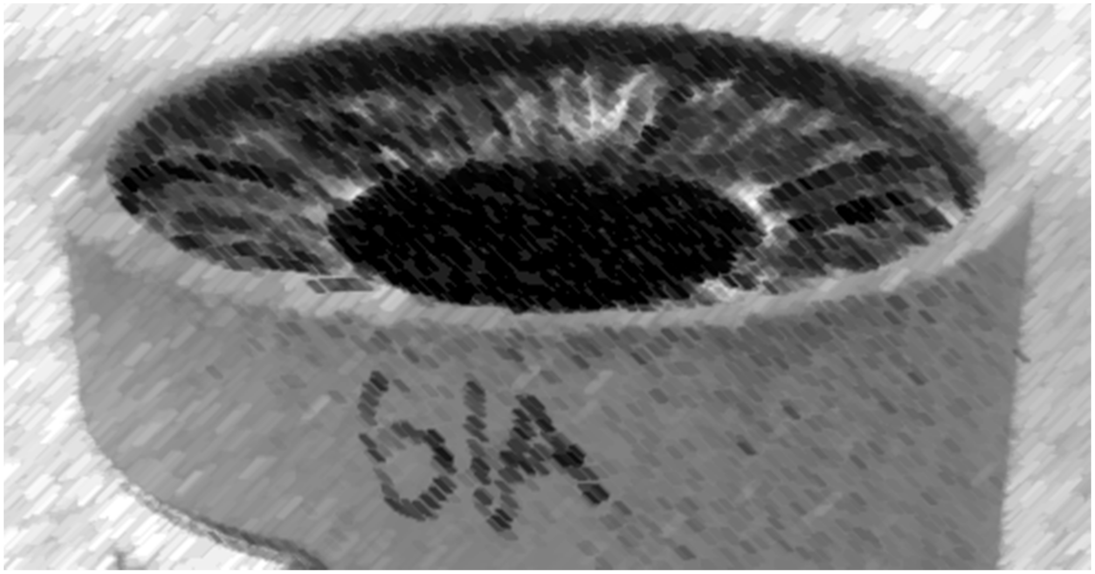


CS61A Lecture 19

Amir Kamil
UC Berkeley
March 6, 2013

Announcements

- HW6 due tomorrow

- Ants project out

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)
        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
```

Building Dictionaries with Lists

Building Dictionaries with Lists

Now that we have lists, we can use them to build dictionaries

Building Dictionaries with Lists

Now that we have lists, we can use them to build dictionaries

We store key-value pairs as 2-element lists inside another list

Building Dictionaries with Lists

Now that we have lists, we can use them to build dictionaries

We store key-value pairs as 2-element lists inside another list

```
records = [['cain',      2.79],
           ['bumgarner', 3.37],
           ['vogelsong', 3.37],
           ['lincecum',  5.18],
           ['zito',      4.15]]
```

Building Dictionaries with Lists

Now that we have lists, we can use them to build dictionaries

We store key-value pairs as 2-element lists inside another list

```
records = [['cain',      2.79],
           ['bumgarner', 3.37],
           ['vogelsong', 3.37],
           ['lincecum',  5.18],
           ['zito',      4.15]]
```

Dictionary operations:

Building Dictionaries with Lists

Now that we have lists, we can use them to build dictionaries

We store key-value pairs as 2-element lists inside another list

```
records = [['cain',      2.79],
           ['bumgarner', 3.37],
           ['vogelsong', 3.37],
           ['lincecum',  5.18],
           ['zito',      4.15]]
```

Dictionary operations:

- **`getitem(key)`**: Look at each record until we find a stored key that matches **`key`**

Building Dictionaries with Lists

Now that we have lists, we can use them to build dictionaries

We store key-value pairs as 2-element lists inside another list

```
records = [['cain',      2.79],
           ['bumgarner', 3.37],
           ['vogelsong', 3.37],
           ['lincecum',  5.18],
           ['zito',      4.15]]
```

Dictionary operations:

- **`getitem(key)`**: Look at each record until we find a stored key that matches **`key`**
- **`setitem(key, value)`**: Check if there is a record with the given key. If so, change the stored value to **`value`**. If not, add a new record that stores **`key`** and **`value`**.

Implementing Dictionaries

Implementing Dictionaries

