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Object-oriented analysis and programming

Advanced programming

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Artur Kulmizev

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Object orientation

Classes

Instance and class variables

Instance and class methods

Inheritance and polymorphism

Encapsulation

Abstract classes

UML diagrams

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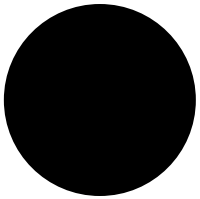
Classes and Objects

Classes describes objects

```
class Circle{
      ....
}
```



```
class Square{
      ....
}
```

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example - Person

```
class Person:

    # constructor
    def __init__(self, name, age):
      self._name = name
      self._age = age
```

Names with underscores denote variables that are meant to be treated as private, i.e. just to be used within the class

Double underscores can be used for the same purpose (name mangling as a result)

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Instance variables

Variable with a unique value for each instance of the class

e.g. in the Person class:

```
_name
_age
```

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Encapsulation

Protect variables so that other classes cannot use them directly

Not strictly implemented in Python, rely on conventions!

Start the name with an underscore

Why is it useful?

–Modularity: Hide implementational details

–Security: Allow control of values

–Flexibility: Allow changing variables types et.c.

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Encapsulation – Java style

Use strictly private variables

–Or protected: visible in a sub classes also

Use public methods to get and set values:

–Get methods – `getAge(self)`

–Set methods – `setAge(self, age)`

Use public methods for other manipulation of the objects

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Encapsulation – Python style

```
class Person:
      ...
    @property
    def age(self):
        return self._age
    @age.setter
    def age(self, age):
        if age <0 or age > 150:
            #Do something!
        self._age = age
```

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Class variables / Static variables

Variable for the full class, has only one value for all Instances, but can be accessed from each instance

All instance of a class share a class variable
Also called **static variables**

example:

```
adultAge = 18
```

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The Person class

```
class Person:

    adultAge = 18

    # constructor
    def __init__(self, name, age):
      self._name = name
      self._age = age

    ...
```

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Class methods / Static methods

A method that cannot use instance variables.

Marked with decorators:

```
@classmethod

or

@staticmethod
```

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The Person class

```
class Person:

    adultAge = 18

    # constructor
    def __init__(self, name, age):
        self._name = name
        self._age = age

    @classmethod
    def getAdultAge(cls):
        return cls.adultAge

    def isAdult(self):
        return self._age >= Person.adultAge
```

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Class methods

```
@classmethod
def getAdultAge(cls):
    return cls.adultAge
```

Class methods are useful when you need to access class variables

`cls` argument is similar to self, but relates to the full class

```
@classmethod
def fromBirthYear(cls, name, byear):
    return cls(name, date.today().year-byear)
```

Useful also for “factory” methods, where we create a new instance of the class

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Static methods

```
@staticmethod
def returnClassification():
    return {“genus”: “homo”;
            ”species”: “sapien”}
```

Static methods usually do not take any arguments

Mainly useful for utility functions,
(they are added to the class namespace)

It is possible to access static variables,
but classmethod is recommended for that

```
@staticmethod
def getAdultAge():
    return Person.adultAge
```

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Calling Class/Static methods

```
@staticmethod
def returnClassification():
    return {“genus”: “homo”;
            ”species”: “sapien”}

@classmethod
def getAdultAge(cls):
    return cls.adultAge

scott = Person(“Scott”, 45)

scott.getAdultAge()              #both options
Person.getAdultAge()             #possible

Person.returnClassification()  #only option
```

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UML

Unified Modeling Language

A tool to express and model ideas

–A graphical description of different aspects of object oriented systems

Class diagrams

–Describe classes and relations between classes

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UML diagram types

Class diagram

Use case diagram

Sequence diagram

Communication diagram

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UML – class description

Class name
variables
methods

Person

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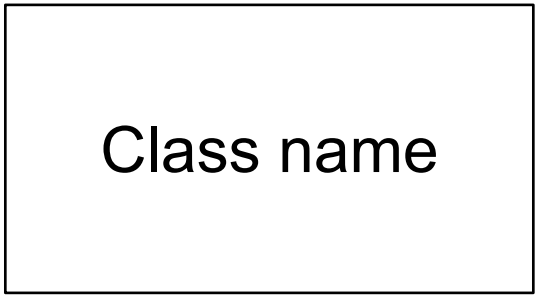
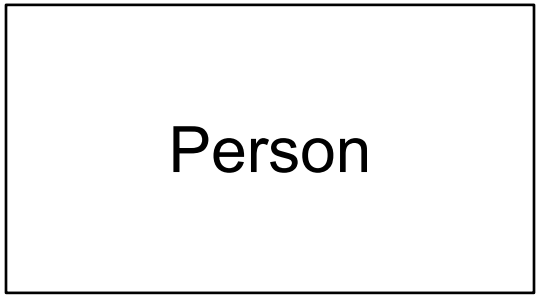
UML – *simplified* class description





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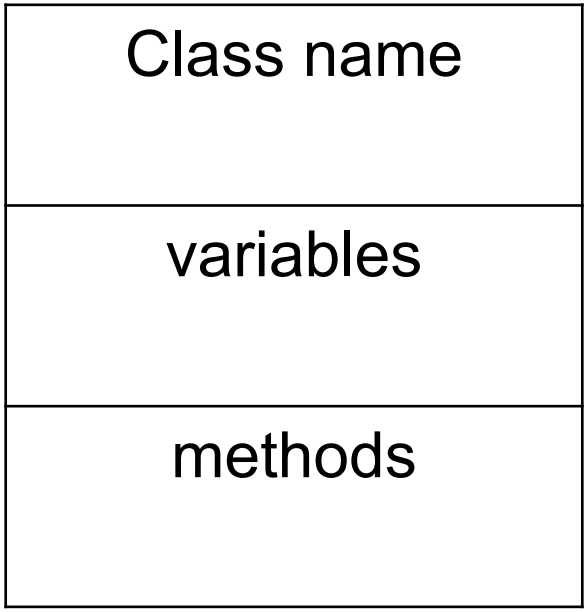
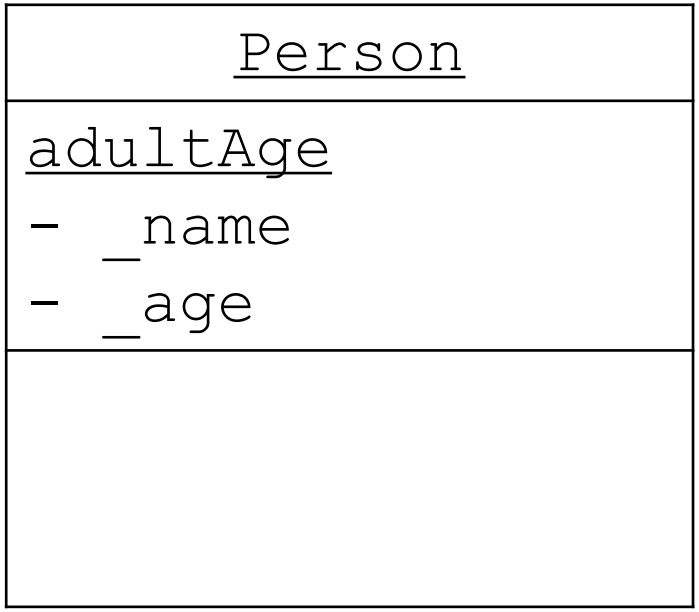
UML – class description





