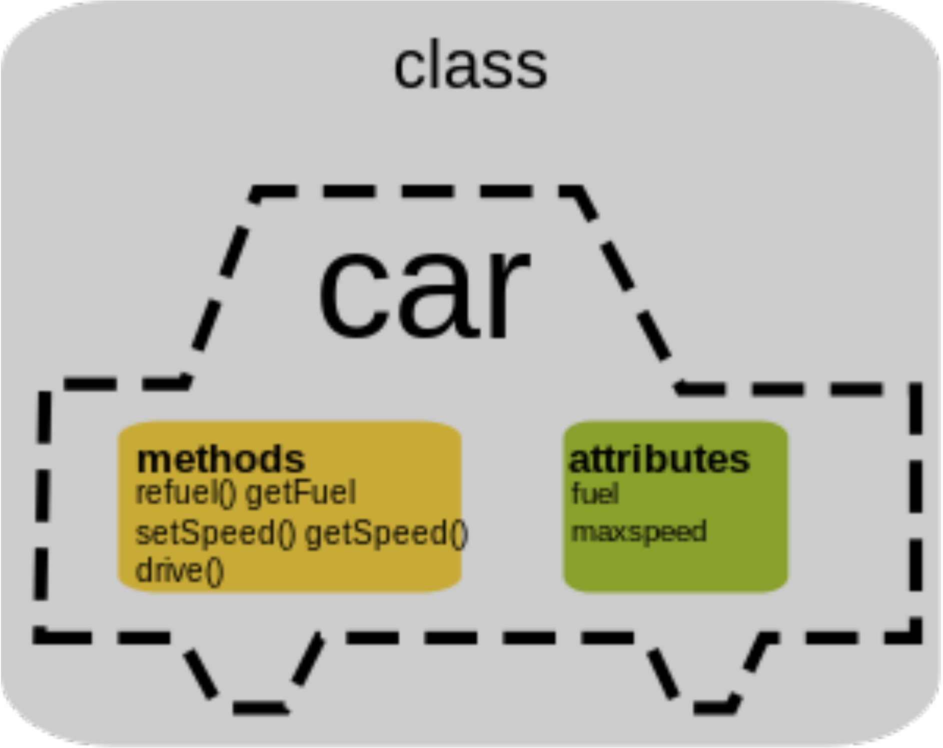
15-112
Fundamentals of Programming

Week 5- Lecture 1:
Intro to Object Oriented Programming (OOP)



June 19, 2017

What is object oriented programming (OOP)?

1. The ability to create your own data types.

```
s = “hello”
print(s.capitalize())

s = set()
s.add(5)
```

These are built-in data types.

2. Designing your programs around the data types you create.

What is object oriented programming (OOP)?

Is every programming language object-oriented?

No. e.g. C

(So OOP is not a necessary approach to programming)

What have we been doing so far?

Procedural programming.

Designing your programs around functions (actions)

Is OOP a useful approach to programming?

Make up your own mind about it.

1. Creating our own data type

2. OOP paradigm

Motivating example

Suppose you want to keep track of the books in your library.

For each book, you want to store:

title, author, year published

How can we do it?

Motivating example

Option 1:

```
book1Title = “Harry Potter and the Prisoner prisoner of Azkaban”
book1Author = “J. K. Rowling”
book1Year = 1999

book2Title = “The Hunger Games”
book2Author = “S. Collins”
book2Year = 2008;
```

Would be better to use one variable for each book.

One variable to hold logically connected data together.
(like lists)

Motivating example

Option 2:

```
book1 = [“Harry Potter and the Prisoner prisoner of Azkaban”, “J.K. Rowling”, 1999]
```

```
book2 = list()
book2.append(“The Hunger Games”)
book2.append(“S. Collins”)
book2.append(2008)
```

Can forget which index corresponds to what.

Hurts readability.

