PROGRAMMING IN PYTHON I

Classes

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Copyright Statement

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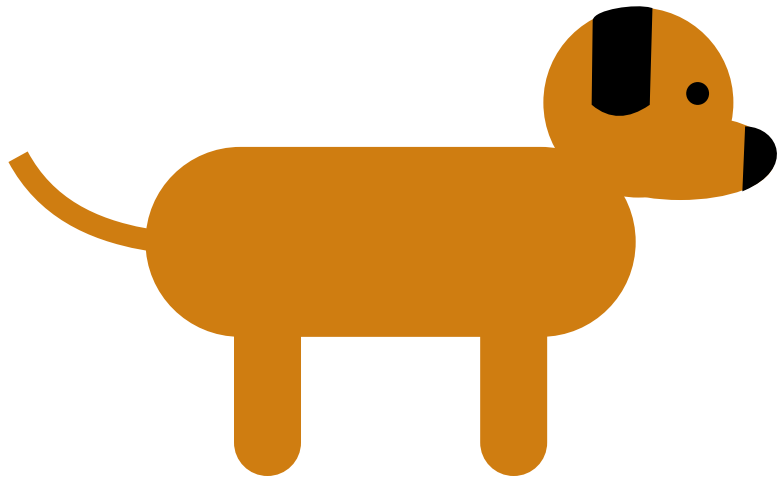
CLASSES IN PYTHON

Motivation

- Often, we want reusability and modularity of our code
  - Easier software design
  - Easier data modeling
- **Object-oriented programming** (OOP) tries to increase reusability and modularity
  - Programming paradigm based on the concept of **objects**
- **Objects** (in OOP)
  - Combination of variables, functions and data structures
  - Can contain state (data) and behavior (methods)
- (**Data**) **Attributes** (aka **fields**)
  - State (data) associated with an object
- **Methods**
  - Behavior (functions) provided by an object

Objects: Example (1)

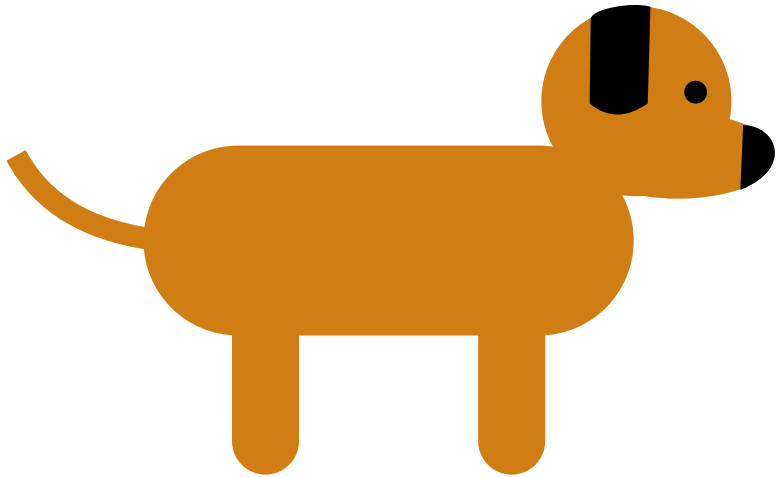
- Example: We want to create an object to describe a dog named “Bello”



Objects: Example (2)

- Our dog object can have attributes that hold values describing the name and fur color

