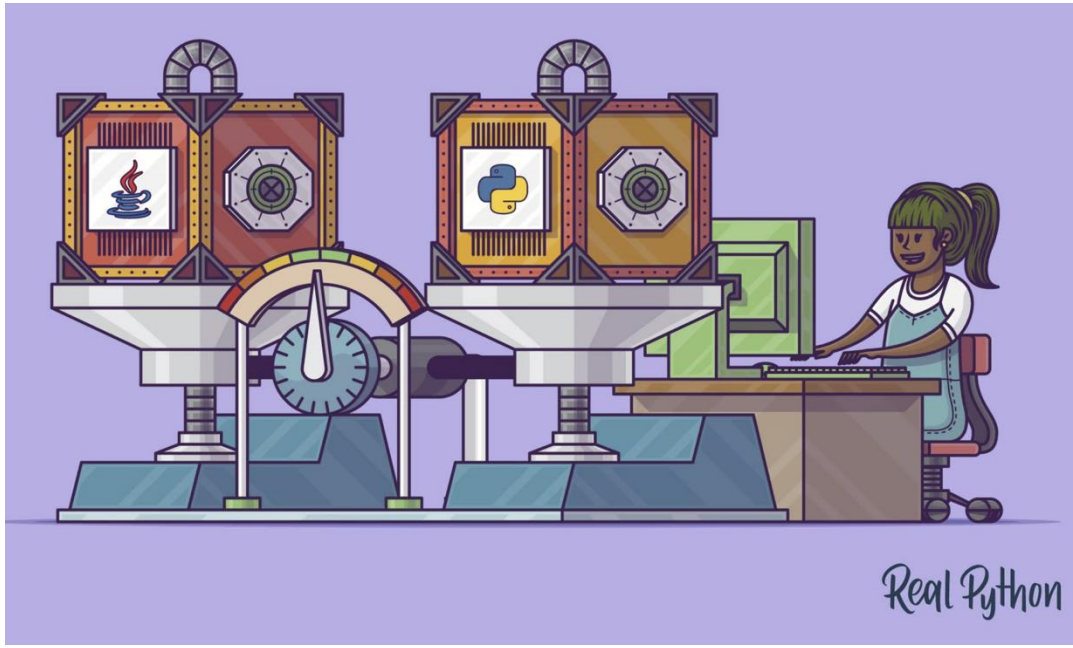
2025

TdP

Object Oriented Programming in Python

Transitioning from Java to Python

Giuseppe Averta
Carlo Masone
Francesca Pistilli
Davide Buoso
Gaetano Falco



https://realpython.com/oop-in-python-vs-java/
https://realpython.com/python3-object-oriented-programming/

Known OOP features (in Java)

