BABEŞ-BOLYAI UNIVERSITY

Faculty of Mathematics and Computer Science

Algorithms and Programming

Lecture 6 – Classes

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Course content

Last time

- Abstract Data Types

- Classes
  - `Flower` example
  - `Rational` example

Today

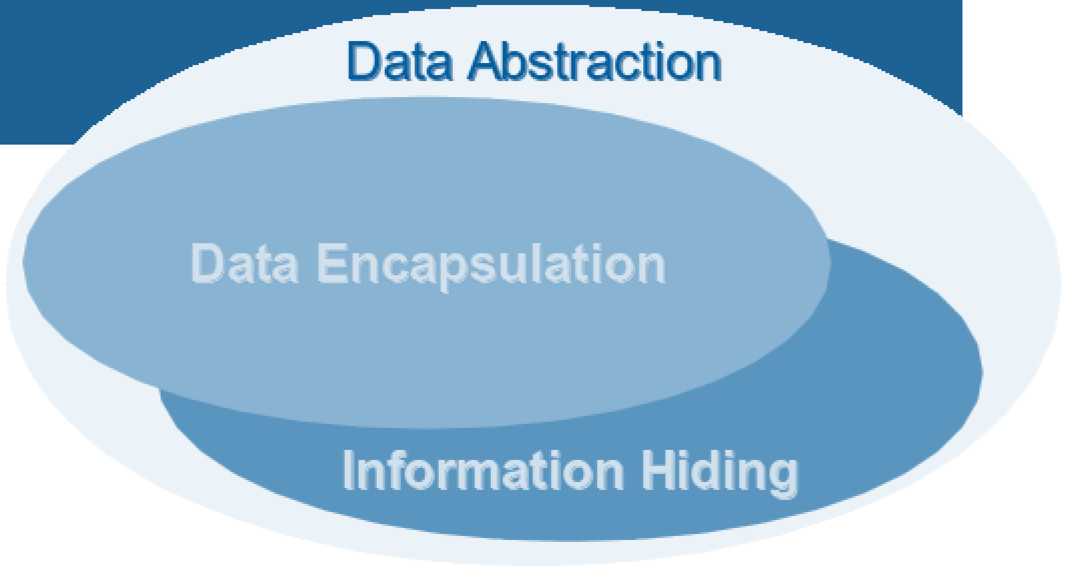
- More on ADT
  - Data abstraction
  - Information hiding
  - Class attributes vs Instance attributes
  - Static methods

- Unified Modelling Language (UML)

Classes

- Creating a new class:
  - Creates a new *type* of an object
  - Allows *instances* of that type
- A class instance can have:
  - *Attributes* (to maintain its state)
  - *Methods* (to modify its state)
- Class name is the type e.g. `class Flower:`
- Instance is one specific object e.g. `f1 = Flower("rose", 5)`
- A class introduces a new namespace

Data Abstraction



- Encapsulation
  - bundling of data with the methods that operate on that data

- Information hiding
  - the principle that some internal information or data is "hidden" so that it can not be changed by accident

- **Data Abstraction = Data Encapsulation + Data Hiding**

Encapsulation

- Often accomplished by providing two types of methods
  - Getter methods
  - Setter methods

Obs. This does not mean that data attributes can be accessed only via the getter methods

```python
class Flower:
    def __init__(self, n = "", p = 0):
        self.name = n
        self.price = p

    def getName(self):
        '''
            getter method: return the name of a flower
        '''
        return self.name

    def getPrice(self):
        '''
            getter method: return the price of a flower
        '''
        return self.price

    def setName(self, n):
        '''
            setter method: set the name of a flower
        '''
        self.name = n

    def setPrice(self, p):
        '''
            setter method: set the price of a flower
        '''
        self.price = p
```

Information hiding

- The internal representation of an object
  - Needs to be hidden outside the object's denition
  - Protect object integrity by preventing users from setting the internal data of the component into an invalid or inconsistent state

- Python not great at information hiding
  - You can access data from outside class definition

```
    print(f1.name)
```

  - You can write data from outside class definition

```
    f1.name = “Lily”
```

  - You can **create data attributes** for an instance from outside class definition

```
    f1.colour = “Purple”
```

  - Not a good style to do any of these

Information hiding

- Divide the code into a public interface and a private implementation of that interface
- Data hiding in Python: public and private members
  - Data hiding in Python is based upon convention
  - Use the convention: _name or __name for fields, methods that are “private“
    - A name prefixed with an underscore (e.g. _spam) should be treated as non-public part of the API (should be considered an implementation detail and subject to change without notice)
    - A name prefixed with two underscores (e.g. __spam) is private and name mangling is employed (Python runtime)

