Core Python:
Classes and Object-oriented Programming

CLASS ATTRIBUTES, METHODS AND PROPERTIES

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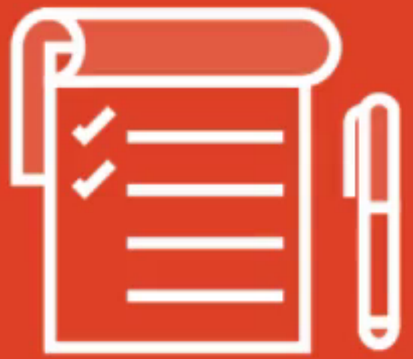
Overview



Review:

- Class definition
- Initializer definition
- Instance attributes

Class attributes

Static methods

Class methods

Interactions with inheritance

Overview

Properties

Specializing properties

Designing for extensibility

Naming Special Functions

`__feature__`

Hard to prounounce!

dunder

Our way of pronouncing special names

A portmanteau of ‘double underscore’

Instead of “underscore underscore name underscore underscore” we'll say “dunder name”

Instances

Instance Attributes

```
class Rectangle:


    def __init__(self, width, height)
        self.width = width
        self.height = height
```

CARGO
CONTAINER
CARGO
CONTAINER
CARGO
CARGO
CARGO
CG 044 283 01
MAX. LOAD
TARE
MAX.GW

Class Attributes

Class Attribute Syntax

```
class MyClass:


    # Define class attributes in the class block

    my_class_attribute = "class attributes go here"

    MY_CONSTANT = "they are often class-specific contants"


    def __init__(self):

        self.my_instance_attribute = "instance attributes here"
```

shipping 〉 shipping.py

Project

shipping
shipping.py
External Libraries
Scratches and Consoles

shipping.py

```python
class ShippingContainer:

    next_serial = 1337

    def __init__(self, owner_code, contents):
        self.owner_code = owner_code
        self.contents = contents
        self.serial = ShippingContainer.next_serial
        ShippingContainer.next_serial += 1
```

Python Console

```
>>> ShippingContainer.next_serial
1340
>>> c5.next_serial
1340
>>> c6.next_serial
1340

>>>
```

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10:1 LF UTF-8 4 spaces Python 3.8 (shipping)

Scopes in Python

Local	Inside the current function
Enclosing	Inside enclosing functions
Global	At the top level of the module
Built-in	In the special `builtins` module

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Moment of Zen

The Zen of Python

Explicit is better than implicit

Readability counts

```
class MyClass:

    b = "on class"

    def __init__(self):
        self.a = "on instance"
        print(self.a)
        print(MyClass.b)
        print(self.b)
        self.a = "re-bound"
        self.b = "new on instance"
        print(self.b)
        print(MyClass.b)
```

- Accesses the **class attribute**
- **Re-binds** the existing instance attribute
- Instance attribute **hides** the class attribute
- Accesses the **instance attribute** via `self`
- Access **class attribute** via the class object

There is
no class scope
in Python.

Scopes in Python

Local	Inside the current function
Enclosing	Inside enclosing functions
Global	At the top level of the module
Built-in	In the special `builtins` module

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shipping
shipping.py
External Libraries
Scratches and Consoles

shipping.py

```python
class ShippingContainer:

    def __init__(self, owner_code, contents):
        self.owner_code = owner_code
        self.contents = contents

```

Python Console

```
>>> c1.contents
['books']
>>> c2 = ShippingContainer("MAE", ["clothes"])
>>> c2.owner_code
'MAE'
>>> c2.contents
['clothes']

>>>
```

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1:1 LF UTF-8 4 spaces Python 3.8 (shipping)

Static Methods

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shipping.py
External Libraries
Scratches and Consoles

shipping.py

```
5       @staticmethod
6       def _generate_serial():
7           result = ShippingContainer.next_serial
8           ShippingContainer.next_serial += 1
9           return result
10
11      def __init__(self, owner_code, contents):
12          self.owner_code = owner_code
13          self.contents = contents
14          self.serial = ShippingContainer._generate_serial()
15
```

Python Console

```
>>> c6 = ShippingContainer("YML", ["coffee"])
>>> c6.serial
1337
>>> ShippingContainer.next_serial
1338

>>>
```

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1:1 UTF-8 4 spaces Python 3.8 (shipping)

The Static Terminology Is a Relic from C and C++

```
#include <stdio.h>

class StaticTest {
private:
    static int x;
public:
    static int count() { return x; }
};

int StaticTest::x = 9;

int main() {
    printf_s("%d\n", StaticTest::count());
}
```

Class Methods

```python
class MyClass:

    attribute = "class attribute"

    @classmethod
    def my_class_method(cls, message):
        cls.attribute = message
```

- Decorated by `classmethod`
- Accepts `cls` as first argument
- Access class attributes via `cls`

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- shipping
  - shipping.py
- External Libraries
- Scratches and Consoles

shipping.py

```python
class ShippingContainer:

    next_serial = 1337

    @classmethod
    def _generate_serial(cls):
        result = cls.next_serial
        cls.next_serial += 1
        return result

    def __init__(self, owner_code, contents):
        self.owner_code = owner_code
        self.contents = contents
        self.serial = ShippingContainer._generate_serial()
```

