CCPS109
Computer Science I
L10

Lecturer: Nhan Tran

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Agenda

Announcement

Assignment is up: Due April 18 @2300hr

Lecture:

Class and Inheritance

Python Class Resource

https://docs.python.org/3/tutorial/classes.html

SPECIAL OPERATORS

- +, -, ==, <, >, len(), print, and many others
- https://docs.python.org/3/reference/datamodel.html#basic-customization
- like `print`, can override these to work with your class
- define them with double underscores before/after

```
__add__(self, other)     →     self + other
__sub__(self, other)     →     self - other
__eq__(self, other)      →     self == other
__lt__(self, other)      →     self < other
__len__(self)            →     len(self)
__str__(self)            →     print self
```

... and others

EXAMPLE: FRACTIONS

- create a **new type** to represent a number as a fraction
- **internal representation** is two integers
  - numerator
  - denominator
- **interface** a.k.a. **methods** a.k.a **how to interact** with `Fraction` objects
  - add, subtract
  - print representation, convert to a float
  - invert the fraction
- the code for this is in the handout, check it out!

THE POWER OF OOP

- **bundle together objects** that share
  - common attributes and
  - procedures that operate on those attributes
- use **abstraction** to make a distinction between how to implement an object vs how to use the object
- build **layers** of object abstractions that inherit behaviors from other classes of objects
- create our **own classes of objects** on top of Python's basic classes

LAST TIME

- Class and objects

TODAY

- more on classes
  - getters and setters
  - information hiding
  - class variables
- inheritance

IMPLEMENTING THE CLASS vs USING THE CLASS

- write code from two different perspectives

implementing a new object type with a class

- **define** the class
- define **data attributes** (WHAT IS the object)
- define **methods** (HOW TO use the object)

using the new object type in code

- create **instances** of the object type
- do **operations** with them

CLASS DEFINITION OF AN OBJECT TYPE vs INSTANCE OF A CLASS

- class name is the **type**
  - `class Coordinate(object)`
- class is defined generically
  - use `self` to refer to some instance while defining the class
  - `(self.x - self.y)**2`
  - `self` is a parameter to methods in class definition
- class defines data and methods **common across all instances**

- instance is **one specific** object

```
coord = Coordinate(1,2)
```

- data attribute values vary between instances

```
c1 = Coordinate(1,2)
c2 = Coordinate(3,4)
```

  - `c1` and `c2` have different data attribute values `c1.x` and `c2.x` because they are different objects
- instance has the **structure of the class**

WHY USE OOP AND CLASSES OF OBJECTS?

- mimic real life
- group different objects part of the same type

Jelly
1 year old
brown

5 years old
brown

Tiger
2 years old
brown

Bean
0 years old
black

2 years old
white

1 year old
b/w

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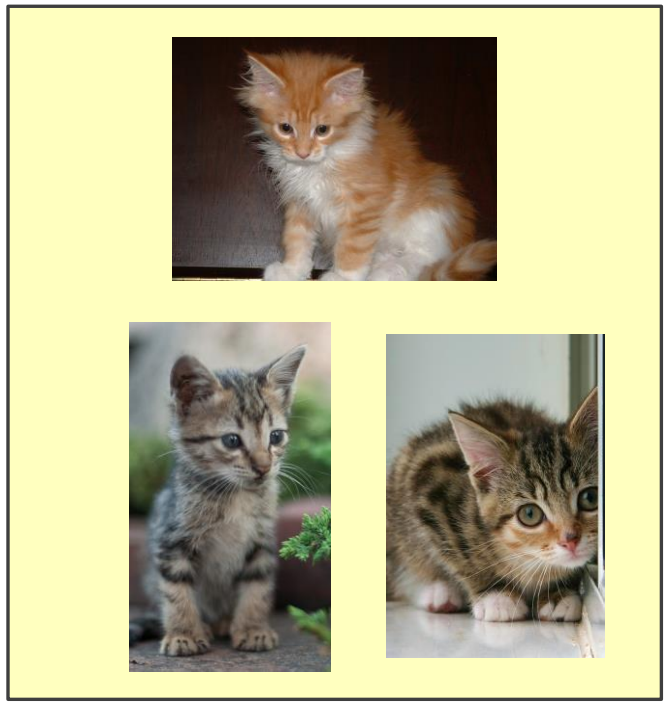

