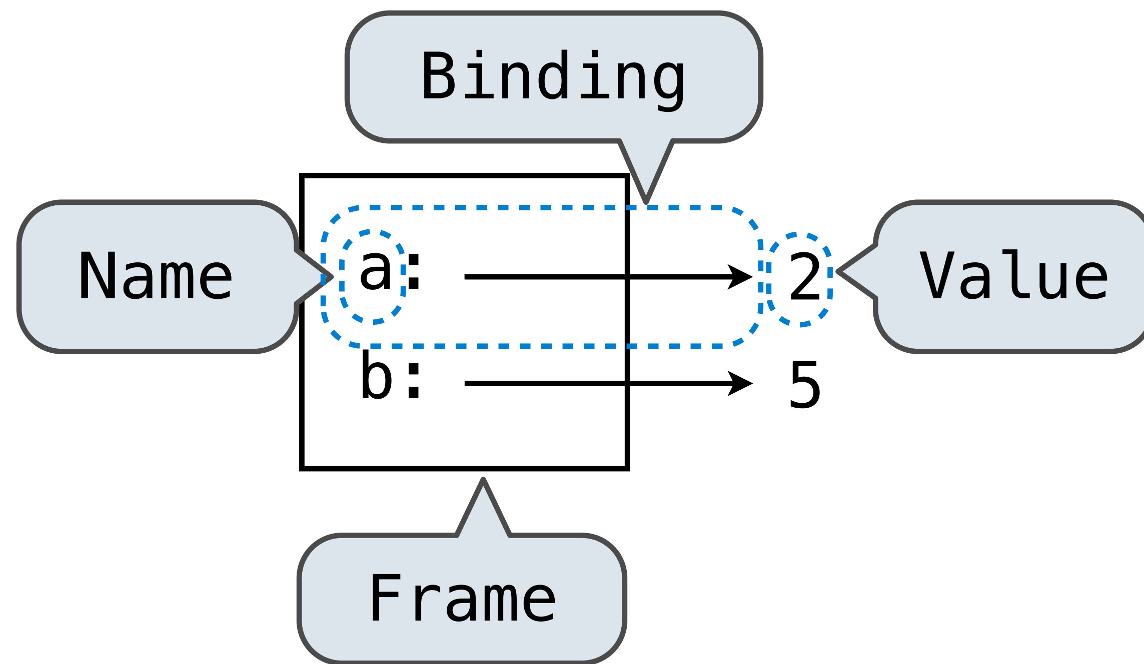
A frame is a rectangle
that contains bindings

Environments:

Cast of Characters: Environment Diagrams



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In a frame, there is at most
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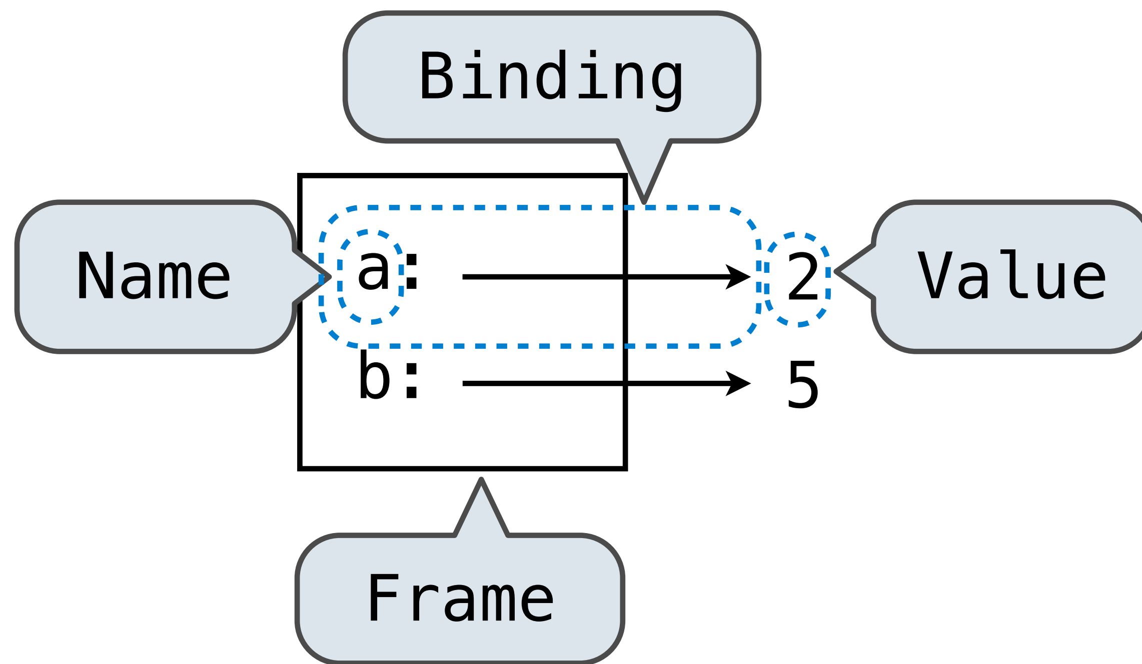

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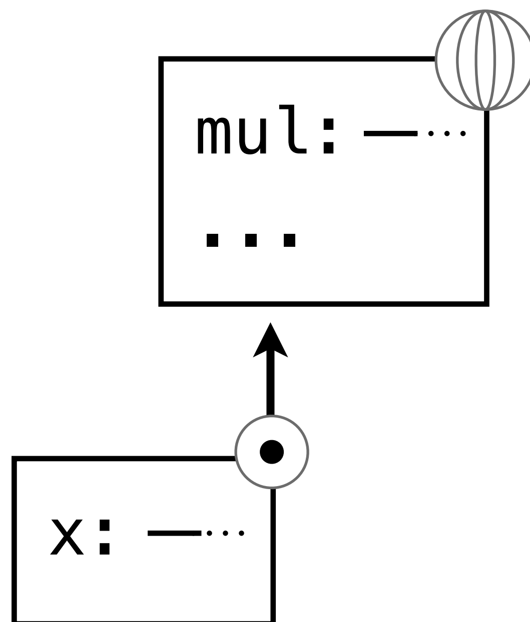

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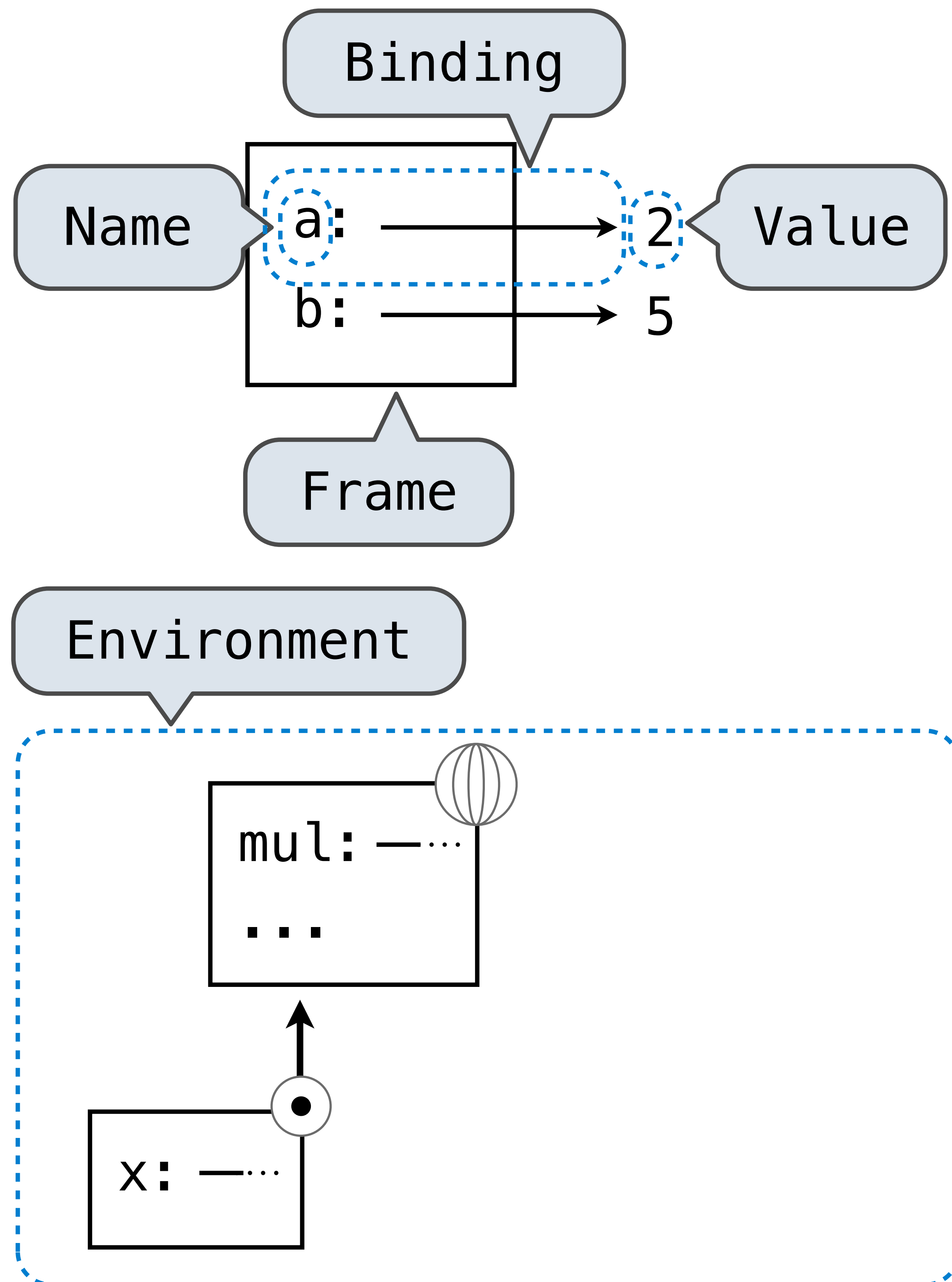

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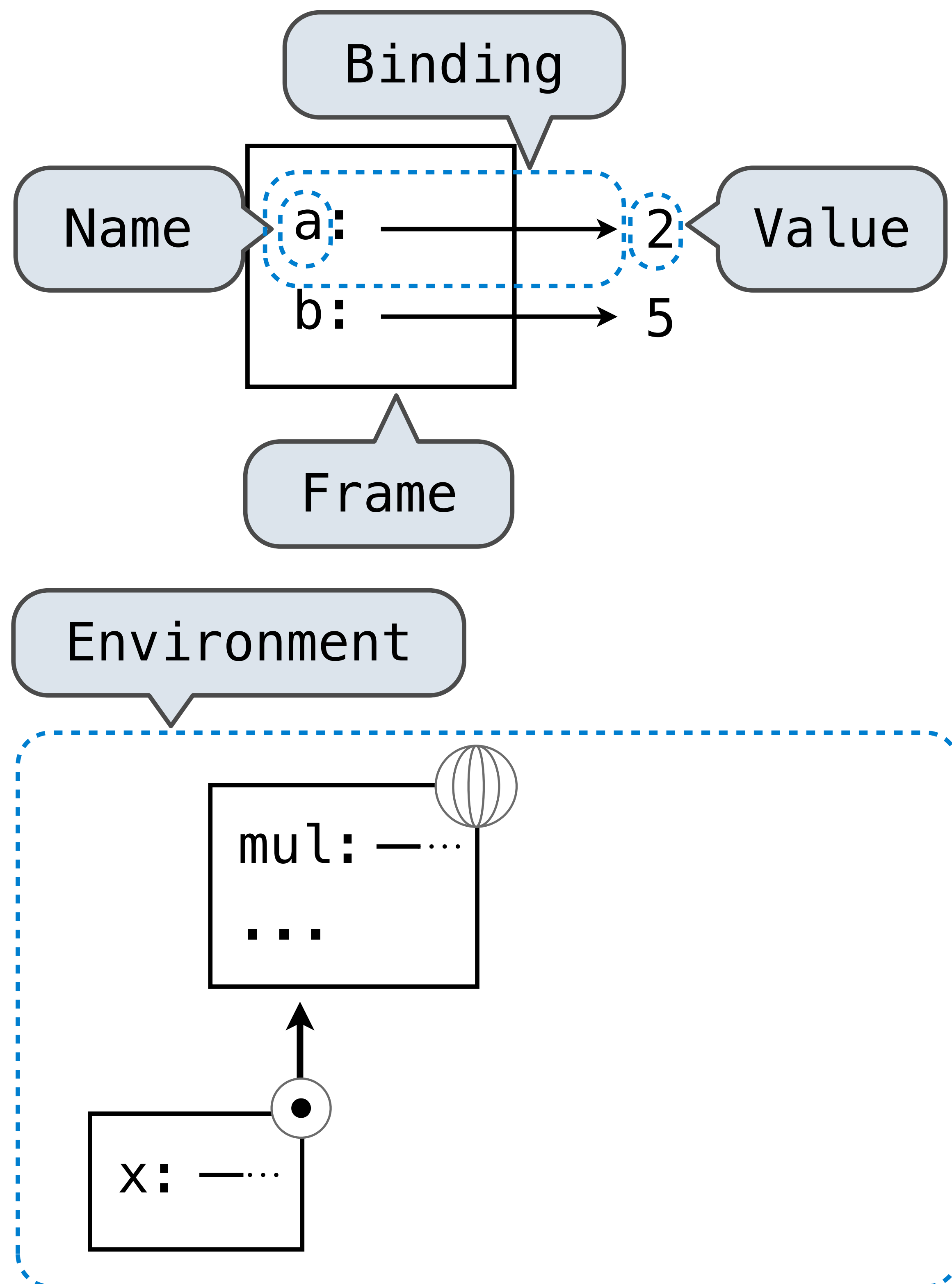

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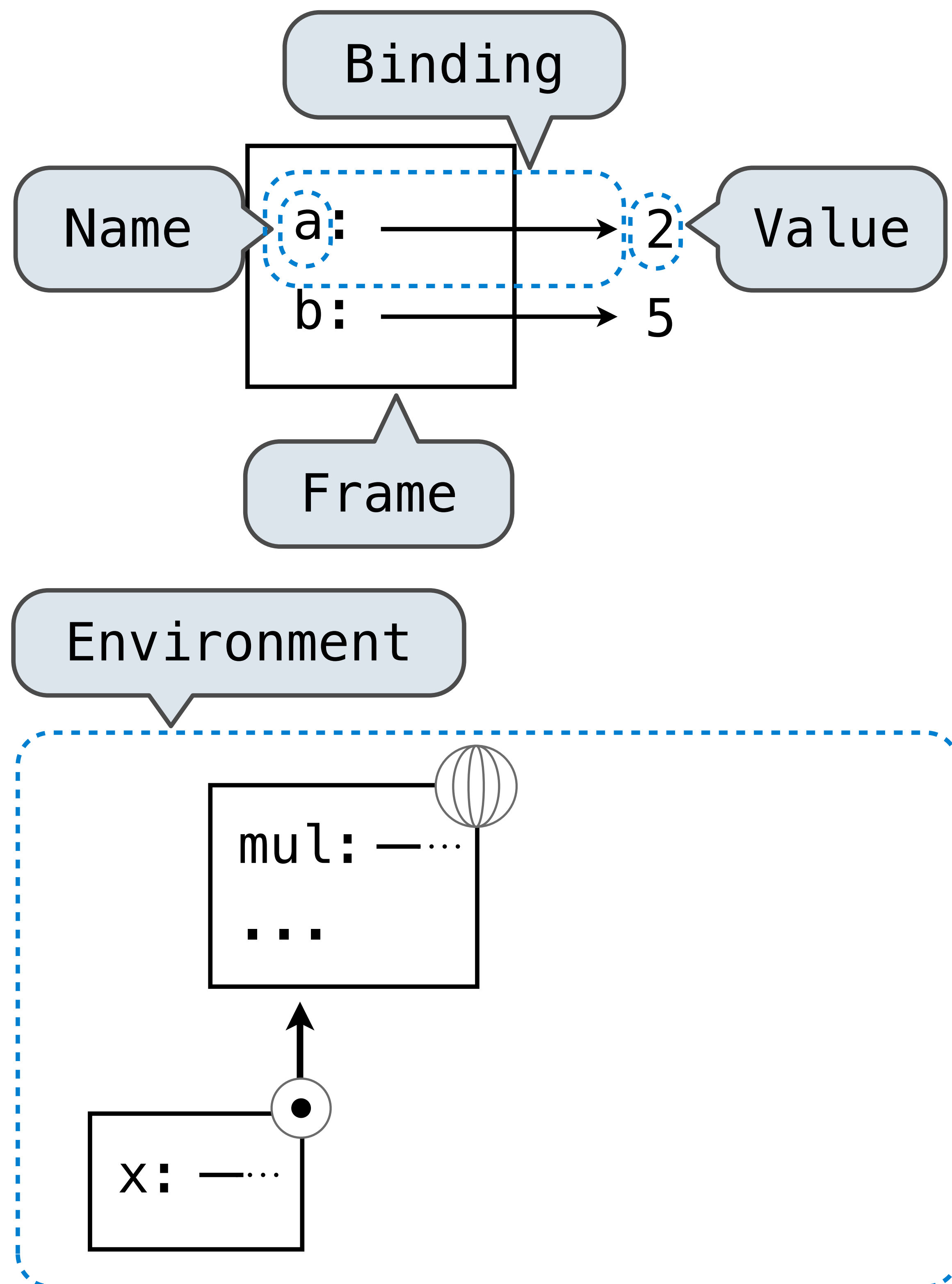

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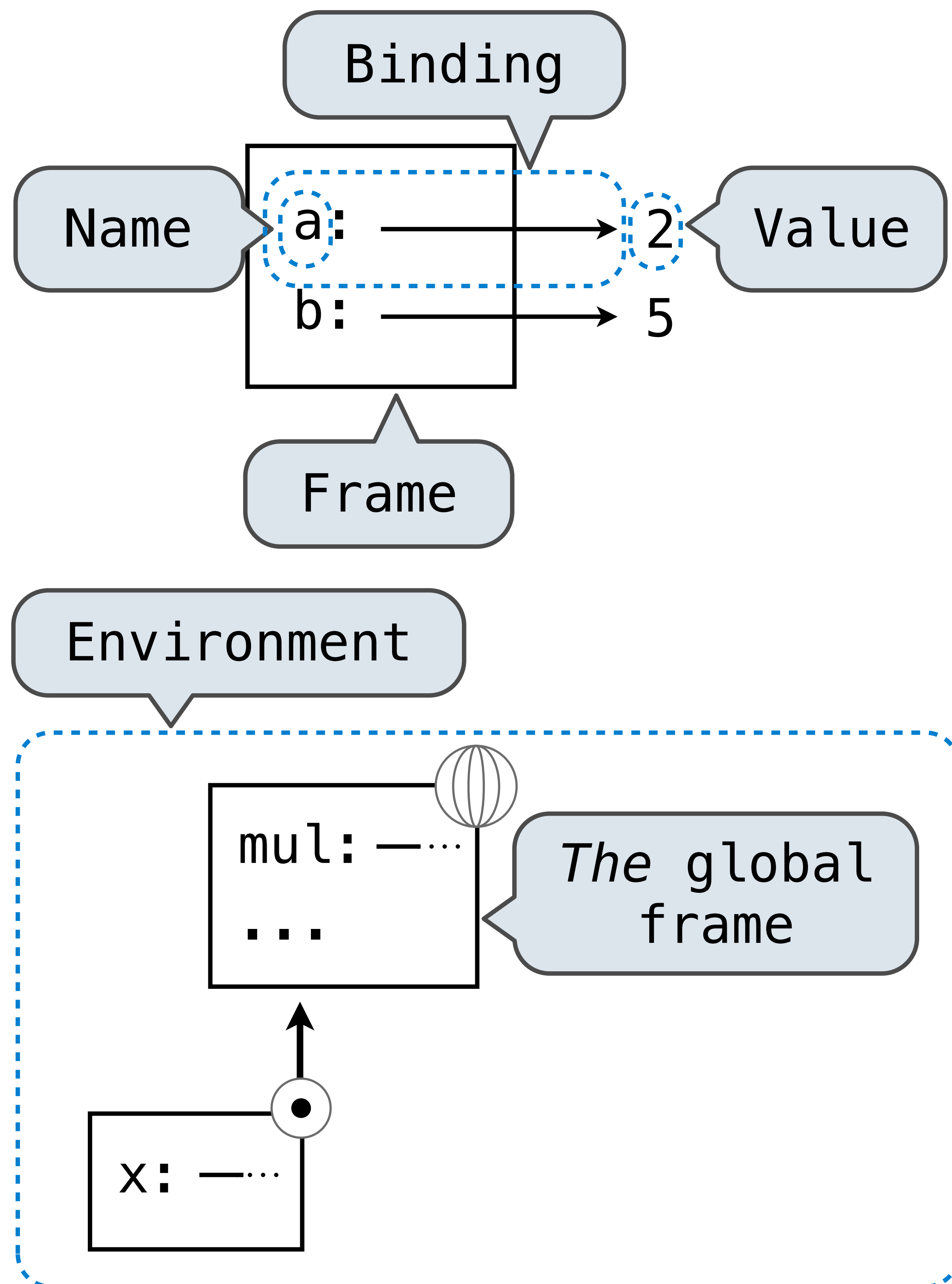
Cast of Characters: Environment Diagrams



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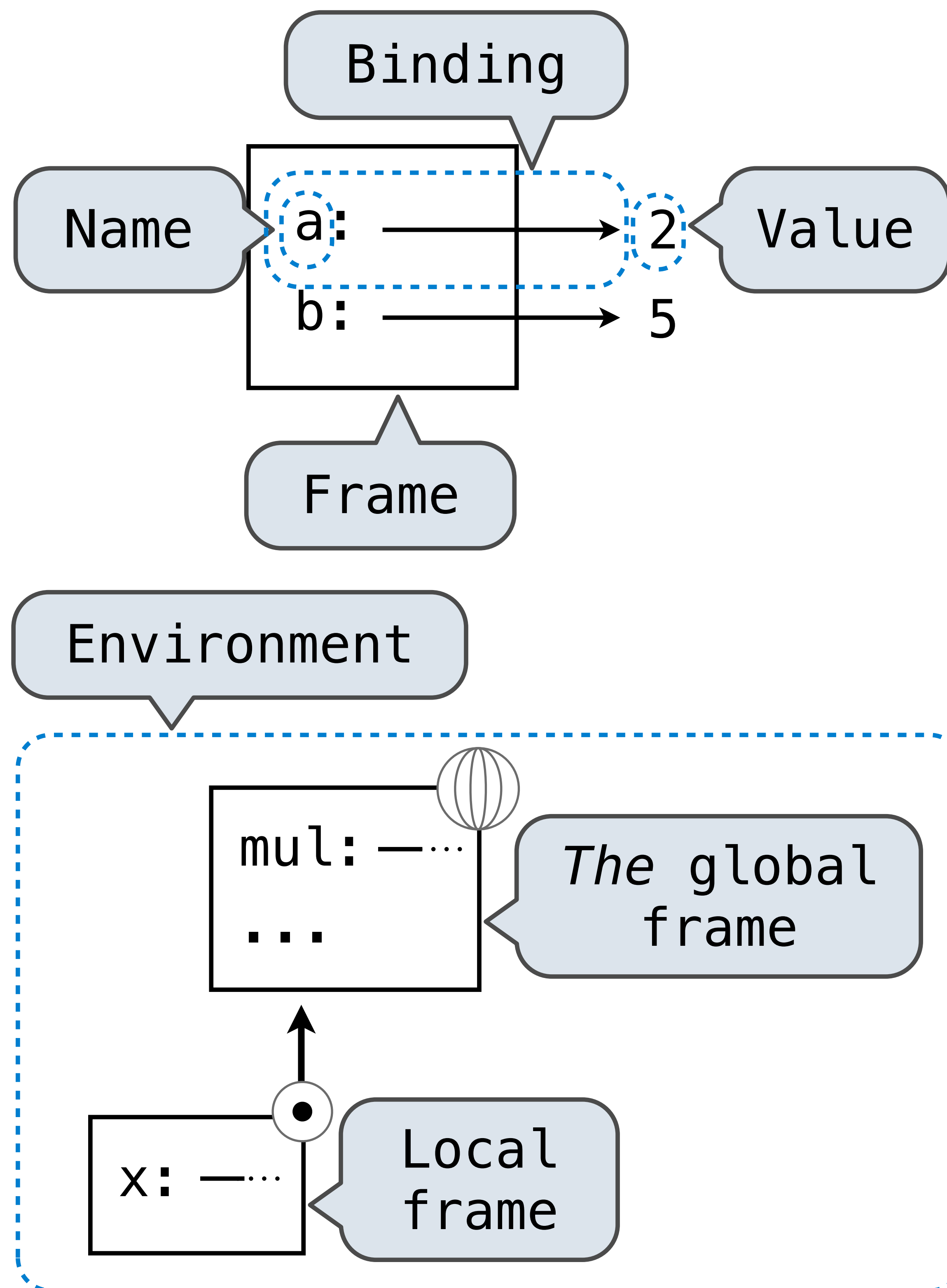

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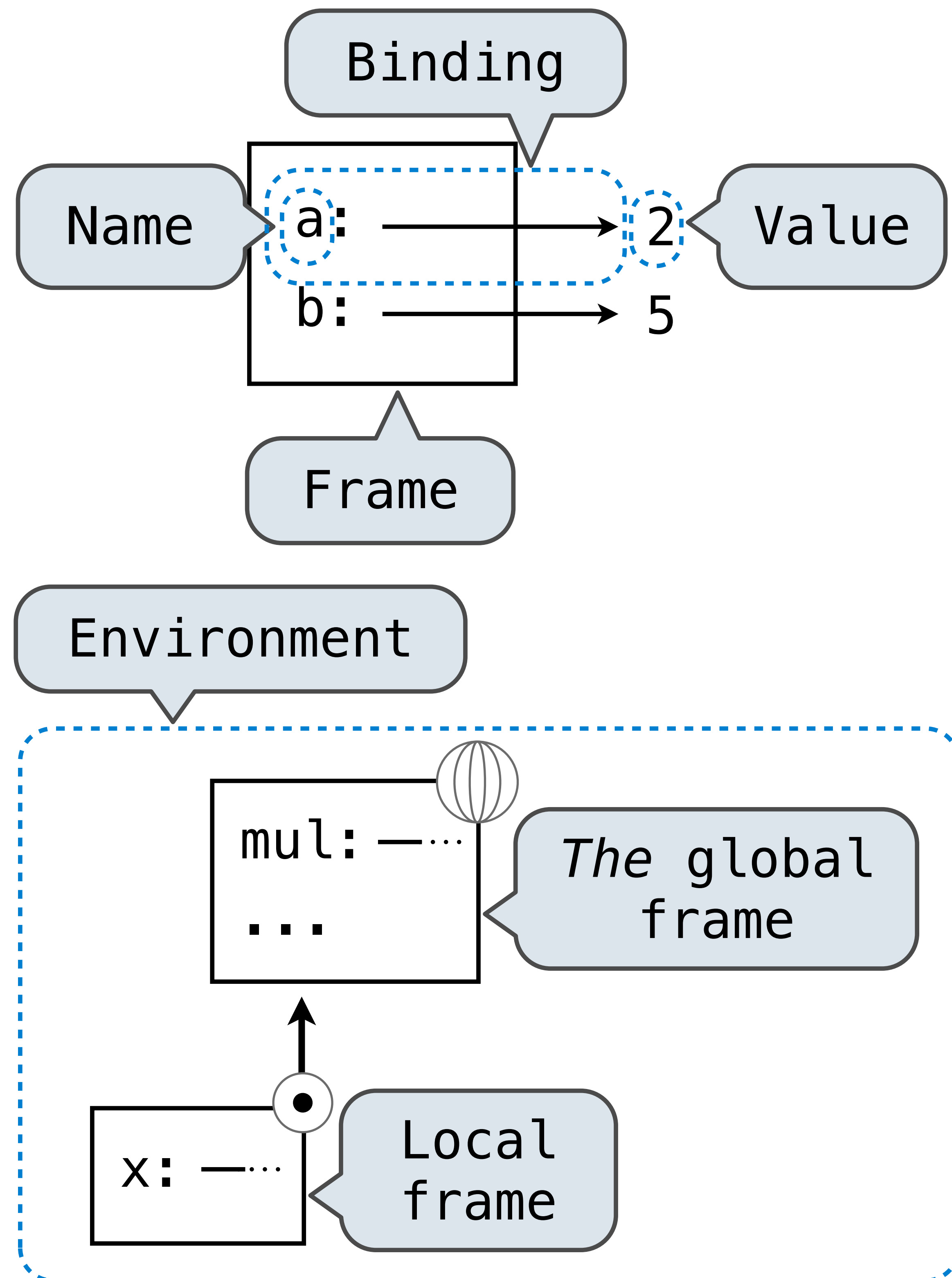

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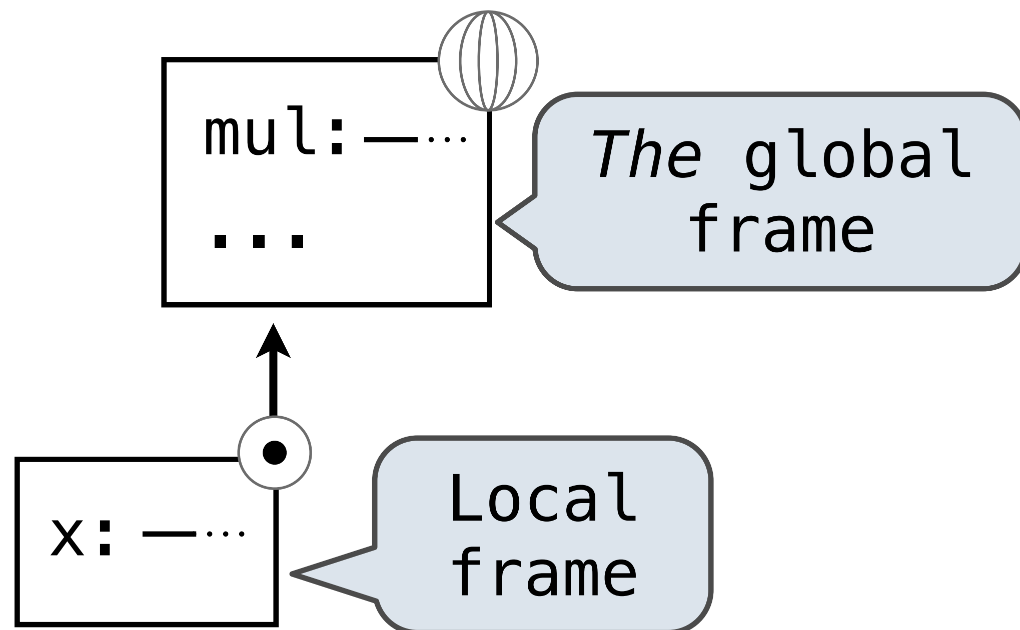
So far, environments only have at most two frames

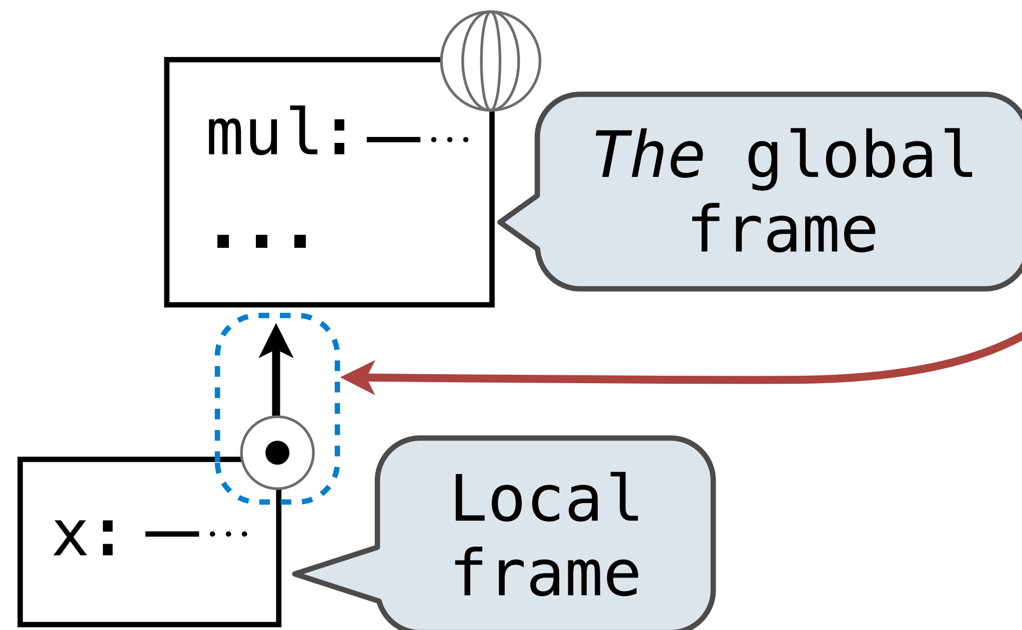
(Friday: longer sequences)

An Environment is a Sequence of Frames



Environments (Memory):

An Environment is a Sequence of Frames



Environments (Memory):

Frames link to each other

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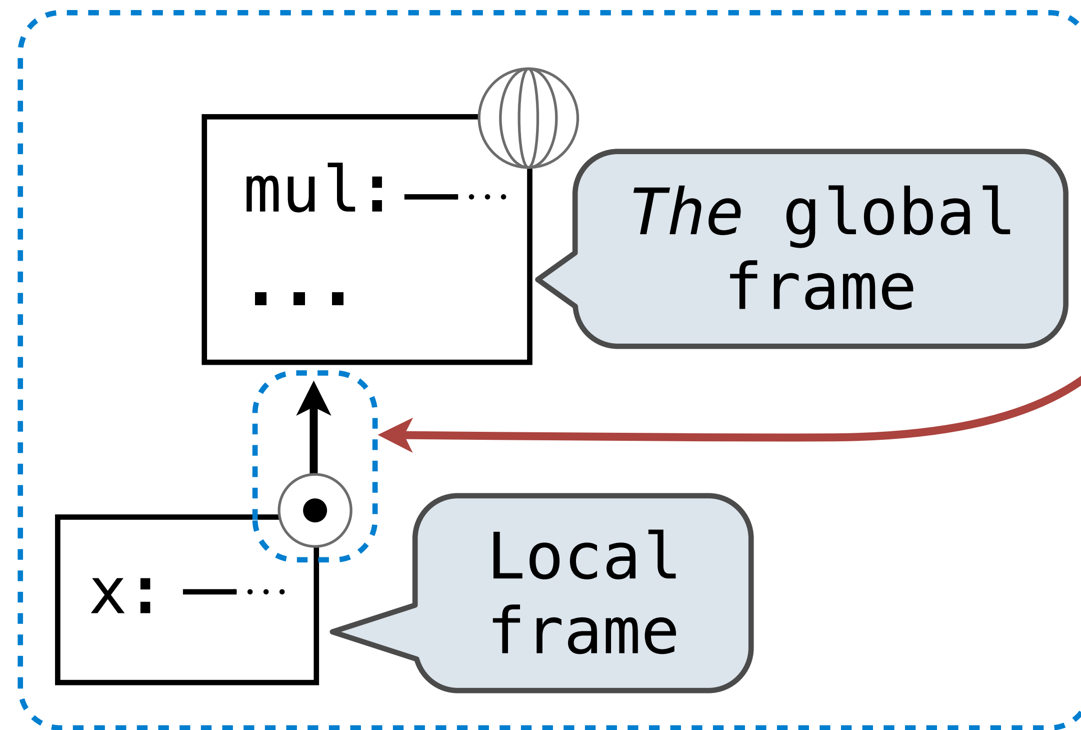

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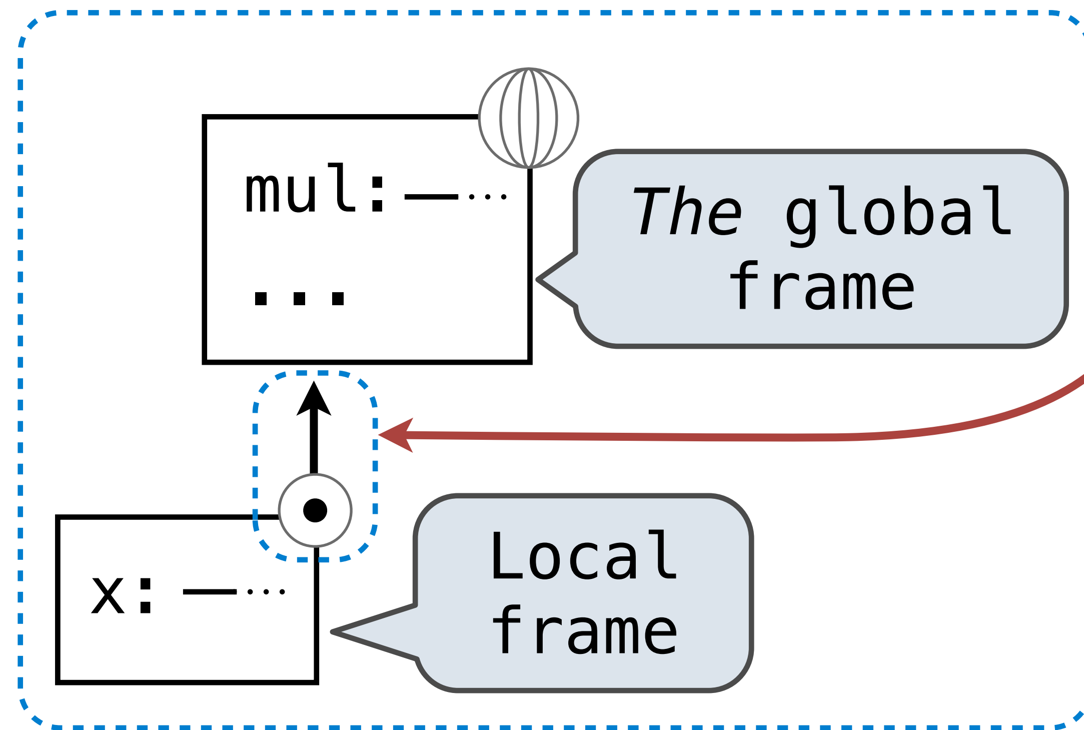

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An environment is a first frame, plus the frames that follow