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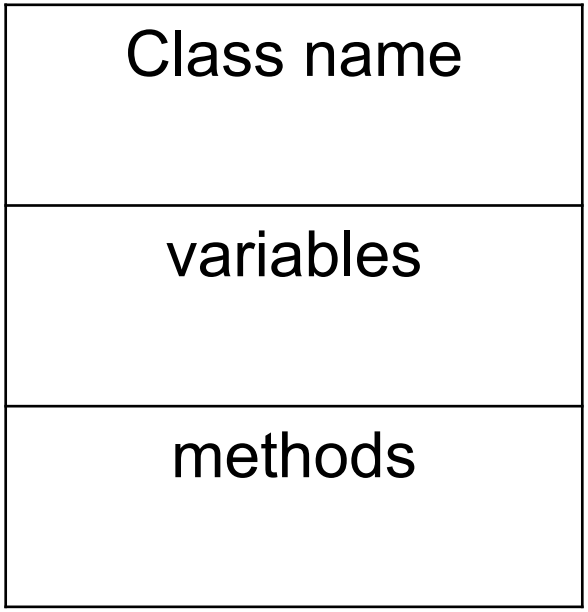
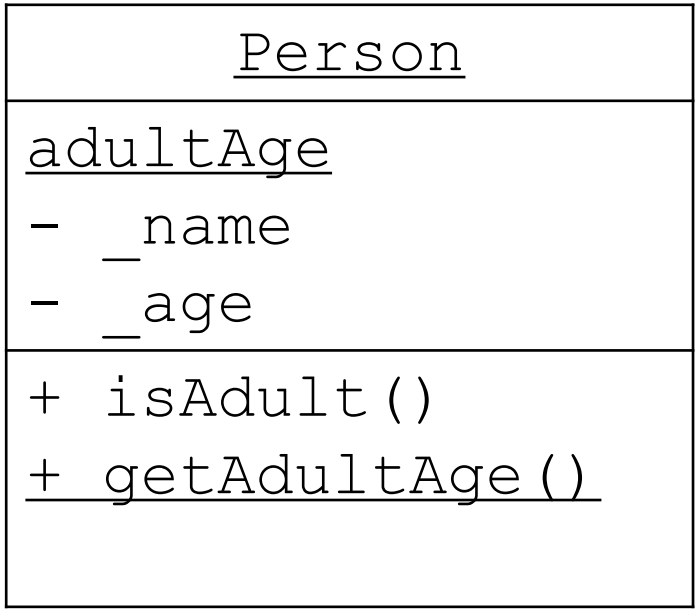
UML – class description





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UML – class description

Person
adultAge - _name - _age
+ isAdult() + getAdultAge()

Instance variable
Instance method
Class variable
Class method
- private
+public

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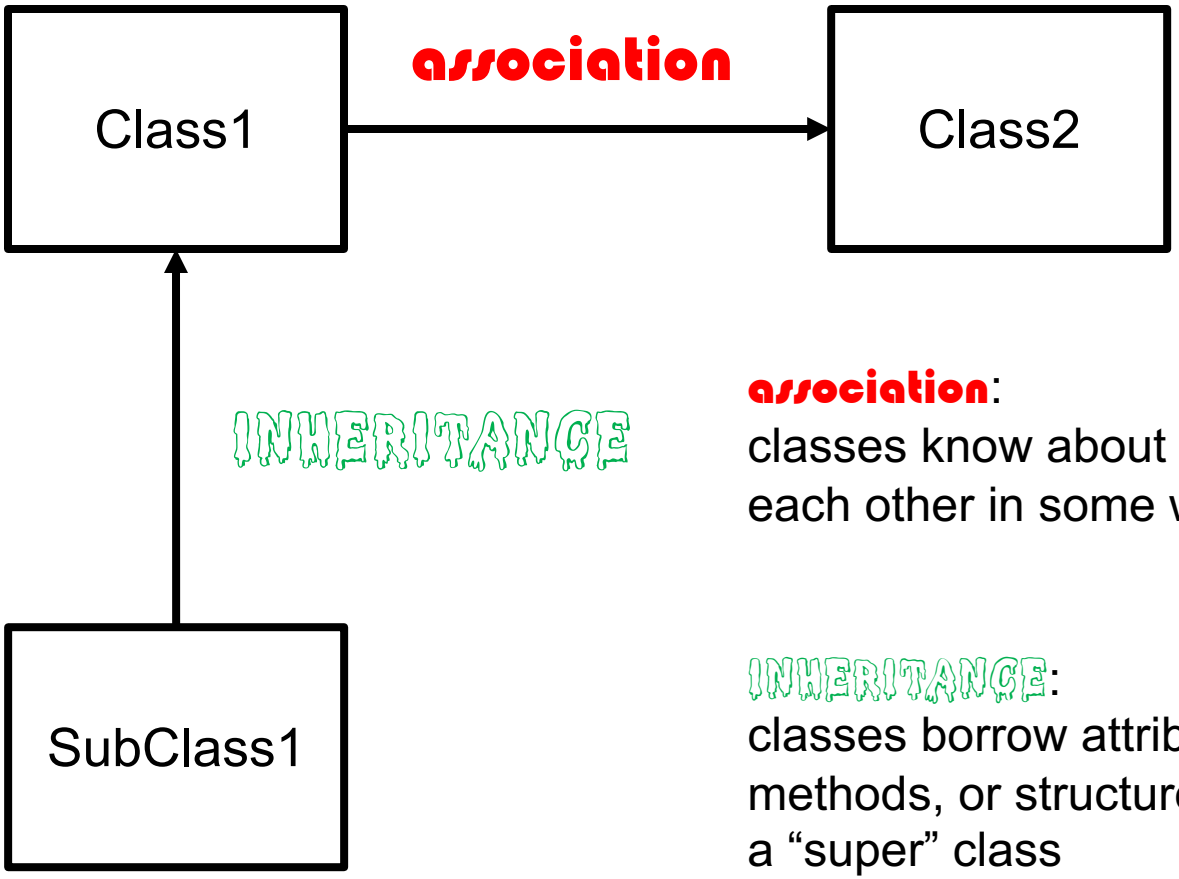
UML – relations between classes



association:
classes know about each other in some way

INHERITANCE:
classes borrow attributes, methods, or structure from a “super” class

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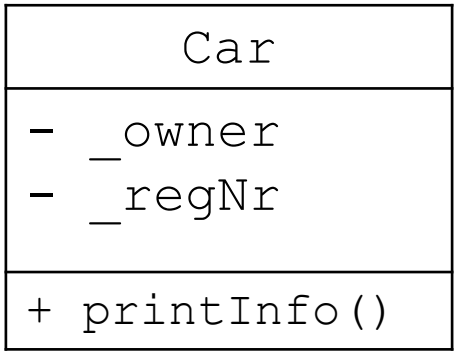
The class Car

```
class Car:

    def __init__(self, owner, reg):
      self._owner = owner
      self._regNr = reg

    def printInfo(self):
      print ("Car: ", self._regNr)
```



