Class vs. instance attributes

INTRODUCTION TO OBJECT-ORIENTED PROGRAMMING IN PYTHON

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Core principles of OOP

Encapsulation:

- Bundling of data and methods

Inheritance:

- Extending the functionality of existing code

Polymorphism:

- Creating a unified interface

Instance-level attributes

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

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

- `name` and `salary` values are specific to each object
- `self` assigns to an object

Class-level attributes

- Data shared among all instances of a class

- Define *class attributes* in the body of `class`

- "Global variable" within the class

Implementing class-level attributes

```
class Employee:
    # Define a class attribute
    # No self. syntax
    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
```

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

Class-level attributes

```
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("John", 40000)
print(emp1.MIN_SALARY)
```

```
30000
```

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

```
30000
```

Modifying class-level attributes

```
emp1 = Employee("John", 40000)
emp2 = Employee("Jane", 60000)

# Update MIN_SALARY of emp1
emp1.MIN_SALARY = 50000

# Print MIN_SALARY for both employees
print(emp1.MIN_SALARY)
print(emp2.MIN_SALARY)
```

```
50000
30000
```

Modifying class-level attributes

- `MIN_SALARY` is created in the class definition

- Updating `MIN_SALARY` of an object will not affect the value in the class definition

- Security - prevent changes being made to software!

Why use class attributes?

Global constants related to the class

- Minimum and maximum values for attributes
  - Prevent invalid data
- Commonly used values and constants, e.g. `host` , `port` for a `Database` class
  - Avoid repetition when creating objects

Let's practice!

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Class methods

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Methods

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

    def give_raise(self, amount):
        self.amount = amount

# Unique attribute values
emp_one = Employee("John", 40000)
emp_one.give_raise(5000)
print(emp_one.salary)
```

```
45000
```

```
# Unique attribute values
emp_two = Employee("Jane", 60000)
emp_two.give_raise(5000)
print(emp_two.salary)
```

```
65000
```

Class methods

- Possible to define class methods
- Must have a narrow scope because they can't use object-level data

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

- As with `self`, `cls` is a convention but any word will work

Alternative constructors

```
class Employee:
  def __init__(self, name, salary):
      self.name = name
      self.salary = salary
  @classmethod
  def from_file(cls, filename):
      with open(filename, "r") as f:
          # Read the first line
          name = f.readline().strip()
          # Read the second line as integer
          salary = int(f.readline().strip())
      return cls(name, salary)
```

- Allow alternative constructors
- Can only have one `__init__()`

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

Alternative constructors

```
class Employee:
  def __init__(self, name, salary):
      self.name = name
      self.salary = salary
  @classmethod
  def from_file(cls, filename):
      with open(filename, "r") as f:
          name = f.readline().strip()
          salary = int(f.readline().strip())
      return cls(name, salary)
```

Employee.txt

```
1  John Smith
2  40000
```

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