Motivating example

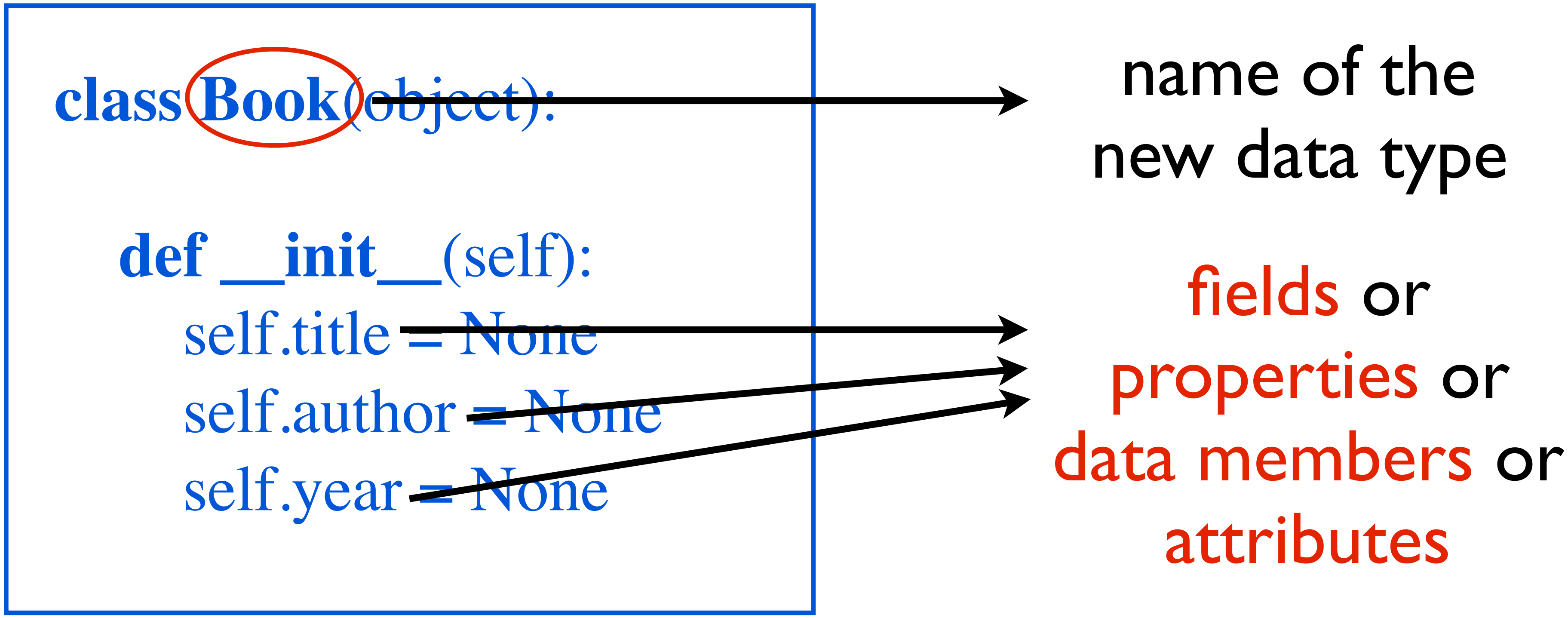
Option 3:

```
book1 = {“title”: “Harry Potter and the Prisoner prisoner of Azkaban”,
          “author”: “J.K. Rowling”,
          “year”: 1999}

book2 = dict()
book2[“title”] = “The Hunger Games”,
book2[“author”] = “S.Collins”
book2[“year”] = 2008
```

Doesn’t really tell us what type of object book1 and book2 are.

They are just dictionaries.

Defining a data type (class) called Book



```
class Book(object):

    def __init__(self):
        self.title = None
        self.author = None
        self.year = None
```

name of the
new data type

fields or
properties or
data members or
attributes

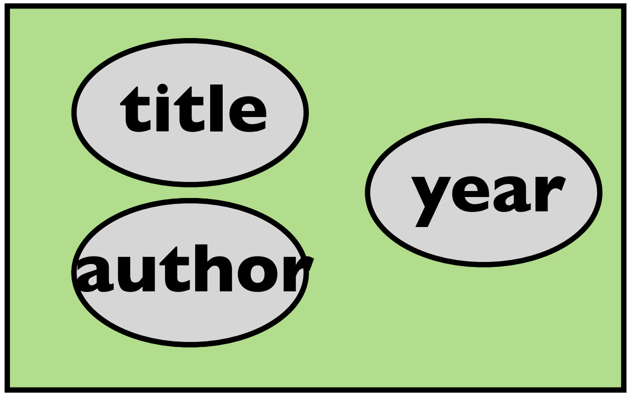
This **defines** a new data type named Book.

__init__ is called a constructor.

Defining a data type (class) called Book

```
class Book(object):

    def __init__(self):
        self.title = None
        self.author = None
        self.year = None
```

Book class



Defining a data type (class) called Book

```
class Book(object):
    def __init__(self):
        self.title = None
        self.author = None
        self.year = None

b = Book()
b.title = “Hamlet”
b.author = “Shakespeare”
b.year = 1602
```

call __init__ with self = b

Creates an object of type Book

b refers to that object.

