UML. Design Principles.

Arthur Molnar

Babes-Bolyai University

arthur@cs.ubbcluj.ro

November 11, 2015

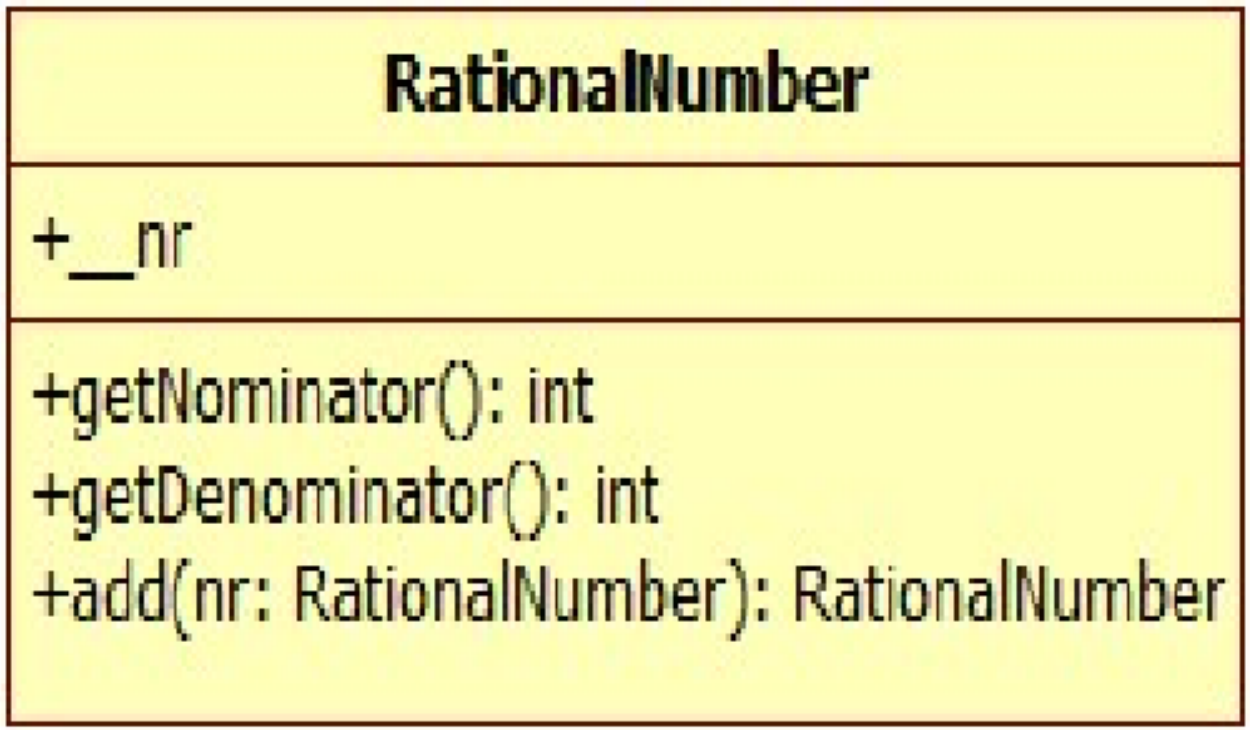
Overview

UML Diagrams

- **Unified Modeling Language (UML)** - a standardized general-purpose modeling language in the field of object-oriented software engineering.
- UML includes a set of graphic notation techniques to create visual models of object-oriented software.

Class Diagrams

UML Class diagrams - describe the structure of a system by showing the system's classes, their attributes, and the relationships between them.



Class Diagrams


```
class RationalNumber:
    def __init__(self, a, b):
        """
          Initialize a rational number
          a,b integer numbers
        """
        self.__nr = [a, b]
    def getDenominator(self):
        """
           Getter method return the
denominator
        """
        return self.__nr[1]
    def getNominator(self):
        """"
          Getter method return the nominator
        """
        return self.__nr[0]
    def add(self, a):
```

Class Diagrams

In the diagram classes are represented using boxes which contain three parts:

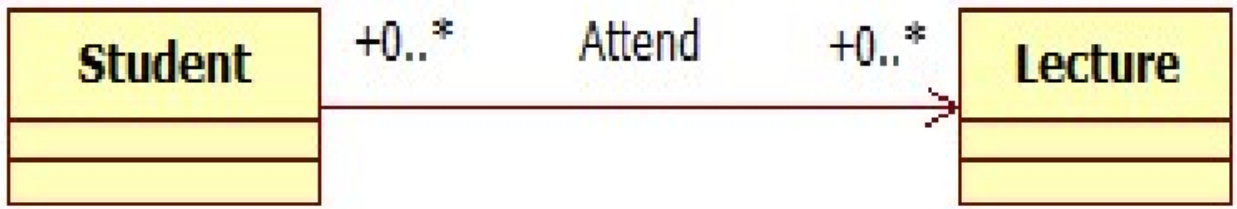
- The upper part holds the name of the class
- The middle part contains the attributes of the class
- The bottom part contains the methods or operations

Relationships

- A relationship is a general term covering the specific types of logical connections found on class diagrams.
- A *Link* is the basic relationship among objects. It is represented as a line connecting two or more object boxes.

Associations

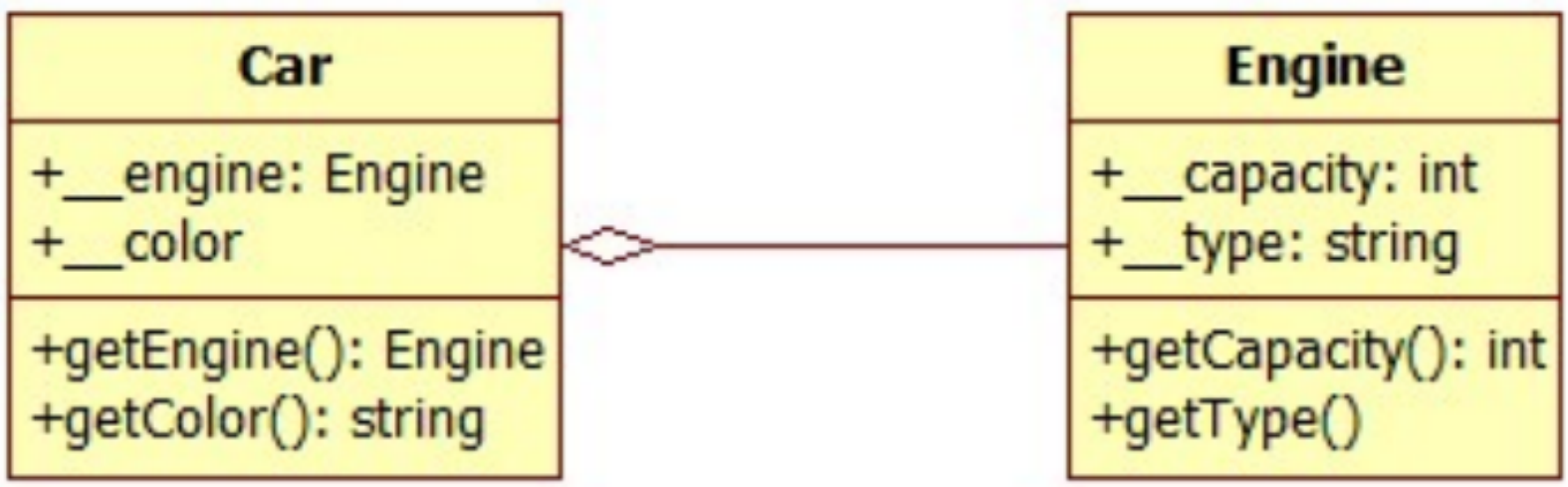
Binary associations (with two ends) are normally represented as a line, with each end connected to a class box.



An association can be named, and the ends of an association can be annotated with role names, ownership indicators, multiplicity, visibility, and other properties. Association can be Bi-directional as well as uni-directional.

Aggregation

Aggregation - an association that represents a part-whole or part-of relationship.



Aggregation

Aggregation - an association that represents a part-whole or part-of relationship.

```
class Car:
    def __init__(self,eng,col):
        """
          Initialize a car
          eng - engine
          col - string, ie White
        """
        self.__engine = eng
        self.__color = col
```

```
class Engine:
    def __init__(self,cap,type):
        """
          initialize the engine
          cap positive integer
          type string
        """
        self.__capacity = cap
        self.__type = type
```

Aggregation


```
class Car:
    def __init__(self,eng,col):
        """
          Initialize a car
          eng - engine
          col - string, ie White
        """
        self.__engine = eng
        self.__color = col
    def getColor(self):
        """
          Getter method for color
          return string
        """
        return self.__color
    def getEngine(self):
        """
          Getter method for engine
          return engine
        """
        return self.__engine
```