Attribute types

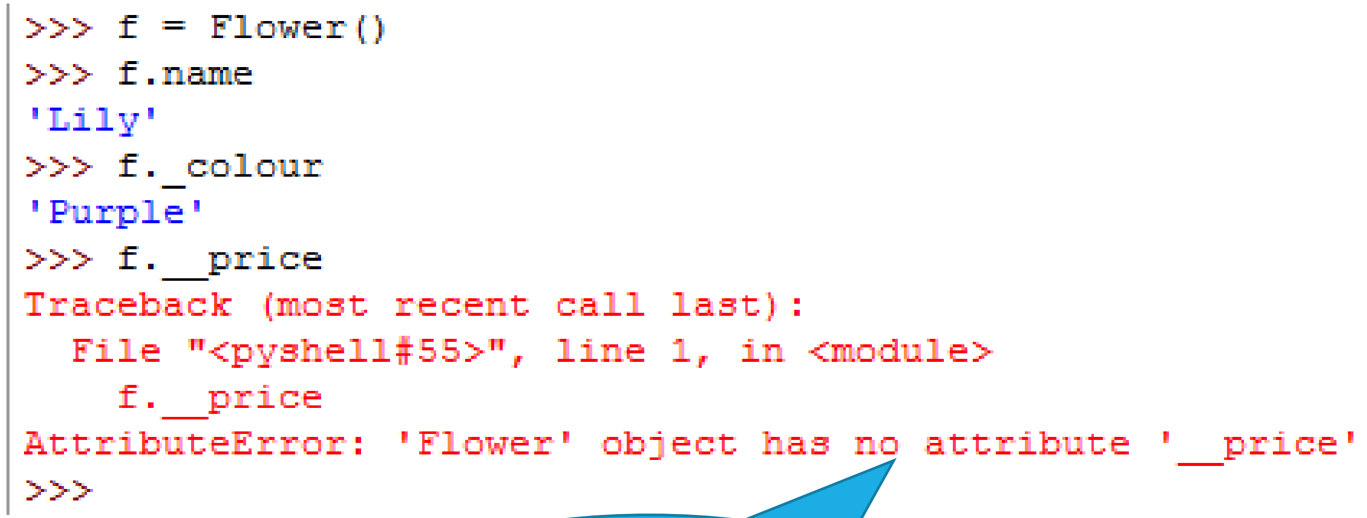
- Private attributes
  - __name
  - should only be used inside the class definition

- Protected (restricted) attributes
  - _name
  - may be used but only under certain conditions

- Public attributes
  - name
  - can be freely used inside or outside class definition

Attribute types: example

```python
class Flower:
    def __init__(self):
        self.name = "Lily"
        self._colour = "Purple"
        self.__price = 10
```



```
>>> f = Flower()
>>> f.name
'Lily'
>>> f._colour
'Purple'
>>> f.__price
Traceback (most recent call last):
  File "<pyshell#55>", line 1, in <module>
    f.__price
AttributeError: 'Flower' object has no attribute '__price'
>>>
```

Information hiding

Data encapsulation: revisited in the Flower example

```
class Flower:
    '''
    a flower is a structure of two elements: name (a string) and price (an integer)
    '''
    def __init__(self, n = "", p = 0):
        self.__name = n
        self.__price = p

    def getName(self):
        return self.__name

    def getPrice(self):
        return self.__price

    def setName(self, n):
        self.__name = n

    def setPrice(self, p):
        self.__price = p
```

Class attributes vs. Instance attributes

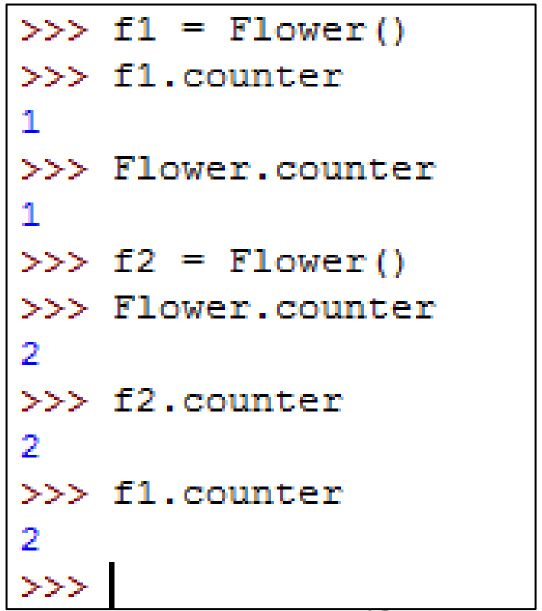
- Instance attributes
  - Owned by the specific instances of the class
  - Usually different for each instance

```
f1 = Flower("rose", 5)
f2 = Flower(“tulip", 3)
```

```
class Flower:
    def __init__(self, n, p = 0):
        '''
            creates a new instance of Flower
        '''
        self.name = n
        self.price = p
        self.size = None
```

- Class attributes
  - Owned by the class itself
  - Same for all instances

```
class Flower:
    counter = 0

    def __init__(self, n="", p = 0):
        '''
            creates a new instance of Flower
        '''
        self.name = n
        self.price = p
        self.size = None

        # use class name or type(self)
        Flower.counter += 1
```

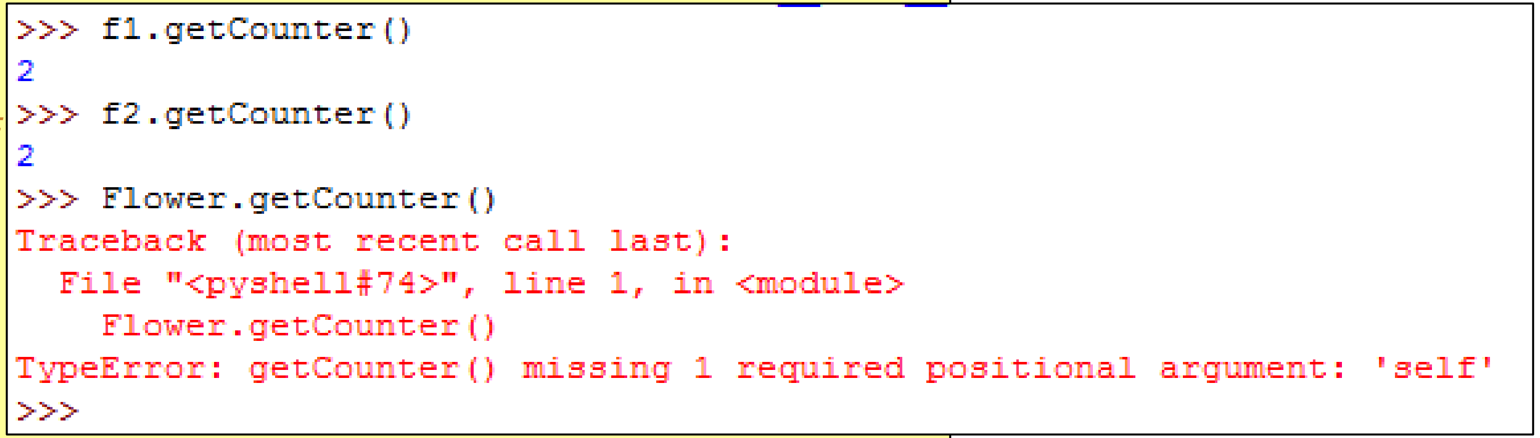


```
>>> f1 = Flower()
>>> f1.counter
1
>>> Flower.counter
1
>>> f2 = Flower()
>>> Flower.counter
2
>>> f2.counter
2
>>> f1.counter
2
>>> 
```

