What is OOP?

OBJECT-ORIENTED PROGRAMMING IN PYTHON

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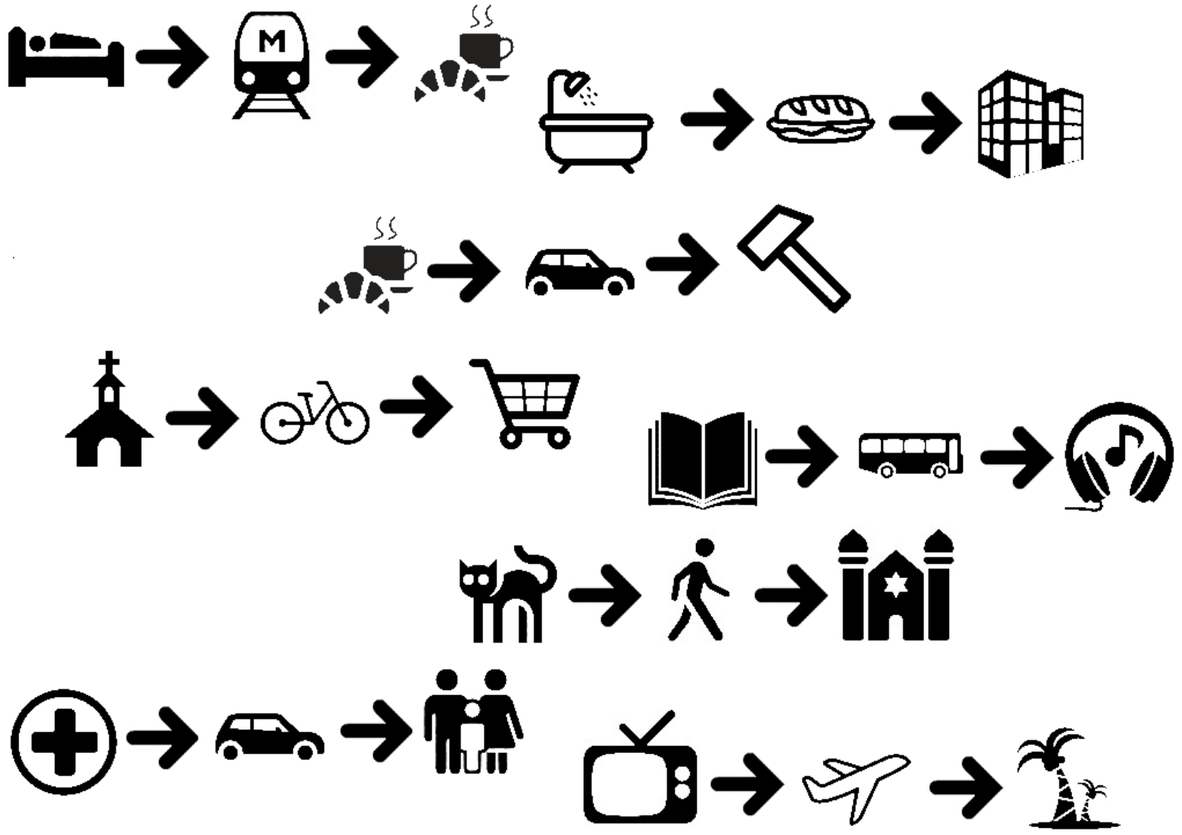
Procedural programming

- Code as a sequence of steps
- Great for data analysis

Thinking in sequences



Procedural programming

- Code as a sequence of steps
- Great for data analysis and scripts

Object-oriented programming

- ***Code as interactions of objects***
- Great for building frameworks and tools
- *Maintainable and reusable code!*

Objects as data structures

$$\text{Object} = \text{state} + \text{behavior}$$

email = lara@company.com
phone = 614-555-0177

place order
cancel order

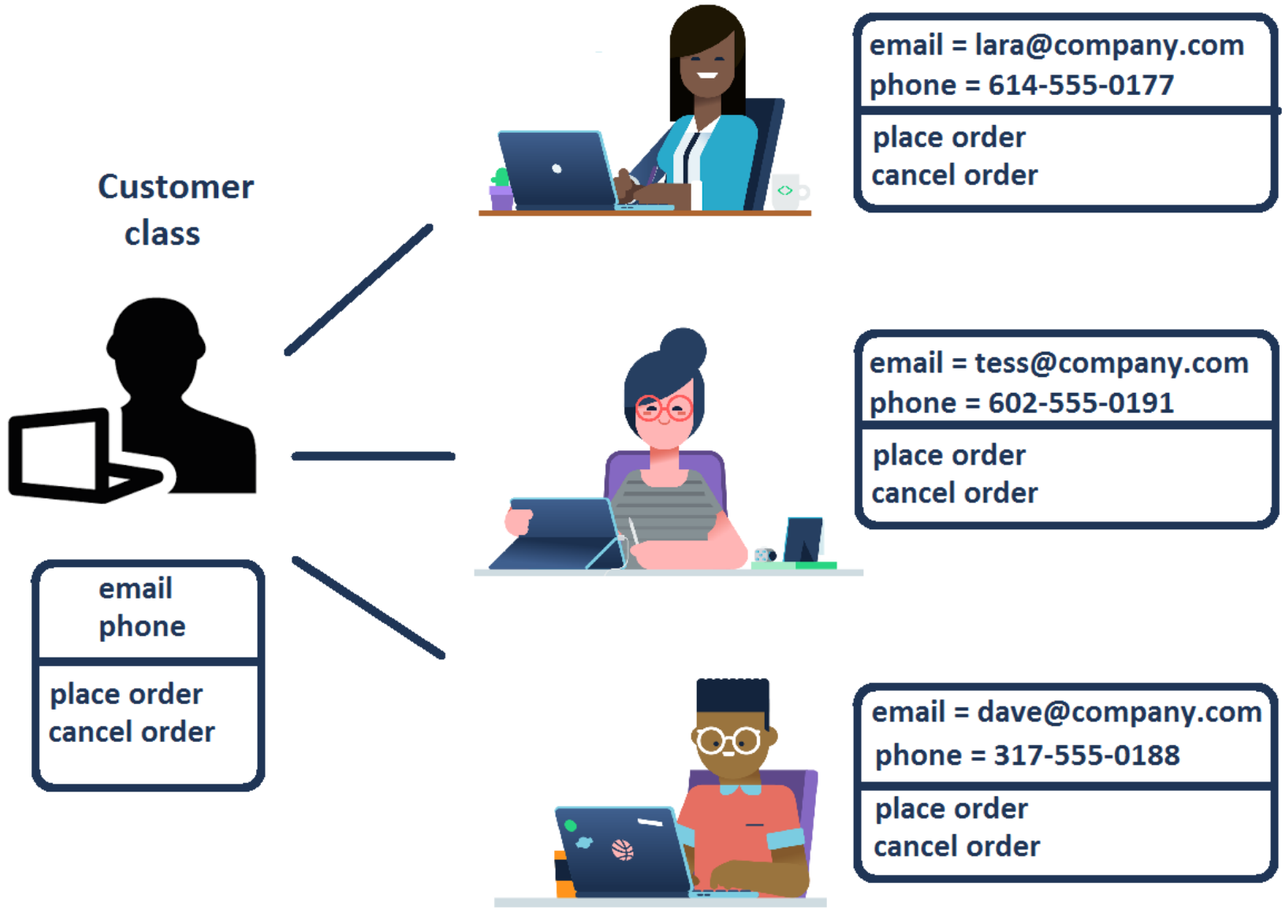
Encapsulation - bundling data with code operating on it

Classes as blueprints

- **Class :** blueprint for objects outlining possible states and behaviors

Classes as blueprints

- **Class :** blueprint for objects outlining possible states and behaviors



Objects in Python

- *Everything in Python is an object*
- Every object has a class
- Use `type()` to find the class

```
import numpy as np
a = np.array([1,2,3,4])
print(type(a))
```

```
numpy.ndarray
```

Object	Class
`5`	`int`
`"Hello"`	`str`
`pd.DataFrame()`	`DataFrame`
`np.mean`	`function`
…	…

Attributes and methods

State ↔ attributes

```
import numpy as np
a = np.array([1,2,3,4])
# shape attribute
a.shape
```

```
(4,)
```

Behavior ↔ methods

```
import numpy as np
a = np.array([1,2,3,4])
# reshape method
a.reshape(2,2)
```

```
array([[1, 2],
       [3, 4]])
```

- Use `obj.` to access attributes and methods

Object = attributes + methods

- attribute ↔ **variables** ↔ `obj.my_attribute` ,
- method ↔ **function()** ↔ `obj.my_method()` .

```
import numpy as np
a = np.array([1,2,3,4])
dir(a)                # <--- list all attributes and methods
```

```
['T',
 '__abs__',
 ...
 'trace',
 'transpose',
 'var',
 'view']
```

Let's review!