```
John Smith
```

When to use class methods

- Alternative constructors
- Methods that don't require instance-level attributes
- Restricting to a single instance (object) of a class
  - Database connections
  - Configuration settings

Let's practice!

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Class inheritance

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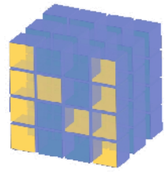
Code reuse

1. Someone has already done it

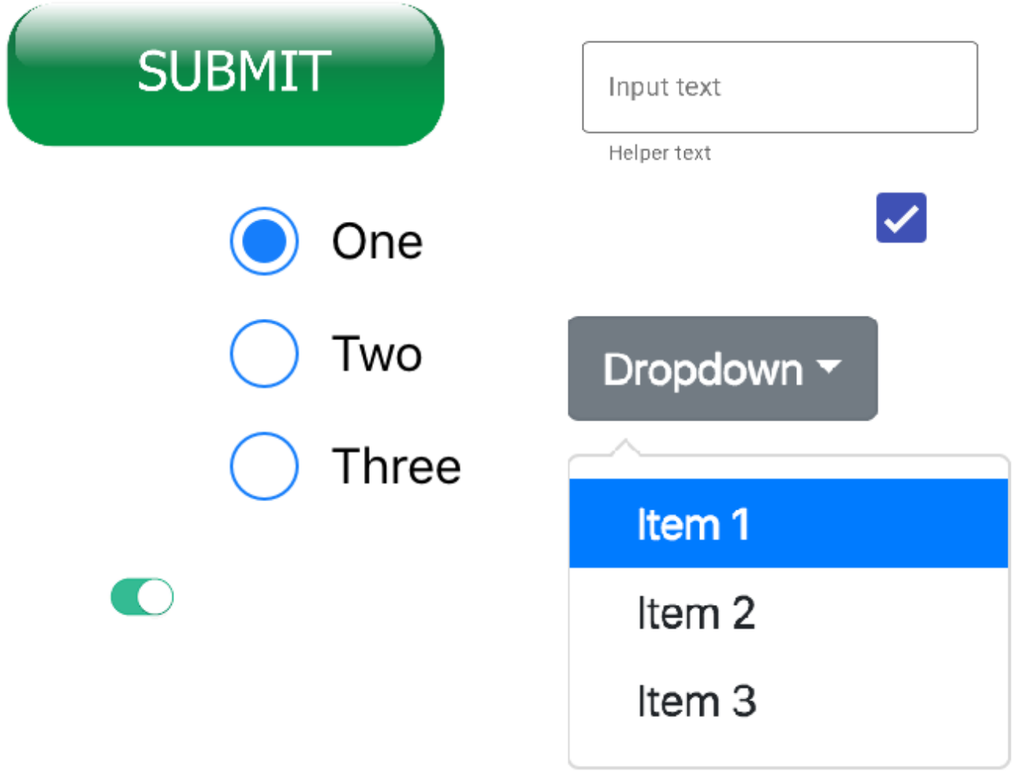
- Packages are great for fixed functionality
- OOP is great for customizing functionality



Code reuse

1. Someone has already done it

2. DRY: Don't Repeat Yourself



Code reuse

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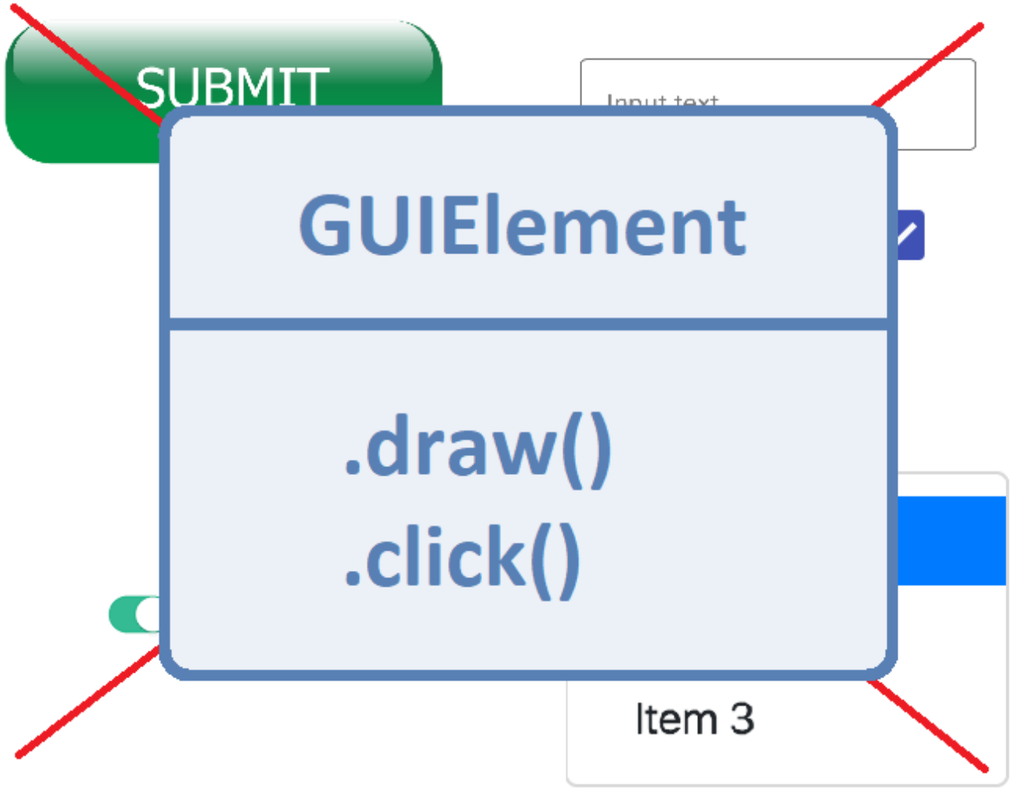
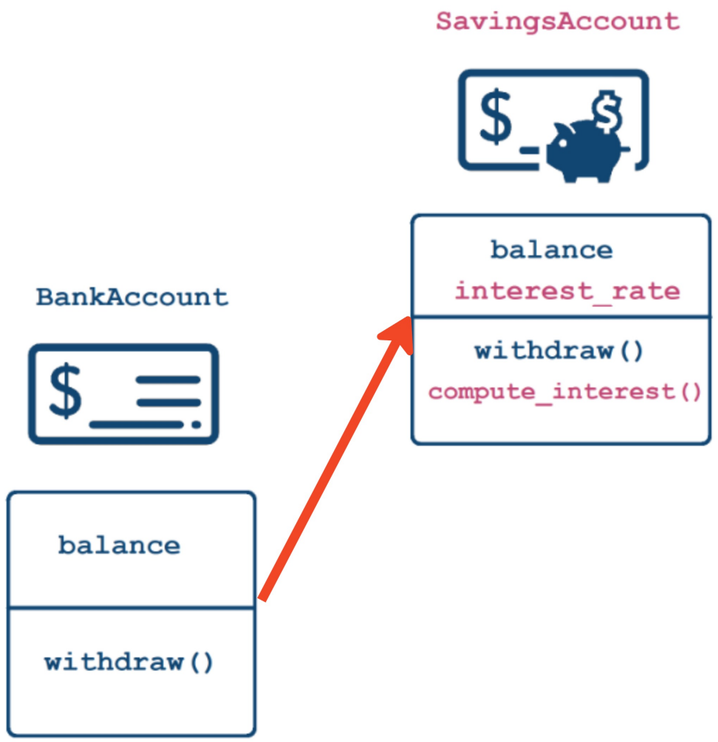


Inheritance

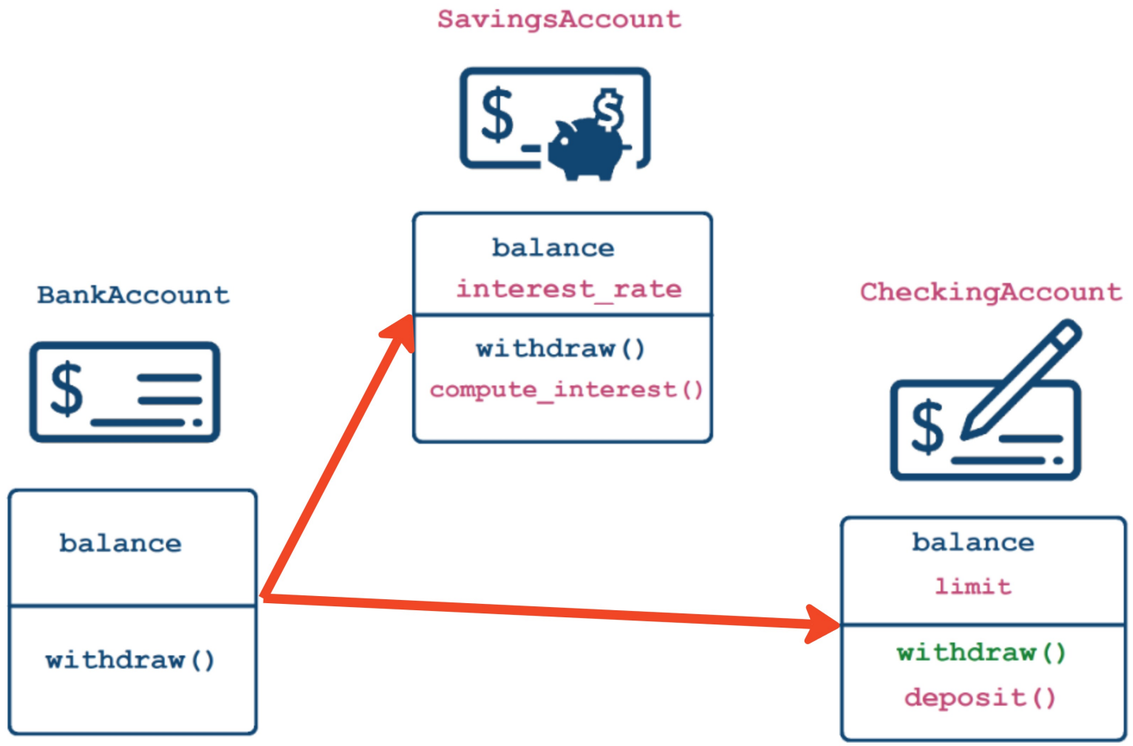