Static methods

- Class attributes can be private

```
class Flower:
    '''
    a flower is a structure of two elements: name (a string) and price (an integer)
    '''
    __counter = 0

    def __init__(self, n = "", p = 0):
        '''
            creates a new instance of F
        '''
        self.__name = n
        self.__price = p
        type(self).__counter += 1

    def getCounter(self):
        return self.__counter
```

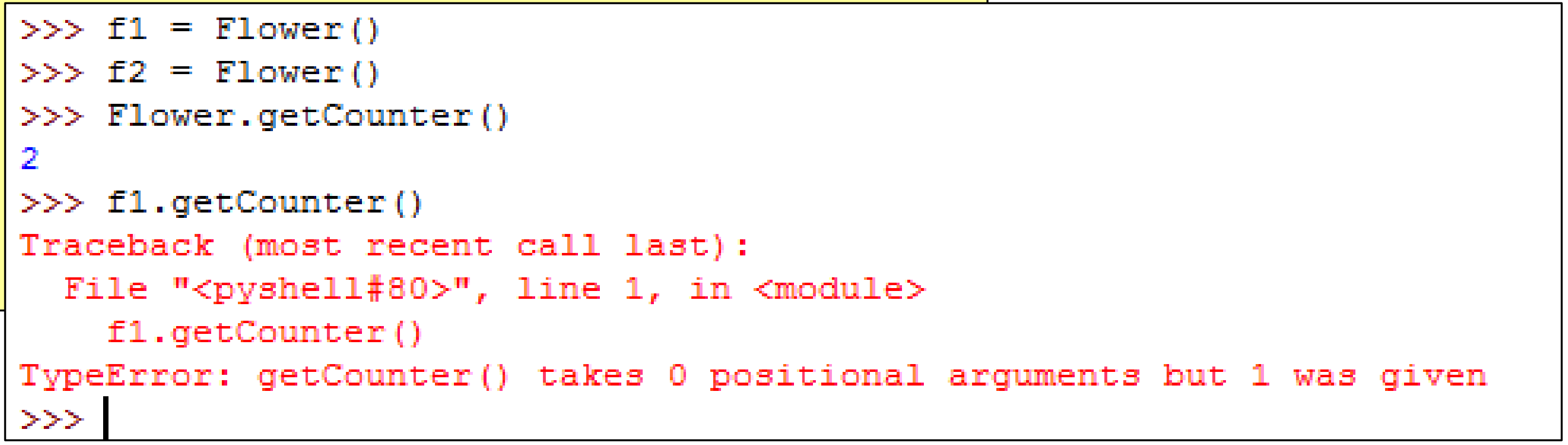


```
>>> f1.getCounter()
2
>>> f2.getCounter()
2
>>> Flower.getCounter()
Traceback (most recent call last):
  File "<pyshell#74>", line 1, in <module>
    Flower.getCounter()
TypeError: getCounter() missing 1 required positional argument: 'self'
>>>
```

Good idea?

Static methods

```python
class Flower:
    '''
    a flower is a structure of two elements: name (a string) and price (an integer)
    '''
    __counter = 0

    def __init__(self, n = "", p = 0):
        '''
            creates a new instance of Flower
        '''
        self.__name = n
        self.__price = p
        type(self).__counter += 1

    def getCounter():
        return Flower.__counter
```

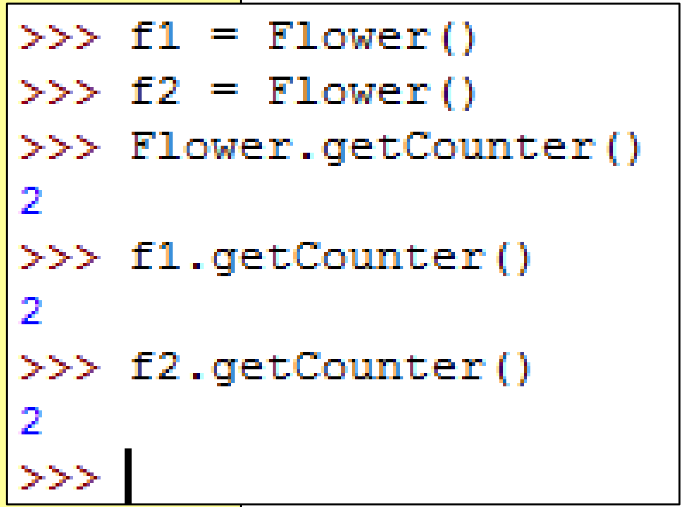


```
>>> f1 = Flower()
>>> f2 = Flower()
>>> Flower.getCounter()
2
>>> f1.getCounter()
Traceback (most recent call last):
  File "<pyshell#80>", line 1, in <module>
    f1.getCounter()
TypeError: getCounter() takes 0 positional arguments but 1 was given
>>> 
```

Static methods

- Add a line "@staticmethod" before method definition
- Use decorator syntax
- Do not require the self argument

```
class Flower:
    '''
    a flower is a structure of two elements: name (a string) and price (an integer)
    '''
    __counter = 0

    def __init__(self, n = "", p = 0):
        '''
            creates a new instance of Flower
        '''
        self.__name = n
        self.__price = p
        type(self).__counter += 1

    @staticmethod
    def getCounter():
        return Flower.__counter
```



```
>>> f1 = Flower()
>>> f2 = Flower()
>>> Flower.getCounter()
2
>>> f1.getCounter()
2
>>> f2.getCounter()
2
>>> 
```