Compare to:

```
b = dict()
b[“title”] = “Hamlet”
b[“author”] = “Shakespeare”
b[“year”] = 1602
```

Creating 2 books

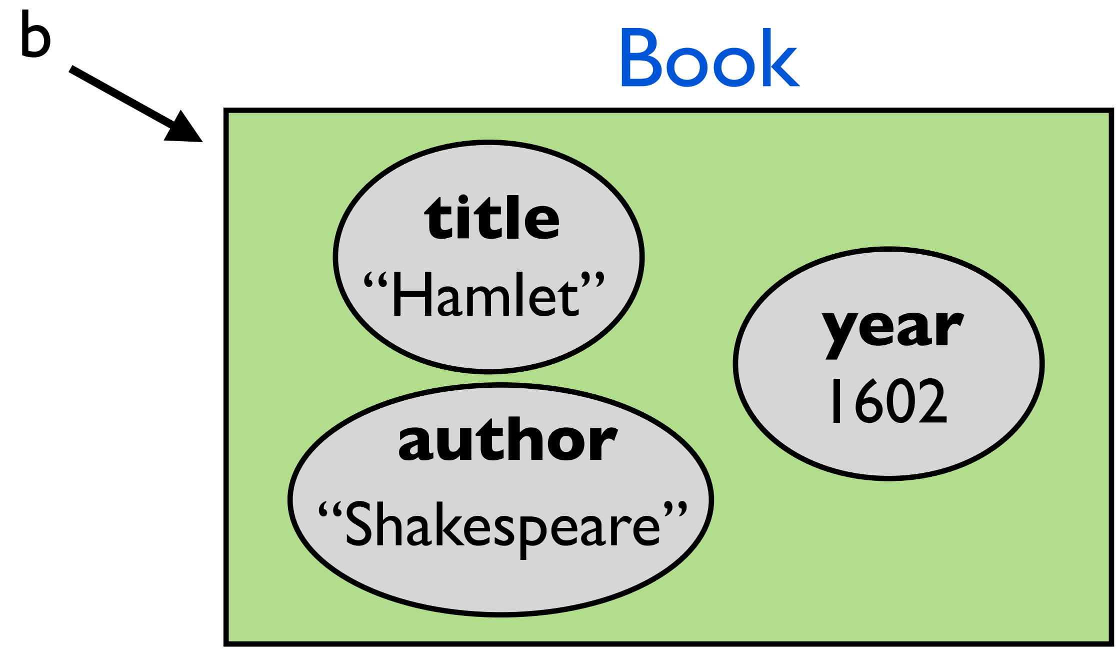
```
class Book(object):
    def __init__(self):
        self.title = None
        self.author = None
        self.year = None

b = Book()
b.title = “Hamlet”
b.author = “Shakespeare”
b.year = 1602

b2 = Book()
b2.title = “It”
b2.author = “S. King”
b2.year = 1987
```

b refers to an object of type Book.

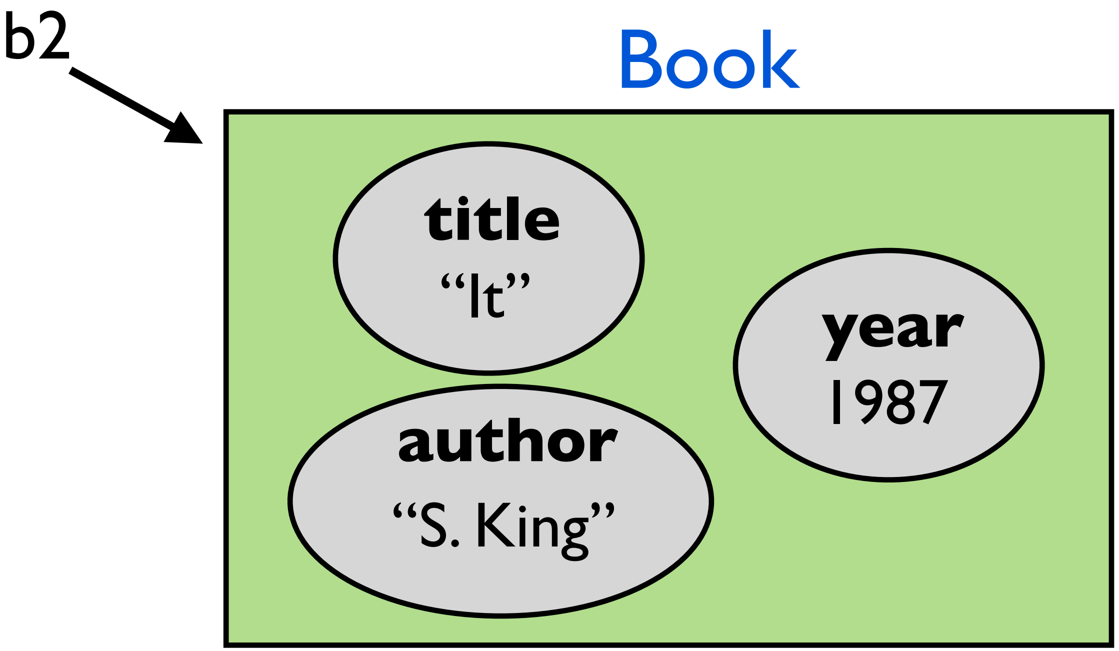
b2 refers to another object of type Book.