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GROUPS OF OBJECTS HAVE ATTRIBUTES (RECAP)

- **data attributes**
  - how can you represent your object with data?
  - **what it is**
  - *for a coordinate: x and y values*
  - *for an animal: age, name*
- **procedural attributes** (behavior/operations/**methods**)
  - how can someone interact with the object?
  - **what it does**
  - *for a coordinate: find distance between two*
  - *for an animal: make a sound*

HOW TO DEFINE A CLASS (RECAP)

```
class Animal:
    def__init_(self, age):
        self.age = age


myanimal = Animal(3)
```

HOW TO DEFINE A CLASS (RECAP)

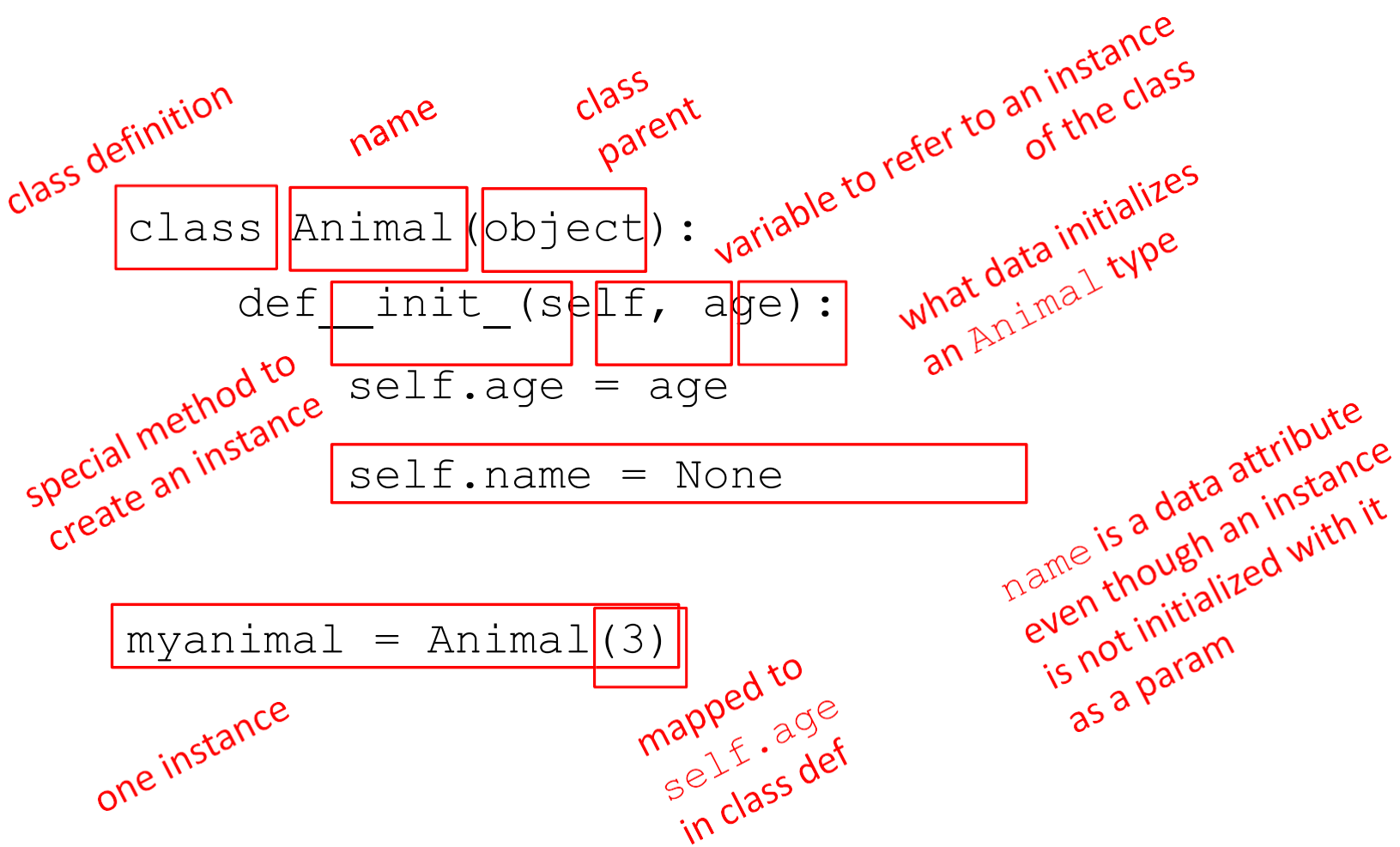
```
class Animal(object):
    def __init_(self, age):
        self.age = age
```

```
myanimal = Animal(3)
```