Attributes

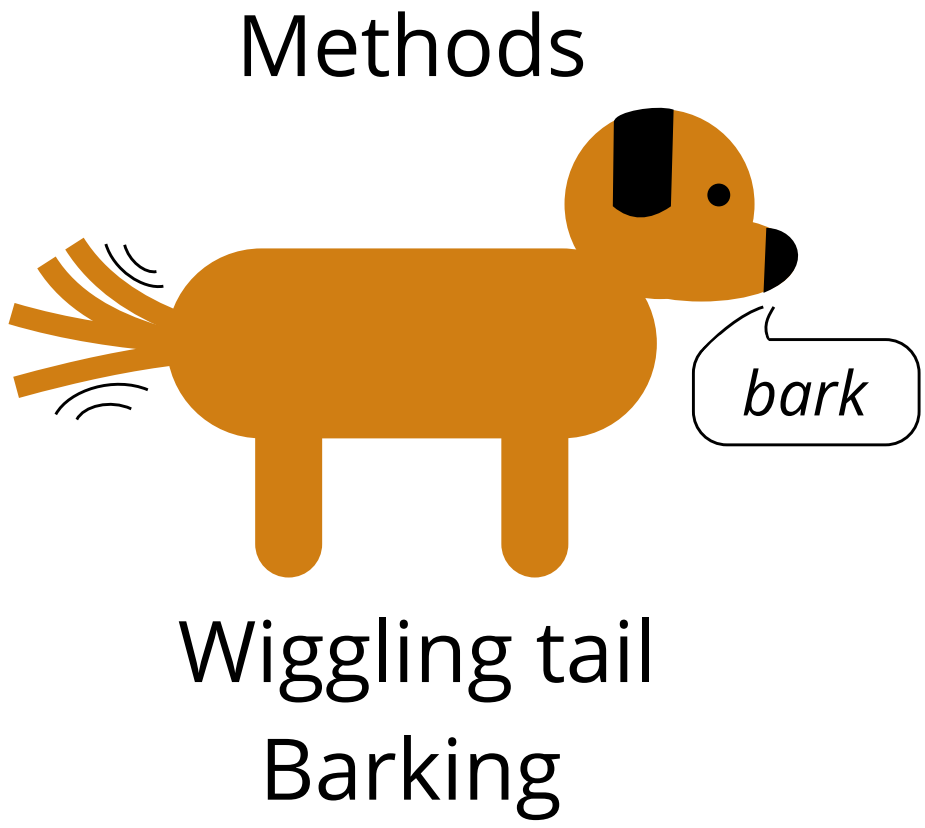


Name: "Bello"

Fur color: "brown"

Objects: Example (3)

- Our dog object can have methods that execute wiggling of its tail and barking

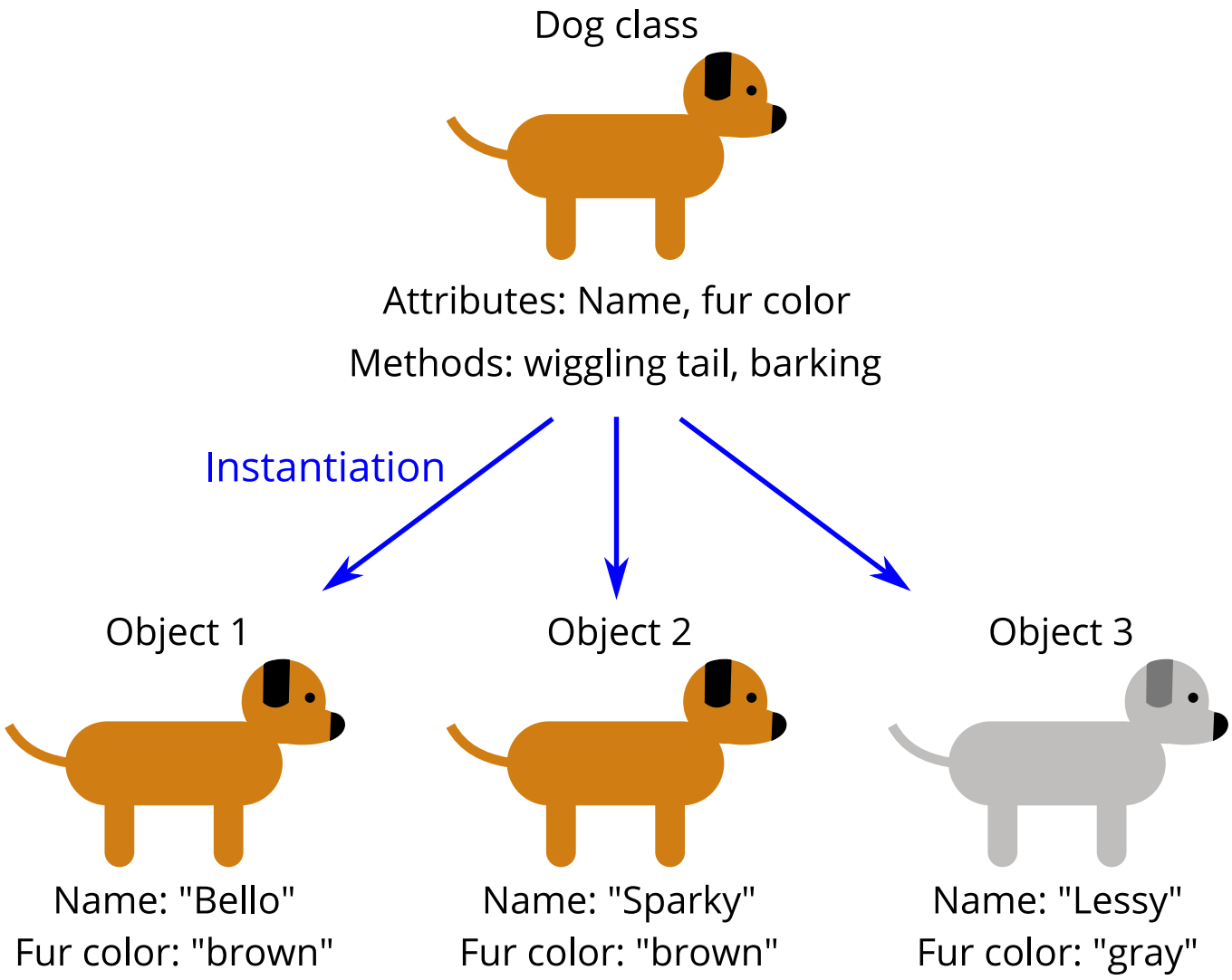


Classes (1)

- **Classes** define objects (like a blue-print). Creating a new class means creating a new **type**
- An **object** is an **instance of a class/type** that exists **uniquely** among all other objects
- Example: Assume we want to describe multiple dogs
  - We would first create a dog class
  - The dog class would contain attributes and methods that are used to describe a dog
  - If we want to describe an individual dog, we create an instance of our dog class (a new object)
  - Each instance is an individual object and contains a copy of the attributes and methods from our dog class

  → We can reuse the code for a dog object for every dog!

