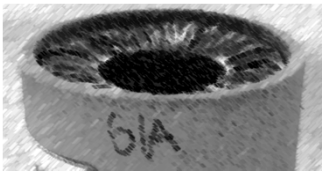


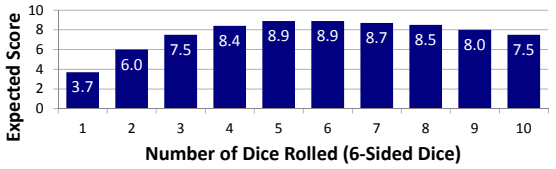
CS61A Lecture 4

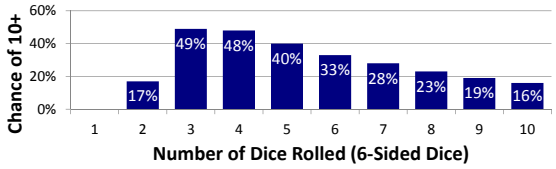
Amir Kamil
UC Berkeley
January 30, 2013

Announcements

- Reminder: hw1 due tonight
- In-class quiz on Friday
  - Covers through Wednesday's lecture
  - Bring a writing implement
- Hog project out
  - Get started early!
  - Try it out online! See the announcement on the website

The Game of Hog





Environment Diagrams

- Every expression is evaluated in the context of an environment
- So far, the current environment is either:
  - The global frame alone, or
  - A local frame, followed by the global frame
- **Important properties of environments:**
  - An environment is a sequence of frames
  - The earliest frame that contains a binding for a name determines the value that the name evaluates to
- The *scope* of a name is the region of code that has access to it

Environment of Function Application

The environment in which a function is applied consists of:

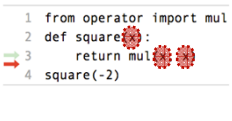
- A *new* local frame *each* time the function is *applied*
- The environment in which the function was *defined*
  - We refer to this as *lexical scoping*
  - So far, this is just the global frame
  - The *current* state of the environment is used, not the state when the function definition was executed

Formal Parameters

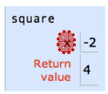
```
def square(x):
    return mul(x, x)
```

vs

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



Formal parameters have local scope



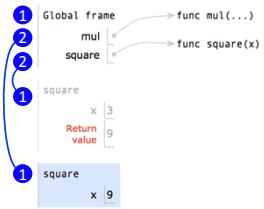
Example: http://goo.gl/boCk0

Multiple Environments in a Diagram

What happens when to the local frame when a function returns?

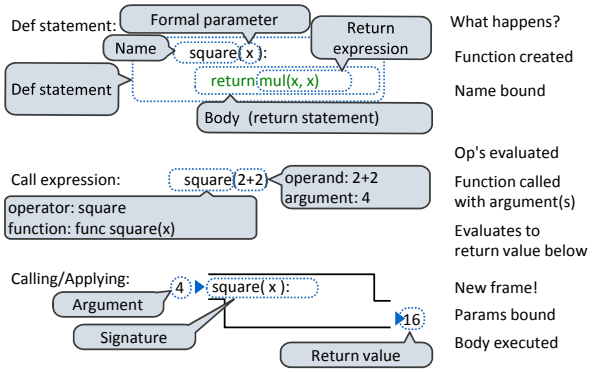
- It sticks around until Python realizes it is no longer needed
- We will soon see cases where it is needed after the call

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



Example: http://goo.gl/hrfnV

Life Cycle of a User-Defined Function



Python Feature Demonstration

Operators

Multiple Return Values

Docstrings

Doctests

Default Arguments

Statements

Statements

A *statement* is executed by the interpreter to perform an action

Types of statements we have seen so far

- An assignment

```
radius = 10
```

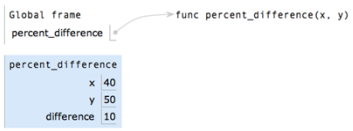
- A function definition

```
def square(x):
    return x * x
```

- Returns, imports, assertions

Local Assignment

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



Execution rule for assignment statements:

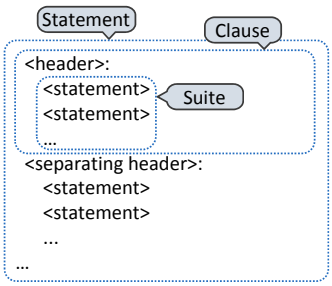
1. Evaluate all expressions right of =, from left to right.
2. Bind the names on the left the resulting values in the first frame of the current environment.

Example: http://goo.gl/1pyzL

Compound Statements

A function definition is a *compound statement*

Compound statements:



The first header determines a statement's type

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

Compound Statements

Compound statements:

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

Suite

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:

1. Execute the first
2. Unless directed otherwise, execute the rest

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
```

1 statement,
3 clauses,
3 headers,
3 suites

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 remaining clauses.

Boolean Contexts

George Boole

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

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
```

Global frame
i 1 2 3
total 1 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.

Example: http://goo.gl/mk7Sc

Locally Defined Functions

Functions can be defined inside other functions

What happens when a def is executed?

1. Create a function value with the given signature and body
2. Bind the given name to that value in the current frame

The name can then be used to call the function.

```
def sum_of_squares(n):
    """Sum of the squares of the integers 1 to n"""
    def square(x):
        return mul(x, x)
    total, k = 0, 1
    while k <= n:
        total, k = total + square(k), k + 1
    return total
```

Locally Defined Functions

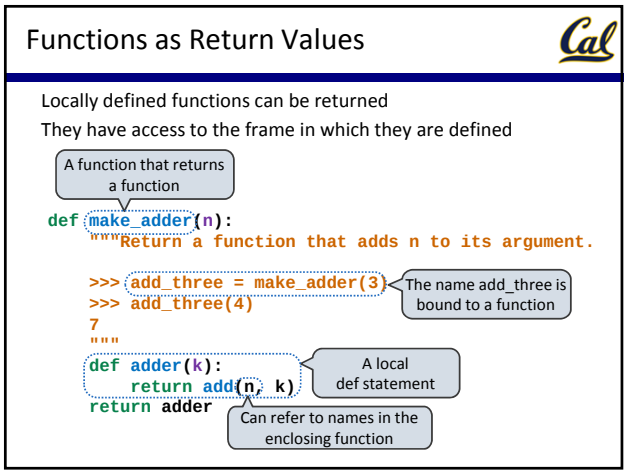
The inner definition is executed each time the outer function is called

```
1 from operator import mul
2 def square_inside():
3     def square(x):
4         return mul(x, x)
5 square_inside()
6 square_inside()
```

Global frame
mul → func mul(...)
square_inside → func square_inside()
f1: square_inside
square → func square(x) [parent=f1]
Return value: None
f2: square_inside
square → func square(x) [parent=f2]
Return value: None

Example: http://goo.gl/pnU8f

Functions as Return Values



Locally defined functions can be returned

They have access to the frame in which they are defined

A function that returns a function

```
def make_adder(n):
    """Return a function that adds n to its argument.

    >>> add_three = make_adder(3)
    >>> add_three(4)
    7
    """
    def adder(k):
        return add(n, k)
    return adder
```

The name add_three is bound to a function

A local def statement

Can refer to names in the enclosing function

Call Expressions as Operators


```
make_adder(1)(2)
```

```
make_adder(1)  (  2  )
```

Operator

Operand 0

An expression that evaluates to a function value

An expression that evaluates to any value

```
def make_adder(n):
    def adder(k):
        return add(n, k)
    return adder
```