$$\text{New class functionality} = \text{Old class functionality} + \text{extra}$$

Example hierarchy

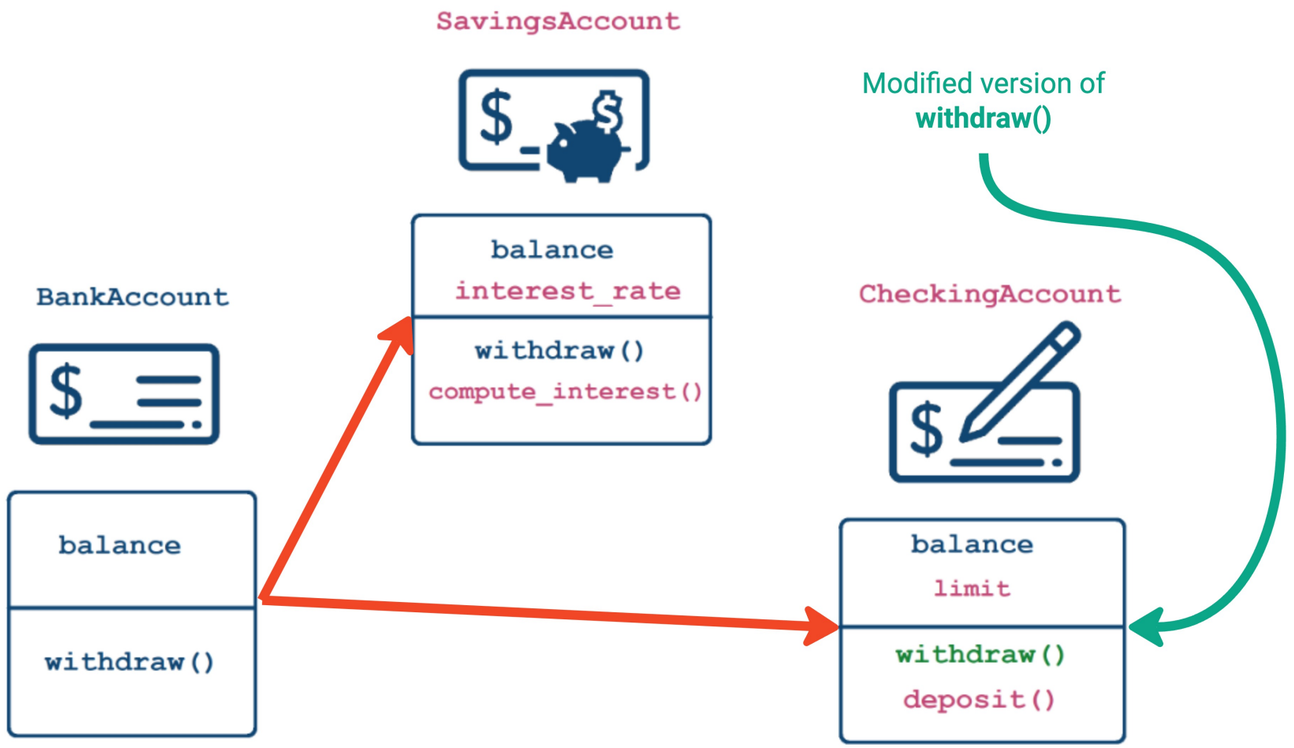
Example hierarchy



Example hierarchy



Example hierarchy



Implementing class inheritance

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

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

# Class inheriting from BankAccount
class SavingsAccount(BankAccount):
    pass
```