Classes (2)


Dog class
Attributes: Name, fur color
Methods: wiggling tail, barking
Instantiation
Object 1
Name: "Bello"
Fur color: "brown"
Object 2
Name: "Sparky"
Fur color: "brown"
Object 3
Name: "Lessy"
Fur color: "gray"

Classes (3)

- We can also create (**derive**) new classes from existing classes, i.e., **extend** existing classes:
  - The new classes are referred to as **child classes** or **subclasses**
  - The classes the subclasses are derived from are referred to as **parent classes**, **base classes** or **superclasses**
- Subclasses can **inherit** attributes and method definitions from their base classes
  - Attributes/methods from parent classes are available in child classes but can be modified/extended

Classes (4)

- Example: Assume that we now want to describe guard dogs that behave like our dog class but also have a “guard” method
  - We can derive a guard-dog class from our dog class, which inherits the attribute and method definitions from the dog class
  - We can add an additional “guard” method to our guard-dog class
  - We can now create instances of our guard-dog class

Classes in Python

- Every class in Python is (indirectly) derived from the base class **object**
- We have already worked with classes in Python!
  - Example: Our integer objects are instances of the `int` class, which is derived from the `object` class
- Classes can be created using the **class** statement
  - Class names (by convention) should be **CapWords**
  - Example: `MyNewClass`
- Similarly to functions, classes create a **namespace**
  - Attributes and methods only exist within the class or an instance thereof

Class Syntax and Terminology

```
class Dog:
    """This class represents dogs."""

    kind = "canine"

    def __init__(self, name):
        self.name = name

    def bark(self):
        print(f"{self.name}: woof!")
```

Class Syntax and Terminology

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Class/Type name

Class Syntax and Terminology

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Class documentation

Class Syntax and Terminology

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```

Class attribute/field (exists only once)

Class Syntax and Terminology

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class Dog:
    """This class represents dogs."""

    kind = "canine"