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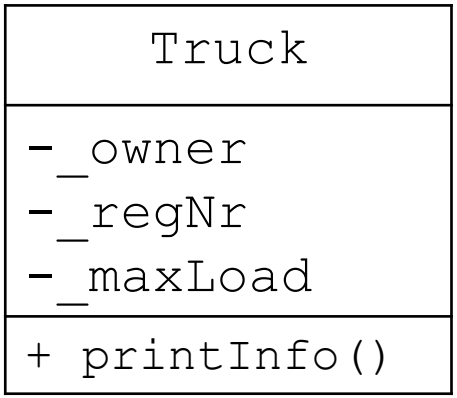
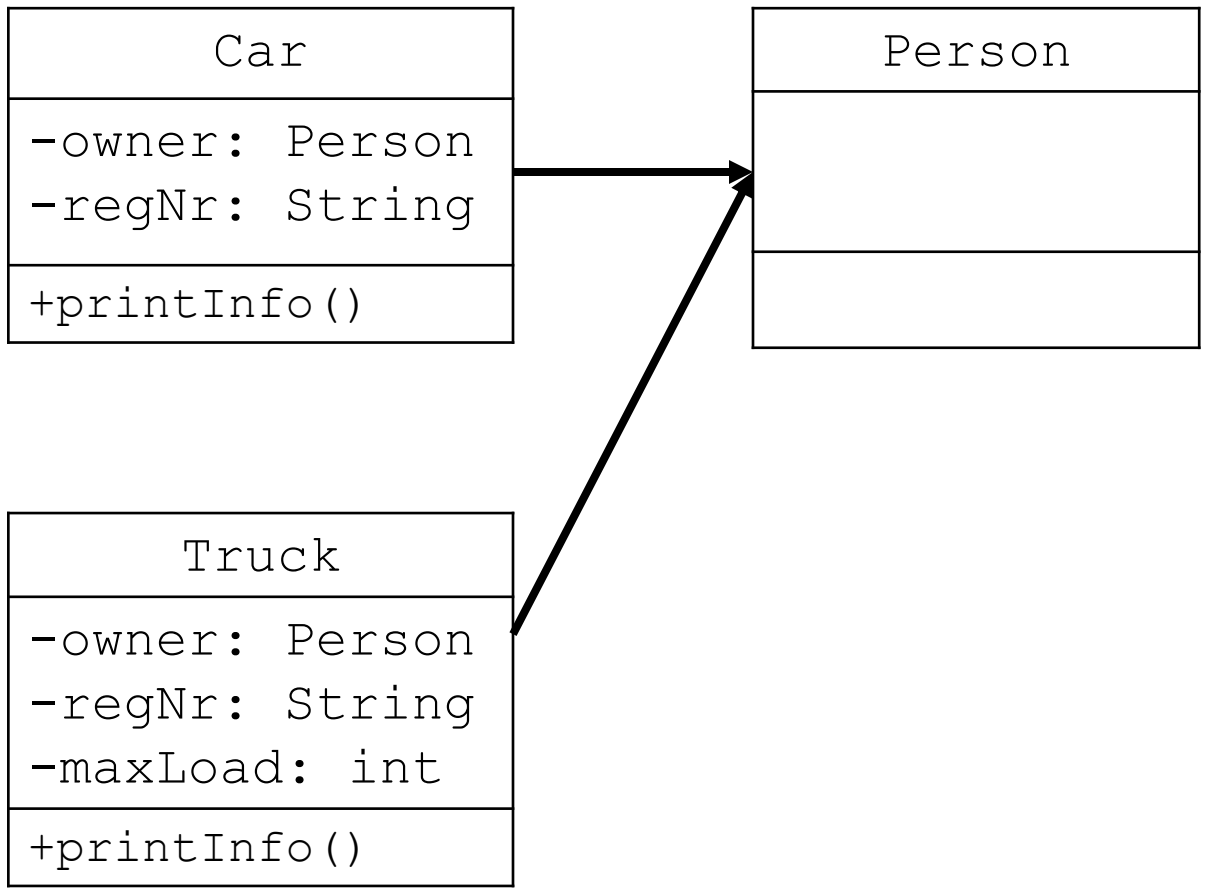
The class Truck

```
class Truck:

    def __init__(self, owner, reg, load):
      self._owner = owner
      self._regNr = reg
      self._maxLoad = load
    }

    def printInfo(self) {
      print ("Truck: ", + self._regNr, \
      ", max load: ", self._maxLoad)
    }
}
```




Car
-owner: Person
-regNr: String
+printInfo()
Person
Truck
-owner: Person
-regNr: String
-maxLoad: int
+printInfo()

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```
scott = Person(“Scott”, 45)
scottsCar = Car(scott, “BBC123”)
scottsTruck = Truck(scott, “TBC123”, 100)

myCar.printInfo())
myTruck.printInfo())
```

Printout:

```
Car: BBC123
Truck: TBC123, max load: 100
```

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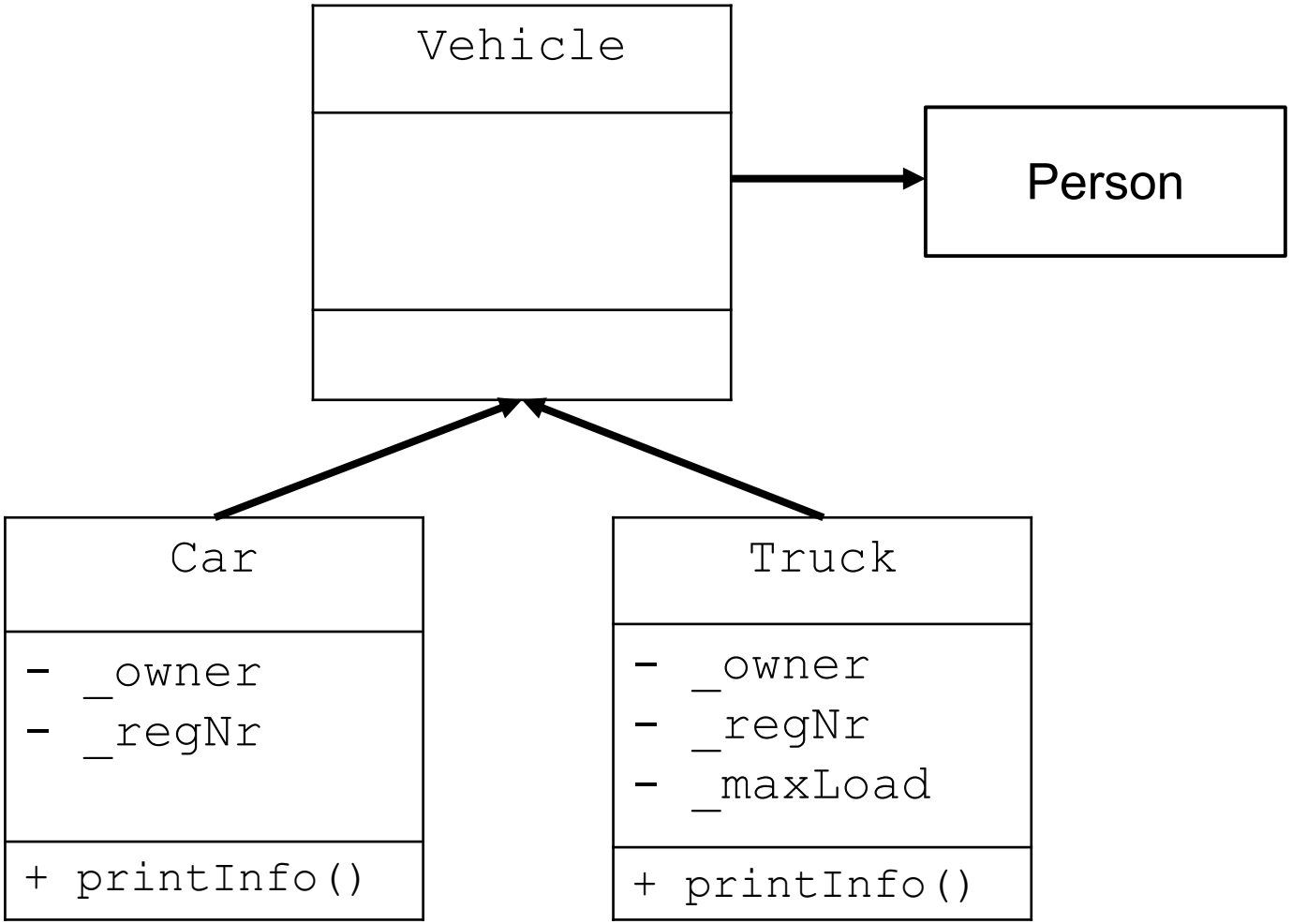
INHERITANCE – both classes are vehicles



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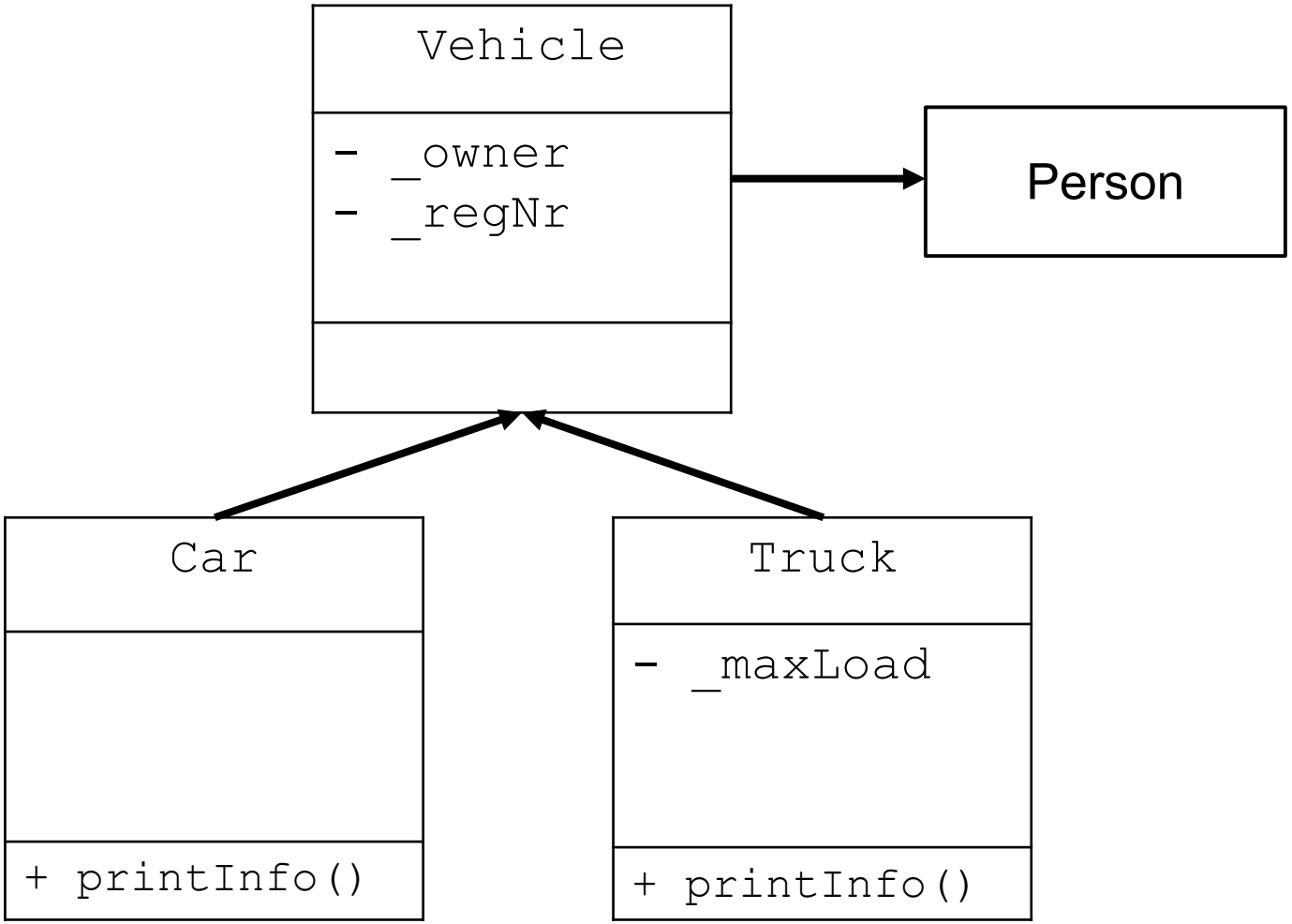
INHERITANCE – both classes are vehicles



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New code with INHERITANCE

```
class Vehicle:
    def __init__(self, o, r):
        self._owner = o
        self._regNr = r


class Car(Vehicle):
    def __init__(self, o, r):
        super().__init__(o, r)


class Truck(Vehicle):
    def __init__(self, o, r, l):
        super().__init__(o, r)
        self._maxLoad = l
```

super keyword used to access parent class!

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Visibility

Python does not have strict typing

Typically subclasses are also expected to be allowed to use private (`_name`) variables

In other languages:

–Private – only in class

–Protected – also in subclasses

–Public – everywhere

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Add super class method – solution 1

```
class Vehicle:

    def __init__(self, owner, reg):
      self._owner = owner
      self._regNr = reg

    def printInfo(self):
      print(Reg nr: ", self._regNr)
```

`printInfo()` in `Vehicle` will likely never be used

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Add super class method – solution 2

```
class Vehicle:

    def __init__(self, owner, reg):
        self._owner = owner
        self._regNr = reg

    @abstractmethod
    def printInfo(self):
        pass
```

If we declare a method as abstract, the class becomes an abstract class, and we cannot create any instances of it

Any subclasses are required to implement all abstract methods!

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Add super class method – solution 3

```
class Vehicle:

    ...