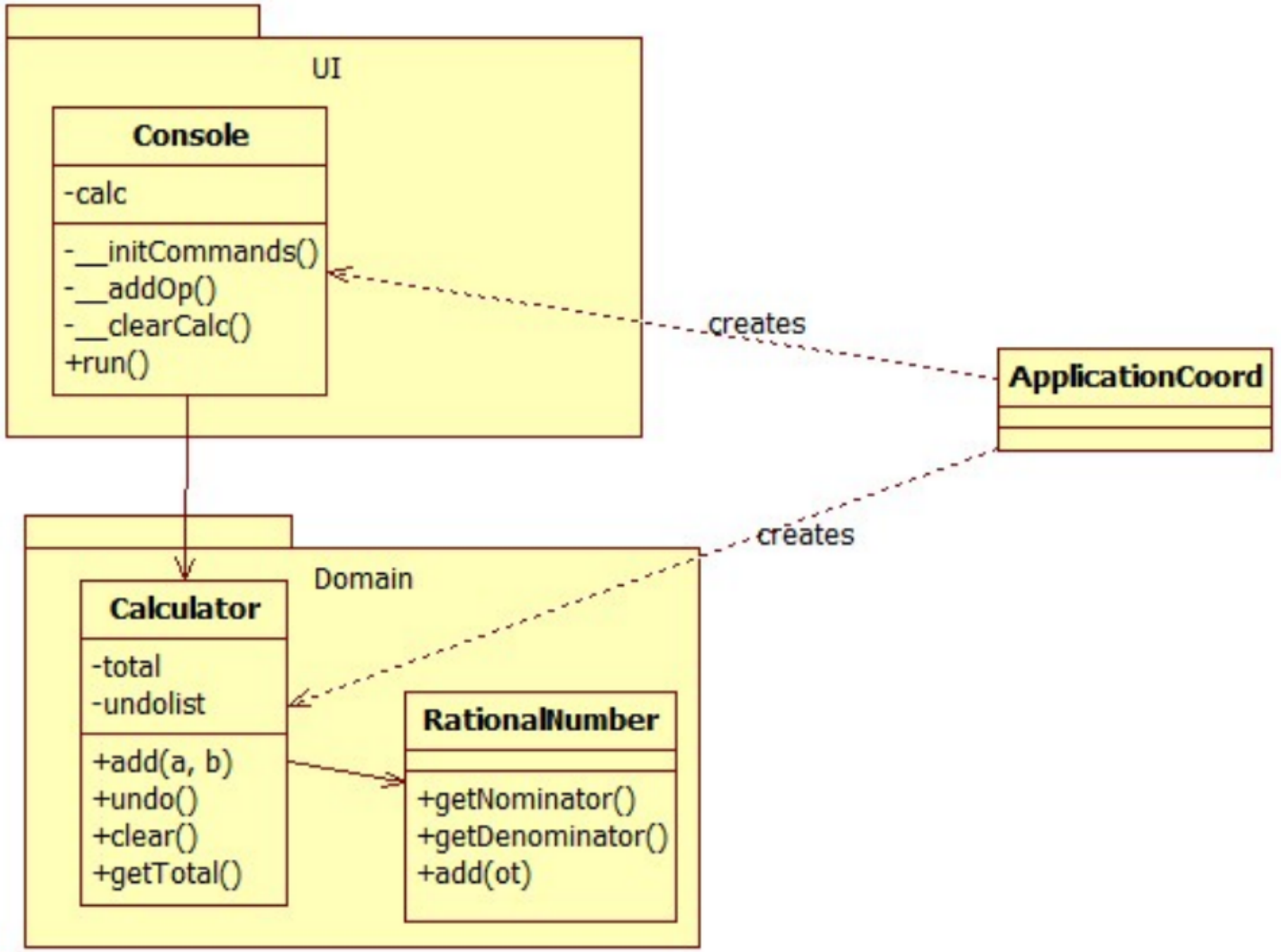
```
class Engine:
    def __init__(self,cap,type):
        """
          initialize the engine
          cap positive integer
          type string
        """
        self.__capacity = cap
        self.__type = type

    def getCapacity(self):
        """
       Getter method for the capacity
        """
        return self.__capacity
    def getType(self):
        """
         Getter method for type
         return string
        """
        return self.__type
```

