



Lecture 03: Object-Oriented Analysis & Design

IN710: Object-Oriented Systems Development

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LECTURE 02: PYTHON 2 RECAP

- ▶ Functional programming
- ▶ Context managers
- ▶ Other in-built functions

NEW GITHUB SETUP

- ▶ Course materials repository has been archived
- ▶ Create new repository for OOSD
- ▶ Submoduling practicals & course materials repositories

LECTURE 03: OBJECT-ORIENTED ANALYSIS & DESIGN TOPICS

- ▶ Object-oriented paradigm
- ▶ Object-oriented analysis, design & modeling
- ▶ KISS
- ▶ DRY
- ▶ YAGNI
- ▶ SOLID

OBJECT-ORIENTED PARADIGM

- ▶ First OO programming language - Simula
 - ▶ Developed in the 1960s
 - ▶ Norwegian Computing Center
- ▶ First pure OO programming language - Smalltalk
 - ▶ Developed in the 1970s
 - ▶ Learning Research Group at Xerox PARC
- ▶ Objective-C & C++
 - ▶ Developed in the mid-1980s
 - ▶ Brad Cox & Bjarne Stroustrup
- ▶ Dominant programming paradigm
 - ▶ Early & mid-1990s
 - ▶ Rising popularity of GUIs. For example, Cocoa on macOS

OBJECT-ORIENTED ANALYSIS

- ▶ Model of the system's functional requirements
- ▶ Independent of implementation constraints
- ▶ Requirements organised around objects
- ▶ Behaviours (processes) & states (data) modeled after real world objects
 - ▶ Considered separately. For example, flows charts (behaviours) & entity-relationship diagrams (states)
- ▶ Common models - use cases & object models

OBJECT-ORIENTED DESIGN

- ▶ Planning a system of interacting objects
- ▶ Purpose of solving a software problem
- ▶ Applying implementation constraints to the conceptual model
- ▶ Designing software architectures by applying architectural patterns & design patterns

OBJECT-ORIENTED MODELING

- ▶ Common approach to modeling applications & systems
- ▶ A technique heavily used by both OOA & OOD
- ▶ Modeling of dynamic behaviour
- ▶ Modeling of static structures
- ▶ Benefits of OOM:
 - ▶ Efficient & effective communication
 - ▶ Useful & stable abstraction

LEARNING ACTIVITY: SYSTEM DESIGN (30 MINUTES)

- ▶ In groups of three or four, design a URL shortener
- ▶ Why do we need a URL shortener?
- ▶ System requirements
 - ▶ Functional
 - ▶ Non-functional
- ▶ Constraints
- ▶ Database design
- ▶ System design & algorithm

KISS

- ▶ Keep it simple stupid
- ▶ Noted by the U.S. Navy in 1960
- ▶ Simplicity in design
- ▶ Unnecessary complexity should be avoided
- ▶ Cyclomatic complexity (code smell)
- ▶ ValueError exception

```
def cyclomatic_complexity(day):  
    if day == 1:  
        return 'Monday'  
    elif day == 2:  
        return 'Tuesday'  
    elif day == 3:  
        return 'Wednesday'  
    elif day == 4:  
        return 'Thursday'  
    elif day == 5:  
        return 'Friday'  
    elif day == 6:  
        return 'Saturday'  
    elif day == 7:  
        return 'Sunday'  
    else:  
        raise ValueError('day must be between 1 & 7. ')  
  
print(cyclomatic_complexity(6))
```

KISS

► Code refactoring

```
def cyclomatic_complexity(day):  
    days = ('Monday', 'Tuesday', 'Wednesday',  
            'Thursday', 'Friday', 'Saturday', 'Sunday')  
    if day >= 1 and day <= 7:  
        return days[day - 1]  
    else:  
        raise ValueError('day must be between 1 & 7. ')  
  
print(cyclomatic_complexity(6))
```

DRY

- ▶ Don't repeat yourself
- ▶ Reduce repetition of information
- ▶ Single representation
- ▶ WET

YAGNI

- ▶ You aren't gonna need it
- ▶ Principle of extreme programming (XP)
- ▶ Functionality shouldn't be added until deemed necessary

SOLID

- ▶ Single responsibility
- ▶ Open-closed
- ▶ Liskov substitution
- ▶ Interface segregation
- ▶ Dependency inversion

SINGLE RESPONSIBILITY

- ▶ Every module, class & function should have a single responsibility
- ▶ Responsibility should be encapsulated by the module, class or function
- ▶ God object (anti-pattern)

SINGLE RESPONSIBILITY

- ▶ Computer class
- ▶ Two responsibilities - CPU & RAM

```
class Computer:
    def fetch(self):
        print('Fetching ... ')

    def decode(self):
        print('Decoding ... ')

    def execute(self):
        print('Executing ... ')

    def read(self):
        print('Reading ... ')

    def write(self):
        print('Writing ... ')
```


