CS61A Lecture 18

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UC Berkeley
March 4, 2013

Announcements

- HW6 due on Thursday
- Trends project due tomorrow
- Ants project out

Persistent Local State

Global frame

make_withdraw

withdraw

func make_withdraw(balance)

func withdraw(amount) [parent=f1]

f1: make_withdraw

balance 50

withdraw

Return value

withdraw [parent=f1]

amount 25

Return value 75

withdraw [parent=f1]

amount 25

Return value 50

A function with a parent frame

The parent contains local state

Every call changes the balance

Example: http://goo.gl/5LZ6F

Non-Local Assignment

```
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

Re-bind balance where it was bound previously

Mutable Values and Persistent State

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Mutable values can be changed without a nonlocal statement.

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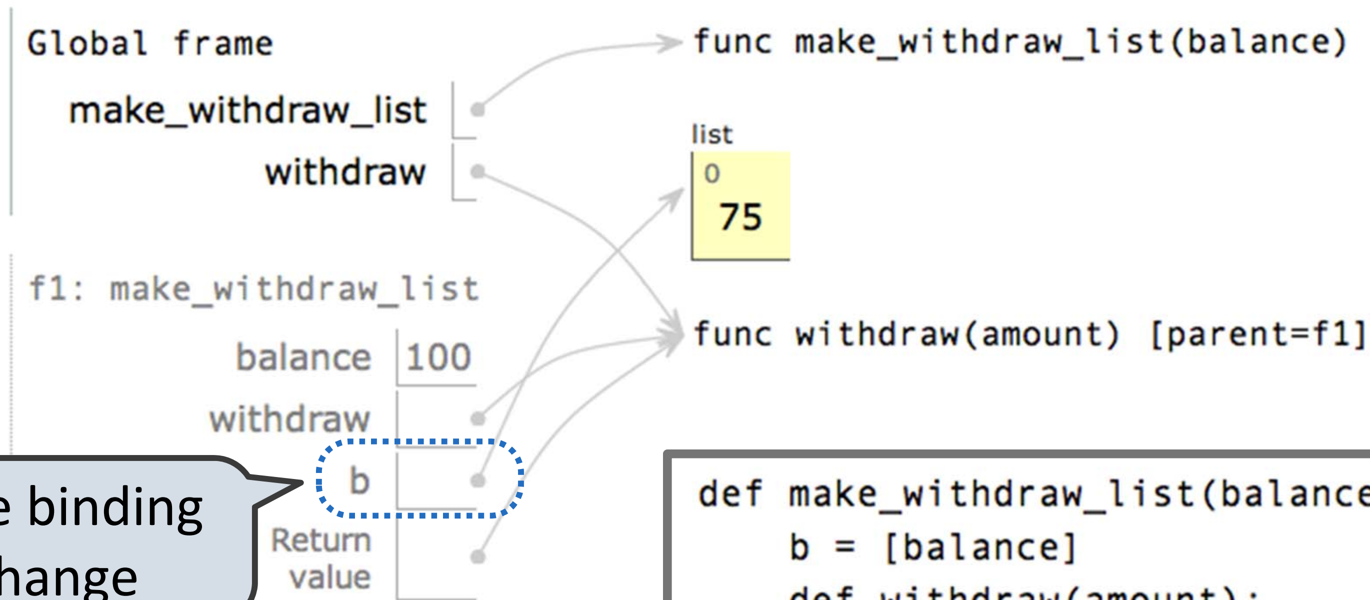
```
def make_withdraw_list(balance):
    b = [balance]
    def withdraw(amount):
        if amount > b[0]:
            return 'Insufficient funds'
        b[0] = b[0] - amount
        return b[0]
    return withdraw

withdraw = make_withdraw_list(100)
withdraw(25)
```

Example: http://goo.gl/cEpmz

Mutable Values and Persistent State

Mutable values can be changed without a nonlocal statement.



Name-value binding cannot change

withdraw [parent=f1]

amount 25

```
def make_withdraw_list(balance):
    b = [balance]
    def withdraw(amount):
        if amount > b[0]:
            return 'Insufficient funds'
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Mutable Values and Persistent State

Mutable values can be changed without a nonlocal statement.

Global frame

make_withdraw_list

withdraw

func make_withdraw_list(balance)

list

0

75

Mutable value can change

func withdraw(amount) [parent=f1]

f1: make_withdraw_list

balance 100

withdraw

b

Return value

Name-value binding cannot change

withdraw [parent=f1]

amount 25

```
def make_withdraw_list(balance):
    b = [balance]
    def withdraw(amount):
        if amount > b[0]:
            return 'Insufficient funds'
        b[0] = b[0] - amount
        return b[0]
    return withdraw

withdraw = make_withdraw_list(100)
withdraw(25)
```

Example: http://goo.gl/cEpmz

Creating Two Withdraw Functions

Global frame

make_withdraw	→ func make_withdraw(balance)
wd	→ func withdraw(amount) [parent=f1]
wd2	→ func withdraw(amount) [parent=f2]

f1: make_withdraw

balance	75
withdraw	→ func withdraw(amount) [parent=f1]
Return value	→ func withdraw(amount) [parent=f1]

f2: make_withdraw

balance	85
withdraw	→ func withdraw(amount) [parent=f2]
Return value	→ func withdraw(amount) [parent=f2]

withdraw [parent=f1]

amount	25
Return value	75

withdraw [parent=f2]

amount	15
Return value	85

```
1  def make_withdraw(balance):
2      def withdraw(amount):
3          nonlocal balance
4          if amount > balance:
5              return 'Insufficient funds'
6          balance = balance - amount
7          return balance
8      return withdraw
9
10 wd = make_withdraw(100)
11 wd2 = make_withdraw(100)
12 wd(25)
13 wd2(15)
```