    def __init__(self, name):
        self.name = name

    def bark(self):
        print(f"{self.name}: woof!")
```

Special method for object initialization. Must be named `__init__`. The first parameter `self` references this new object. All object methods must have `self` as first parameter.

Class Syntax and Terminology

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    def bark(self):
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```

Object/Instance attribute/field (exists for each object).

Object attributes must be accessed with `self.attribute` within the class definition

Class Syntax and Terminology

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class Dog:
    """This class represents dogs."""

    kind = "canine"

    def __init__(self, name):
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Method (“belongs” to the `self` object). Object methods are bound to the object they were invoked on.

Class Syntax and Terminology

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class Dog:
    """This class represents dogs."""

    kind = "canine"

    def __init__(self, name):
        self.name = name

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```

Access of the above created object attribute `name`. The same preceding `self` must be done when calling object methods.

Access and Instantiation

- Access of class or object attributes via `MyClass.attribute` or `my_obj.attribute`:
  - `Dog.kind` `my_dog.name`
- Instantiation/Creation of new objects/instances via `my_obj = MyClass(...)`, where `...` are the arguments that will be passed in addition to `self` to the special method `__init__(self, ...)` (if there are any):
  - `d = Dog("Bello")`
  - This will create a new `Dog` object (with the object attribute `name` set to `"Bello"`) and store it in the variable `d`.
