Big Idea™: Interface *vs* Implementation

Interface

***What* something does**

Example: a stack

- **create** an empty stack
- **push** an item to top
- **pop** an item from top
- get stack **length** (size)

```
s = makeStack()
push(s, 42)

print(len(s))    # 1

value = pop(s)

print(value)     # 42
print(len(s))    # 0
```

Interface design

Python interface (client code)

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print(value)     # 42
print(len(s))    # 0
```

Implementation

***How* it's done**

Example: a stack

- How to store elements?
- What is an empty stack?
- Where is top of stack?

Encoding

how to use preexisting data structures to implement new data structure

Big Idea™: Interface *vs* Implementation

Interface

***What* something does**

Example: a stack

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Implementation

***How* it's done**

Example: a stack

- store items in a **list**
- top is **end** of list

Encoding

how to use preexisting data structures to implement new data structure

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Implementation

***How* it's done**

Example: a stack

- store items in a **list**
- top is **end** of list

```
def makeStack():
  return []

def push(stack, item):
  return stack.append(item)

def pop(stack):
  return stack.pop()
```

Big Idea™: Interface *vs* Implementation

Interface

***What* something does**

Example: a stack

- **create** an empty stack
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print(len(s))     # 1

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print(value)      # 42
print(len(s))     # 0
```

Implementation

***How* it's done**

Example: a stack

- store items in a **list**
- top is **beginning** of list

We can change implementation without changing interface!

```
def makeStack():
  return []

def push(stack, item):
  return stack.insert(0, item)

def pop(stack):
  return stack.pop(0)
```

Drawbacks of procedural implementation?

Client code

```
import stack1
import stack2

s1 = stack1.makeStack()
stack1.push(s1, 1)
stack1.push(s1, 2)

s2 = stack2.makeStack()
stack2.push(s2, 3)
stack2.push(s2, 4)

value = stack2.pop(s1)

print(value)
```

Name T. 11 / 13

Implementations

```
def makeStack():
  return []

def push(stack, item):
  return stack.append(item)

def pop(stack):
  return stack.pop()
```

stack1.py

```
def makeStack():
  return []

def push(stack, item):
  return stack.insert(0, item)

def pop(stack):
  return stack.pop(0)
```

stack2.py

Drawbacks of procedural implementation?

Client code

```
import stack1
import stack2

s1 = stack1.makeStack()
stack1.push(s1, 1)
stack1.push(s1, 2)

s2 = stack2.makeStack()
stack2.push(s2, 3)
stack2.push(s2, 4)

value = stack2.pop(s1)

print(value)
```

implementation details can "leak",
causing data and behavior to become separated

Implementations

```
def makeStack():
  return []

def push(stack, item):
  return stack.append(item)

def pop(stack):
  return stack.pop()
```