- `BankAccount` : Parent class whose functionality is being extended/inherited
- `SavingsAccount` : Child/sub-class that will inherit the functionality and add more

Child class has all of 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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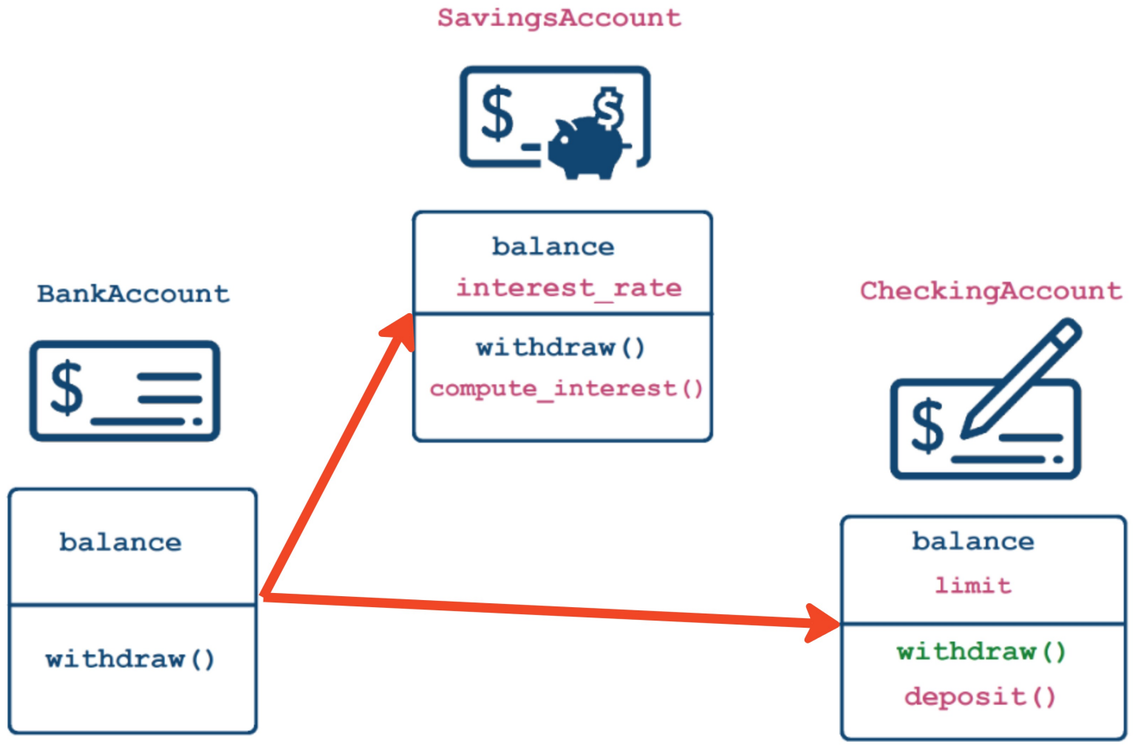