- Invocation of methods via `my_obj.method(...)`, where `...` are the arguments that will be passed in addition to `self` to `method` (if there are any):
  - `d.bark()`
  - This will call `Dog.bark(d)`, i.e., `self` is automatically set to the object the method was invoked on (here: `self=d`)

Inheritance

- Syntax to extend a base class (inherit from a base class):
  - `class MyClass(object)`[1]
  - `class MySpecializedClass(MyClass)`
  - `class GuardDog(Dog)`
- All attributes and methods are inherited. Additional attributes and methods can be provided and behavior of existing methods can be changed (**method overriding**)
- Special built-in **super** for accessing the base class:

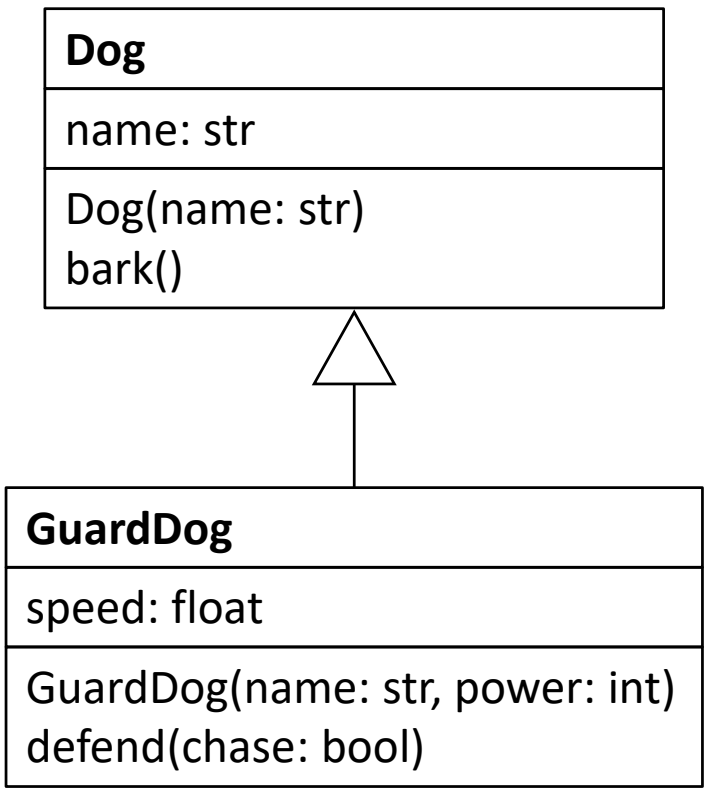
```
class GuardDog(Dog):
    def __init__(self, name, power):
        super().__init__(name)
        self.power = power
```

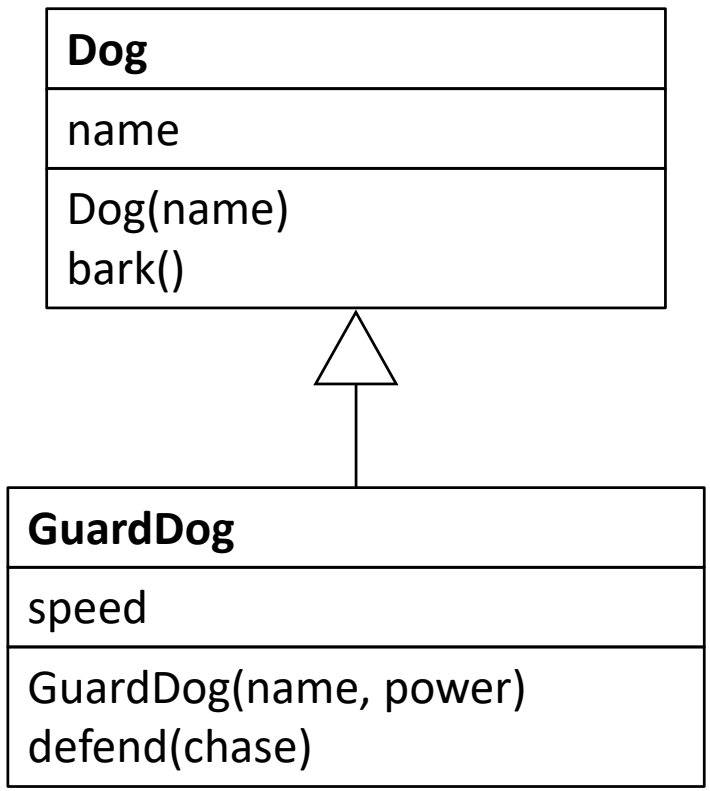
- Python supports multiple inheritance