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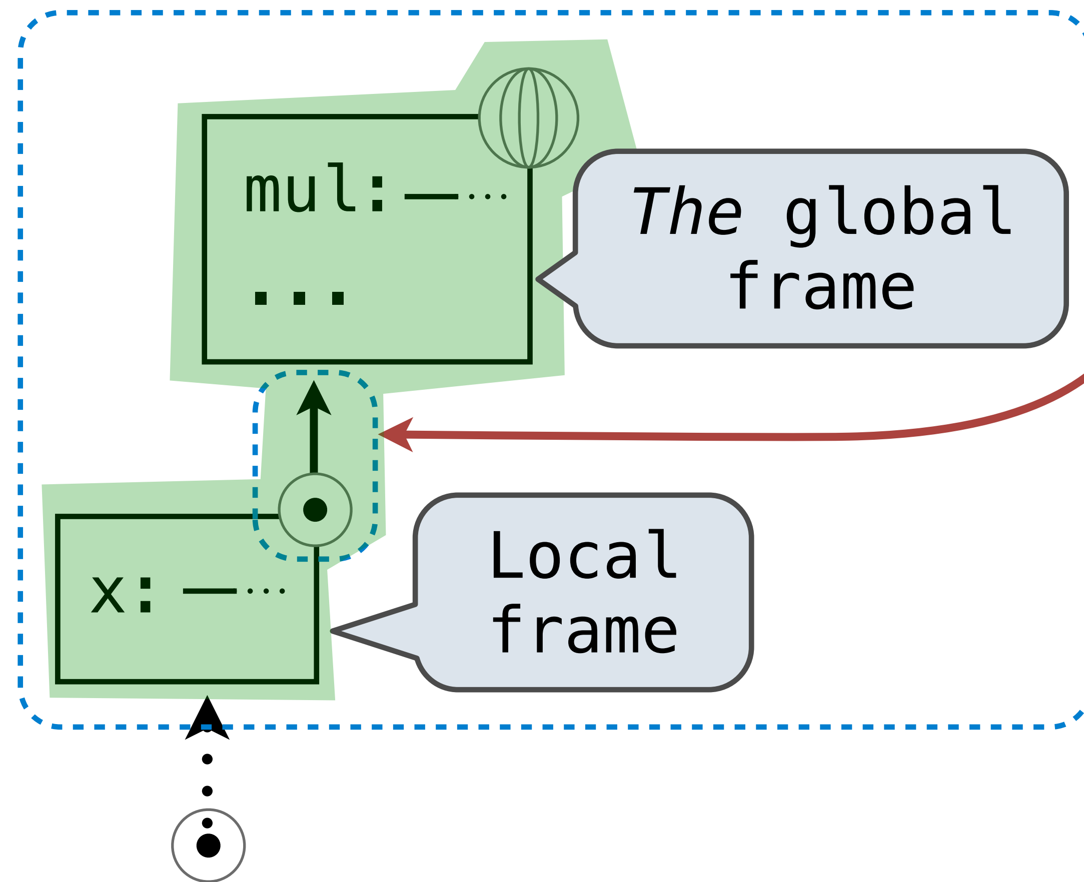

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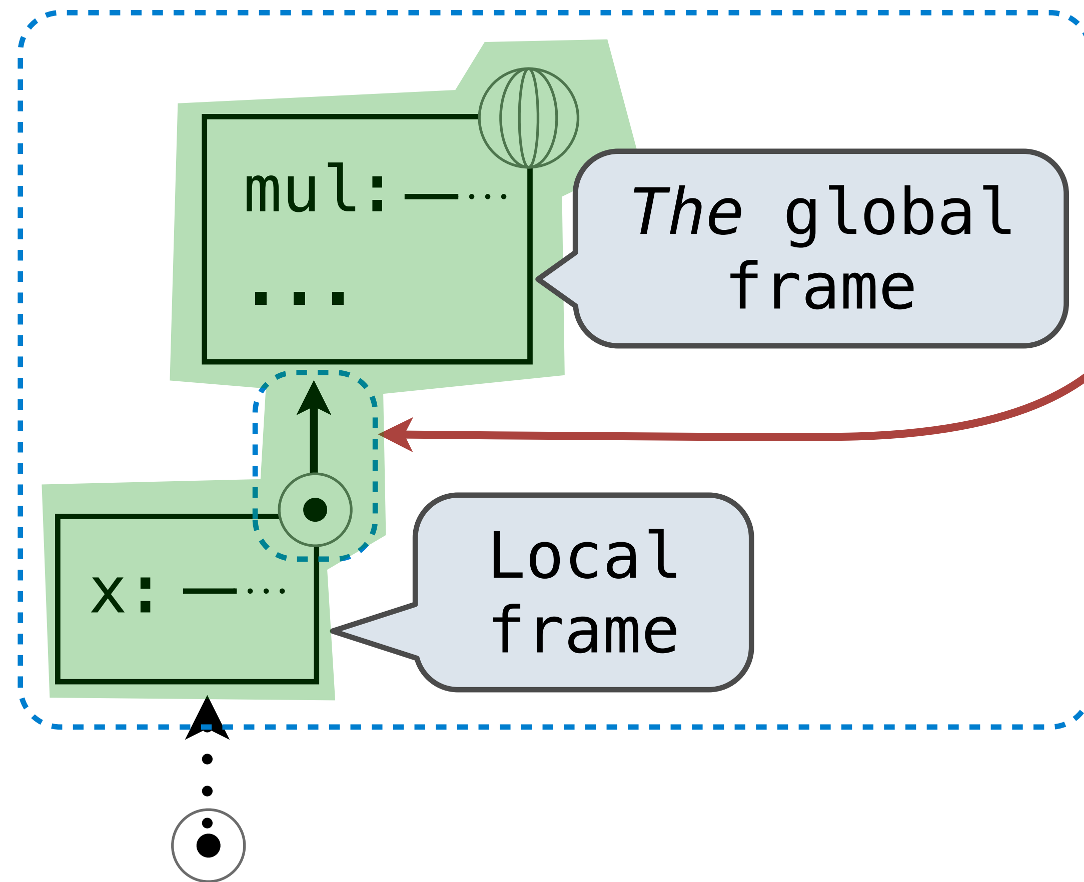

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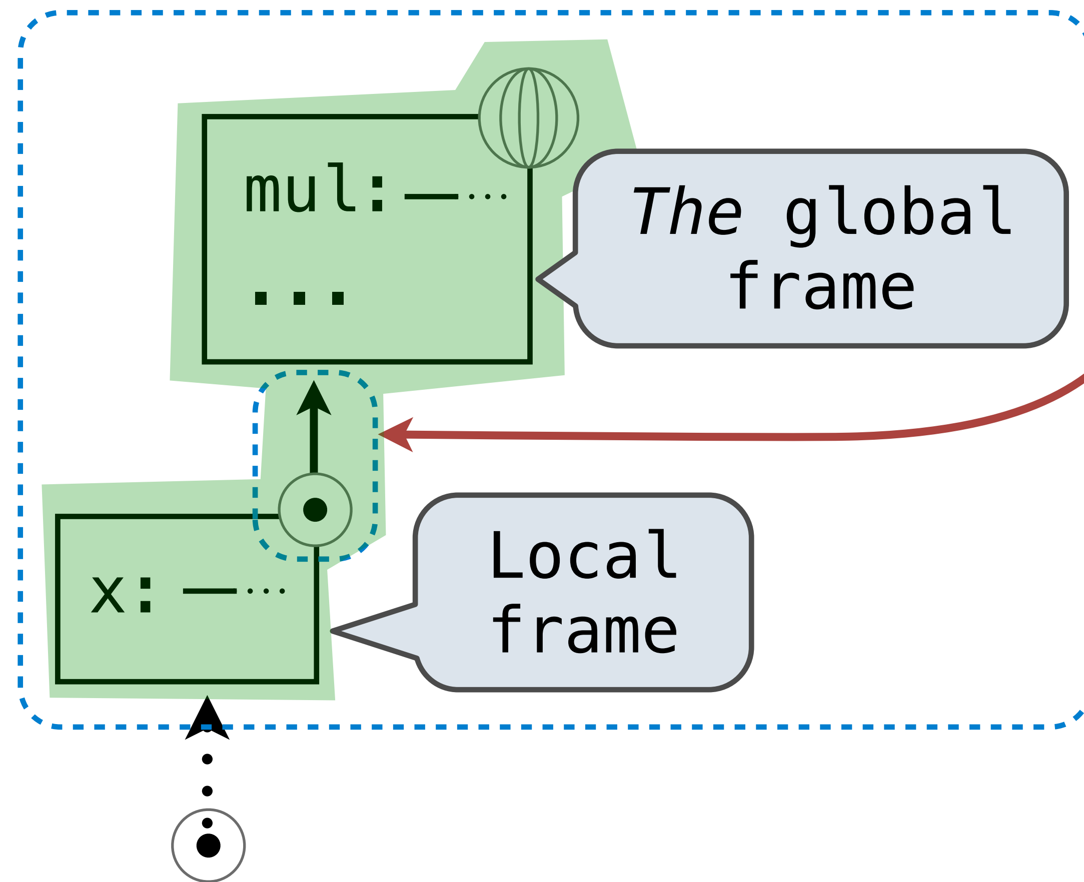

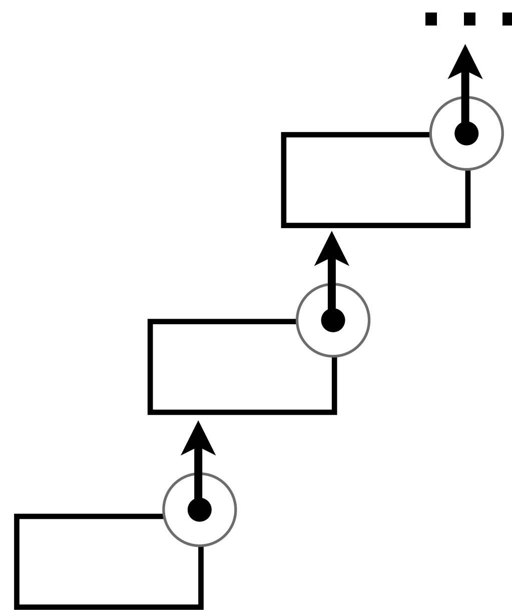

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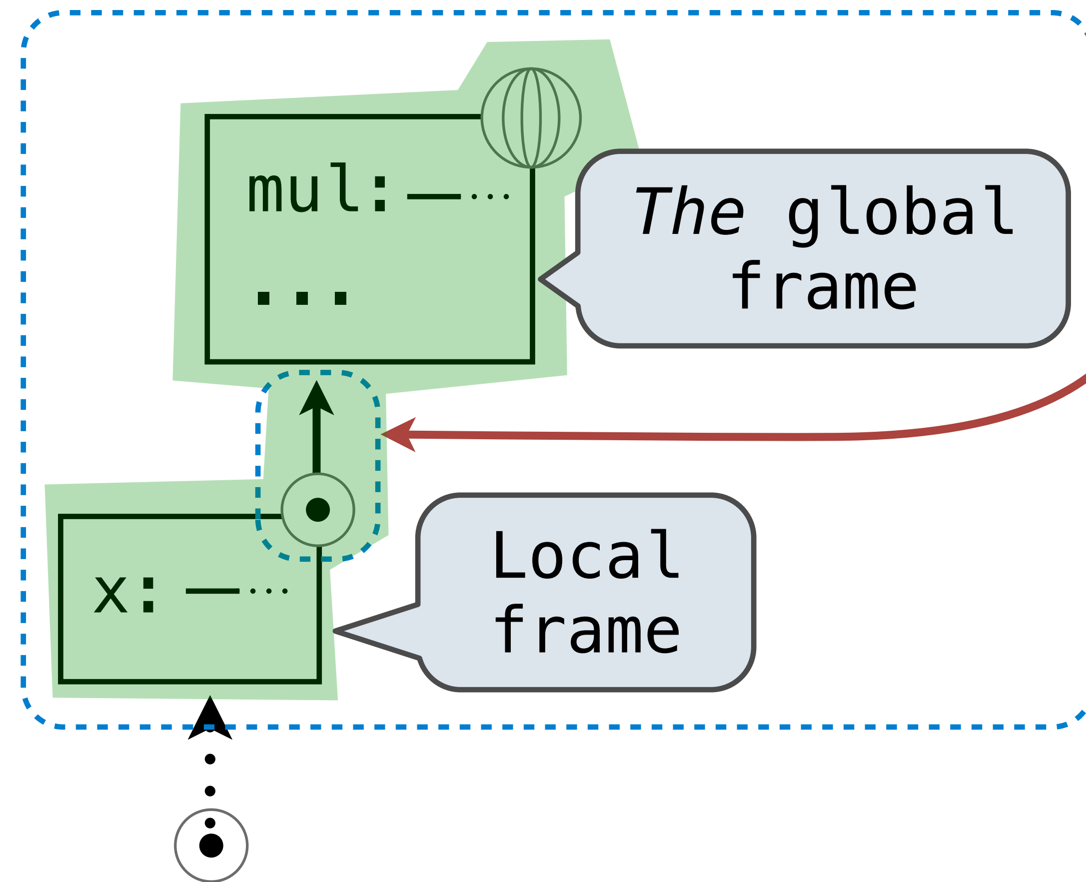

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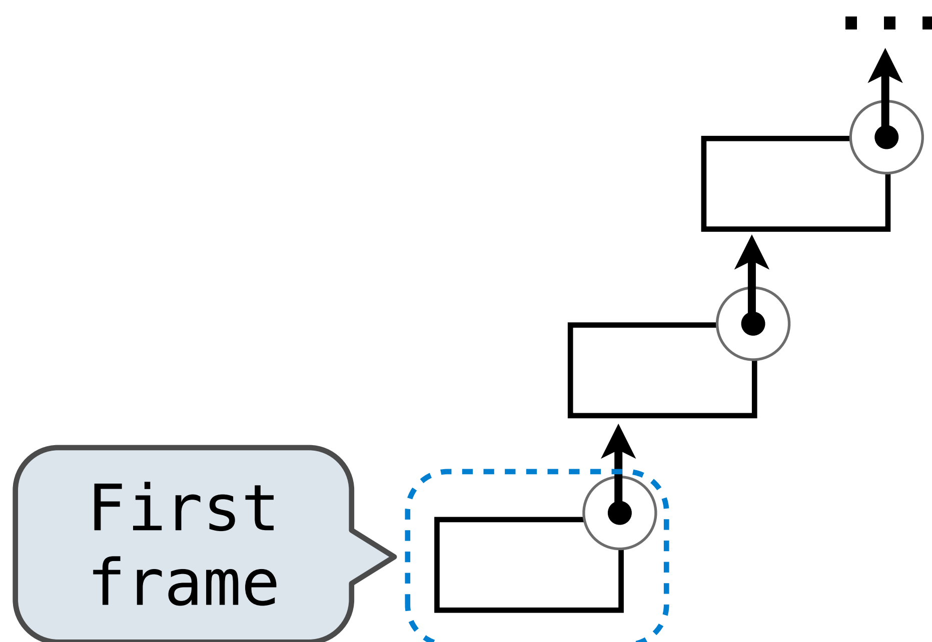

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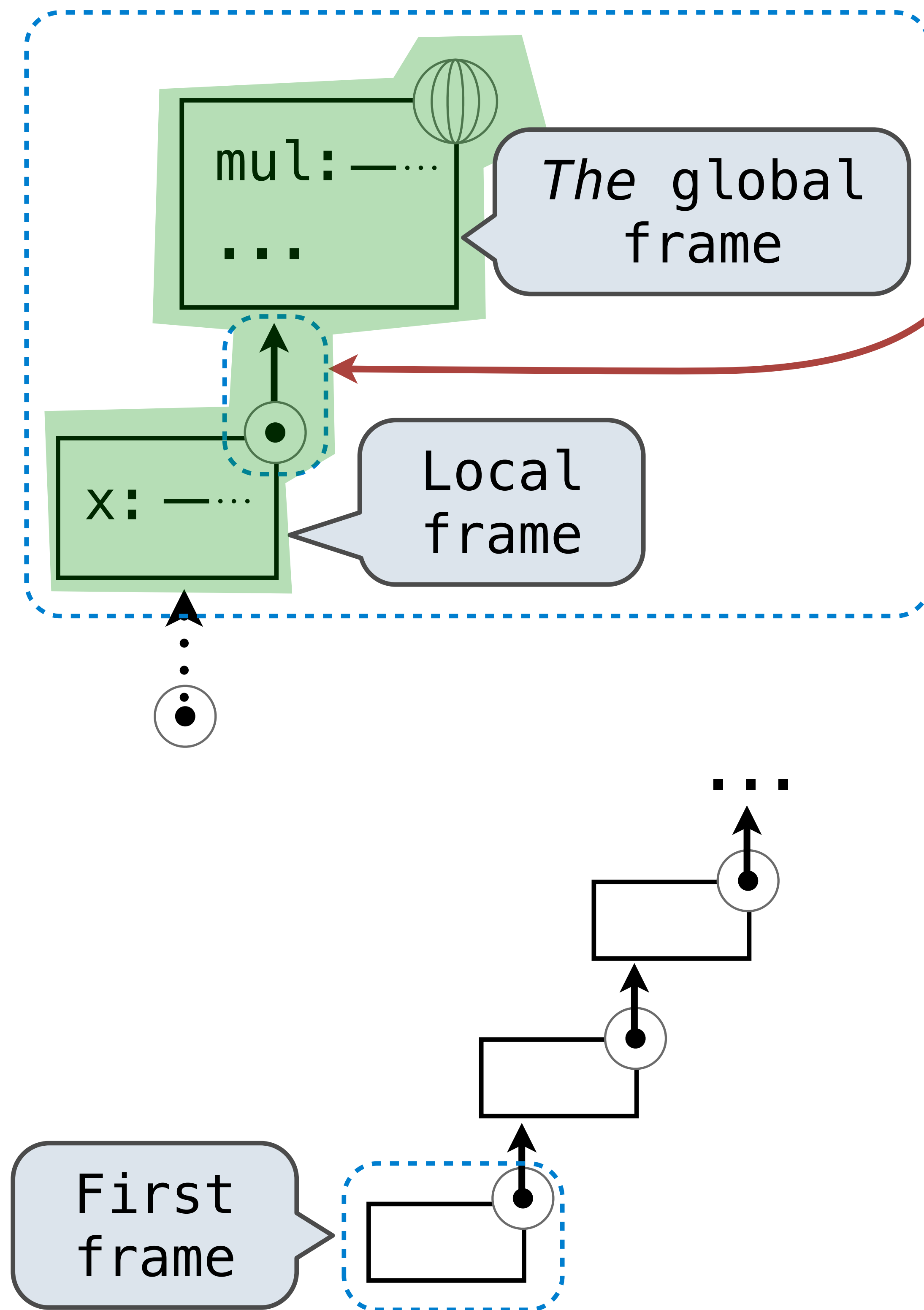

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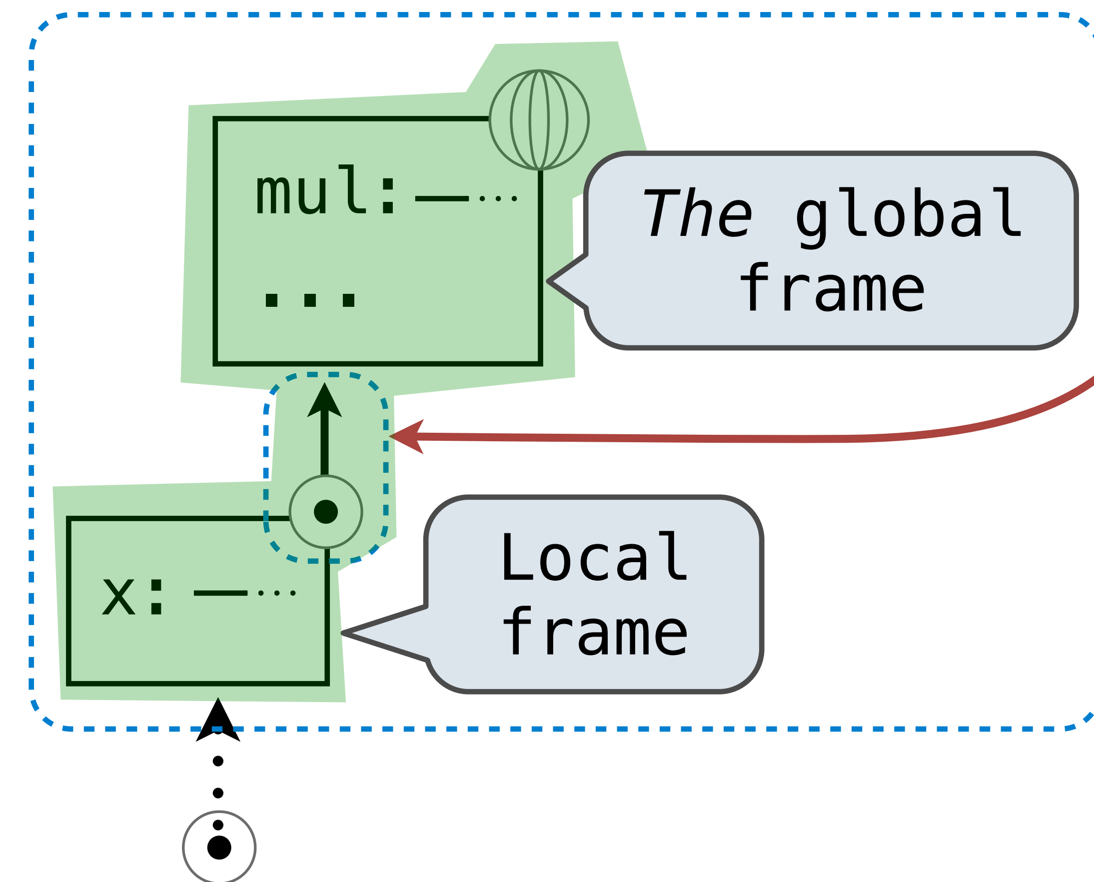

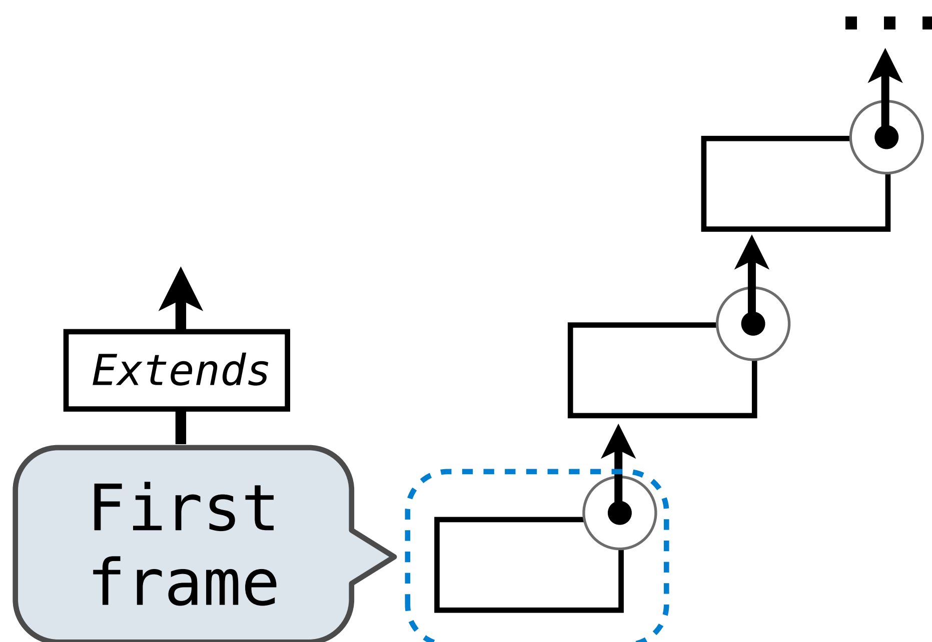

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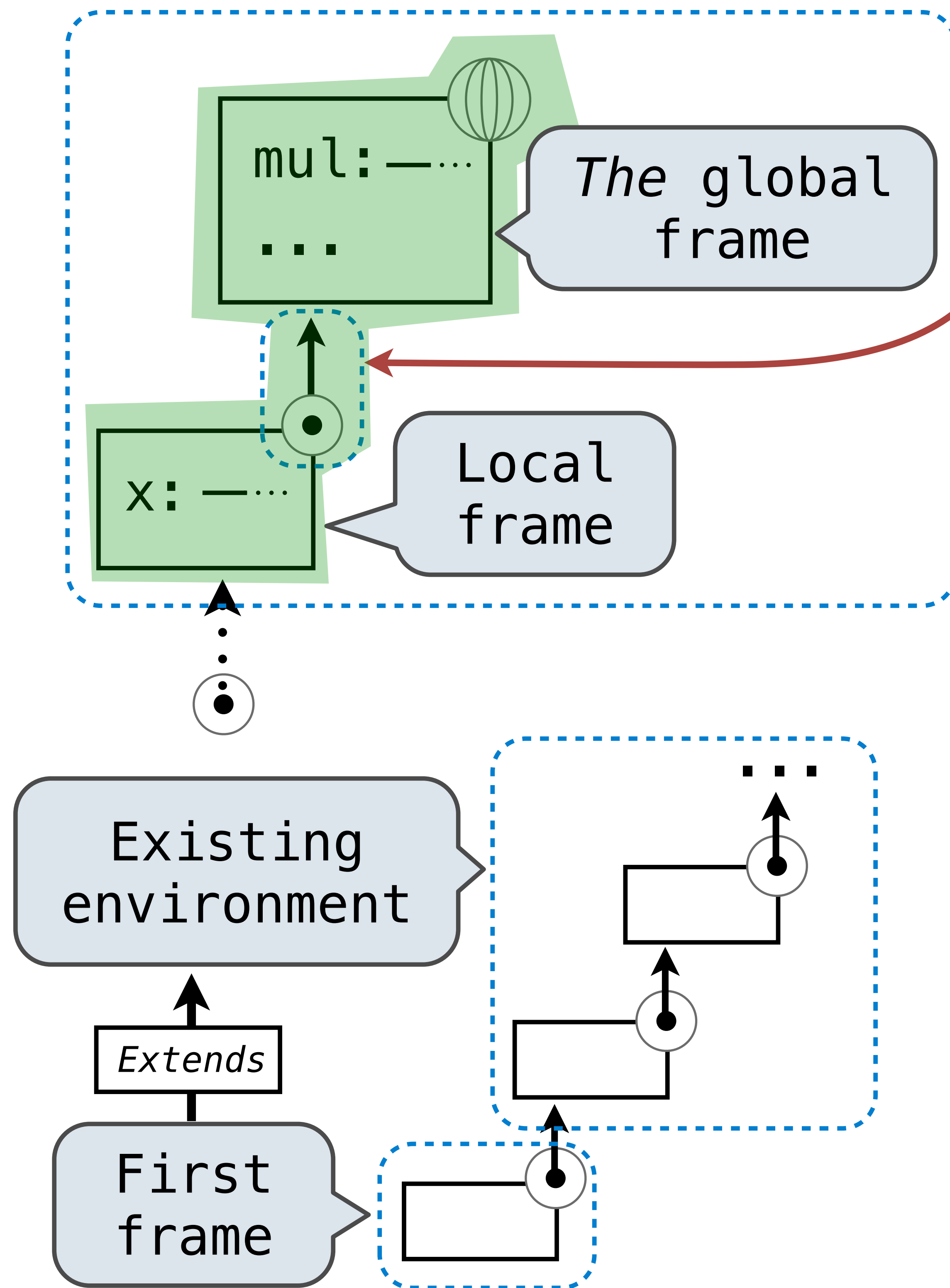

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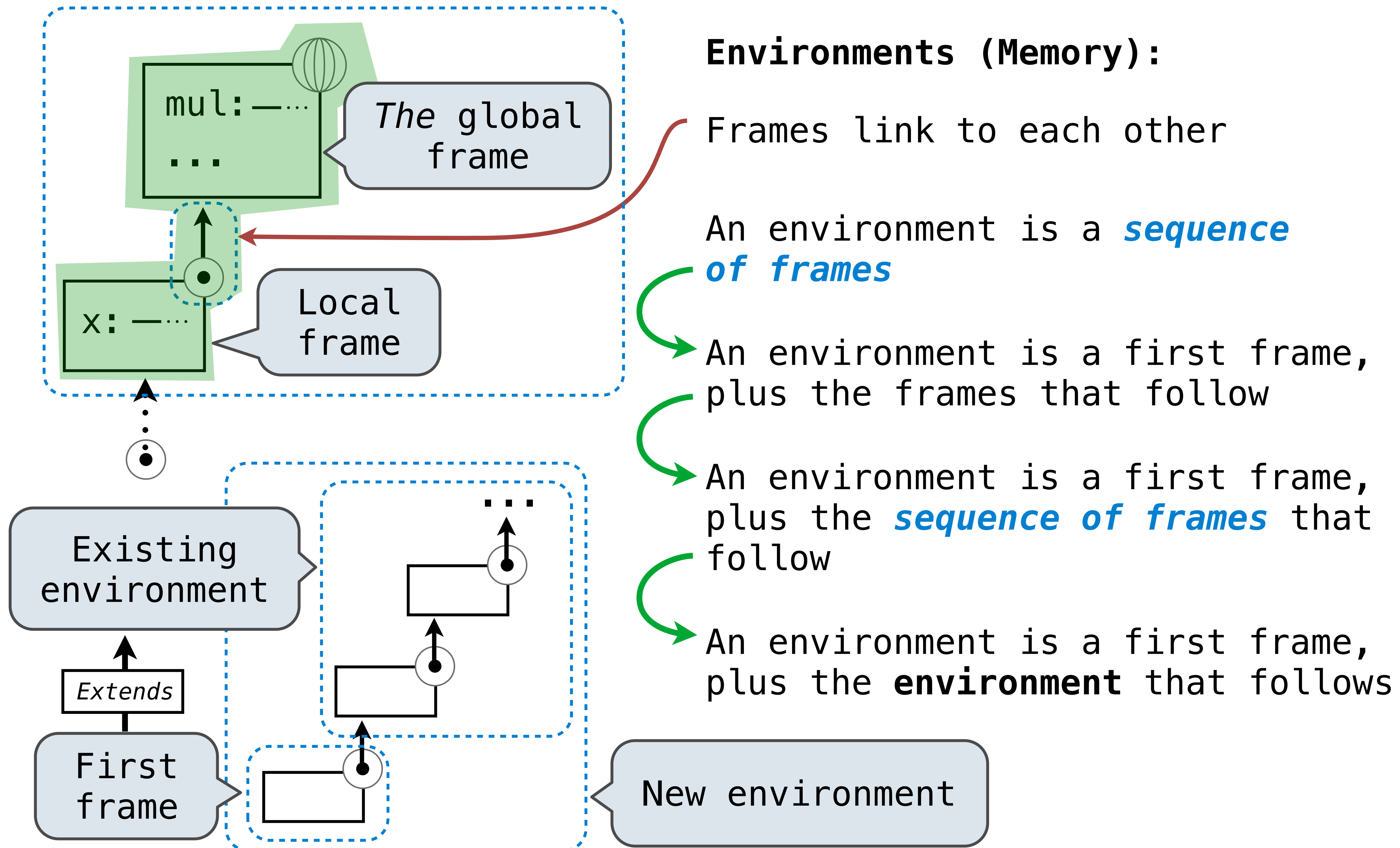

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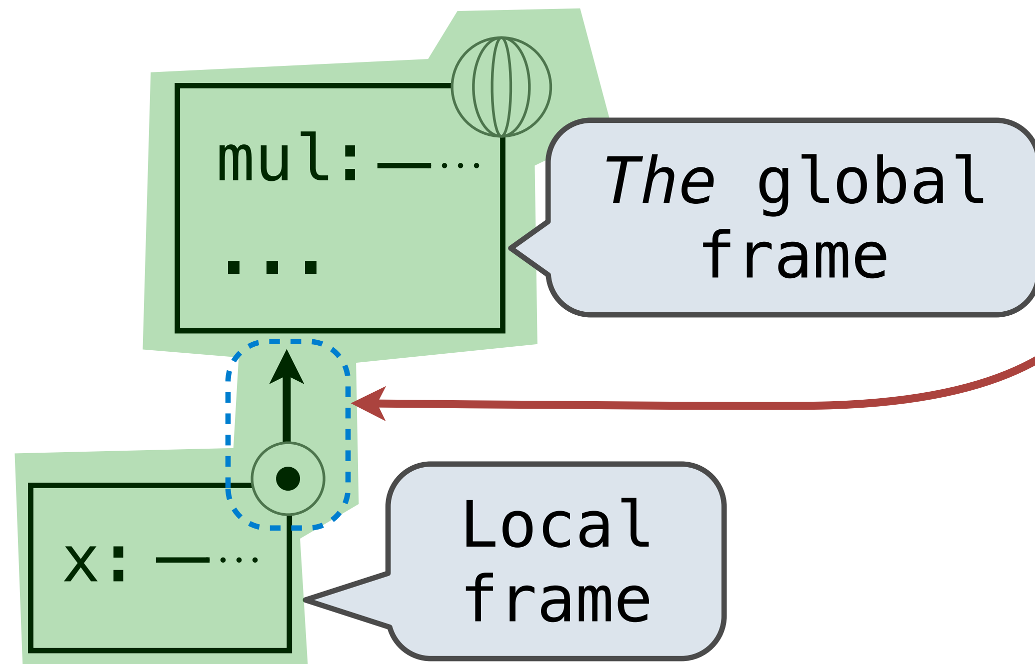
An Expression is Evaluated in an Environment



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Expressions (Program):

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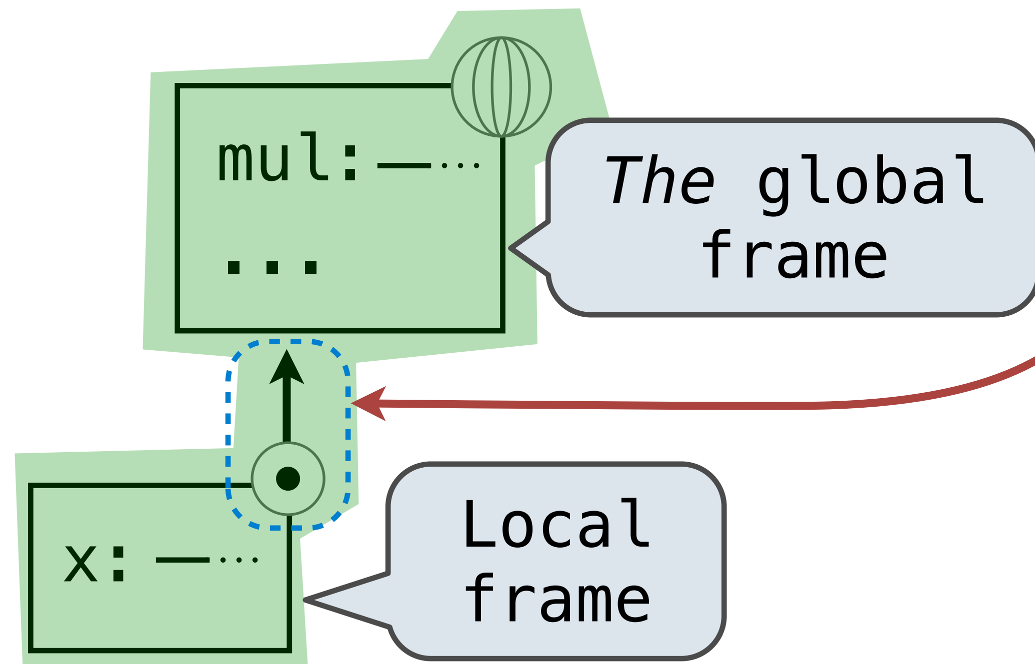

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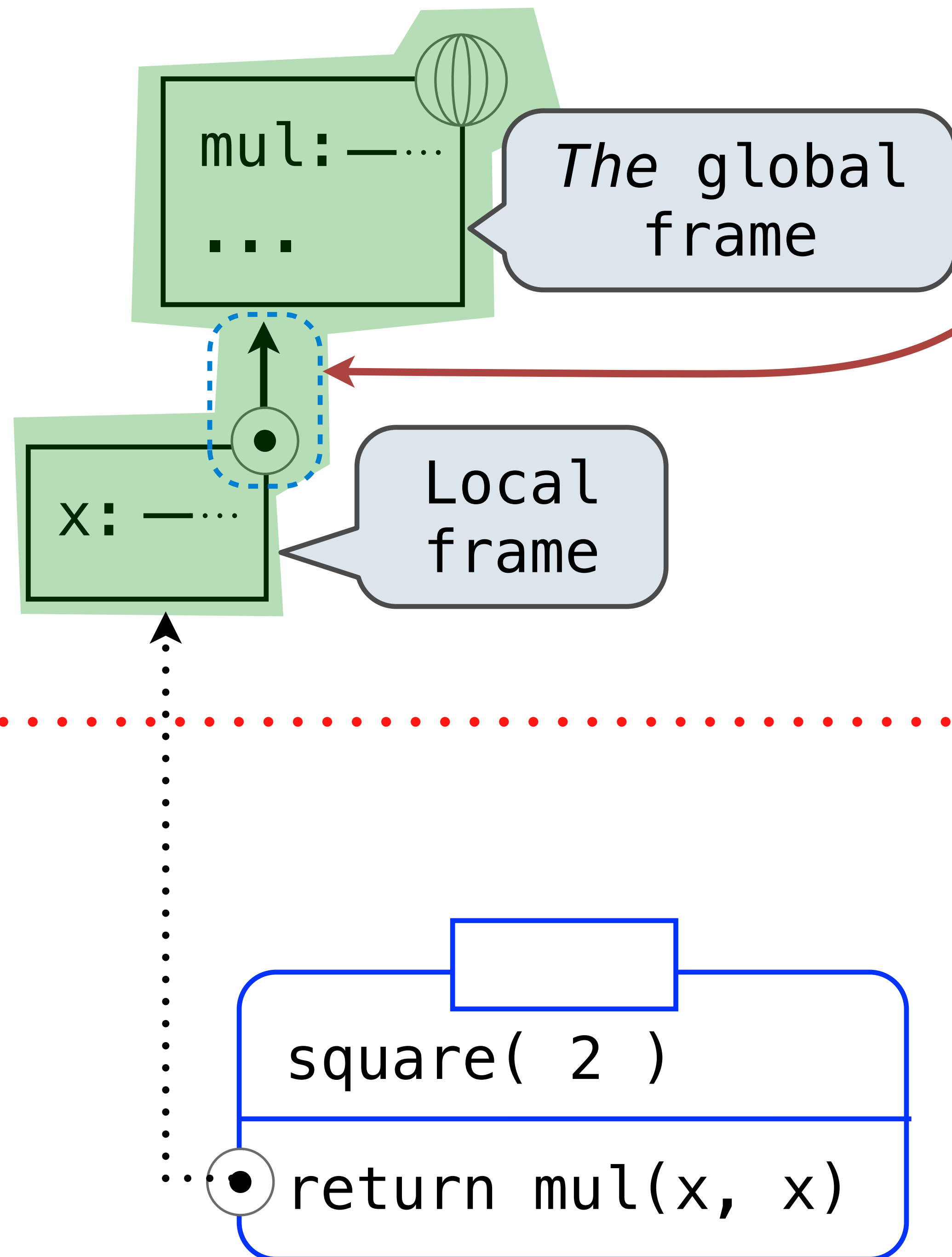