one instance

mapped to `self.age` in class def

HOW TO DEFINE A CLASS (RECAP)



GETTER AND SETTER METHODS

```
class Animal(object):
    def_init_(self, age):
        self.age = age
        self.name = None
    def get_age(self):
        return self.age
    def get_name(self):
        return self.name

    def set_age(self, newage):
        self.age = newage
    def set_name(self, newname=""):
        self.name = newname
    def_str__(self):
        return "animal:"+str(self.name)+":"+str(self.age)
```

GETTER AND SETTER METHODS

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class Animal(object):
    def __init__(self, age):
        self.age = age
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    def get_age(self):
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        return self.name

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    def set_name(self, newname=""):
        self.name = newname
    def __str__(self):
        return "animal:"+str(self.name)+":"+str(self.age)
```

getter

setter

- **getters and setters** should be used outside of class to access data attributes

AN INSTANCE and DOT NOTATION (RECAP)

- instantiation creates an **instance of an object**

```
a = Animal(3)
```

- **dot notation** used to access attributes (data and methods) though it is better to use getters and setters to access data attributes

```
a.age
```

```
a.get_age()
```

AN INSTANCE and DOT NOTATION (RECAP)

- instantiation creates an **instance of an object**

```
a = Animal(3)
```

- **dot notation** used to access attributes (data and methods) though it is better to use getters and setters to access data attributes

```
a.age
```

- access data attribute
- allowed, but not recommended

```
a.get_age()
```

- access method
- best to use getters and setters

INFORMATION HIDING

- author of class definition may **change data attribute** variable names

```
class Animal(object):
    def_init_(self, age):
        self.years = age
    def get_age(self):
        return self.years
```

- if you are **accessing data attributes** outside the class and class **definition changes**, may get errors

INFORMATION HIDING

- author of class definition may **change data attribute** variable names

replaced `age` data attribute by `years`

```
class Animal(object):
    def __init__(self, age):
        self.years = age
    def get_age(self):
        return self.years
```

- if you are **accessing data attributes** outside the class and class **definition changes**, may get errors

- outside of class, use getters and setters instead
  use `a.get_age()` NOT `a.age`
  - good style
  - easy to maintain code
  - prevents bugs

PYTHON NOT GREAT AT INFORMATION HIDING

- allows you to **access data** from outside class definition

```
print(a.age)
```

- allows you to **write to data** from outside class definition

```
a.age = 'infinite'
```

- allows you to **create data attributes** for an instance from outside class definition

```
a.size = "tiny"
```

- it's **not good style** to do any of these!

DEFAULT ARGUMENTS

- **default arguments** for formal parameters are used if no actual argument is given

```
def set_name(self, newname=""):
    self.name = newname
```

- default argument used here