OBJECT-ORIENTED PROGRAMMING IN PYTHON

Class anatomy: attributes and methods

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A basic class

```
class Customer:
    # code for class goes here
    pass
```

- `class <name>:` starts a class definition
- code inside `class` is indented
- use `pass` to create an "empty" class

```
c1 = Customer()
c2 = Customer()
```

- use `ClassName()` to create an object of class `ClassName`

Add methods to a class

```
class Customer:

    def identify(self, name):
      print("I am Customer " + name)
```

- method definition = function definition within class
- **use `self` as the 1st argument in method definition**

```
cust = Customer()
cust.identify("Laura")
```

```
I am Customer Laura
```

- ignore `self` when calling method on an object

```
class Customer:

    def identify(self, name):
      print("I am Customer " + name)

cust = Customer()
cust.identify("Laura")
```

What is self?

- classes are templates, how to refer data of a particular object?
- `self` is a stand-in for a particular object used in class definition
- should be the first argument of any method
- Python will take care of `self` when method called from an object:

`cust.identify("Laura")` *will be interpreted as* `Customer.identify(cust, "Laura")`

We need attributes

- **Encapsulation:** bundling data with methods that operate on data
- E.g. `Customer` 's' name should be an attribute

$$\text{Attributes are created by assignment } (=) \text{ in methods}$$

Add an attribute to class

```
class Customer:
    # set the name attribute of an object to new_name
    def set_name(self, new_name):
      # Create an attribute by assigning a value
      self.name = new_name          # <-- will create .name when set_name is called
```

```
cust = Customer()                   # <--.name doesn't exist here yet
cust.set_name("Lara de Silva")      # <--.name is created and set to "Lara de Silva"
print(cust.name)                    # <--.name can be used
```

```
Lara de Silva
```

Old version

```
class Customer:



    # Using a parameter
    def identify(self, name):
      print("I am Customer" + name)
```

```
cust = Customer()

cust.identify("Eris Odoro")
```

```
I am Customer Eris Odoro
```

New version

```
class Customer:
    def set_name(self, new_name):
        self.name = new_name

    # Using .name from the object it*self*
    def identify(self):
      print("I am Customer" + self.name)
```

```
cust = Customer()
cust.set_name("Rashid Volkov")
cust.identify()
```

```
I am Customer Rashid Volkov
```

Let's practice!

OBJECT-ORIENTED PROGRAMMING IN PYTHON

Class anatomy: the __init__ constructor

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Methods and attributes

- Methods are function definitions within a class
- `self` as the first argument
- Define attributes by assignment
- Refer to attributes in class via `self.___`

```
class MyClass:
    # function definition in class
    # first argument is self
    def my_method1(self, other_args...):
        # do things here

    def my_method2(self, my_attr):
        # attribute created by assignment
        self.my_attr = my_attr
        ...
```

Constructor

- Add data to object when creating it?
- **Constructor** `__init__()` method is called every time an object is created.

```
class Customer:
        def __init__(self, name):
         self.name = name            # <--- Create the .name attribute and set it to name parameter
         print("The __init__ method was called")

cust = Customer("Lara de Silva")   #<--- __init__ is implicitly called
print(cust.name)
```

```
The __init__ method was called
Lara de Silva
```

```
class Customer:
       def __init__(self, name, balance):  # <-- balance parameter added
        self.name = name
        self.balance = balance              # <-- balance attribute added
        print("The __init__ method was called")
cust = Customer("Lara de Silva", 1000)     # <-- __init__ is called
print(cust.name)
print(cust.balance)
```

```
The __init__ method was called
Lara de Silva
1000
```

```
class Customer:
        def __init__(self, name, balance=0):  #<--set default value for balance
         self.name = name
         self.balance = balance
         print("The __init__ method was called")

cust = Customer("Lara de Silva") # <-- don't specify balance explicitly
print(cust.name)
print(cust.balance) # <-- attribute is created anyway
```

```
The __init__ method was called
Lara de Silva
0
```

Attributes in methods

```
class MyClass:
    def my_method1(self, attr1):
        self.attr1 = attr1
        ...

    def my_method2(self, attr2):
        self.attr2 = attr2
        ...
```

```
obj = MyClass()
obj.my_method1(val1) # <-- attr1 created
obj.my_method2(val2) # <-- attr2 created
```

Attributes in the constructor

```
class MyClass:
    def __init__(self, attr1, attr2):
        self.attr1 = attr1
        self.attr2 = attr2
        ...
# All attributes are created
obj = MyClass(val1, val2)
```

- easier to know all the attributes
- attributes are created when the object is created
- *more usable and maintainable code*

Best practices

1. Initialize attributes in `__init__()`

Best practices

1. Initialize attributes in `__init__()`

2. Naming

`CamelCase` for classes, `lower_snake_case` for functions and attributes

Best practices

1. Initialize attributes in `__init__()`

2. Naming

`CamelCase` for class, `lower_snake_case` for functions and attributes

3. Keep `self` as `self`

```
class MyClass:
    # This works but isn't recommended
    def my_method(kitty, attr):
       kitty.attr = attr
```

Best practices

1. Initialize attributes in `__init__()`

2. Naming

`CamelCase` for class, `lower_snake_case` for functions and attributes

3. `self` is `self`

4. Use docstrings

```
class MyClass:
    """This class does nothing"""
    pass
```

Let's practice!

OBJECT-ORIENTED PROGRAMMING IN PYTHON

Instance and class data

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Core principles of OOP

Inheritance:

- Extending functionality of existing code

Polymorphism:

- Creating a unified interface

Encapsulation:

- Bundling of data and methods

Instance-level data

```
class Employee:
    def __init__(self, name, salary):
        self.name = name
        self.salary = salary

emp1 = Employee("Teo Mille", 50000)
emp2 = Employee("Marta Popov", 65000)
```

- `name`, `salary` are *instance attributes*
- `self` binds to an instance

Class-level data

- Data shared among all instances of a class
- Define *class attributes* in the body of `class`

```
class MyClass:
    # Define a class attribute
    CLASS_ATTR_NAME = attr_value
```

- "Global variable" within the class

Class-level data

```
class Employee:
  # Define a class attribute
  MIN_SALARY = 30000    #<--- no self.
  def __init__(self, name, salary):
      self.name = name
      # Use class name to access class attribute
      if salary >= Employee.MIN_SALARY:
        self.salary = salary
      else:
        self.salary = Employee.MIN_SALARY
```

- `MIN_SALARY` is shared among all instances
- Don't use `self` to *define* class attribute
- use `ClassName.ATTR_NAME` to *access* the class attribute value

Class-level data

```
class Employee:
  # Define a class attribute
  MIN_SALARY = 30000
  def __init__(self, name, salary):
      self.name = name
      # Use class name to access class attribute
      if salary >= Employee.MIN_SALARY:
        self.salary = salary
      else:
        self.salary = Employee.MIN_SALARY
```

```
emp1 = Employee("TBD", 40000)
print(emp1.MIN_SALARY)
```

```
30000
```

```
emp2 = Employee("TBD", 60000)
print(emp2.MIN_SALARY)
```

```
30000
```

Why use class attributes?

Global constants related to the class

- minimal/maximal values for attributes
- commonly used values and constants, e.g. `pi` for a `Circle` class
- ...