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15:1 UTF-8 4 spaces Python 3.8 (shipping)

Choosing

@classmethod

Requires access to the class object to call other class methods or the constructor

@staticmethod

No access needed to either *class* or *instance* objects

Most likely an implementation detail of the class

May be able to be moved outside the class to become a global-scope function in the module

Options for Locating Functions

Global Function

```
class SplineReticulator:

    def reticulate(x, y):
        return _tricky_math(x, y)

# Global function
def _tricky_math(x, y):
    return 2 * x**2 - 4*y
```

@staticmethod

```
class SplineReticulator:

    def reticulate(x, y):
        return self._tricky_math(x, y)

    @staticmethod
    def _tricky_math(x, y):
        return 2 * x**2 - 4*y
```

also known as Factory function

The ‘named constructor’ idiom

A factory method which returns an instance of a class. The method name allows callers to express intent, and allows construction to be performed with different combinations of arguments.

Originally a C++ idiom, also applicable in Python

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- shipping
  - shipping.py
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- Scratches and Consoles

shipping.py

```python
    @classmethod
    def create_with_items(cls, owner_code, items):
        return cls(owner_code, contents=list(items))

    def __init__(self, owner_code, contents):
        self.owner_code = owner_code
        self.contents = contents
        self.serial = ShippingContainer._generate_serial()

```

ShippingContainer

Python Console

```
>>> from shipping import *
>>> c8 = ShippingContainer.create_with_items("MAE", {"food", "textiles", "minerals"})
>>> c8
<shipping.ShippingContainer object at 0x10944e7c0>
>>> c8.contents
['textiles', 'food', 'minerals']

>>>
```

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1:1 LF UTF-8 4 spaces Python 3.8 (shipping)

MSCU
M. G. W.
TARE
NET
CU.CAP.
HJCU
8281 98 8
22G1
MAX GROSS
TARE
PAYLOAD
CUBE
HANJIN
SHIPPING
CO.,LTD.
CAXU
MAXGROSS
TARE
NET
CUCAP

ISO:6346 BIC Code

Category identifier

Check digit

CSQU3054383

Owner code

Serial number

shipping / shipping.py

Project

shipping
- iso6346.py
- shipping.py

External Libraries

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```python

    @classmethod
    def create_with_items(cls, owner_code, items):
        return cls(owner_code, contents=list(items))

    def __init__(self, owner_code, contents):
        self.owner_code = owner_code
        self.contents = contents
        self.bic = ShippingContainer._make_bic_code(
            owner_code=owner_code,
            serial=ShippingContainer._generate_serial()
        )
```

Python Console

```
>>> from shipping import *
>>> c = ShippingContainer.create_empty("YML")
>>> c.bic
'YMLU0013374'

>>>
```

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1:1 LF UTF-8 4 spaces Python 3.8 (shipping)

Static Methods with Inheritance

MAERSK
SEALAND
INGER

ISO:6346 BIC Code

Category identifier

Check digit

CSQR3054381

Owner code

Serial number

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shipping

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shipping
- iso6346.py
- shipping.py

External Libraries

Scratches and Consoles

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```
    def create_with_items(cls, owner_code, items):
        return cls(owner_code, contents=list(items))

    def __init__(self, owner_code, contents):
        self.owner_code = owner_code
        self.contents = contents
        self.bic = self._make_bic_code(
            owner_code=owner_code,
            serial=ShippingContainer._generate_serial()
        )


class RefrigeratedShippingContainer(ShippingContainer):
```

Python Console

```
>>> from shipping import *
>>> r2 = RefrigeratedShippingContainer("MAE", ["fish"])
>>> r2.bic
'MAER0013370'

>>>
```

Special Variables

r2 = {RefrigeratedShippingContainer} <shipping.Ref... View

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For polymorphic dispatch invoke static methods through `self`.

Class Methods with Inheritance

shipping / shipping.py

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- shipping
  - iso6346.py
  - shipping.py
- External Libraries
- Scratches and Consoles

shipping.py

```python
class RefrigeratedShippingContainer(ShippingContainer):

    MAX_CELSIUS = 4.0

    def __init__(self, owner_code, contents, *, celsius, **kwargs):
        super().__init__(owner_code, contents, **kwargs)
        if celsius > RefrigeratedShippingContainer.MAX_CELSIUS:
            raise ValueError("Temperature too hot!")
        self.celsius = celsius

    @staticmethod
```

RefrigeratedShippingContainer

Python Console

```
2.0
>>> r3.bic
'ESCR0013370'
>>> r3.celsius = 12
>>> r3.celsius
12

>>>
```