    @abstractmethod
    def printInfo(self):
        print("Reg nr: ", self._regNr)

class Truck(Vehicle):
    def printInfo(self):
        super().printInfo()
        print(" max load: ", self._maxLoad)
```

An abstract class can contain an implementation that can be used in subclasses, using the keyword SUPER

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POLYMORPHISM

Different methods are called depending on which subclass is called, even if we do not know what the subclass actually is

Example:

–If we have a list with both trucks and cars, and call `printInfo()` on each item, we will automatically use the correct variant, depending on if the object is a Truck or a Car

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Duck typing

In Python, this is not restricted to inheritance hierarchies

As long as classes we want to call have the same interface, we can call the same method on them

–Duck typing

Duck typing is not restricted to inheritance hierarchies

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Inheritance - terms

Super class – The class you inherit from, e.g. Vehicle

Sub class – The class that inherits from a super class, e.g Car and Truck

Simple inheritance – When a class inherits only from one super class (the normal case)

Multiple inheritance – When the class inherits from more than one super class (Caution needed, can be error prone, duck typing often better alternative)

SUPER - keyword used to access the super class

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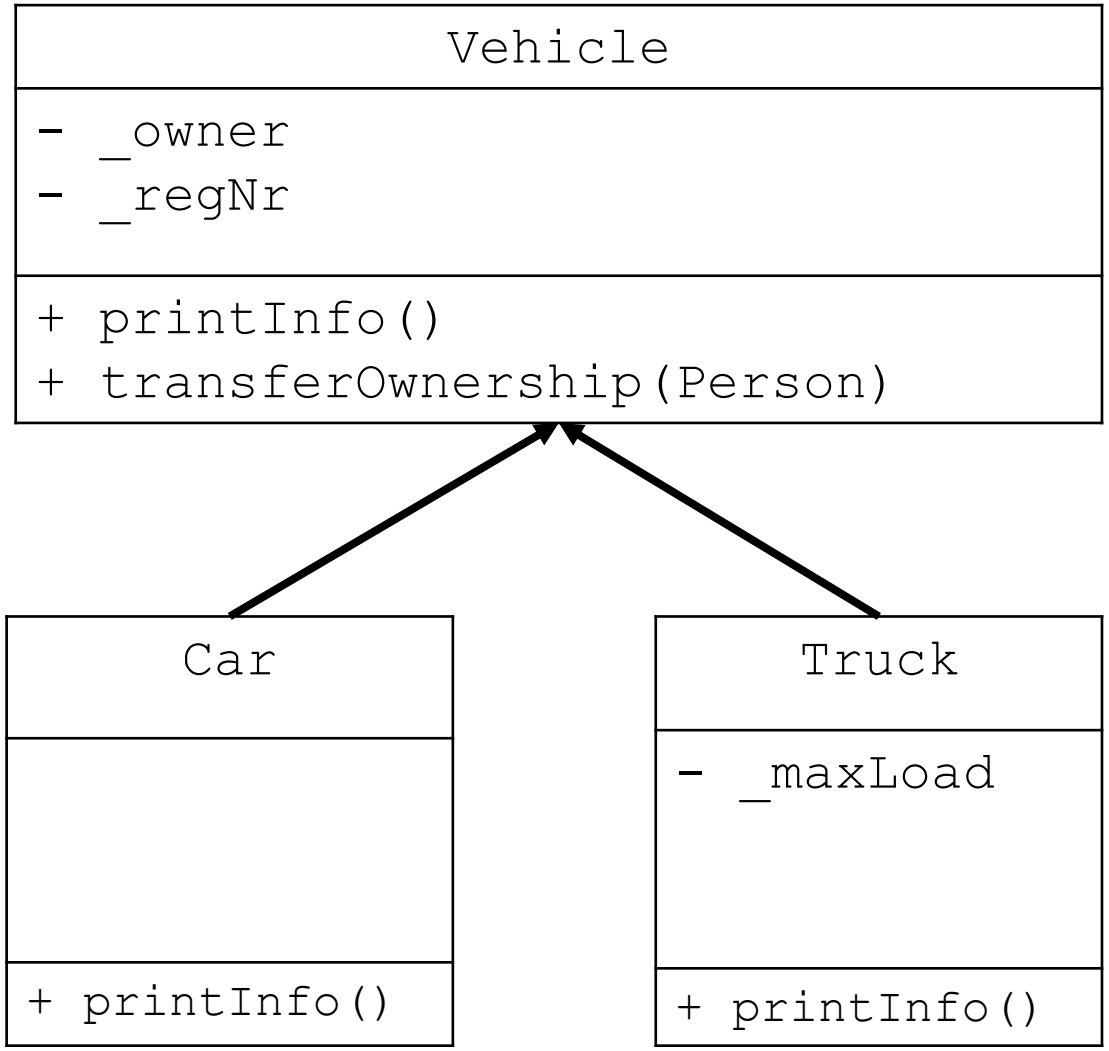
INHERITANCE – what sees what?



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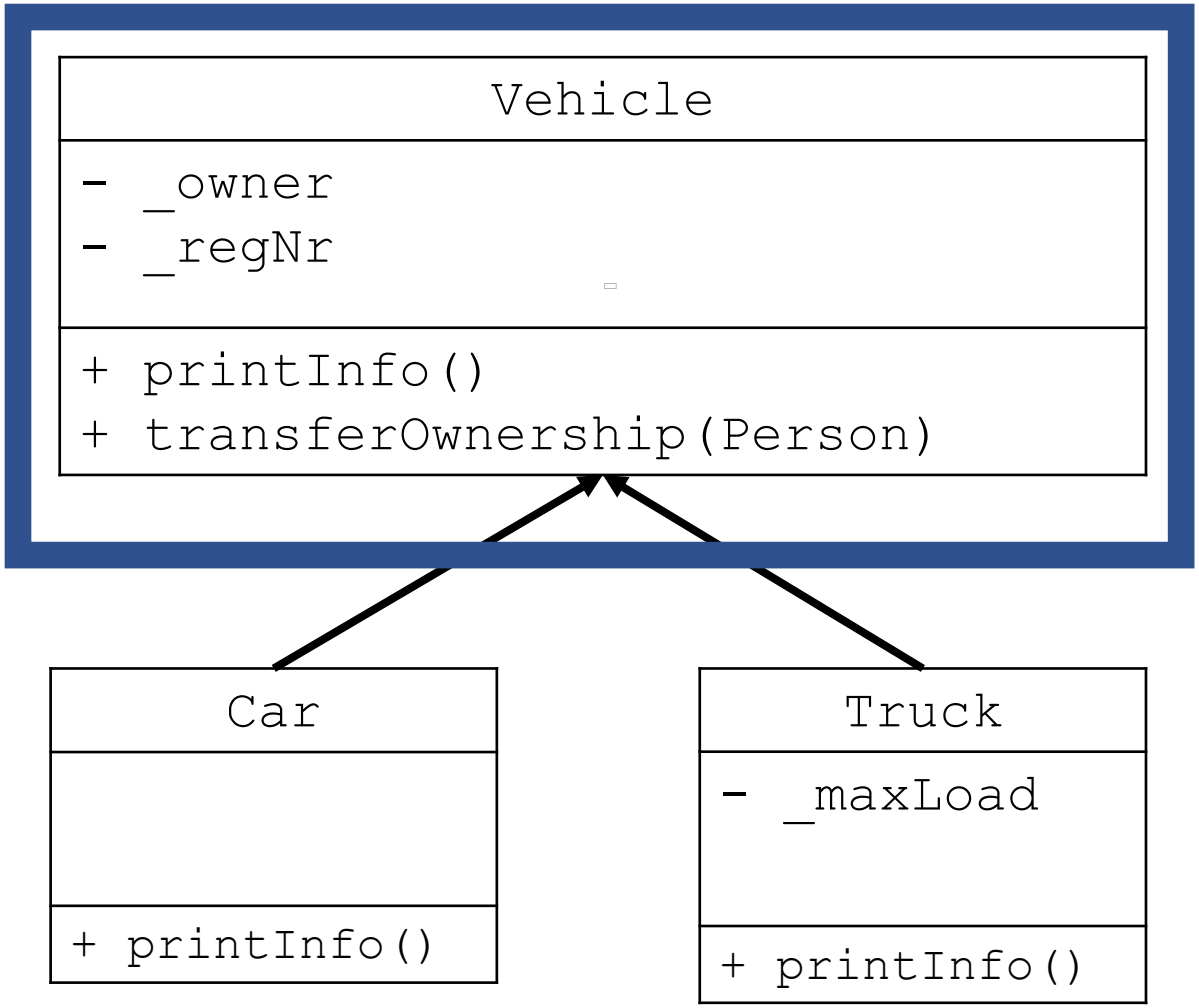
INHERITANCE – what sees what?



The `Vehicle` Class only sees itself!

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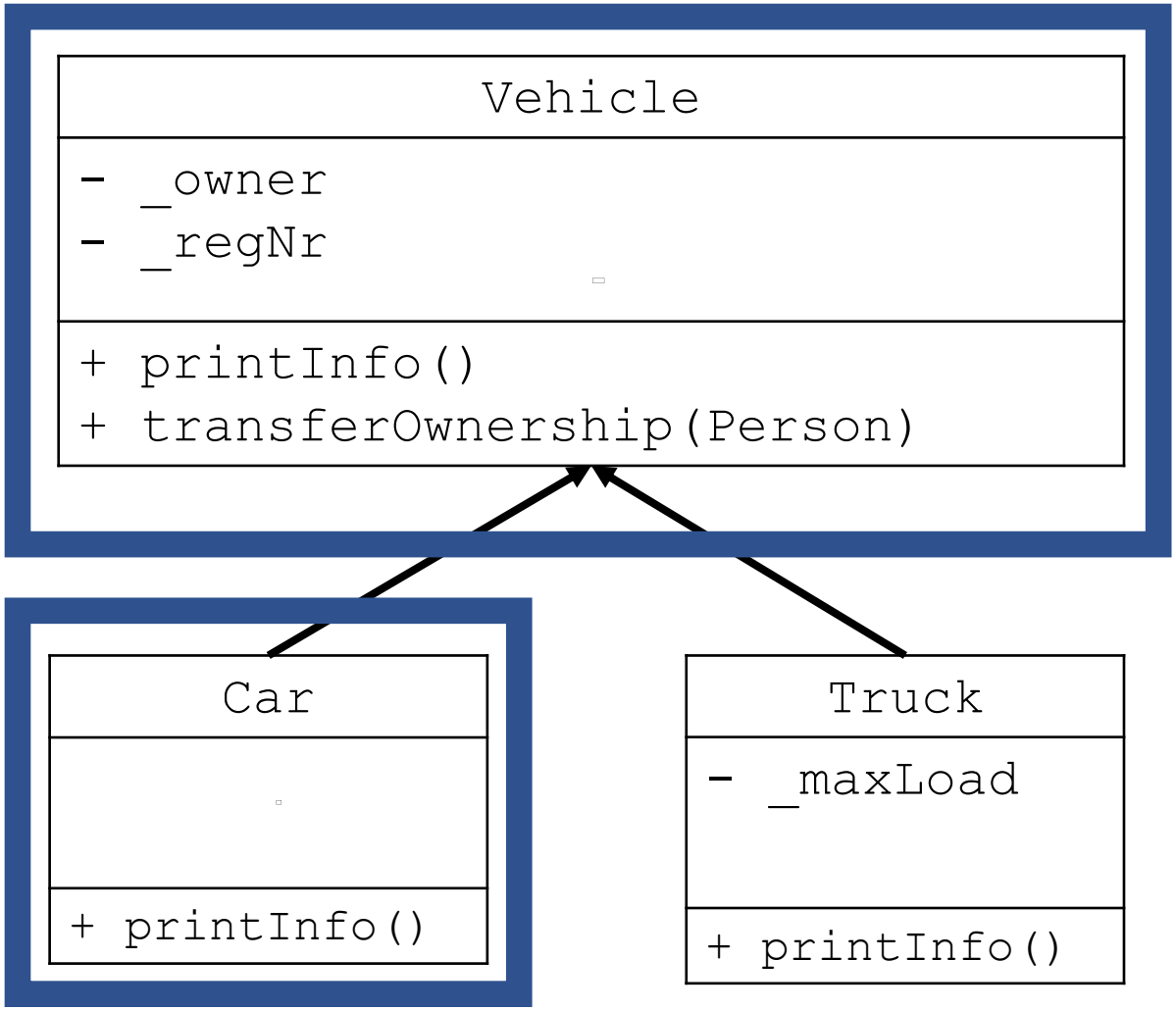
INHERITANCE – what sees what?



The `Car` Class sees itself and `Vehicle`!

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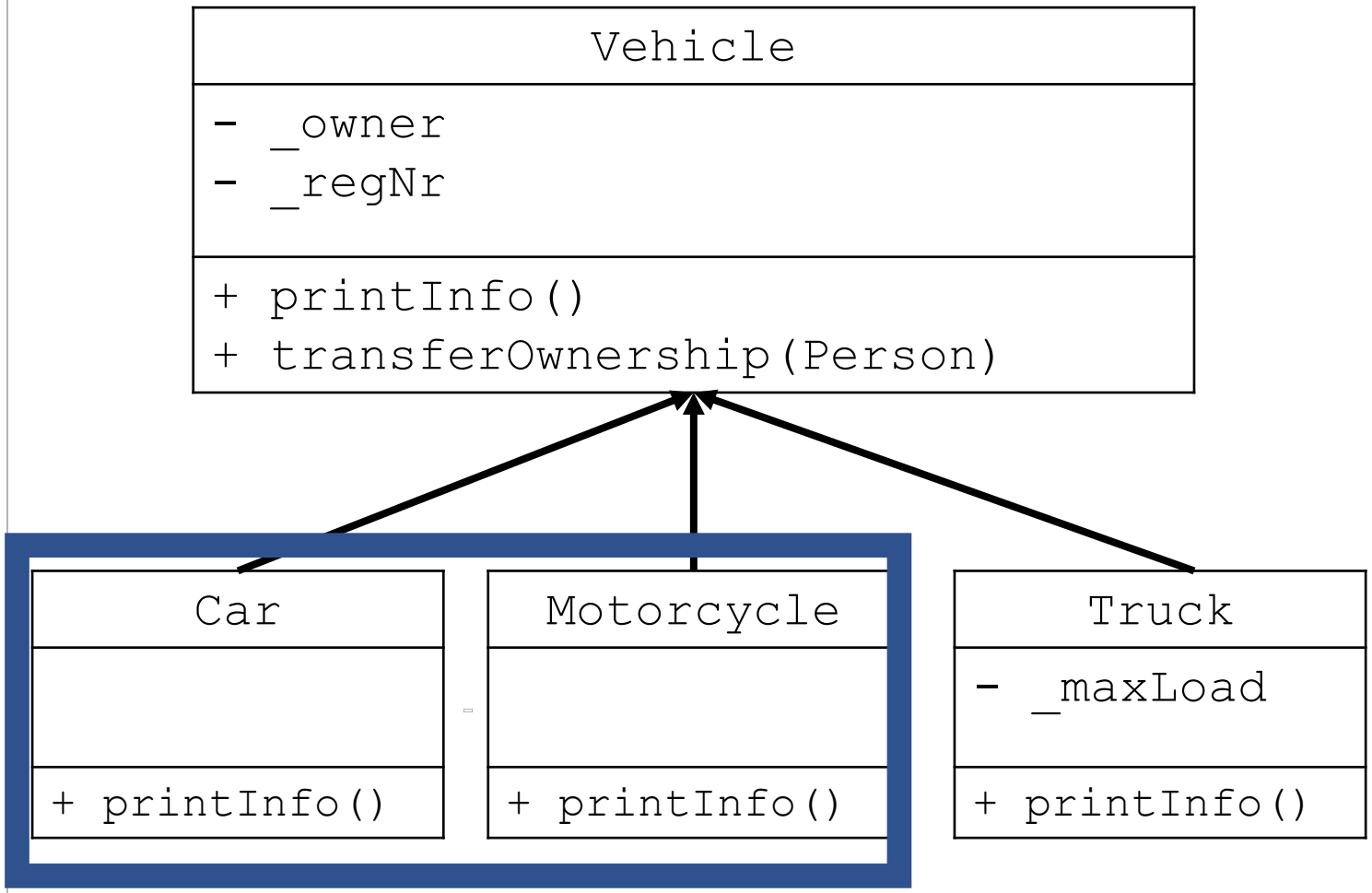
INHERITANCE – can we have deeper hierarchies?



The `Car` and `Motorcycle` classes can have passengers...

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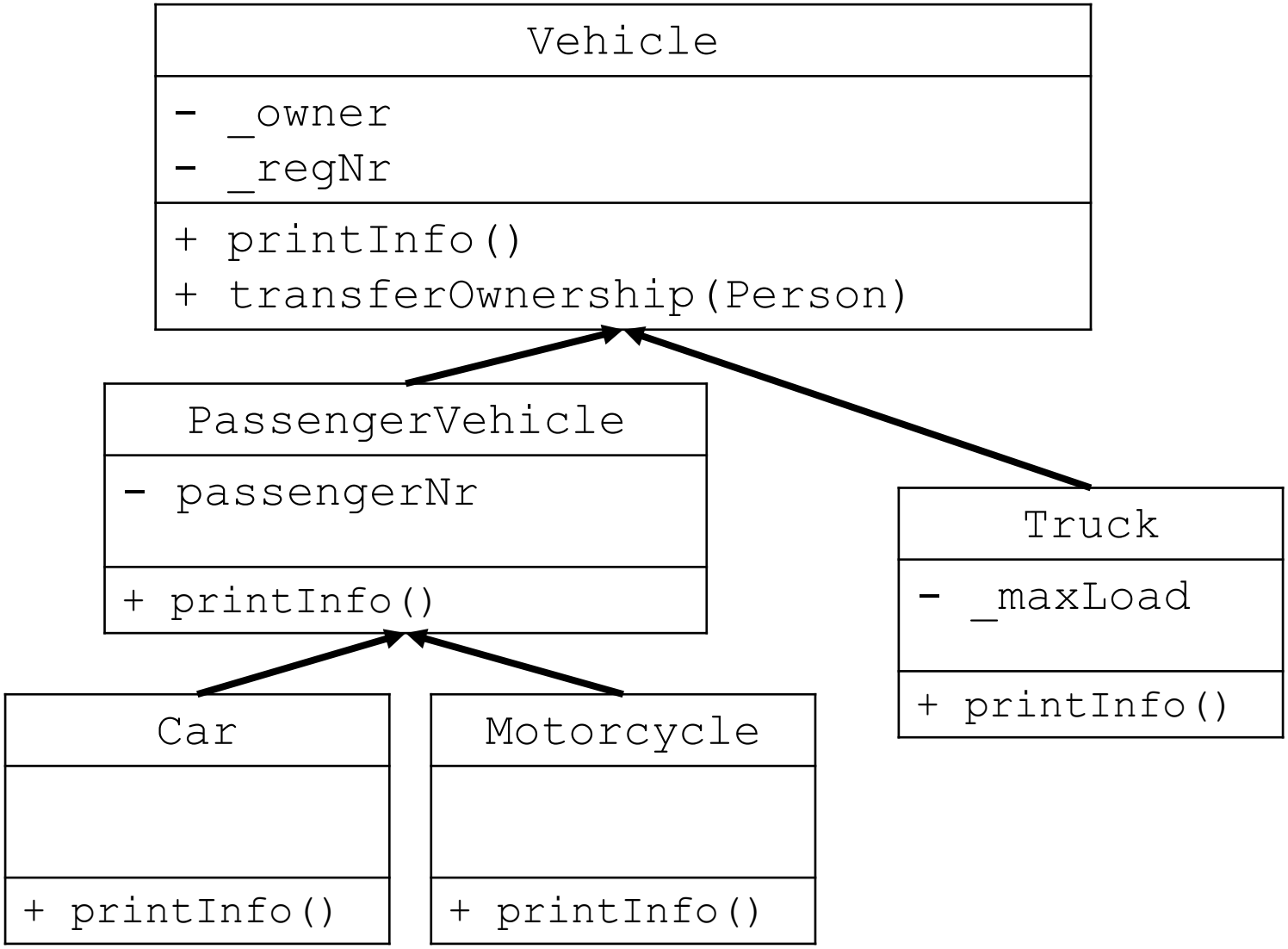
INHERITANCE – can we have deeper hierarchies?



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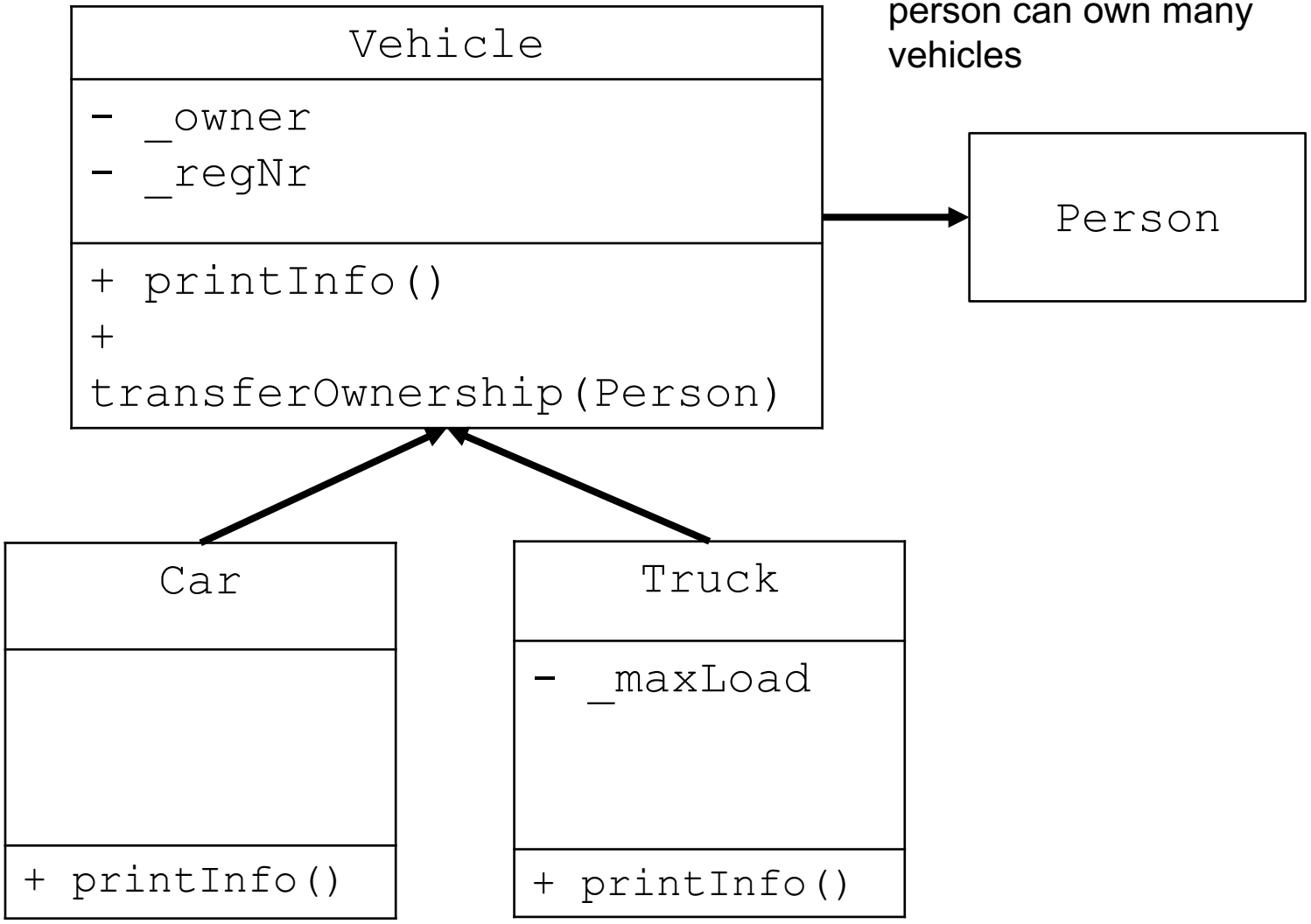
multiplicity

A vehicle can only be owned by a single person, whereas a person can own many vehicles



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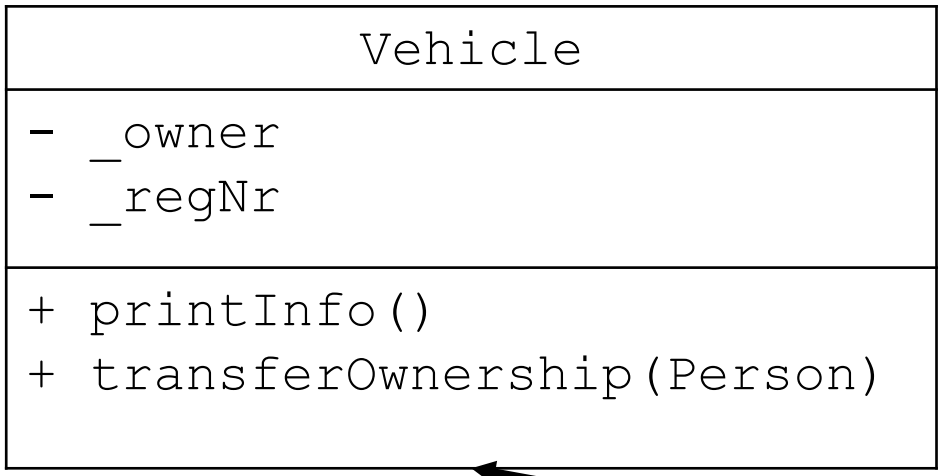
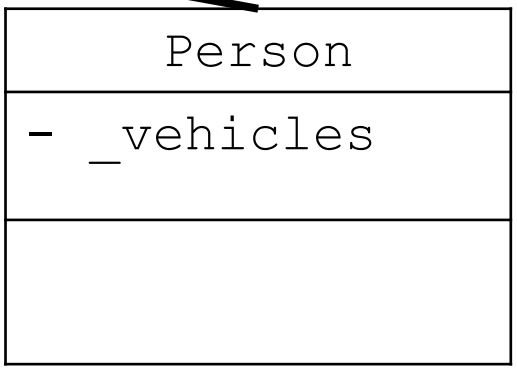
multiplicity



The `Person` class now knows about which vehicles a person owns, rather than the vehicles knowing who owns them