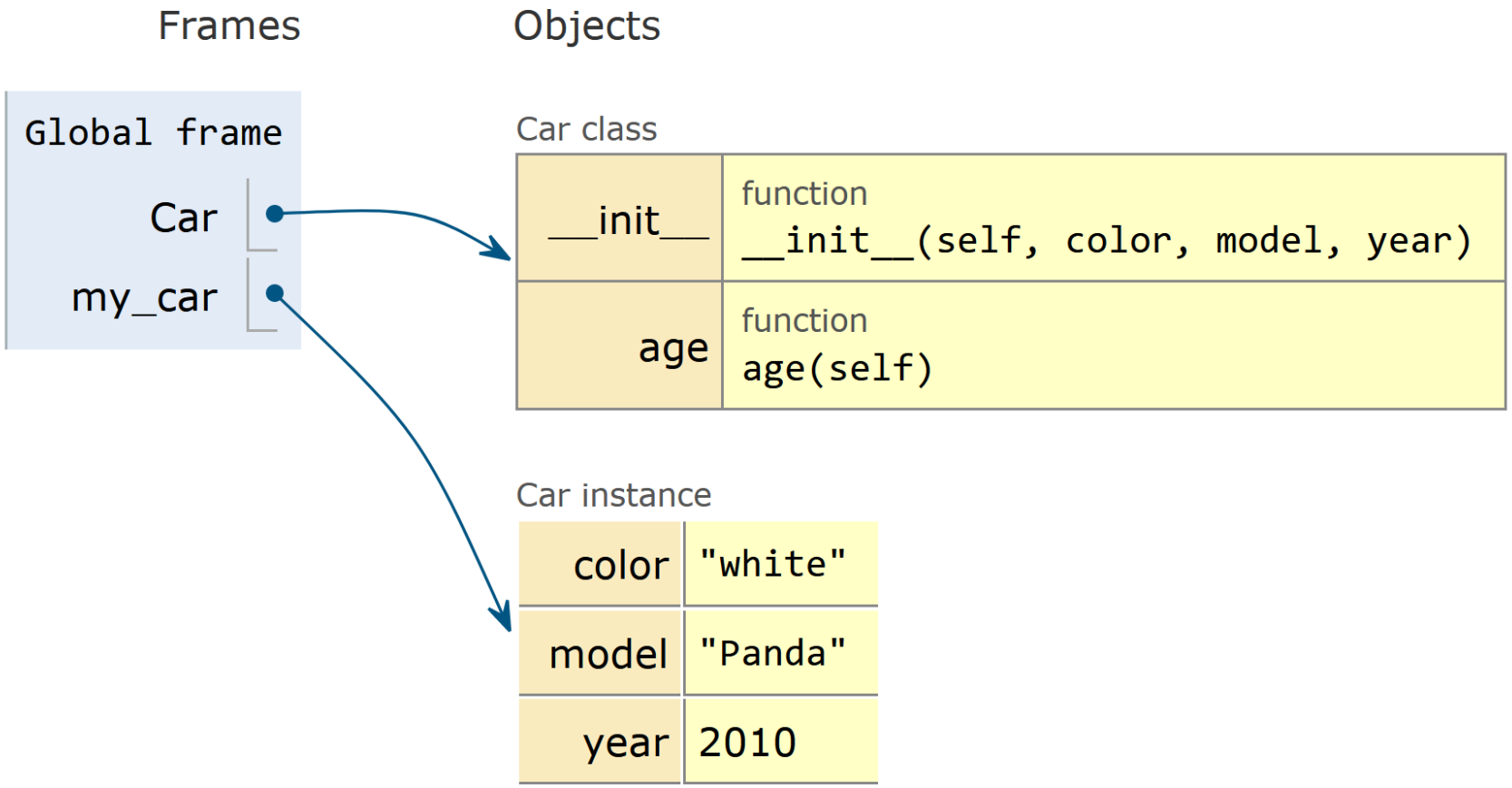
- Classes
- Objects
- Properties
- Methods
- Visibility
- Constructor
- Encapsulation
- Inheritance
- Polymorphism
- Annotations
- Overloading

We assume these concepts are known in Java, let's see how they map in Python

Classes and Objects

```
class Car:
    def __init__(self, color, model, year):
        self.color = color
        self.model = model
        self.year = year

    def age(self):
        return 2024 - self.year

my_car = Car("white", "Panda", 2010)

print(my_car.age())
```

Visual representation



Classes and Objects

Class definition

```
class Car:
    def __init__(self, color, model, year):
        self.color = color
        self.model = model
        self.year = year

    def age(self):
        return 2024 - self.year

my_car = Car("white", "Panda", 2010)

print(my_car.age())
```

Method definition

Instance

"new"

Method call

Classes and Objects

```
class Car:
    def __init__(self, color, model, year):
        self.color = color
        self.model = model
        self.year = year

    def age(self):
        return 2024 - self.year

my_car = Car("white", "Panda", 2010)

print(my_car.age())
```

Constructor

Constructor parameters

"new"

Constructor arguments

Classes and Objects

```
class Car:
    def __init__(self, color, model, year):
        self.color = color
        self.model = model
        self.year = year

    def age(self):
        return 2024 - self.year

my_car = Car("white", "Panda", 2010)

print(my_car.age())
```