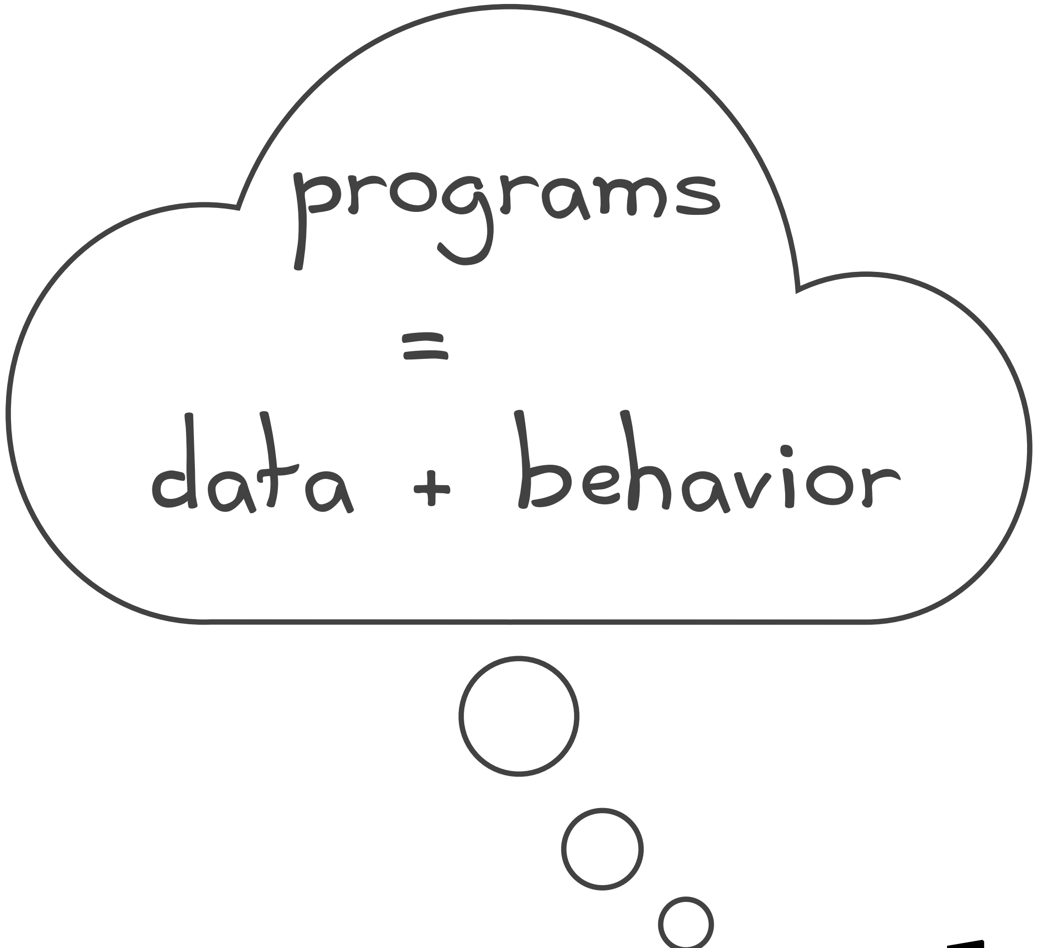
stack1.py

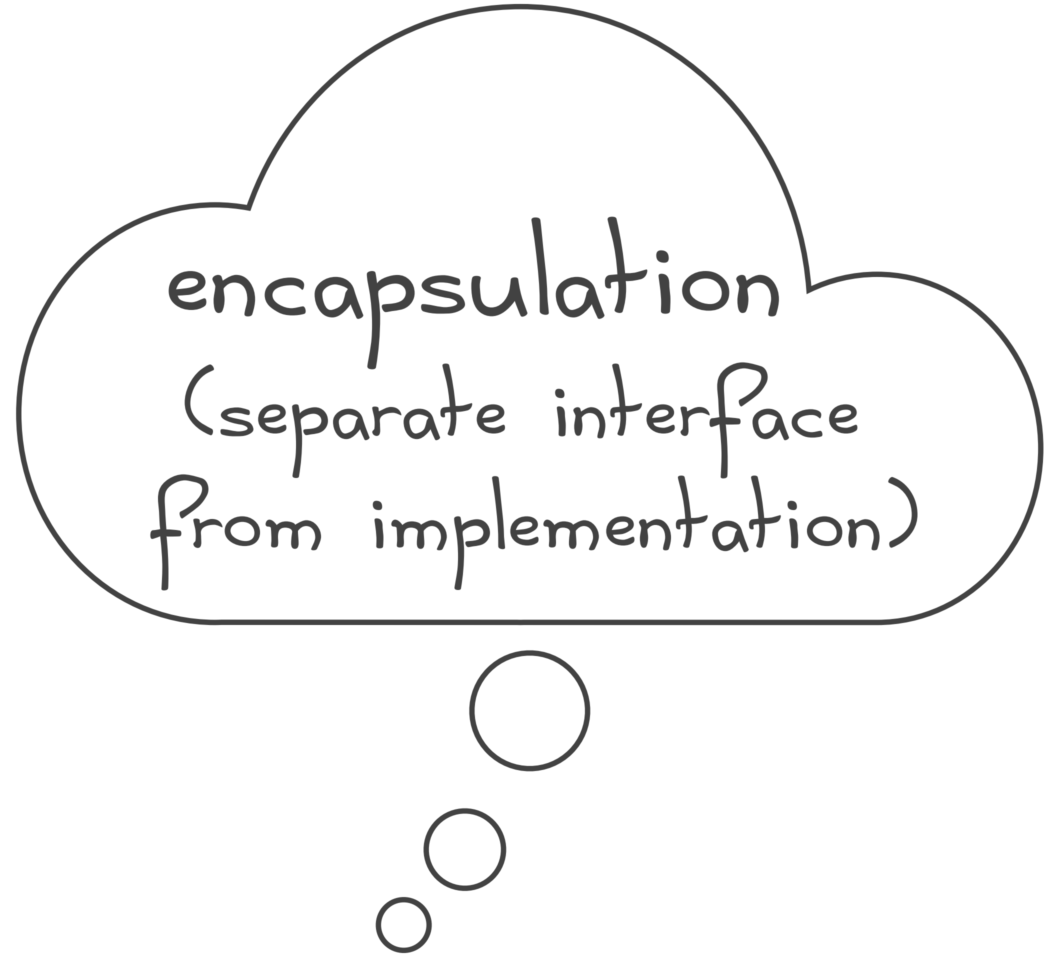
```
def makeStack():
  return []

def push(stack, item):
  return stack.insert(0, item)

def pop(stack):
  return stack.pop(0)
```

stack2.py





object

- combines data & behavior
- access only through interface
- knows about itself
  (can access its own data and behavior)

an object is sort-of
like a little state machine!

Object-oriented programming languages **differ** in:

- how the programmer specifies an object's **interface**
- how the programmer specifies an object's **implementation**
- how objects are **created**, **initialized**, **queried**, and **updated**
- **encapsulation** mechanism
  how strictly the language *enforces* the separation between interface & implementation

Procedural *vs* object-oriented clients in Python

Procedural

```
import stack1
import stack2

s1 = stack1.makeStack()
stack1.push(s1, 1)
stack1.push(s1, 2)

s2 = stack2.makeStack()
stack2.push(s2, 3)
stack2.push(s2, 4)

value = stack2.pop(s1)

print(value)
```

implementation details can "leak", causing data and behavior to become separated

Object-oriented

```
import stack1
import stack2

s1 = stack1.Stack()
s1.push(1)
s1.push(2)

s2 = stack2.Stack()
s2.push(3)
s2.push(4)

value = s1.pop()

print(value)
```

create an instance of the Stack class (i.e., "instantiate")

object stores its own data, method operates on the object's data

Classes are patterns for objects

A class is like

a cookie cutter

ecx.images-amazon.com/images/I/21owTyO6HaL.jpg

Objects are like

cookies

eclecticrecipes.com/wp-content/uploads/2013/02/heart-6.jpg

images.edge-generalmills.com/9b6a8635-686e-4b7d-863b-7dd3d8d25a04.jpg

A procedural stack implementation

Encoded as a list, where the top of the stack is at the end of the list.

The next several slides transform the procedural implementation to an OO implementation.

```
def makeStack():
    '''Creates a new stack'''
    return []

def push(stack, item):
    '''Push item onto top of stack'''
    stack.append(item)

def pop(stack):
    '''Removes and returns the item on top of stack'''
    return stack.pop()
```

An object-oriented stack implementation

Encoded as a list, where the top of the stack is at the front of the list.

```
class Stack:
  '''A LIFO data structure'''

  def makeStack():
    '''Creates a new stack'''
    return []

  def push(stack, item):
    '''Push item onto top of stack'''
    stack.append(item)

  def pop(stack):
    '''Removes and returns the item on top of stack'''
    return stack.pop()
```

Not yet correct

encoding should be a data attribute (instance initialization, not instance creation)

An object-oriented stack implementation

Encoded as a list, where the top of the stack is at the front of the list.

```
class Stack:
    '''A LIFO data structure'''

    def makeStack():
        '''Initializes a new stack'''
        values = []

    def push(item):
        '''Push item onto top of stack'''
        values.append(item)

    def pop():
        '''Removes and returns the item on top of stack'''
        return values.pop()
```

Not yet correct

values is a local variable :(

An object-oriented stack implementation

Encoded as a list, where the top of the stack is at the front of the list.

```
class Stack:
  '''A LIFO data structure'''

  def makeStack(self):
    '''Initializes a new stack'''
    self.values = []

  def push(self, item):
    '''Push item onto top of stack'''
    self.values.append(item)

  def pop(self):
    '''Removes and returns the item on top of stack'''
    return self.values.pop()
```