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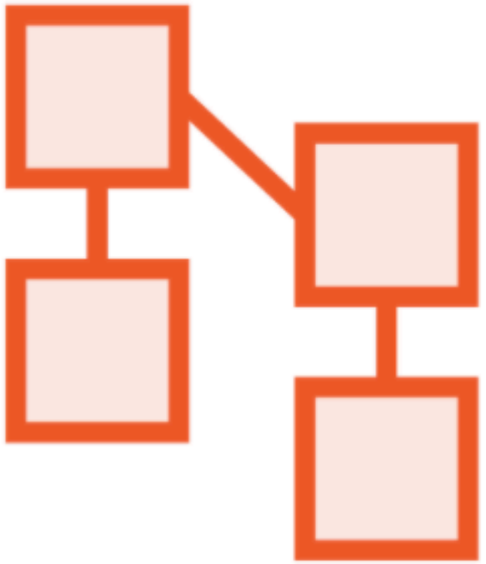
1:1 LF UTF-8 4 spaces Python 3.8 (shipping)

Class Invariant Violation

`celsius` must never exceed `MAX_CELSIUS`

Avoid Circular Dependencies



Base classes should have no knowledge of subclasses

Use `**kwargs` to thread arguments through named-constructor class-methods to more specialized subclasses.

Encapsulation with Properties

Establishing a Class Invariant

```
class RefrigeratedShippingContainer(ShippingContainer):

    MAX_CELSIUS = 4.0

    def __init__(self, owner_code, contents, *, celsius, **kwargs):
        super().__init__(owner_code, contents, **kwargs)
        if celsius > RefrigeratedShippingContainer.MAX_CELSIUS:
            raise ValueError("Temperature too hot!")
        self.celsius = celsius
```

Class Invariant Violation

`celsius` must never exceed `MAX_CELSIUS`

Maintaining the Maximum Temperature Invariant

```
class RefrigeratedShippingContainer(ShippingContainer):

    MAX_CELSIUS = 4.0

    def __init__(self, owner_code, contents, *, celsius, **kwargs):
        super().__init__(owner_code, contents, **kwargs)
        if celsius > RefrigeratedShippingContainer.MAX_CELSIUS:
            raise ValueError("Temperature too hot!")
        self._celsius = celsius

    def get_celsius(self):
        return self._celsius

    def set_celsius(self, value):
        if celsius > RefrigeratedShippingContainer.MAX_CELSIUS:
            raise ValueError("Temperature too hot!")
        self._celsius = value
```

Getters and Setters Are Not Pythonic

≠

Encapsulate getter and setter methods in properties which behave like attributes

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- shipping
  - iso6346.py
  - shipping.py
- External Libraries
- Scratches and Consoles

shipping.py

```
38
39      MAX_CELSIUS = 4.0
40
41      def __init__(self, owner_code, contents, *, celsius, **kwargs):
42          super().__init__(owner_code, contents, **kwargs)
43          if celsius > RefrigeratedShippingContainer.MAX_CELSIUS:
44              raise ValueError("Temperature too hot!")
45          self._celsius = celsius
46
47      @property
48      def celsius(self):
49          return self._celsius
```

RefrigeratedShippingContainer

Python Console

```
>>> r4.celsius = -5.0
Traceback (most recent call last):
  File "<input>", line 1, in <module>
AttributeError: can't set attribute

>>>
```