SavingsAccount
balance
interest_rate
withdraw()
compute_interest()
BankAccount
balance
withdraw()
CheckingAccount
balance
limit
withdraw()
deposit()

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 for SavingsAccount with an additional argument
    def __init__(self, balance, interest_rate):
        # Call the parent constructor using ClassName.__init__()
        # self is a SavingsAccount but also a BankAccount
        BankAccount.__init__(self, balance)
        # 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 constructor

Create objects with a customized constructor

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

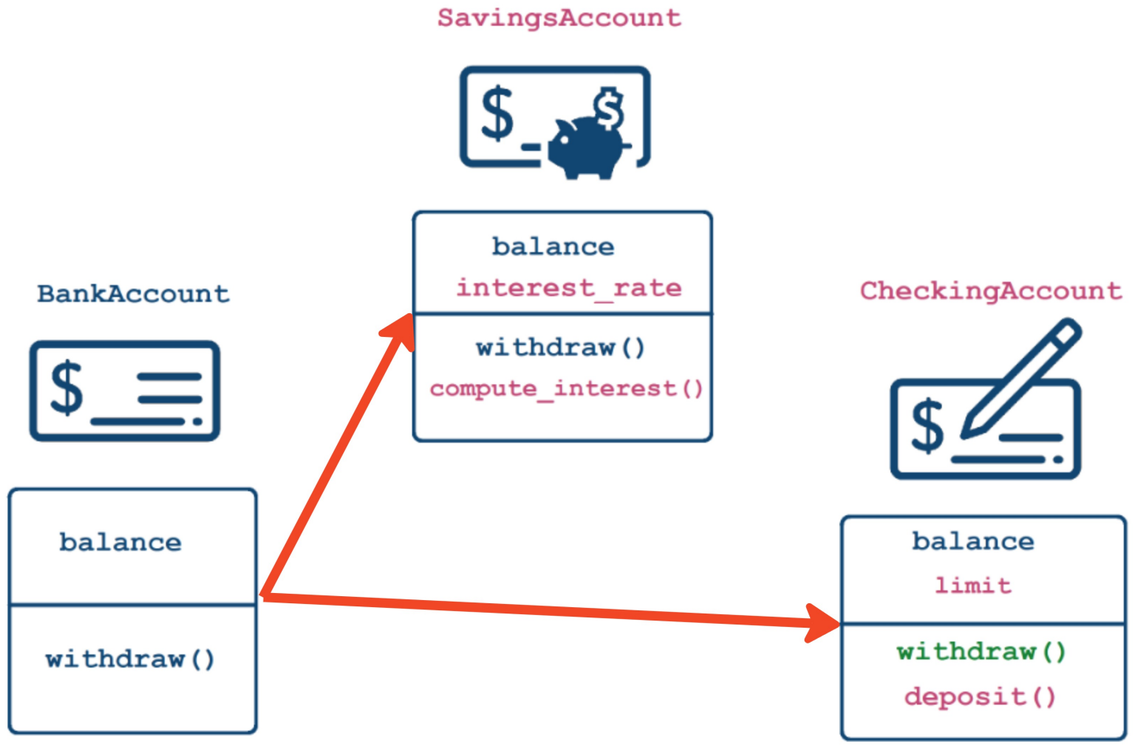
```
0.03
```

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()

Adding a second child class

```
class CheckingAccount(BankAccount):
    def __init__(self, balance, limit):
        BankAccount.__init__(self, balance) # Call the ParentClass constructor
        self.limit = limit
    def deposit(self, amount):
        self.balance += amount
    def withdraw(self, amount, fee=0): # New fee argument
        if amount <= self.limit:
            BankAccount.withdraw(self, amount + fee)
        else:
            pass # Won't run if the condition isn't met
```

```
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'
```

- Violates polymorphism
  - Parent / child classes have different methods

Let's practice!

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