Not yet correct

explicit self

the name "self" is a convention

An object-oriented stack implementation

Encoded as a list, where the top of the stack is at the front of the list.

```
class Stack:
  '''A LIFO data structure'''

  def __init__(self):
    '''Initializes a new stack'''
    self.values = []

  def push(self, item):
    '''Push item onto top of stack'''
    self.values.append(item)

  def pop(self):
    '''Removes and returns the item on top of stack'''
    return self.values.pop()
```

Correct, but not idiomatic

constructor

__init__ is a "special method" that Python calls automatically, to initialize an instance.

An object-oriented stack implementation

Encoded as a list, where the top of the stack is at the front of the list.

```
class Stack:
  '''A LIFO data structure'''

  def __init__(self):
    '''Initializes a new stack'''
    self._values = []

  def push(self, item):
    '''Push item onto top of stack'''
    self._values.append(item)

  def pop(self):
    '''Removes and returns the item on top of stack'''
    return self._values.pop()
```

"private" field

By convention, if a member begins with _, it's not part of the interface. Clients shouldn't access it directly.

An object-oriented stack implementation

Encoded as a list, where the top of the stack is at the front of the list.

```
class Stack:
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    def __init__(self):
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    def push(self, item):
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    def pop(self):
        '''Removes and returns the item on top of stack'''
        return self._values.pop()
```

Client code

```
s = Stack()
s.push(1)
print(s.pop())
```

An object-oriented stack implementation

Encoded as a list, where the top of the stack is at the front of the list.

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class Stack:
  '''A LIFO data structure'''

  def __init__(self):
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    self._values = []

  def push(self, item):
    '''Push item onto top of stack'''
    self._values.append(item)

  def pop(self):
    '''Removes and returns the item on top of stack'''
    return self._values.pop()

  def len(self):
    '''Returns the number of elements in the stack'''
    return len(self._values)
```

Correct, but not idiomatic

Client code

```
s = Stack()
s.push(1)
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An object-oriented stack implementation

Encoded as a list, where the top of the stack is at the front of the list.

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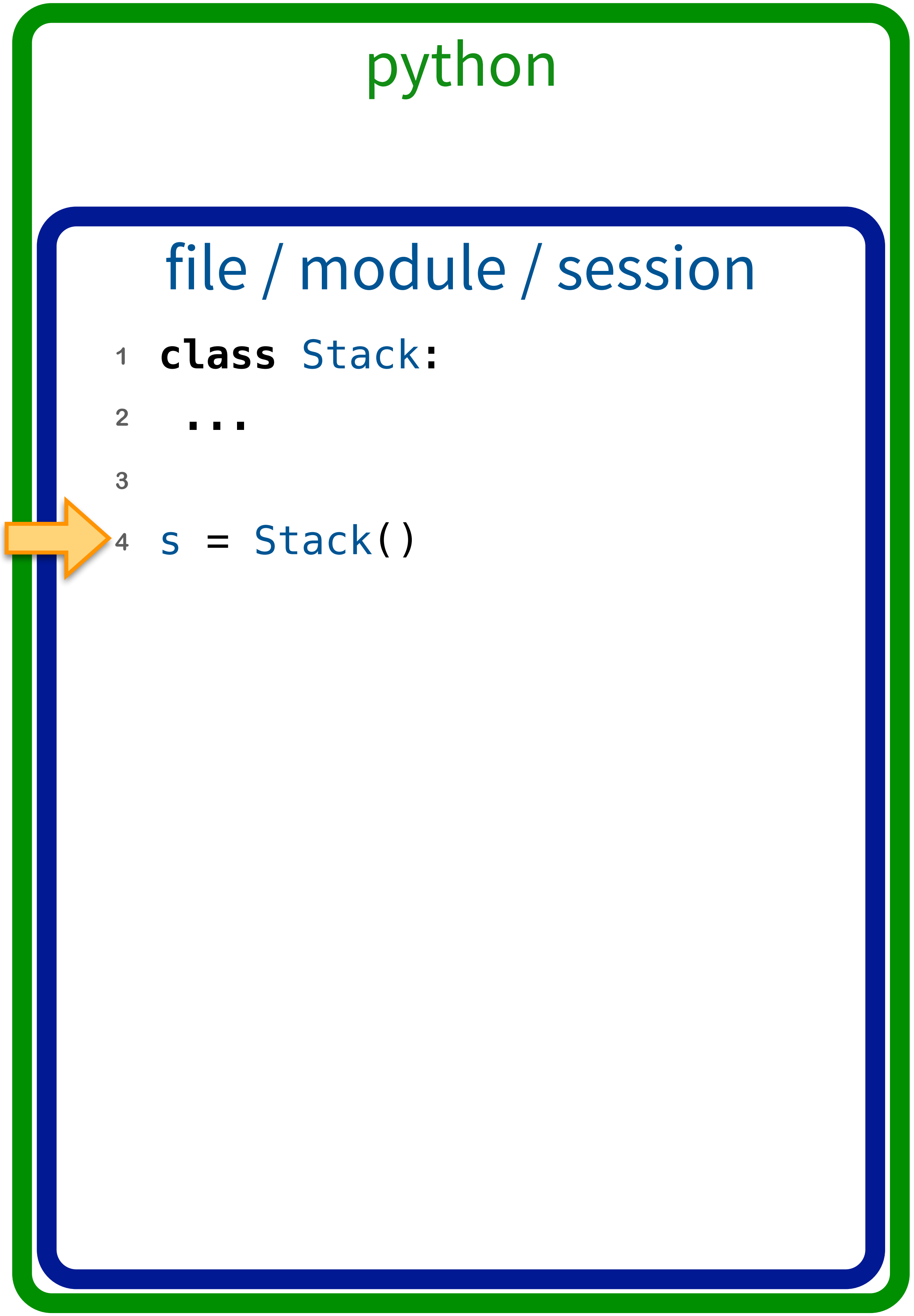
  def push(self, item):
    '''Push item onto top of stack'''
    self._values.append(item)

  def pop(self):
    '''Removes and returns the item on top of stack'''
    return self._values.pop()