SINGLE RESPONSIBILITY

► CPU & RAM class

```
class CPU:
    def fetch(self):
        print('Fetching...')

    def decode(self):
        print('Decoding...')

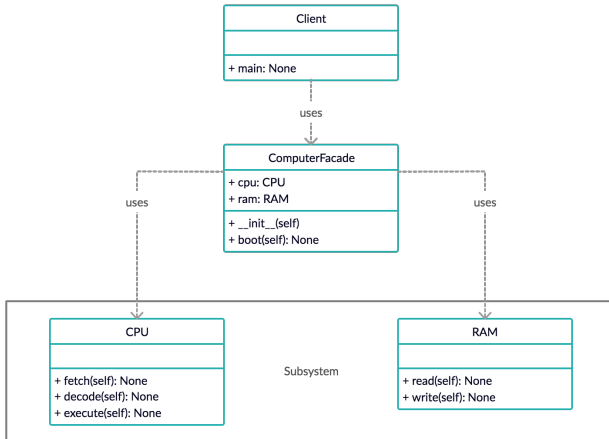
    def execute(self):
        print('Executing...')

class RAM:
    def read(self):
        print('Reading...')

    def write(self):
        print('Writing...')
```

FAÇADE PATTERN: UML

- Consider the following UML diagram:



FAÇADE PATTERN

- ▶ Structural pattern
- ▶ A simple interface to the complex logic of one or several subsystems
- ▶ Delegates the client's request(s) to the appropriate objects within the subsystem(s)

```
class ComputerFacade:
    def __init__(self):
        self.cpu = CPU()
        self.ram = RAM()

    def boot(self):
        self.cpu.fetch()
        self.ram.read()
        self.cpu.decode()
        self.ram.write()
        self.cpu.execute()

def main():
    computer_facade = ComputerFacade()
    computer_facade.boot()

if __name__ == '__main__':
    main()
```

OPEN-CLOSED

- ▶ Open for extension
- ▶ Closed for modification
- ▶ Modules, classes & methods

OPEN-CLOSED

► Animal class

```
class Animal:
    def __init__(self, name):
        self._name = name

    @property
    def name(self):
        return self._name

def main():
    animals = (
        Animal('Cow'),
        Animal('Pig')
    )

    for a in animals:
        if a.name == 'Cow':
            print('Moo!')
        elif a.name == 'Pig':
            print('Oink!')

if __name__ == '__main__':
    main()  # Moo!
           # Oink!
```

OPEN-CLOSED

- If we want to add a new animal, we have to modify the main function

```
class Animal:
    def __init__(self, name):
        self.__name = name

    @property
    def name(self):
        return self.__name

def main():
    animals = (
        Animal('Cow'),
        Animal('Pig'),
        Animal('Sheep')
    )

    for a in animals:
        if a.name == 'Cow':
            print('Moo!')
        elif a.name == 'Pig':
            print('Oink!')
        elif a.name == 'Sheep':
            print('Baa!')

if __name__ == '__main__':
    main()  # Moo!
           # Oink!
           # Baa!
```

OPEN-CLOSED

- ▶ Cow, Pig & Sheep class extend from the Animal class
- ▶ Each child class has their own implementation of the sound() abstract method

```
from abc import ABC, abstractmethod
```

```
class Animal(ABC):  
    def __init__(self, name):  
        self._name = name
```

```
    @property  
    def name(self):  
        return self._name
```

```
    @abstractmethod  
    def sound(self):  
        pass
```

```
class Cow(Animal):  
    def sound(self):  
        print('Moo!')
```

```
class Pig(Animal):  
    def sound(self):  
        print('Oink!')
```

```
class Sheep(Animal):  
    def sound(self):  
        print('Baa!')
```

LISKOV SUBSTITUTION

- ▶ Barbara Liskov - Turing Award winner
- ▶ If S is a subtype of T then objects of type T may be replaced with objects of type S without altering any of the desirable properties of the program
- ▶ Strong behavioural subtyping
- ▶ **Task 2 in today's practical - square/rectangle problem**
- ▶ Git commands:
 - ▶ `$ git submodule add jURL to repository`
 - ▶ `$ git submodule foreach git pull`

INTERFACE SEGREGATION

- ▶ First used by Robert C. Martin while consulting at Xerox
- ▶ Xerox had created a new printer system that could perform a variety of tasks
- ▶ The software for this system was created from the ground up
- ▶ As the software grew, making modifications became more & more difficult
- ▶ The design problem was a single class was used by almost all of the tasks
- ▶ Clients shouldn't be forced to depend upon interfaces that they don't use

INTERFACE SEGREGATION

- ▶ Circle & Square class extend from the Shape class
- ▶ Each child class has their own implementation of the draw_circle() & draw_square() abstract method

```
from abc import ABC, abstractmethod
```

```
class Shape(ABC):  
    @abstractmethod  
    def draw_circle(self):  
        pass
```

```
    @abstractmethod  
    def draw_square(self):  
        pass
```

```
class Circle(Shape):  
    def draw_circle(self):  
        pass
```

```
    def draw_square(self):  
        pass
```

```
class Square(Shape):  
    def draw_circle(self):  
        pass
```

```
    def draw_square(self):  
        pass
```