Dependency, Package

Dependency - a relationship in which one element, the client, uses or depends on another element, the supplier

- Create instances
- Have a method parameter
- Use an object in a method

Dependency, Package



Design principles

Create software:

- Easy to understand, modify, maintain, test
- Classes - abstract, encapsulate, hide implementation, easy to test, easy to reuse

General scope: **managing dependency**

- Single responsibility
- Separation of concerns
- Low Coupling
- High Cohesion

Design principles

Problem statement
Write a program for managing students (CRUD operations – **C**reate **R**ead **U**pdate **D**elete)

	Features
F1	create a student
F2	list students
F3	find a student
F4	delete student

Iteration Plan IT1 - F1; IT2 - F2; IT3 - F3; IT4 - F4

Running scenario

user	app	description
‘a’		add a student
	give student id	
1		
	give name	
‘Ion’		
	new student added	
‘a’		add student
	give student id	
1		
	give name	
‘’		
	id already exists, name can not be empty	

Layered architecture

- **Layer** - a logical structuring mechanism for the elements that make up your software solution
- A multilayered software architecture is using different layers for allocating the responsibilities of an application.
- A layer is a group of classes (or modules) that have the same set of module dependencies to other modules and are reusable in similar circumstances.

Layered architecture

Layers our programs will use...

- **User Interface Layer** (aka View Layer, UI layer or Presentation layer)
- **Application Layer** (aka Service Layer or GRASP Controller Layer)
- **Domain layer** (Business Layer, Business logic Layer or Model Layer)
- **Infrastructure Layer** (data access or other persistence, logging, network I/O e.g. sending emails, and other kind of technical services)

GRASP patterns

General Responsibility Assignment Software Patterns (or **Principles**) consists of guidelines for assigning responsibility to classes and objects in object oriented design.

- High Cohesion
- Low Coupling
- Information Expert
- Controller
- Protected Variations
- Creator
- Pure Fabrication

High Cohesion

- **High Cohesion** - an evaluative pattern that attempts to keep objects appropriately focused, manageable and understandable.
- High cohesion means that the responsibilities of a given element are strongly related and highly focused.
- Breaking programs into classes and subsystems is an example of activities that increase the cohesive properties of a system.
- Alternatively, low cohesion is a situation in which a given element has too many unrelated responsibilities. Elements with low cohesion often suffer from being hard to comprehend, hard to reuse, hard to maintain and adverse to change

Low Coupling

Assign responsibilities so that coupling remains low

Low Coupling dictates how to assign responsibilities to support:

- Low dependency between classes;
- Low impact in a class of changes in other classes;
- High reuse potential

Low Coupling

Form of coupling:

- TypeX has an attribute (field) that refers to a TypeY instance, or TypeY itself.
- TypeX has a method which references an instance of TypeY, or TypeY itself, by any means. (parameter, local variable, return value, method invocation)
- TypeX is a direct or indirect subclass of TypeY.

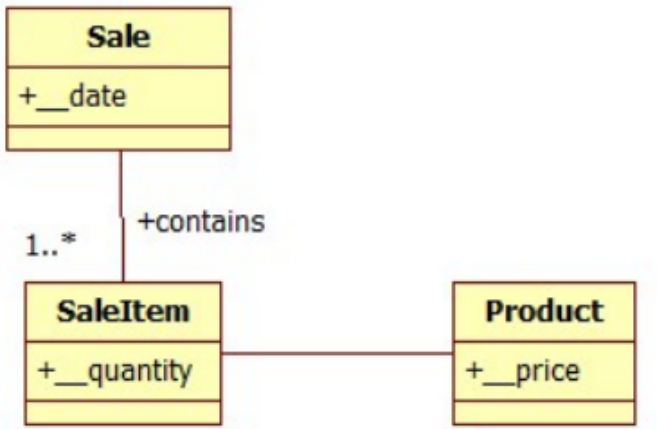
Information Expert

Assign a responsibility to the class that has the information necessary to fulfill the responsibility.