```
def dictionary():
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
    def setitem(key, value):
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
    def setitem(key, value):
        for item in records:
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
    def setitem(key, value):
        for item in records:
            if item[0] == key:
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
    def setitem(key, value):
        for item in records:
            if item[0] == key:
                item[1] = value
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
    def setitem(key, value):
        for item in records:
            if item[0] == key:
                item[1] = value
                return
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
    def setitem(key, value):
        for item in records:
            if item[0] == key:
                item[1] = value
                return
        records.append([key, value])
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
    def setitem(key, value):
        for item in records:
            if item[0] == key:
                item[1] = value
                return
        records.append([key, value])
    def dispatch(message, key=None, value=None):
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
    def setitem(key, value):
        for item in records:
            if item[0] == key:
                item[1] = value
                return
        records.append([key, value])
    def dispatch(message, key=None, value=None):
        if message == 'getitem':
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
    def setitem(key, value):
        for item in records:
            if item[0] == key:
                item[1] = value
                return
        records.append([key, value])
    def dispatch(message, key=None, value=None):
        if message == 'getitem':
            return getitem(key)
```

Implementing Dictionaries

```python
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
    def setitem(key, value):
        for item in records:
            if item[0] == key:
                item[1] = value
                return
        records.append([key, value])
    def dispatch(message, key=None, value=None):
        if message == 'getitem':
            return getitem(key)
        elif message == 'setitem':
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
    def setitem(key, value):
        for item in records:
            if item[0] == key:
                item[1] = value
                return
        records.append([key, value])
    def dispatch(message, key=None, value=None):
        if message == 'getitem':
            return getitem(key)
        elif message == 'setitem':
            setitem(key, value)
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
    def setitem(key, value):
        for item in records:
            if item[0] == key:
                item[1] = value
                return
        records.append([key, value])
    def dispatch(message, key=None, value=None):
        if message == 'getitem':
            return getitem(key)
        elif message == 'setitem':
            setitem(key, value)
        elif message == 'keys':
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
    def setitem(key, value):
        for item in records:
            if item[0] == key:
                item[1] = value
                return
        records.append([key, value])
    def dispatch(message, key=None, value=None):
        if message == 'getitem':
            return getitem(key)
        elif message == 'setitem':
            setitem(key, value)
        elif message == 'keys':
            return tuple(k for k, _ in records)
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
    def setitem(key, value):
        for item in records:
            if item[0] == key:
                item[1] = value
                return
        records.append([key, value])
    def dispatch(message, key=None, value=None):
        if message == 'getitem':
            return getitem(key)
        elif message == 'setitem':
            setitem(key, value)
        elif message == 'keys':
            return tuple(k for k, _ in records)
        elif message == 'values':
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
    def setitem(key, value):
        for item in records:
            if item[0] == key:
                item[1] = value
                return
        records.append([key, value])
    def dispatch(message, key=None, value=None):
        if message == 'getitem':
            return getitem(key)
        elif message == 'setitem':
            setitem(key, value)
        elif message == 'keys':
            return tuple(k for k, _ in records)
        elif message == 'values':
            return tuple(v for _, v in records)
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
    def setitem(key, value):
        for item in records:
            if item[0] == key:
                item[1] = value
                return
        records.append([key, value])
    def dispatch(message, key=None, value=None):
        if message == 'getitem':
            return getitem(key)
        elif message == 'setitem':
            setitem(key, value)
        elif message == 'keys':
            return tuple(k for k, _ in records)
        elif message == 'values':
            return tuple(v for _, v in records)
    return dispatch
```

Implementing Dictionaries

```
def dictionary():
    """Return a functional implementation of a dictionary."""
    records = []
    def getitem(key):
        for k, v in records:
            if k == key:
                return v
    def setitem(key, value):
        for item in records:
            if item[0] == key:
                item[1] = value
                return
        records.append([key, value])
    def dispatch(message, key=None, value=None):
        if message == 'getitem':
            return getitem(key)
        elif message == 'setitem':
            setitem(key, value)
        elif message == 'keys':
            return tuple(k for k, _ in records)
        elif message == 'values':
            return tuple(v for _, v in records)
    return dispatch
```

Question: Do we need a nonlocal statement here?

Dispatch Dictionaries

Dispatch Dictionaries

Enumerating different messages in a conditional statement isn't very convenient:

Dispatch Dictionaries

Enumerating different messages in a conditional statement isn't very convenient:

- Equality tests are repetitive

Dispatch Dictionaries

Enumerating different messages in a conditional statement isn't very convenient:

- Equality tests are repetitive
- We can't add new messages without writing new code

Dispatch Dictionaries

Enumerating different messages in a conditional statement isn't very convenient:

- Equality tests are repetitive
- We can't add new messages without writing new code

A dispatch dictionary has messages as keys and functions (or data objects) as values.

Dispatch Dictionaries

Enumerating different messages in a conditional statement isn't very convenient:

- Equality tests are repetitive
- We can't add new messages without writing new code

A dispatch dictionary has messages as keys and functions (or data objects) as values.

Dictionaries handle the message look-up logic; we concentrate on implementing useful behavior.

An Account as a Dispatch Dictionary

An Account as a Dispatch Dictionary