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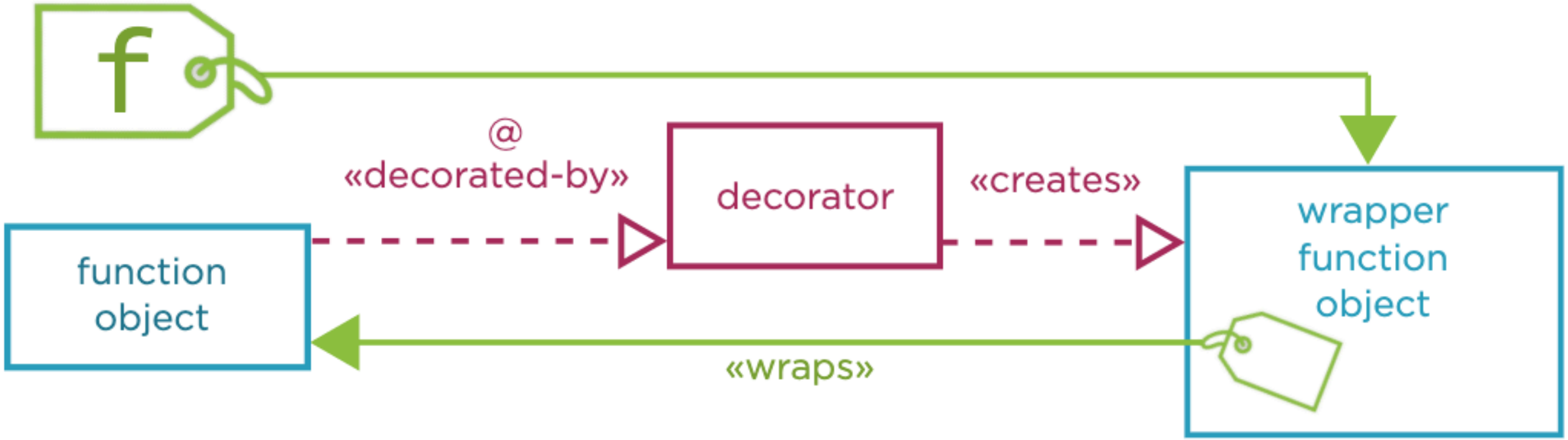
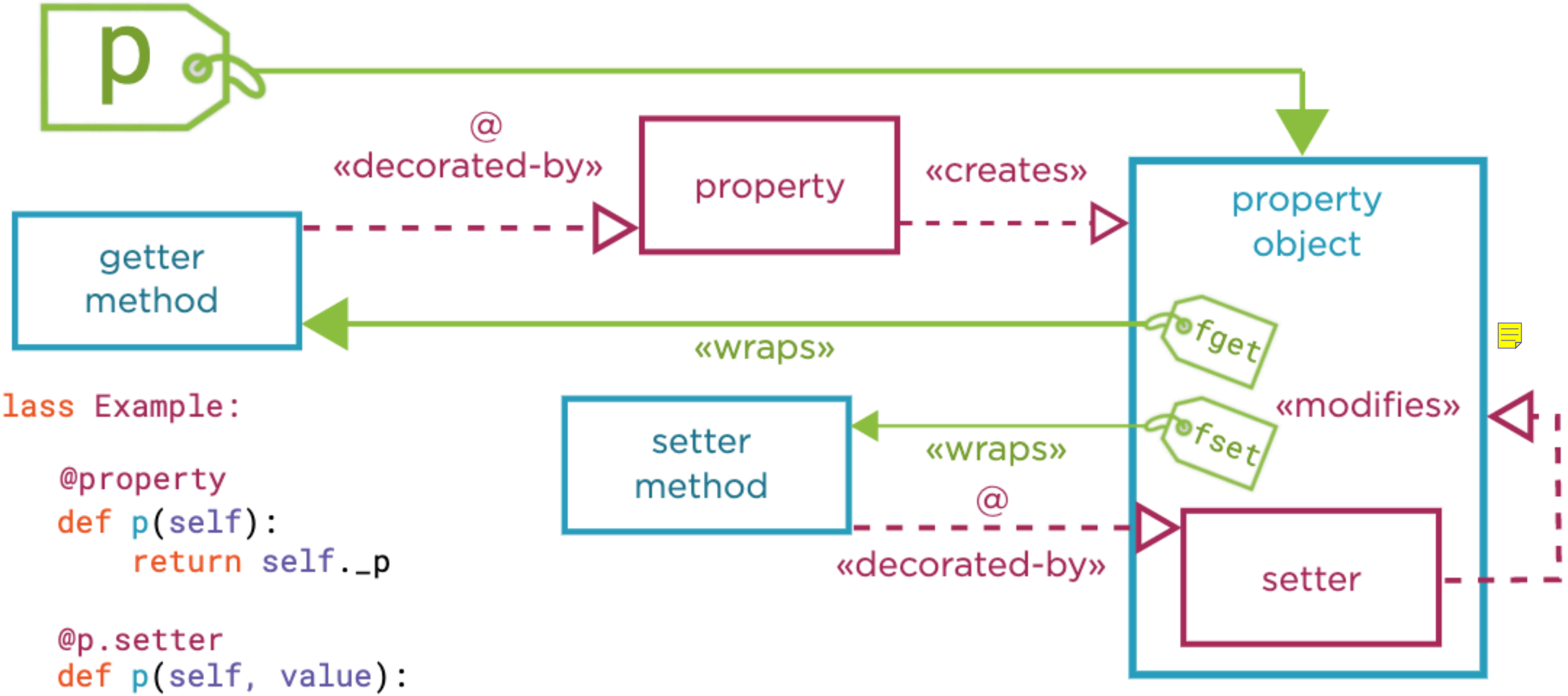
Decorator Recap




```
@decorator
def f():
    do_something()
```

The @property Decorator




```
class Example:

    @property
    def p(self):
        return self._p

    @p.setter
    def p(self, value):
        self._p = value
```

shipping 〉 shipping.py

Project

shipping
- iso6346.py
- shipping.py

External Libraries

Scratches and Consoles

shipping.py

```
46
47      @property
48      def celsius(self):
49          return self._celsius
50
51      @celsius.setter
52      def celsius(self, value):
53          if value > RefrigeratedShippingContainer.MAX_CELSIUS:
54              raise ValueError("Temperature too hot!")
55          self._celsius = value
```

RefrigeratedShippingContainer

Python Console

```
-19.0
>>> r5.celsius = +5.0
Traceback (most recent call last):
  File "<input>", line 1, in <module>
  File "/var/folders/bb/w8tlddfn2fz1lhtlj_rxp_000000gn/T/tmpf7_msa50/build/shipping/shipping.py", line 54, in celsius
    raise ValueError("Temperature too hot!")
ValueError: Temperature too hot!

>>>
```

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1:1 UTF-8 4 spaces Python 3.8 (shipping)

C
F
50
40
30
20
10
0
10
20
30
40
120
100
80
60
40
20
0
20
40

shipping / shipping.py

Project

- shipping
  - iso6346.py
  - shipping.py
- External Libraries
- Scratches and Consoles

shipping.py

```
37  class RefrigeratedShippingContainer(ShippingContainer):
38
39      MAX_CELSIUS = 4.0
40
41      def __init__(self, owner_code, contents, *, celsius, **kwargs):
42          super().__init__(owner_code, contents, **kwargs)
43          self.celsius = celsius
44
45      @staticmethod
46      def _c_to_f(celsius):
```