Creating 2 books

```
b = Book()
b.title = “Hamlet”
b.author = “Shakespeare”
b.year = 1602
```



```
b2 = Book()
b2.title = “It”
b2.author = “S. King”
b2.year = 1987
```



Initializing fields at object creation

```
class Book(object):
    def __init__(self, title, author, year):
        self.title = title
        self.author = author
        self.year = year
```

```
b.title = “Hamlet”
b.author = “Shakespeare”
b.year = 1602
```

```
b = Book(“Hamlet”, “Shakespeare”, 1602)
```

Initializing fields at object creation

```
class Book(object):
    def __init__(self, t, a, y):
        self.title = t
        self.author = a
        self.year = y
```

```
b.title = “Hamlet”
b.author = “Shakespeare”
b.year = 1602
```

```
b = Book(“Hamlet”, “Shakespeare”, 1602)
```

Initializing fields at object creation

```
class Book(object):
    def __init__(self, title, author):
        self.title = title
        self.author = author
        self.year = None
```

b.title = “Hamlet”

b.author = “Shakespeare”

```
b = Book(“Hamlet”, “Shakespeare”)
```

Initializing fields at object creation

```
class Book(object):
    def __init__(foo, title, author):
        foo.title = title
        foo.author = author
        foo.year = None
```

```
b = Book(“Hamlet”, “Shakespeare”)
```

```
b.title = “Hamlet”
b.author = “Shakespeare”
```

Another Example

Imagine you have a website that allows users to sign-up.

You want to keep track of the users.

```
class User(object):
    def __init__(self, username, email, password):
        self.username = username
        self.email = email
        self.password = password
```

Other Examples

```
class Account(object):
    def __init__(self):
        self.balance = None
        self.numWithdrawals = None
        self.isRich = False
```

Account is the *type*.

```
a1 = Account()
a1.balance = 1000000
a1.isRich = True

a2 = Account()
a2.balance = 10
a2.numWithdrawals = 1
```

Creating different *objects* of the same *type* (Account).

Other Examples

```
class Cat(object):
    def __init__(self, name, age, isFriendly):
        self.name = None
        self.age = None
        self.isFriendly = None
```

Cat is the *type*.

```
c1 = Cat("Tobias", 6, False)

c2 = Cat("Frisky", 1, True)
```

Creating different *objects* of the same *type* (Cat).

Other Examples

```
class Rectangle(object):
    def __init__(self, x, y, width, height):
        self.x = x
        self.y = y
        self.width = width
        self.height = height
```

Rectangle is the *type*.

```
r1 = Rectangle(0, 0, 4, 5)
```

Creating different *objects*
of the same *type* (Rectangle).

```
r2 = Rectangle(1, -1, 2, 1)
```

An object has 2 parts

1. **instance variables**: a collection of data attributes

2. **methods**: functions that act on that data

```
s = set()
s.add(5)
```

This is like having
a function called add:

```
add(s, 5)
```

How can you define methods?

1. Creating our own data type

Step 1: Defining the instance variables

Step 2: Adding methods to our data type

2. OOP paradigm

Example: Rectangle

```
class Rectangle(object):
        def __init__(self, width, height):
                self.width = width
                self.height = height


def getArea(rec):
        return rec.width*rec.height


r = Rectangle(3, 5)
print (“The area is”,  getArea(r))
```

Defining a **function**
that acts on a rectangle object

Example: Rectangle

```
class Rectangle(object):
    def __init__(self, width, height):
        self.width = width
        self.height = height

    def getArea(self):
        return self.width*self.height
```

Defining a **method**

that acts on a rectangle object

```
r = Rectangle(3, 5)
print (“The area is”,  r.getArea())
```

Example: Rectangle

```
class Rectangle(object):
    def __init__(self, width, height):
        self.width = width
        self.height = height

    def getArea(self):
        return self.width*self.height
```

read/return data

```
    def getPerimeter(self):
        return 2*(self.width + self.height)
```

read/return data

```
    def doubleDimensions(self):
        self.width *= 2
        self.height *= 2
```

modify data

```
    def rotate90Degrees(self):
        (self.width, self.height) = (self.height, self.width)
```

modify data

Example: Rectangle

```
r1 = Rectangle(3, 5)
r2 = Rectangle(1, 4)
r3 = Rectangle(6, 7)
print (“The width of r1 is %d.”  %  r1.width)
r1.width = 10
print (“The area of r2 is %d.”  %  r2.getArea())
print (“The perimeter of r3 is %d.”  %  r.getPerimeter())
r3.doubleDimensions()
print (“The perimeter of r3 is %d.”  %  r.getPerimeter())
```