- **Information Expert** is a principle used to determine where to delegate responsibilities. These responsibilities include methods, computed fields and so on.
- Using the principle of Information Expert a general approach to assigning responsibilities is to look at a given responsibility, determine the information needed to fulfil it, and then determine where that information is stored.
- Information Expert will lead to placing the responsibility on the class with the most information required to fulfil it

Information Expert

Point of Sale application



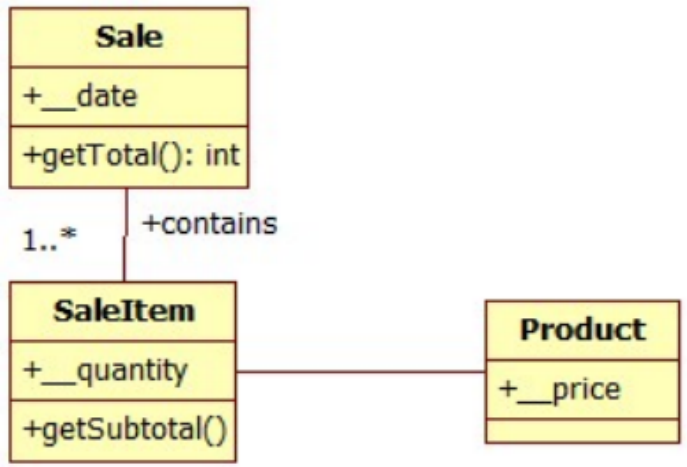
Who is responsible with computing the total?

Wee need all the SaleItems to compute the total.

Information Expert → **Sale**

Information Expert

Point of Sale application



According to the Expert

SaleItem should be responsible with computing the subtotal (quantity * price)

Information Expert

Point of Sale application

1. Maintain encapsulation of information
2. Promotes low coupling
3. Promotes highly cohesive classes
4. Can cause a class to become excessively complex

Creator

- Creation of objects is one of the most common activities in an object - oriented system. Which class is responsible for creating objects is a fundamental property of the relationship between objects of particular classes.

Creator

- Creator pattern is responsible for creating an object of the class. In general, a class B should be responsible for creating instances of class A if one, or preferably more, of the following apply:
  - Instances of B contains or compositely aggregates instances of A
  - Instances of B record instances of A
  - Instances of B closely use instances of A
  - Instances of B have the initializing information for instances of A and pass it on creation.

Work Items

	Task
T1	Create Student
T2	Validate student
T3	Store student (Create repository)
T4	Add student (Create Controller)
T5	Create UI

Creator

Task: create Student

```
def testCreateStudent():
    """
      Testing student creation
    """
    st = Student("1", "Ion", "Adr")
    assert st.getId() == "1"
    assert st.getName() == "Ion"
    assert st.getAdr() == "Adr"
```

```
class Student:
    def __init__(self, id, name, adr):
        """
         Create a new student
         id, name, address String
        """
        self.id = id
        self.name = name
        self.adr = adr

    def getId(self):
        return self.id

    def getName(self):
        return self.name

    def getAdr(self):
        return self.adr
```

Protected Variations

- How responsibilities should be assigned in such a fashion that the current or future variations in the system do not cause major problems with system operation and/or revision?
- Create new classes to encapsulate such variations.
- The **protected variations** pattern protects elements from the variations on other elements (objects, systems, subsystems) by wrapping the focus of instability to a separate class. (with an interface and using polymorphism to create various implementations of this interface).

Protected Variations

Task: Validate student, possible validation designs

- A class member function in Student that returns true/false
- A static function returning the list of errors
- A separate class that encapsulate the validation algorithm

Validator class - The protected variations pattern protects elements from the variations on other elements (objects, systems, subsystems) by wrapping the focus of instability to a separate class

Protected Variations

Task: Validate student

```
def testStudentValidator():
    """
      Test validate functionality
    """
  validator = StudentValidator()
  st = Student("", "Ion", "str")
    try:
        validator.validate(st)
        assert False
    except ValueError:
        assert True
    st = Student("", "", "")
    try:
        validator.validate(st)
        assert False
    except ValueError:
        assert True
```

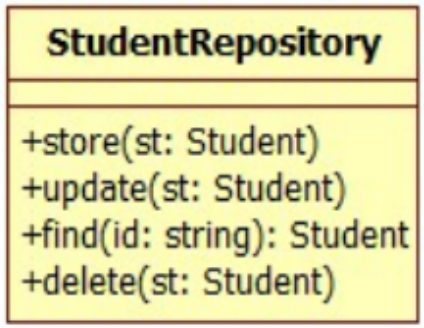
```
class StudentValidator:
    """
      Class responsible with validation
    """
    def validate(self, st):
        """
          Validate a student
          st - student
          raise ValueError
         if: Id, name or address is empty
        """
      errors = ""
      if (st.id==""):
         errors+="Id can not be empty;"
      if (st.name==""):
         errors+="Name can not be empty;"
      if (st.adr==""):
         errors+="Address can not be
empty"
      if len(errors)>0:
        raise ValueError(errors)
```