Class methods

- Methods are already "shared": same code for every instance
- Class methods can't use instance-level data

```
class MyClass:

  @classmethod                              # <---use decorator to declare a class method
  def my_awesome_method(cls, args...): # <---cls argument refers to the class
    # Do stuff here
    # Can't use any instance attributes :(
```

```
MyClass.my_awesome_method(args...)
```

Alternative constructors

```
class Employee:
  MIN_SALARY = 30000
  def __init__(self, name, salary=30000):
      self.name = name
      if salary >= Employee.MIN_SALARY:
        self.salary = salary
      else:
        self.salary = Employee.MIN_SALARY
```

- Can only have one `__init__()`

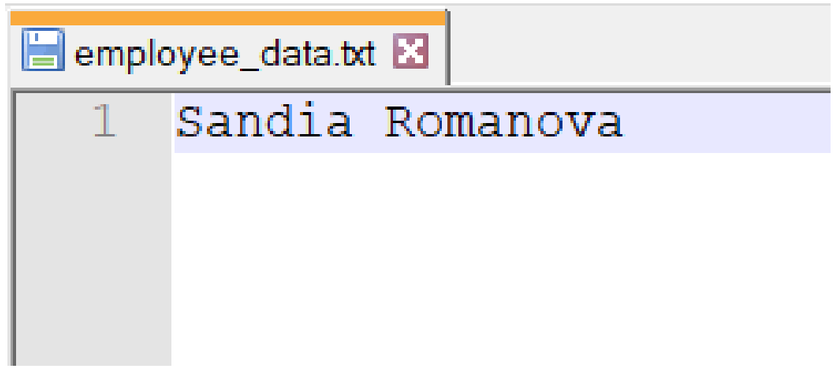
```
  @classmethod
  def from_file(cls, filename):
      with open(filename, "r") as f:
          name = f.readline()
      return cls(name)
```

- **Use class methods to create objects**
- Use `return` to return an object
- `cls(...)` will call `__init__(...)`

Alternative constructors

```
class Employee:
  MIN_SALARY = 30000
  def __init__(self, name, salary=30000):
      self.name = name
      if salary >= Employee.MIN_SALARY:
        self.salary = salary
      else:
        self.salary = Employee.MIN_SALARY

  @classmethod
  def from_file(cls, filename):
      with open(filename, "r") as f:
          name = f.readline()
      return cls(name)
```




```
# Create an employee without calling Employee()
emp = Employee.from_file("employee_data.txt")
type(emp)
```

```
__main__.Employee
```

Let's practice!

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Class inheritance

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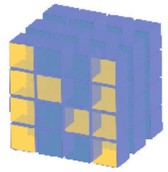
Code reuse

Code reuse

1. Someone has already done it

- Modules are great for fixed functionality
- OOP is great for customizing functionality

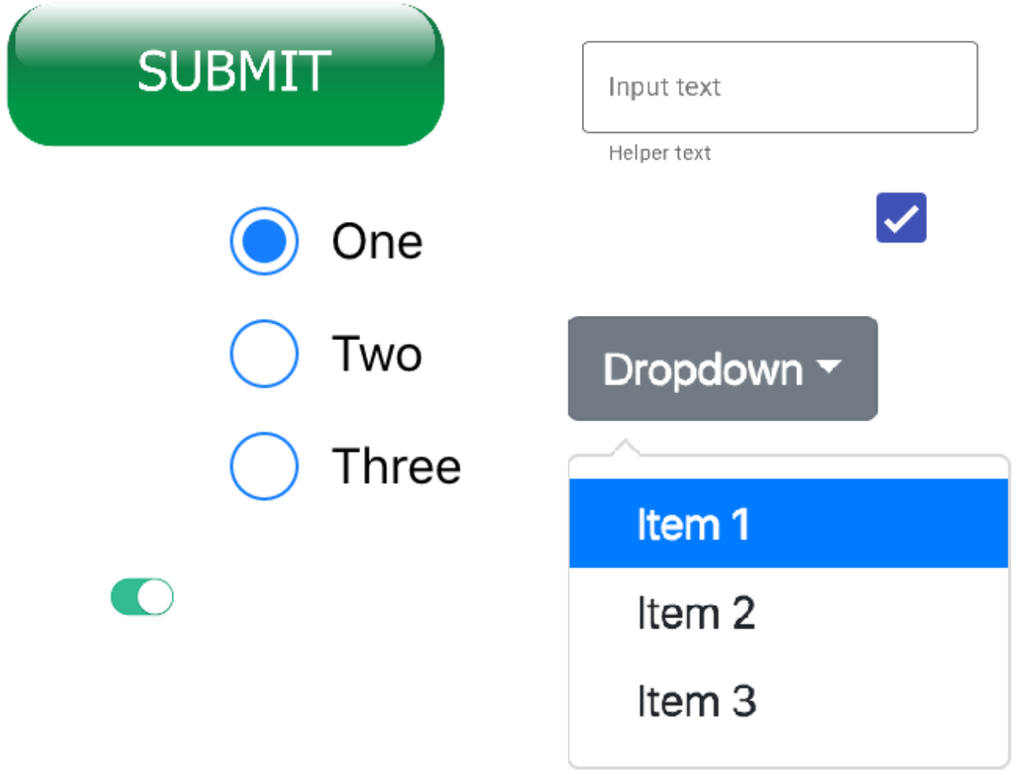


NumPy

Code reuse

1. Someone has already done it

2. DRY: Don't Repeat Yourself



Code reuse

1. Someone has already done it

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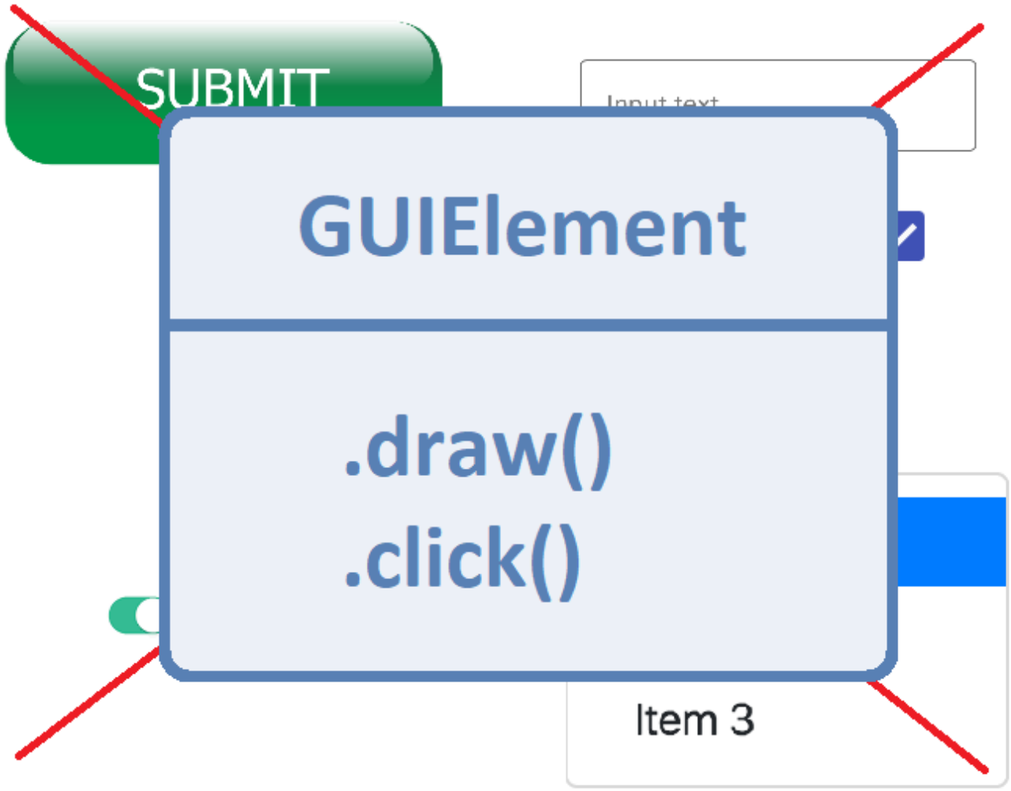