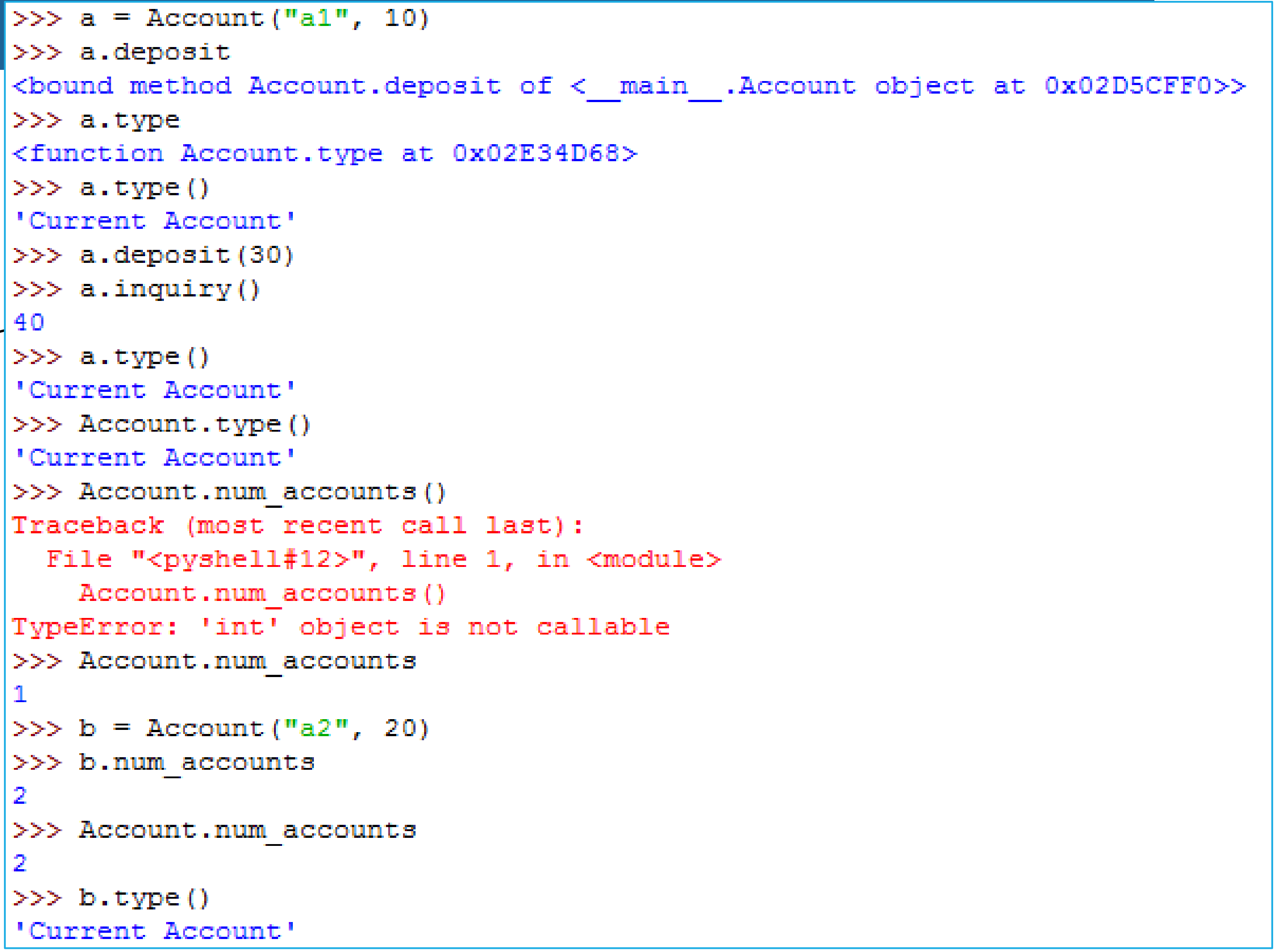
Example 1

```
class Student:

    __studentCount = 0

    def __init__(self, name=“”):
        self.__name = name

        Student.__studentCount += 1

    def setName(self, name):
        self.__name = name

    def getName(self):
        return self.__name

    @staticmethod
    def getStudentCount():
        return Student.__studentCount
```

```
s1 = Student()
s2 = Student()

s1.setName("Erin")
s2.setName("Carla")

print(s1.getName())
print(s2.getName())

print(Student.getStudentCount())
```