Properties

Classes and Objects

```
class Car:                    "this"
    def __init__(self, color, model, year):
        self.color = color
        self.model = model
        self.year = year
                  "this"
    def age(self):          "this"
        return 2024 - self.year

my_car = Car("white", "Panda", 2010)
         "this"
print(my_car.age())
```

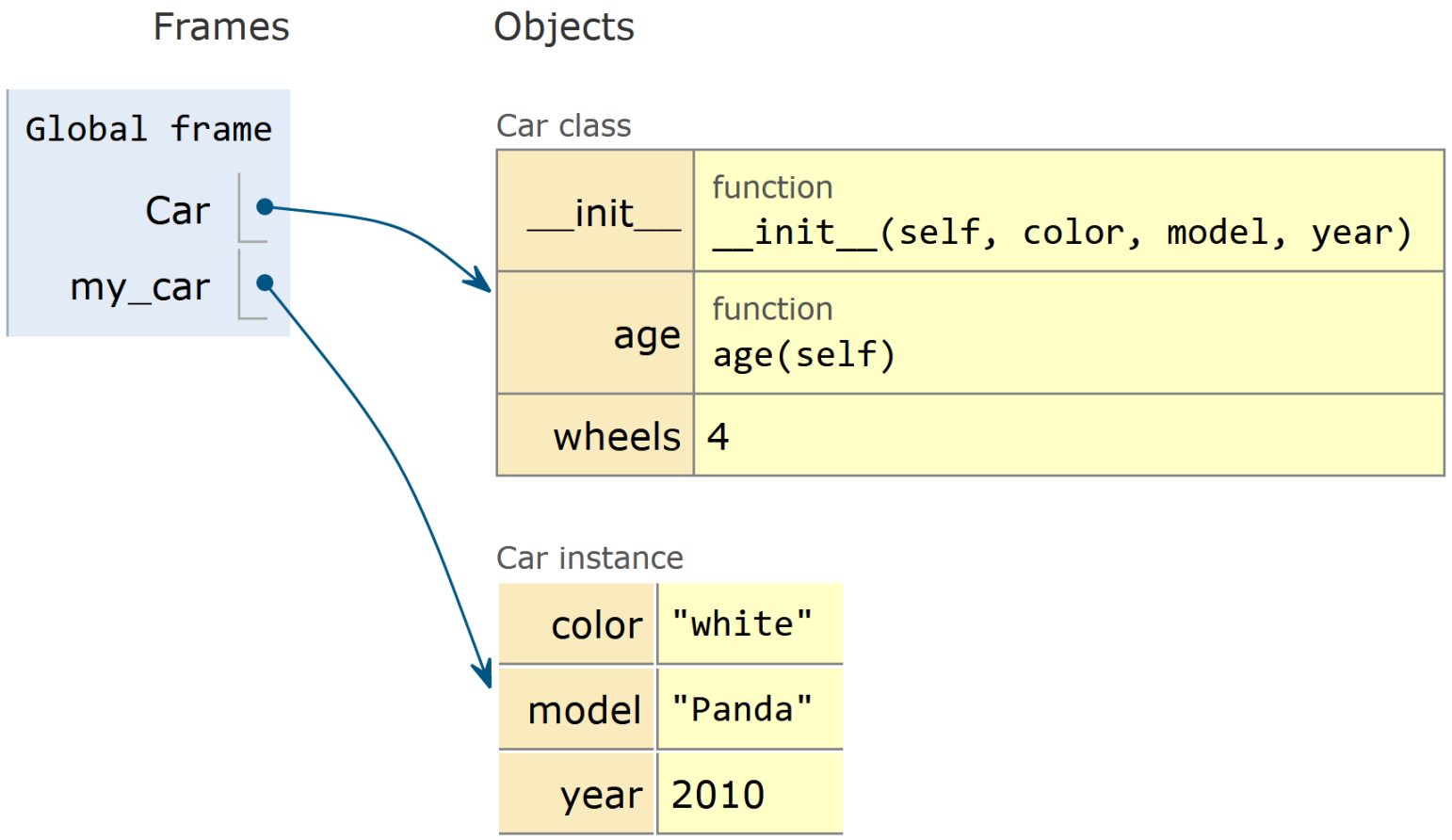
What is '`self`'?