RefrigeratedShippingContainer

Python Console

```
  File "/var/folders/bb/w8tlddfn2fz1lhtlj_rxp_000000gn/T/tmp1zoz7572/build/shipping/shipping.py", line 22, in create_empt
    return cls(owner_code, contents=[], **kwargs)
  File "/var/folders/bb/w8tlddfn2fz1lhtlj_rxp_000000gn/T/tmp1zoz7572/build/shipping/shipping.py", line 43, in __init__
    self.celsius = celsius
  File "/var/folders/bb/w8tlddfn2fz1lhtlj_rxp_000000gn/T/tmp1zoz7572/build/shipping/shipping.py", line 60, in celsius
    raise ValueError("Temperature too hot!")
ValueError: Temperature too hot!

>>>
```

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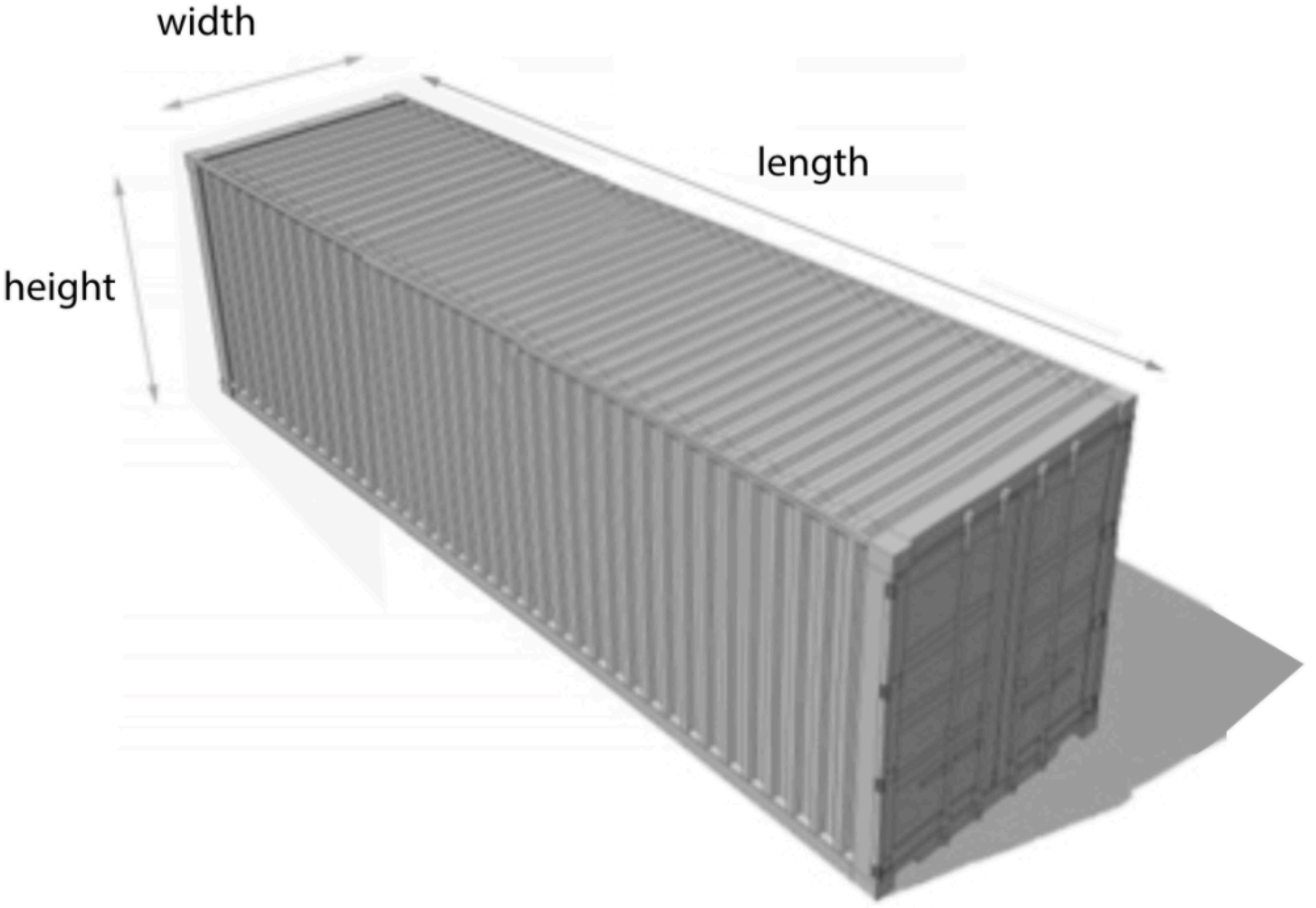
Weak Encapsulation

Too many properties can lead to
excessive coupling

Tell! Don't ask.

Tell other objects what to do instead of asking them their state and responding to it.