[1] All classes inherit from the base class `object` automatically.

Graphical Class (Hierarchy) Notation

- UML (Unified Modeling Language) class diagram
- Very common. Allows to quickly model classes with instance attributes, methods, types, inheritance, etc.





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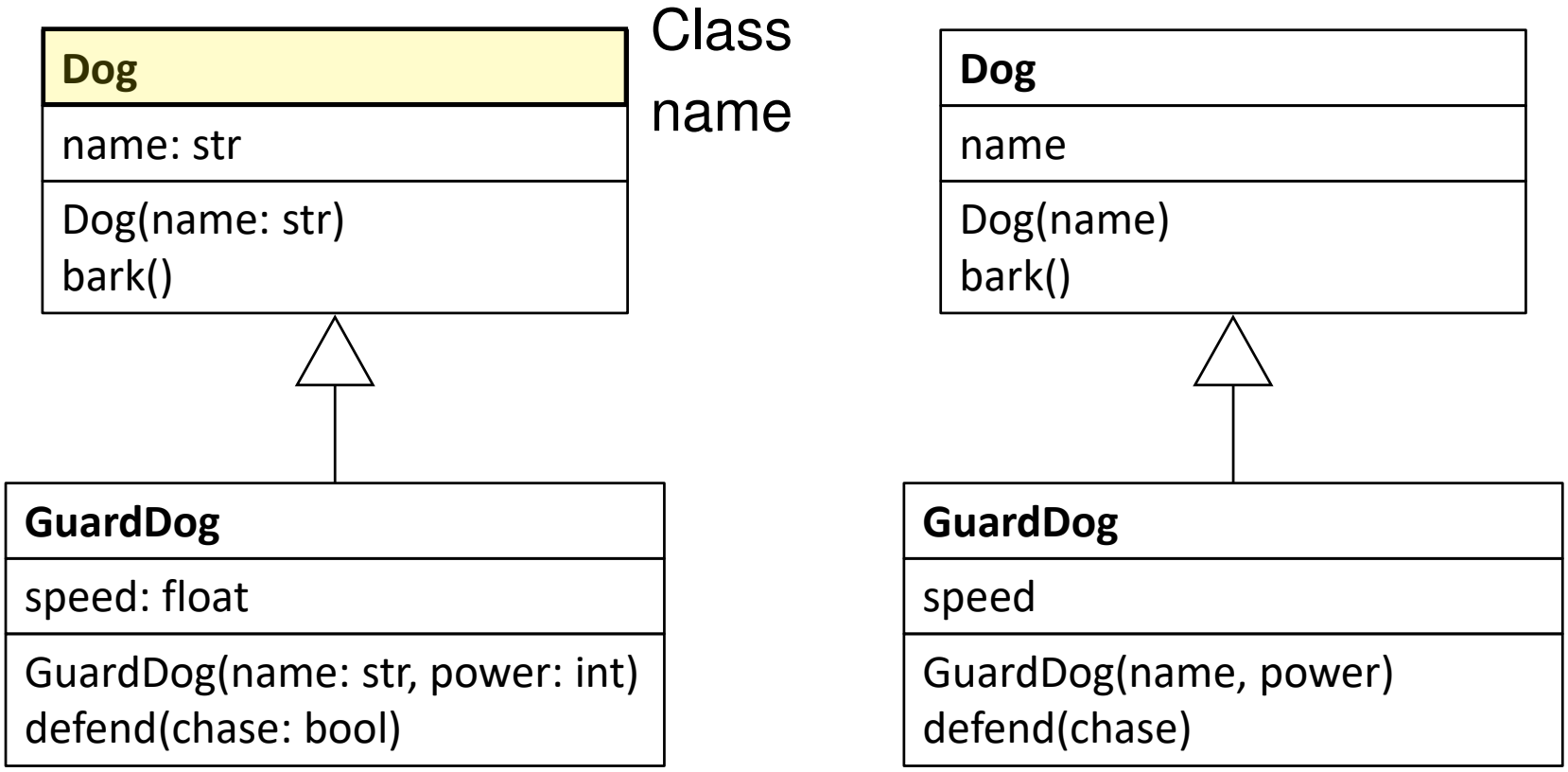

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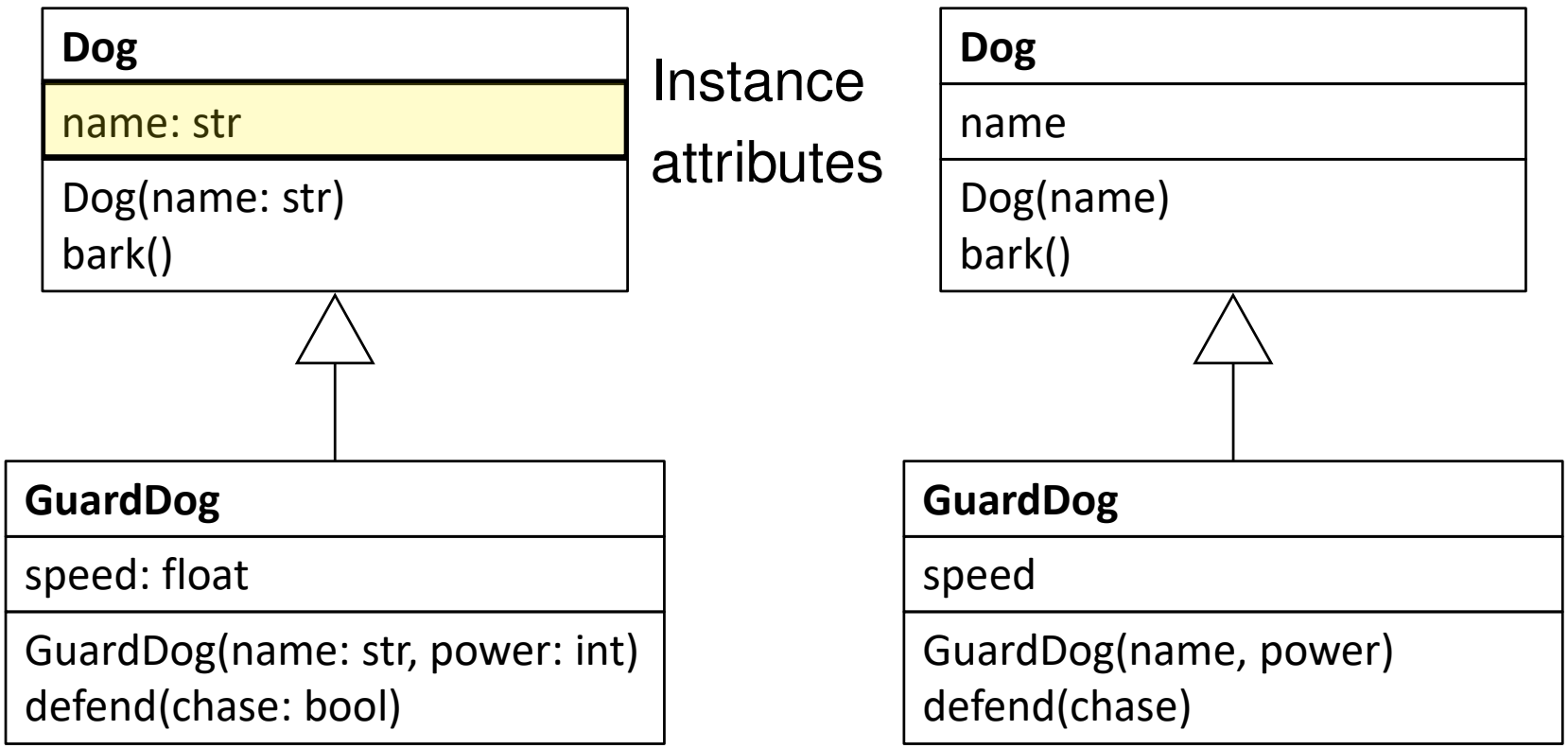

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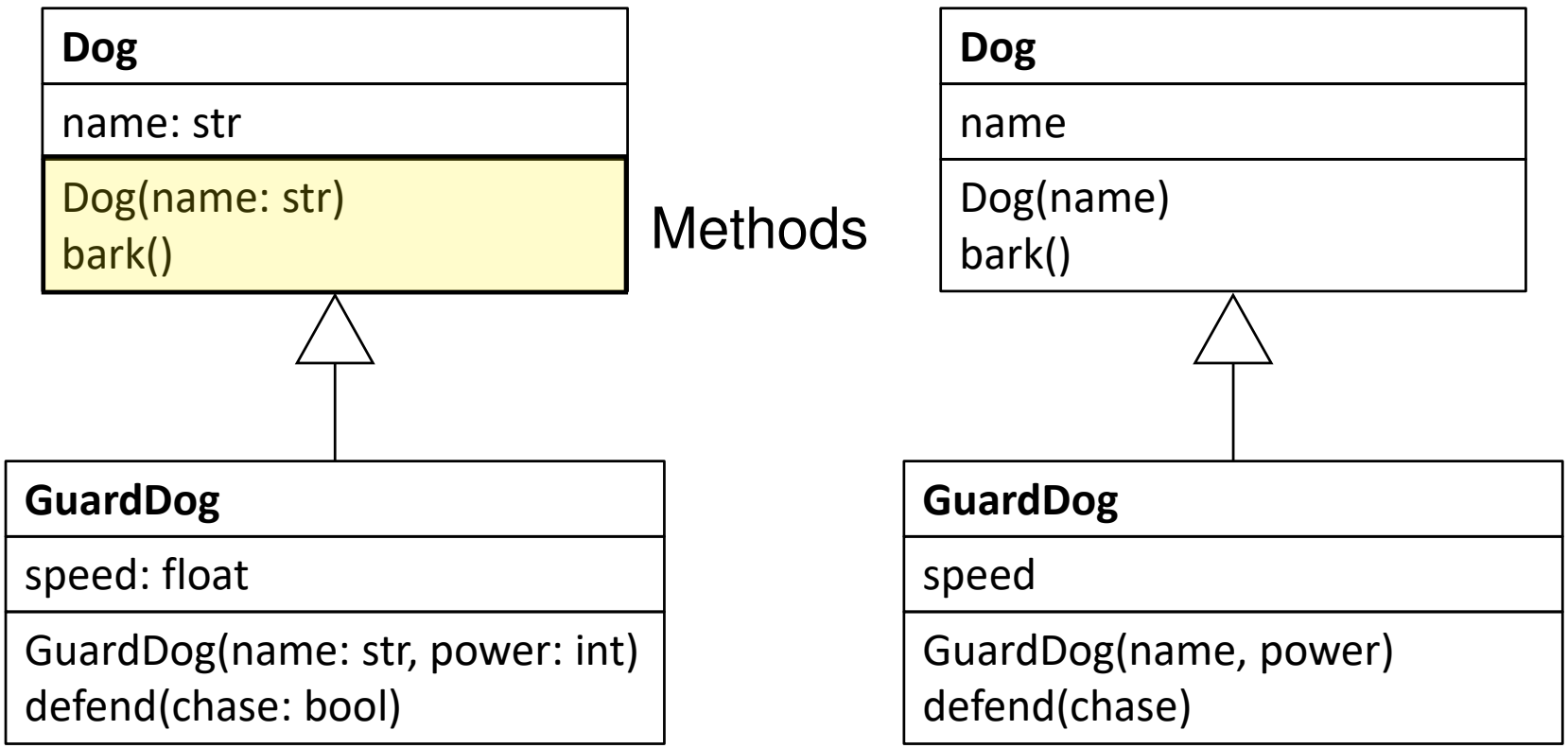

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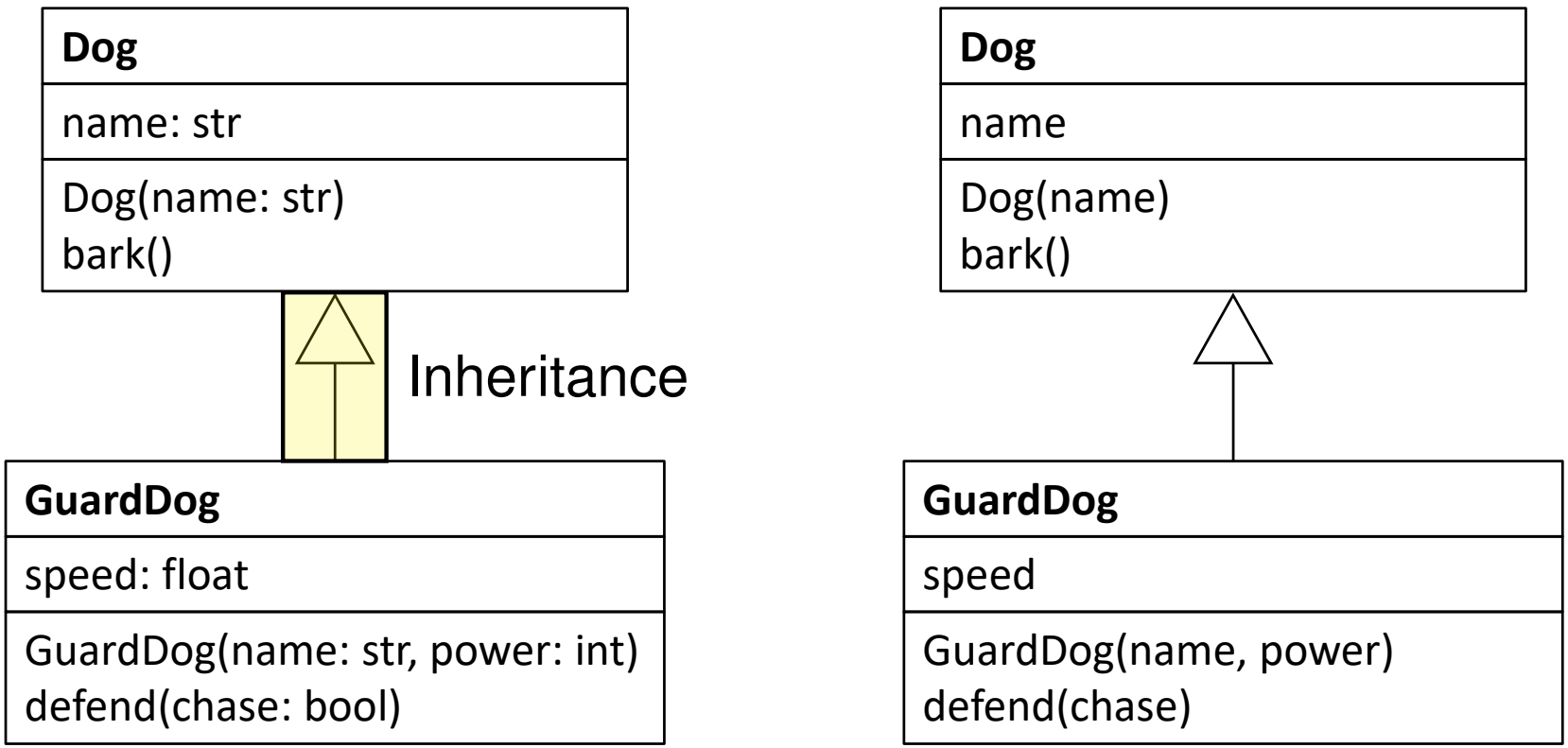

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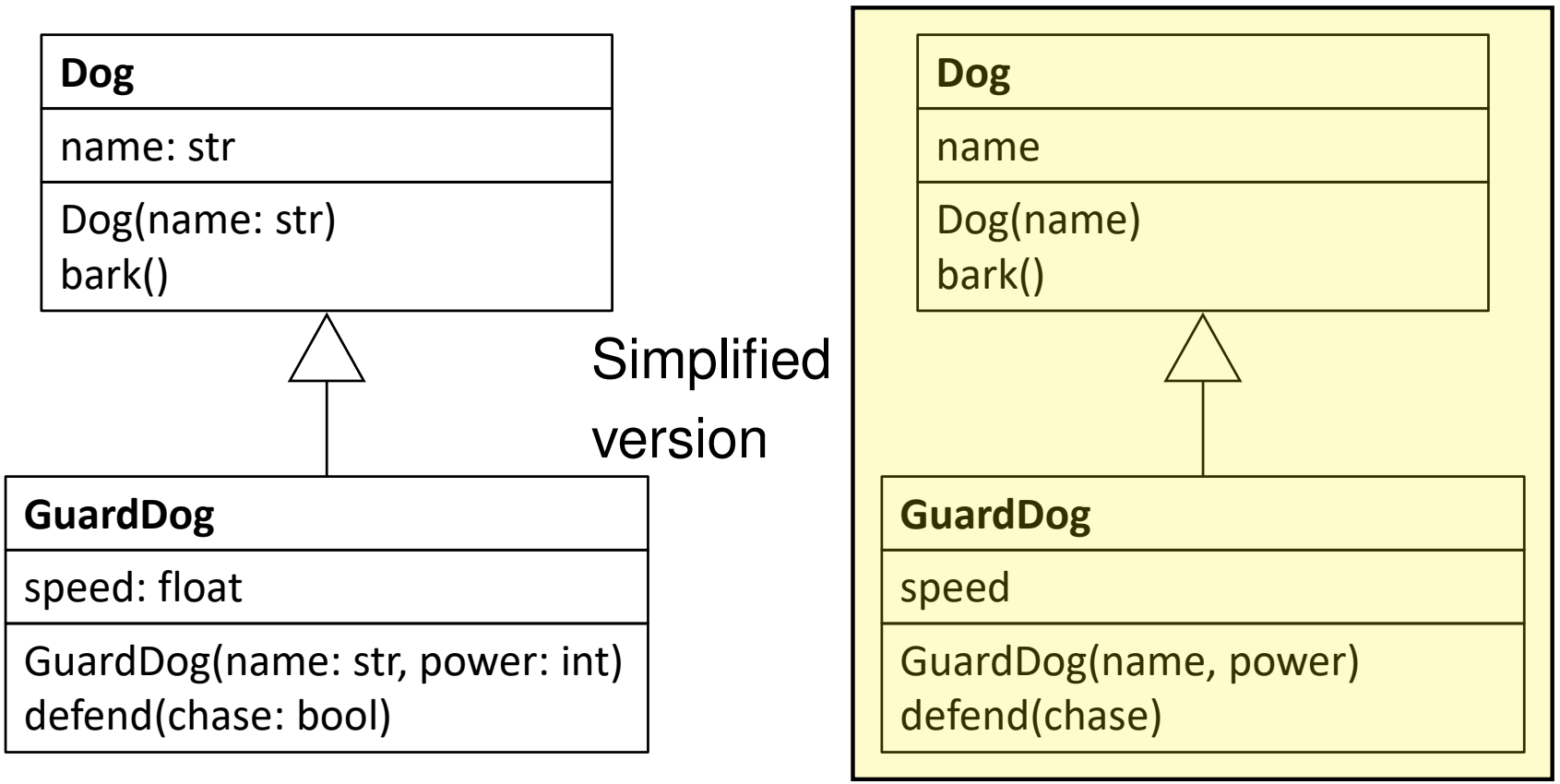

Method Resolution Order (MRO)

- The **method resolution order (MRO)** determines which method is ultimately invoked when you write something like `my_object.some_method()`
- The MRO is tighly bound to the class hierarchy. In the single inheritance case, it is a **bottom-to-top** search:
  1. Get the class of `my_object`
  2. Does the class contain an implementation for `some_method()`?
  3. If yes, execute this method
  4. If no, get the parent class, go to step 2, and repeat until the first implementation is found
- This is done for **every** method call, and the search is always started in the class of the corresponding object!

Useful Built-in Functionality

- **type(x)**: Returns the class/type of `x`
- **isinstance(x, y)**: Check if `x` is an instance of class/type `y` or of a subclass thereof
  - `isinstance(123, int)` → True
  - `isinstance(my_dog, Dog)` → True
  - `isinstance(my_guard_dog, Dog)` → True
  - `isinstance(my_dog, GuardDog)` → False
- **issubclass(x, y)**: Check if `x` is a class or subclass of class/type `y`
  - `issubclass(Dog, Dog)` → True
  - `issubclass(GuardDog, Dog)` → True
  - `issubclass(Dog, GuardDog)` → False