- Each method receives, as a first argument, the reference to the object instance
- By convention, this parameter is called `self`
- Upon calling a method, `self` is initialized with the reference to the instance
- `my_car.age()` sets `self` to `my_car`
  - Equivalent to `Car.age(my_car)` (static method call with explicit self)
- Using **`self`** is always mandatory (unlike `this`, that can be omitted)

Class attributes vs. instance attributes

```
class Car:
    wheels = 4  # class attribute (‘static’ in Java)

    def __init__(self, color, model, year):
        self.color = color  # instance attribute
        self.model = model
        self.year = year

print(Car.wheels)
print(my_car.wheels) # instances may access class attributes
```

Class attributes vs. instance attributes



Dynamic nature of attributes

- Instance attributes are normally defined in the `__init__` constructor
  - All instances will have the same set of attributes
  - Their value may be redefined in methods (`self.`*`name`*) or in external code (`my_car.`*`name`*)
- However, new attributes may be created later
  - In any instance method (just assign a value to `self.`*`new_name`*)
  - In the external code (just assign a value to `my_car.`*`new_name`*)
  - Such attribute is assigned to the specific instance, only
  - Works also for class-level attributes (`Car.`*`new_name`*)
  - Try to avoid this possibility, as it renders the code much less readable

Getters and Setters? No, thanks

- In Java, object properties (= instance attributes) are normally defined with a private visibility, and are not accessible from outside the class methods
  - `get`*`Xxx`*`()` and `set`*`Xxx`*`(`*`xxx`*`)` methods must be defined, for each property *xxx*
- In Python, attributes are always visible, and no getter/setters are required
  - Just read/write the attribute value

Visibility conventions

- All class-level attributes and instance-level attributes are **public**
- By convention, if you consider an attribute to be “private”, prefix it with one or two “_” (underscore)
- `self.counter`
  - may be accessed (read/written) by anyone
- `self._counter`
  - may still be accessed by anyone, but it’s not polite to do that, and your IDE may send you a warning. You should consider it a private value
- `self.__counter` (*two* underscores)
  - it is difficult to access if you are outside a method (Python will mangle its name to _ClassName__counter), so you will not access it by mistake (unless you really really want)

Getters and Setters, if/when you want them

- Need to customize what happens when you read/write a ‘private’ attribute?
- Use the `@property` annotation
- `@property` for the getter method
- `@name.setter` for the setter method
  - If omitted, it will be read-only
- Both methods have the *name* of the property

```python
class Car:
    def __init__(self, color, model, year):
        self.color = color
        self.model = model
        self.year = year
        self._voltage = 12

    @property
    def voltage(self):
        return self._voltage

    @voltage.setter
    def voltage(self, volts):
        print("Warning: this can cause problems!")
        self._voltage = volts
```

Special methods

- All objects can customize their behavior in implicit and arithmetic operators, by defining special methods
- Such methods have all a double-underscore at the beginning & end of the name
- Hence, the definition of "*dunder*" (double underscore) methods
- Example: `__init__(self, …)` # pronounced: *dunder-init*

  – Full list of *dunder* methods: https://docs.python.org/3/reference/datamodel.html#special-method-names

Dunder methods: convert to string

- `__str__(self)`
  - string printable representation (like toString())
- `__repr__(self)`
  - programmer-oriented printable representation (usually, the object creation)

```
class Car:
    # ...

    def __str__(self):
        return f"{self.make}, {self.model}, {self.color}: ({self.year})"

    def __repr__(self):
        return (
            f"{type(self).__name__}"
            f'(make="{self.make}", '
            f'model="{self.model}", '
            f"year={self.year}, "
            f'color="{self.color}")'
        )
```

```
>>> toyota_camry = Car("Toyota", "Camry", 2022, "Red")

>>> str(toyota_camry)
'Toyota, Camry, Red: (2022)'
>>> print(toyota_camry)
Toyota, Camry, Red: (2022)

>>> toyota_camry
Car(make="Toyota", model="Camry", year=2022, color="Red")
>>> repr(toyota_camry)
'Car(make="Toyota", model="Camry", year=2022, color="Red")'
```