Properties and Inheritance


width
length
height

shipping / shipping.py

shipping.py

```python

    @fahrenheit.setter
    def fahrenheit(self, value):
        self.celsius = RefrigeratedShippingContainer._f_to_c(value)

    @property
    def volume_ft3(self):
        return (
            super().volume_ft3
            - RefrigeratedShippingContainer.FRIDGE_VOLUME_FT3
        )

    @staticmethod
    def _make_bic_code(owner_code, serial):
        return iso6346.create(
            owner_code=owner_code,
            serial=str(serial).zfill(6),
            category="R"
        )
```

RefrigeratedShippingContainer

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86:1 LF UTF-8 4 spaces Python 3.8 (shipping)

To override a property getter, redefine in a derived class.

Carrier
THINLINE
ESS
2710044

shipping / shipping.py

shipping.py

```
            category="R"
        )


class HeatedRefrigeratedShippingContainer(RefrigeratedShippingContainer):

    MIN_CELSIUS = -20

    @RefrigeratedShippingContainer.celsius.setter
    def celsius(self, value):
        if value < HeatedRefrigeratedShippingContainer.MIN_CELSIUS:
            raise ValueError("Temperature too cold!")
        RefrigeratedShippingContainer.celsius.fset(self, value)
```

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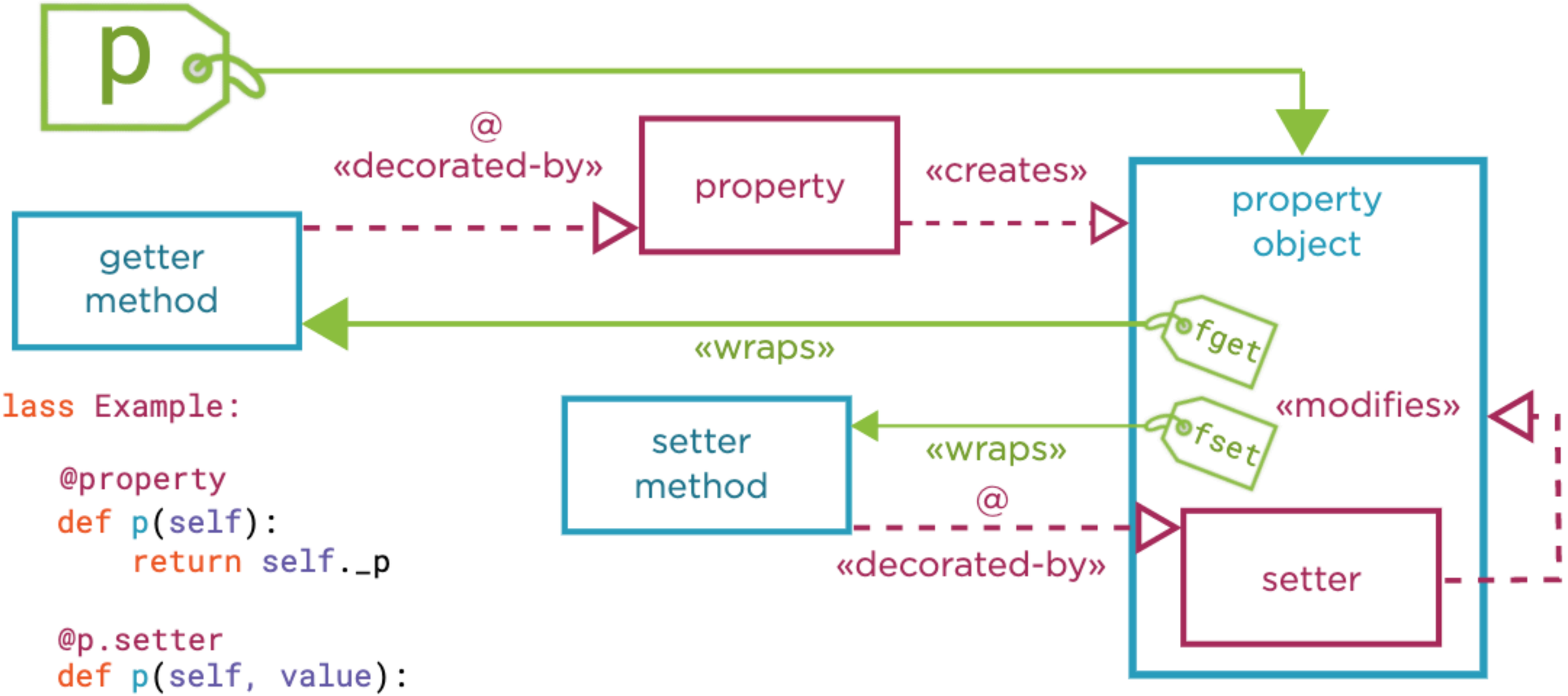
The @property Decorator