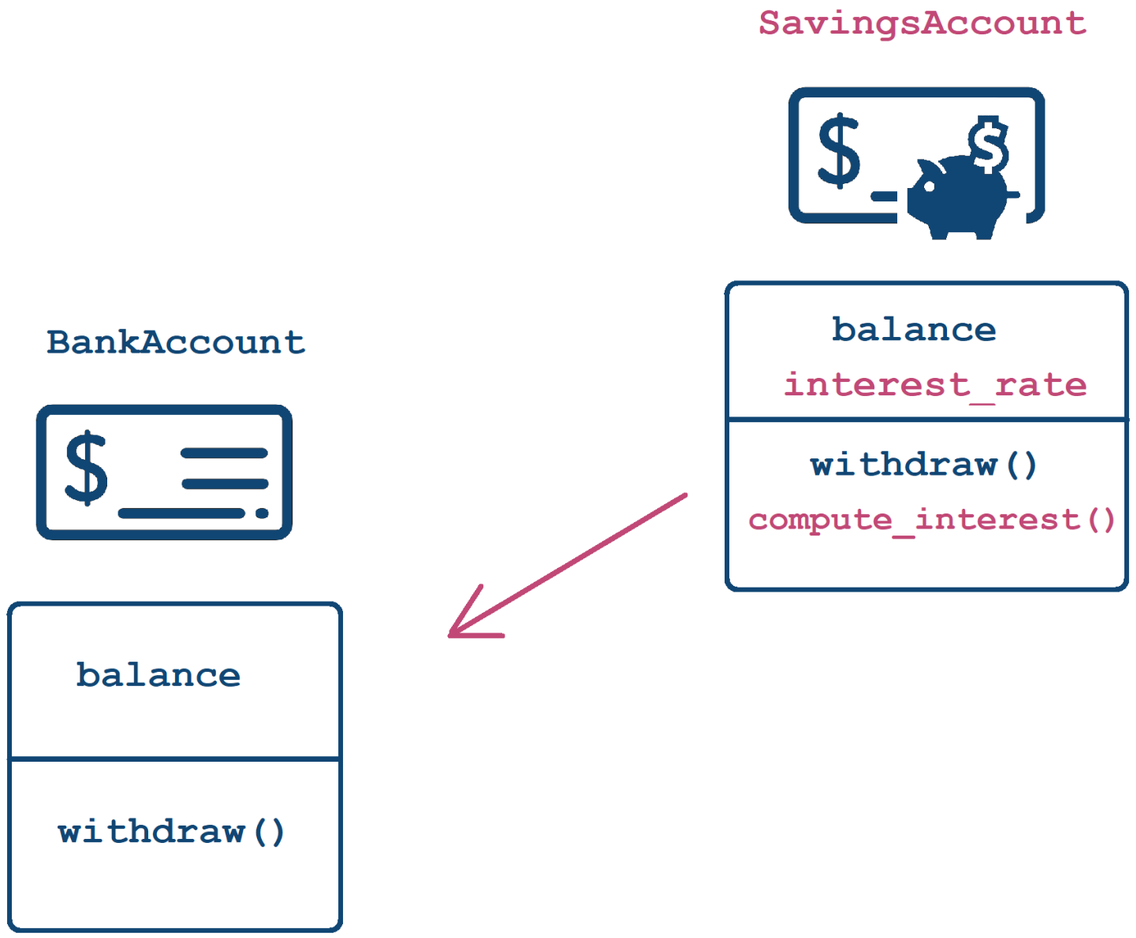
Inheritance

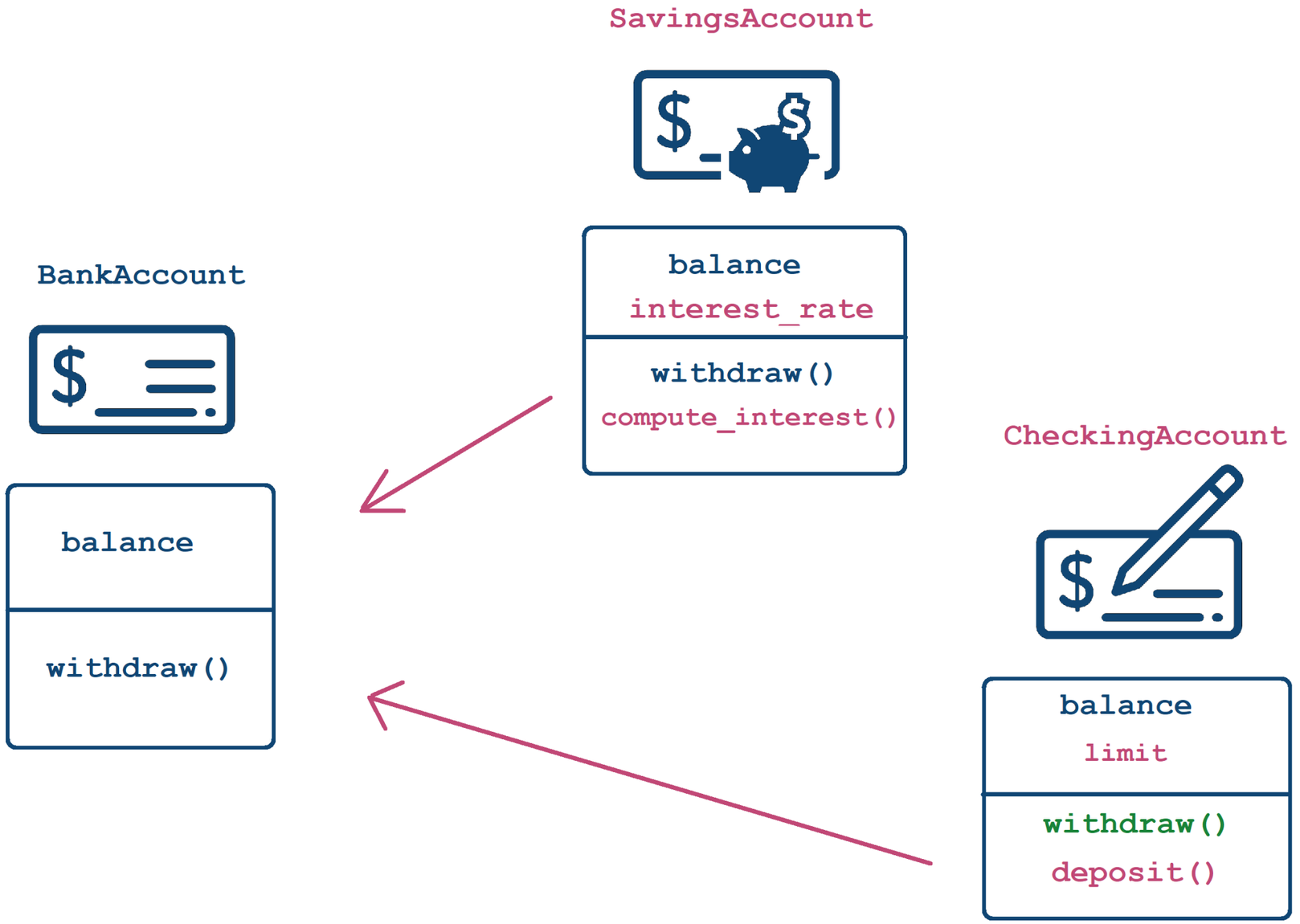
$$\text{New class functionality} = \text{Old class functionality} + \text{extra}$$