Dunder methods: comparisons

- `__eq__(self, other)`
  - implements `==` operator
  - Replaces Java's .equal()
- `__lt__(self, other)`
  - Implements `<` operator
  - Replaces Java's Comparator, Comparable, compare(), compareTo()
- Other operators (>, <=, !=, >=) are inferred from these methods
- All data structures (dictionaries, sets, …) and methods (sort, max, index, …) honor these operators

Dunder methods: operators overloading

- `object.__add__(self, other)`
- `object.__sub__(self, other)`
- `object.__mul__(self, other)`
- `object.__matmul__(self, other)`
- `object.__truediv__(self, other)`
- `object.__floordiv__(self, other)`
- `object.__mod__(self, other)`
- `object.__divmod__(self, other)`
- `object.__pow__(self, other[, modulo])`
- `object.__lshift__(self, other)`
- `object.__rshift__(self, other)`
- `object.__and__(self, other)`
- `object.__xor__(self, other)`
- `object.__or__(self, other)`

- `object.__neg__(self)`
- `object.__pos__(self)`
- `object.__abs__(self)`
- `object.__invert__(self)`

- `object.__complex__(self)`
- `object.__int__(self)`
- `object.__float__(self)`

- `object.__radd__(self, other)`
- `object.__rsub__(self, other)`
- `object.__rmul__(self, other)`
- `object.__rmatmul__(self, other)`
- `object.__rtruediv__(self, other)`
- `object.__rfloordiv__(self, other)`
- `object.__rmod__(self, other)`
- `object.__rdivmod__(self, other)`
- `object.__rpow__(self, other[, modulo])`
- `object.__rlshift__(self, other)`
- `object.__rrshift__(self, other)`
- `object.__rand__(self, other)`
- `object.__rxor__(self, other)`
- `object.__ror__(self, other)`

- `object.__round__(self[, ndigits])`
- `object.__trunc__(self)`
- `object.__floor__(self)`
- `object.__ceil__(self)`