```
a = Animal(3)
a.set_name()
print(a.get_name())
```

prints ""

- argument passed in is used here

```
a = Animal(3)
a.set_name("fluffy")
print(a.get_name())
```

prints "fluffy"

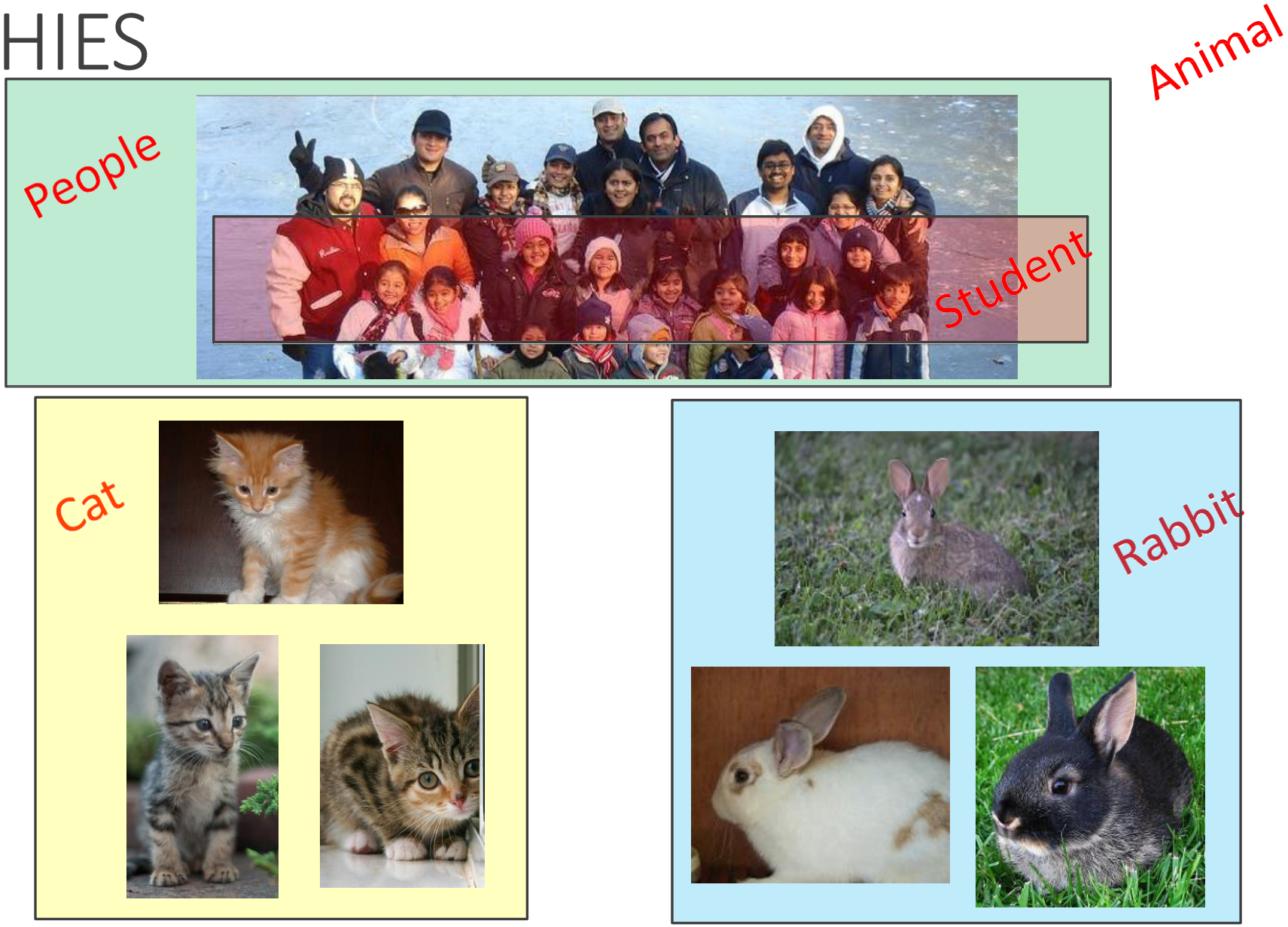
HIERARCHIES

People

Cat

Rabbit

HIERARCHIES



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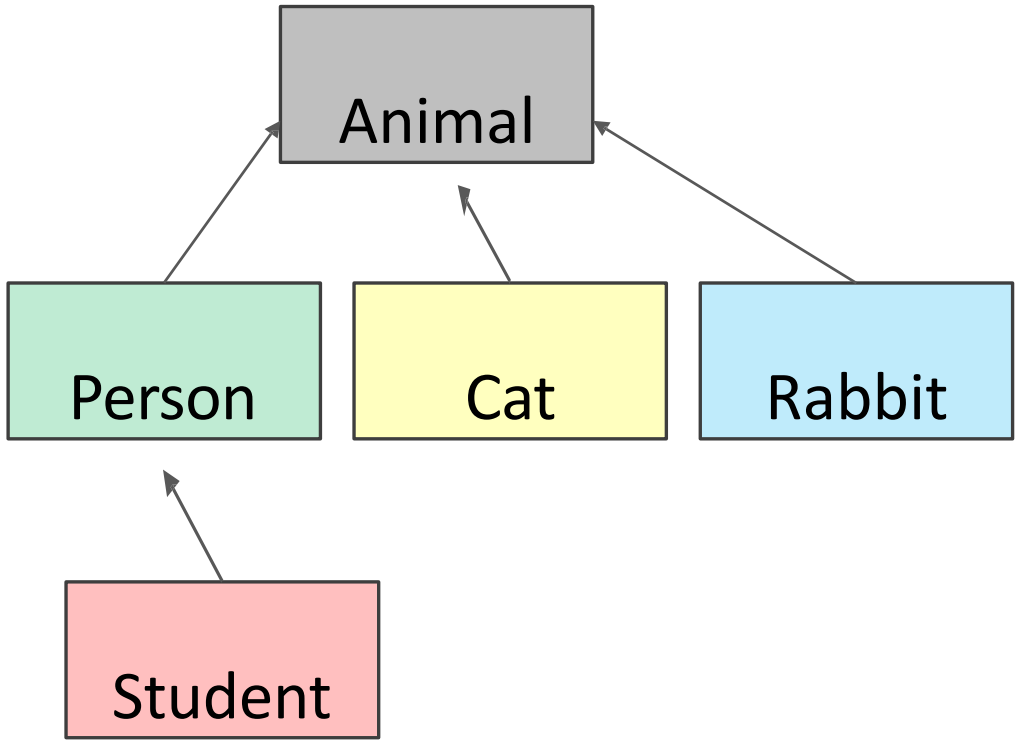
HIERARCHIES

- **parent class** (superclass)