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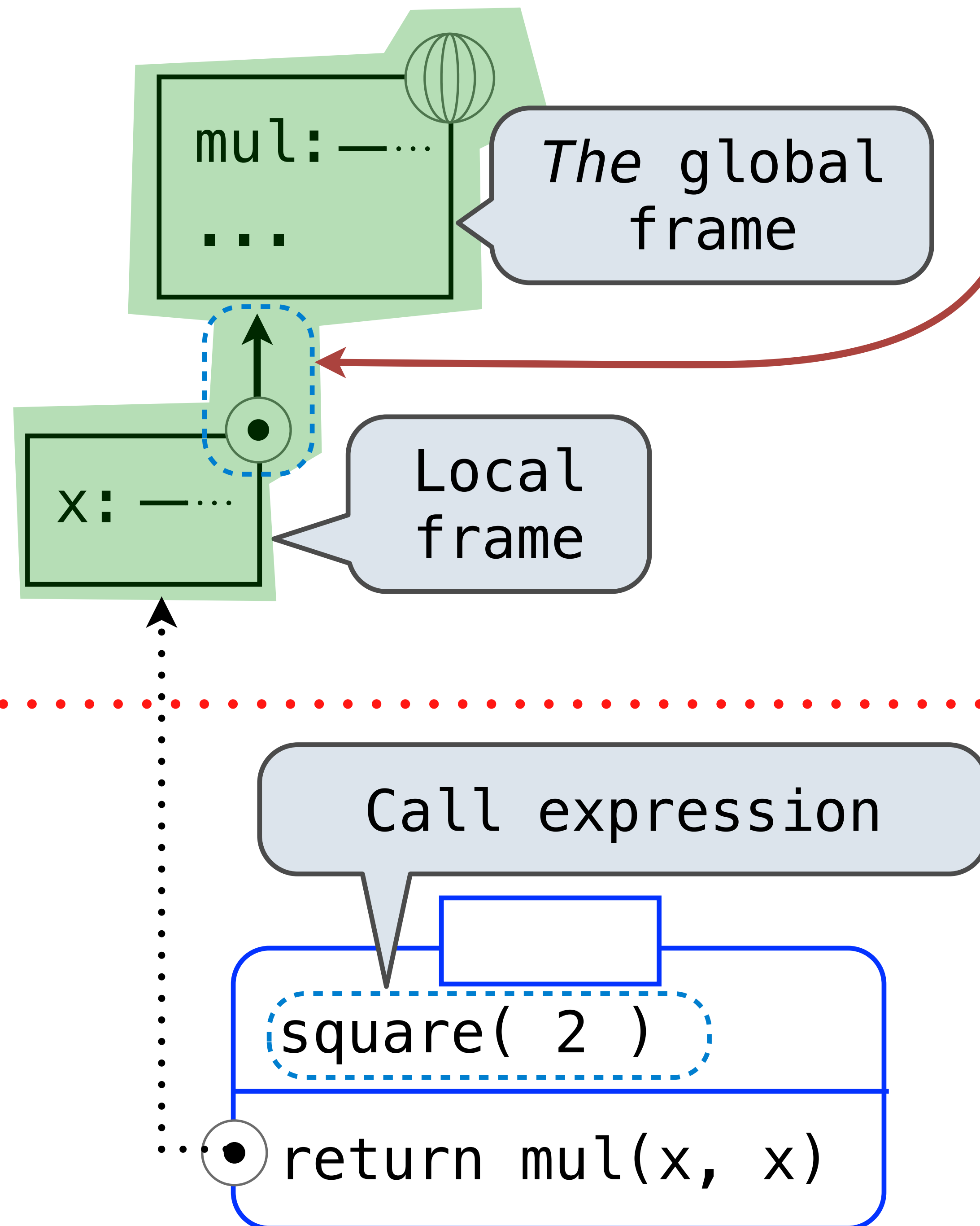

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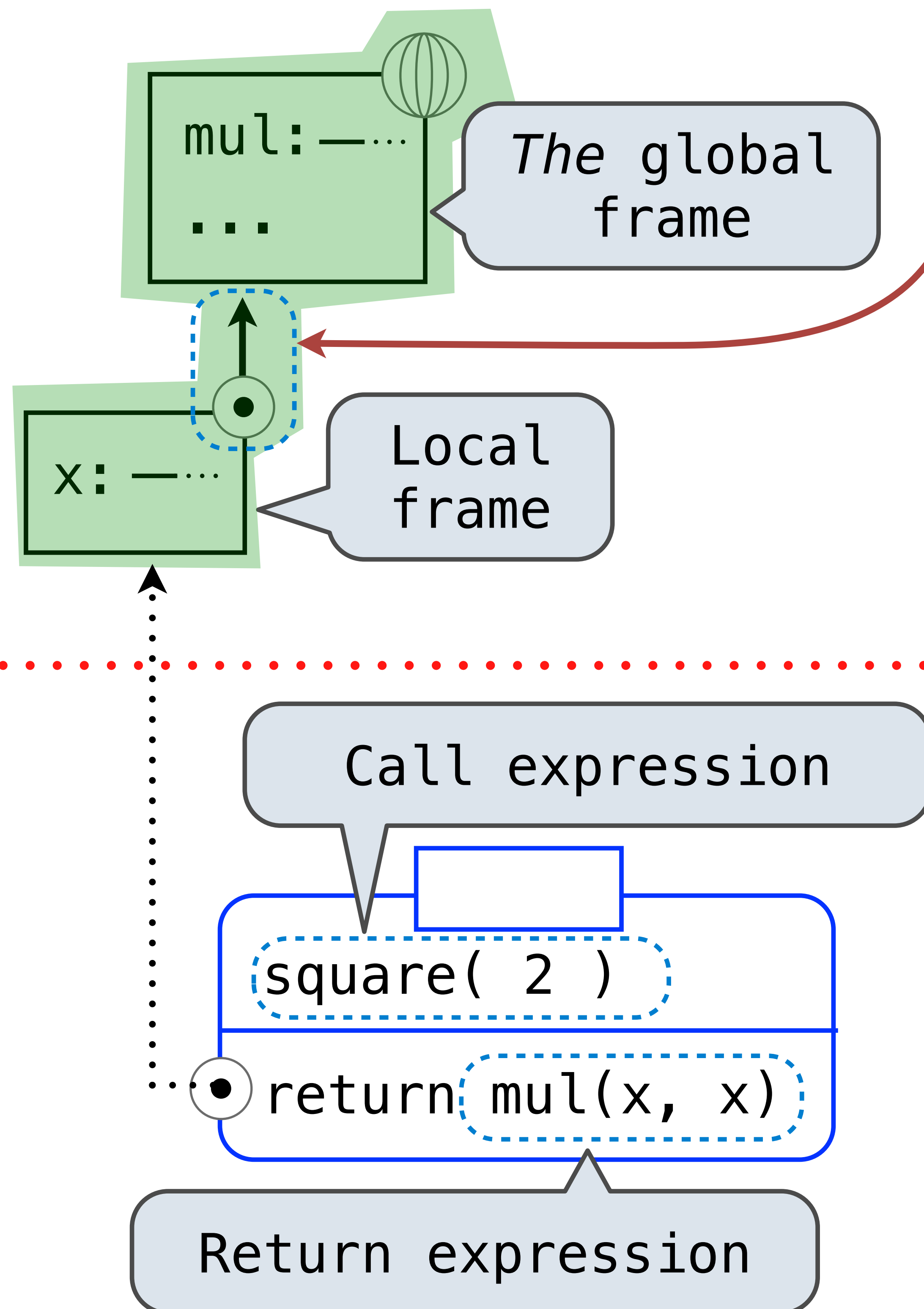

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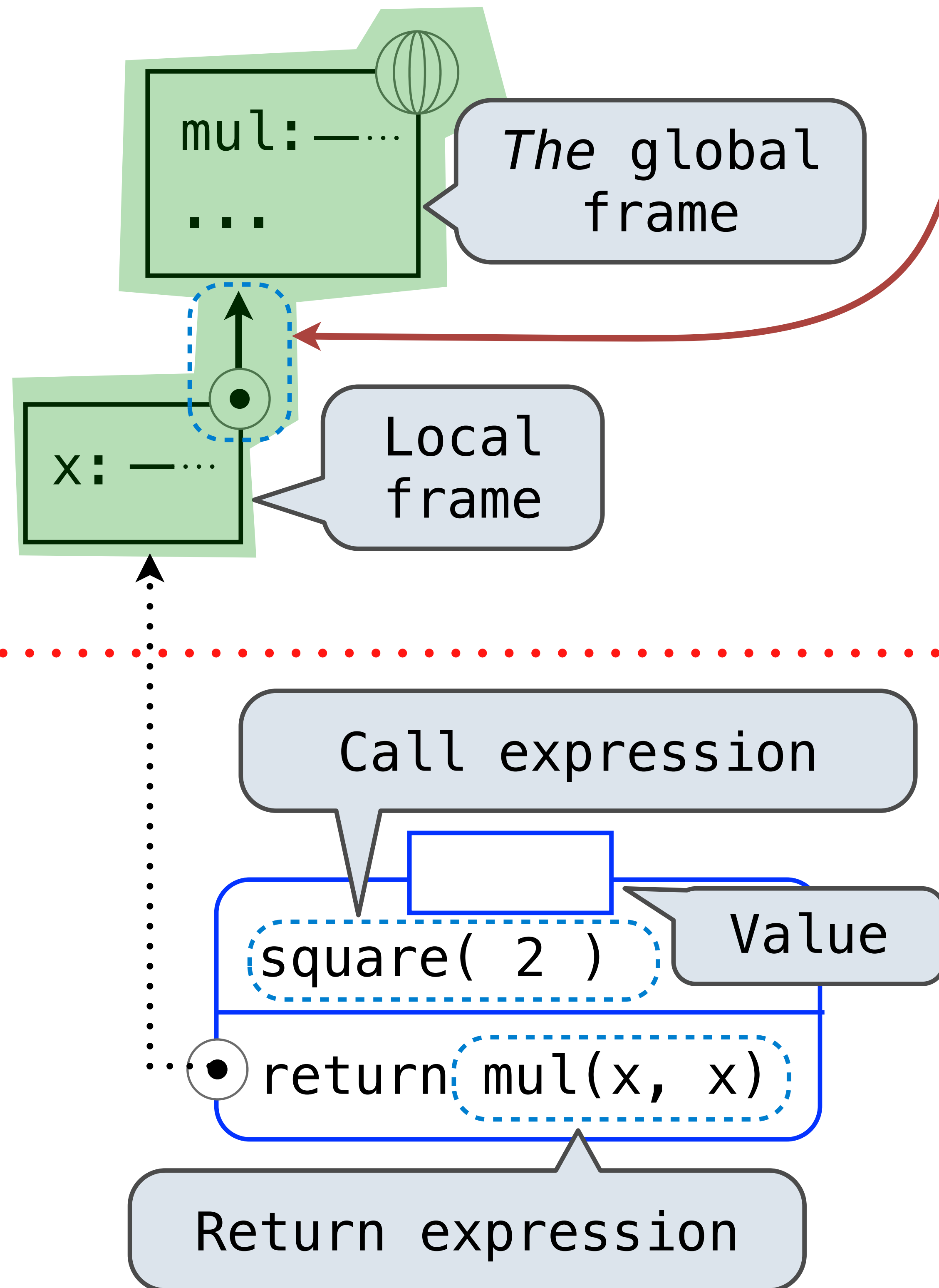

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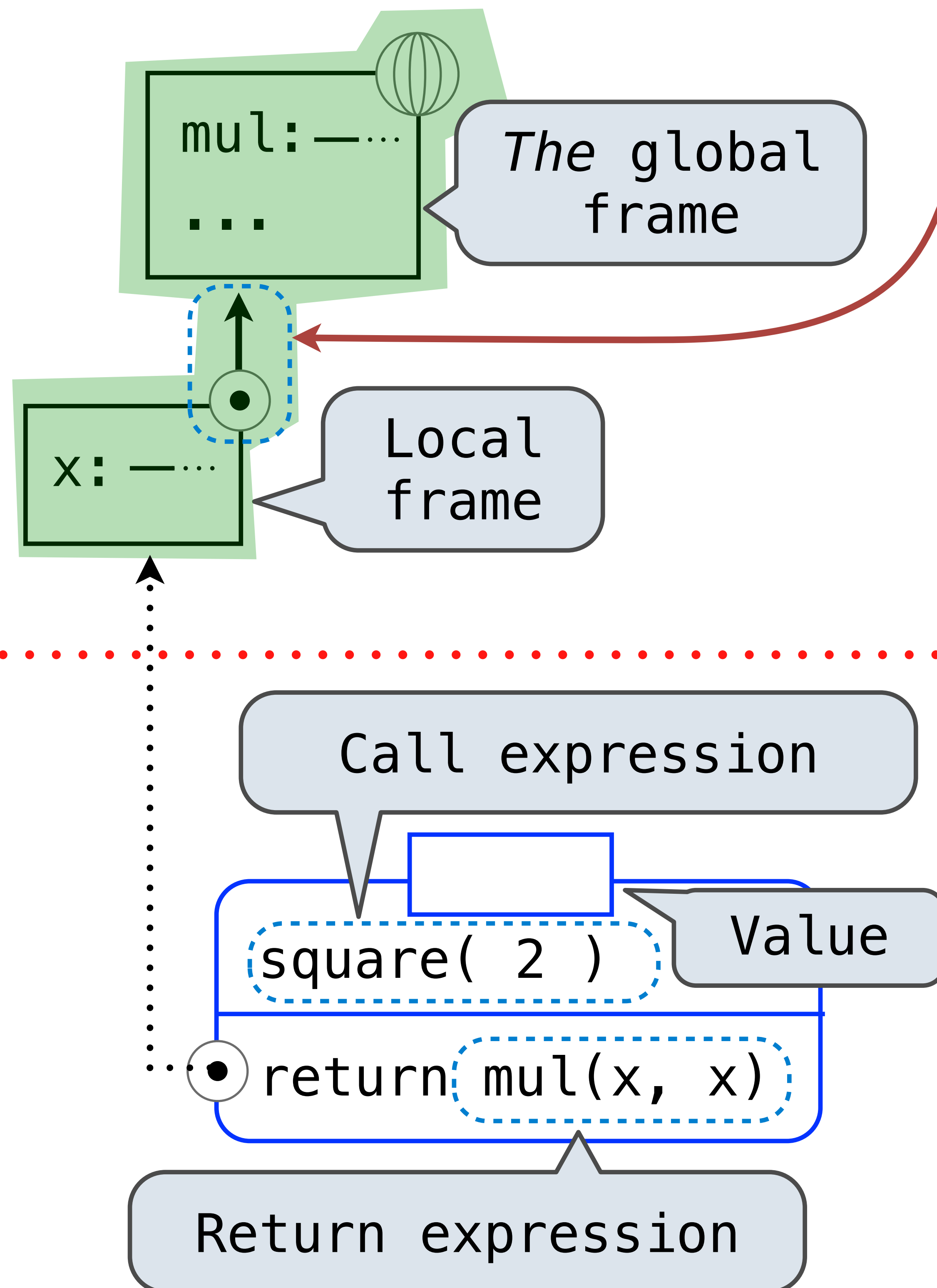

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Not part of an environment

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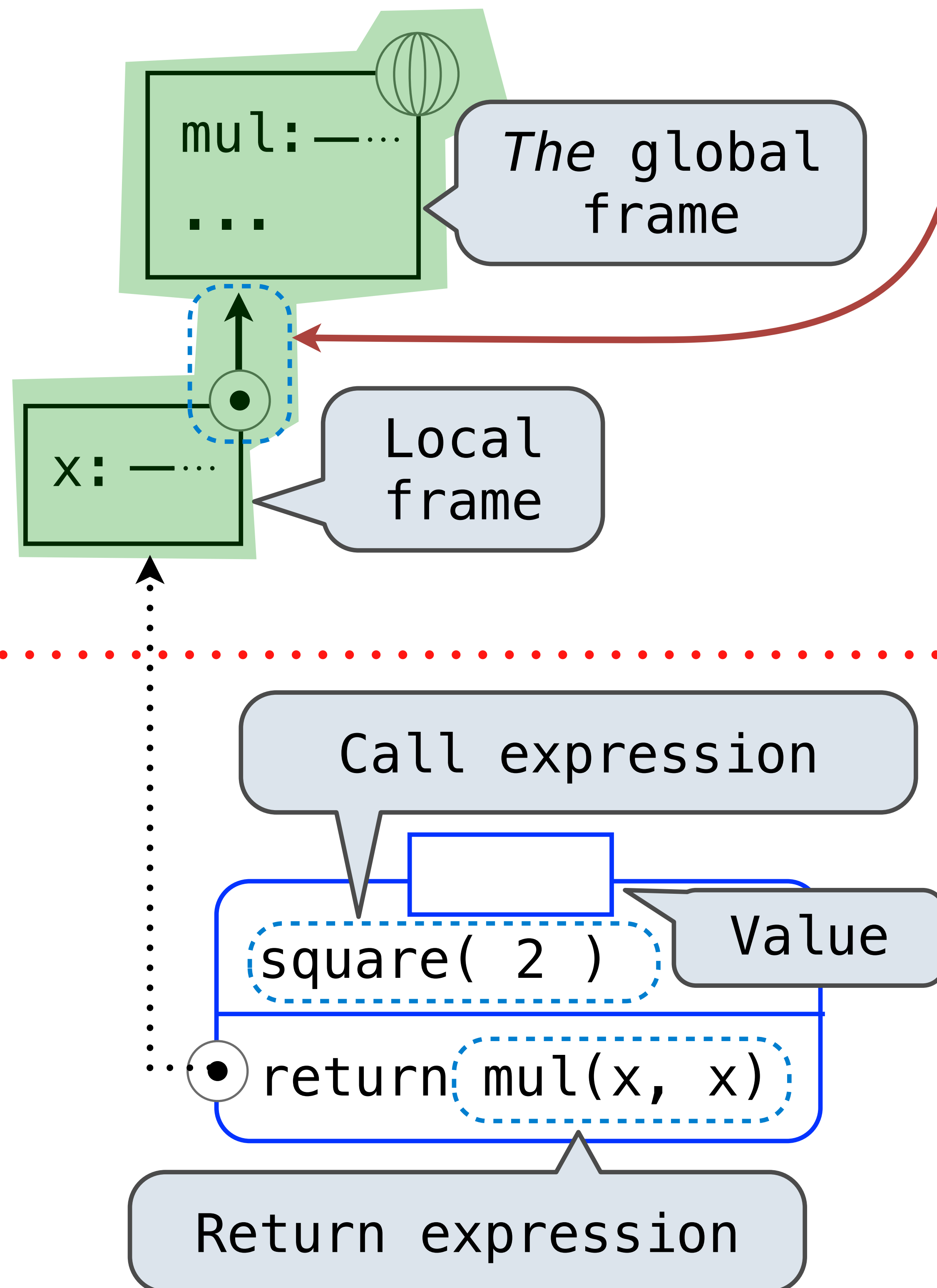

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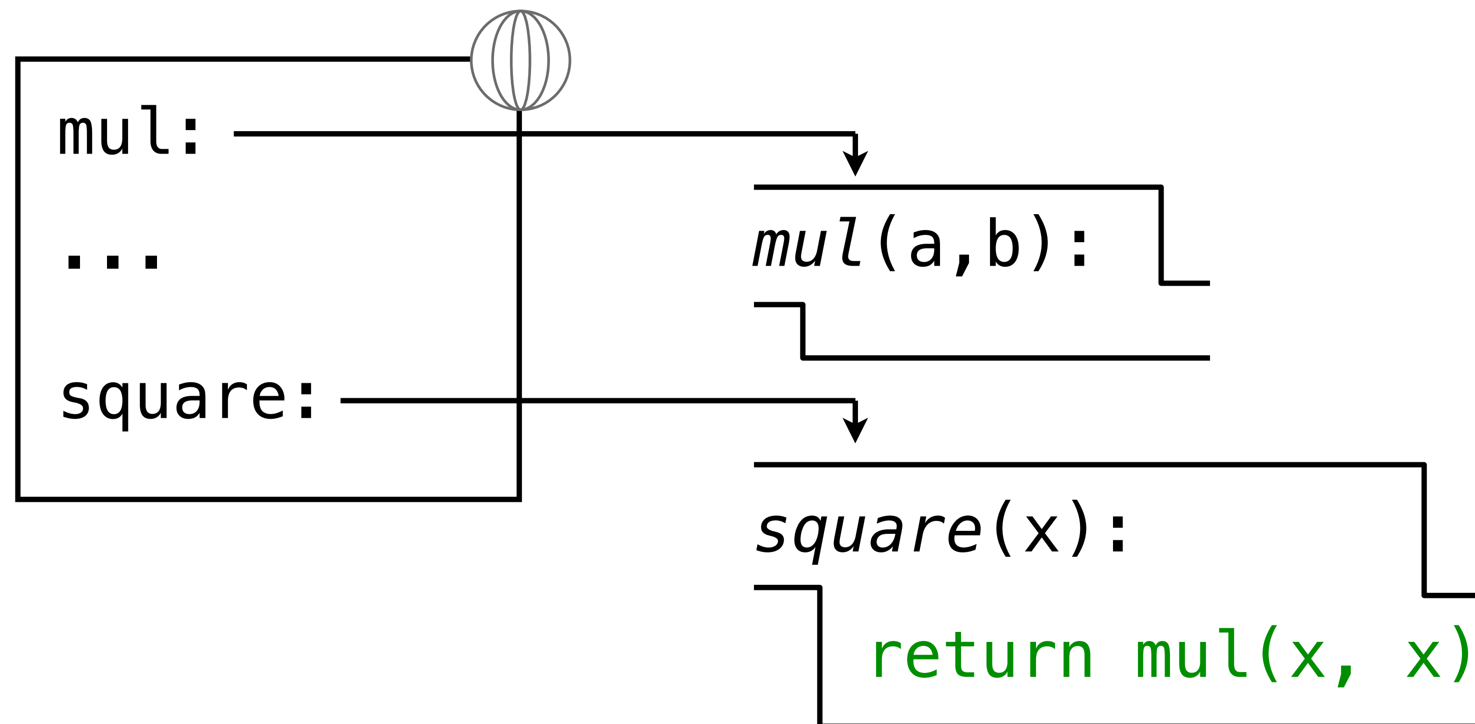
They are evaluated in an environment to yield a value

Multiple Environments in One Diagram!