INTERFACE SEGREGATION

- Each child class has their own implementation of the draw() abstract method

```
from abc import ABC, abstractmethod
```

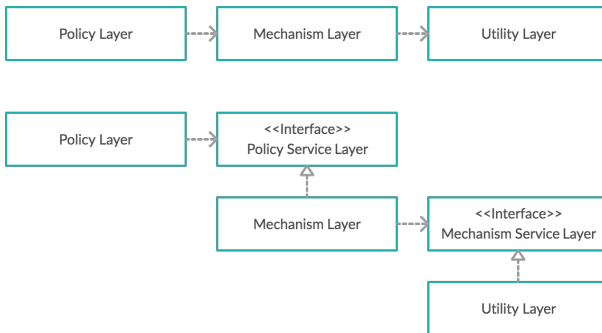
```
class Shape(ABC):  
    @abstractmethod  
    def draw(self):  
        pass
```

```
class Circle(Shape):  
    def draw(self):  
        pass
```

```
class Square(Shape):  
    def draw(self):  
        pass
```

DEPENDENCY INVERSION

- ▶ High-level modules shouldn't depend on low-level modules
- ▶ Both should depend on abstractions
- ▶ Abstractions shouldn't depend on details
- ▶ Details should depend on abstractions



DEPENDENCY INVERSION

► Calculator class

```
class Calculator:
    def addition(self, num.1, num.2):
        return num.1 + num.2

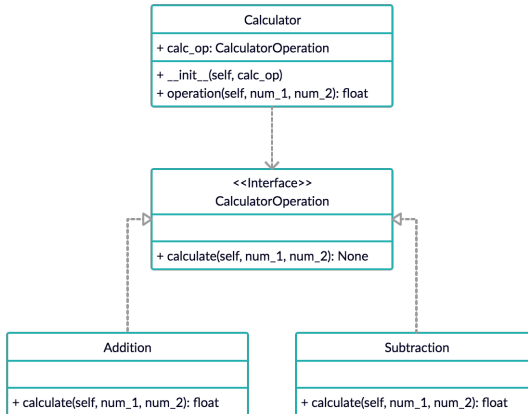
    def subtraction(self, num.1, num.2):
        return num.1 - num.2

def main():
    calc = Calculator()
    print(calc.addition(10, 5))
    print(calc.subtraction(10, 5))

if __name__ == '__main__':
    main() # 15
          # 5
```

DEPENDENCY INVERSION: UML

- Consider the following UML diagram:



DEPENDENCY INVERSION

► Dependency injection via constructor

```
from abc import ABC, abstractmethod

class CalculatorOperation(ABC):
    @abstractmethod
    def calculate(self, num_1, num_2):
        pass

class Calculator:
    def __init__(self, calc_op):
        self.calc_op = calc_op

    def operation(self, num_1, num_2):
        return self.calc_op.calculate(num_1, num_2)

class Addition(CalculatorOperation):
    def calculate(self, num_1, num_2):
        return num_1 + num_2

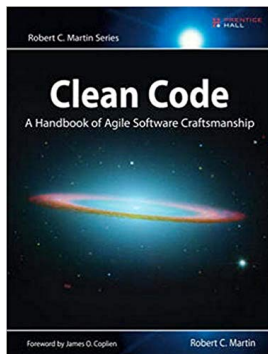
class Subtraction(CalculatorOperation):
    def calculate(self, num_1, num_2):
        return num_1 - num_2

def main():
    addition = Calculator(Addition())
    subtraction = Calculator(Subtraction())
    print(addition.operation(10, 5))
    print(subtraction.operation(10, 5))

if __name__ == '__main__':
    main() # 15
          # 5
```

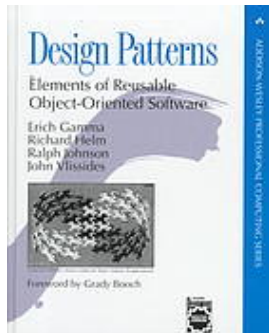
RECOMMENDED READING

- ▶ Clean Code: A Handbook of Agile Software Craftsmanship
- ▶ Robert C. Martin



RECOMMENDED READING

- ▶ Design Patterns: Elements of Reusable Object-Oriented Software
- ▶ Gang of Four (GoF)



PRACTICAL

- ▶ Series of tasks covering today's lecture
- ▶ Worth 1% of your final mark for the Object-Oriented Systems Development course
- ▶ Deadline: Tuesday, 10 March at 5pm

LECTURE 04: EXCEPTIONS & AUTOMATION TESTING TOPICS

- ▶ Syntax errors
- ▶ Exceptions
- ▶ Automation testing
 - ▶ Unit testing
 - ▶ Integration testing
 - ▶ End-end testing
 - ▶ User acceptance testing
- ▶ Software development testing practices
 - ▶ Test-driven development
 - ▶ Behaviour-driven development
 - ▶ Continuous integration