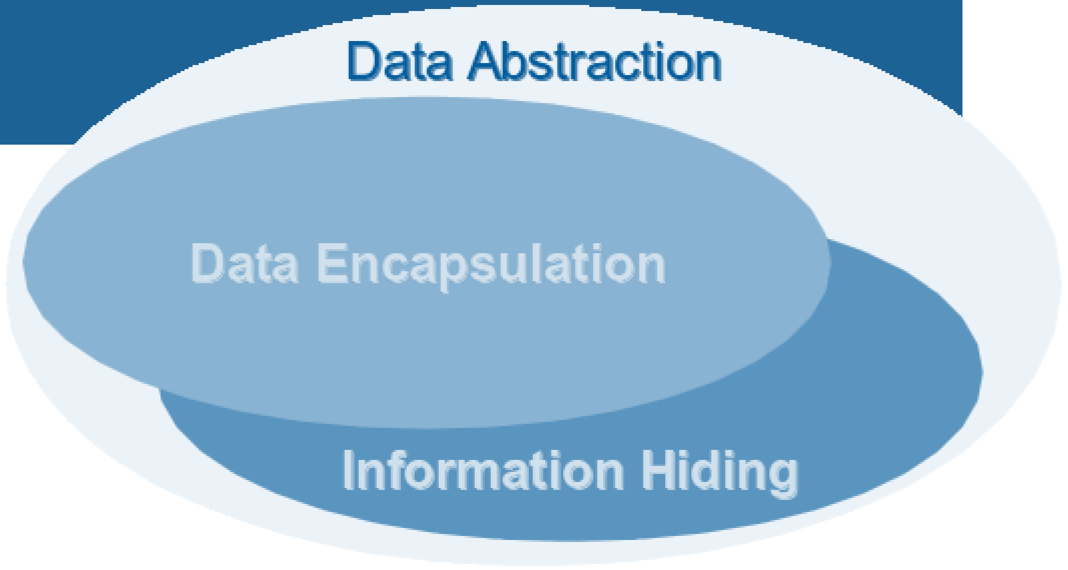
Example 2

```python
class Account(object):
    num_accounts = 0

    def __init__(self, name, balance):
        self.name = name
        self.balance = balance
        Account.num_accounts += 1

    def del_account(self):
        Account.num_accounts -= 1

    def deposit(self, amt):
        self.balance = self.balance + amt

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

    def inquiry(self):
        return self.balance

    @staticmethod
    def type():
        return "Current Account"
```



```
>>> a = Account("a1", 10)
>>> a.deposit
<bound method Account.deposit of <__main__.Account object at 0x02D5CFF0>>
>>> a.type
<function Account.type at 0x02E34D68>
>>> a.type()
'Current Account'
>>> a.deposit(30)
>>> a.inquiry()
40
>>> a.type()
'Current Account'
>>> Account.type()
'Current Account'
>>> Account.num_accounts()
Traceback (most recent call last):
  File "<pyshell#12>", line 1, in <module>
    Account.num_accounts()
TypeError: 'int' object is not callable
>>> Account.num_accounts
1
>>> b = Account("a2", 20)
>>> b.num_accounts
2
>>> Account.num_accounts
2
>>> b.type()
'Current Account'
```

Recap: Data Abstraction



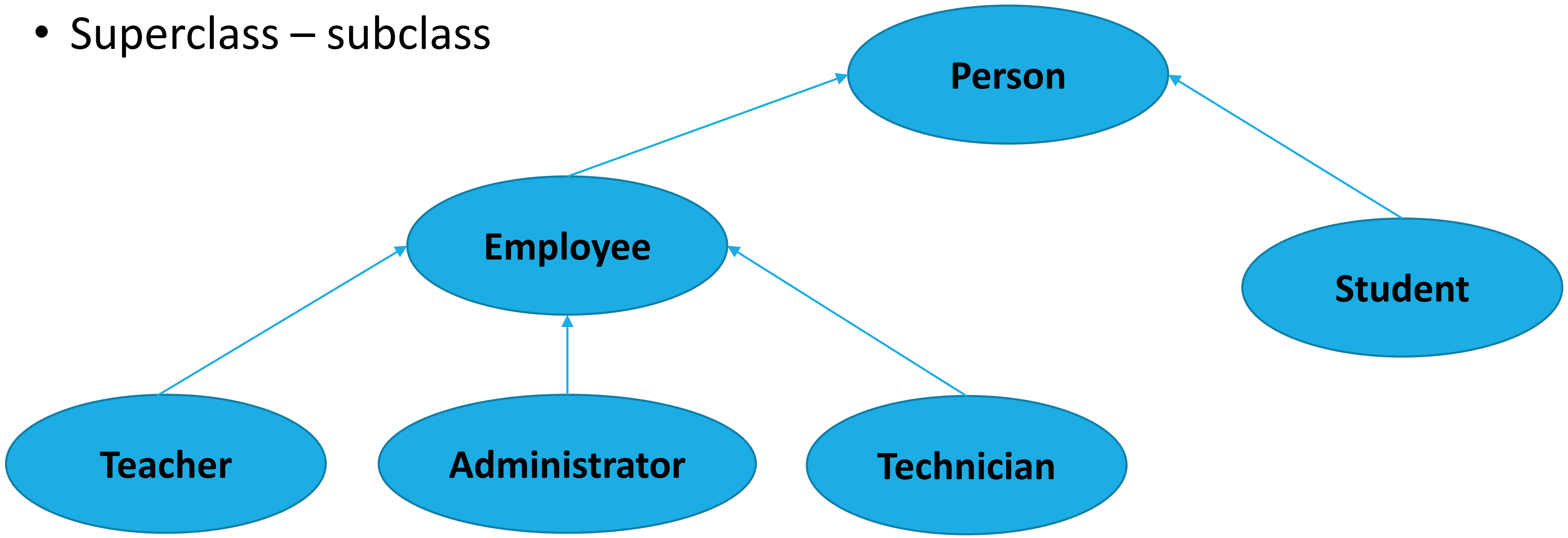
- Encapsulation
  - bundling of data with the methods that operate on that data

- Information hiding
  - the principle that some internal information or data is "hidden" so that it can not be changed by accident