```
def account(balance):
```

An Account as a Dispatch Dictionary

```
def account(balance):
    """Return an account that is represented as a
      dispatch dictionary."""
```

An Account as a Dispatch Dictionary

```
def account(balance):
    """Return an account that is represented as a
      dispatch dictionary."""

    def withdraw(amount):
```

An Account as a Dispatch Dictionary

```
def account(balance):
    """Return an account that is represented as a
      dispatch dictionary."""

    def withdraw(amount):
        if amount > dispatch['balance']:
```

An Account as a Dispatch Dictionary

```
def account(balance):
    """Return an account that is represented as a
      dispatch dictionary."""

    def withdraw(amount):
        if amount > dispatch['balance']:
            return 'Insufficient funds'
```

An Account as a Dispatch Dictionary

```
def account(balance):
    """Return an account that is represented as a
      dispatch dictionary."""

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

An Account as a Dispatch Dictionary

```
def account(balance):
    """Return an account that is represented as a
      dispatch dictionary."""

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

An Account as a Dispatch Dictionary

```
def account(balance):
    """Return an account that is represented as a
      dispatch dictionary."""

    def withdraw(amount):
        if amount > dispatch['balance']:
            return 'Insufficient funds'
        dispatch['balance'] -= amount
        return dispatch['balance']

    def deposit(amount):
```

An Account as a Dispatch Dictionary

```
def account(balance):
    """Return an account that is represented as a
      dispatch dictionary."""

    def withdraw(amount):
        if amount > dispatch['balance']:
            return 'Insufficient funds'
        dispatch['balance'] -= amount
        return dispatch['balance']

    def deposit(amount):
        dispatch['balance'] += amount
```

An Account as a Dispatch Dictionary

```
def account(balance):
    """Return an account that is represented as a
      dispatch dictionary."""

    def withdraw(amount):
        if amount > dispatch['balance']:
            return 'Insufficient funds'
        dispatch['balance'] -= amount
        return dispatch['balance']

    def deposit(amount):
        dispatch['balance'] += amount
        return dispatch['balance']
```

An Account as a Dispatch Dictionary

```
def account(balance):
    """Return an account that is represented as a
      dispatch dictionary."""

    def withdraw(amount):
        if amount > dispatch['balance']:
            return 'Insufficient funds'
        dispatch['balance'] -= amount
        return dispatch['balance']

    def deposit(amount):
        dispatch['balance'] += amount
        return dispatch['balance']

    dispatch = {'balance': balance, 'withdraw': withdraw,
                'deposit': deposit}
```

An Account as a Dispatch Dictionary

```
def account(balance):
    """Return an account that is represented as a
      dispatch dictionary."""

    def withdraw(amount):
        if amount > dispatch['balance']:
            return 'Insufficient funds'
        dispatch['balance'] -= amount
        return dispatch['balance']

    def deposit(amount):
        dispatch['balance'] += amount
        return dispatch['balance']

    dispatch = {'balance': balance, 'withdraw': withdraw,
                'deposit': deposit}

    return dispatch
```

An Account as a Dispatch Dictionary

```
def account(balance):
    """Return an account that is represented as a
      dispatch dictionary."""

    def withdraw(amount):
        if amount > dispatch['balance']:
            return 'Insufficient funds'
        dispatch['balance'] -= amount
        return dispatch['balance']

    def deposit(amount):
        dispatch['balance'] += amount
        return dispatch['balance']

    dispatch = {'balance': balance, 'withdraw': withdraw,
                'deposit': deposit}