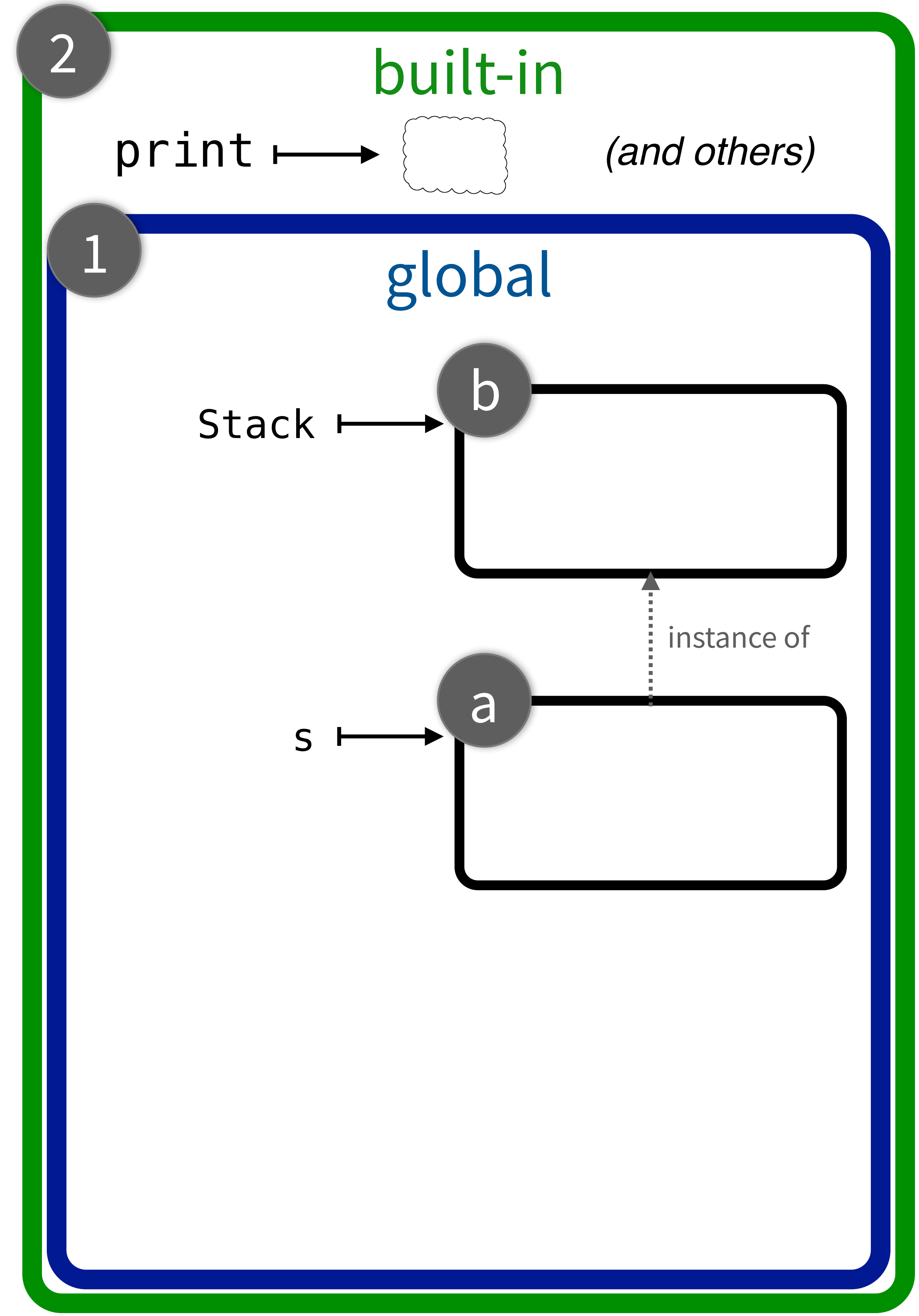
  def __len__(self):
    '''Returns the number of elements in the stack'''
    return len(self._values)
```

Client code

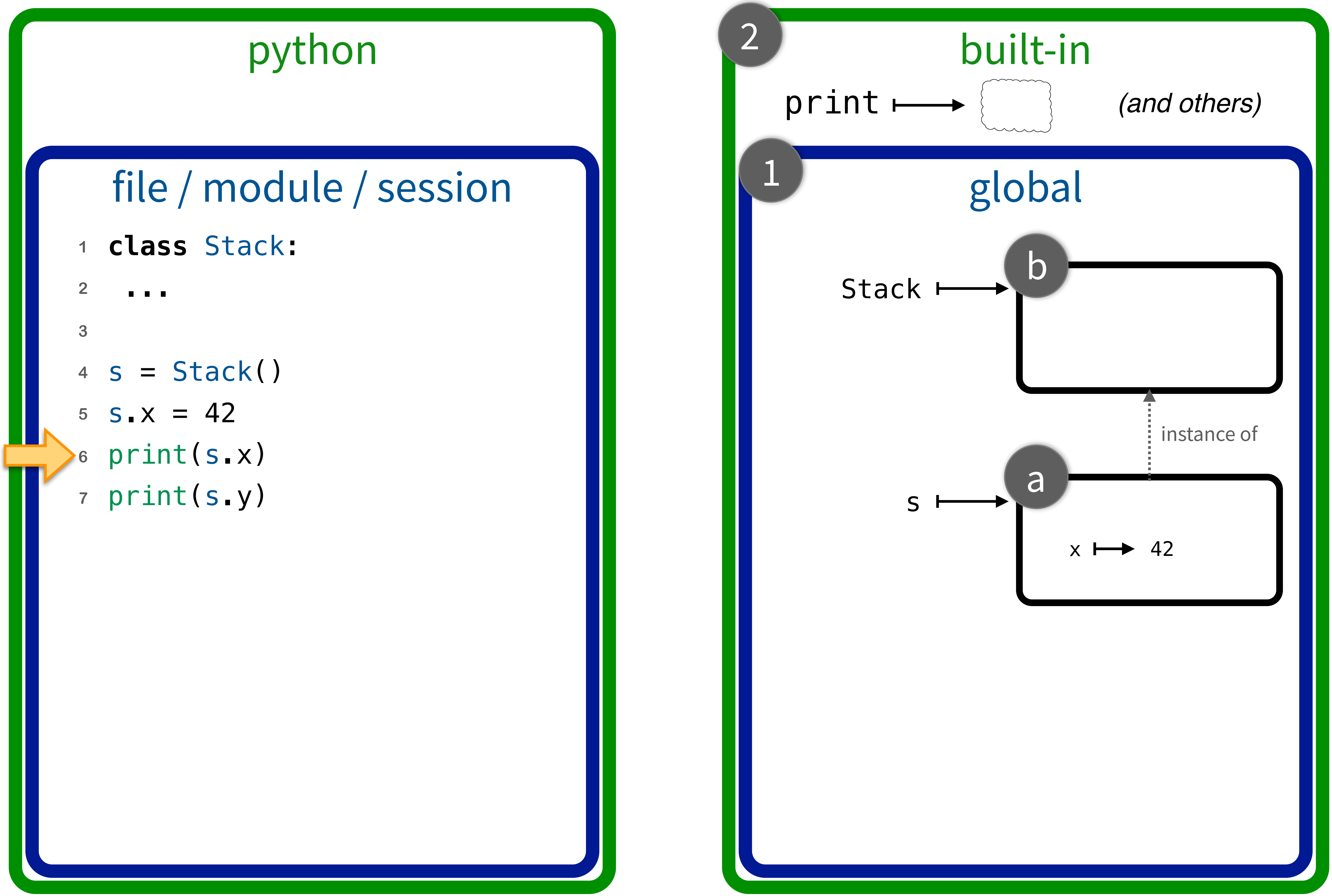
```
s = Stack()
s.push(1)
print(len(s))
```



scopes
(determined by program code)



namespaces
(a snapshot of program execution)