- **Data Abstraction = Data Encapsulation + Data Hiding**

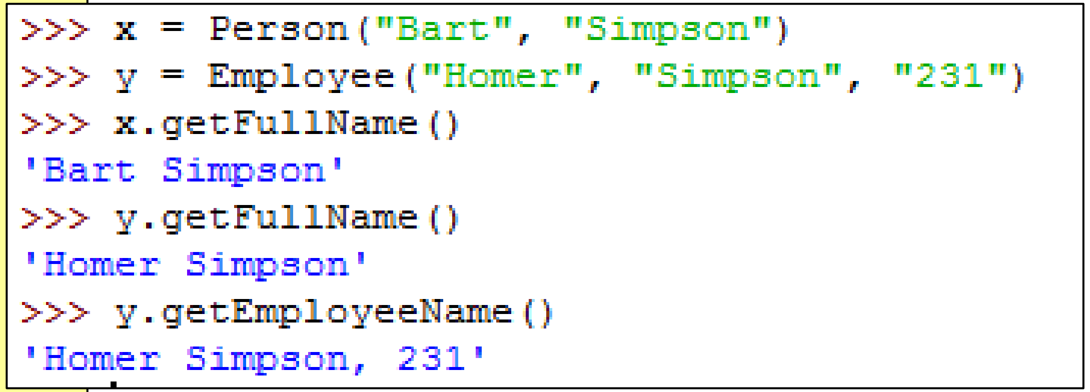
Inheritance

- Classes can inherit from other classes
  - Attributes and behaviour methods
  - Superclass – subclass



Inheritance

```python
class Person:
    def __init__(self, first, last):
        self.firstname = first
        self.lastname = last

    def getFullName(self):
        return self.firstname + " " + self.lastname

class Employee(Person):
    def __init__(self, first, last, staffid):
        Person.__init__(self, first, last)
        self.staffnumber = staffid

    def getEmployeeName(self):
        return self.getFullName() + ", " +  self.staffnumber
```



```
>>> x = Person("Bart", "Simpson")
>>> y = Employee("Homer", "Simpson", "231")
>>> x.getFullName()
'Bart Simpson'
>>> y.getFullName()
'Homer Simpson'
>>> y.getEmployeeName()
'Homer Simpson, 231'
```

```python
super().__init__(self, first, last)
```

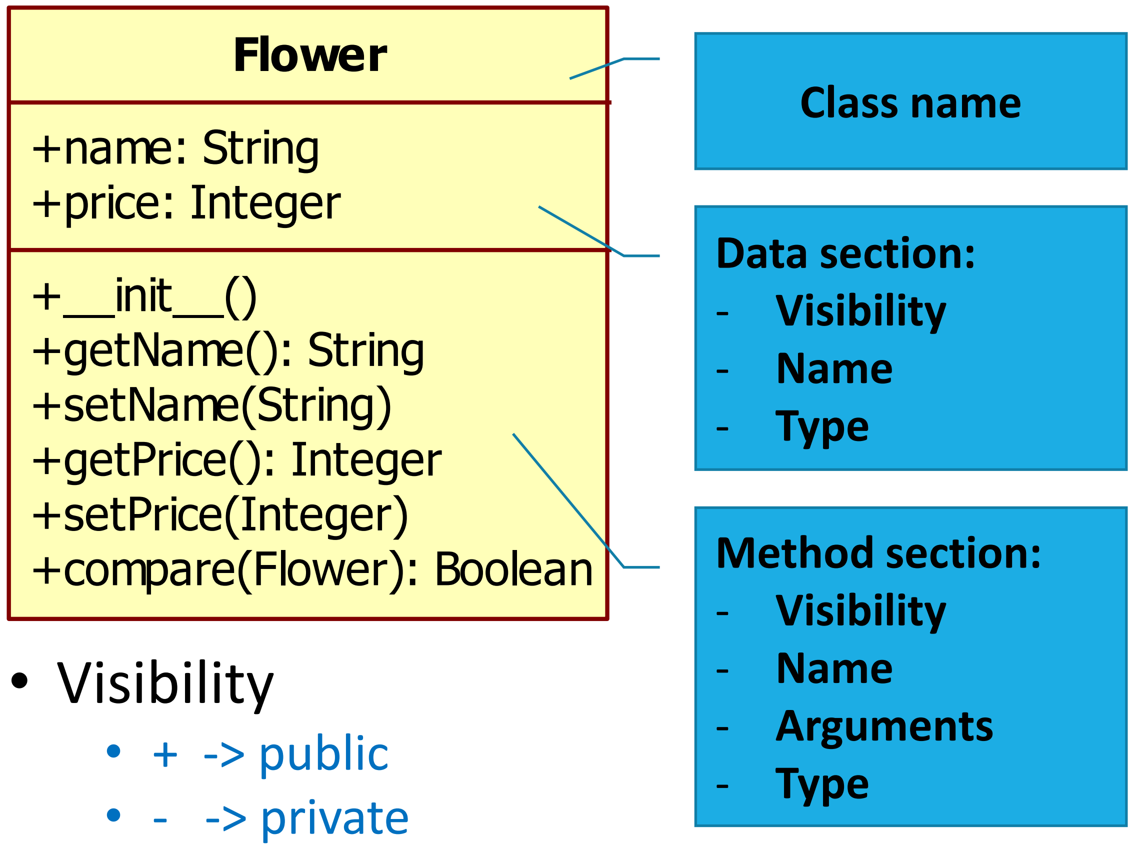
Unified Modelling Language (UML)

- UML
  - Standardized general-purpose modeling language
  - Includes graphical notations to model concepts in the field of object-oriented software engineering
  - Visual models of object-oriented applications

- Class diagram
  - Describe the structure of the application using
    - Classes (attributes and methods)
    - Relationships between classes