Example 2: Cat

```
class Cat(object):
    def __init__(self, weight, age, isFriendly):
        self.weight = weight
        self.age = age
        self.isFriendly = isFriendly

    def printInfo(self):
        print (“I weigh ”, self.weight, “kg.”)
        print (“I am ”, self.age, “ years old.”)
        if (self.isFriendly):
            print (“I am the nicest cat in the world.”)
        else:
            print (“One more step and I will attack!!!”)

    …
```

Example 2: Cat

```
…

def feed(self, food):
    self.weight += food
    print (“It was not Fancy Feast’s seafood”)
    self.wail()

def wail(self):
    print (“Miiiiaaaaawwwww”)
    self.moodSwing()

def moodSwing(self):
    self.isFriendly = (random.randint(0,1) == 0)

…
```

Example 2: Cat

```
frisky = Cat(4.2, 2, True)
tiger = Cat(102, 5, False)

frisky.printInfo()
tiger.printInfo()

frisky.feed(0.2)
tiger.feed(3)

frisky.printInfo()
tiger.printInfo()
```

1. Creating our own data type

Step 1: Defining the instance variables

Step 2: Adding methods to our data type

2. OOP paradigm

The general idea behind OOP

1. Group data together with the methods into one unit.

2. Methods represent the interface:

    - control how the object should be used.
    - hide internal complexities.

3. Design programs around objects.

Idea 1: group together data and methods

Encapsulate the data together with the methods that act on them.

data
(fields/properties)

methods
that act on the data

All in one unit

Idea 1 advantages

Adds another layer of organizational structure.

Our data types better correspond to objects in reality.

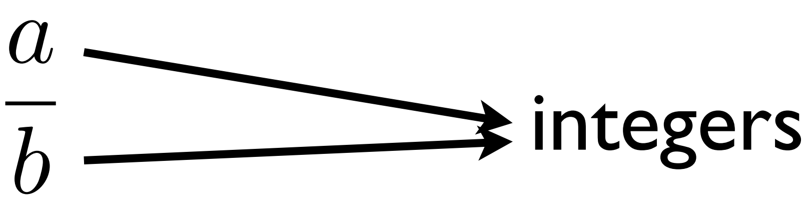
Objects in real life have
- properties
- actions that they can perform

Your new data type is easily shareable.
- everything is in one unit.
- all you need to provide is a documentation.

Example: Representing fractions

Rational numbers: a number that can be expressed as a ratio of two integers.

Also called fractions.



$$\frac{a}{b}$$

integers

$a =$ numerator

$b =$ denominator (cannot be 0)

Example: Representing fractions

```
class Fraction(object):
        def __init__(self, n, d):
                self.numerator = n
                self.denominator = d

        def toString(self):
                return str(self.numerator) + “ / ” + str(self.denominator)

        def toFloat(self):
                return self.numerator / self.denominator

        def simplify(self):
                # code for simplifying

        def add(self, other):
                # code for adding

        def multiply(self, other):
               # code for multiplying
        …
```

Example: Representing fractions

Everything you might want to do with rational numbers is packaged up nicely into one unit:

the new data type Fraction.

The general idea behind OOP

1. Group together data together with the methods into one unit.

2. Methods represent the interface:

    - control how the object should be used.
    - hide internal complexities.

3. Design programs around objects.

Idea 2: Methods are the interface

Methods should be the only way to read and process the data/fields.

don’t access data members directly.

If done right, the hope is that the code is:

- easy to handle/maintain
- easy to fix bugs

Expanding the Cat class (1/3)

```
class Cat(object):

    def __init__(self, n, w, a, f):
        self.name = n
        self.weight = w
        self.age = a
        self.isFriendly = f


    …
```

Could do:

```
c = Cat(“tiger”, 98, 2, False)
c.weight = -1
```

But this is not processing data through the methods.