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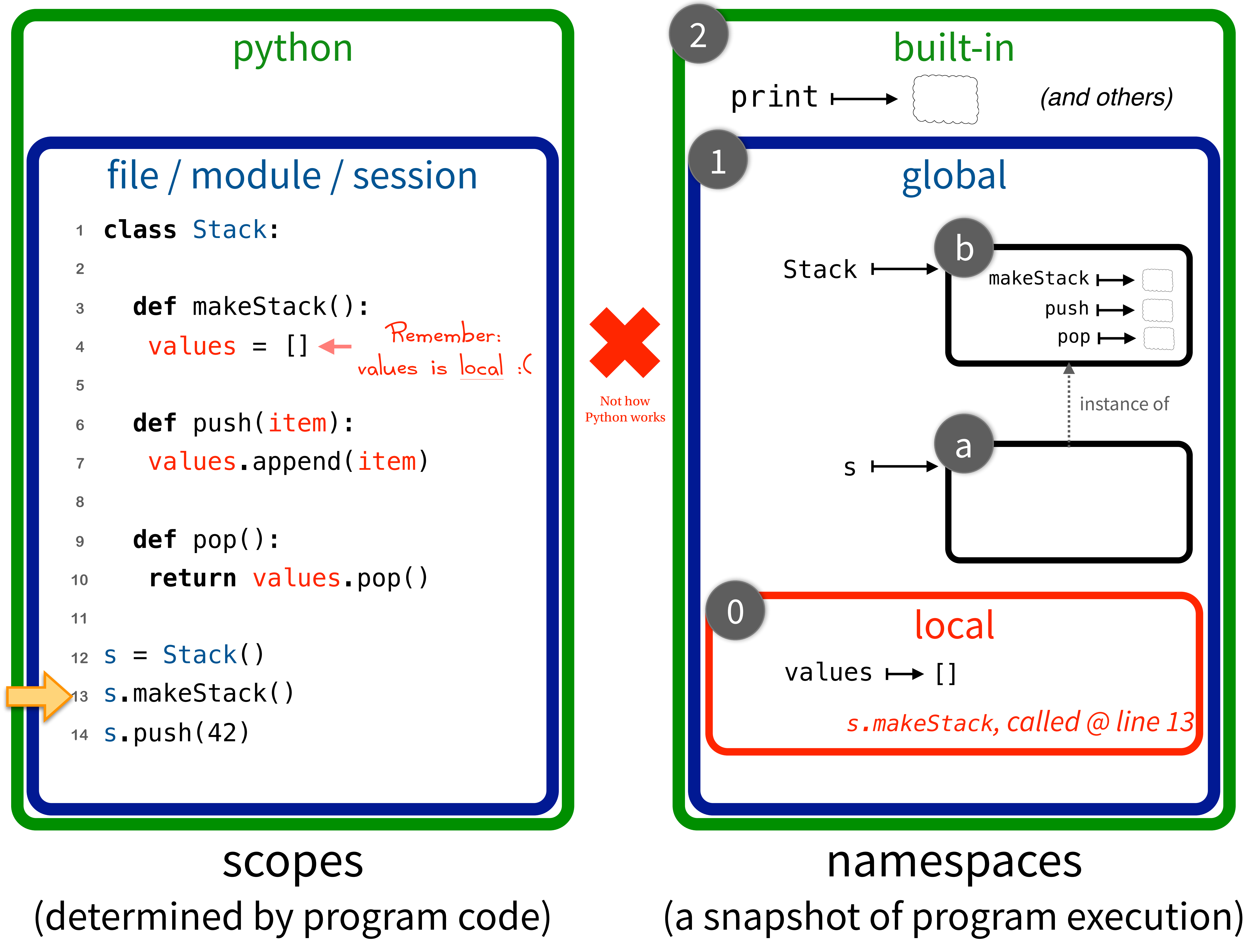
python
file / module / session
1 class Stack:
2
3 def makeStack():
4 values = []
5
6 def push(item):
7 values.append(item)
8
9 def pop():
10 return values.pop()
11
12 s = Stack()
13 s.makeStack()
14 s.push(42)
Remember:
values is local :(
Not how
Python works