`_vehicles` could be implemented as a list of `Vehicle` objects



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OO[ADP]

OOA (object oriented analysis)

–Analyze the problem

–Create use cases – what does the program need to do?

–Decide which classes are needed and how they should cooperate

OOD (object oriented design)

–Make the design more specific and detailed

–Decide on methods and variables for each class

OOP (object oriented programming)

–Implement the design in some object oriented programming language

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OOA/OOD – possible workflow

Find object candidates

Make a first cleanup among objects

Classify the objects

Group objects and describe relations between them

Define use cases and validate the system

Draw class diagrams

Design classes in detail

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Find object candidates

Noun-verb method

–Nouns – possible classes

–Verbs – possible methods

Checklist

–Physical objects (car, house)

–Locations (room, garden)

–Concepts (bank account, transaction)

–Roles (customer, player)

–Events (landing, break)

–…

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First cleanup

Are some objects really the same, but with different names?

–e.g. Agent, Player

Are some objects obviously implausible, i.e. should maybe be variables instead

–e.g. Name, can probably be an instance variable instead of a class

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Classify the objects

Work for instance with CRC-cards

–C – class, the name of the class

–R – responsibility of the class

–C – collaborators, classes that the class collaborate with

Create CRC cards for your class candidates

CRC-cards can be moved around, grouped, updated, thrown away as you continue working

Name

Responsibilities Collaborators

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Use cases and validation

Use cases

–Specifications of what the program should do

Validation

–Can the classes be used to perform the use cases?

–Have we found the right classes?

–Have we identified all classes needed?

–Which classes cooperate, and how?

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Design classes in detail

Which methods are needed?

–Especially public methods – the interface of the class

What variables are needed?

–Which data structures would be a good fit?

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Assignment 4

Text-based game based on OOD

Should be fully object-oriented

–i.e. all code should be in methods in classes

–Except a very small main program, like for instance:

```
# get filename from command line args
reader = HouseReader()
myHouse = reader.initialize(filename)
myHouse.play()

# or
myHouse = House(filename)
myHouse.play()
```