UML Class Diagram

- Specification of a class

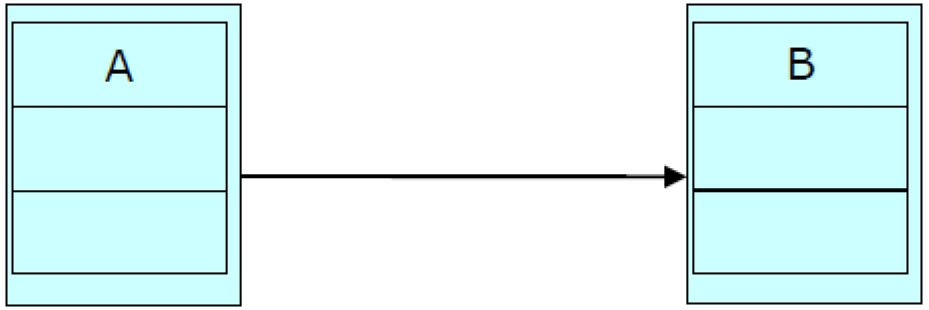


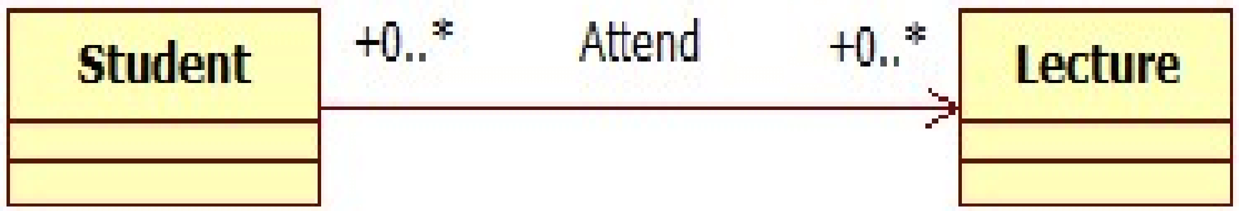
```python
class Flower:
    def __init__(self):
        self.name = ""
        self.price = ""

    def getName(self):
        return self.name

    def setName(self, n):
        self.name = n

    def getPrice(self):
        return self.price

    def setPrice(self, p):
        self.__price = p

    def compare(self, other):
        if ((self.name == other.name) and
            (self.price == other.price)):
            return True
        else:
            return False
```

- Visibility
  - + -> public
  - - -> private
  - # -> protected

Relationships between classes: Association

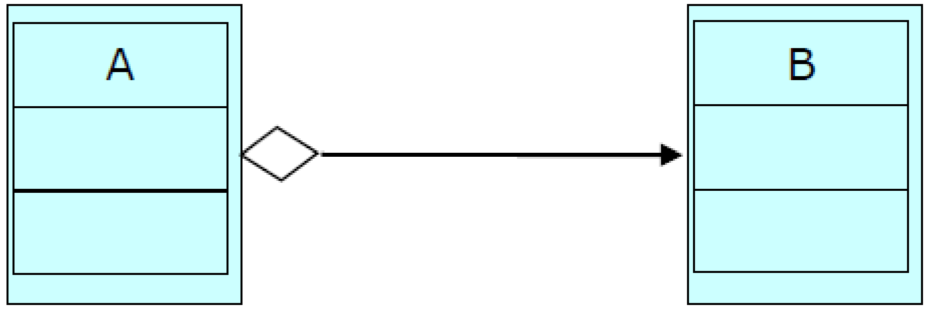
- Association
  - Class A uses class B
  - Objects of A are connected to objects of B
- An association can be named
- The ends of an association can be annotated with role names, ownership indicators, multiplicity, visibility
- Association can be bi-directional as well as uni-directional