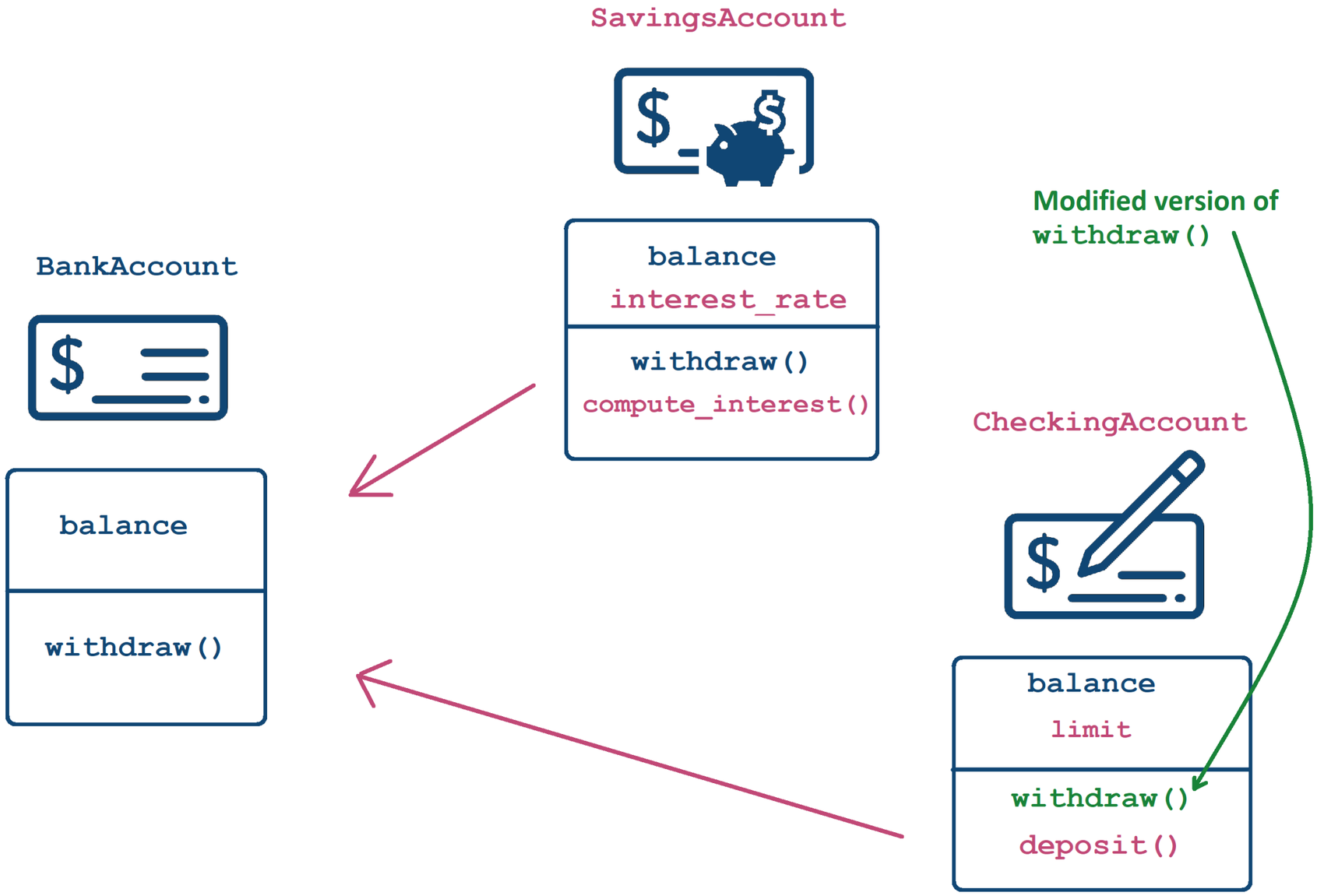
BankAccount

balance

withdraw()


SavingsAccount
balance
interest_rate
withdraw()
compute_interest()
BankAccount
balance
withdraw()


SavingsAccount
balance
interest_rate
withdraw()
compute_interest()
BankAccount
balance
withdraw()
CheckingAccount
balance
limit
withdraw()
deposit()


SavingsAccount
BankAccount
balance
withdraw()
balance
interest_rate
withdraw()
compute_interest()
Modified version of
withdraw()
CheckingAccount
balance
limit
withdraw()
deposit()

Implementing class inheritance

```
class BankAccount:
    def __init__(self, balance):
        self.balance = balance

    def withdraw(self, amount):
        self.balance -= amount

# Empty class inherited from BankAccount
class SavingsAccount(BankAccount):
    pass
```

```
class MyChild(MyParent):
    # Do stuff here
```

- `MyParent` : class whose functionality is being extended/inherited
- `MyChild` : class that will inherit the functionality and add more

Child class has all of the the parent data

```
# Constructor inherited from BankAccount
savings_acct = SavingsAccount(1000)
type(savings_acct)
```

```
__main__.SavingsAccount
```

```
# Attribute inherited from BankAccount
savings_acct.balance
```

```
1000
```

```
# Method inherited from BankAccount
savings_acct.withdraw(300)
```

Inheritance: "is-a" relationship

A `SavingsAccount` is a `BankAccount`

(possibly with special features)

```
savings_acct = SavingsAccount(1000)
isinstance(savings_acct, SavingsAccount)
```

```
True
```

```
acct = BankAccount(500)
isinstance(acct,SavingsAccount)
```

```
False
```

```
isinstance(savings_acct, BankAccount)
```

```
True
```

```
isinstance(acct,BankAccount)
```

```
True
```

Let's practice!

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Customizing functionality via inheritance

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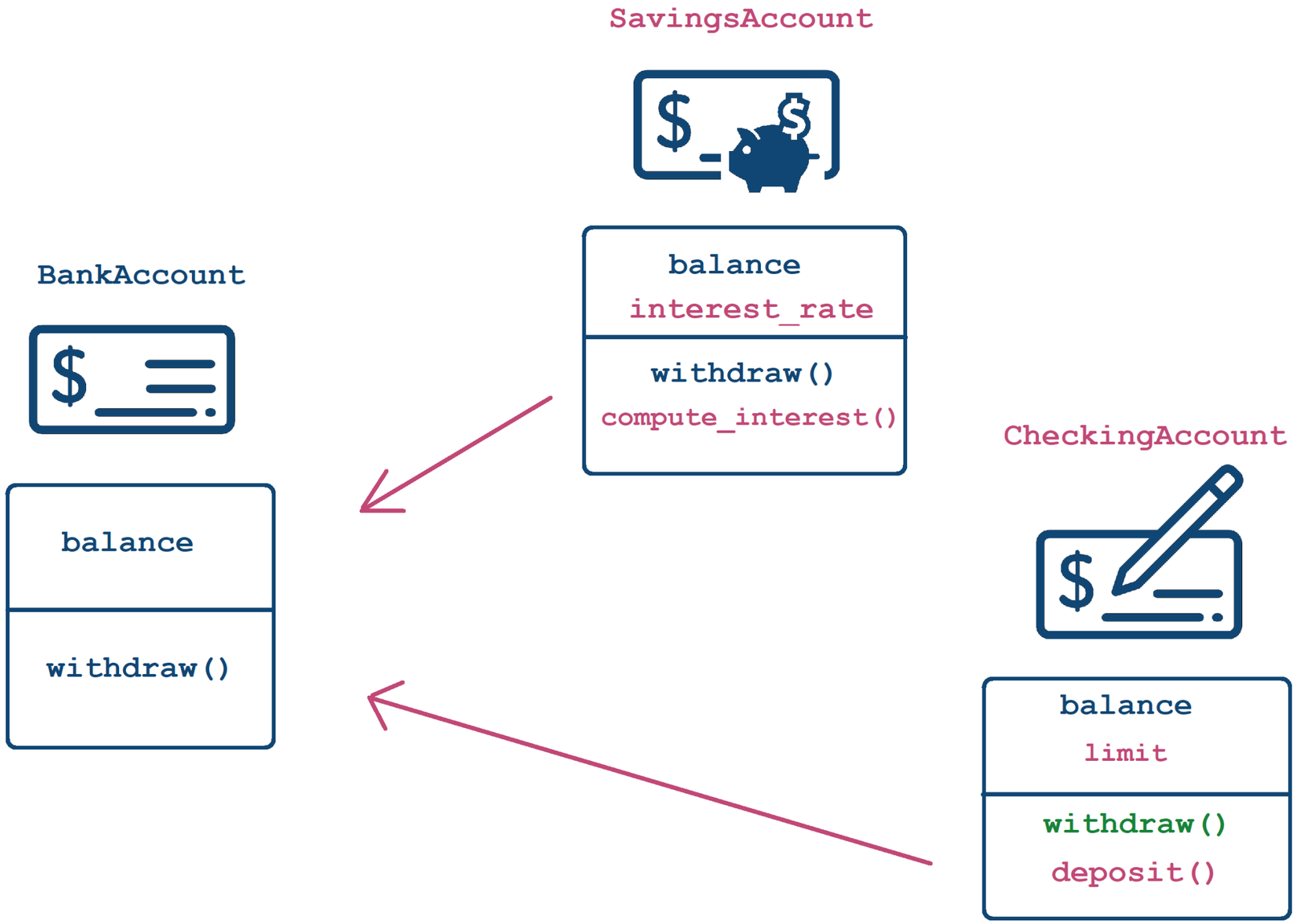

SavingsAccount
balance
interest_rate
withdraw()
compute_interest()
BankAccount
balance
withdraw()
CheckingAccount
balance
limit
withdraw()
deposit()

What we have so far

```
class BankAccount:
    def __init__(self, balance):
        self.balance = balance

    def withdraw(self, amount):
        self.balance -=amount

# Empty class inherited from BankAccount
class SavingsAccount(BankAccount):
    pass
```