    return dispatch
```

Question: Why `dispatch['balance']` and not balance?

The Story So Far About Data

The Story So Far About Data

Data abstraction: Enforce a separation between how data values are represented and how they are used.

The Story So Far About Data

Data abstraction: Enforce a separation between how data values are represented and how they are used.

Abstract data types: A representation of a data type is valid if it satisfies certain behavior conditions.

The Story So Far About Data

Data abstraction: Enforce a separation between how data values are represented and how they are used.

Abstract data types: A representation of a data type is valid if it satisfies certain behavior conditions.

Message passing: We can organize large programs by building components that relate to each other by passing messages.

The Story So Far About Data

Data abstraction: Enforce a separation between how data values are represented and how they are used.

Abstract data types: A representation of a data type is valid if it satisfies certain behavior conditions.

Message passing: We can organize large programs by building components that relate to each other by passing messages.

Dispatch functions/dictionaries: A single object can include many different (but related) behaviors that all manipulate the same local state.

The Story So Far About Data

Data abstraction: Enforce a separation between how data values are represented and how they are used.

Abstract data types: A representation of a data type is valid if it satisfies certain behavior conditions.

Message passing: We can organize large programs by building components that relate to each other by passing messages.

Dispatch functions/dictionaries: A single object can include many different (but related) behaviors that all manipulate the same local state.

(All of these techniques can be implemented using only functions and assignment.)

Object-Oriented Programming

Object-Oriented Programming

A method for organizing modular programs

Object-Oriented Programming

A method for organizing modular programs

- Abstraction barriers

Object-Oriented Programming

A method for organizing modular programs

- Abstraction barriers
- Message passing

Object-Oriented Programming

A method for organizing modular programs

- Abstraction barriers
- Message passing
- Bundling together information and related behavior

Object-Oriented Programming

A method for organizing modular programs

- Abstraction barriers
- Message passing
- Bundling together information and related behavior

A metaphor for computation using distributed state

Object-Oriented Programming

A method for organizing modular programs

- Abstraction barriers
- Message passing
- Bundling together information and related behavior

A metaphor for computation using distributed state

- Each *object* has its own local state.

Object-Oriented Programming

A method for organizing modular programs

- Abstraction barriers
- Message passing
- Bundling together information and related behavior

A metaphor for computation using distributed state

- Each *object* has its own local state.
- Each object also knows how to manage its own local state, based on the messages it receives.

Object-Oriented Programming

A method for organizing modular programs

- Abstraction barriers
- Message passing
- Bundling together information and related behavior

A metaphor for computation using distributed state

- Each *object* has its own local state.
- Each object also knows how to manage its own local state, based on the messages it receives.
- Several objects may all be instances of a common type.

Object-Oriented Programming

A method for organizing modular programs

- Abstraction barriers
- Message passing
- Bundling together information and related behavior

A metaphor for computation using distributed state

- Each *object* has its own local state.
- Each object also knows how to manage its own local state, based on the messages it receives.
- Several objects may all be instances of a common type.
- Different types may relate to each other as well.

Object-Oriented Programming

A method for organizing modular programs

- Abstraction barriers
- Message passing
- Bundling together information and related behavior

A metaphor for computation using distributed state

- Each *object* has its own local state.
- Each object also knows how to manage its own local state, based on the messages it receives.
- Several objects may all be instances of a common type.
- Different types may relate to each other as well.

Specialized syntax & vocabulary to support this metaphor

Classes

Classes

A *class* serves as a template for its *instances*.

Classes

A *class* serves as a template for its *instances*.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

Classes

A *class* serves as a template for its *instances*.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```
>>> a = Account('Jim')
```

Classes

A *class* serves as a template for its *instances*.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```
>>> a = Account('Jim')
>>> a.holder
```

Classes

A *class* serves as a template for its *instances*.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
```

Classes

A *class* serves as a template for its *instances*.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
```

Classes

A *class* serves as a template for its *instances*.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

Classes

A *class* serves as a template for its *instances*.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

Idea: All bank accounts should have "withdraw" and "deposit" behaviors that all work in the same way.

Classes

A *class* serves as a template for its *instances*.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

Idea: All bank accounts should have "withdraw" and "deposit" behaviors that all work in the same way.

```
>>> a.deposit(15)
```

Classes

A *class* serves as a template for its *instances*.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

Idea: All bank accounts should have "withdraw" and "deposit" behaviors that all work in the same way.

```
>>> a.deposit(15)
15
```

Classes

A *class* serves as a template for its *instances*.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

Idea: All bank accounts should have "withdraw" and "deposit" behaviors that all work in the same way.

```
>>> a.deposit(15)
15
>>> a.withdraw(10)
```

Classes

A *class* serves as a template for its *instances*.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

Idea: All bank accounts should have "withdraw" and "deposit" behaviors that all work in the same way.

```
>>> a.deposit(15)
15
>>> a.withdraw(10)
5
```

Classes

A *class* serves as a template for its *instances*.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

Idea: All bank accounts should have "withdraw" and "deposit" behaviors that all work in the same way.

```
>>> a.deposit(15)
15
>>> a.withdraw(10)
5
>>> a.balance
```

Classes

A *class* serves as a template for its *instances*.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

Idea: All bank accounts should have "withdraw" and "deposit" behaviors that all work in the same way.

```
>>> a.deposit(15)
15
>>> a.withdraw(10)
5
>>> a.balance
5
```

Classes

A *class* serves as a template for its *instances*.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

Idea: All bank accounts should have "withdraw" and "deposit" behaviors that all work in the same way.

```
>>> a.deposit(15)
15
>>> a.withdraw(10)
5
>>> a.balance
5
>>> a.withdraw(10)
```

Classes

A *class* serves as a template for its *instances*.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

Idea: All bank accounts should have "withdraw" and "deposit" behaviors that all work in the same way.