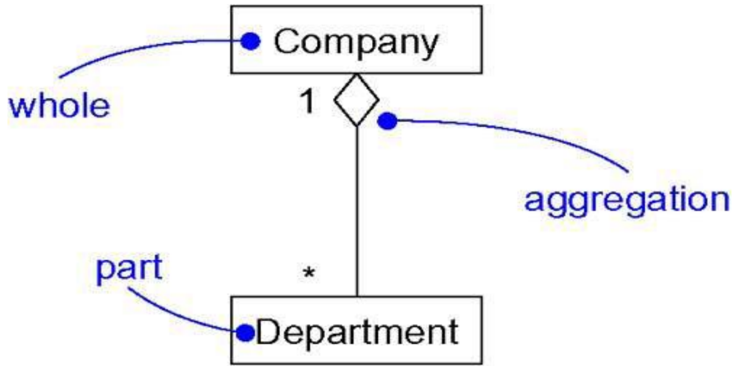


Relationships between classes: Aggregation

- Aggregation
  - A contains 1 or more B
  - B exists without A

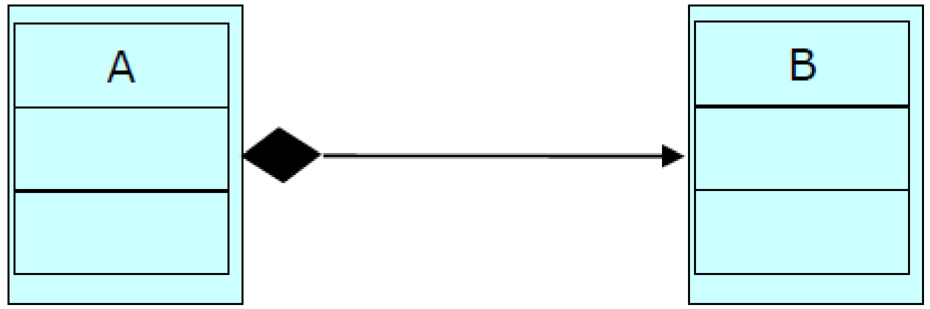


- Special kind of association used to model a „whole/part” relationship

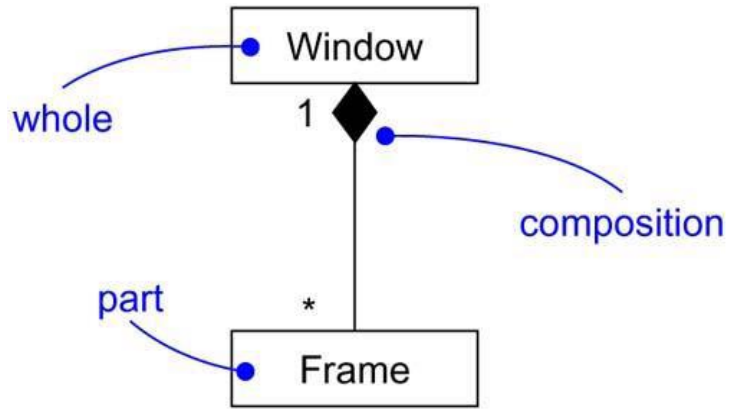


Relationships between classes: Composition

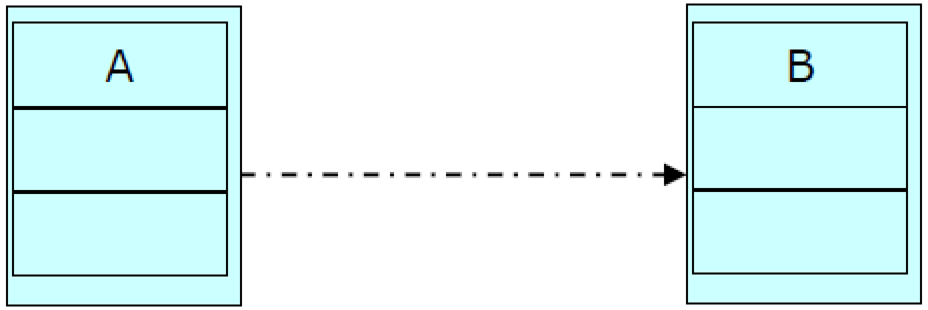
- Composition
  - A contains 1 or more B
  - B is created by A



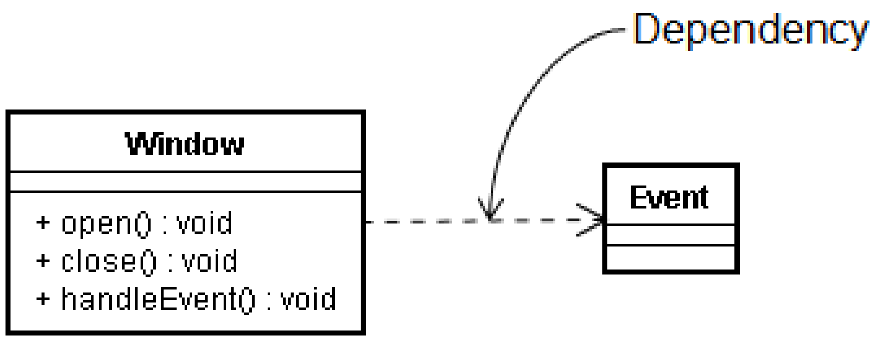
- Variation of simple aggregation: introduces a strong ownership and coincident lifetime as part of the whole



Relationships between classes: Dependency

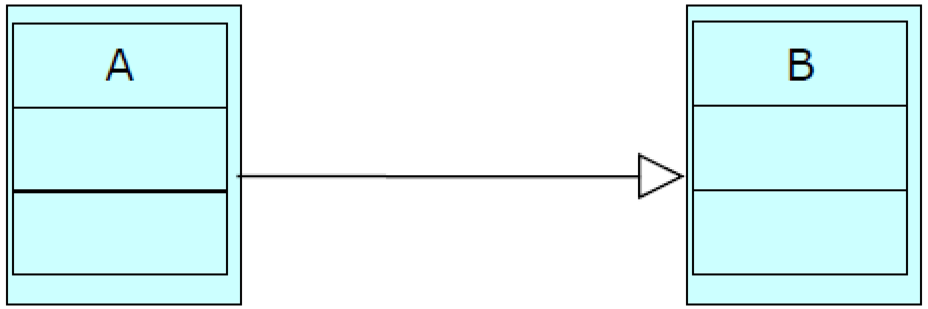


- Dependency
  - A depends on B
- Shows that:
  - one class uses operations from another class, or
  - it uses variables or arguments typed by the other class
  - if the used class changes => the operation of the other class may be affected

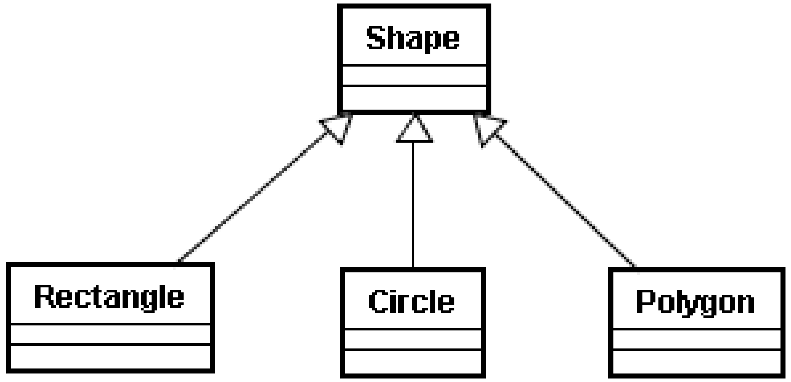


Relationships between classes: Generalization

- Generalization
  - A is a B



- Child class inherits attributes and methods from parent class



Recap today

- ADT
  - Data encapsulation
  - Information hiding
  - Class attributes
  - Instance attributes
  - Static methods

- UML
  - Class diagram
  - Relationships between classes

Next time

- Testing and debugging

Reading materials and useful links

1. The Python Programming Language - https://www.python.org/
2. The Python Standard Library - https://docs.python.org/3/library/index.html
3. The Python Tutorial - https://docs.python.org/3/tutorial/
4. M. Frentiu, H.F. Pop, Fundamentals of Programming, Cluj University Press, 2006.
5. MIT OpenCourseWare, Introduction to Computer Science and Programming in Python, https://ocw.mit.edu, 2016.
6. K. Beck, Test Driven Development: By Example. Addison-Wesley Longman, 2002. http://en.wikipedia.org/wiki/Test-driven_development
7. M. Fowler, Refactoring. Improving the Design of Existing Code, Addison-Wesley, 1999. http://refactoring.com/catalog/index.html