Expanding the Cat class (2/3)

```
...

def setWeight(self, newWeight):
    if (newWeight > 0):
        self.weight = newWeight

def getWeight(self):
    return self.weight

def getAge(self):
    return self.age

def setAge(self, newAge):
    if(newAge >= 0):
        self.age = newAge

...
```

Instead of:

```
c = Cat(“tiger”, 98, 2, False)
c.weight = -1
```

do:

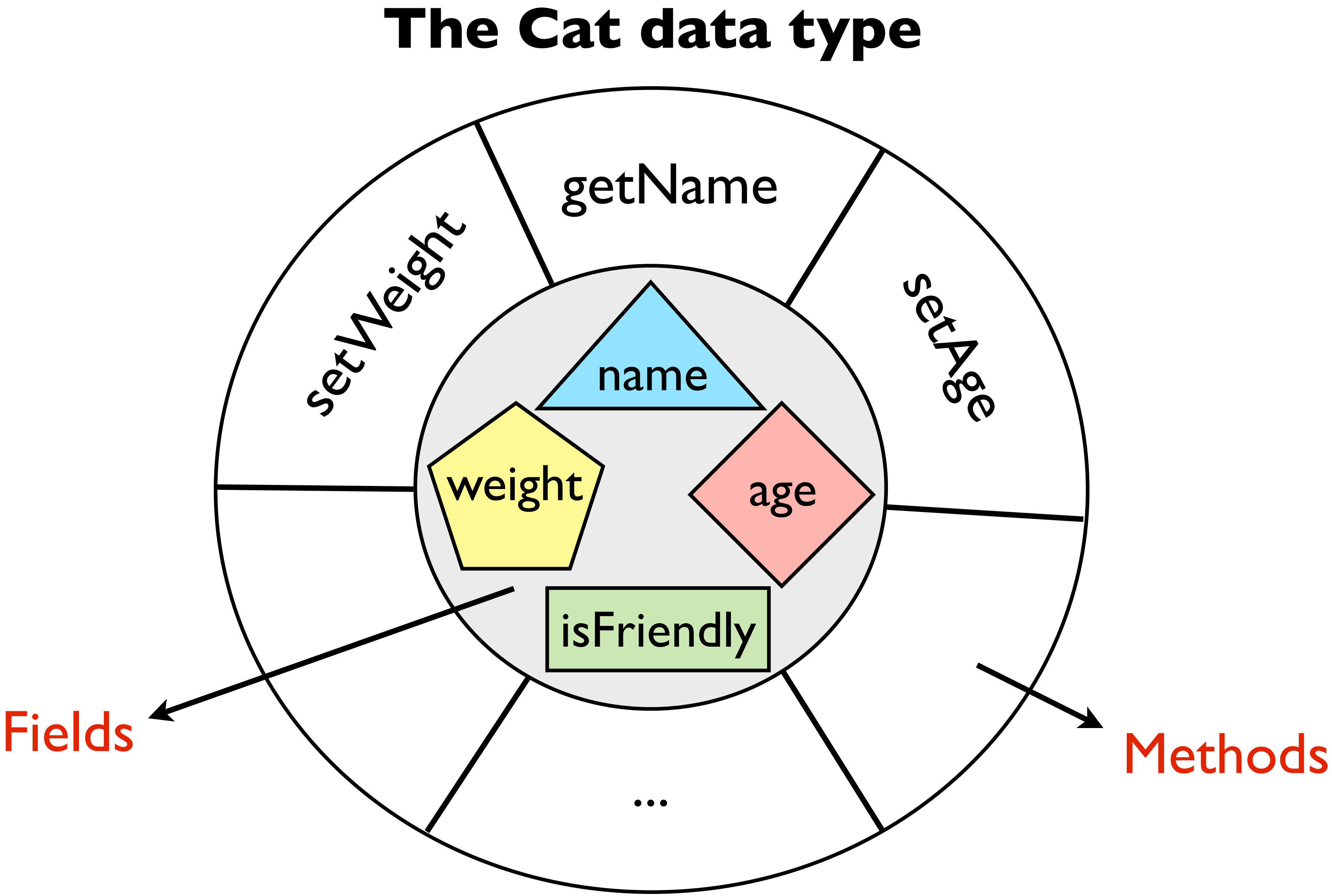
```
c = Cat(“tiger”, 98, 2, False)
c.setWeight(-1)
```

Expanding the Cat class (3/3)

```
...
def getName(self):
        return self.name

def getIsFriendly(self):
        return self.isFriendly

def feed(self, food):
        self.weight += food
        self.isFriendly = (random.randint(0,1) == 0)
```

There are no methods to directly change the name or isFriendly fields.

Idea 2: Methods are the interface



Common Types of Methods

Observers

```
def getName(self):
    return self.name
```

```
def getAge(self):
    return self.age
```

Usually named getBlla(), where Blla is the field name.

Modifiers

```
def setWeight(self, newWeight):
    if (newWeight > 0):
        self.weight = newWeight
```

Usually named setBlla(*input*), where Blla is the field name.