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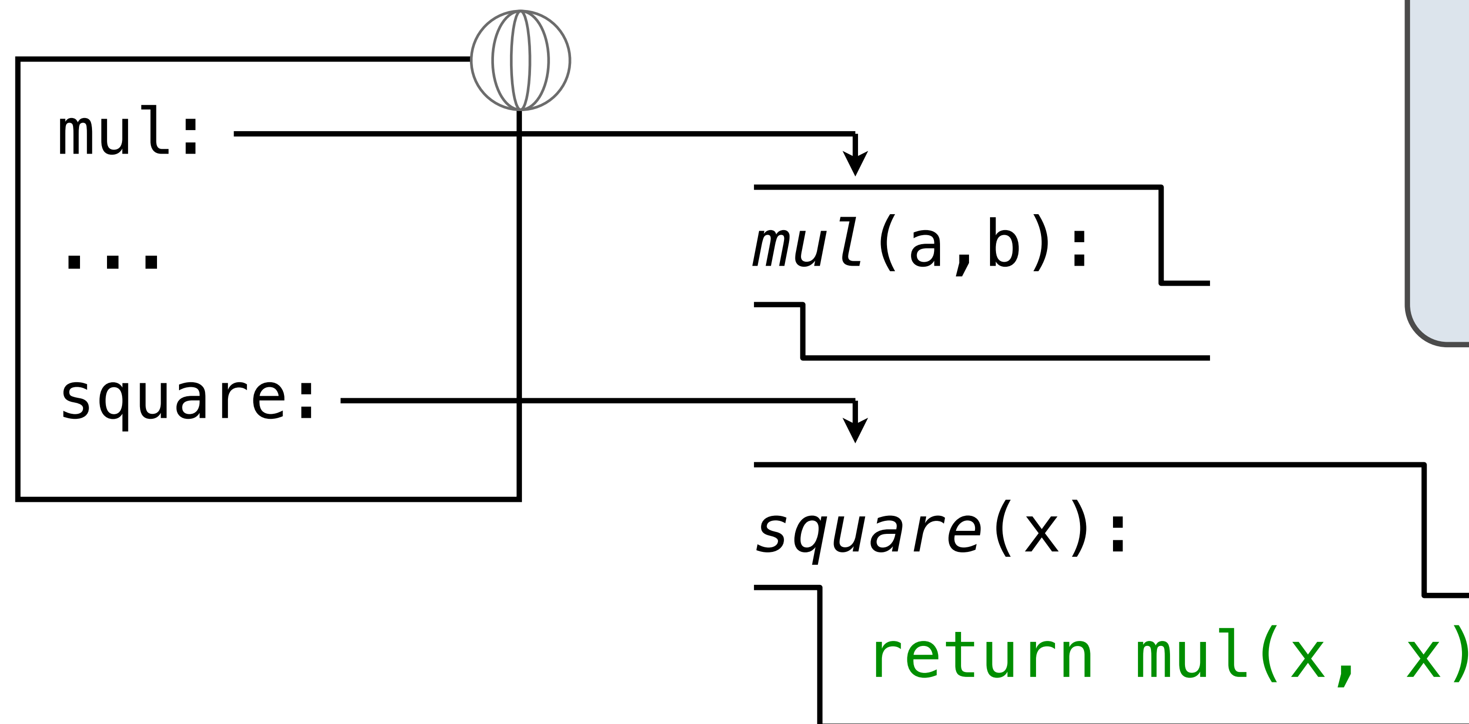
from operator import mul
def square(x):
    return mul(x, x)
square(square(3))
```

Multiple Environments in One Diagram!



Every call to a user-defined function creates a new local frame

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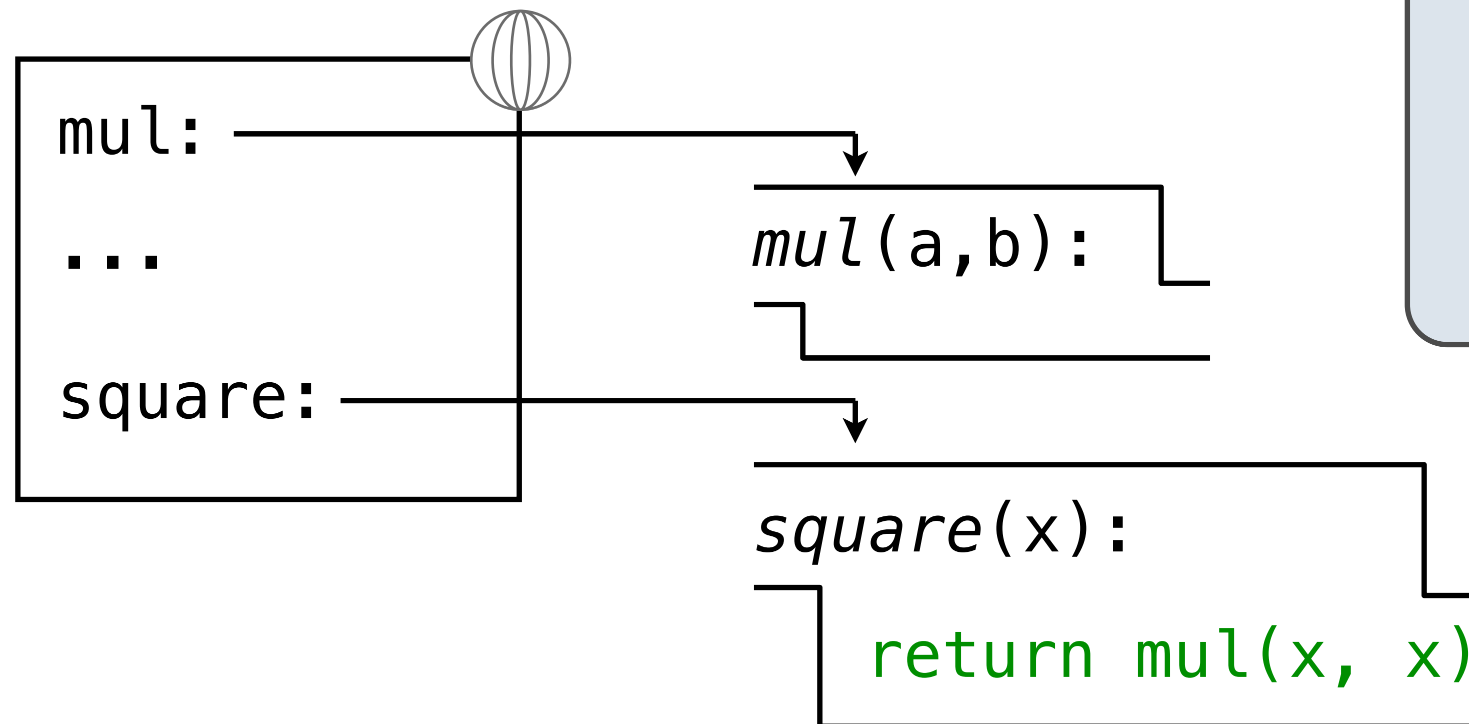

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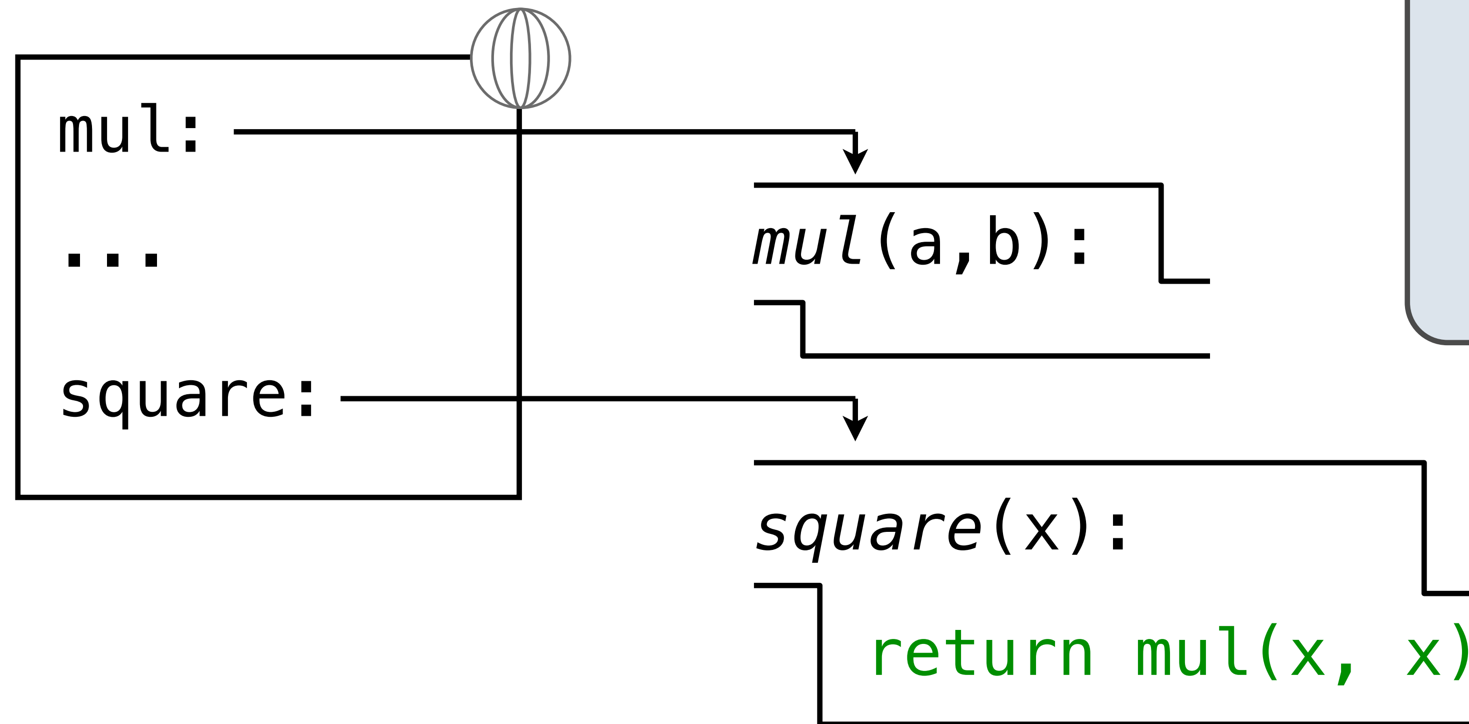

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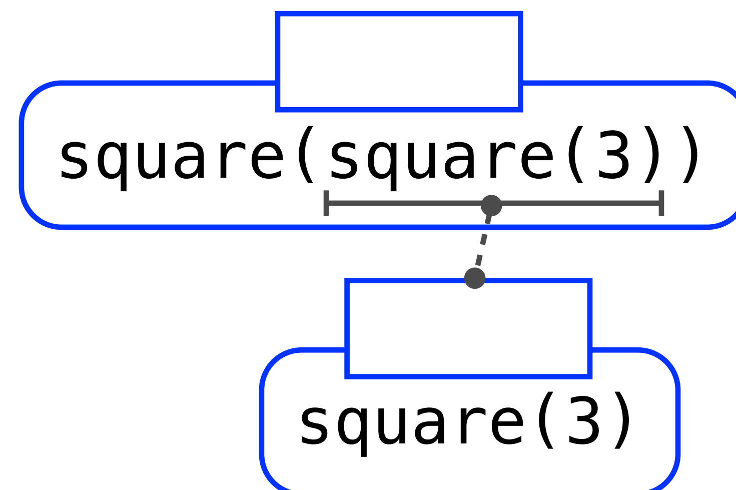


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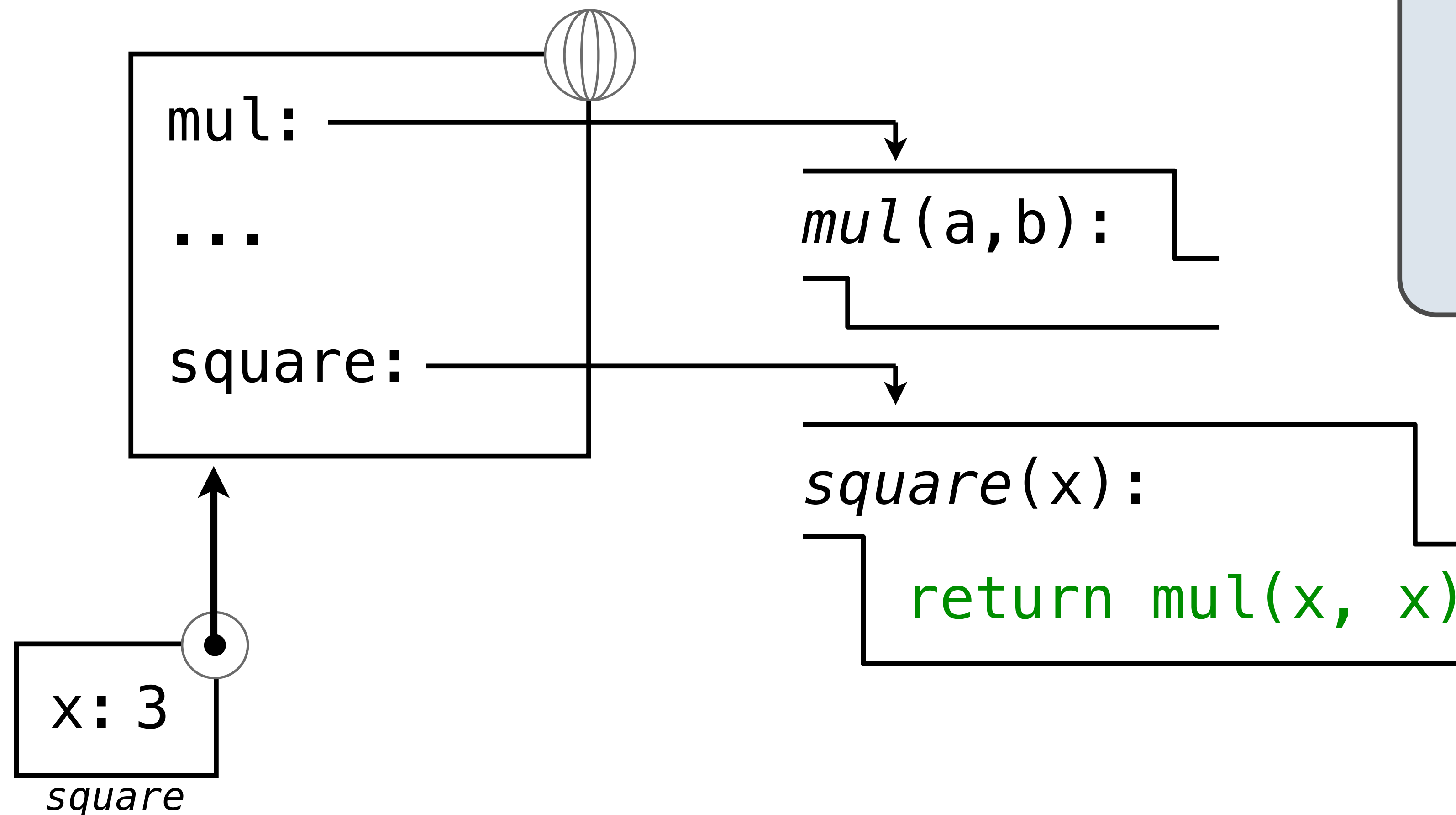

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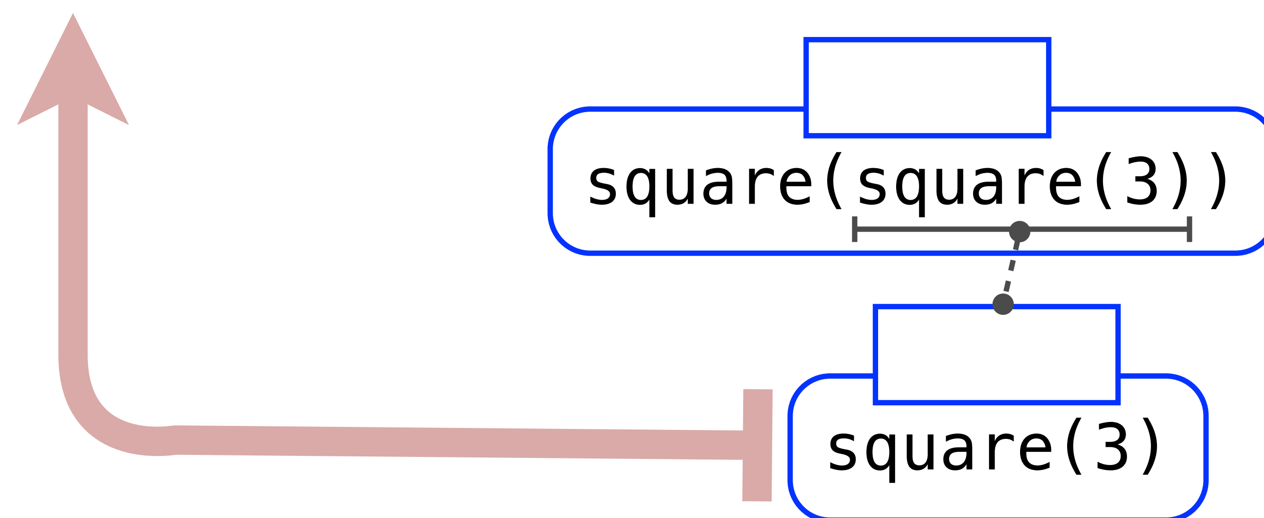


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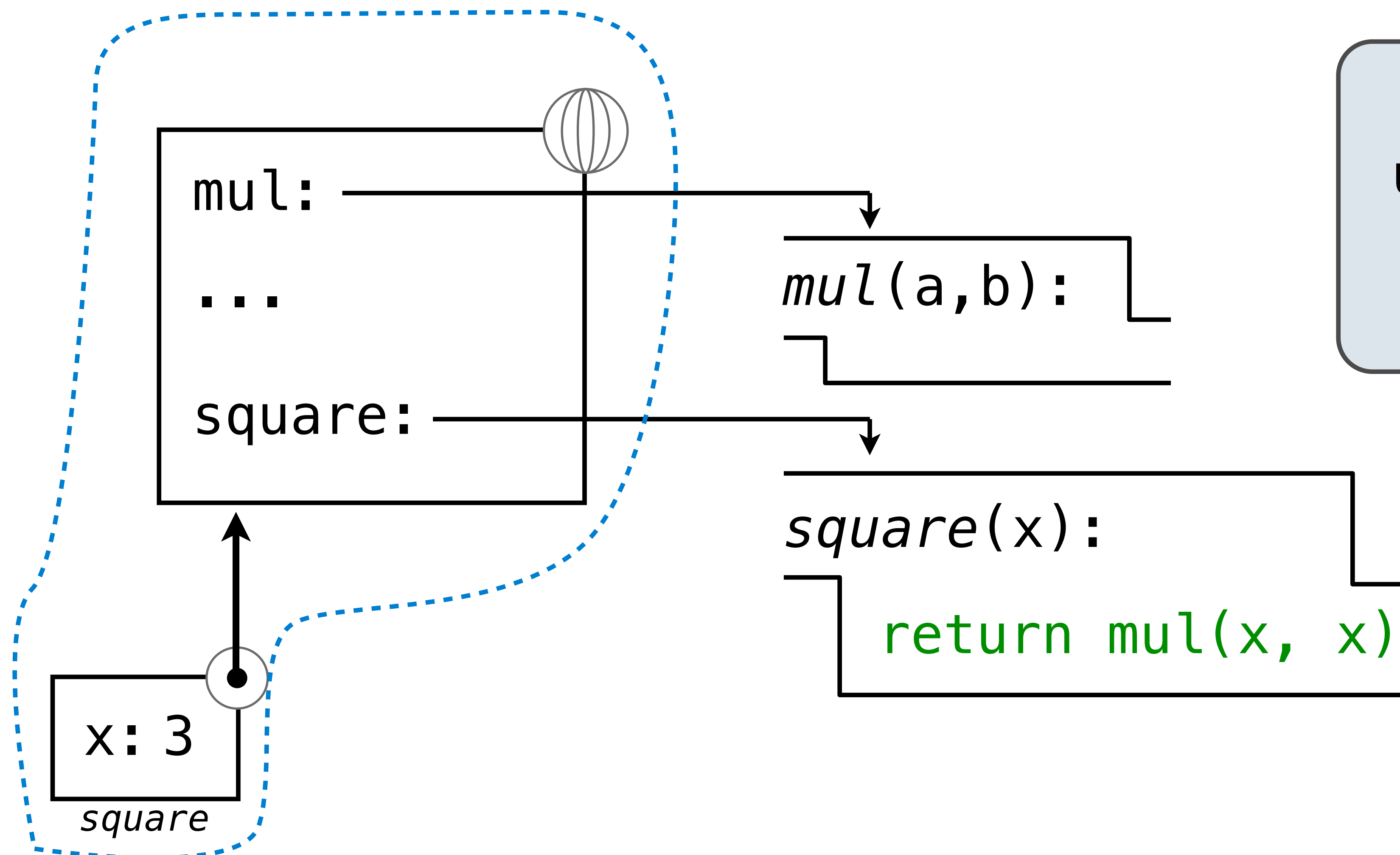

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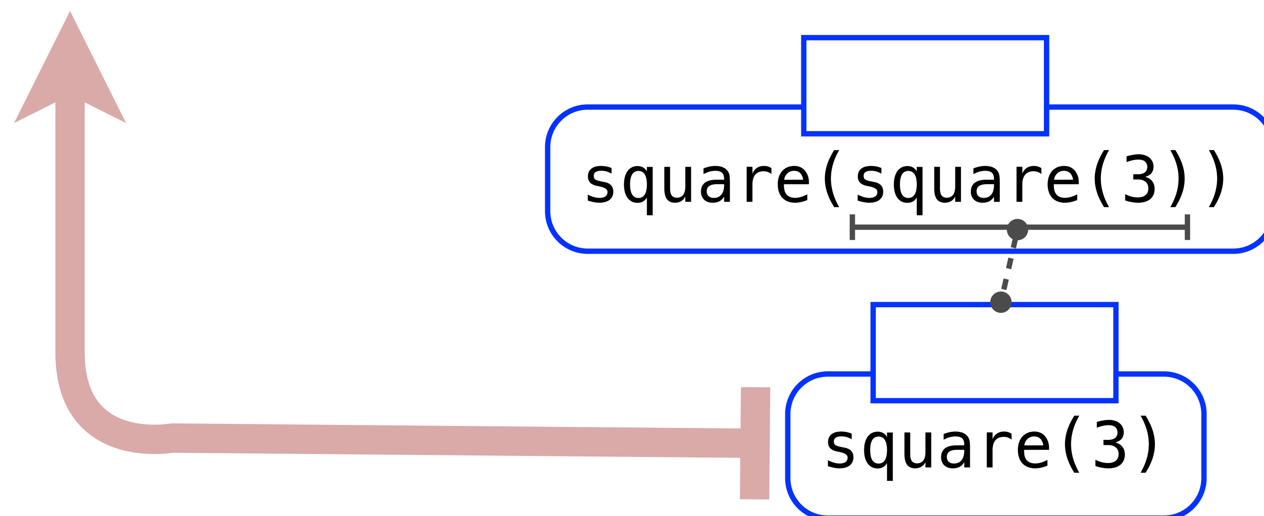


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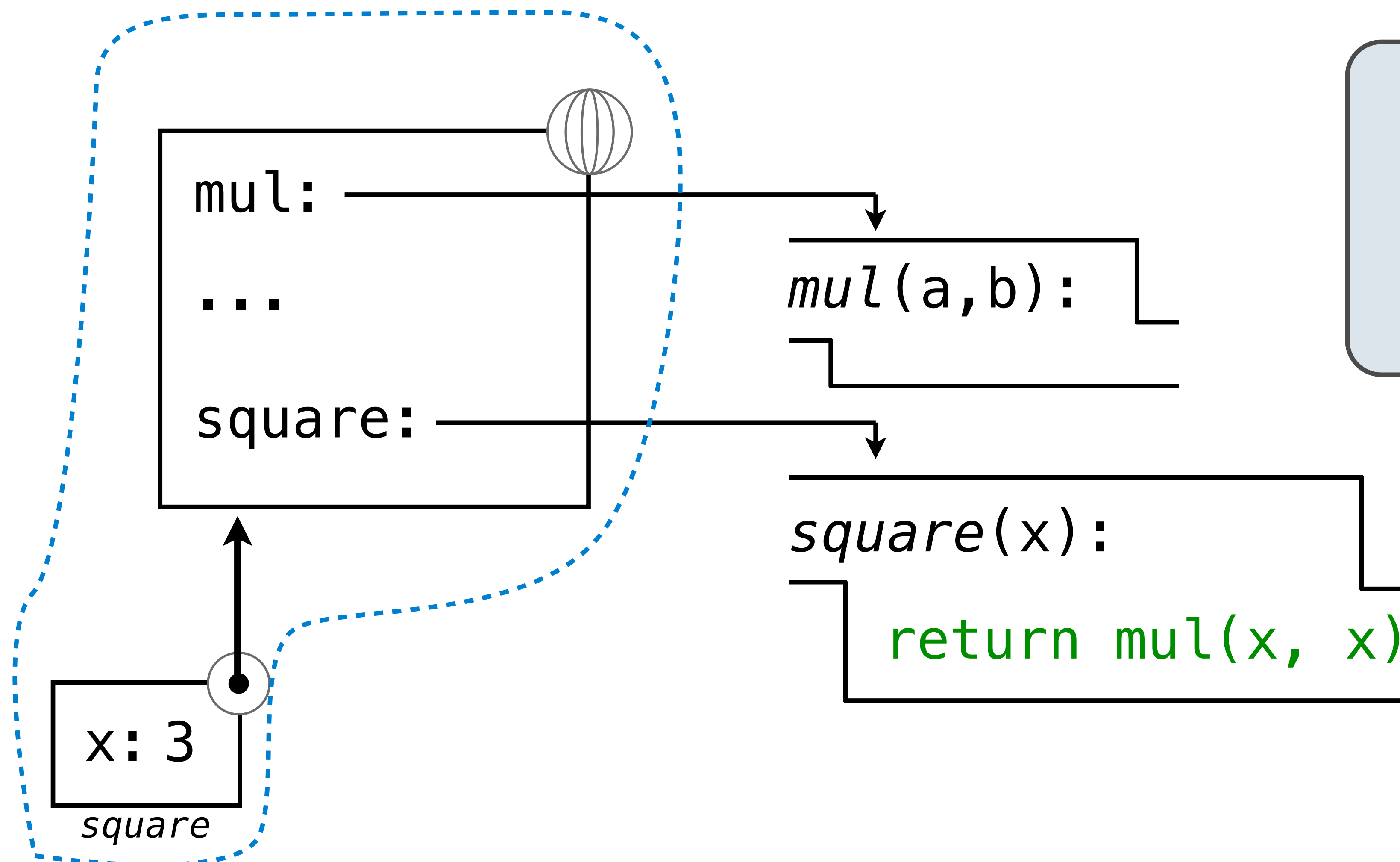

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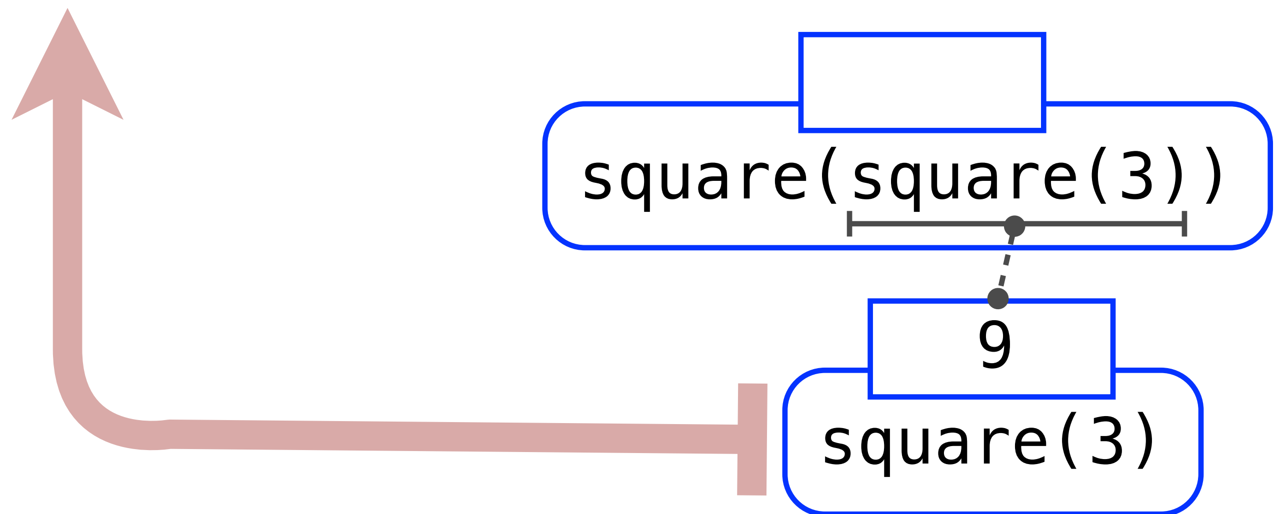


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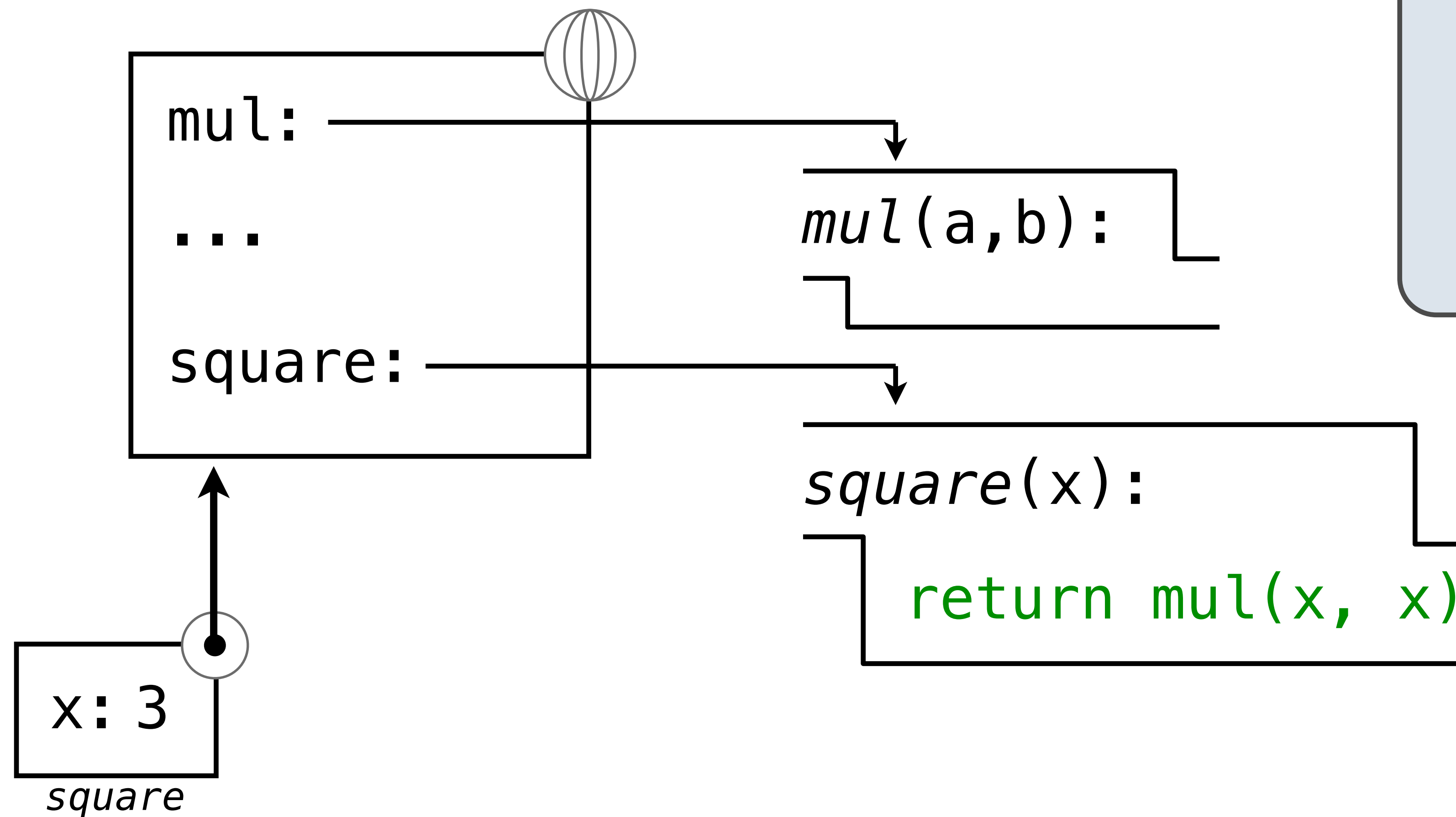

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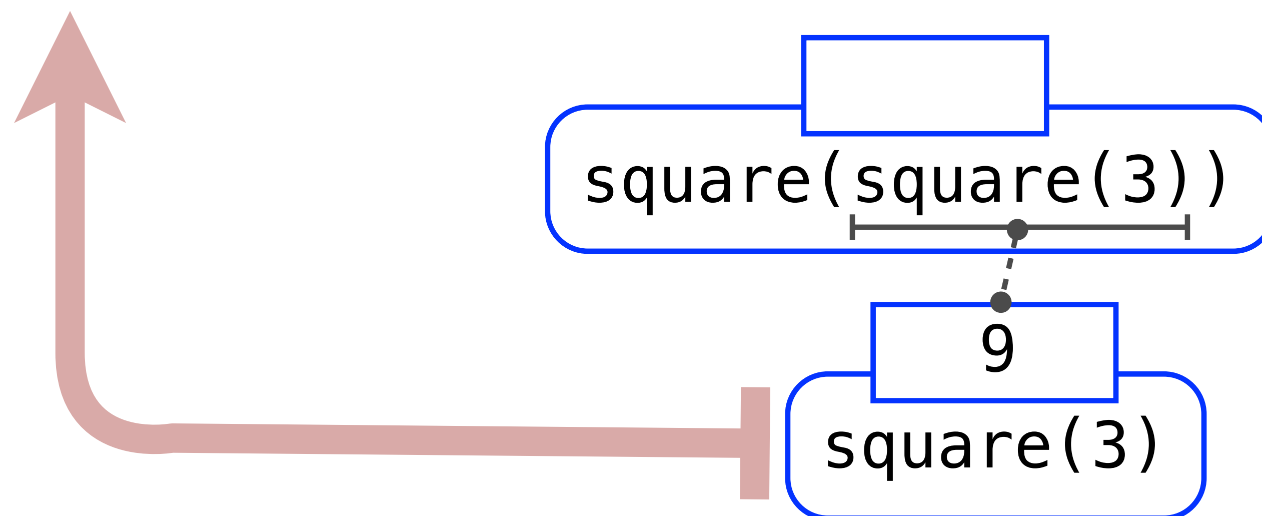


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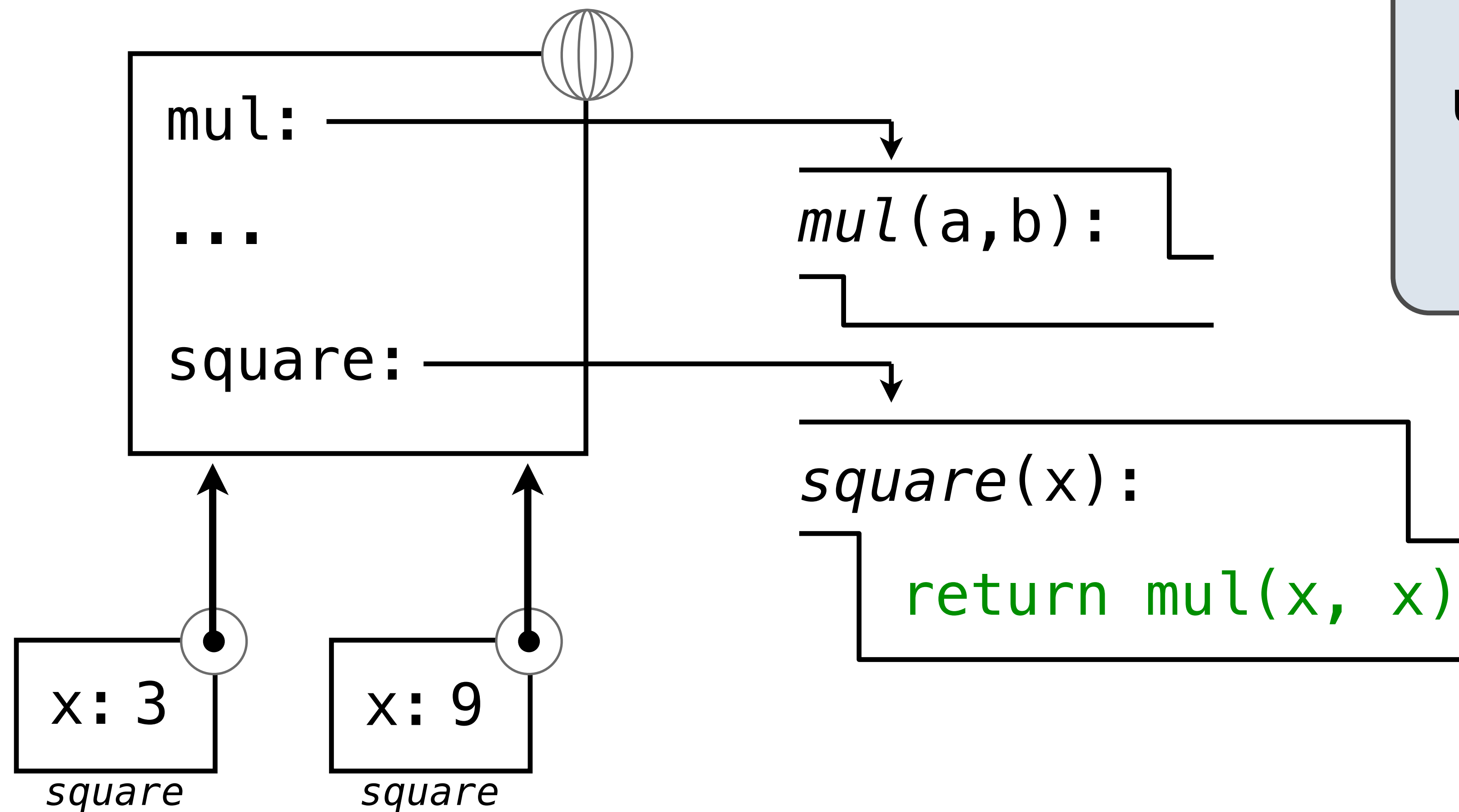

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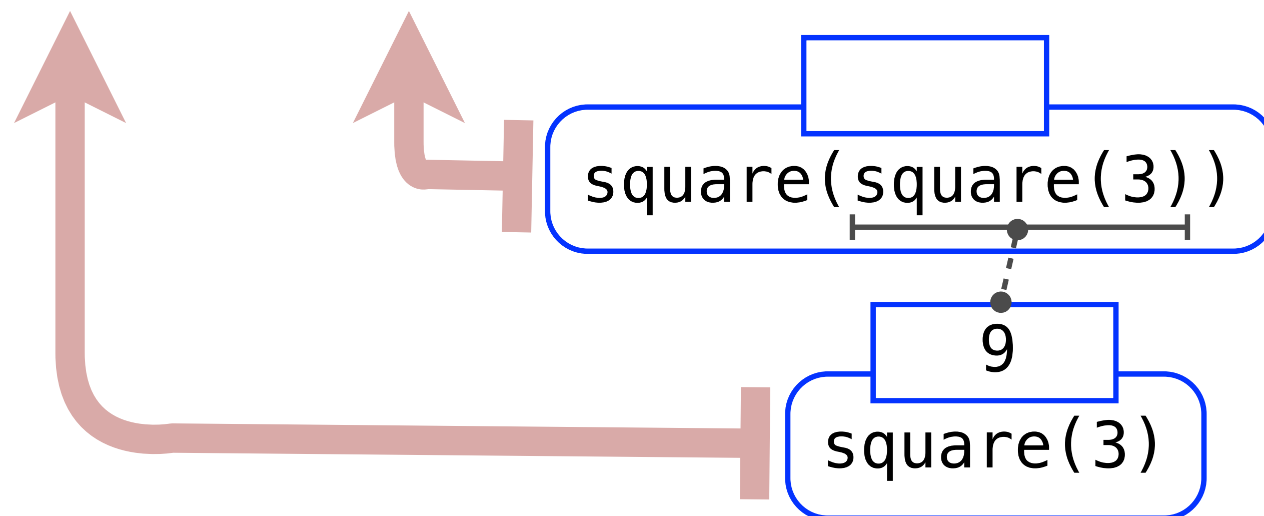


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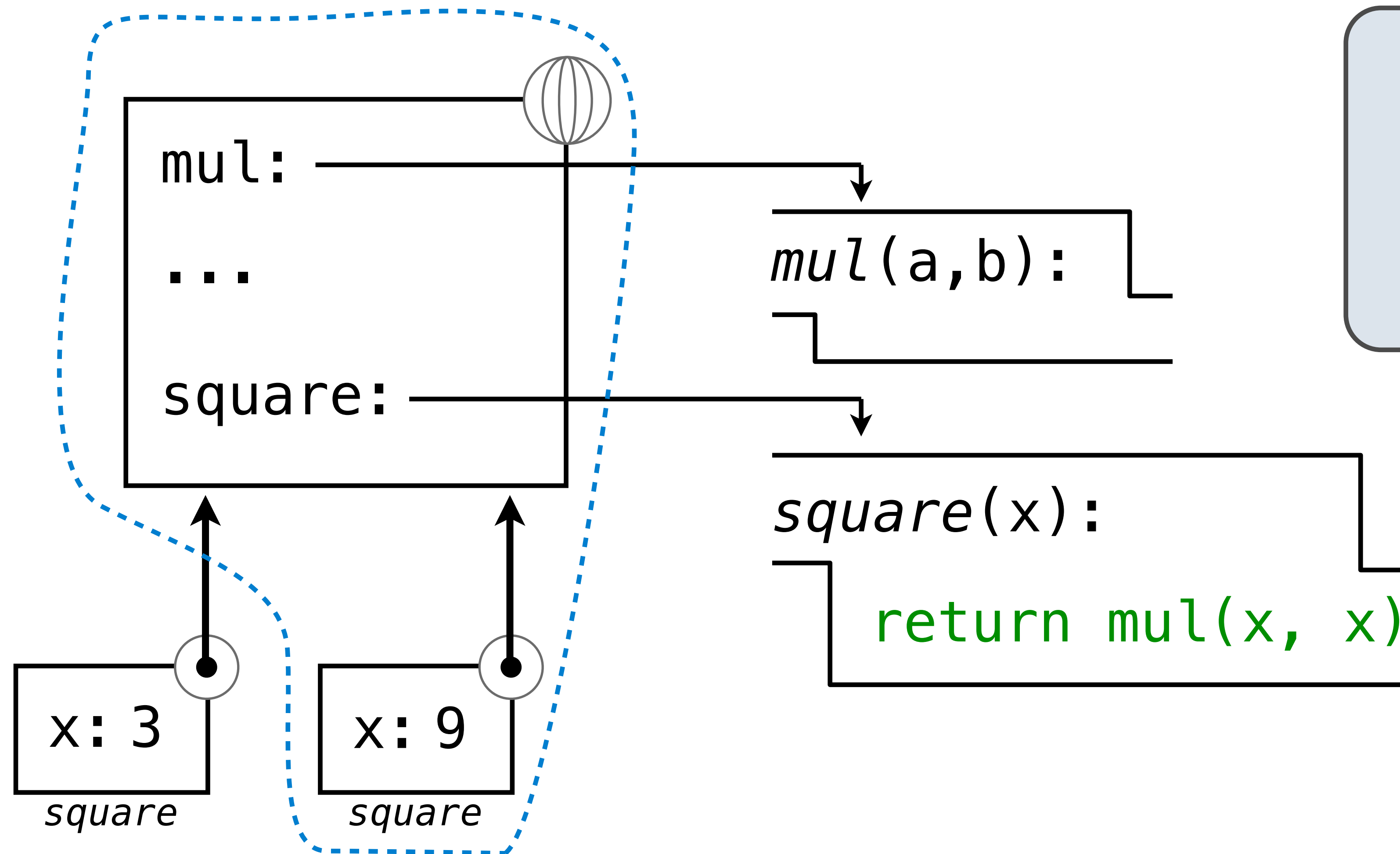

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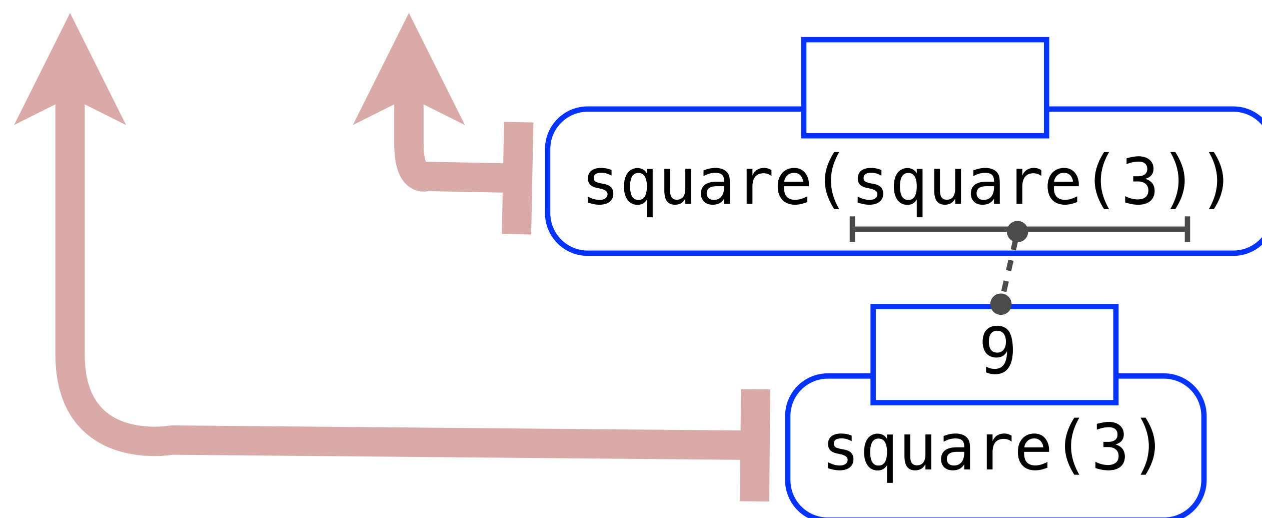


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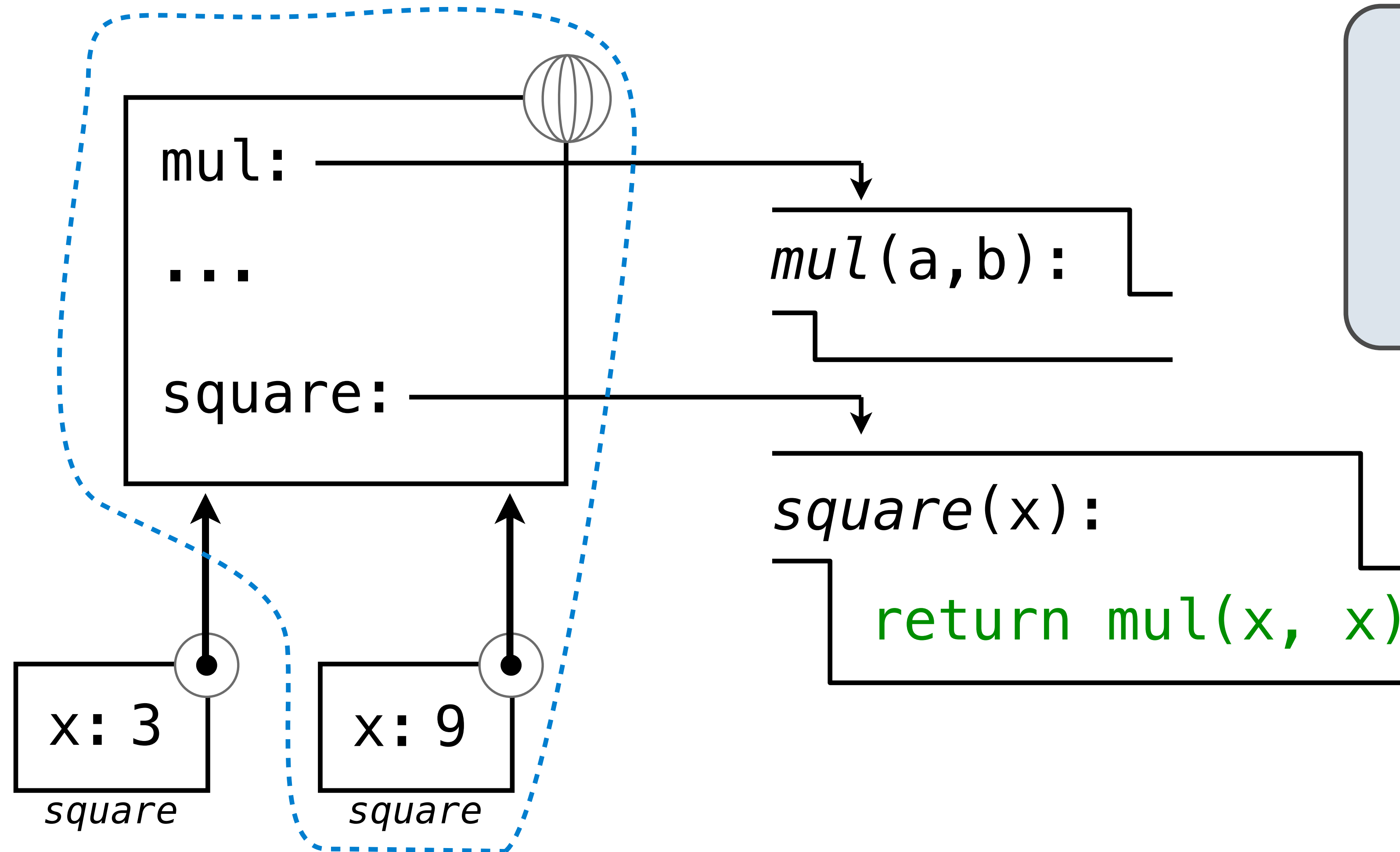

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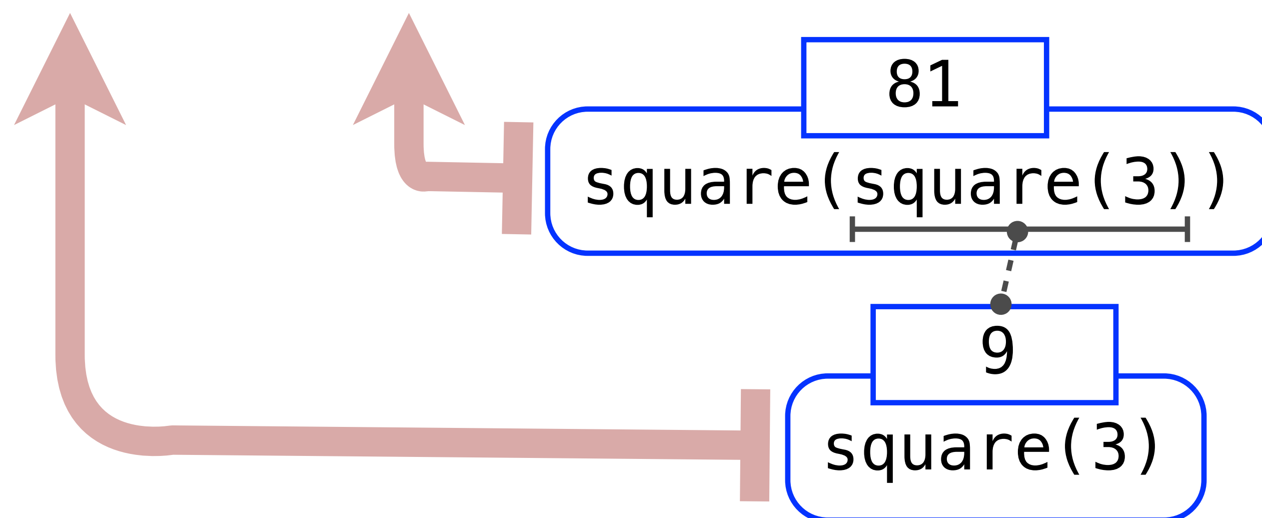


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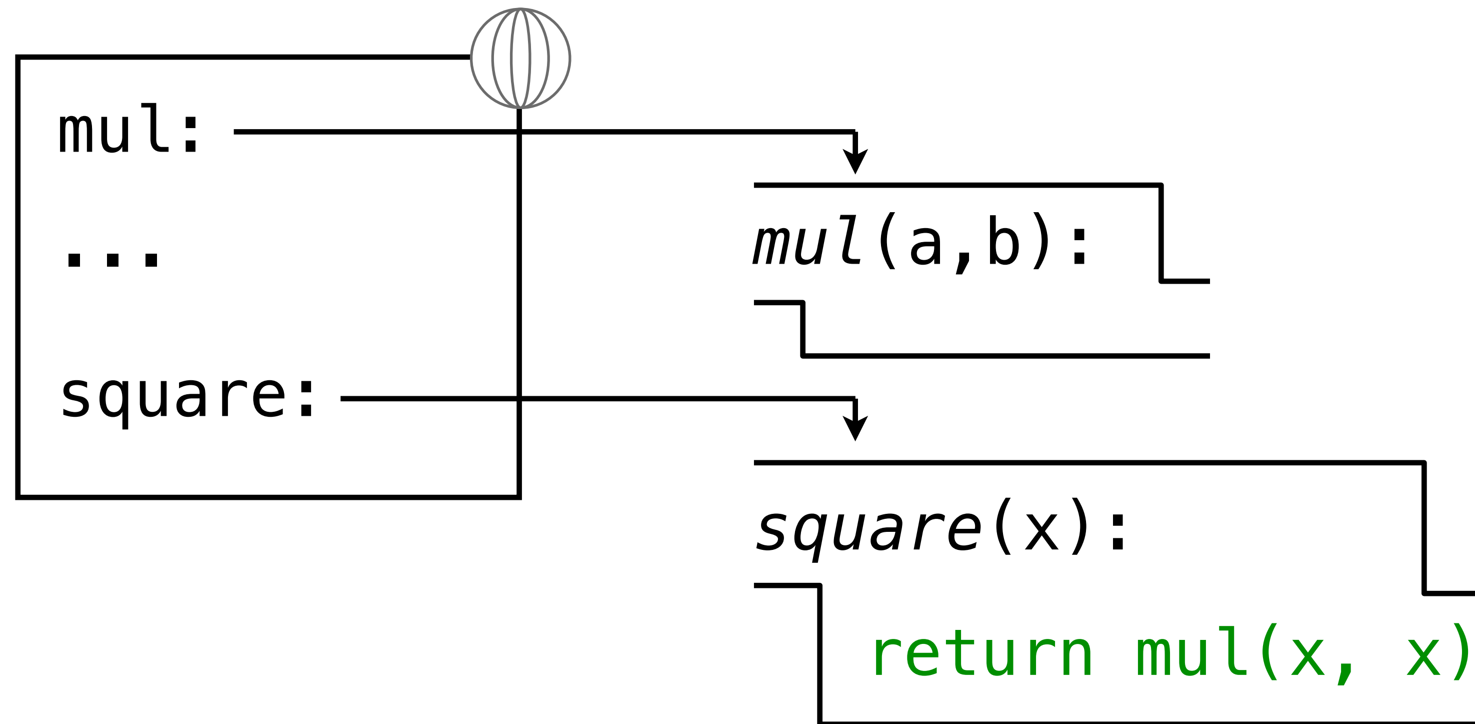
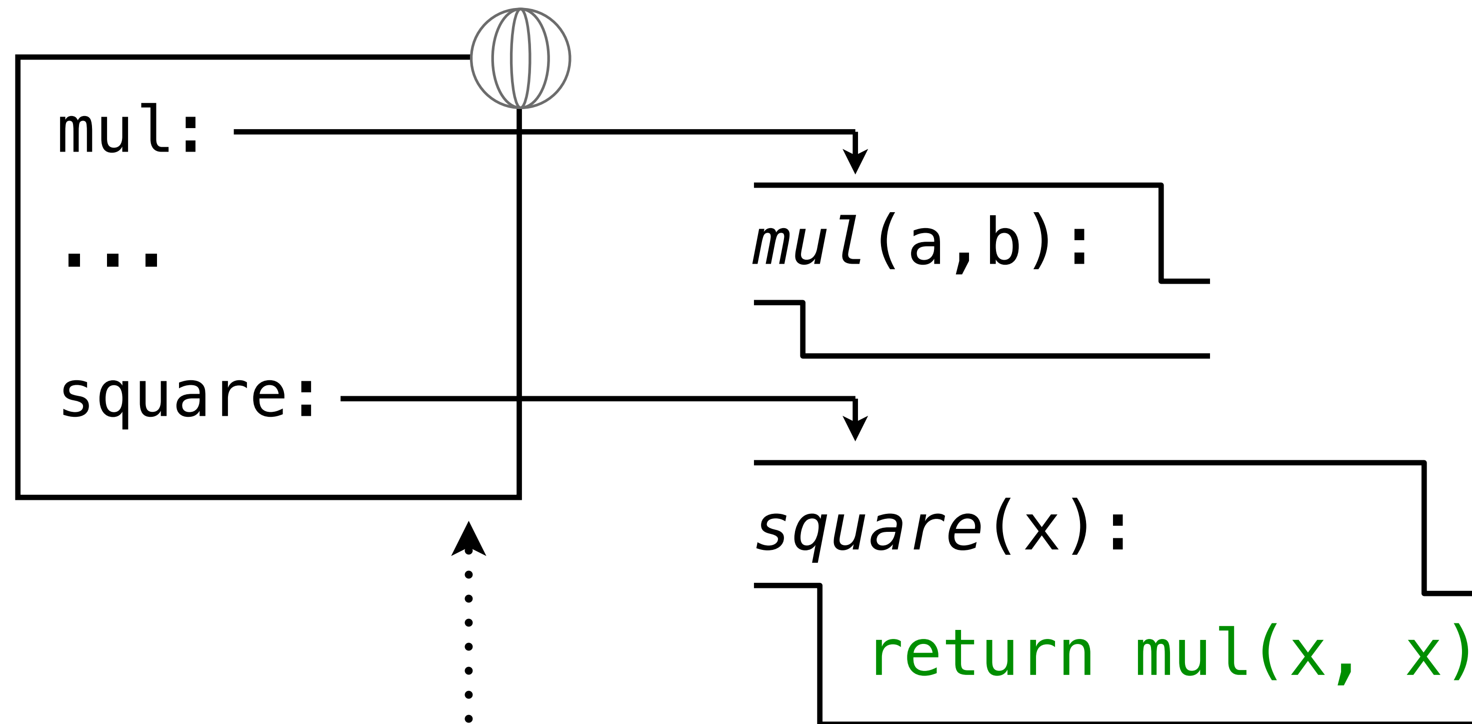
```