Customizing constructors

```
class SavingsAccount(BankAccount):

    # Constructor speficially for SavingsAccount with an additional parameter
    def __init__(self, balance, interest_rate):
        # Call the parent constructor using ClassName.__init__()
        BankAccount.__init__(self, balance)  # <--- self is a SavingsAccount but also a BankAccount
        # Add more functionality
        self.interest_rate = interest_rate
```

- Can run constructor of the parent class first by `Parent.__init__(self, args...)`
- Add more functionality
- Don't *have* to call the parent constructors

Create objects with a customized constructor

```
# Construct the object using the new constructor
acct = SavingsAccount(1000, 0.03)
acct.interest_rate
```

```
0.03
```

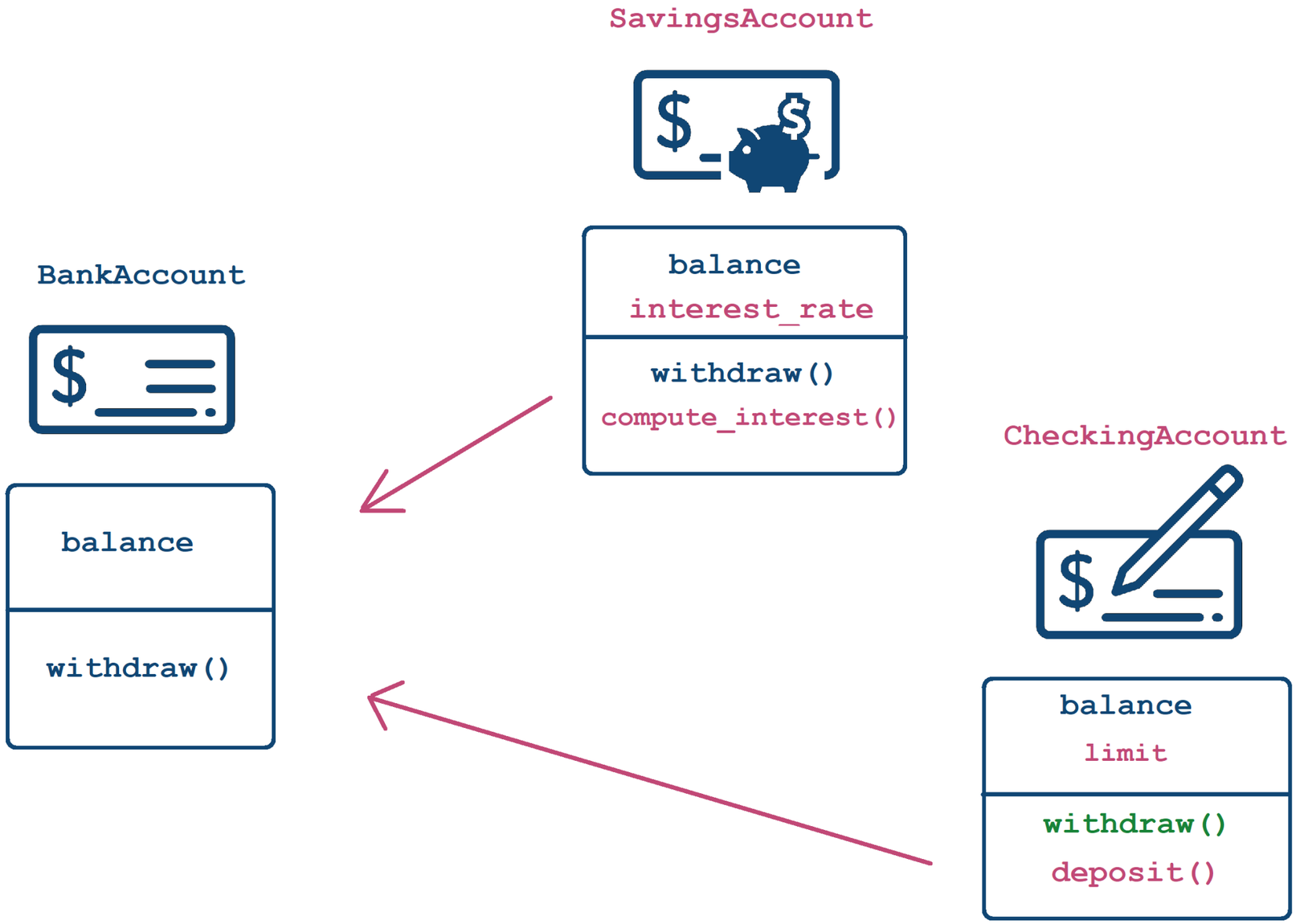
Adding functionality

- Add methods as usual
- Can use the data from both the parent and the child class

```
class SavingsAccount(BankAccount):

  def __init__(self, balance, interest_rate):
     BankAccount.__init__(self, balance)
     self.interest_rate = interest_rate

  # New functionality
  def compute_interest(self, n_periods = 1):
     return self.balance * ( (1 + self.interest_rate) ** n_periods - 1)
```


SavingsAccount
balance
interest_rate
withdraw()
compute_interest()
BankAccount
balance
withdraw()
CheckingAccount
balance
limit
withdraw()
deposit()

Customizing functionality

```
class CheckingAccount(BankAccount):
  def __init__(self, balance, limit):
    BankAccount.__init__(self, content)
    self.limit = limit
  def deposit(self, amount):
    self.balance += amount
  def withdraw(self, amount, fee=0):
    if fee <= self.limit:
      BankAccount.withdraw(self, amount - fee)
    else:
      BankAccount.withdraw(self,
                           amount - self.limit)
```

- Can change the signature (add parameters)
- Use `Parent.method(self, args...)` to call a method from the parent class

```
check_acct = CheckingAccount(1000, 25)

# Will call withdraw from CheckingAccount
check_acct.withdraw(200)
```

```
# Will call withdraw from CheckingAccount
check_acct.withdraw(200, fee=15)
```

```
bank_acct = BankAccount(1000)

# Will call withdraw from BankAccount
bank_acct.withdraw(200)
```

```
# Will produce an error
bank_acct.withdraw(200, fee=15)
```

```
TypeError: withdraw() got an unexpected
 keyword argument 'fee'
```

Let's practice!

OBJECT-ORIENTED PROGRAMMING IN PYTHON

Operator overloading: comparison

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Object equality

```
class Customer:
  def __init__(self, name, balance):
    self.name, self.balance = name, balance



customer1 = Customer("Maryam Azar", 3000)
customer2 = Customer("Maryam Azar", 3000)
customer1 == customer2
```

```
False
```

Object equality

```
class Customer:
  def __init__(self, name, balance, id):
    self.name, self.balance = name, balance
    self.id = id

customer1 = Customer("Maryam Azar", 3000, 123)
customer2 = Customer("Maryam Azar", 3000, 123)
customer1 == customer2
```

```
False
```

Variables are references

```
customer1 = Customer("Maryam Azar", 3000, 123)
customer2 = Customer("Maryam Azar", 3000, 123)
```

```
print(customer1)
```

```
<__main__.Customer at 0x1f8598e2e48>
```

```
print(customer2)
```

```
<__main__.Customer at 0x1f8598e2240>
```

Custom comparison

```
import numpy as np


# Two different arrays containing the same data
array1 = np.array([1,2,3])
array2 = np.array([1,2,3])


array1 == array2
```

```
True
```

Overloading __eq__()

```
class Customer:
  def __init__(self, id, name):
    self.id, self.name = id, name
  # Will be called when == is used
  def __eq__(self, other):
    # Diagnostic printout
    print("__eq__() is called")

    # Returns True if all attributes match
    return (self.id == other.id) and \
           (self.name == other.name)
```

- `__eq__()` is called when 2 objects of a class are compared using `==`
- accepts 2 arguments, `self` and `other` - objects to compare
- returns a Boolean

Comparison of objects

```
# Two equal objects

customer1 = Customer(123, "Maryam Azar")
customer2 = Customer(123, "Maryam Azar")

customer1 == customer2
```

```
__eq__() is called
True
```

```
# Two unequal objects - different ids

customer1 = Customer(123, "Maryam Azar")
customer2 = Customer(456, "Maryam Azar")

customer1 == customer2
```

```
__eq__() is called
False
```

Other comparison operators

Operator	Method
`==`	`__eq__()`
`!=`	`__ne__()`
`>=`	`__ge__()`
`<=`	`__le__()`
`>`	`__gt__()`
`<`	`__lt__()`

- `__hash__()` to use objects as dictionary keys and in sets

Let's practice!