2
built-in
print
(and others)
1
global
Stack
b
makeStack
push
pop
instance of
a
s
0
local
values
[]
s.makeStack, called @ line 13
scopes
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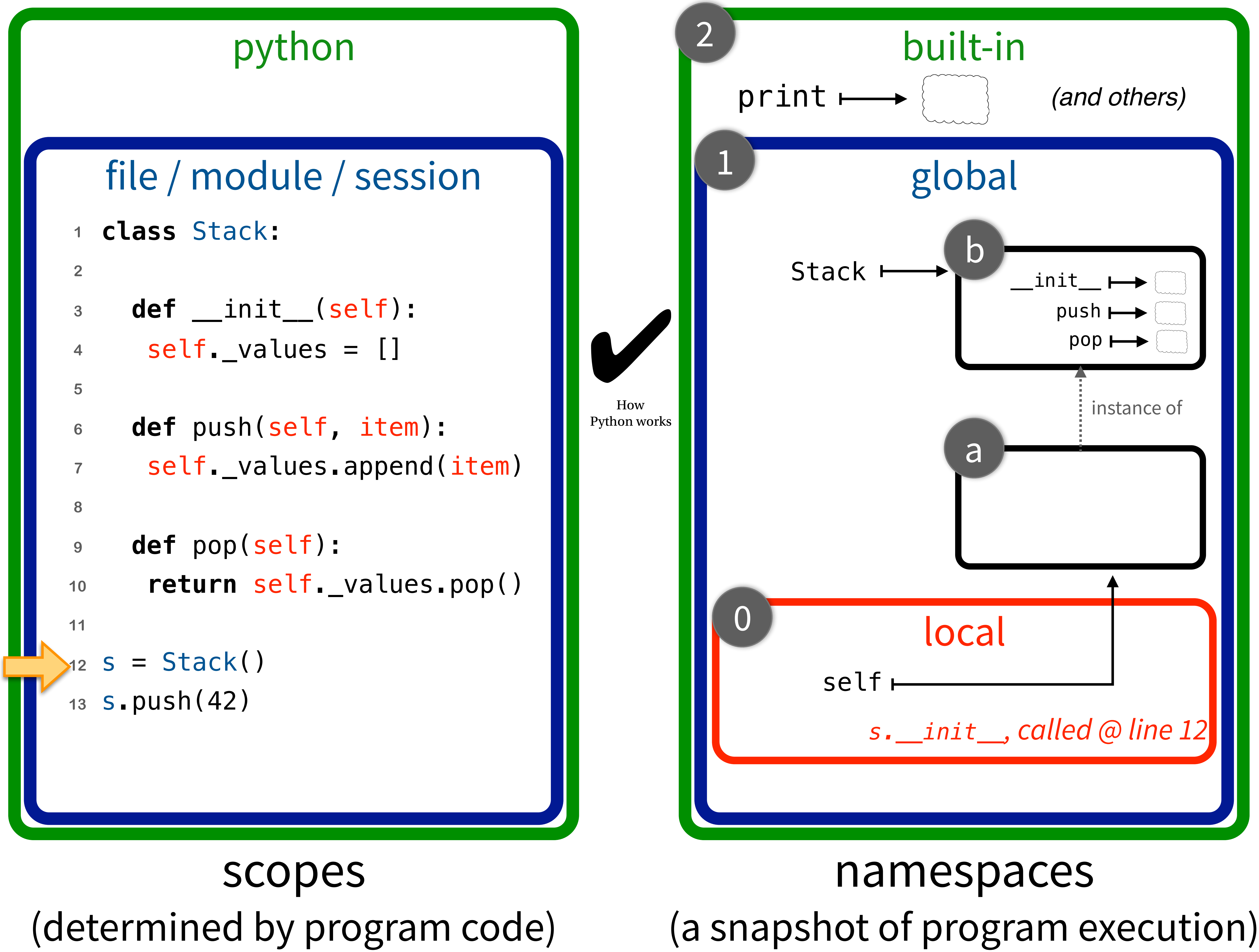
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scopes
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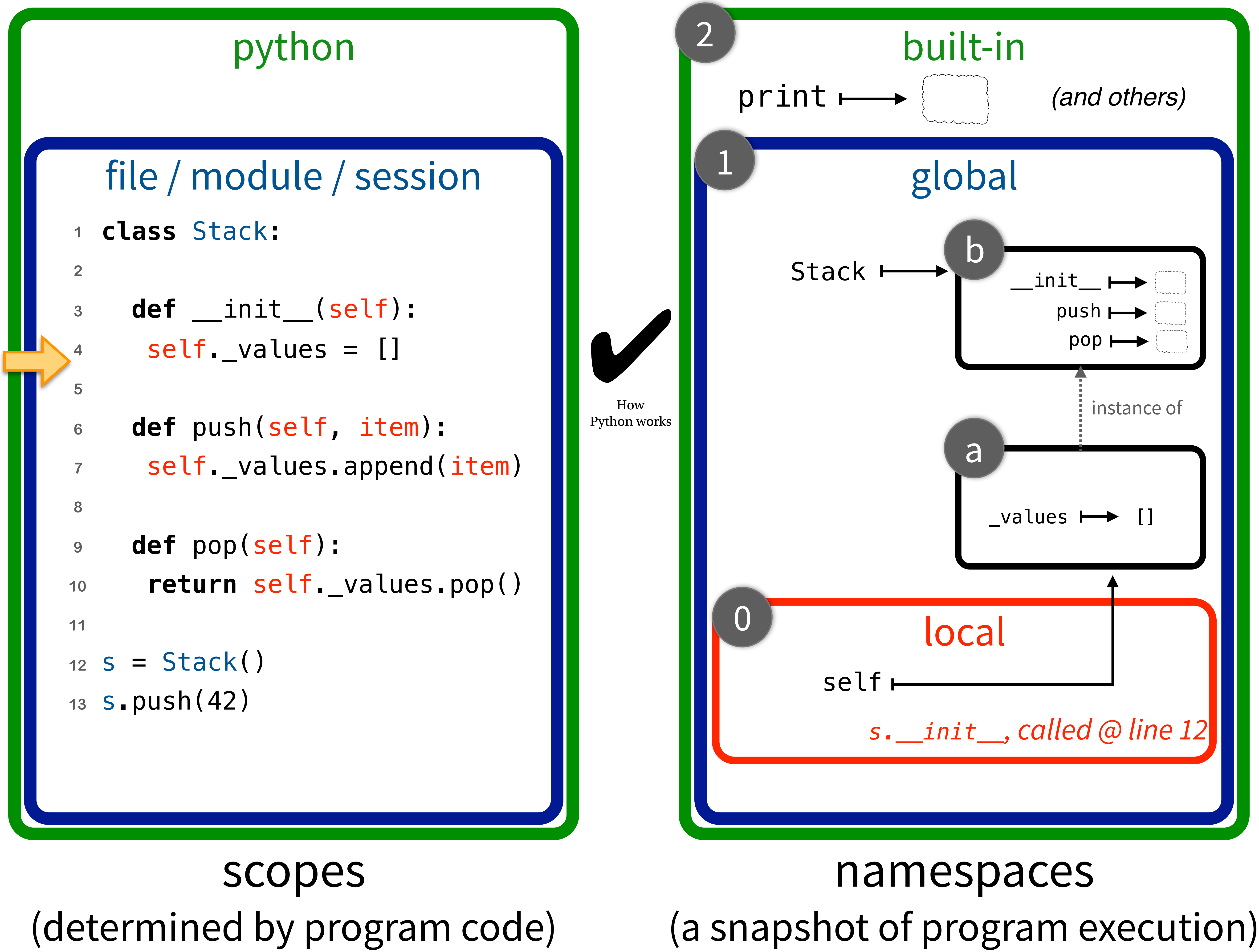