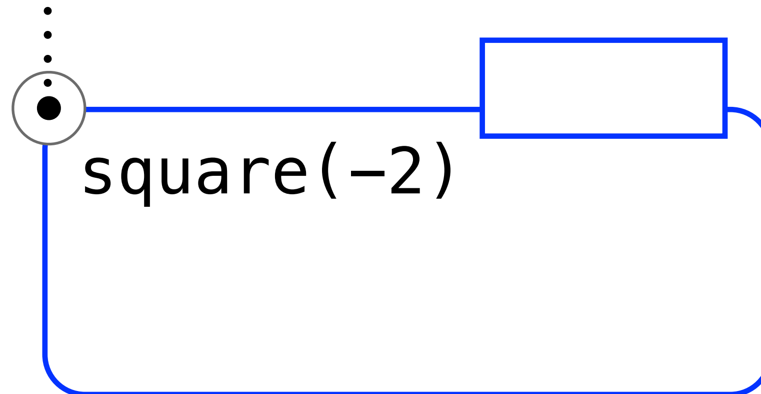
Names Have No Meaning Without Environments




```
from operator import mul
def square(x):
    return mul(x, x)
square(-2)
```

Names Have No Meaning Without Environments



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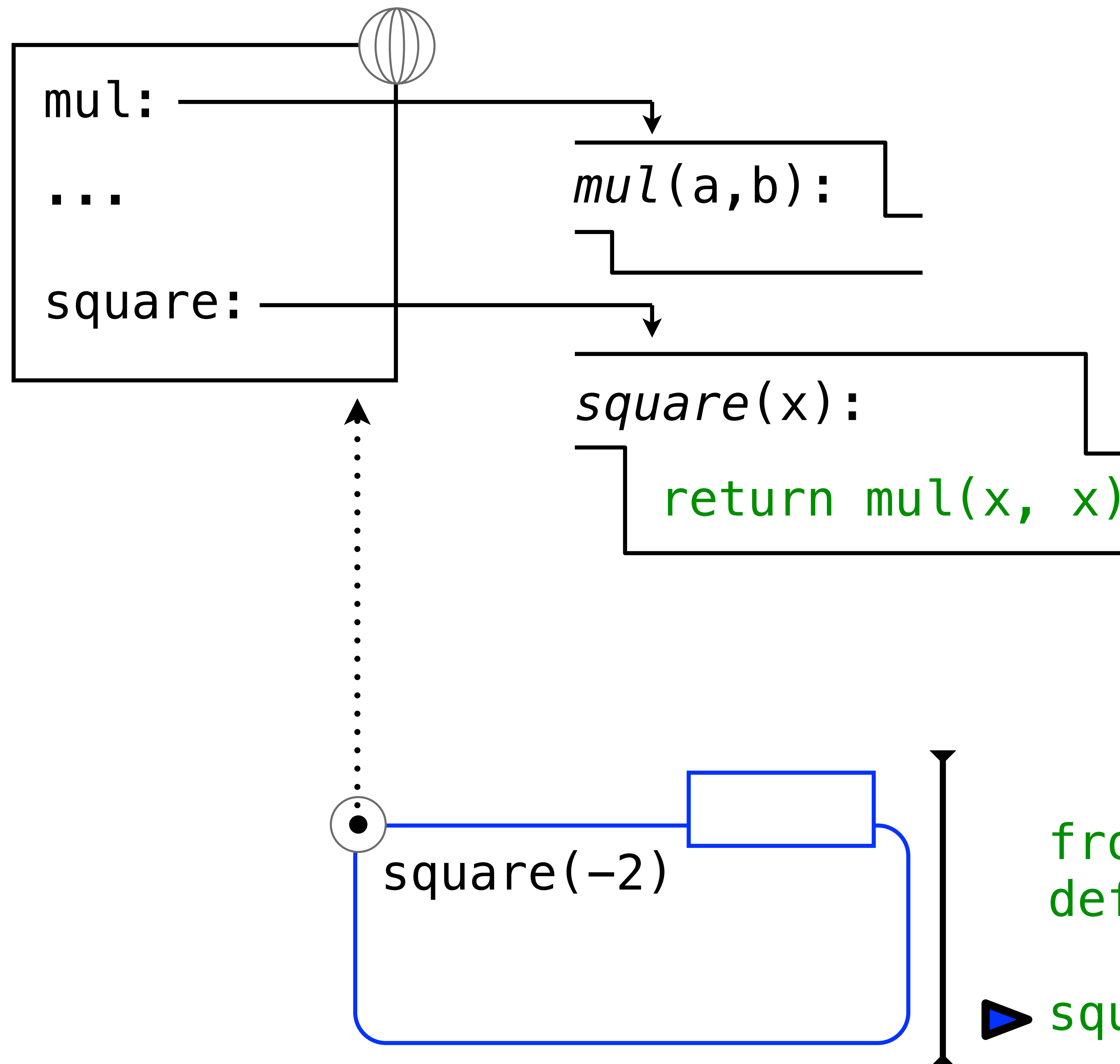
Names Have No Meaning Without Environments

A name evaluates to the **value bound** to that name

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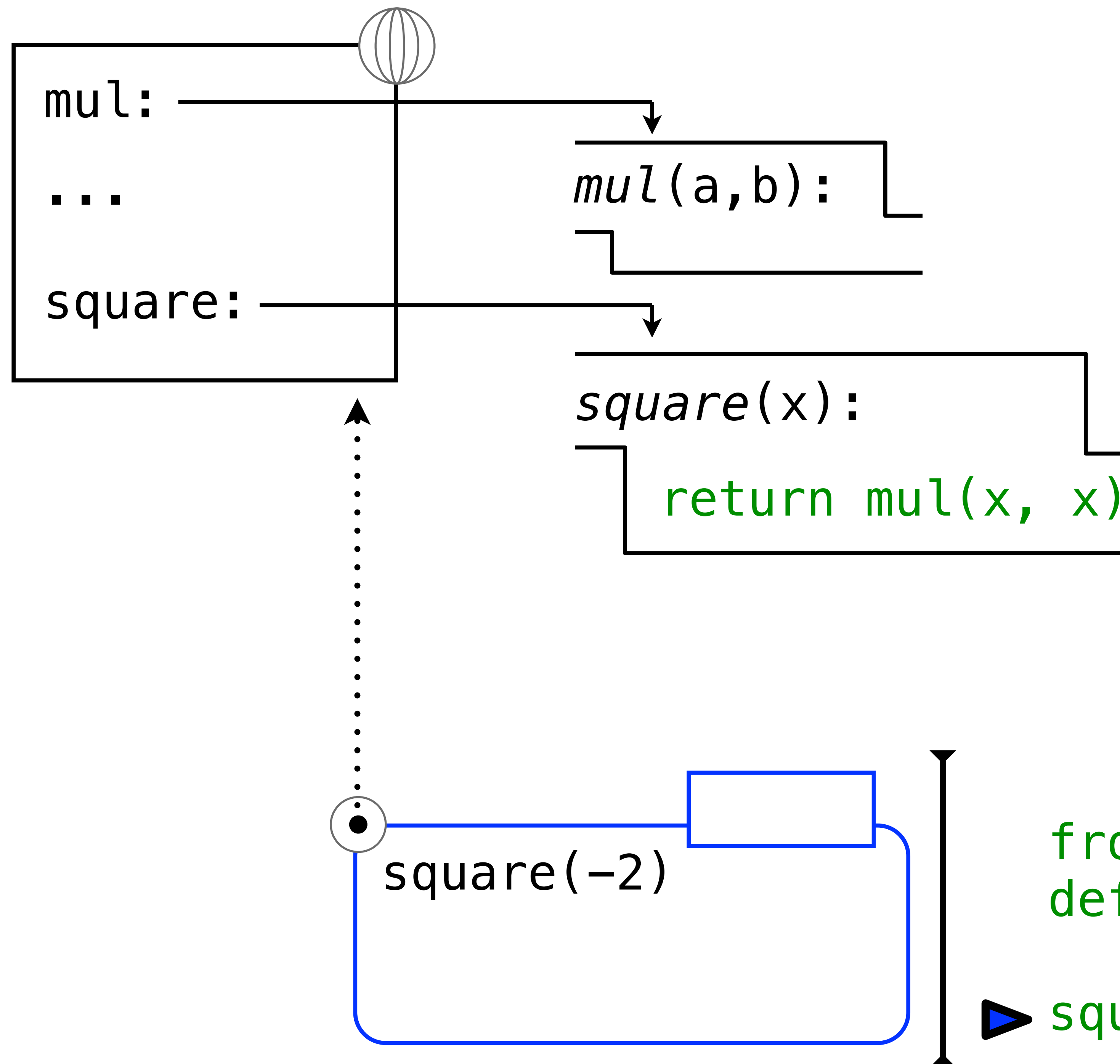

A name evaluates to the **value** **bound** to that name

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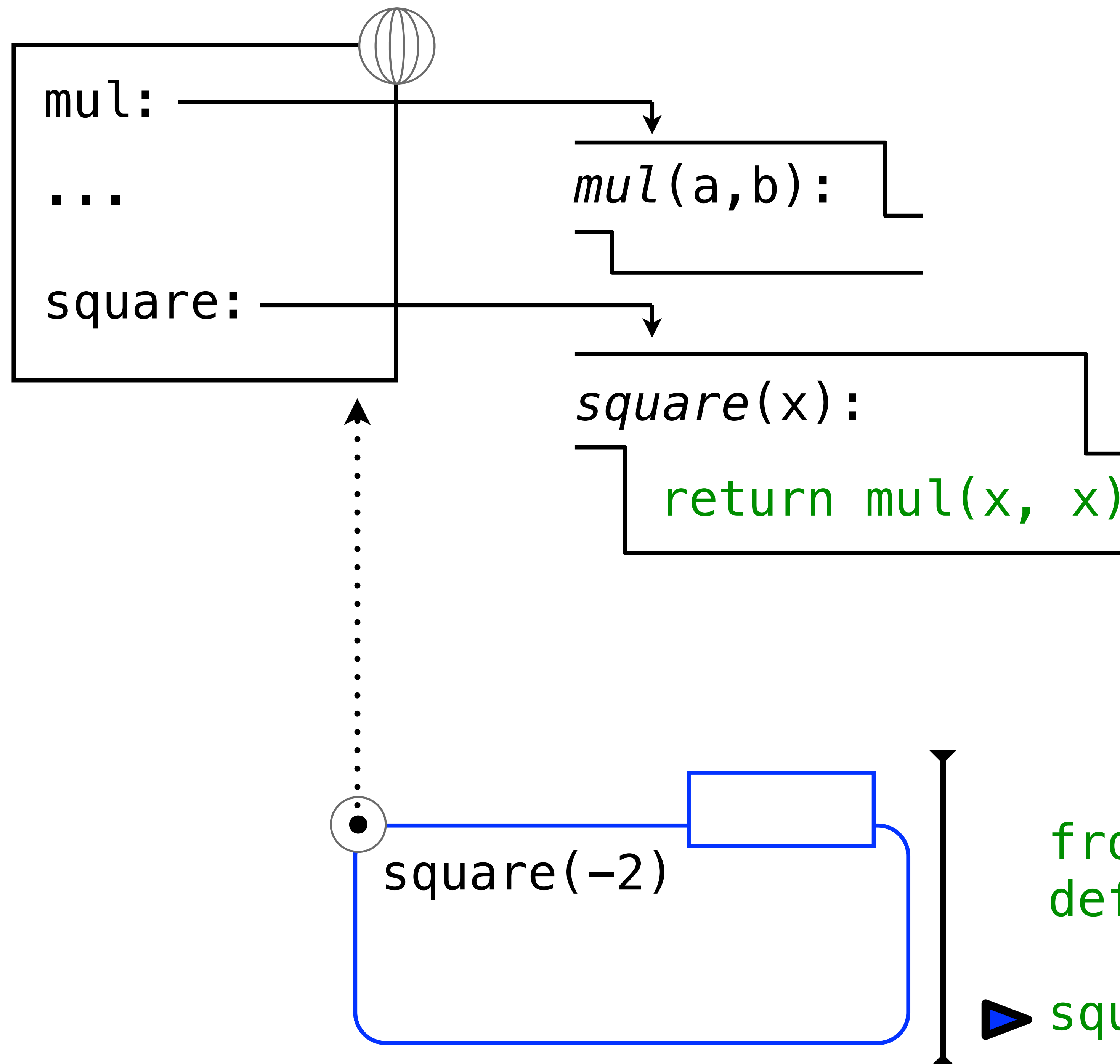

A name evaluates to the **value bound** to that name

...in the **earliest** frame of the **current environment**

...in which that **name is found**

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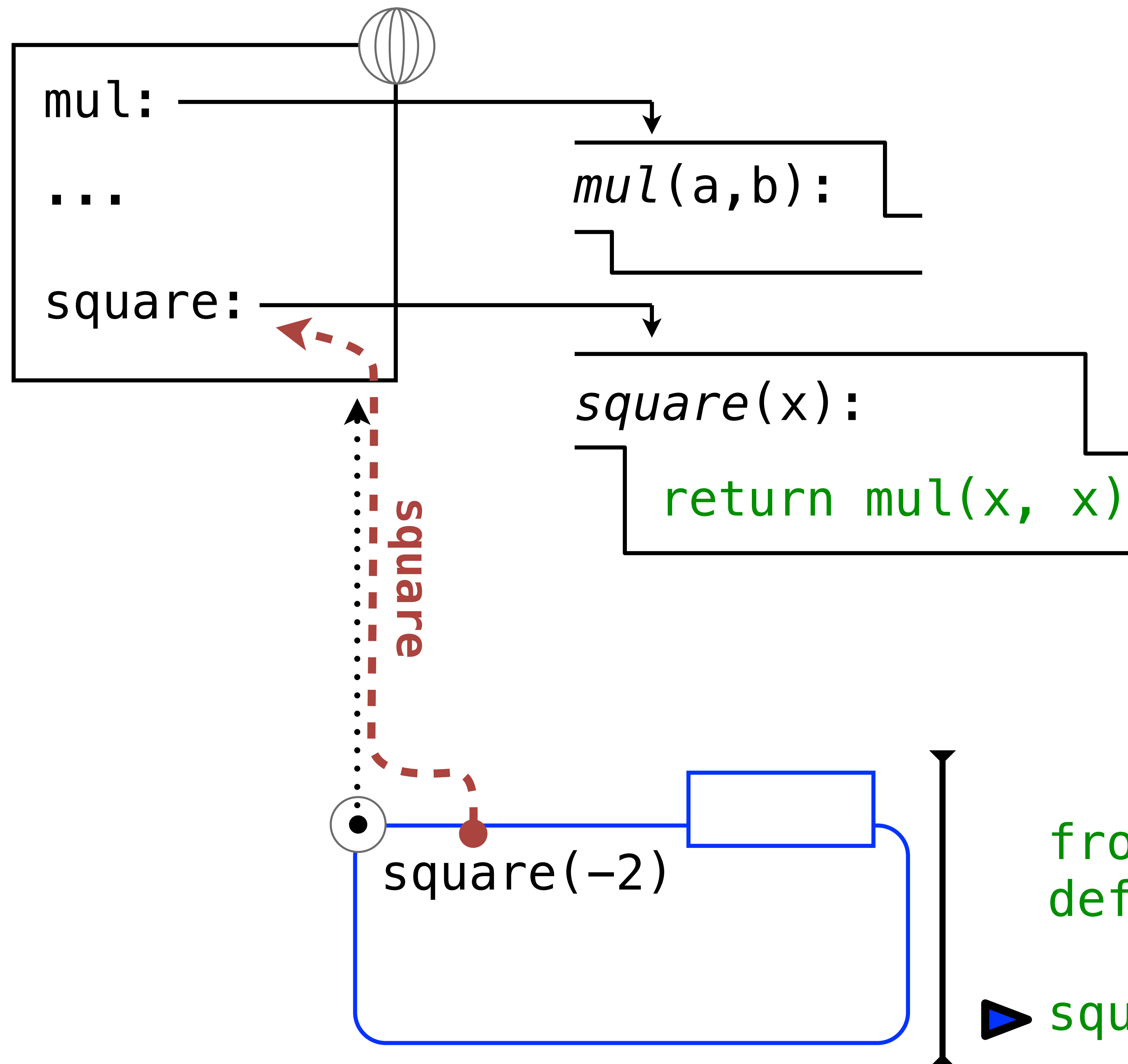
Names Have No Meaning Without Environments



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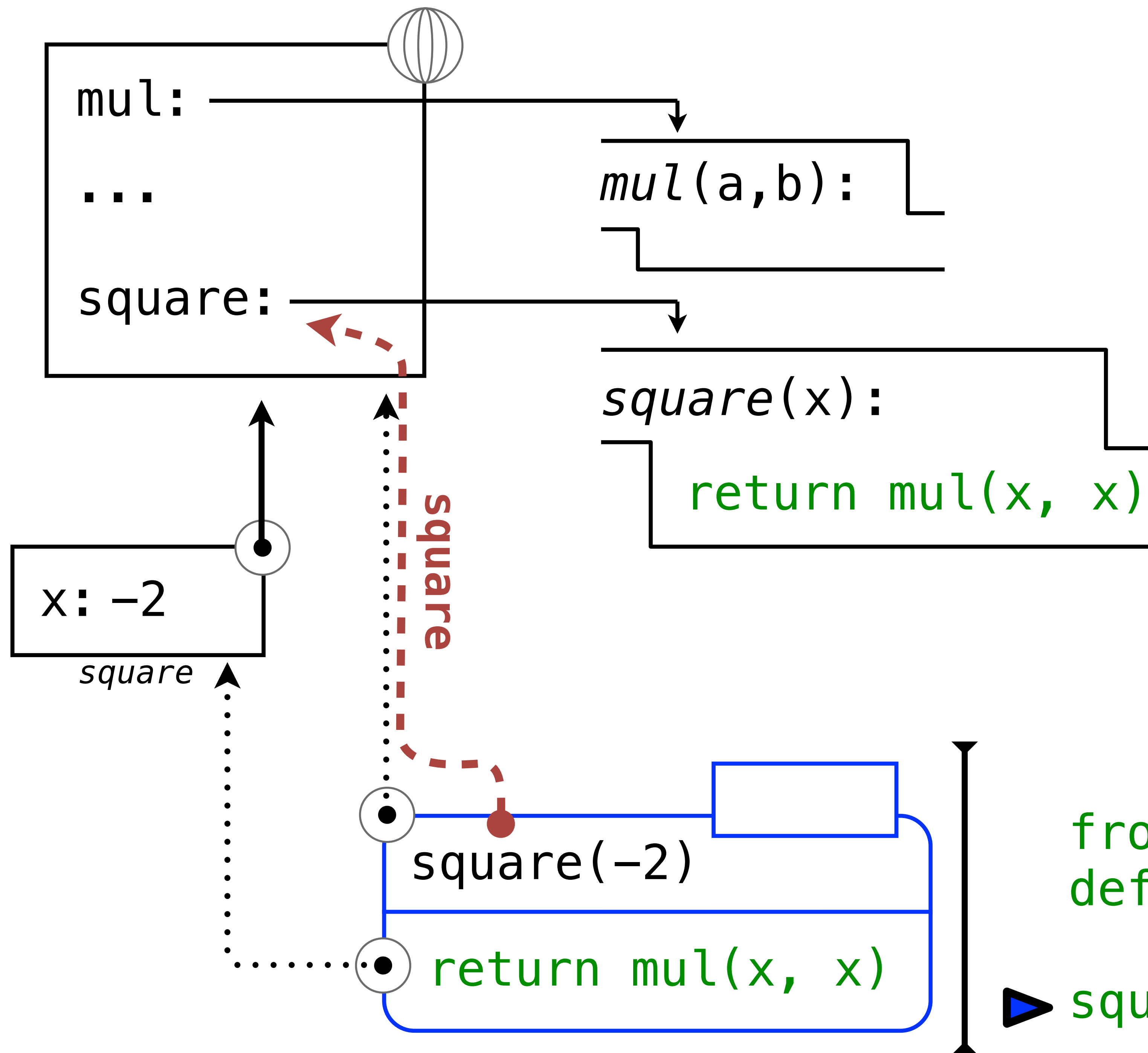

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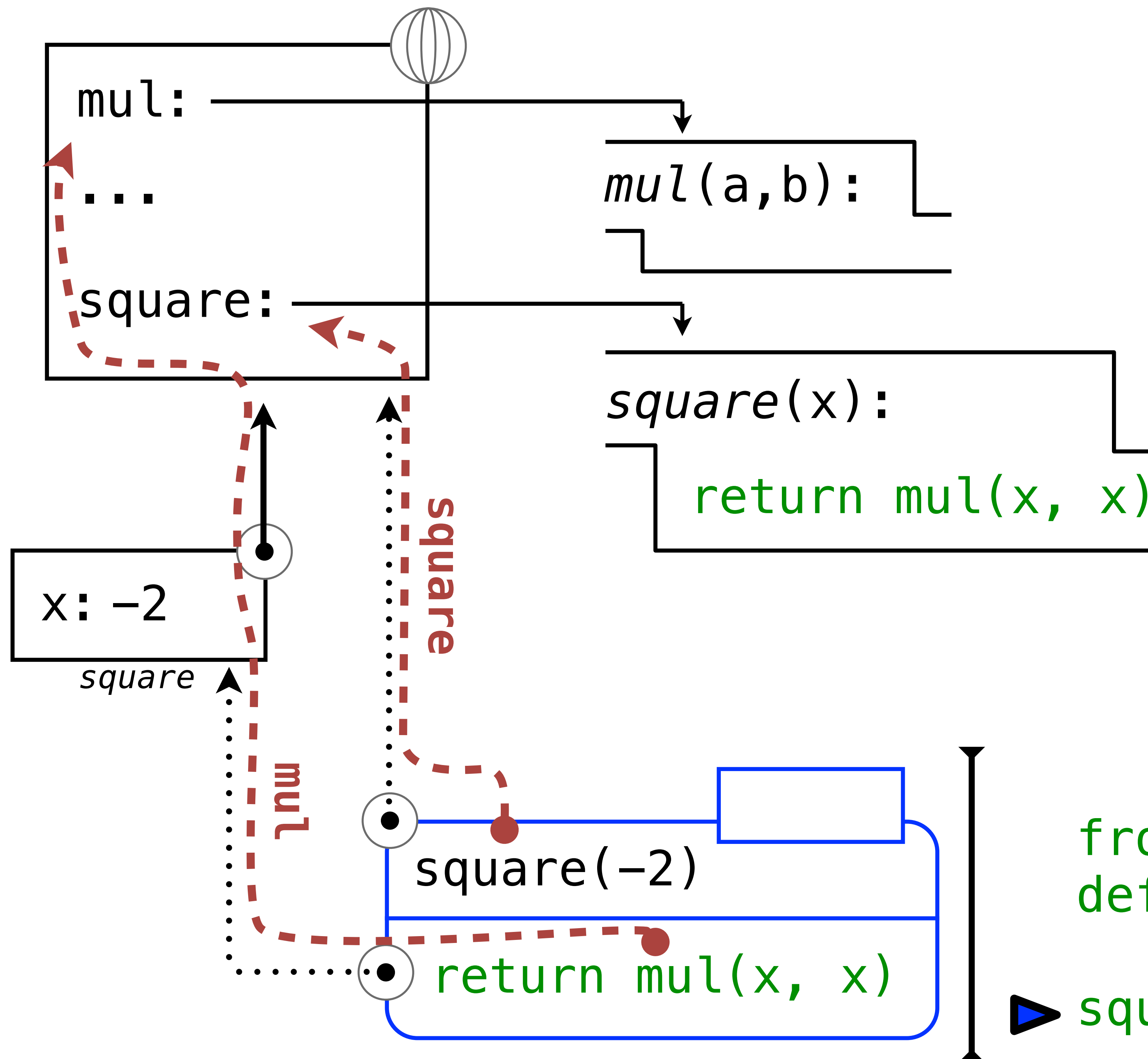

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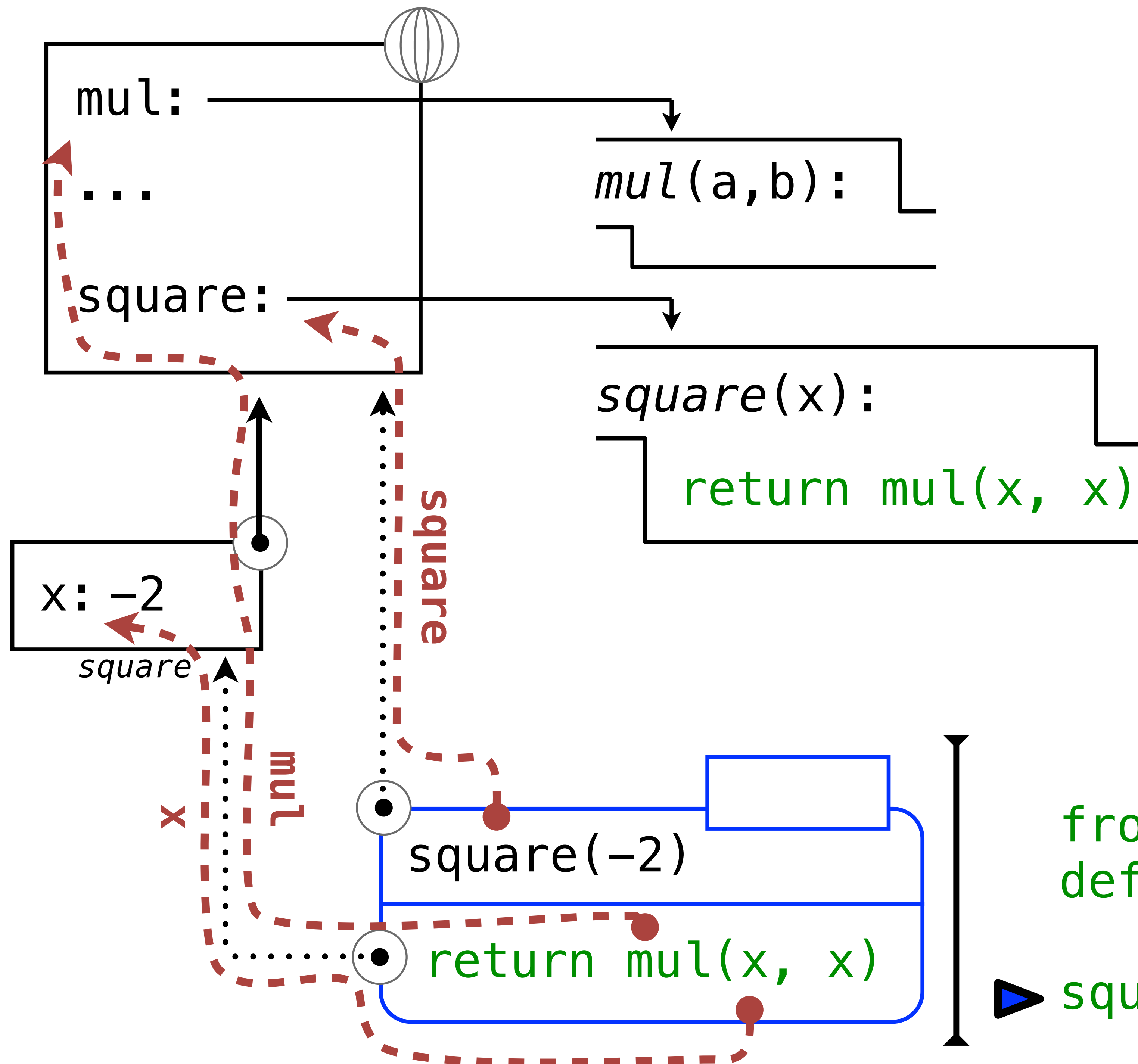

A name evaluates to the **value bound** to that name

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```
from operator import mul
def square(x):
    return mul(x, x)
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```

Formal Parameters

Formal Parameters

```
def square(x):
    return mul(x, x)
```

Formal Parameters

```
def square(x):
    return mul(x, x)
```

vs

Formal Parameters

```
def square(x):                      def square(y):
    return mul(x, x)        vs          return mul(y, y)
```

Formal Parameters

```
def square(x):
    return mul(x, x)
```

vs

```
def square(y):
    return mul(y, y)
```

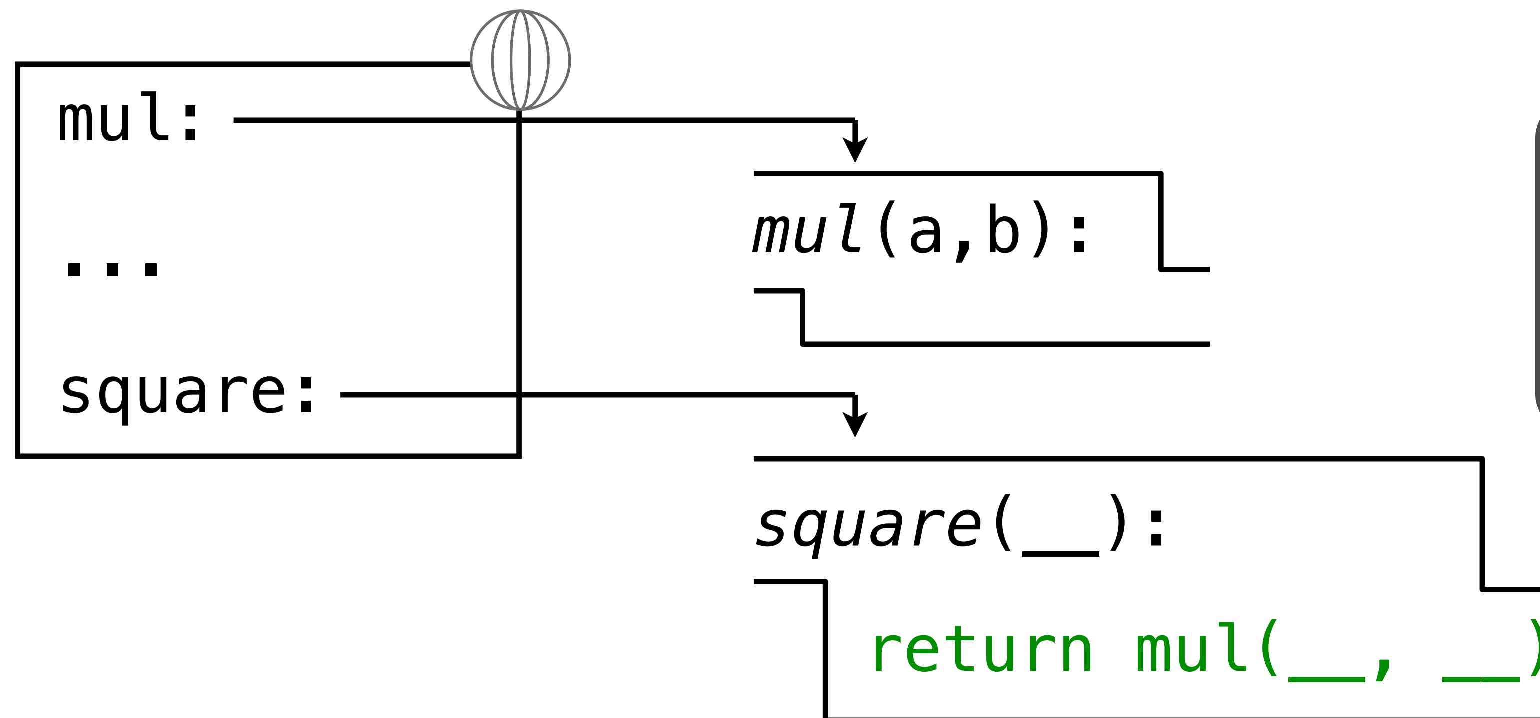
Formal parameter names stay *local* to their frame

Formal Parameters

```
def square(x):
    return mul(x, x)
```

vs

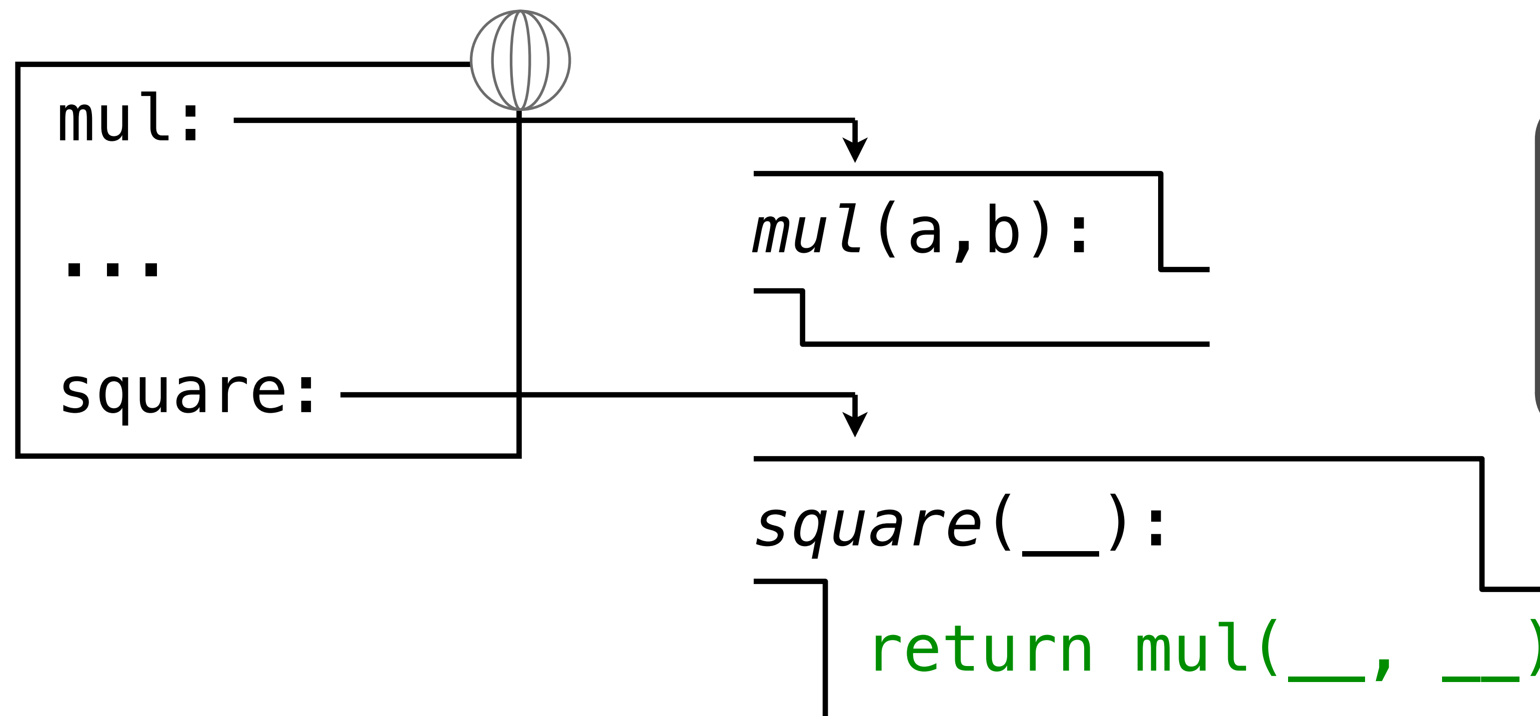
```
def square(y):
    return mul(y, y)
```



Formal parameter names stay *local* to their frame

Formal Parameters

```
def square(x):                    def square(y):
    return mul(x, x)      vs          return mul(y, y)
```