OBJECT-ORIENTED PROGRAMMING IN PYTHON

Operator overloading: string representation

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Printing an object

```
class Customer:
  def __init__(self, name, balance):
    self.name, self.balance = name, balance

cust = Customer("Maryam Azar", 3000)
print(cust)
```

```
<__main__.Customer at 0x1f8598e2240>
```

```
import numpy as np

arr = np.array([1,2,3])
print(arr)
```

```
[1 2 3]
```

`__str__()`

- `print(obj)`, `str(obj)`

```
print(np.array([1,2,3]))
```

```
[1 2 3]
```

```
str(np.array([1,2,3]))
```

```
[1 2 3]
```

- informal, for end user
- ***str***ing representation

`__repr__()`

- `repr(obj)`, printing in console

```
repr(np.array([1,2,3]))
```

```
array([1,2,3])
```

```
np.array([1,2,3])
```

```
array([1,2,3])
```

- formal, for developer
- ***repr***oducible ***repr***esentation
- fallback for `print()`

Implementation: str

```
class Customer:
  def __init__(self, name, balance):
    self.name, self.balance = name, balance

  def __str__(self):
    cust_str = """
    Customer:
      name: {name}
      balance: {balance}
    """.format(name = self.name, \
               balance = self.balance)
    return cust_str
```

```
cust = Customer("Maryam Azar", 3000)

# Will implicitly call __str__()
print(cust)
```

```
Customer:
  name: Maryam Azar
  balance: 3000
```

Implementation: repr

```
class Customer:
  def __init__(self, name, balance):
    self.name, self.balance = name, balance

  def __repr__(self):
    # Notice the '...' around name
    return "Customer('{name}', {balance})".format(name = self.name, balance = self.balance)
cust = Customer("Maryam Azar", 3000)
cust # <--- # Will implicitly call __repr__()
```

```
Customer('Maryam Azar', 3000) # <--- not Customer(Maryam Azar, 3000)
```

- Surround string arguments with quotation marks in the `__repr__()` output

Let's practice!

OBJECT-ORIENTED PROGRAMMING IN PYTHON

Exceptions

OBJECT-ORIENTED PROGRAMMING IN PYTHON

Alex Yarosh
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```
a = 1
a / 0
```

```
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
    1/0
ZeroDivisionError: division by zero
```

```
a = [1,2,3]
a[5]
```

```
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
    a[5]
IndexError: list index out of range
```

```
a = 1
a + "Hello"
```

```
Traceback (most recent call last):
  File "<stdin>", line 2, in <module>
    a + "Hello"
TypeError: unsupported operand type(s) for +: /
'int' and 'str'
```

```
a = 1
a + b
```

```
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
    a + b
NameError: name 'b' is not defined
```

Exception handling

- Prevent the program from terminating when an exception is raised
- `try` - `except` - `finally`:

```
try:
  # Try running some code
except ExceptionNameHere:
  # Run this code if ExceptionNameHere happens
except AnotherExceptionHere:      #<-- multiple except blocks
  # Run this code if AnotherExceptionHere happens
...
finally:                          #<-- optional
  # Run this code no matter what
```

Raising exceptions

- `raise ExceptionNameHere('Error message here')`

```
def make_list_of_ones(length):
    if length <= 0:
       raise ValueError("Invalid length!")  # <--- Will stop the program and raise an error
    return [1]*length
```

```
make_list_of_ones(-1)
```

```
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
    make_list_of_ones(-1)
  File "<stdin>", line 3, in make_list_of_ones
    raise ValueError("Invalid length!")
ValueError: Invalid length!
```

Exceptions are classes

- standard exceptions are inherited from `BaseException` or `Exception`

```
BaseException
+-- Exception
    +-- ArithmeticError                    # <---
    |    +-- FloatingPointError
    |    +-- OverflowError
    |    +-- ZeroDivisionError             # <---
    +-- TypeError
    +-- ValueError
    |    +-- UnicodeError
    |         +-- UnicodeDecodeError
    |         +-- UnicodeEncodeError
    |         +-- UnicodeTranslateError
    +-- RuntimeError
   ...
+-- SystemExit
...
```

[1] https://docs.python.org/3/library/exceptions.html

Custom exceptions

- Inherit from `Exception` or one of its subclasses
- Usually an empty class

```
class BalanceError(Exception): pass
```

```
class Customer:
    def __init__(self, name, balance):
     if balance < 0 :
        raise BalanceError("Balance has to be non-negative!")
     else:
        self.name, self.balance = name, balance
```

```
cust = Customer("Larry Torres", -100)
```

```
Traceback (most recent call last):
  File "script.py", line 11, in <module>
    cust = Customer("Larry Torres", -100)
  File "script.py", line 6, in __init__
    raise BalanceError("Balance has to be non-negative!")
BalanceError: Balance has to be non-negative!
```

- Exception interrupted the constructor → object not created

```
cust
```

```
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
    cust
NameError: name 'cust' is not defined
```

Catching custom exceptions

```
try:
  cust = Customer("Larry Torres", -100)
except BalanceError:
  cust = Customer("Larry Torres", 0)
```

Let's practice!

OBJECT-ORIENTED PROGRAMMING IN PYTHON

Designing for inheritance and polymorphism

OBJECT-ORIENTED PROGRAMMING IN PYTHON

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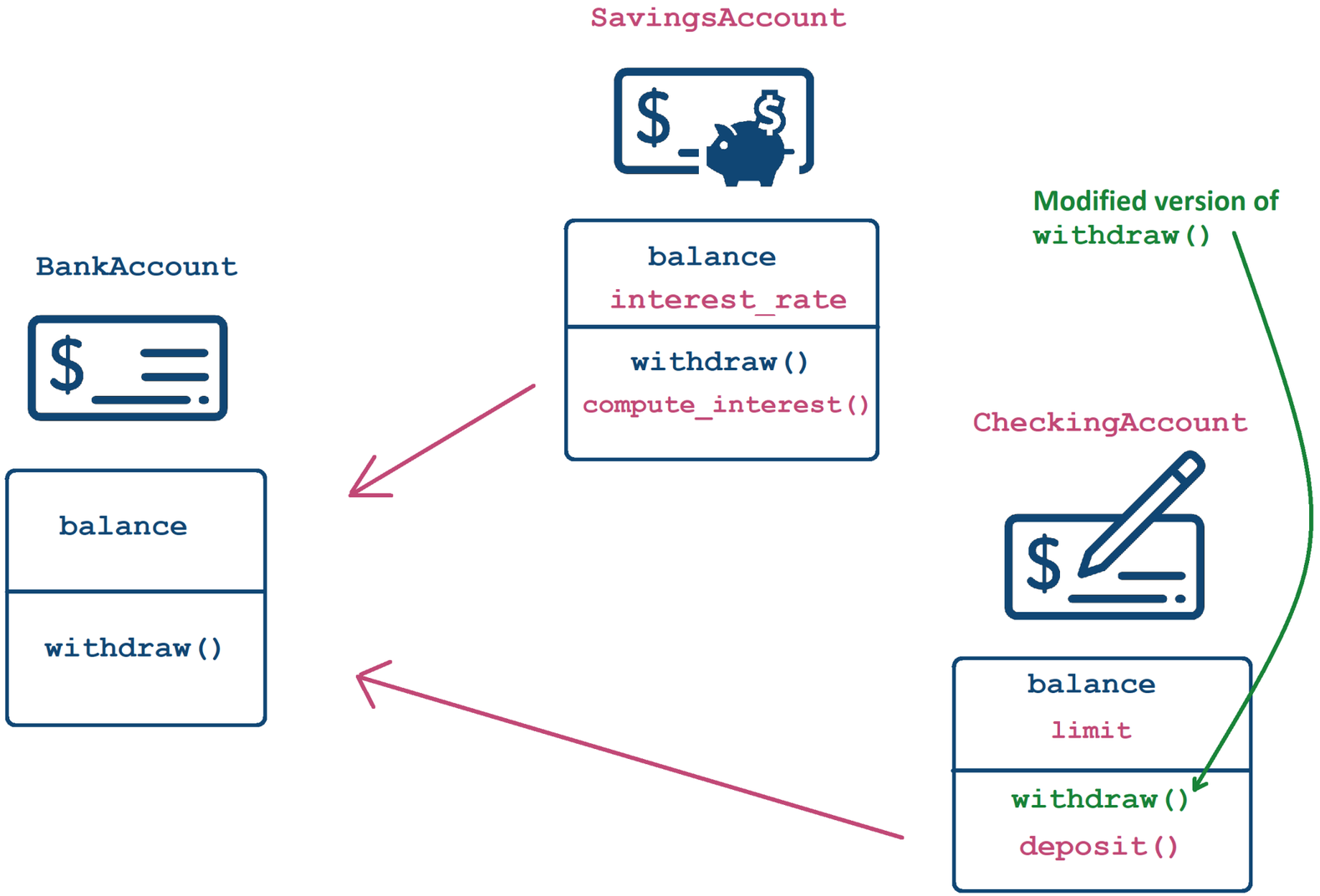
Polymorphism

Using a unified interface to operate on objects of different classes


SavingsAccount
balance
interest_rate
withdraw()
compute_interest()
Modified version of
withdraw()
BankAccount
balance
withdraw()
CheckingAccount
balance
limit
withdraw()
deposit()

All that matters is the interface