Pure Fabrication

- When an expert violates high cohesion and low coupling
- Assign a highly cohesive set of responsibilities to an artificial class that does not represent anything in the problem domain, in order to support high cohesion, low coupling, and reuse
- **Pure Fabrication** - a class that does not represent a concept in the problem domain is specially made up to achieve low coupling, high cohesion
- Problem: Store **Student** (in memory, file or database)
- **Expert** pattern? Student is the "expert" to perform this operation

Pure Fabrication - Repository

- Problem: Store **Student** (in memory, file or database)
- **Expert** pattern - Student is the "expert" to perform this operation. But putting this responsibility into the Student class will result in low cohesion, poor reuse
- Solution - **Pure Fabrication**



Class created with the responsibility to store Students

The Student class easy to reuse, has High cohesion, Low coupling

Repository will deal with the problem of managing a list o students (persistent storage)

Repository Pattern

A **repository** represents all objects of a certain type as a conceptual set. Objects of the appropriate type are added and removed, and the machinery behind the REPOSITORY inserts them or deletes them from a persistent storage.

Repository Pattern

Task: Create repository

```
def testStoreStudent():
    st = Student("1", "Ion", "Adr")
    rep = InMemoryRepository()
    assert rep.size()==0
    rep.store(st)
    assert rep.size()==1
    st2 = Student("2", "Vasile", "Adr2")
    rep.store(st2)
    assert rep.size()==2
    st3 = Student("2", "Ana", "Adr3")
    try:
        rep.store(st3)
        assert False
    except ValueError:
        pass
```

Task: Create repository

```
class InMemoryRepository:
    """
     Manage the store/retrieval of students
    """
    def __init__(self):
        self.students = {}

    def store(self, st):
        """
          Store students
          st is a student
          raise RepositoryException if we have a student with the same id
        """
        if st.getId() in self.students:
            raise ValueError("A student with this id already exist")

        if (self.validator!=None):
            self.validator.validate(st)

        self.students[st.getId()] = st
```

GRASP Controller

- Decouple the event source(s) from the objects that actually handle the events.
- **Controller** is defined as the first object beyond the UI layer that receives and coordinates ("controls") a system operation.
- The controller should delegate to other objects the work that needs to be done; it coordinates or controls the activity. It should not do much work itself.
- Controller encapsulate knowledge about the current state of a use case presentation layer decoupled from problem domain

Task: create controller

First create the test...

```
def tesCreateStudent():
    """
      Test store student
    """
    rep = InMemoryRepository()
    val = StudentValidator()
    ctr = StudentController(rep, val)
    st = ctr.createStudent("1", "Ion", "Adr")
    assert st.getId()=="1"
    assert st.getName()=="Ion"
    try:
        st = ctr.createStudent("1", "Vasile", "Adr")
        assert False
    except ValueError:
        pass
    try:
        st = ctr.createStudent("1", "", "")
        assert False
    except ValueError:
        pass
```

Task: create controller

Student Controller...

```
class StudentController:
    """
      Use case controller for CRUD Operations on student
    """
    def __init__(self, rep, validator):
        self.rep = rep
        self.validator = validator

    def createStudent(self, id, name, adr):
        """
          store a student
          id, name, address of the student as strings
          return the Student
          raise ValueError if a student with this id already exists
          raise ValueError if the student is invalid
        """
        st = Student(id, name, adr)
        if (self.validator!=None):
            self.validator.validate(st)
        self.rep.store(st)
        return st
```

Application coordinator

- **Dependency injection** - a design pattern in object-oriented computer programming whose purpose is to reduce the coupling between software components.
- Frequently an object uses (depends on) work produced by another part of the system.
- With **DI**, the object does not need to know in advance about how the other part of the system works. Instead, the programmer provides (injects) the relevant system component in advance along with a contract that it will behave in a certain way

Assemble everything


```
#create validator
validator = StudentValidator()
#crate repository
rep = InMemoryRepository(None)
#create console provide(inject) a validator and a repository
ctr = StudentController(rep, validator)
#create console provide controller
ui = Console(ctr)
ui.showUI()
```

Review the sample application and outline the used patterns