Formal parameter names stay *local* to their frame

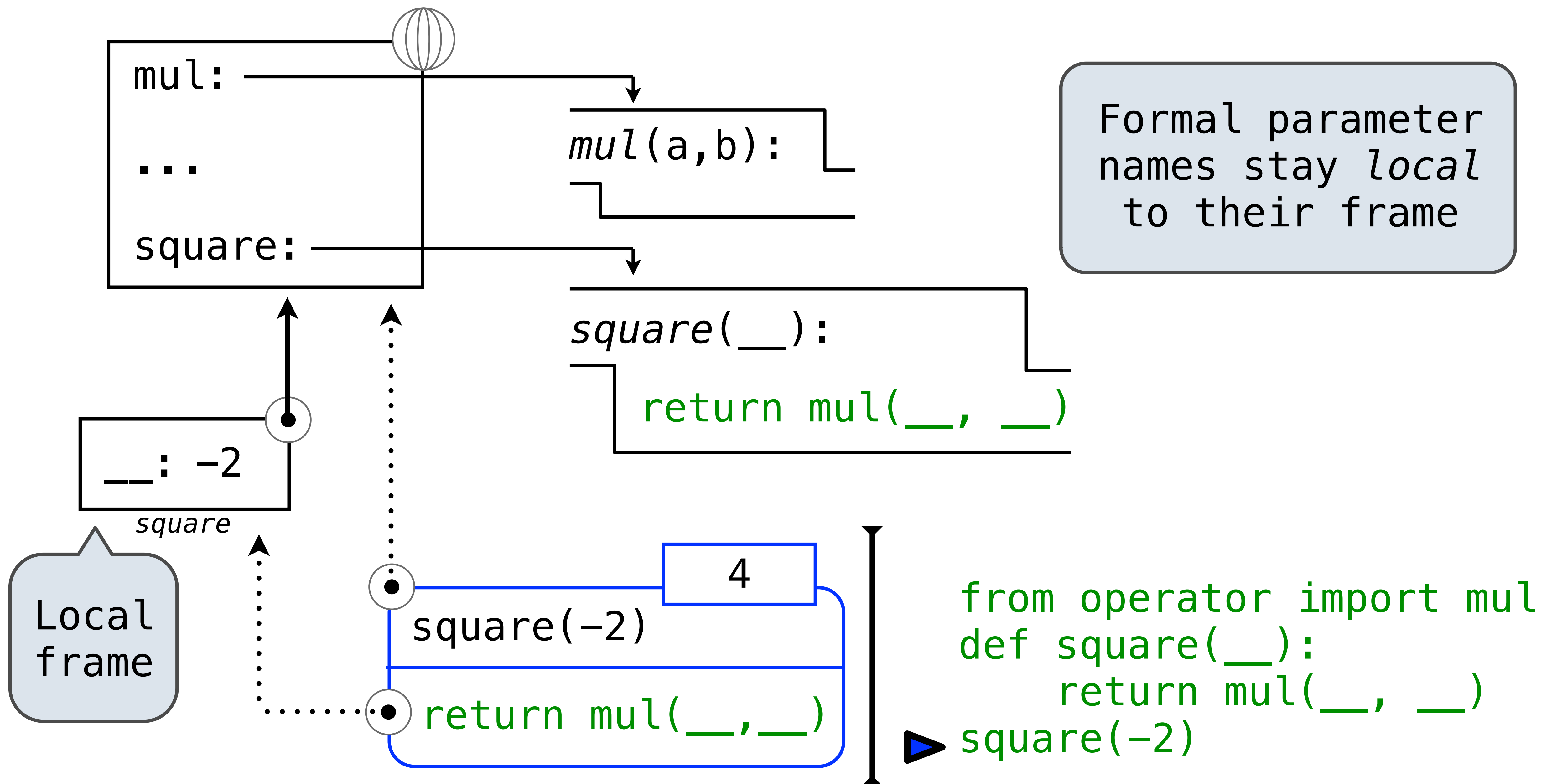
```
from operator import mul
def square(__):
    return mul(__, __)
square(-2)
```

Formal Parameters

```
def square(x):
    return mul(x, x)
```

vs

```
def square(y):
    return mul(y, y)
```



Shadowing Names

Careful!

```
def square(mul):
    return mul(mul, mul)
square(-2)
```

Shadowing Names

Careful!

```
def square(mul):
    return mul(mul, mul)
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```

If we use this formal parameter

Shadowing Names

Careful!

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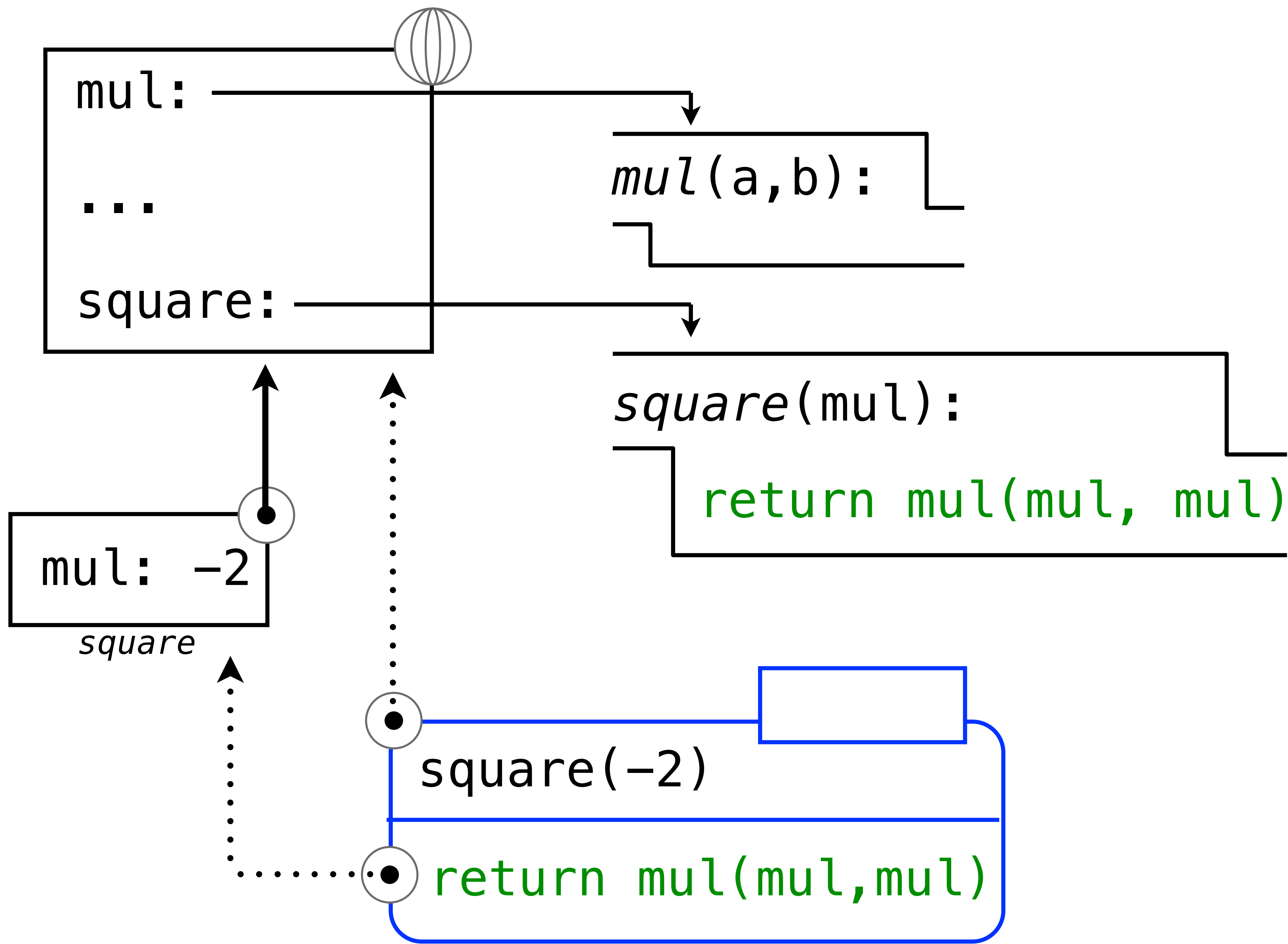
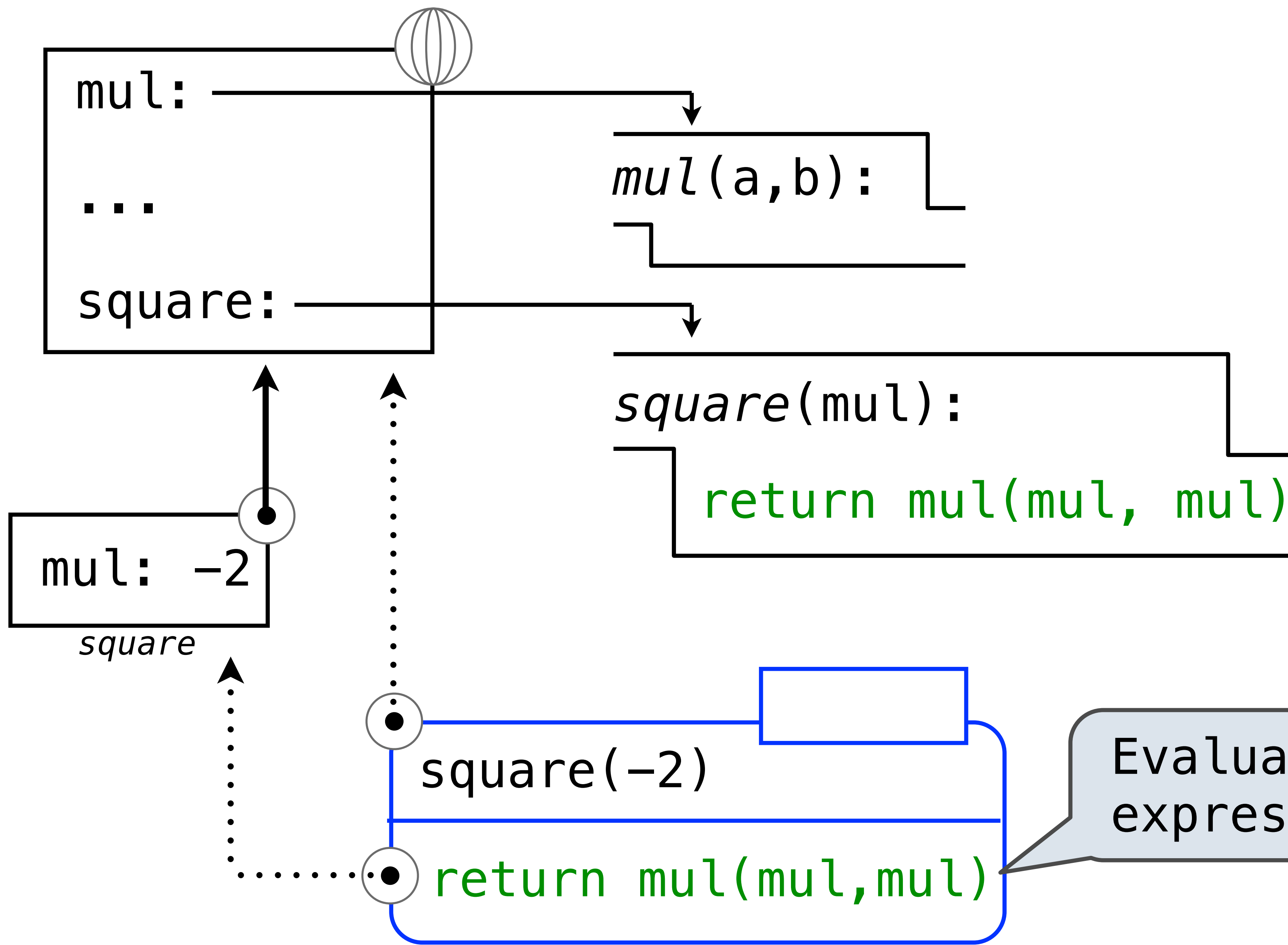


Shadowing Names

Careful!

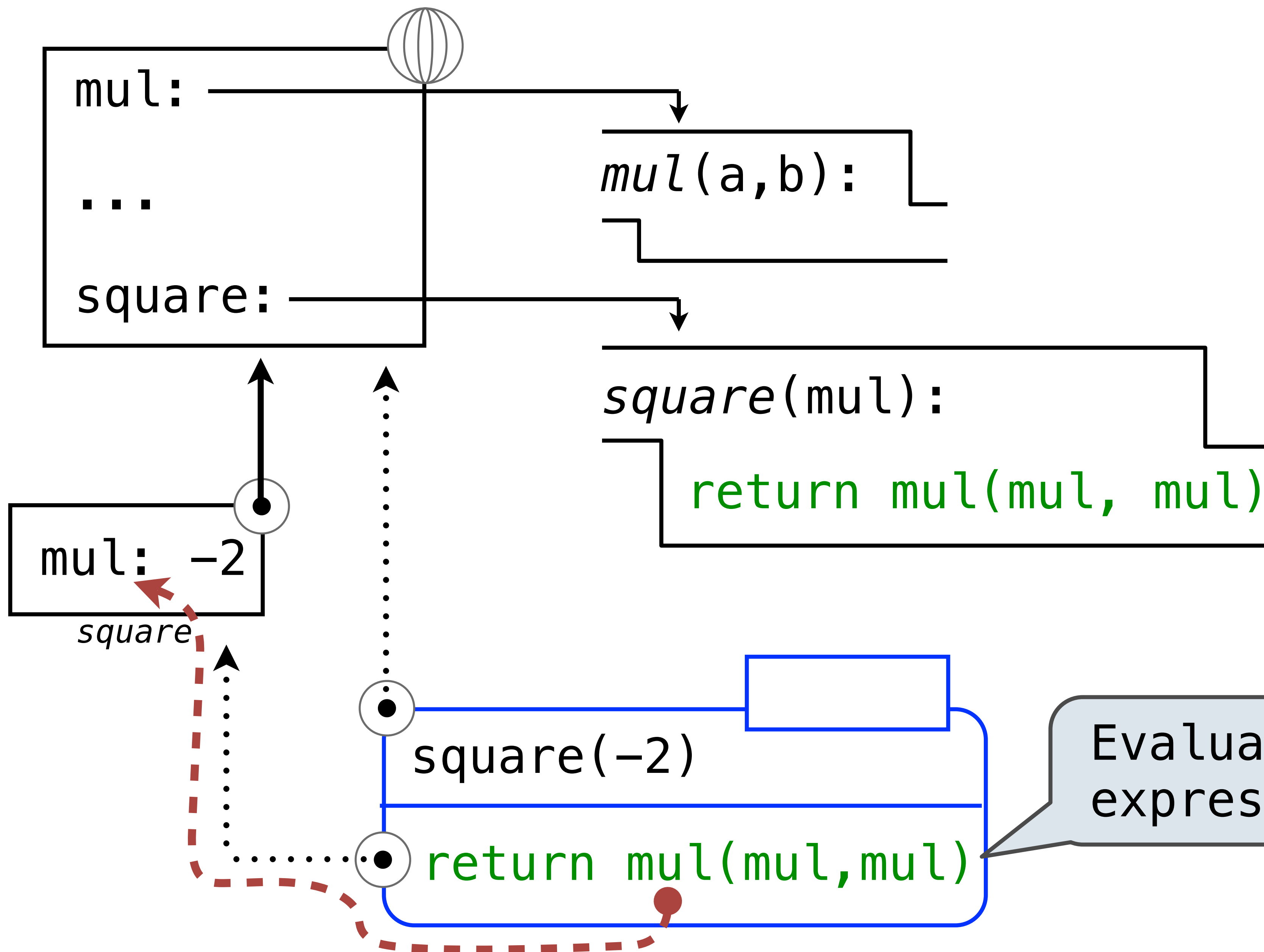
```
def square(mul):
    return mul(mul, mul)
square(-2)
```

If we use this formal parameter



Evaluating this call expression will fail

Shadowing Names



Python Feature Demonstration

<Demo>

Operators

Multiple Return Values

Docstrings

Doctests

Default Arguments

Statements

</Demo>

Statements

```
A statement
is executed by the interpret
to perform an action
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Statements

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```

Compound statements:

```
<header>:
    <statement>
    <statement>
    ...
<separating header>:
    <statement>
    <statement>
    ...
...
```

Statements

A statement
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Compound statements:

Statement

```
<header>:
    <statement>
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    ...
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    <statement>
    ...
...
```

Statements

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```
<header>:
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    <statement>
    ...
...
```

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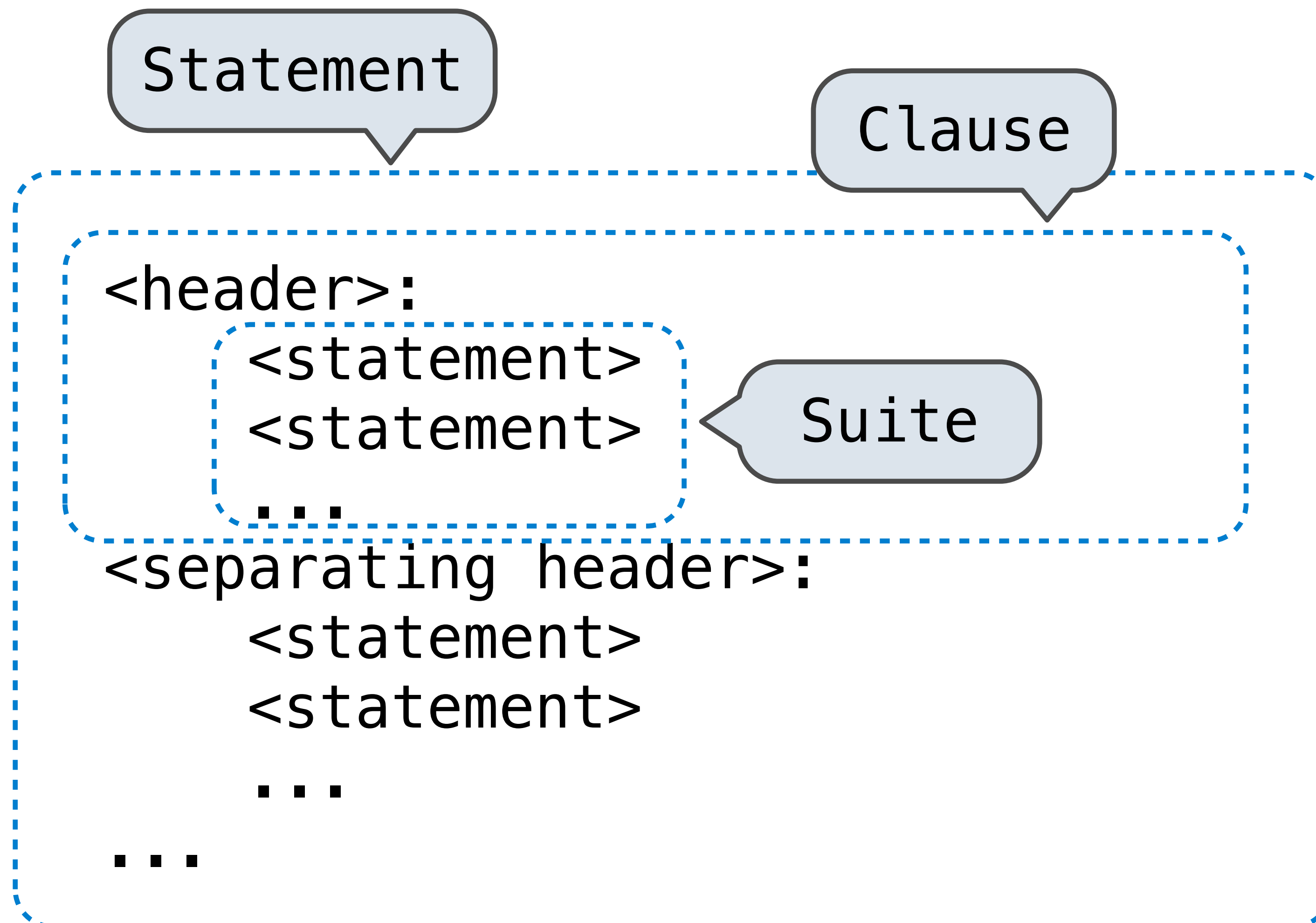
Compound statements:



Statements

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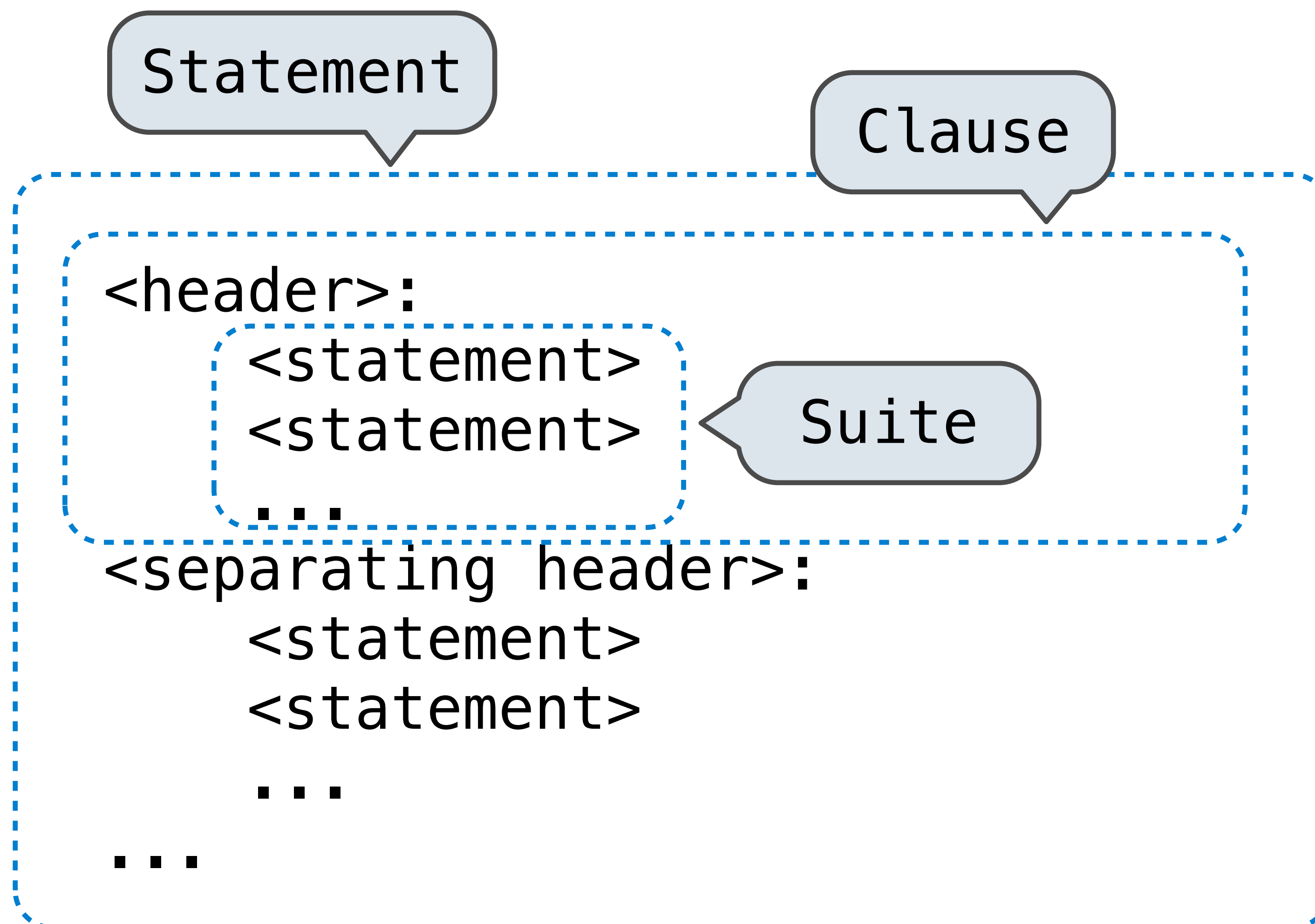

The first header determines a statement's type

Statements

A statement

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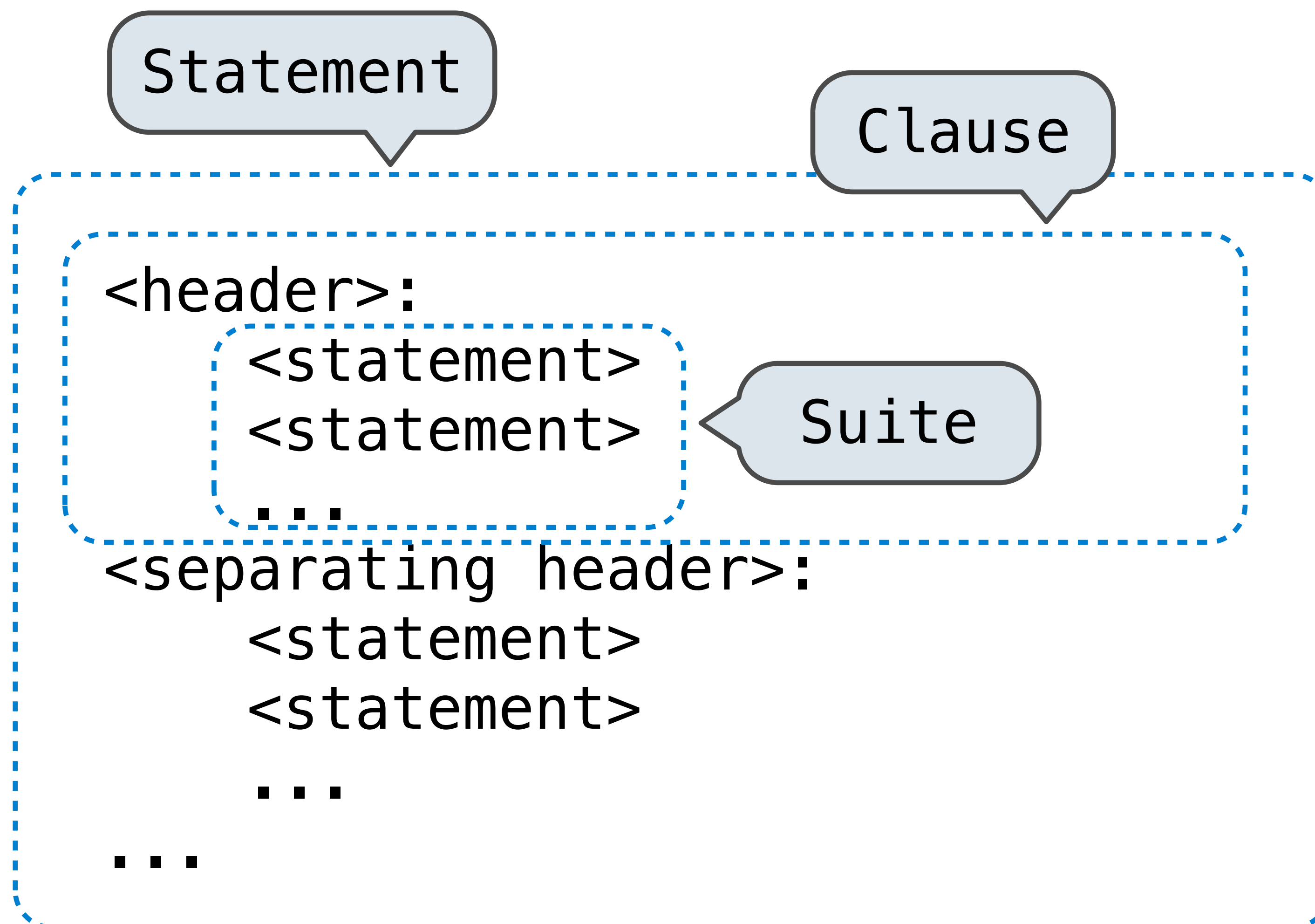
Compound statements:



The first header determines a statement's type

The header of a clause "controls" the suite that follows

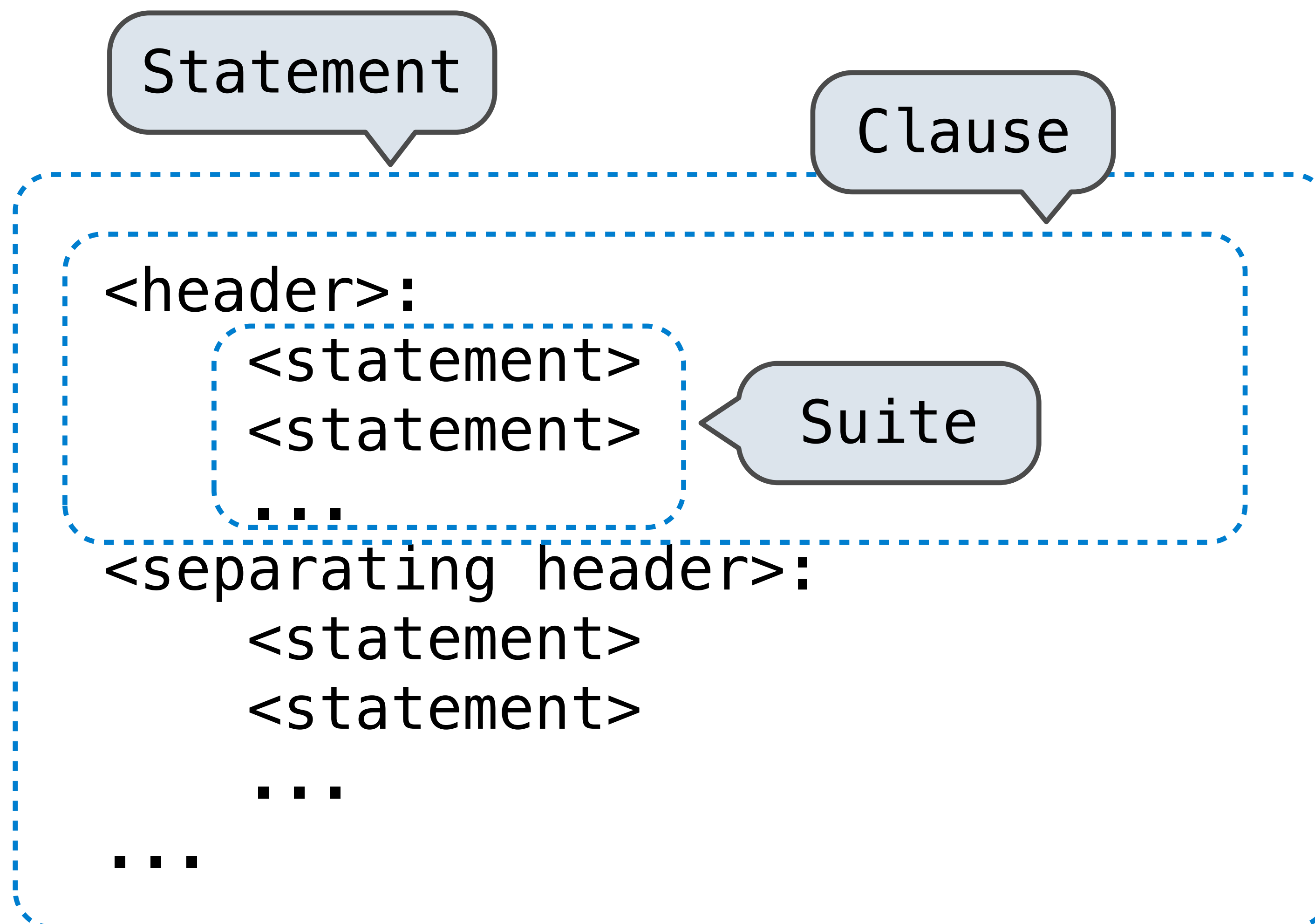
Statements

A statement

is executed by the interpret

to perform an action

Compound statements:



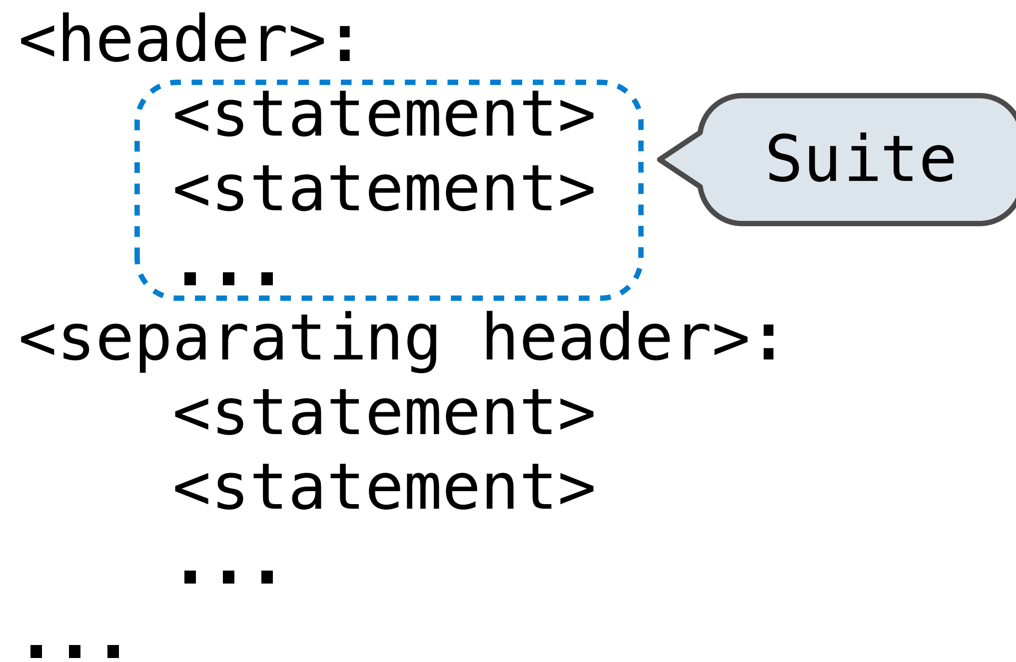
The first header determines a statement's type

The header of a clause "controls" the suite that follows

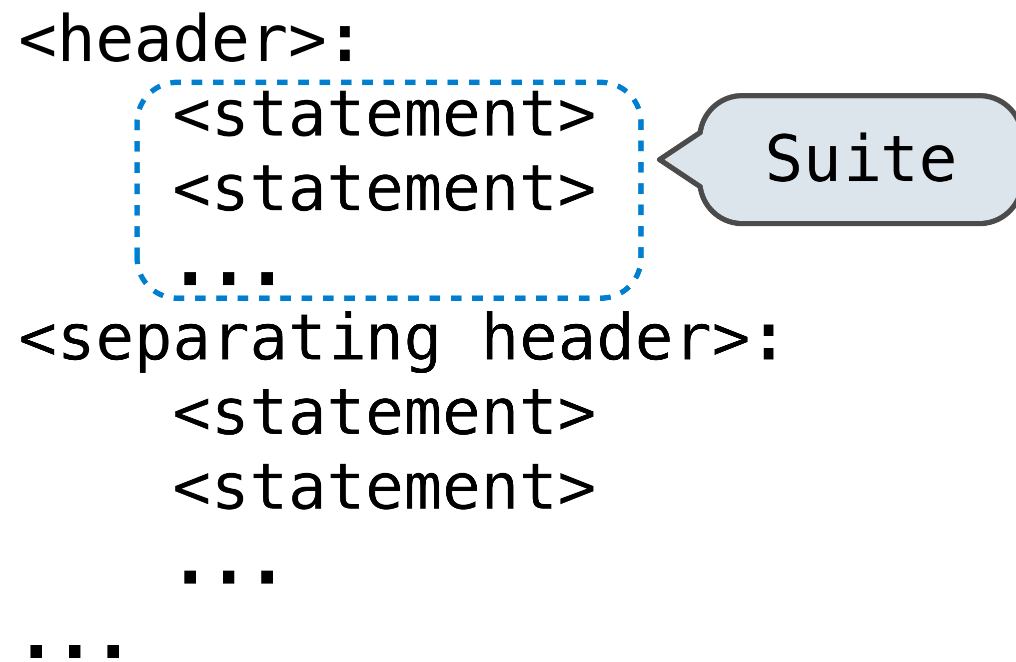
def statements are compound statements

Compound Statements

Compound statements:



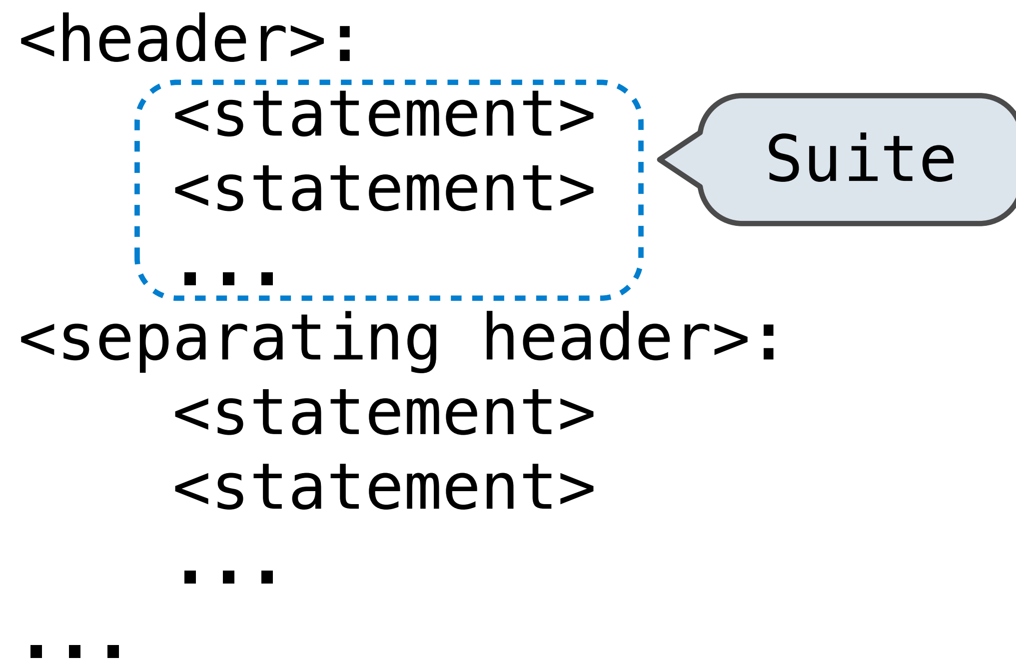
Compound Statements



A suite is a sequence of statements

Compound Statements

Compound statements:

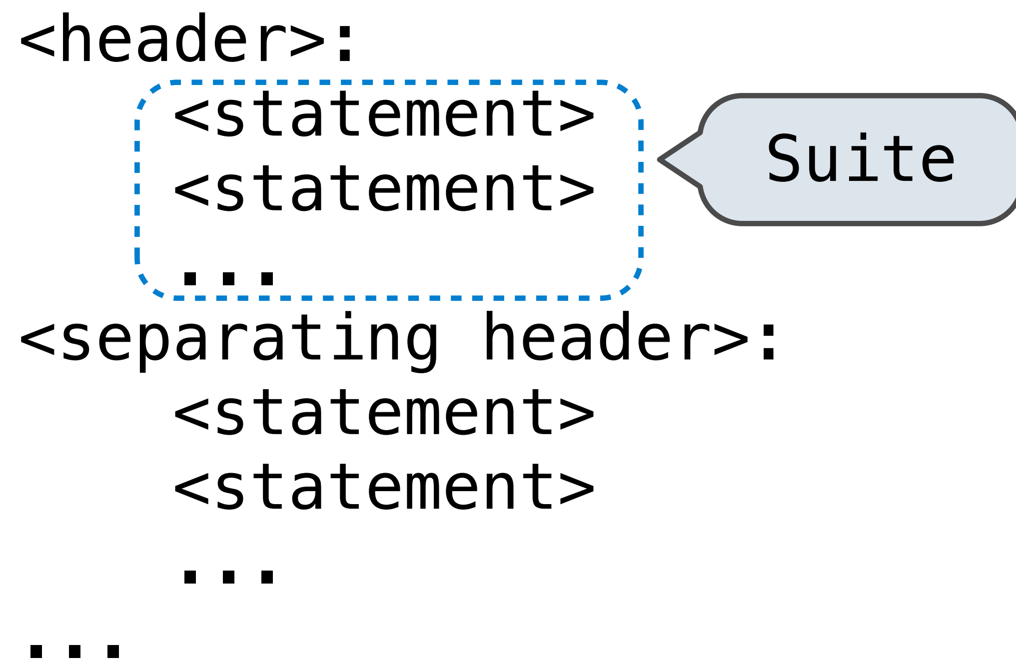


A suite is a sequence of statements

To “execute” a suite means to execute its sequence of statements, in order

Compound Statements

Compound statements:



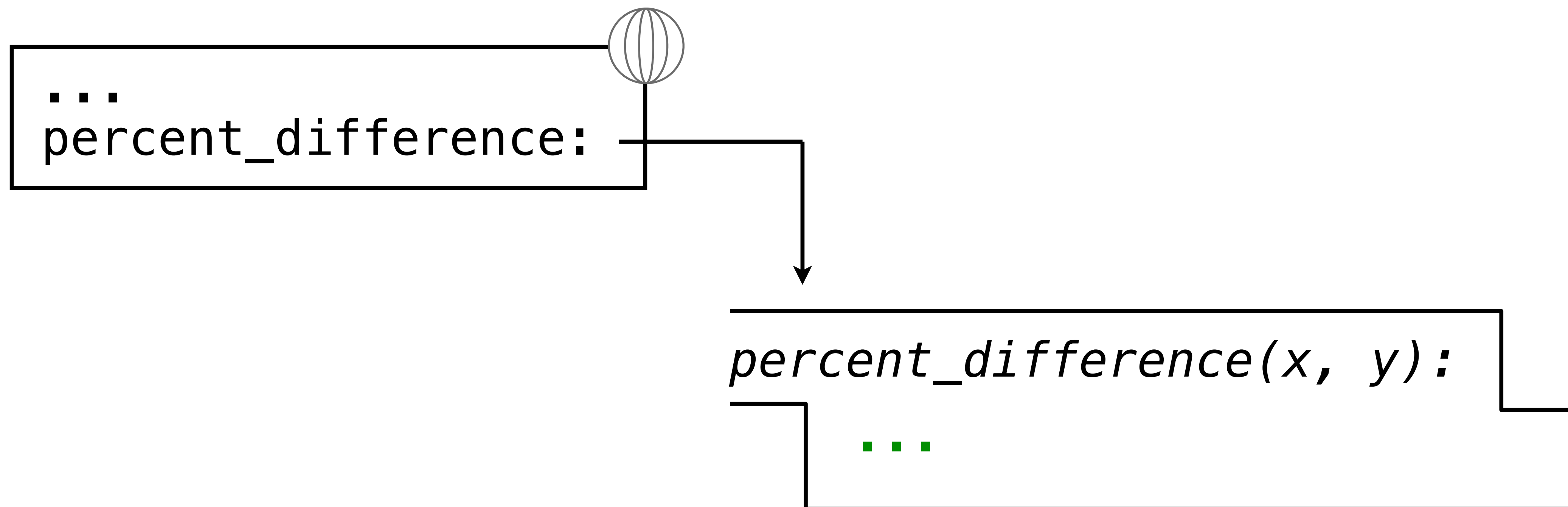
A suite is a sequence of statements

To "execute" a suite means to execute its sequence of statements, in order

Execution Rule for a sequence of statements:

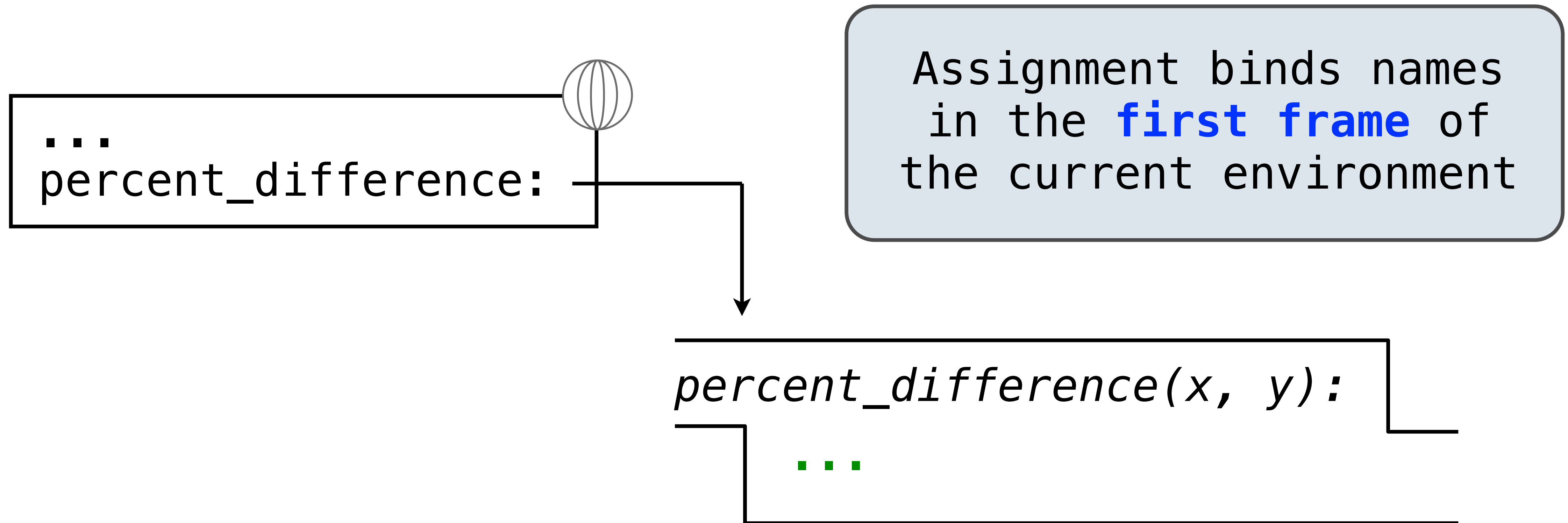
- Execute the first
- Unless directed otherwise, execute the rest

Local Assignment




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

Local Assignment

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percent_difference(40, 50)
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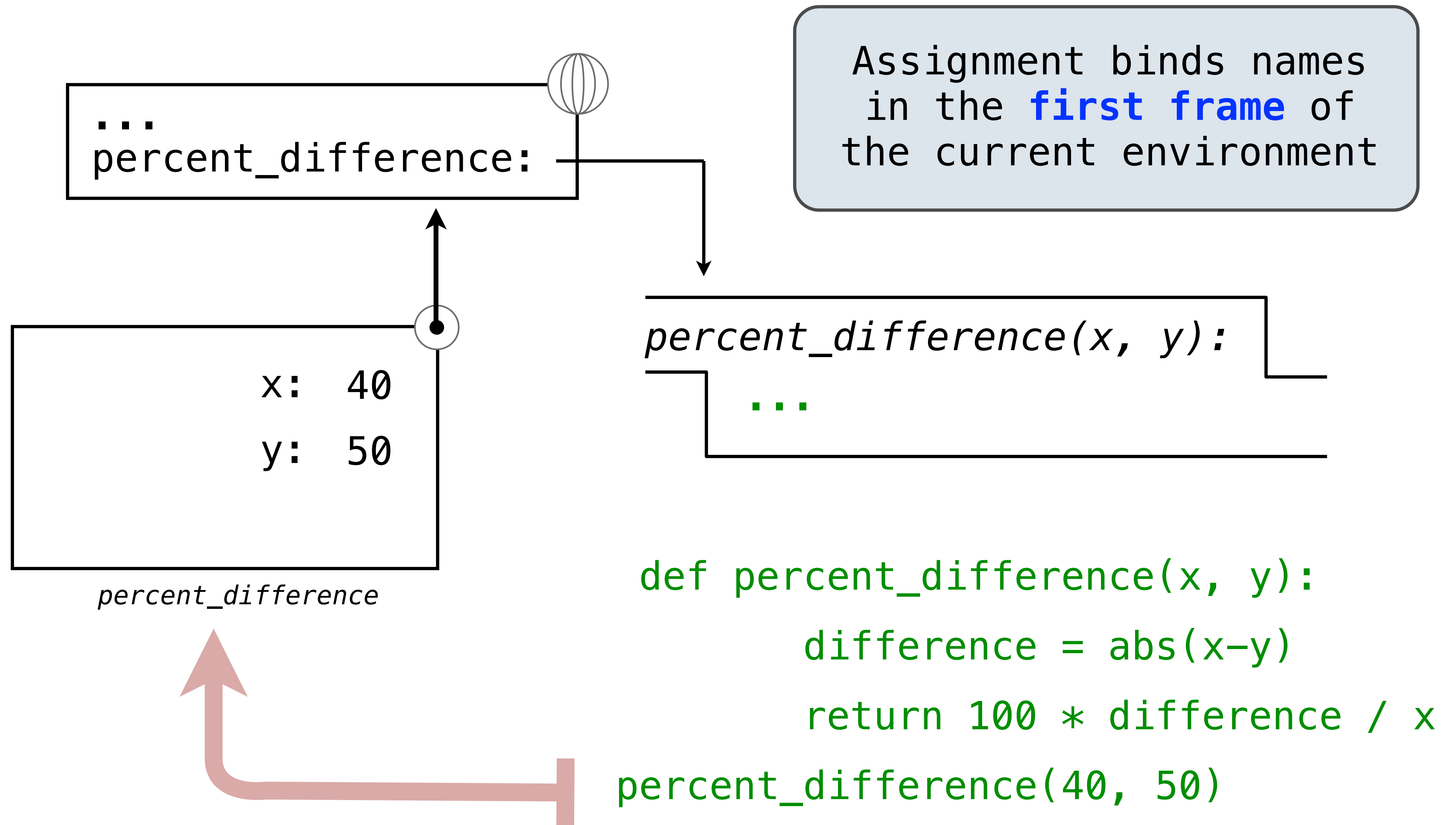
Local Assignment



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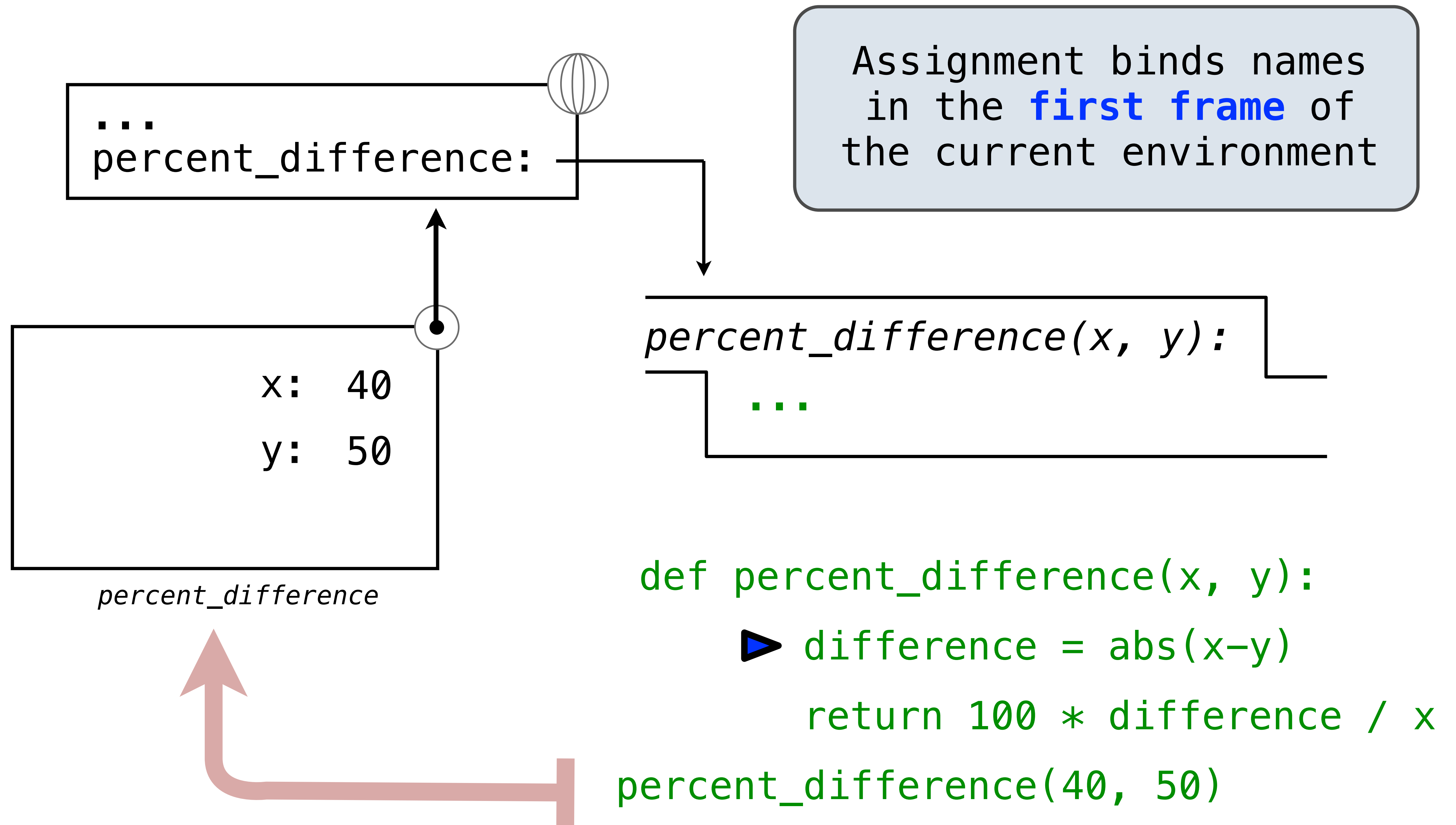

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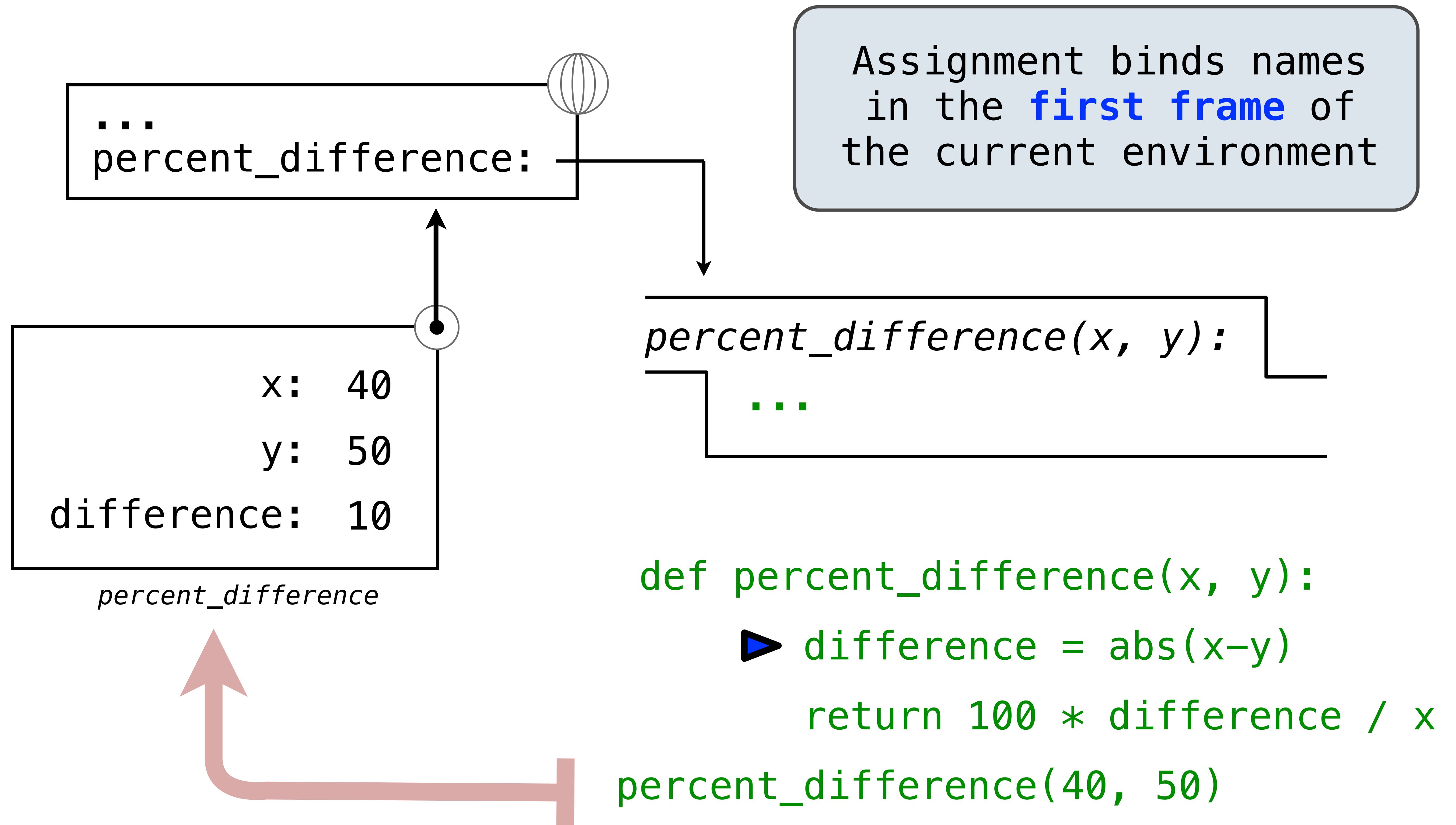

Conditional Statements