Common Types of Methods

```
…
def getWeight(self):
    return self.weight

def getAge(self):
    return self.age
```

Observer Methods

```
def setWeight(self, newWeight):
    if (newWeight > 0):
        self.weight = newWeight

def setAge(self, newAge):
    if (newAge >= 0):
        self.age = newAge

…
```

Modifier Methods

The general idea behind OOP

1. Group together data together with the methods into one unit.

2. Methods represent the interface:

    - control how the object should be used.
    - hide internal complexities.

3. Design programs around objects.

Idea 3: Objects are at the center

Privilege data over action

Procedural Programming Paradigm

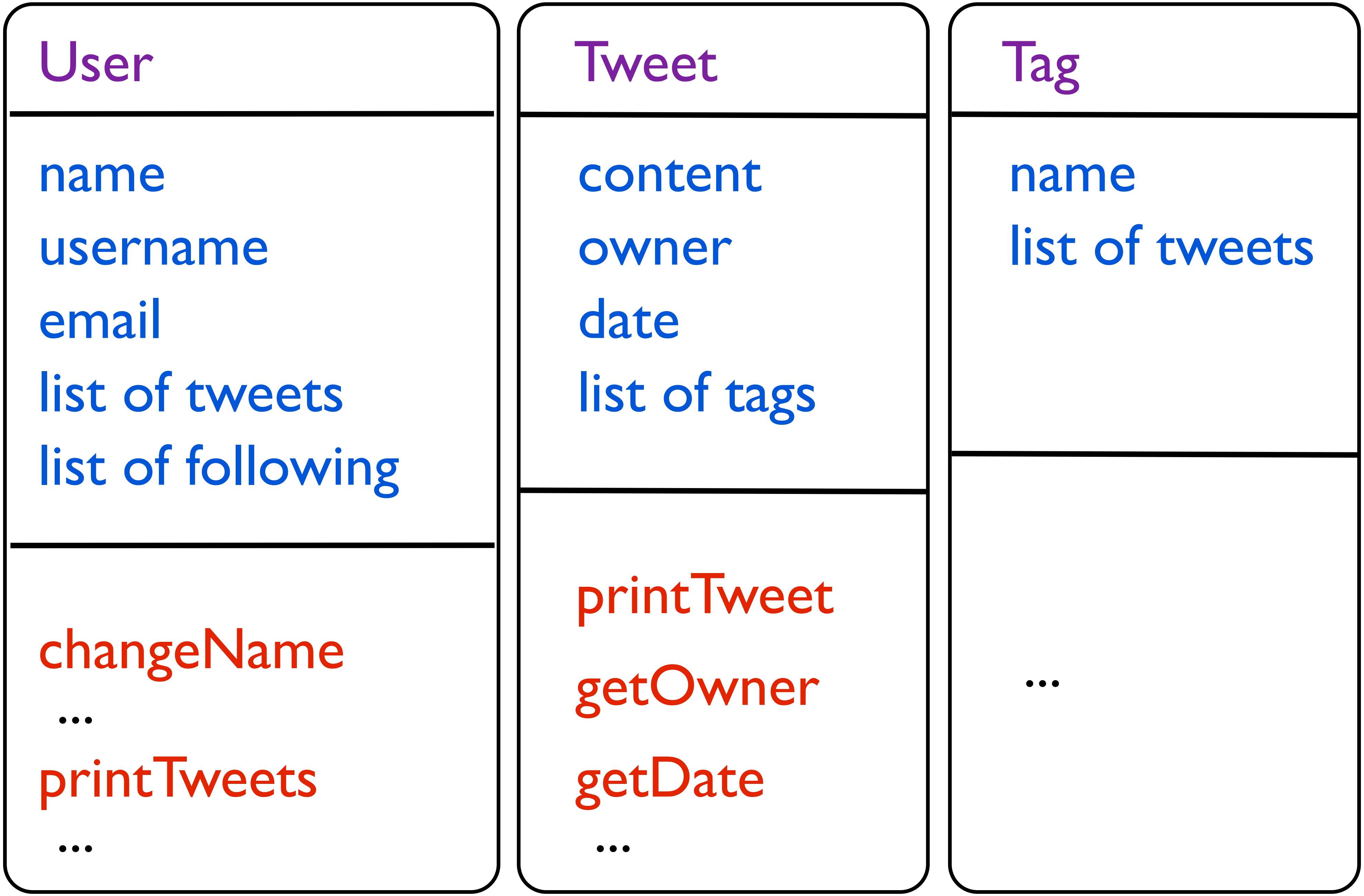
Decompose problem into a series of actions/functions.

Object Oriented Programming Paradigm

Decompose problem first into bunch of data types.

In both, we have actions and data types.
Difference is which one you end up thinking about first.