- **child class** (subclass)
  - **inherits** all data and behaviors of parent class
  - **add** more **info**
  - **add** more **behavior**
  - **override** behavior



INHERITANCE: PARENT CLASS

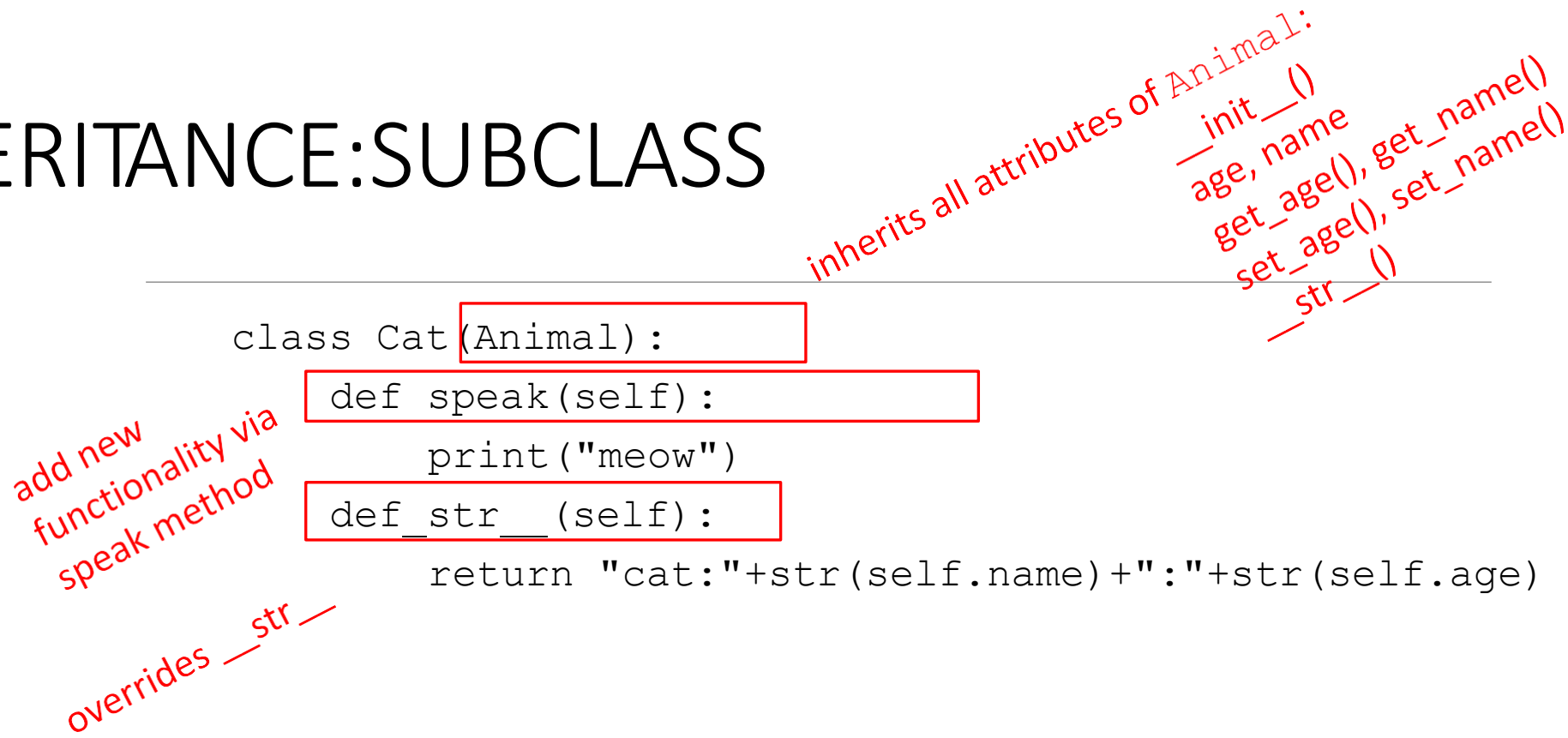
```
class Animal(object):                    '#(object)'optional'
    def_init_(self, age):
        self.age = age  self.name
        = None
    def get_age(self):
        return self.age
    def get_name(self):
        return self.name
    def set_age(self, newage):
        self.age = newage
    def set_name(self, newname=""):
        self.name = newname
    def_str_(self):
        return "animal:"+str(self.name)+":"+str(self.age)
```

everything is an object
class `object`
implements basic
operations in Python, like
binding variables, etc

INHERITANCE:SUBCLASS