```
def absolute_value(x):
        """Return the absolute value of x."""
        if x > 0:
            return x
        elif x == 0:
            return 0
        else:
            return -x
```

Conditional Statements

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def absolute_value(x):
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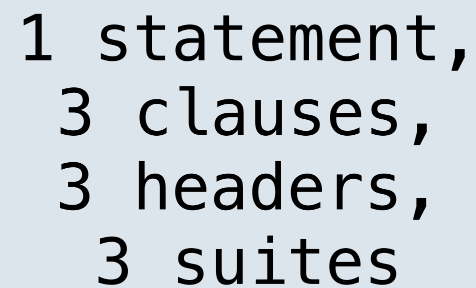
```

1 statement,
3 clauses,
3 headers,
3 suites

Execution rule for conditional statements:

Conditional Statements




```
def absolute_value(x):
        """Return the absolute value of x."""
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            return -x
```

Execution rule for conditional statements:

Each clause is considered in order.

1. Evaluate the header's expression.

2. If it is a true value, execute the suite & skip the rest.

Boolean Contexts

```
def absolute_value(x):
        """Return the absolute value of x."""
        if x > 0:
            return x
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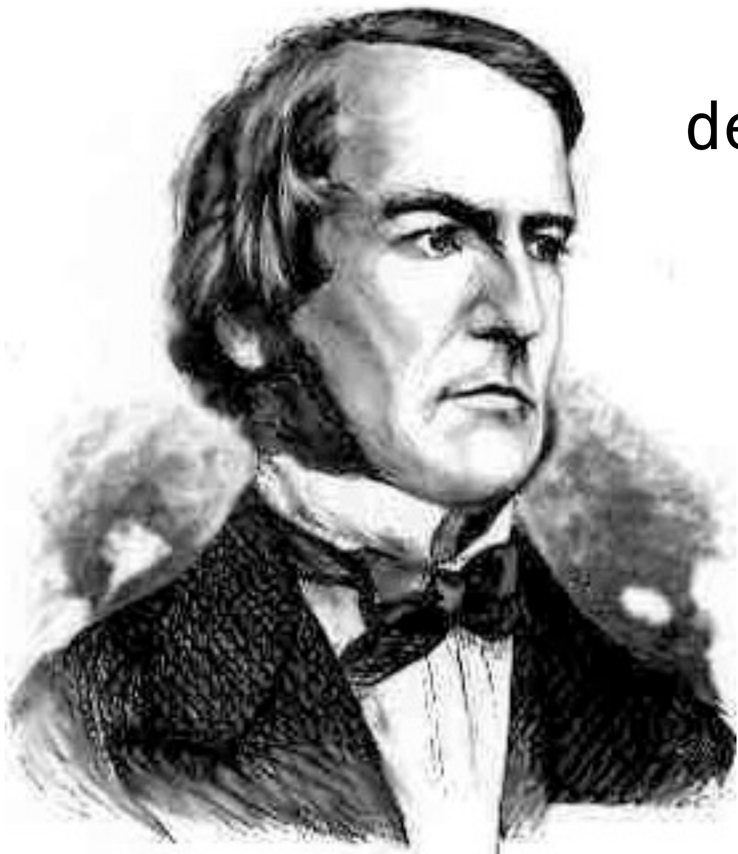
```

George Boole

Boolean Contexts



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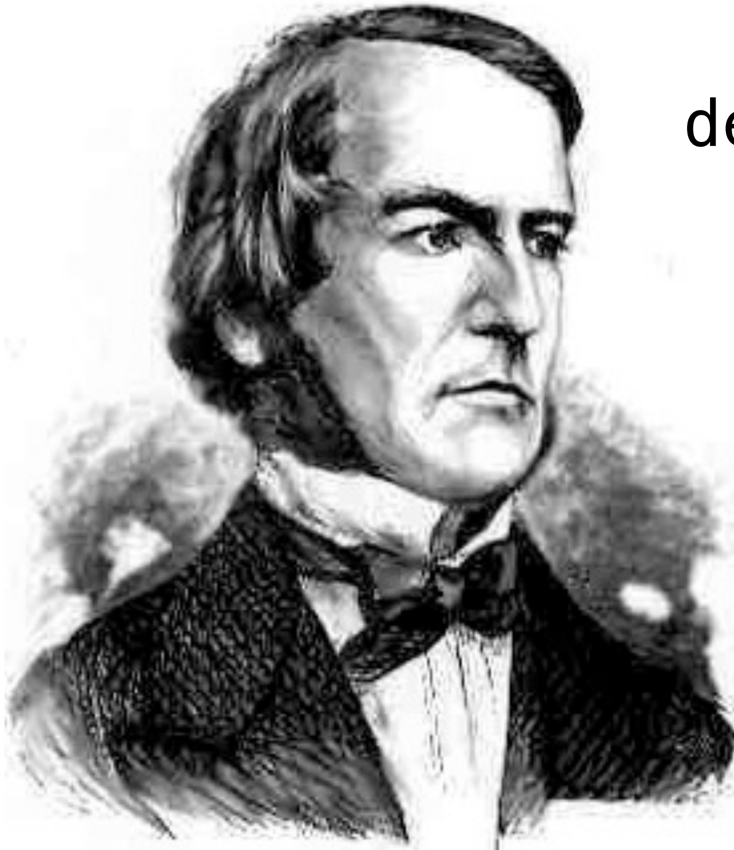

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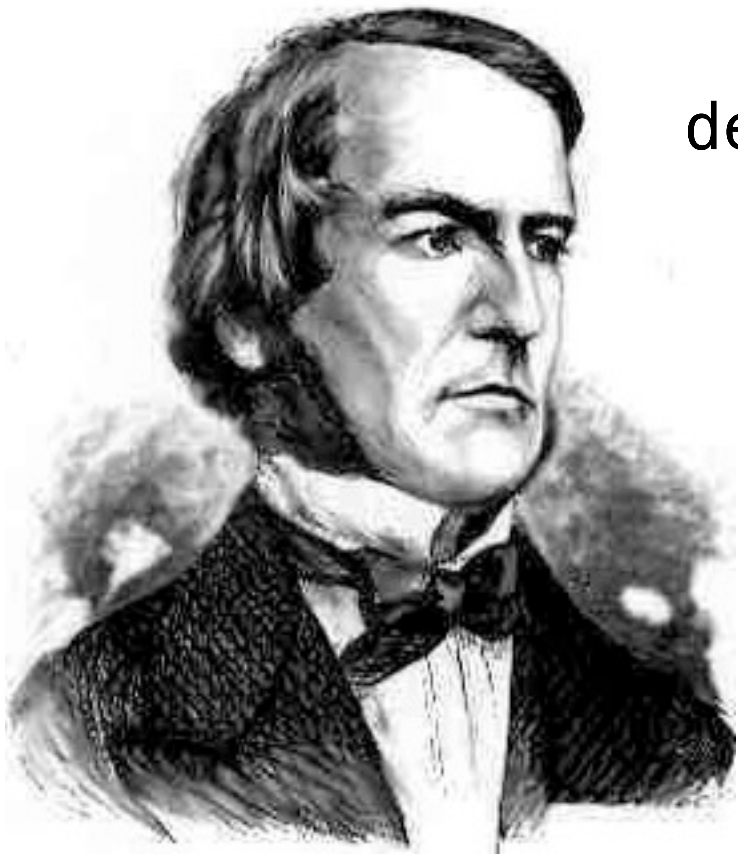
Two boolean contexts

Boolean Contexts



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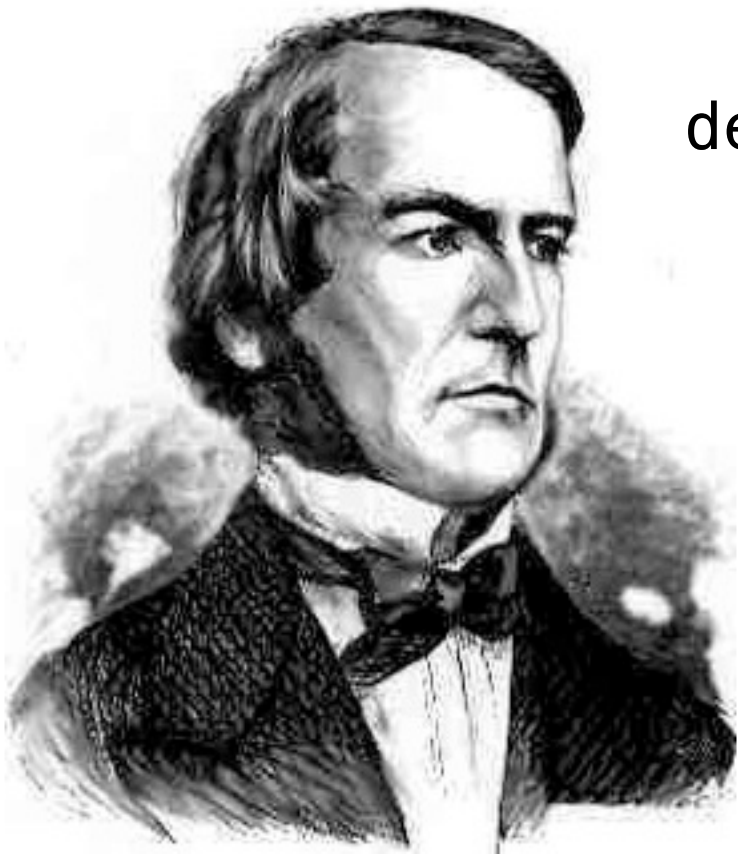
Two boolean contexts

Boolean Contexts



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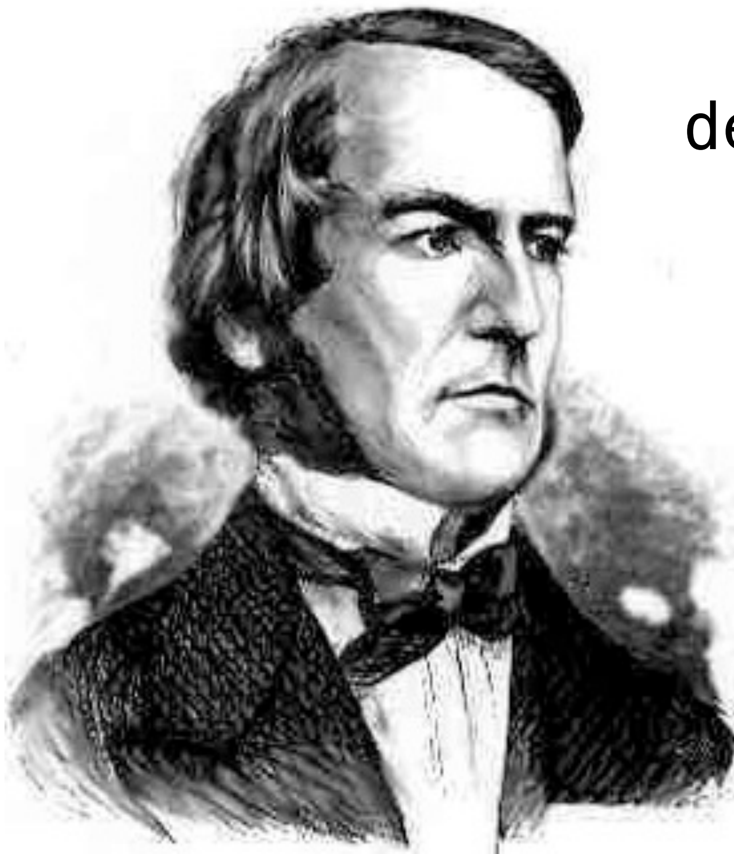

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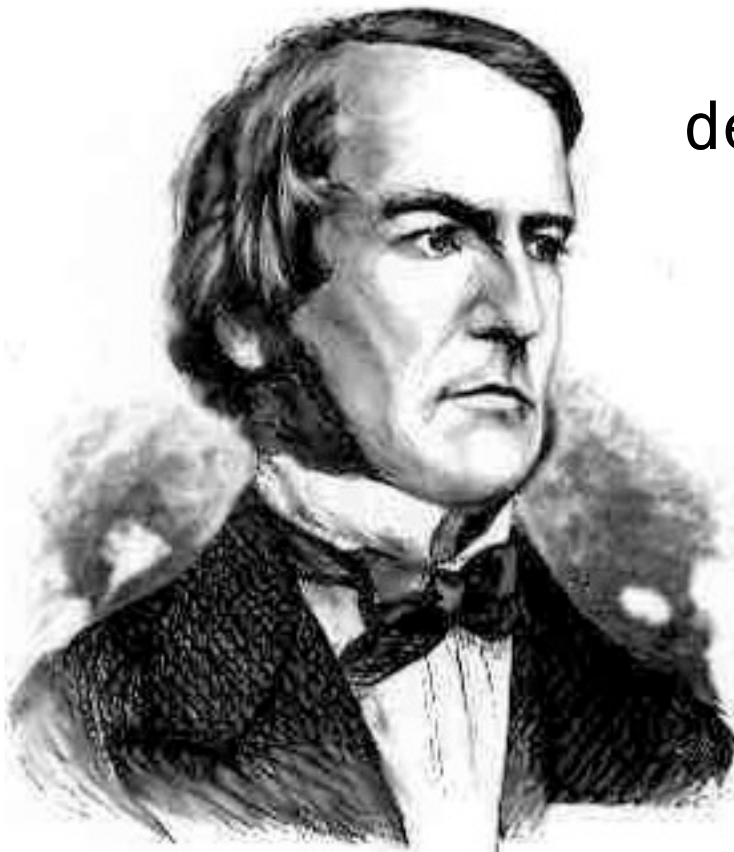
```

Two boolean contexts

False values in Python: False, 0, ‘’, None

Boolean Contexts



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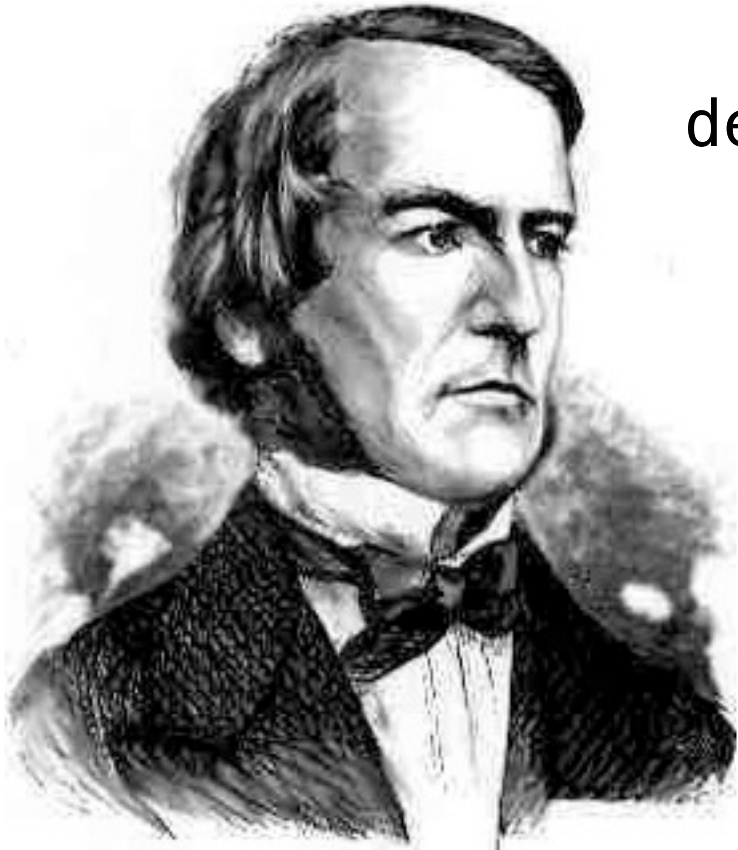
Two boolean contexts

False values in Python: False, 0, ‘’, None *(more to come)*

Boolean Contexts



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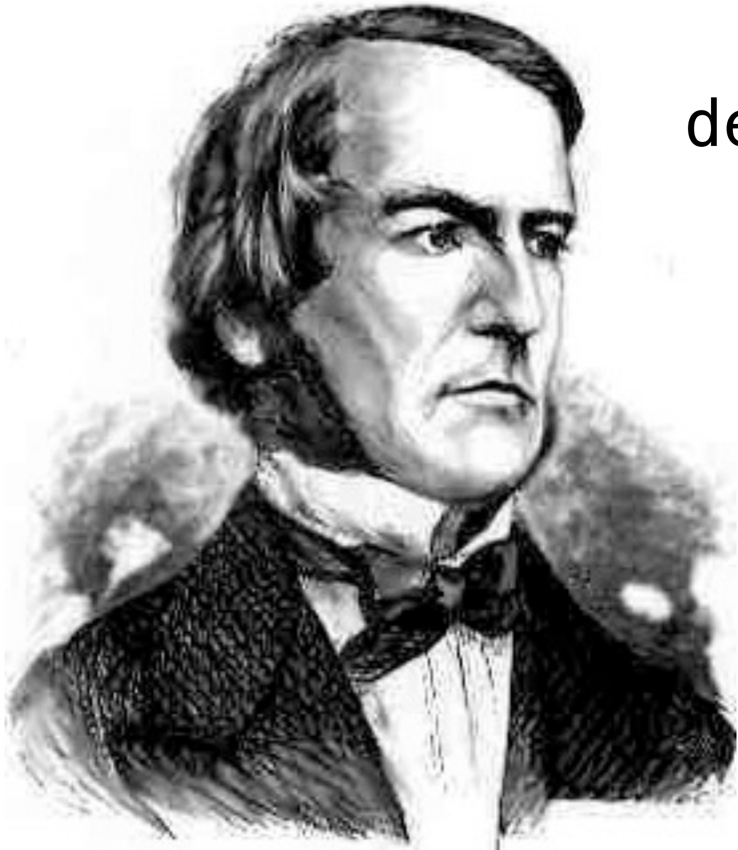
Two boolean contexts

False values in Python: False, 0, ‘’, None *(more to come)*

True values in Python: Anything else (True)

Boolean Contexts



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```

Two boolean contexts

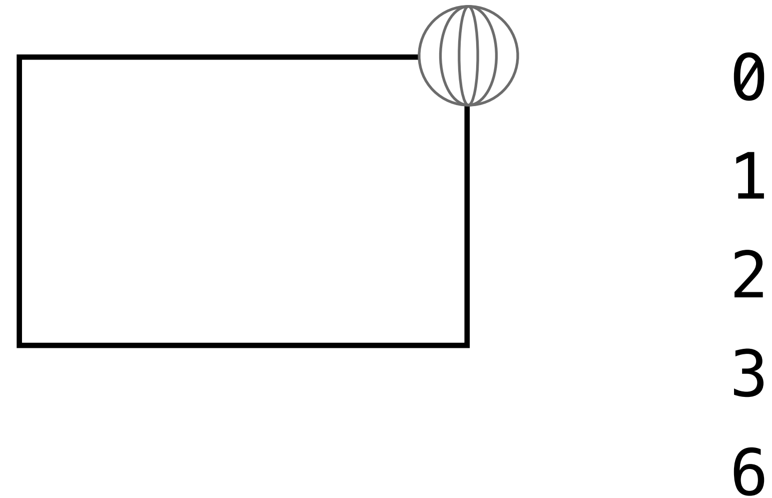
False values in Python: False, 0, ‘’, None *(more to come)*

True values in Python: Anything else (True)

Read Section 1.5.4!

Iteration

```
i, total = 0, 0
while i < 3:
    i = i + 1
    total = total + i
```



0
1
2
3
6

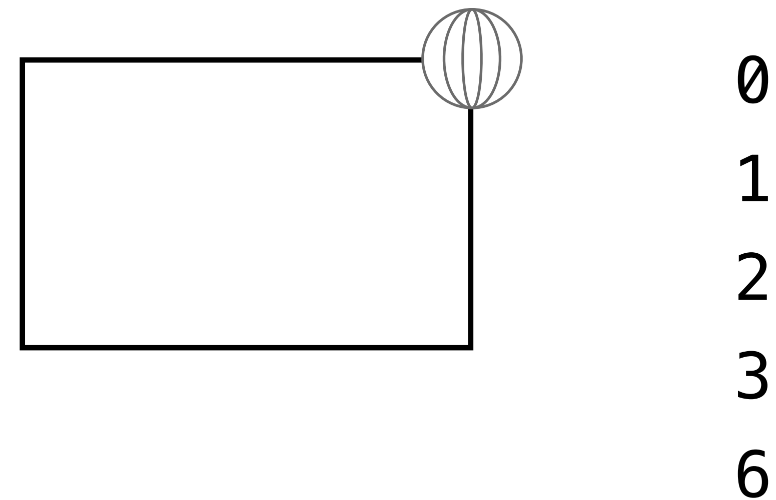
Execution rule for while statements:

1. Evaluate the header's expression.

2. If it is a true value,
   execute the (*whole*) suite,
   then return to step 1.

Iteration

```
i, total = 0, 0
while i < 3:
    i = i + 1
    total = total + i
```



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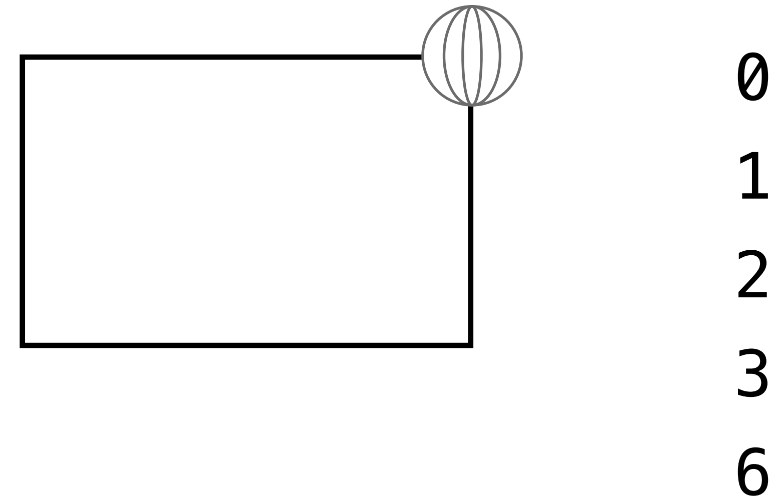

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Iteration