Example: http://goo.gl/glTyB

Multiple References to a Withdraw Function

```
1  def make_withdraw(balance):
2      def withdraw(amount):
3          nonlocal balance
4          if amount > balance:
5              return 'Insufficient funds'
6          balance = balance - amount
7          return balance
8      return withdraw
9
10 wd = make_withdraw(100)
11 wd2 = wd
12 wd(25)
13 wd2(15)
```

Example: http://goo.gl/X2qG9

The Benefits of Non-Local Assignment

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- Ability to maintain some state that is local to a function, but evolves over successive calls to that function.

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- Ability to maintain some state that is local to a function, but evolves over successive calls to that function.
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- An abstraction of a bank account that manages its own internal state.

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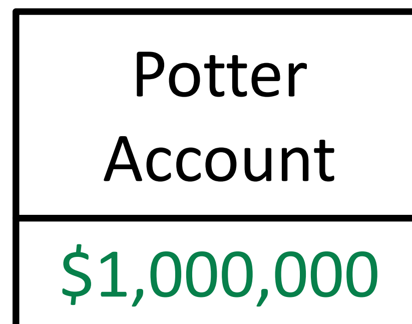

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mul(add(2, mul(4, 6)), 3)
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mul(      26          , 3)
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A Mutable Container

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def container(contents):
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    >>> get, put = container('hello')
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    >>> put('world')
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    def get():
        return contents
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    def get():
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    def get():
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    def put(value):
        nonlocal contents
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    def get():
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Dispatch Functions

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def pair(x, y):
    """Return a function that behaves like a pair."""
    def dispatch(m):
        if m == 0:
            return x
        elif m == 1:
            return y
    return dispatch
```

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Message argument can be anything, but strings are most common

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Message argument can be anything, but strings are most common

The body of a dispatch function is always the same:

- One conditional statement with several clauses
- Headers perform equality tests on the message

Message Passing

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An approach to organizing the relationship among different pieces of a program

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Different objects pass messages to each other

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Encapsulates the behavior of all operations on a piece of data

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Different objects pass messages to each other

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Encapsulates the behavior of all operations on a piece of data

Important historical role:
The message passing approach strongly influenced object-oriented programming
(next lecture)

Mutable Container with Message Passing

```
def container(contents):






    def get():
        return contents
    def put(value):
        nonlocal contents
        contents = value
    return put, get
```

Mutable Container with Message Passing

```
def container_dispatch(contents):
```

```
def container(contents):




    def get():
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```

Mutable Container with Message Passing

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def container_dispatch(contents):

    def dispatch(message,
                 value=None):
```

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                 value=None):

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        if message == 'get':
```

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def container_dispatch(contents):

    def dispatch(message,
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def container(contents):



        def get():

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Mutable Recursive Lists

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    def dispatch(message, value=None):
        nonlocal contents
        if message == 'len':
```

Mutable Recursive Lists

```
def mutable_rlist():
    contents = empty_rlist
    def dispatch(message, value=None):
        nonlocal contents
        if message == 'len':
            return len_rlist(contents)
```

Mutable Recursive Lists

```
def mutable_rlist():
    contents = empty_rlist
    def dispatch(message, value=None):
        nonlocal contents
        if message == 'len':
            return len_rlist(contents)
        elif message == 'getitem':
```

Mutable Recursive Lists

```
def mutable_rlist():
    contents = empty_rlist
    def dispatch(message, value=None):
        nonlocal contents
        if message == 'len':
            return len_rlist(contents)
        elif message == 'getitem':
            return getitem_rlist(contents, value)
```

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```
def mutable_rlist():
    contents = empty_rlist
    def dispatch(message, value=None):
        nonlocal contents
        if message == 'len':
            return len_rlist(contents)
        elif message == 'getitem':
            return getitem_rlist(contents, value)
        elif message == 'push':
```

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def mutable_rlist():
    contents = empty_rlist
    def dispatch(message, value=None):
        nonlocal contents
        if message == 'len':
            return len_rlist(contents)
        elif message == 'getitem':
            return getitem_rlist(contents, value)
        elif message == 'push':
            contents = make_rlist(value, contents)
```

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    contents = empty_rlist
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        if message == 'len':
            return len_rlist(contents)
        elif message == 'getitem':
            return getitem_rlist(contents, value)
        elif message == 'push':
            contents = make_rlist(value, contents)
        elif message == 'pop':
```

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    contents = empty_rlist
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        elif message == 'push':
            contents = make_rlist(value, contents)
        elif message == 'pop':
            item = first(contents)
```

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            contents = rest(contents)
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            return item
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        elif message == 'getitem':
            return getitem_rlist(contents, value)
        elif message == 'push':
            contents = make_rlist(value, contents)
        elif message == 'pop':
            item = first(contents)
            contents = rest(contents)
            return item
        elif message == 'str':
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            contents = make_rlist(value, contents)
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        elif message == 'str':
            return str_rlist(contents)
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        elif message == 'push':
            contents = make_rlist(value, contents)
        elif message == 'pop':
            item = first(contents)
            contents = rest(contents)
            return item
        elif message == 'str':
            return str_rlist(contents)
    return dispatch
```