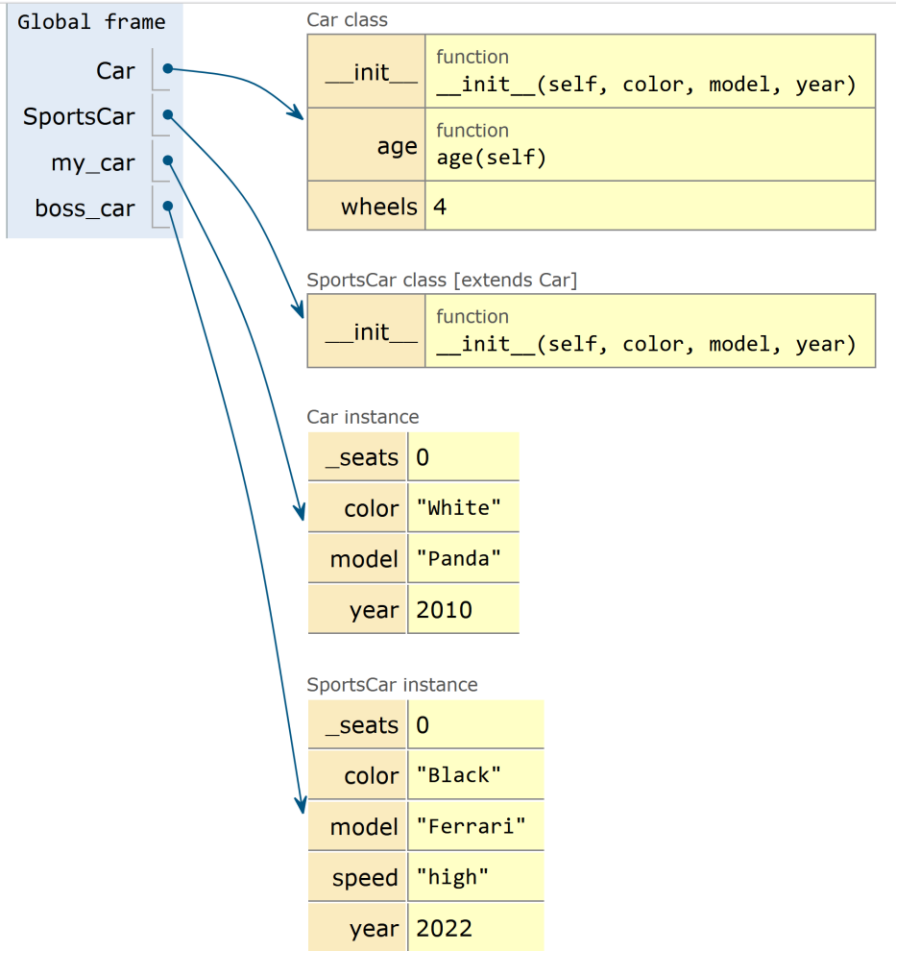
- `object.__index__(self)`

Inheritance

- A class may inherit from another class
  - `class SportsCar(Car):`
- All attributes and methods are inherited
- Must call parent class' __init__ method
  -
```
def __init__(self):
    Car.__init__()   # or: super().__init__()
    self.speed = 'high'
```

Example

```python
class Car:

    wheels = 4

    def __init__(self, color, model, year):
        self.color = color
        self.model = model
        self.year = year
        self._seats = 0

    def age(self):
        return 2024 - self.year

class SportsCar(Car):
    def __init__(self, color, model, year):
        super().__init__(color, model, year)
        self.speed = 'high'

my_car = Car('White', 'Panda', 2010)
boss_car = SportsCar('Black', 'Ferrari', 2022)
```



Multiple Inheritance

- In Python, it's possible for a class to inherit from more than one superclass:
  - `class SportsCar(Car, ExpensiveGadget):`
- All attributes and methods for both superclasses are imported, in the order of declaration
- Must call **both** constructors, `Car.__init__()` and `ExpensiveGadget.__init__()`

- There are **no** 'interfaces' in Python, thanks to multiple inheritance

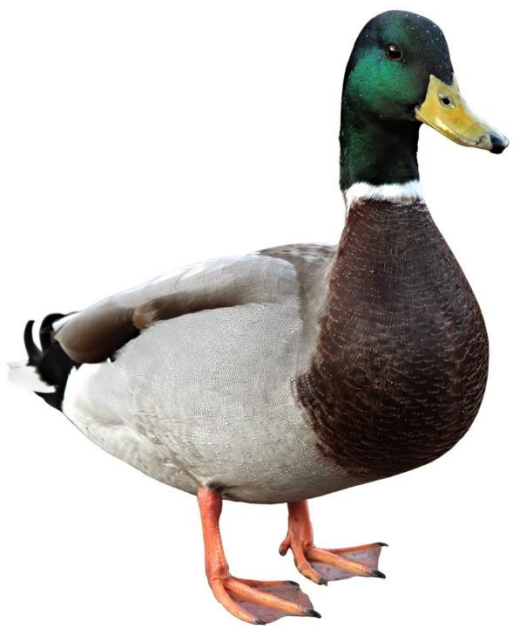
Polymorphism

- Polymorphism = calling the same method / function / operation, with different data types
- Java examples:
  - With sub-classes: `public double area(Polygon p)`, called with an object of type `Rectangle`, which is a sub-class of `Polygon`, or implements a `Polygon` interface
  - With overloaded methods: `public double area(Polygon p)` and `public double area(Conic c)`
- Java selects which method to call based on the signature of the methods and of the inheritance relationships

Polymorphism in Python

- In Python, method parameters don't have a type specification: cannot check for subclasses or signatures
- Python uses a strategy called "Duck Typing"

> "If it walks like a duck and it quacks like a duck, then it must be a duck"



Duck typing

- The type or the class of an object is less important than the methods it defines
- When you use duck typing, you do not check types at all. Instead, you check for the presence of a given method or attribute

Example (1)

```
def pretty_print(data_provider):
    data = data_provider.read_data()
    for d in data:
        print(d[0])
```

What is the allowed type of `data_provider`?