```
class Cat(Animal):
    def speak(self):
        print("meow")
    def__str__(self):
        return "cat:"+str(self.name)+":"+str(self.age)
```

INHERITANCE:SUBCLASS



- add new functionality with `speak()`
  - instance of type `Cat` can be called with new methods
  - instance of type `Animal` throws error if called with `Cat`'s new method
- `__init__` is not missing, uses the `Animal` version

WHICH METHOD TO USE?

- subclass can have **methods with same name** as superclass
- for an instance of a class, look for a method name in **current class definition**
- if not found, look for method name **up the hierarchy** (in parent, then grandparent, and so on)
- use first method up the hierarchy that you found with that method name

```
class Person(Animal):
    def __init__(self, name, age):
        Animal.__init__(self, age)
        self.set_name(name)
        self.friends = []
    def get_friends(self):
        return self.friends

    def add_friend(self, fname):
        if fname not in self.friends:
            self.friends.append(fname)

    def speak(self):
        print("hello")
    def age_diff(self, other):
        diff = self.age - other.age
        print(abs(diff), "year difference")
    def __str__(self):
        return "person:"+str(self.name)+":"+str(self.age)
```

```
class Person(Animal):
    def __init__(self, name, age):
        Animal.__init__(self, age)
        self.set_name(name)
        self.friends = []
    def get_friends(self):
        return self.friends

    def add_friend(self, fname):
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    def speak(self):
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    def age_diff(self, other):
        diff = self.age - other.age
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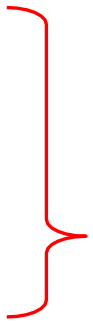
    def __str__(self):
        return "person:"+str(self.name)+":"+str(self.age)
```



parent class is Animal

call Animal constructor

call Animal's method

add a new data attribute

```
class Person(Animal):
    def __init__(self, name, age):
        Animal.__init__(self, age)
        self.set_name(name)
        self.friends = []
    def get_friends(self):
        return self.friends
    def add_friend(self, fname):
        if fname not in self.friends:
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    def speak(self):
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    def age_diff(self, other):
        diff = self.age - other.age
        print(abs(diff), "year difference")
    def __str__(self):
        return "person:"+str(self.name)+":"+str(self.age)
```

new methods

```
class Person(Animal):
    def __init__(self, name, age):
        Animal.__init__(self, age)
        self.set_name(name)
        self.friends = []
    def get_friends(self):
        return self.friends

    def add_friend(self, fname):
        if fname not in self.friends:
            self.friends.append(fname)

    def speak(self):
        print("hello")
    def age_diff(self, other):
        diff = self.age - other.age
        print(abs(diff), "year difference")
    def __str__(self):
        return "person:"+str(self.name)+":"+str(self.age)
```

override Animal's __str__ method

```
class Person(Animal):
    def __init__(self, name, age):
        Animal.__init__(self, age)
        self.set_name(name)
        self.friends = []
    def get_friends(self):
        return self.friends
    def add_friend(self, fname):
        if fname not in self.friends:
            self.friends.append(fname)
    def speak(self):
        print("hello")
    def age_diff(self, other):
        diff = self.age - other.age
        print(abs(diff), "year difference")
    def __str__(self):
        return "person:"+str(self.name)+":"+str(self.age)
```

parent class is Animal

call Animal constructor

call Animal's method

add a new data attribute

new methods

override Animal's __str__ method

```
import random

class Student(Person):
    def _init_(self, name, age, major=None):
        Person._init_(self, name, age)
        self.major = major
    def change_major(self, major):
        self.major = major
    def speak(self):
        r = random.random()
        if r < 0.25:
            print("i have homework")
        elif 0.25 <= r < 0.5:
            print("i need sleep")
        elif 0.5 <= r < 0.75:
            print("i should eat")
        else:
            print("i am watching tv")
    def_str__(self):
        return "student:"+str(self.name)+":"+str(self.age)+":"+str(self.major)
```

bring in methods from `random` class

inherits `Person` and `Animal` attributes