```
>>> a.deposit(15)
15
>>> a.withdraw(10)
5
>>> a.balance
5
>>> a.withdraw(10)
'Insufficient funds'
```

Classes

A *class* serves as a template for its *instances*.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

Idea: All bank accounts should have "withdraw" and "deposit" behaviors that all work in the same way.

Better idea: All bank accounts share a "withdraw" method.

```
>>> a.deposit(15)
15
>>> a.withdraw(10)
5
>>> a.balance
5
>>> a.withdraw(10)
'Insufficient funds'
```

The Class Statement

The Class Statement

```
class <name>(<base class>):
    <suite>
```

The Class Statement

```
class <name>(<base class>):
    <suite>
```

Next lecture

The Class Statement

```
class <name>(<base class>):
    <suite>
```

Next lecture

A class statement **creates** a new class and **binds** that class to `<name>` in the first frame of the current environment.

The Class Statement

```
class <name>(<base class>):
    <suite>
```

Next lecture

A class statement **creates** a new class and **binds** that class to `<name>` in the first frame of the current environment.

Statements in the `<suite>` create attributes of the class.

The Class Statement

```
class <name>(<base class>):
    <suite>
```

Next lecture

A class statement **creates** a new class and **binds** that class to `<name>` in the first frame of the current environment.

Statements in the `<suite>` create attributes of the class.

As soon as an instance is created, it is passed to `__init__`, which is an attribute of the class.

The Class Statement

```
class <name>(<base class>):
      <suite>
```

Next lecture

A class statement **creates** a new class and **binds** that class to `<name>` in the first frame of the current environment.

Statements in the `<suite>` create attributes of the class.

As soon as an instance is created, it is passed to `__init__`, which is an attribute of the class.

```
class Account(object):
```

The Class Statement

```
class <name>(<base class>):
    <suite>
```

Next lecture

A class statement **creates** a new class and **binds** that class to `<name>` in the first frame of the current environment.

Statements in the `<suite>` create attributes of the class.

As soon as an instance is created, it is passed to `__init__`, which is an attribute of the class.

```
class Account(object):
    def __init__(self, account_holder):
```

The Class Statement

```
class <name>(<base class>):
    <suite>
```

Next lecture

A class statement **creates** a new class and **binds** that class to `<name>` in the first frame of the current environment.

Statements in the `<suite>` create attributes of the class.

As soon as an instance is created, it is passed to `__init__`, which is an attribute of the class.

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
```

The Class Statement

```
class <name>(<base class>):
    <suite>
```

Next lecture

A class statement **creates** a new class and **binds** that class to `<name>` in the first frame of the current environment.

Statements in the `<suite>` create attributes of the class.

As soon as an instance is created, it is passed to `__init__`, which is an attribute of the class.

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
```

Initialization

Initialization

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

Initialization

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

When a class is called:

Initialization

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

When a class is called:

1. A new instance of that class is created:

Initialization

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

When a class is called:

1. A new instance of that class is created:
2. The constructor `__init__` of the class is called with the new object as its first argument (called `self`), along with additional arguments provided in the call expression.

Initialization

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

When a class is called:

1. A new instance of that class is created: 
2. The constructor `__init__` of the class is called with the new object as its first argument (called `self`), along with additional arguments provided in the call expression.

Initialization

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

When a class is called:

1. A new instance of that class is created: 
2. The constructor `__init__` of the class is called with the new object as its first argument (called `self`), along with additional arguments provided in the call expression.

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
```

Initialization

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

When a class is called:

1. A new instance of that class is created: 
2. The constructor `__init__` of the class is called with the new object as its first argument (called `self`), along with additional arguments provided in the call expression.

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
```

Initialization

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes.

```
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```

When a class is called:

1. A new instance of that class is created: 
2. The constructor `__init__` of the class is called with the new object as its first argument (called `self`), along with additional arguments provided in the call expression.

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
```

Object Identity

Object Identity

Every object that is an instance of a user-defined class has a unique identity:

Object Identity

Every object that is an instance of a user-defined class has a unique identity:

```
>>> a = Account('Jim')
>>> b = Account('Jack')
```

Object Identity

Every object that is an instance of a user-defined class has a unique identity:

```
>>> a = Account('Jim')
>>> b = Account('Jack')
```

Identity testing is performed by "is" and "is not" operators:

Object Identity

Every object that is an instance of a user-defined class has a unique identity:

```
>>> a = Account('Jim')
>>> b = Account('Jack')
```

Identity testing is performed by "is" and "is not" operators:

```
>>> a is a
True
>>> a is not b
True
```

Object Identity

Every object that is an instance of a user-defined class has a unique identity:

```
>>> a = Account('Jim')
>>> b = Account('Jack')
```

Identity testing is performed by "is" and "is not" operators:

```
>>> a is a
True
>>> a is not b
True
```

Binding an object to a new name using assignment **does not** create a new object:

Object Identity

Every object that is an instance of a user-defined class has a unique identity:

```
>>> a = Account('Jim')
>>> b = Account('Jack')
```

Identity testing is performed by "is" and "is not" operators:

```
>>> a is a
True
>>> a is not b
True
```

Binding an object to a new name using assignment **does not** create a new object:

```
>>> c = a
>>> c is a
True
```

Methods

Methods

Methods are defined in the suite of a class statement

Methods

Methods are defined in the suite of a class statement

```
class Account(object):
```

Methods

Methods are defined in the suite of a class statement

```
class Account(object):
    def __init__(self, account_holder):
```

Methods

Methods are defined in the suite of a class statement

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
```

Methods

Methods are defined in the suite of a class statement

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
```

Methods

Methods are defined in the suite of a class statement

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
    def deposit(self, amount):
```

Methods

Methods are defined in the suite of a class statement

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
    def deposit(self, amount):
        self.balance = self.balance + amount
```

Methods

Methods are defined in the suite of a class statement

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance
```

Methods

Methods are defined in the suite of a class statement

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance
    def withdraw(self, amount):
```

Methods

Methods are defined in the suite of a class statement

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance
    def withdraw(self, amount):
        if amount > self.balance:
```

Methods

Methods are defined in the suite of a class statement

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance
    def withdraw(self, amount):
        if amount > self.balance:
            return 'Insufficient funds'
```

Methods

Methods are defined in the suite of a class statement

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance
    def withdraw(self, amount):
        if amount > self.balance:
            return 'Insufficient funds'
        self.balance = self.balance - amount
```

Methods

Methods are defined in the suite of a class statement

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance
    def withdraw(self, amount):
        if amount > self.balance:
            return 'Insufficient funds'
        self.balance = self.balance - amount
        return self.balance
```

Methods

Methods are defined in the suite of a class statement

```
class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance
    def withdraw(self, amount):
        if amount > self.balance:
            return 'Insufficient funds'
        self.balance = self.balance - amount
        return self.balance
```

These def statements create function objects as always,
but their names are bound as attributes of the class.

Invoking Methods

Invoking Methods

All invoked methods have access to the object via the `self` parameter, and so they can all access and manipulate the object's state.

Invoking Methods

All invoked methods have access to the object via the **self** parameter, and so they can all access and manipulate the object's state.

```
class Account(object):
    ...
    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance
```

Invoking Methods

All invoked methods have access to the object via the **self** parameter, and so they can all access and manipulate the object's state.

```
class Account(object):
    ...
    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance
```

Called with two arguments

Invoking Methods

All invoked methods have access to the object via the **self** parameter, and so they can all access and manipulate the object's state.

```
class Account(object):
    ...
    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance
```

Called with two arguments

Dot notation automatically supplies the first argument to a method.

Invoking Methods

All invoked methods have access to the object via the **self** parameter, and so they can all access and manipulate the object's state.

```
class Account(object):
    ...
    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance
```

Called with two arguments

Dot notation automatically supplies the first argument to a method.

```
>>> tom_account = Account('Tom')
>>> tom_account.deposit(100)
100
```

Invoking Methods

All invoked methods have access to the object via the **self** parameter, and so they can all access and manipulate the object's state.

```
class Account(object):
    ...
    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance
```

Called with two arguments

Dot notation automatically supplies the first argument to a method.

```
>>> tom_account = Account('Tom')
>>> tom_account.deposit(100)
100
```

Invoked with one argument

Dot Expressions

Dot Expressions

Objects receive messages via dot notation

Dot Expressions

Objects receive messages via dot notation

Dot notation accesses attributes of the instance or its class

Dot Expressions

Objects receive messages via dot notation

Dot notation accesses attributes of the instance or its class

```
<expression> . <name>
```

Dot Expressions

Objects receive messages via dot notation

Dot notation accesses attributes of the instance or its class

```
<expression> . <name>
```

The `<expression>` can be any valid Python expression

Dot Expressions

Objects receive messages via dot notation

Dot notation accesses attributes of the instance or its class

`<expression> . <name>`

The **`<expression>`** can be any valid Python expression

The **`<name>`** must be a simple name

Dot Expressions

Objects receive messages via dot notation

Dot notation accesses attributes of the instance or its class

`<expression> . <name>`

The `<expression>` can be any valid Python expression

The `<name>` must be a simple name

Evaluates to the value of the attribute **looked up** by `<name>` in the object that is the value of the `<expression>`

Dot Expressions

Objects receive messages via dot notation

Dot notation accesses attributes of the instance or its class

<expression> . <name>

The **<expression>** can be any valid Python expression

The **<name>** must be a simple name

Evaluates to the value of the attribute **looked up** by **<name>** in the object that is the value of the **<expression>**