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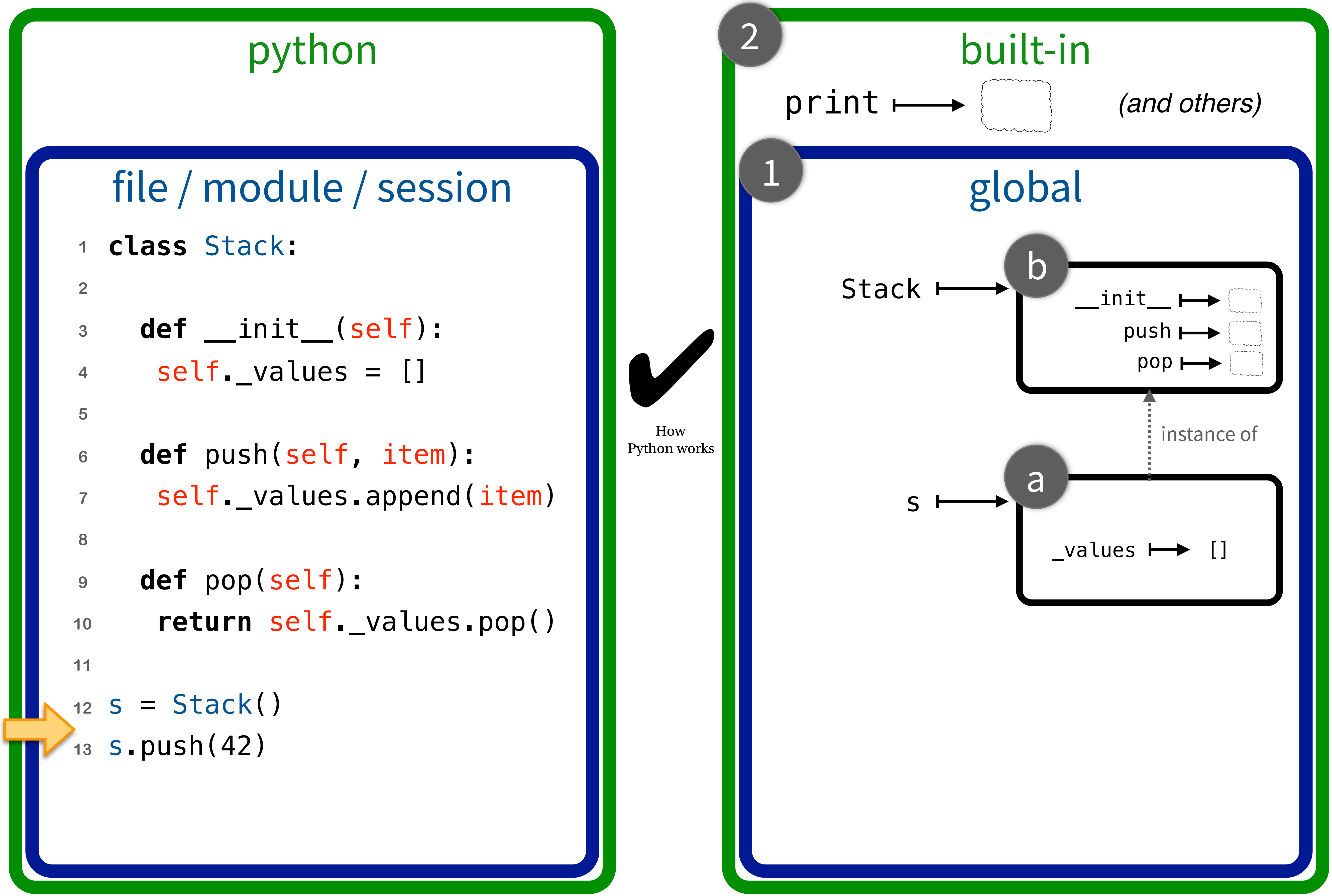

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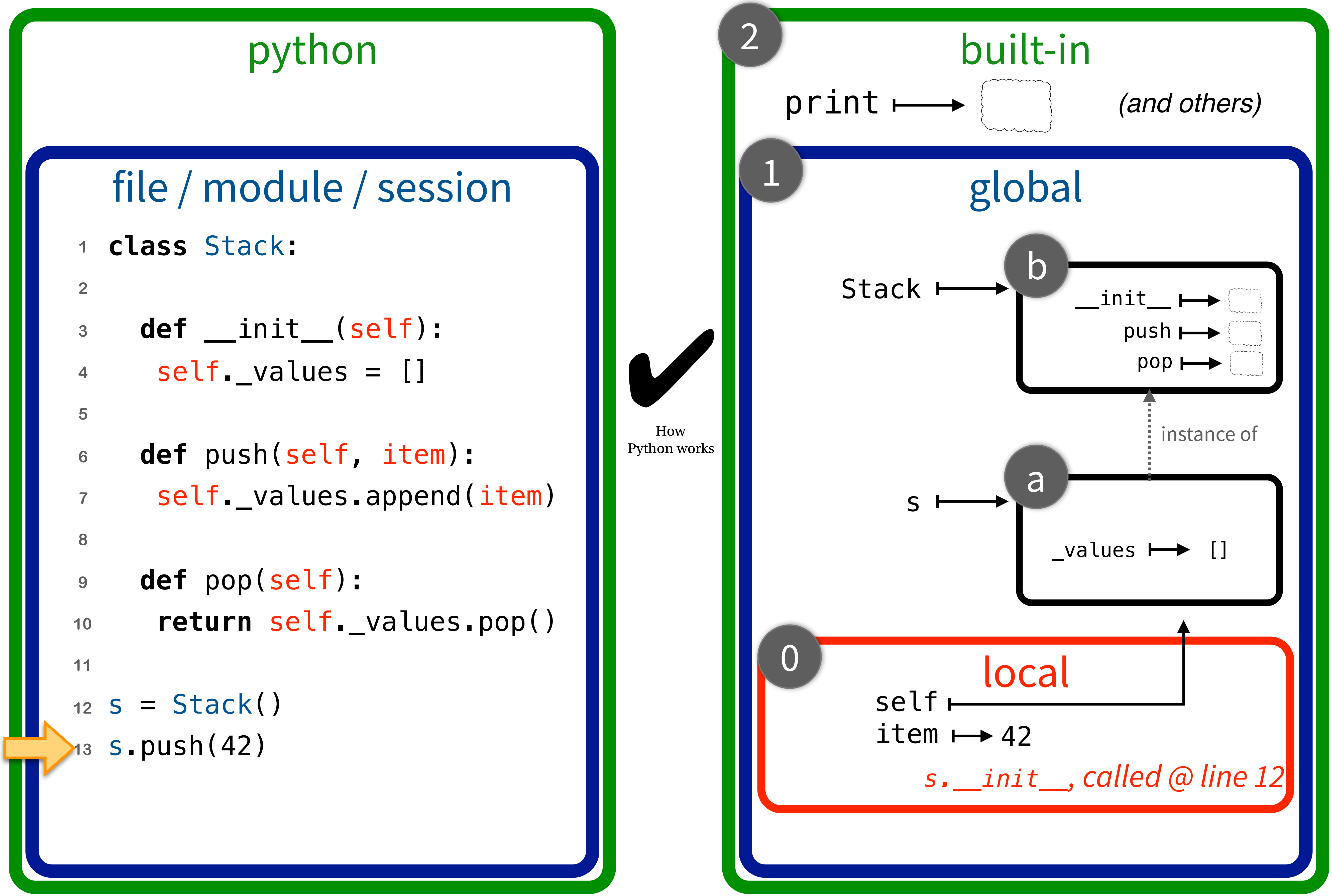

scopes
(determined by program code)

namespaces
(a snapshot of program execution)

python

file / module / session