```
import random

class Student(Person):
    def_init_(self, name, age, major=None):
        Person._init_(self, name, age)
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```

bring in methods from `random` class

inherits `Person` and `Animal` attributes

adds new data

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import random

class Student(Person):
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        self.major = major
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    def __str__(self):
        return
        "student:"+str(self.name)+":"+str(self.age)+":"+str(self.major)
```

bring in methods from `random` class

inherits `Person` and `Animal` attributes

adds new data

CLASS VARIABLES AND THE `Rabbit` SUBCLASS

- **class variables** and their values are shared between all instances of a class

parent class

```
class Rabbit(Animal):
        tag = 1
        def_init_(self, age, parent1=None, parent2=None):
            Animal._init_(self, age)
            self.parent1 = parent1
            self.parent2 = parent2
            self.rid = Rabbit.tag
            Rabbit.tag += 1
```

- `tag` used to give **unique id** to each new rabbit instance

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```

class variable

instance variable

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```

access class variable

incrementing class variable changes it for all instances that may reference it

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```

parent class

class variable

instance variable

access class variable

incrementing class variable changes it for all instances that may reference it

  - `tag` used to give **unique id** to each new rabbit instance

Rabbit GETTER METHODS

```
class Rabbit(Animal):
    tag = 1
    def __init__(self, age, parent1=None, parent2=None):
        Animal.__init__(self, age)
        self.parent1 = parent1
        self.parent2 = parent2
        self.rid = Rabbit.tag
        Rabbit.tag += 1
    def get_rid(self):
        return str(self.rid).zfill(3)
    def get_parent1(self):
        return self.parent1
    def get_parent2(self):
        return self.parent2
```

Rabbit GETTER METHODS

```
class Rabbit(Animal):
    tag = 1
    def __init__(self, age, parent1=None, parent2=None):
        Animal.__init__(self, age)
        self.parent1 = parent1
        self.parent2 = parent2
        self.rid = Rabbit.tag
        Rabbit.tag += 1
    def get_rid(self):
        return str(self.rid).zfill(3)
    def get_parent1(self):
        return self.parent1
    def get_parent2(self):
        return self.parent2
```

method on a string to pad the beginning with zeros for example, 001 not 1

- getter methods specific for a `Rabbit` class
- there are also getters `get_name` and `get_age` inherited from `Animal`

WORKING WITH YOUR OWN TYPES

```
def __add_(self, other):
        # returning object of same type as this class
        return Rabbit(0, self, other)
```

recall Rabbit's `_init_(self, age, parent1=None, parent2=None)`

- define **+ operator** between two `Rabbit` instances
  - define what something like this does: `r4 = r1 + r2` where `r1` and `r2` are `Rabbit` instances
  - `r4` is a new `Rabbit` instance with age 0
  - `r4` has `self` as one parent and `other` as the other parent
  - in `__init__`, **`parent1 and parent2 are of type Rabbit`**

SPECIAL METHOD TO COMPARE TWO `Rabbits`

- decide that two rabbits are equal if they have the **same two parents**

booleans

```
def __eq__(self, other):
    parents_same = self.parent1.rid == other.parent1.rid \
                   and self.parent2.rid == other.parent2.rid
    parents_opposite = self.parent2.rid == other.parent1.rid \
                       and self.parent1.rid == other.parent2.rid
    return parents_same or parents_opposite
```

- compare ids of parents since **ids are unique** (due to class var)
- note you can't compare objects directly
  - for ex. with `self.parent1 == other.parent1`
  - this calls the `__eq__` method over and over until call it on `None` and gives an `AttributeError` when it tries to do `None.parent1`

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- decide that two rabbits are equal if they have the **same two parents**

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```

booleans

- compare ids of parents since **ids are unique** (due to class var)
- note you can't compare objects directly
  - for ex. with `self.parent1 == other.parent1`
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OBJECT ORIENTED PROGRAMMING

- create your own **collections of data**
- **organize** information
- **division** of work
- access information in a **consistent** manner
- add **layers** of complexity
- like functions, classes are a mechanism for **decomposition** and **abstraction** in programming

End of Classes and Inheritance.