```
tom_account.deposit(10)
```

Dot Expressions

Objects receive messages via dot notation

Dot notation accesses attributes of the instance or its class

```
<expression> . <name>
```

The `<expression>` can be any valid Python expression

The `<name>` must be a simple name

Evaluates to the value of the attribute **looked up** by `<name>` in the object that is the value of the `<expression>`

```
tom_account.deposit(10)
```

Dot expression

Dot Expressions

Objects receive messages via dot notation

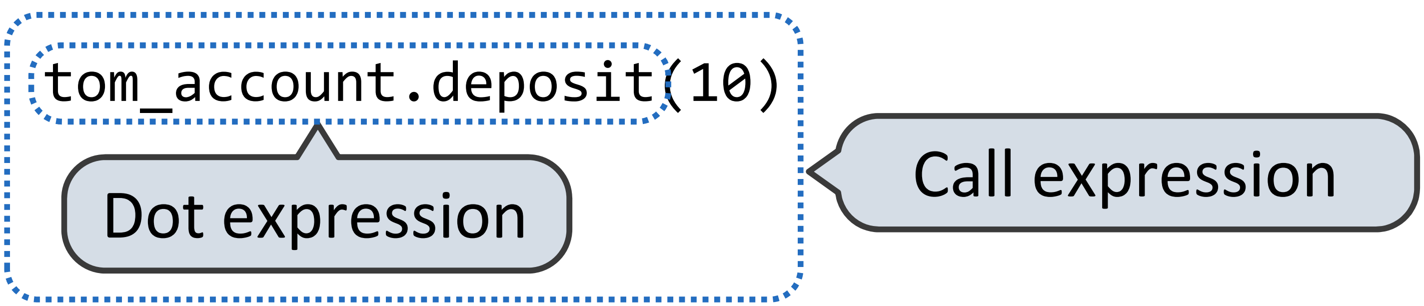
Dot notation accesses attributes of the instance or its class

<expression> . <name>

The **<expression>** can be any valid Python expression

The **<name>** must be a simple name

Evaluates to the value of the attribute **looked up** by **<name>** in the object that is the value of the **<expression>**



Accessing Attributes

Accessing Attributes

Using **`getattr`**, we can look up an attribute using a string, just as we did with a dispatch function/dictionary

Accessing Attributes

Using **`getattr`**, we can look up an attribute using a string, just as we did with a dispatch function/dictionary

```
>>> getattr(tom_account, 'balance')
```

Accessing Attributes

Using **`getattr`**, we can look up an attribute using a string, just as we did with a dispatch function/dictionary

```
>>> getattr(tom_account, 'balance')
10
```

Accessing Attributes

Using **`getattr`**, we can look up an attribute using a string, just as we did with a dispatch function/dictionary

```
>>> getattr(tom_account, 'balance')
10

>>> hasattr(tom_account, 'deposit')
```

Accessing Attributes

Using **`getattr`**, we can look up an attribute using a string, just as we did with a dispatch function/dictionary

```
>>> getattr(tom_account, 'balance')
10

>>> hasattr(tom_account, 'deposit')
True
```

Accessing Attributes

Using **`getattr`**, we can look up an attribute using a string, just as we did with a dispatch function/dictionary

```
>>> getattr(tom_account, 'balance')
10

>>> hasattr(tom_account, 'deposit')
True
```

`getattr` and dot expressions look up a name in the same way

Accessing Attributes

Using **`getattr`**, we can look up an attribute using a string, just as we did with a dispatch function/dictionary

```
>>> getattr(tom_account, 'balance')
10

>>> hasattr(tom_account, 'deposit')
True
```

`getattr` and dot expressions look up a name in the same way

Looking up an attribute name in an object may return:

Accessing Attributes

Using **`getattr`**, we can look up an attribute using a string, just as we did with a dispatch function/dictionary

```
>>> getattr(tom_account, 'balance')
10

>>> hasattr(tom_account, 'deposit')
True
```

`getattr` and dot expressions look up a name in the same way

Looking up an attribute name in an object may return:

- One of its instance attributes, **or**

Accessing Attributes

Using **getattr**, we can look up an attribute using a string, just as we did with a dispatch function/dictionary

```
>>> getattr(tom_account, 'balance')
10

>>> hasattr(tom_account, 'deposit')
True
```

getattr and dot expressions look up a name in the same way

Looking up an attribute name in an object may return:

- One of its instance attributes, **or**
- One of the attributes of its class

Methods and Functions

Methods and Functions

Python distinguishes between:

Methods and Functions

Python distinguishes between:

- *Functions*, which we have been creating since the beginning of the course, and

Methods and Functions

Python distinguishes between:

- *Functions*, which we have been creating since the beginning of the course, and
- *Bound methods*, which couple together a function and the object on which that method will be invoked.

Methods and Functions

Python distinguishes between:

- *Functions*, which we have been creating since the beginning of the course, and
- *Bound methods*, which couple together a function and the object on which that method will be invoked.