Duck typing says: any class that has a `read_data` method.

The function may be called with totally different classes as parameters

```
source_database = DatabaseAccess('localhost', 'root', 'root', 'data')
pretty_print(source_database)


source_file = FileAccess('data.csv')
pretty_print(source_file)
```

Example (2)

```
class DatabaseAccess():
    def __init__(self, server, username, password, database):
        self.connection = mysql.connector.connect(server, username, password, database)

    def read_data(self):
        cursor = self.connection.cursor()
        cursor.execute('SELECT * FROM numbers')
        result = cursor.fetchall()
        return result
```

```
class FileAccess():
    def __init__(self, file_name):
        self.file_name = file_name

    def read_data(self):
        with open(self.file_name, 'r') as f:
            lines = f.readlines()
        result = []
        for line in lines:
            result.append(line.rstrip().split(','))
        return result
```

Two unrelated classes, both implementing a read_data method, are interchangeable in pretty_print.

Polymorphism

- Inside a polymorphic function, you may check the classes of the received instances. Useful to avoid errors before calling methods that might not exist.
- Do not abuse, it defeats the simplicity of Duck Typing

isinstance(*object*, *classinfo*)

Return `True` if the *object* argument is an instance of the *classinfo* argument, or of a (direct, indirect, or virtual) subclass thereof. If *object* is not an object of the given type, the function always returns `False`. If *classinfo* is a tuple of type objects (or recursively, other such tuples) or a Union Type of multiple types, return `True` if *object* is an instance of any of the types. If *classinfo* is not a type or tuple of types and such tuples, a `TypeError` exception is raised. `TypeError` may not be raised for an invalid type if an earlier check succeeds.

Protocols

- Many built-in functions, operators, and keywords are polymorphic
- The set of required methods is called "protocol"
- Examples:
  - The `len()` function accepts any object with a `__len__()` method
  - Any object can be iterated if it has a `__iter__()` method
  - An object can be indexed if it has a `__getitem__()` method
  - An object may be used in the `with` statement if it implements an `__enter__()` and an `__exit__()` method

https://mypy.readthedocs.io/en/stable/protocols.html#predefined-protocol-reference

A Well-Defined class

- To correctly interoperate in the Python world, your class must define
  - An `__init__()` method
  - A set of `self.name` instance attributes initialized in the `__init__()` method
  - A `__repr__()` method for conversion to a (programmer-oriented) string
  - An `__eq__()` method for allowing == and != comparisons
  - If required, ordering methods such as `__le__()` for allowing < > <= >= comparisons
  - A `__hash__()` method to be used by sets and dict keys
  - If required, setter/getter methods for attributes

Boilerplate code

  - Plus any other methods specifying its behavior

Dataclasses

- The “boilerplate” code can be automatically generated by the `@dataclass` decorator
  - Especially useful for classes with basic behavior, such as “data container” classes

Python

```
class RegularCard:
    def __init__(self, rank, suit):
        self.rank = rank
        self.suit = suit
```

…plus boilerplate dunder methods

Python

```
from dataclasses import dataclass

@dataclass
class DataClassCard:
    rank: str
    suit: str
```

- `@dataclass` decorator
- List of attributes
- Expected types of attributes, after colon

https://docs.python.org/3/library/dataclasses.html
https://realpython.com/python-data-classes/

License

- These slides are distributed under a Creative Commons license “**Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0)**”
- **You are free to:**
  - **Share** — copy and redistribute the material in any medium or format
  - **Adapt** — remix, transform, and build upon the material
  - The licensor cannot revoke these freedoms as long as you follow the license terms.
- **Under the following terms:**
  - **Attribution** — You must give appropriate credit, provide a link to the license, and indicate if changes were made. You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.
  - **NonCommercial** — You may not use the material for commercial purposes.
  - **ShareAlike** — If you remix, transform, or build upon the material, you must distribute your contributions under the same license as the original.
  - **No additional restrictions** — You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits.
- https://creativecommons.org/licenses/by-nc-sa/4.0/