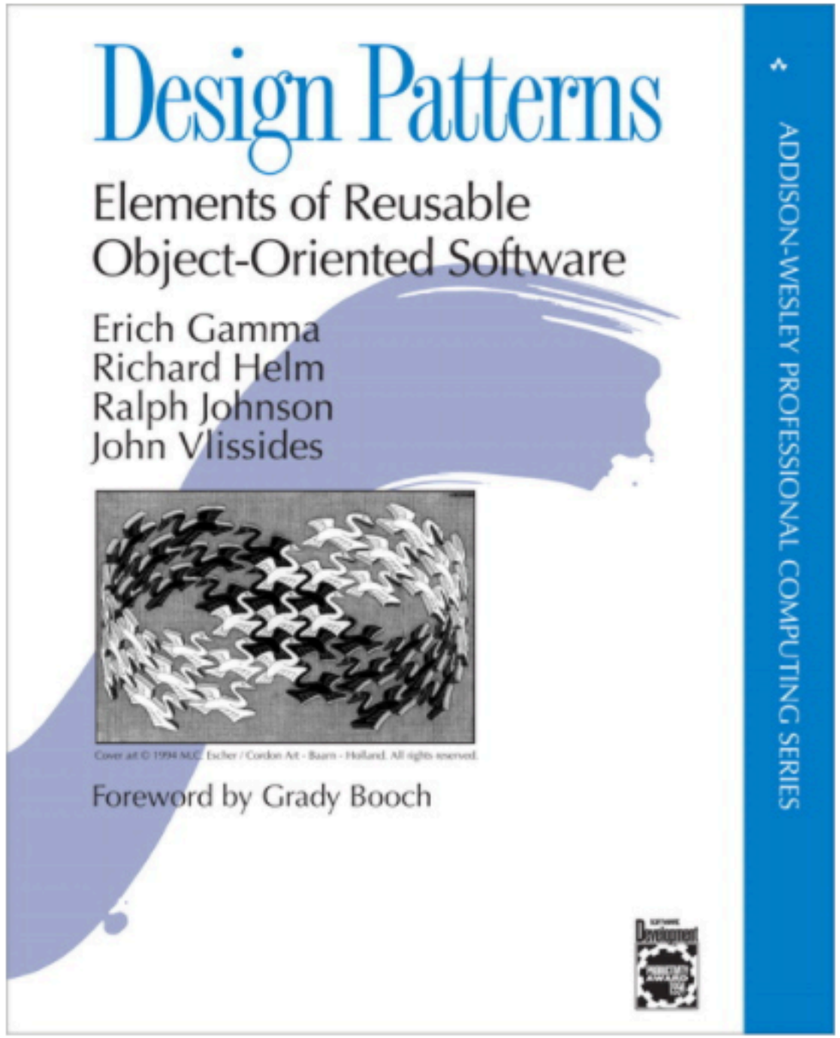

```
class Example:

    @property
    def p(self):
        return self._p

    @p.setter
    def p(self, value):
        self._p = value
```

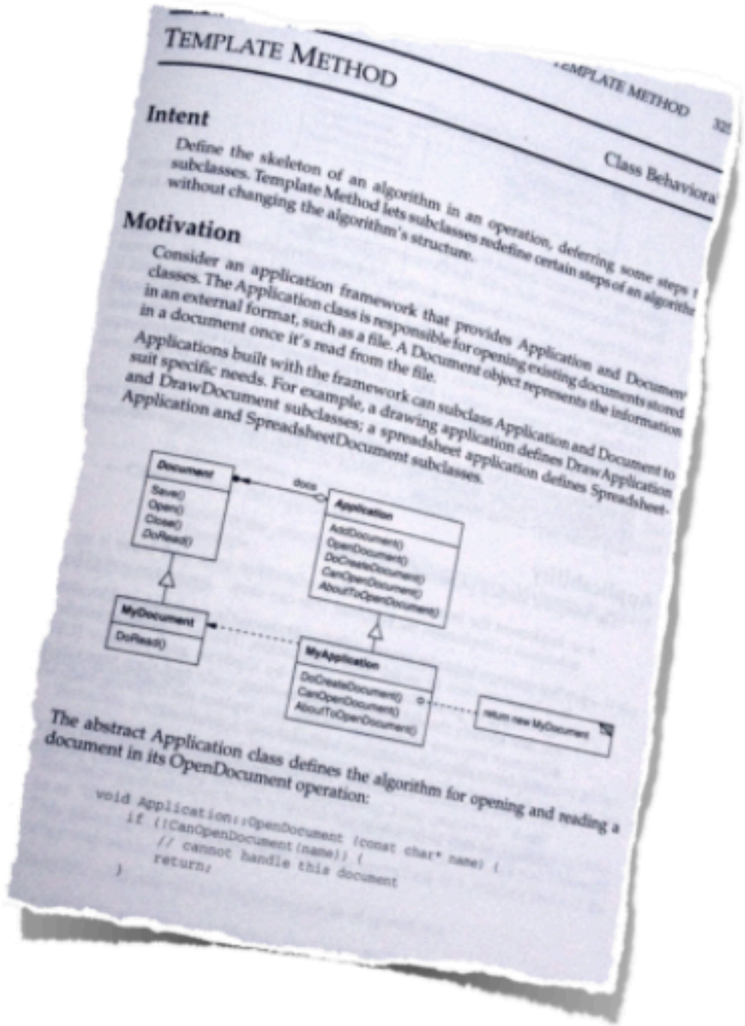
Overriding Properties with the Template Method

Overriding @property Setters Gets Messy

```
class HeatedRefrigeratedShippingContainer(RefrigeratedShippingContainer):


    MIN_CELSIUS = -20



    @RefrigeratedShippingContainer.celsius.setter
    def celsius(self, value):
        if value < HeatedRefrigeratedShippingContainer.MIN_CELSIUS:
            raise ValueError("Temperature too cold!")
        RefrigeratedShippingContainer.celsius.fset(self, value)
```

The Template Method Design Pattern





TEMPLATE METHOD

Class Behavioral

Intent

Define the skeleton of an algorithm in an operation, deferring some steps to subclasses. Template Method lets subclasses redefine certain steps of an algorithm without changing the algorithm's structure.