Simplified Twitter using OOP



User

name
username
email
list of tweets
list of following

changeName
…
printTweets
…

Tweet

content
owner
date
list of tags

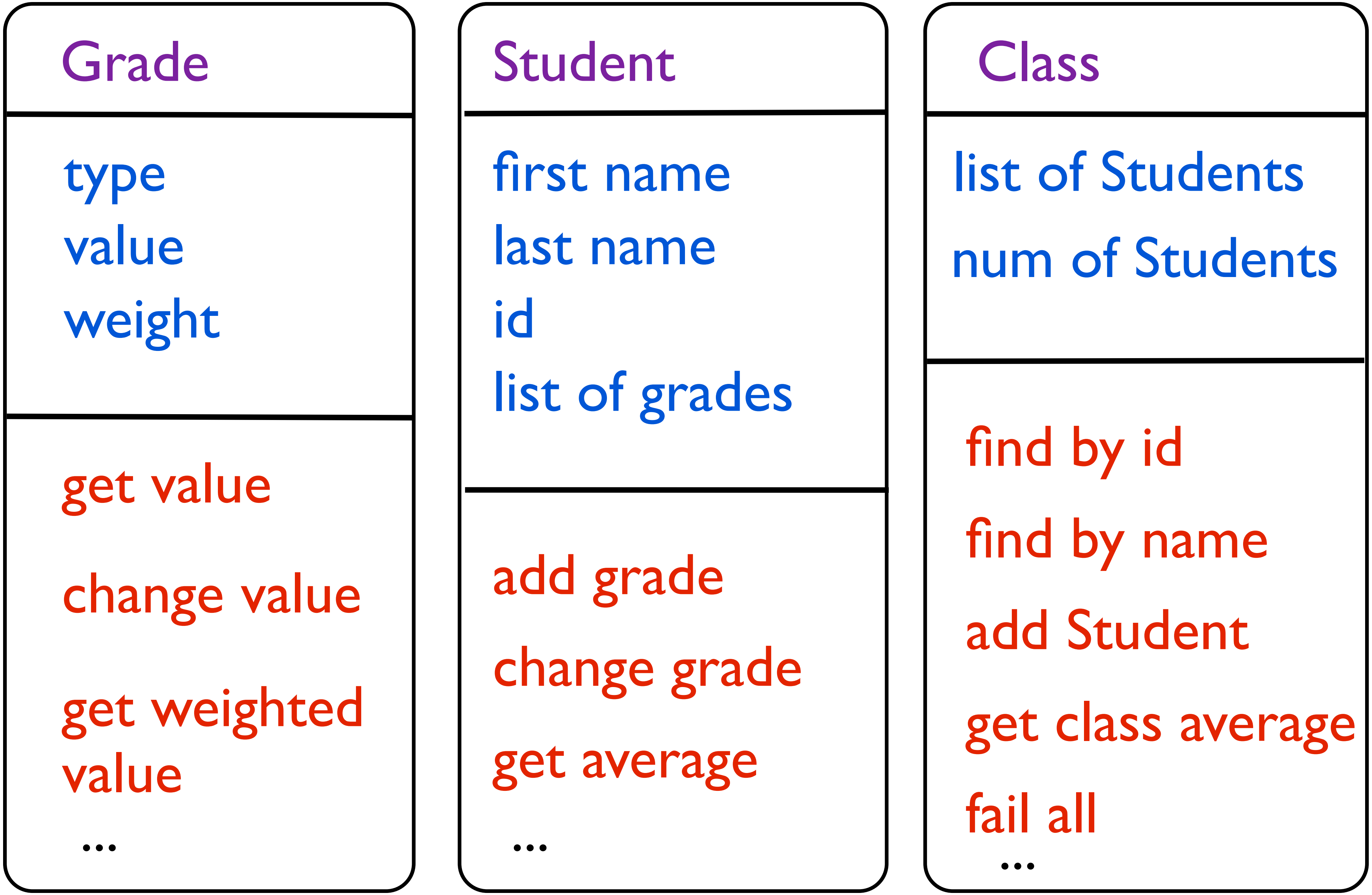
printTweet
getOwner
getDate
…

Tag

name
list of tweets

…

Managing my classes using OOP



Grade

type
value
weight

get value

change value

get weighted value

...

Student

first name
last name
id
list of grades

add grade

change grade

get average

...

Class

list of Students

num of Students

find by id

find by name

add Student

get class average

fail all

...

Summary

Using a class, we can **define** a new data type.

The new data type encapsulates:

- data members (usually called *fields* or *properties*)
- methods (operations acting on the data members)

The methods control how you are allowed to read and process the data members.

Once the new data type is defined:

Can create objects (instances) of the new data type.

Each object gets its own copy of the data members.

Data type's methods = allowed operations on the object