```python
class Stack:

  def __init__(self):
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  def push(self, item):
    self._values.append(item)

  def pop(self):
    return self._values.pop()

s = Stack()
s.push(42)
```
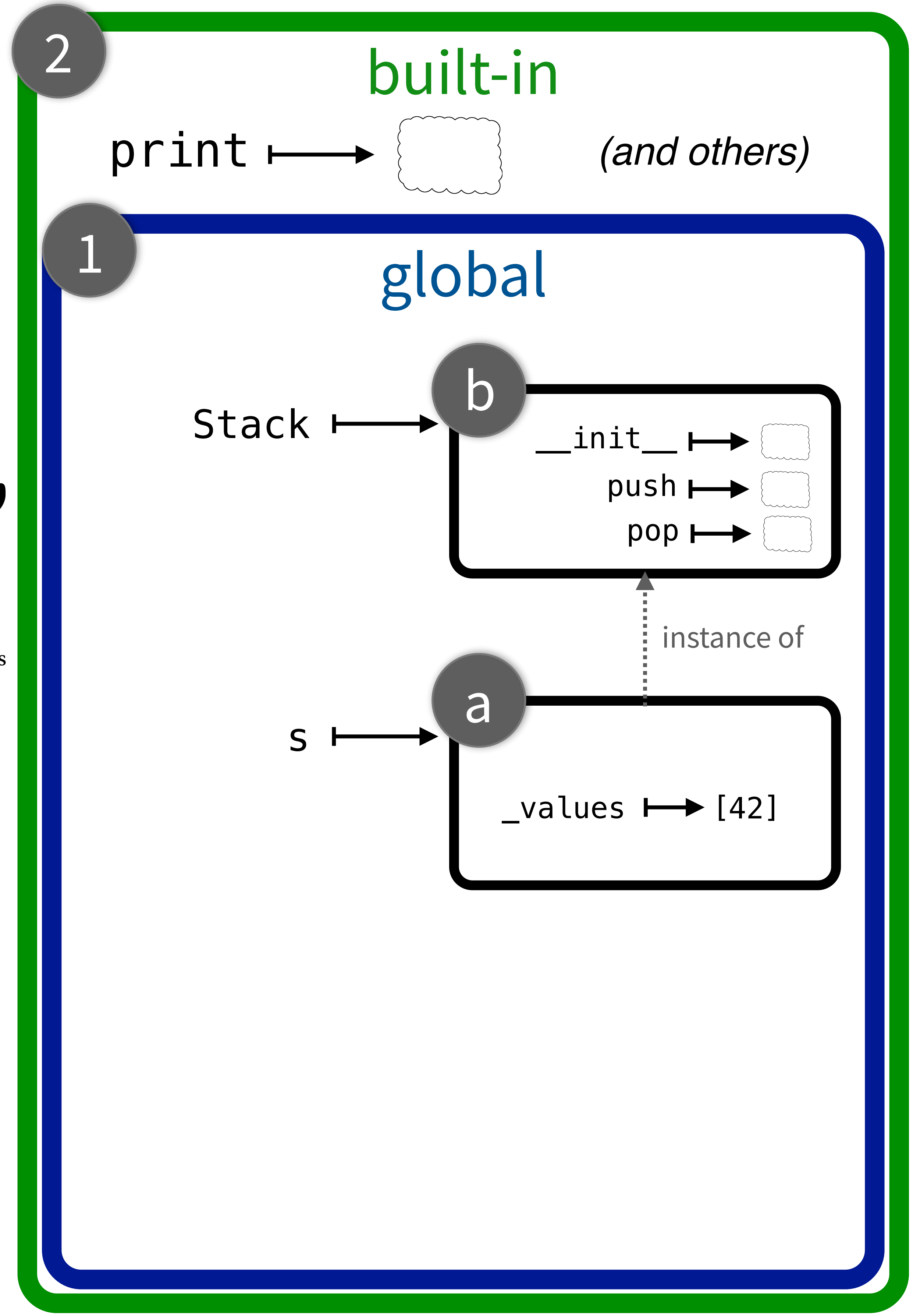

How Python works

scopes

(determined by program code)



namespaces

(a snapshot of program execution)

Python tutor: pythontutor.com/visualize.html