Motivation

Consider an application framework that provides Application and Document classes. The Application class is responsible for opening existing documents stored in an external format, such as a file. A Document object represents the information in a document once it's read from the file.

Applications built with the framework can subclass Application and Document to suit specific needs. For example, a drawing application defines DrawApplication and DrawDocument subclasses; a spreadsheet application defines SpreadsheetApplication and SpreadsheetDocument subclasses.

The abstract Application class defines the algorithm for opening and reading a document in its OpenDocument operation:

```
void Application::OpenDocument (const char* name) {
    if (!CanOpenDocument(name)) {
        // cannot handle this document
        return;
    }
```

```python
class AbstractClass:

    def template_method(self):
        self._part1()  # No implementation
        self._part2()  # Abstract implementation
        self._part3()  # Default implementation

    def _part2(self):
        raise NotImplementedError("Override this method")

    def _part3(self):
        print("Done!") # Optionally override


class ConcreteClass(AbstractClass):

    def _part1(self):
        print("About to perform action")

    def _part2(self):
        perform_action()

    def _part3(self):
        print("Action performed!")
```

- Operation defined in terms of as yet undefined steps.
- Abstract sub-operations must be overridden
- Or may have default implementations, which may be overridden
- The concrete class fills in the details by overriding methods from the abstract class.

“All problems in computer science can be solved by another level of indirection”

David Wheeler

shipping 〉 shipping.py

shipping.py

```
69      @celsius.setter
70      def celsius(self, value):
71          self._set_celsius(value)
72
73      def _set_celsius(self, value):
74          if value > RefrigeratedShippingContainer.MAX_CELSIUS:
```

Python Console

```
  File "/var/folders/bb/w8tlddfn2fz1lhtlj_rxp_000000gn/T/tmp7zntz92b/build/shipping/shipping.py", line 107, in _set_celsi
    raise ValueError("Temperature too cold!")
ValueError: Temperature too cold!
>>> h.celsius = 5
Traceback (most recent call last):
  File "<input>", line 1, in <module>
  File "/var/folders/bb/w8tlddfn2fz1lhtlj_rxp_000000gn/T/tmp7zntz92b/build/shipping/shipping.py", line 71, in celsius
    self._set_celsius(value)
  File "/var/folders/bb/w8tlddfn2fz1lhtlj_rxp_000000gn/T/tmp7zntz92b/build/shipping/shipping.py", line 108, in _set_celsi
    super()._set_celsius(value)
  File "/var/folders/bb/w8tlddfn2fz1lhtlj_rxp_000000gn/T/tmp7zntz92b/build/shipping/shipping.py", line 75, in _set_celsiu
    raise ValueError("Temperature too hot!")
ValueError: Temperature too hot!

>>>
```

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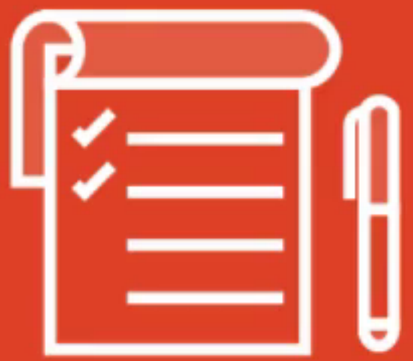
Don't override properties directly. Delegate to regular methods and override those instead.

“All problems in computer science can be solved by another level of indirection … except for the problem of too many levels of indirection”

Kevlin Henney

Summary



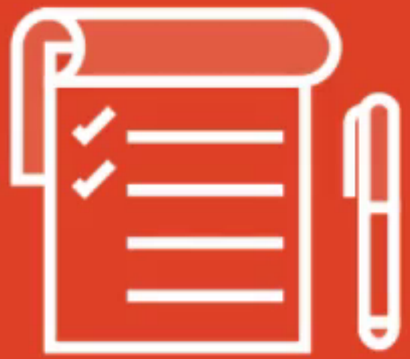
Class attributes versus instance attributes

Class attributes are shared between instances

Navigate to class attributes via the class

Assigning to self always creates an instance attribute

Summary



Use `@staticmethod` for methods which need neither the class nor the instance

Use `@classmethod` for methods which needs the class but not the instance

Use `@classmethod` for the named-constructor idiom

Static- and class-methods can be overridden

Summary

Static- and class-methods are polymorphic when invoked through `self`

Use the `@property` decorator instead of getters and setters

Easily override properties by delegating to regular methods