```
# Withdraw amount from each of accounts in list_of_accounts
def batch_withdraw(list_of_accounts, amount):
    for acct in list_of_accounts:
        acct.withdraw(amount)
b, c, s = BankAccount(1000), CheckingAccount(2000), SavingsAccount(3000)
batch_withdraw([b,c,s]) # <-- Will use BankAccount.withdraw(),
                            # then CheckingAccount.withdraw(),
                            # then SavingsAccount.withdraw()
```

- `batch_withdraw()` doesn't need to check the object to know which `withdraw()` to call

Liskov substitution principle

> **Base class should be interchangeable with any of its subclasses without altering any properties of the program**

Wherever `BankAccount` works, `CheckingAccount` should work as well

Liskov substitution principle

> **Base class should be interchangeable with any of its subclasses without altering any properties of the program**

Syntactically

- function signatures are compatible
  - arguments, returned values

Semantically

- the state of the object and the program remains consistent
  - subclass method doesn't strengthen input conditions
  - subclass method doesn't weaken output conditions
  - no additional exceptions

Violating LSP

→ Syntactic incompatibility

`BankAccount.withdraw()` requires 1 parameter, but `CheckingAccount.withdraw()` requires 2

→ Subclass strengthening input conditions

`BankAccount.withdraw()` accepts any amount, but `CheckingAccount.withdraw()` assumes that the amount is limited

→ Subclass weakening output conditions

`BankAccount.withdraw()` can only leave a positive balance or cause an error, `CheckingAccount.withdraw()` can leave balance negative

Violating LSP

→ Changing additional attributes in subclass's method

→ Throwing additional exceptions in subclass's method

No LSP – No Inheritance

Let's practice!

OBJECT-ORIENTED PROGRAMMING IN PYTHON

Managing data access: private attributes

OBJECT-ORIENTED PROGRAMMING IN PYTHON

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datacamp

All class data is public

We are all adults here

Restricting access

- Naming conventions
- Use `@property` to customize access
- Overriding `__getattr__()` and `__setattr__()`

Naming convention: internal attributes

`obj._att_name` , `obj._method_name()`

- Starts with a single `_` → "internal"
- Not a part of the public API
- As a class user: "don't touch this"
- As a class developer: use for implementation details, helper functions..

`df._is_mixed_type` , `datetime._ymd2ord()`

Naming convention: pseudoprivate attributes

`obj.__attr_name` , `obj.__method_name()`

- Starts but doesn't end with `__` → "private"
- Not inherited
- Name mangling: `obj.__attr_name` is interpreted as `obj._MyClass__attr_name`
- Used to prevent name clashes in inherited classes

*Leading **and** trailing `__` are **only** used for built-in Python methods (`__init__()` , `__repr__()`)!*

Let's practice!

OBJECT-ORIENTED PROGRAMMING IN PYTHON

Properties

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Changing attribute values

```
class Employee:
  def set_name(self, name):
    self.name = name
  def set_salary(self, salary):
    self.salary = salary
  def give_raise(self, amount):
    self.salary = self.salary + amount
  def __init__(self, name, salary):
    self.name, self.salary = name, salary
```

```
emp = Employee("Miriam Azari", 35000)
# Use dot syntax and = to alter atributes
emp.salary = emp.salary + 5000
```

Changing attribute values

```
class Employee:
  def set_name(self, name):
    self.name = name
  def set_salary(self, salary):
    self.salary = salary
  def give_raise(self, amount):
    self.salary = self.salary + amount
  def __init__(self, name, salary):
    self.name, self.salary = name, salary
```

```
emp = Employee("Miriam Azari", 35000)
# Use dot syntax and = to alter atributes
emp.salary = emp.salary + 5000
```

Control attribute access?

- check the value for validity
- or make attributes read-only
  - modifying `set_salary()` wouldn't prevent `emp.salary = -100`

Restricted and read-only attributes

```
import pandas as pd
df = pd.DataFrame({"colA": [1,2], "colB":[3,4]})
df
```

```
  colA colB
0    1    3
1    2    4
```

```
df.columns = ["new_colA", "new_colB"]
df
```

```
  new_colA  new_colB
0    1    3
1    2    4
```

```
# will cause an error
df.columns = ["new_colA", "new_colB", "extra"]
df
```

```
ValueError: Length mismatch:
Expected axis has 2 elements,
new values have 3 elements
```

```
df.shape = (43, 27)
df
```

```
AttributeError: can't set attribute
```

@property

```
class Employer:
  def __init__(self, name, new_salary):
     self._salary = new_salary

  @property
  def salary(self):
     return self._salary

  @salary.setter
  def salary(self, new_salary):
     if new_salary < 0:
        raise ValueError("Invalid salary")
     self._salary = new_salary
```

← Use "protected" attribute with leading `_` to store data

← Use `@property` on a *method* whose name is exactly the name of the restricted attribute; *return the internal attribute*

← Use `@attr.setter` on a method `attr()` that will be called on `obj.attr = value`

- the value to assign passed as argument

@property

```
class Employer:
  def __init__(self, name, new_salary):
     self._salary = new_salary

  @property
  def salary(self):
     return self._salary

  @salary.setter
  def salary(self, new_salary):
     if new_salary < 0:
        raise ValueError("Invalid salary")
     self._salary = new_salary
```

```
emp = Employee("Miriam Azari", 35000)
# accessing the "property"
emp.salary
```

```
35000
```

```
emp.salary = 60000 # <-- @salary.setter
```

```
emp.salary = -1000
```

```
ValueError: Invalid salary
```

Why use @property?

User-facing: behave like attributes

Developer-facing: give control of access

Other possibilities

→ Do not add `@attr.setter`

Create a read-only property

→ Add `@attr.getter`

Use for the method that is called when the property's *value is retrieved*

→ Add `@attr.deleter`

Use for the method that is called when the property is *deleted using* `del`

Let's practice!

OBJECT-ORIENTED PROGRAMMING IN PYTHON

Congratulations!

OBJECT-ORIENTED PROGRAMMING IN PYTHON

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Overview

Chapter 1

- Classes and objects
- Attributes and methods

Chapter 2

- Class inheritance
- Polymorphism
- Class-level data

Chapter 3

- Object equality
- String representation
- Exceptions

Chapter 4

- Designing for inheritance
- Levels of data access
- Properties

What's next?

Functionality

- Multiple inheritance and mix-in classes
- Overriding built-in operators like `+`
- `__getattr__()`, `__setattr__()`
- Custom iterators
- Abstract base classes
- Dataclasses *(new in Python 3.7)*

What's next?

Functionality

- Multiple inheritance and mixin classes
- Overriding built-in operators like `+`
- `__getattr__()`, `__setattr__()`
- Custom iterators
- Abstract base classes
- Dataclasses *(new in Python 3.7)*

Design

- SOLID principles

Single-responsibility principle

Open-closed principle

***L**iskov substitution principle*

Interface segregation principle

Dependency inversion principle

- Design patterns

Thank you!

OBJECT-ORIENTED PROGRAMMING IN PYTHON