```
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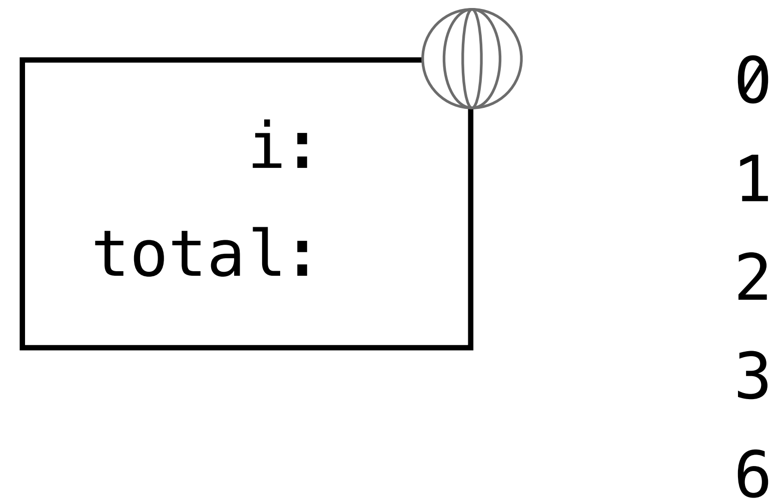
```



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1
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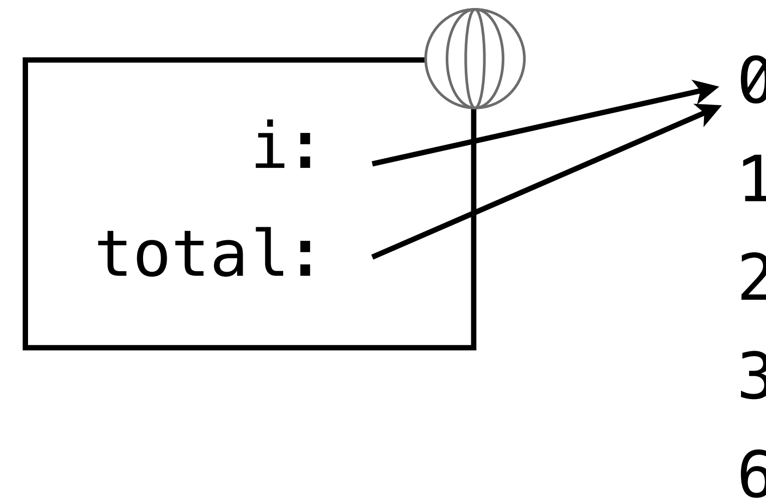

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Iteration

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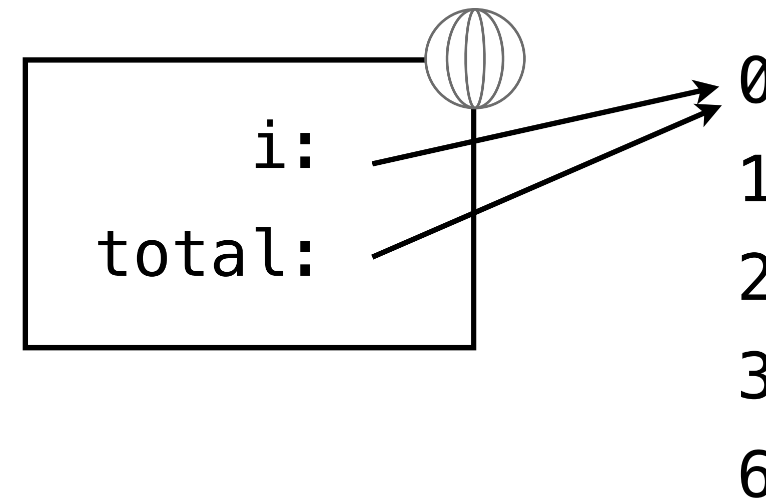

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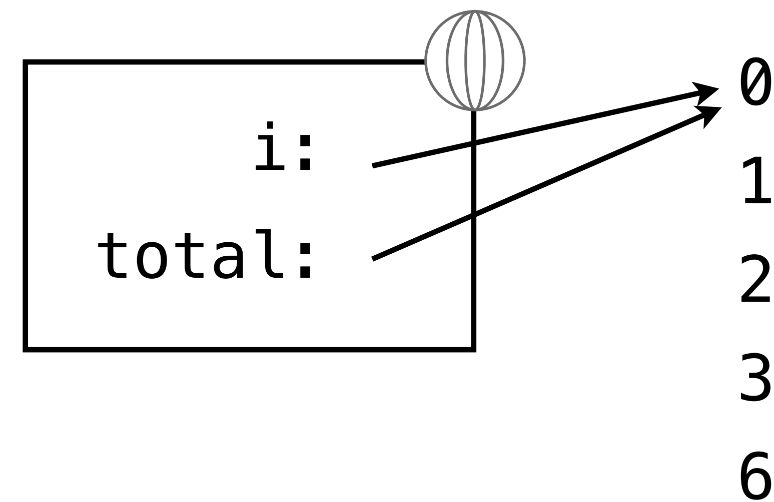

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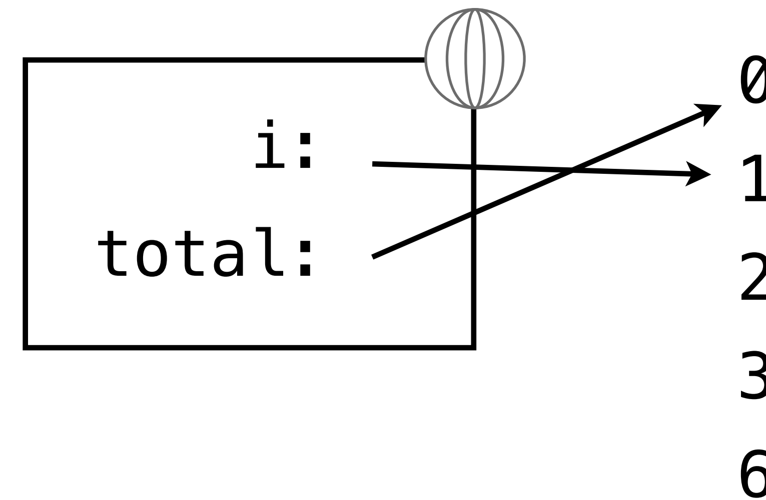

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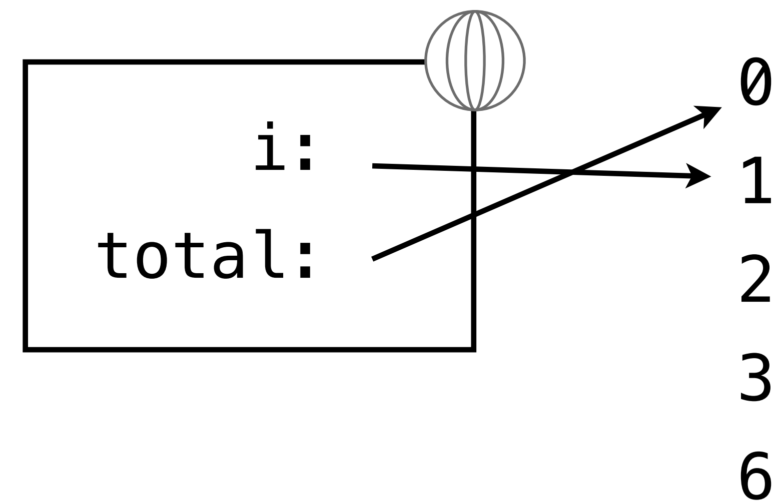

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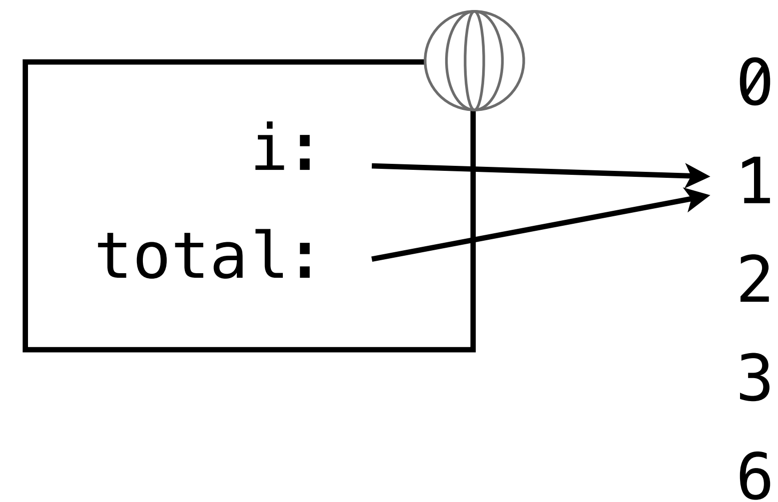

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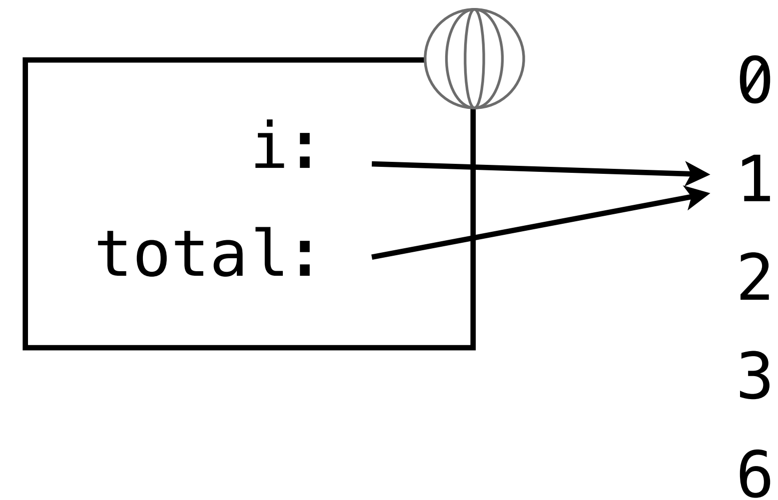

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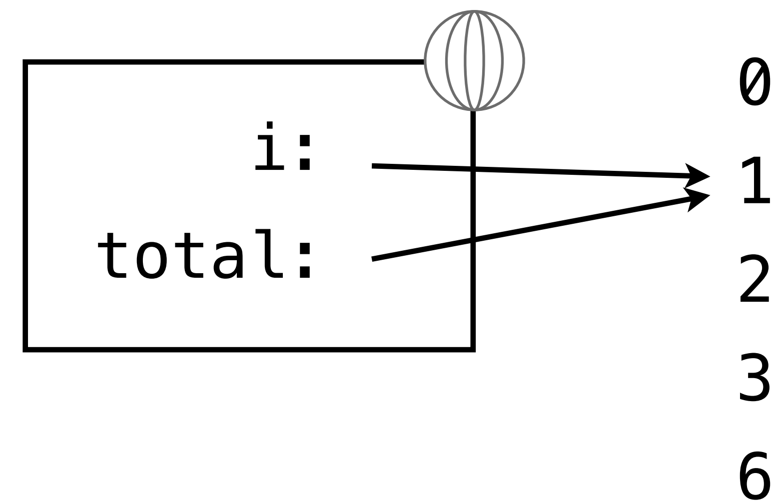

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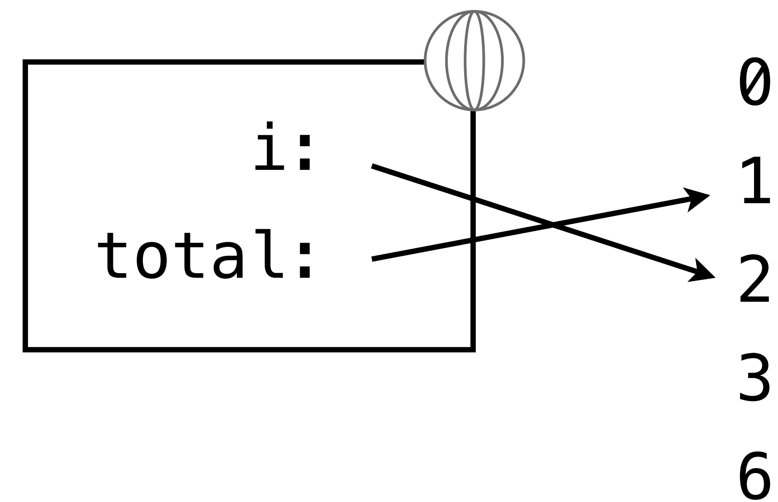

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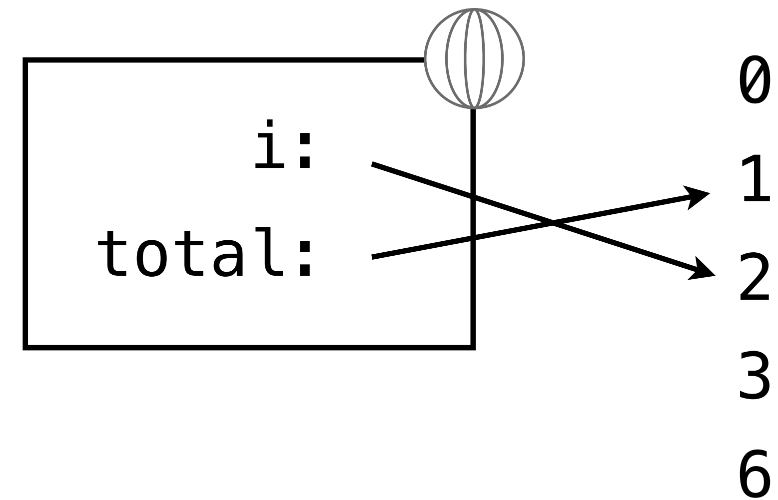

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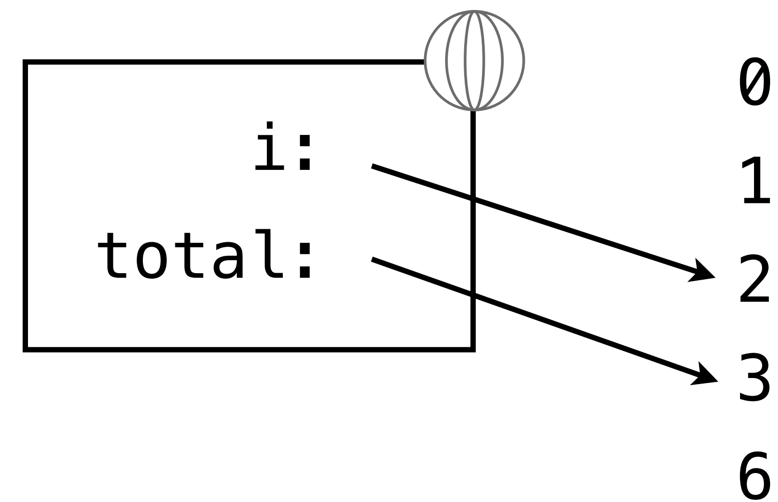

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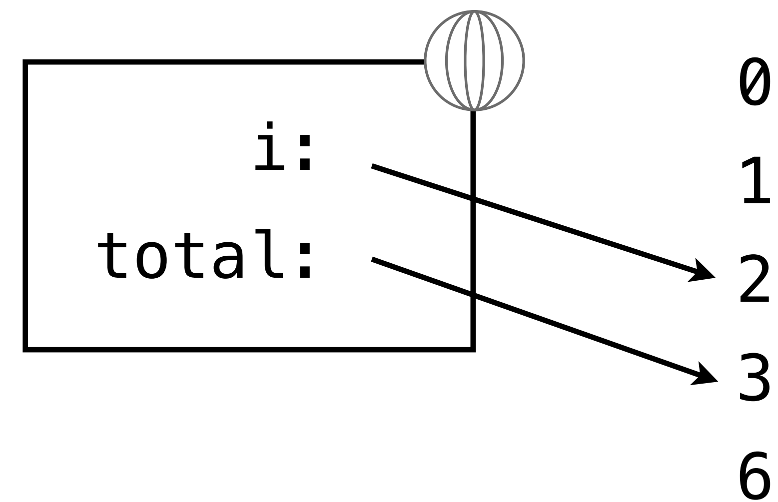

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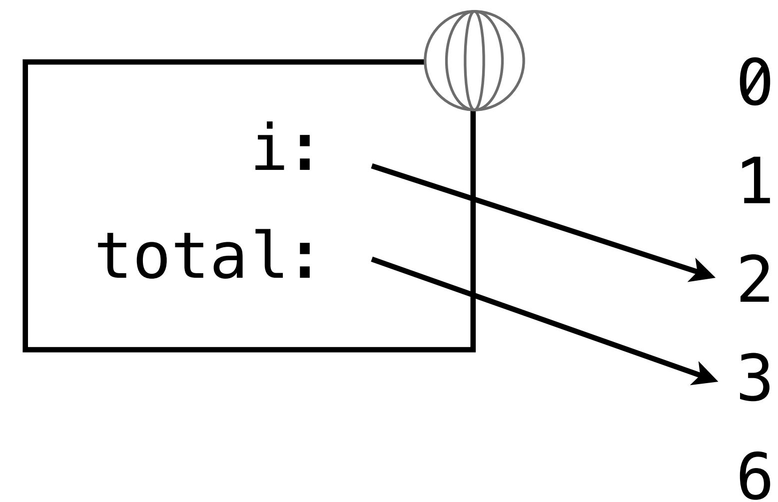

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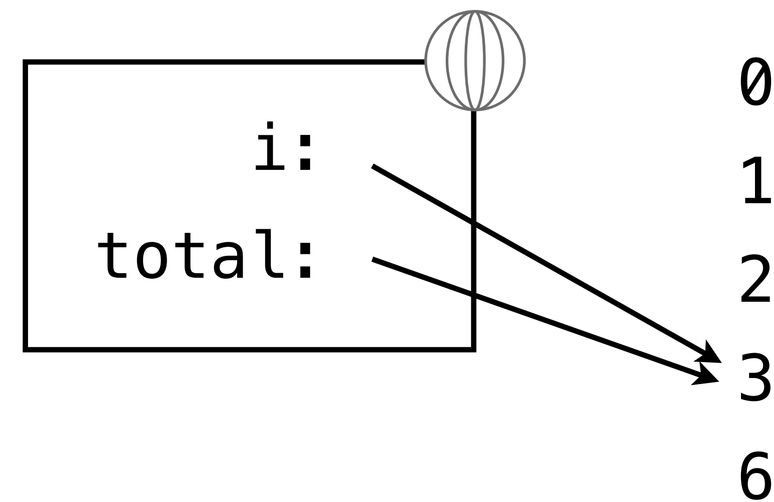

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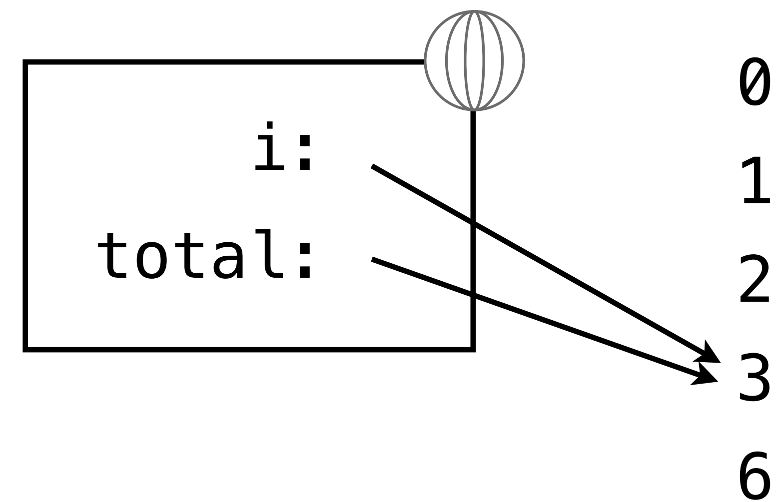

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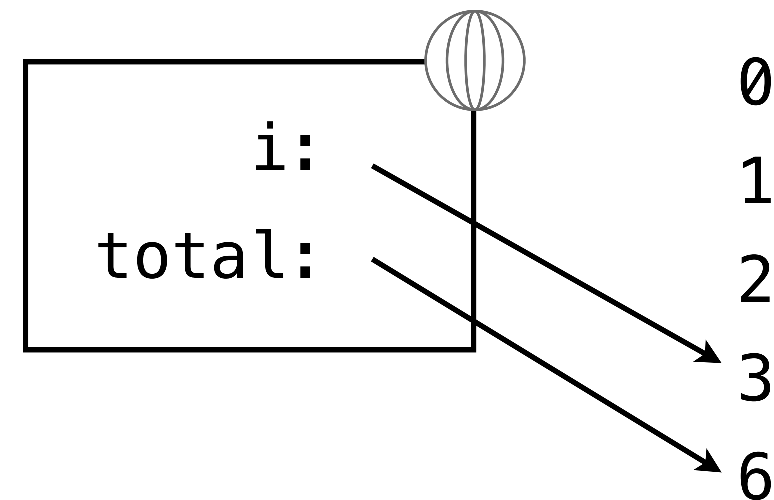

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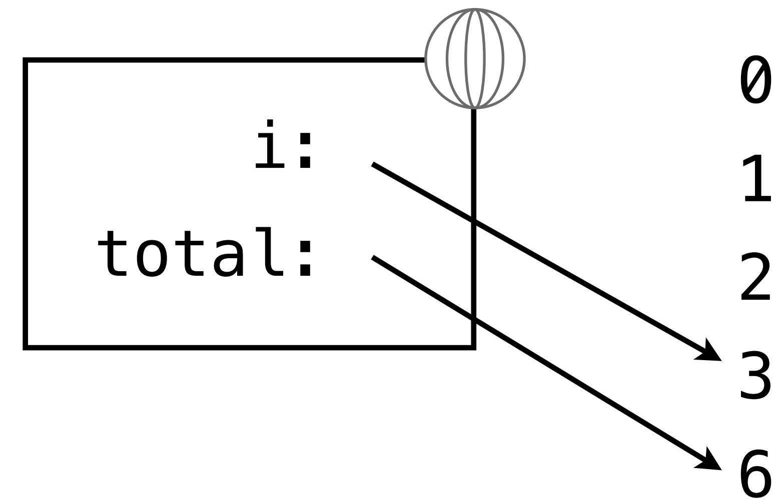

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The Fibonacci Sequence

The Fibonacci Sequence

0, 1, 1, 2, 3, 5, 8, 13, ...

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def fib(n):
    """Compute the nth Fibonacci number, for n >= 2."""
    pred, curr = 0, 1   # First two Fibonacci numbers
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    while k < n:
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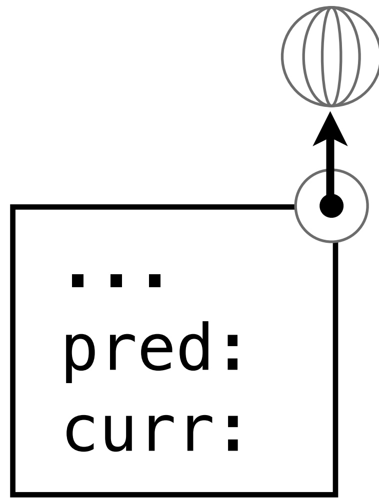

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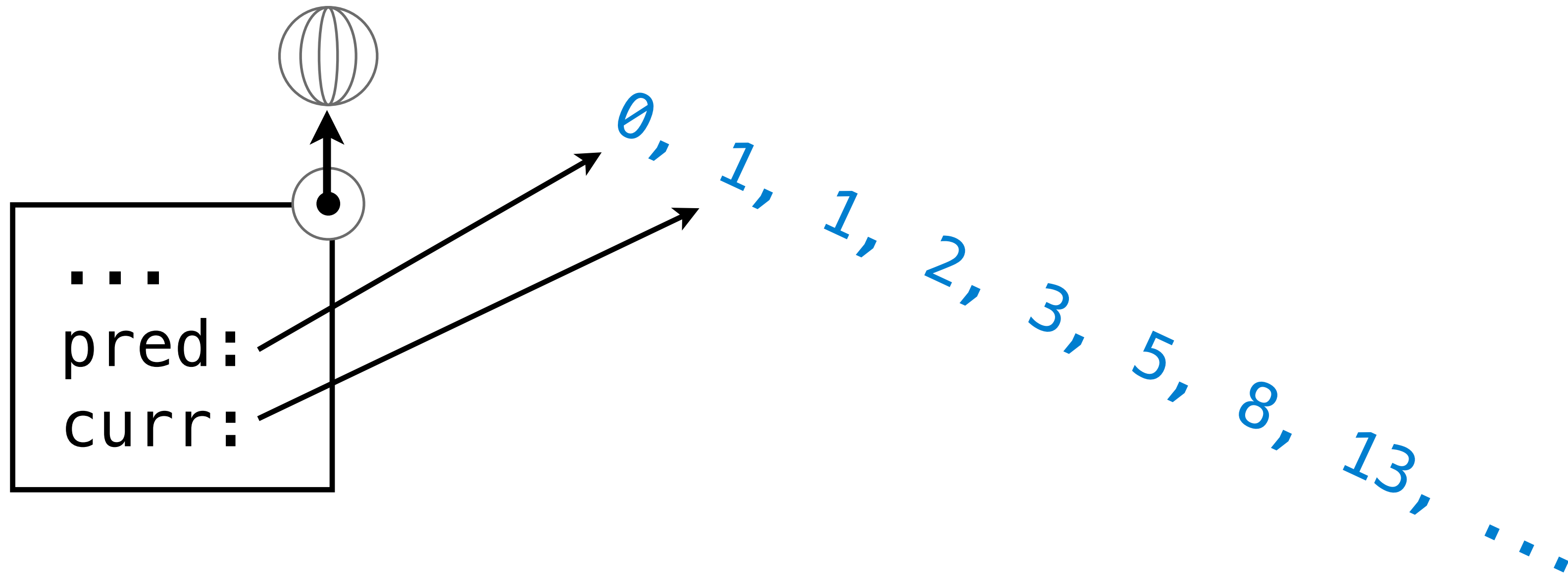


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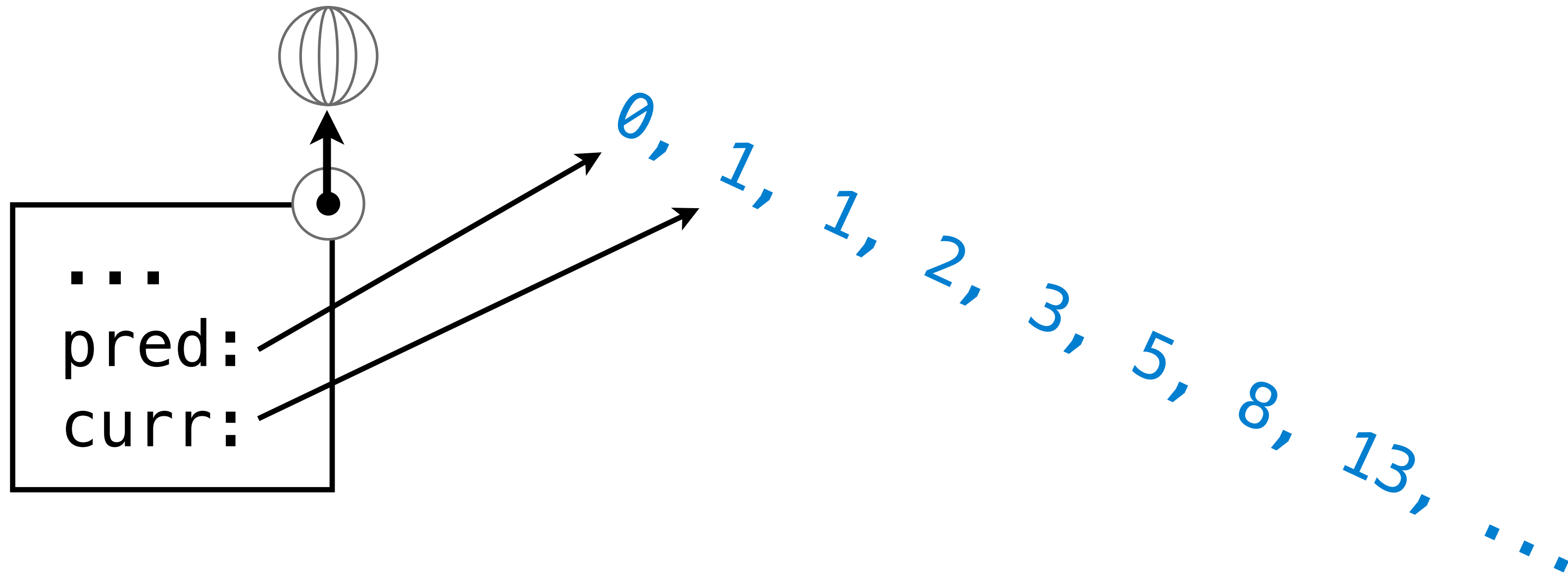


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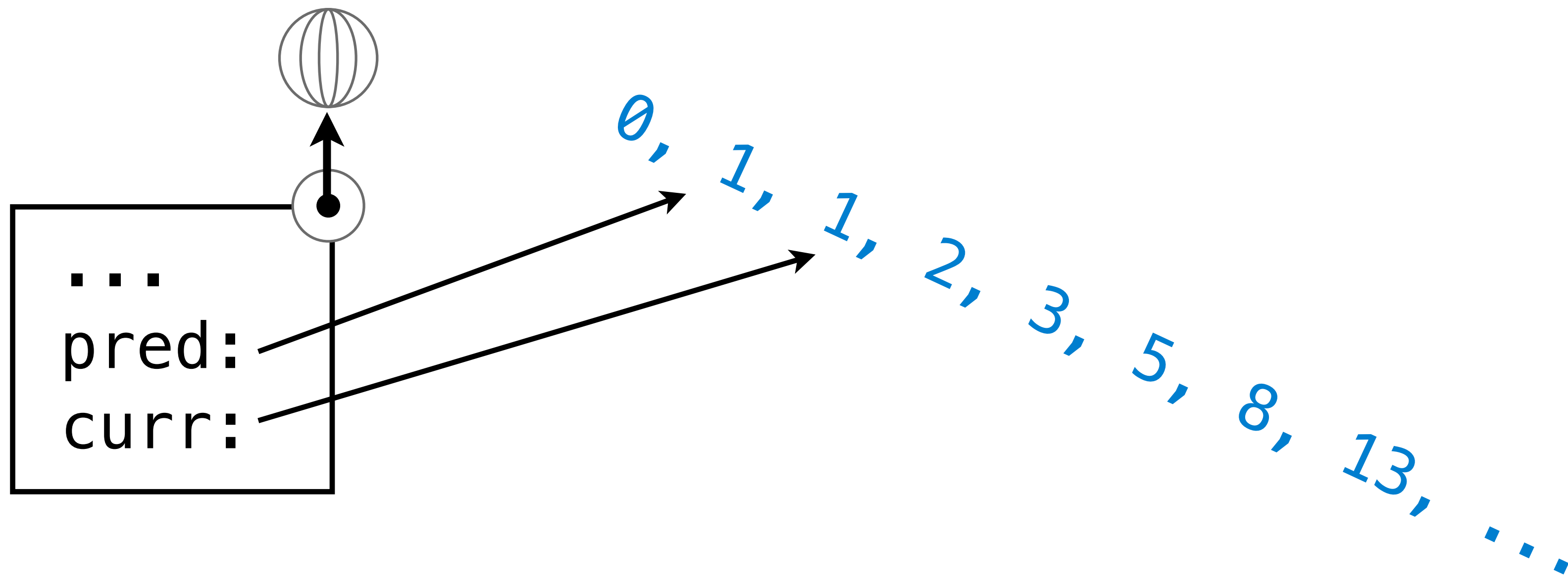


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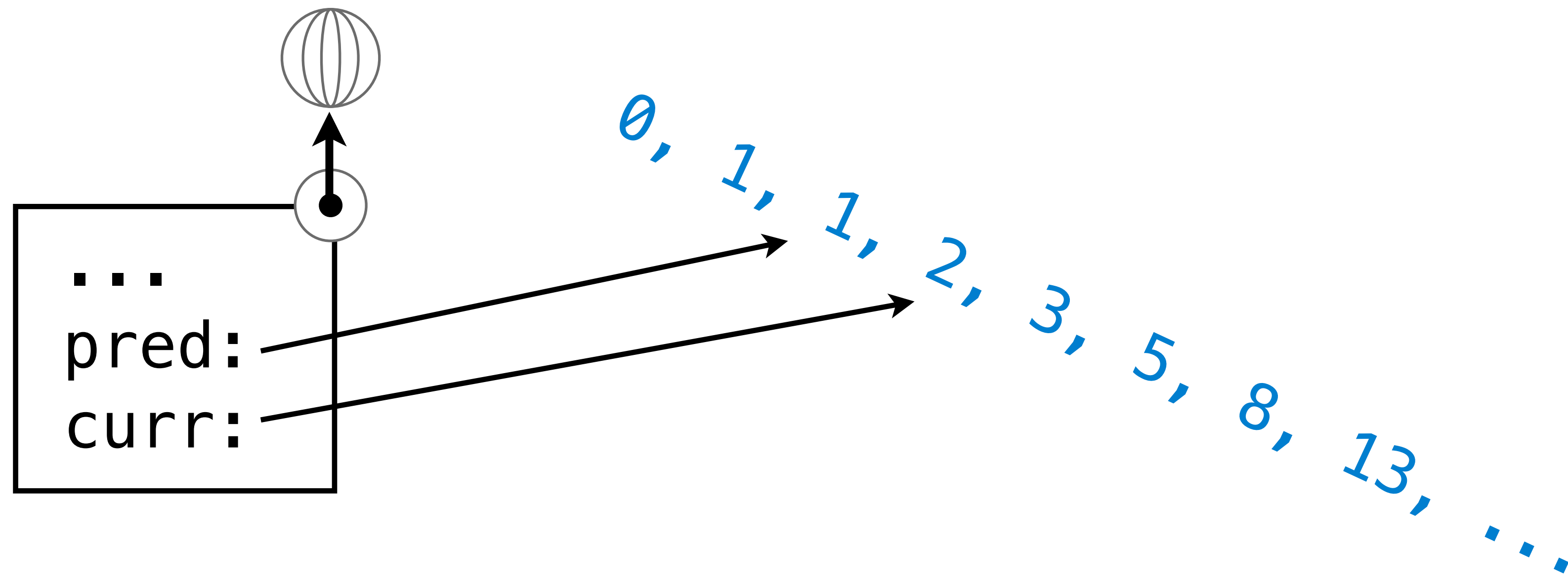


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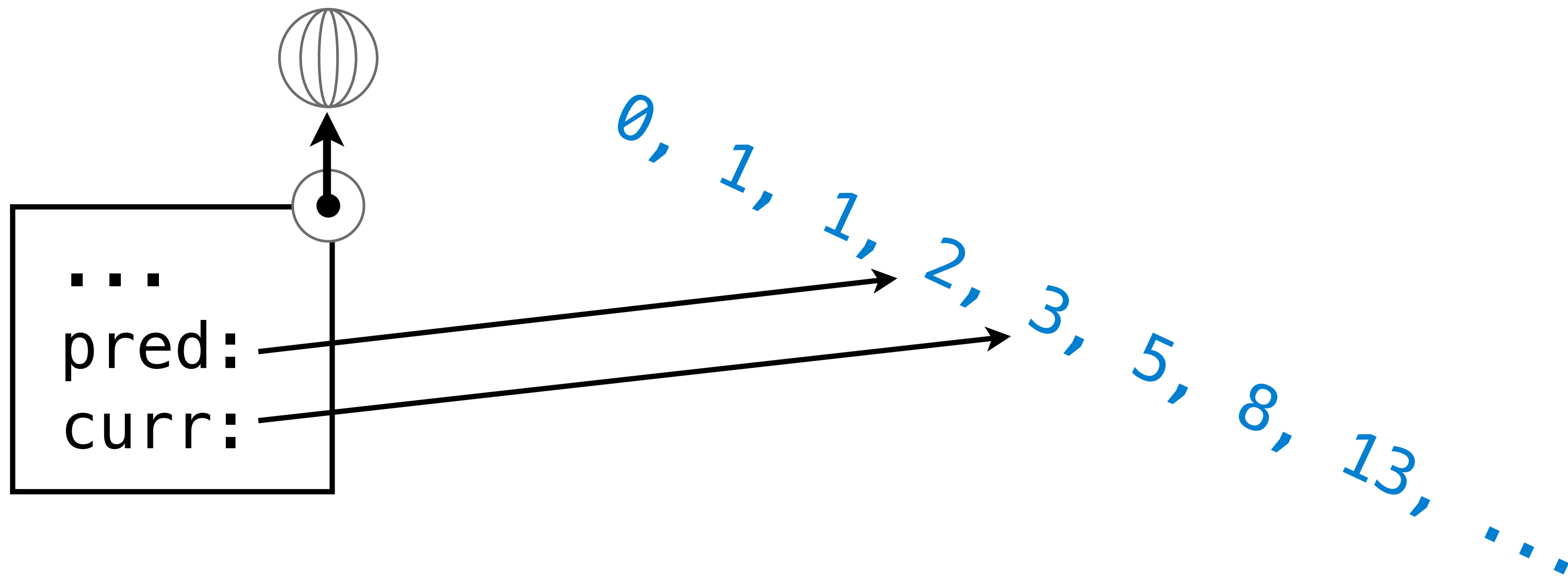


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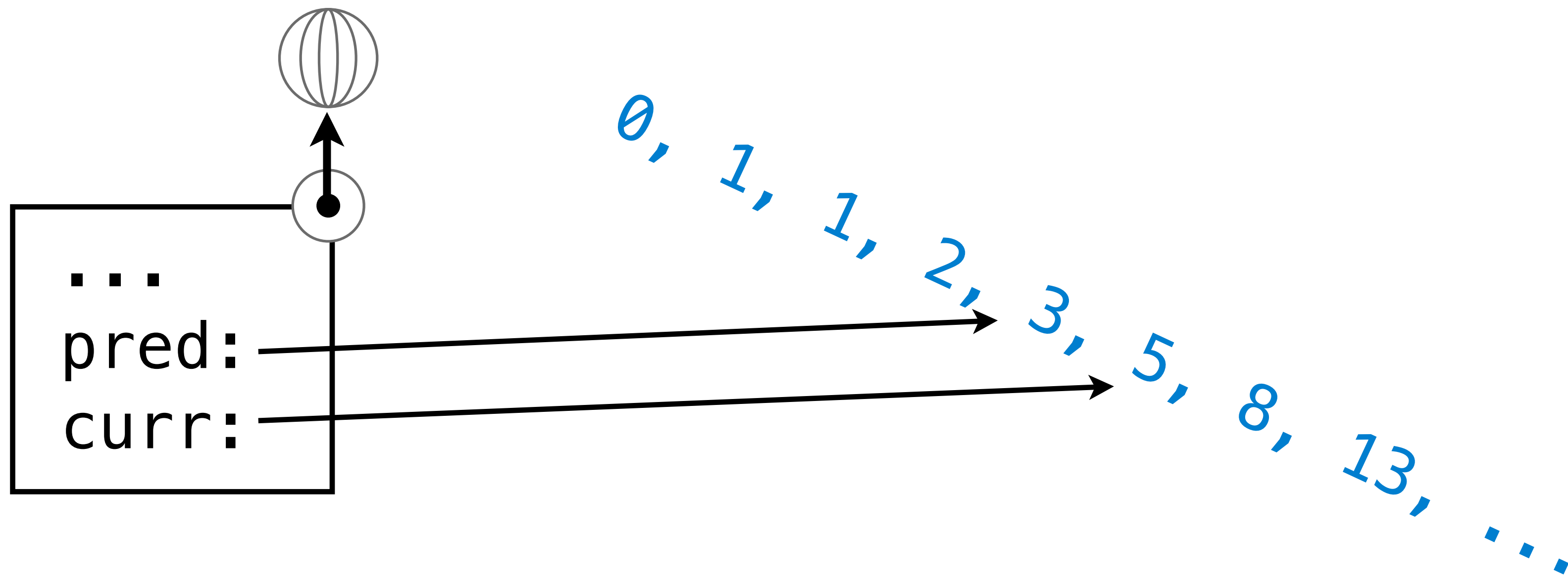


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Project 1: Pig

(Demo)