```
Object  +  Function  =  Bound Method
```

Methods and Functions

Python distinguishes between:

- *Functions*, which we have been creating since the beginning of the course, and
- *Bound methods*, which couple together a function and the object on which that method will be invoked.

```
Object   +   Function   =   Bound Method
```

```
>>> type(Account.deposit)
```

Methods and Functions

Python distinguishes between:

- *Functions*, which we have been creating since the beginning of the course, and
- *Bound methods*, which couple together a function and the object on which that method will be invoked.

```
Object  +  Function  =  Bound Method
```

```
>>> type(Account.deposit)
<class 'function'>
```

Methods and Functions

Python distinguishes between:

- *Functions*, which we have been creating since the beginning of the course, and
- *Bound methods*, which couple together a function and the object on which that method will be invoked.

```
Object  +  Function  =  Bound Method
```

```
>>> type(Account.deposit)
<class 'function'>
>>> type(tom_account.deposit)
```

Methods and Functions

Python distinguishes between:

- *Functions*, which we have been creating since the beginning of the course, and
- *Bound methods*, which couple together a function and the object on which that method will be invoked.

```
Object  +  Function  =  Bound Method
```

```
>>> type(Account.deposit)
<class 'function'>
>>> type(tom_account.deposit)
<class 'method'>
```

Methods and Functions

Python distinguishes between:

- *Functions*, which we have been creating since the beginning of the course, and
- *Bound methods*, which couple together a function and the object on which that method will be invoked.

```
Object  +  Function  =  Bound Method
```

```
>>> type(Account.deposit)
<class 'function'>
>>> type(tom_account.deposit)
<class 'method'>

>>> Account.deposit(tom_account, 1001)
```

Methods and Functions

Python distinguishes between:

- *Functions*, which we have been creating since the beginning of the course, and
- *Bound methods*, which couple together a function and the object on which that method will be invoked.

```
Object + Function = Bound Method
```

```
>>> type(Account.deposit)
<class 'function'>
>>> type(tom_account.deposit)
<class 'method'>

>>> Account.deposit(tom_account, 1001)
1011
```

Methods and Functions

Python distinguishes between:

- *Functions*, which we have been creating since the beginning of the course, and
- *Bound methods*, which couple together a function and the object on which that method will be invoked.

```
Object   +   Function   =   Bound Method
```

```
>>> type(Account.deposit)
<class 'function'>
>>> type(tom_account.deposit)
<class 'method'>

>>> Account.deposit(tom_account, 1001)
1011
>>> tom_account.deposit(1000)
```

Methods and Functions

Python distinguishes between:

- *Functions*, which we have been creating since the beginning of the course, and
- *Bound methods*, which couple together a function and the object on which that method will be invoked.

```
Object   +   Function   =   Bound Method
```

```
>>> type(Account.deposit)
<class 'function'>
>>> type(tom_account.deposit)
<class 'method'>

>>> Account.deposit(tom_account, 1001)
1011
>>> tom_account.deposit(1000)
2011
```

Methods and Currying

Methods and Currying

Earlier, we saw *currying*, which converts a function that takes in multiple arguments into multiple chained functions.

Methods and Currying

Earlier, we saw *currying*, which converts a function that takes in multiple arguments into multiple chained functions.

```
def curry(f):
    def outer(x):
        def inner(*args):
            return f(x, *args)
        return inner
    return outer
```

Methods and Currying

Earlier, we saw *currying*, which converts a function that takes in multiple arguments into multiple chained functions.

```
def curry(f):
    def outer(x):
        def inner(*args):
            return f(x, *args)
        return inner
    return outer
```

```
>>> add2 = curry(add)(2)
>>> add2(3)
5
```

Methods and Currying

Earlier, we saw *currying*, which converts a function that takes in multiple arguments into multiple chained functions.

The same procedure can be used to create a bound method from a function

```
def curry(f):
    def outer(x):
        def inner(*args):
            return f(x, *args)
        return inner
    return outer
```

```
>>> add2 = curry(add)(2)
>>> add2(3)
5
```

Methods and Currying

Earlier, we saw *currying*, which converts a function that takes in multiple arguments into multiple chained functions.

The same procedure can be used to create a bound method from a function

```
def curry(f):
    def outer(x):
        def inner(*args):
            return f(x, *args)
        return inner
    return outer
```

```
>>> add2 = curry(add)(2)
>>> add2(3)
5

>>> tom_deposit = curry(Account.deposit)(tom_account)
>>> tom_deposit(1000)
3011
```