Lecture 8: Program Testing

- **Associations, Data transfer objects**
- **Program testing/debugging**
- **Program inspection**

Layered architecture – GUI Example

Tkinter is the most commonly used GUI toolkit for Python (available on most Unix platforms, as well as on Windows and Macintosh systems)

Review StudentCRUD application with GUI

Tkinter (or any other python GUI toolkit) is not a requirement for the exam

Associations

In real life, there are lots of many-to-many associations

In a software these general associations complicate implementation and maintenance

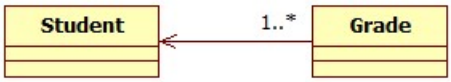
- bidirectional association means that both objects can be understood only together

It is important to constrain relationships as much as possible:

- Imposing a traversal direction
- Adding a qualifier, reduce multiplicity
- Eliminating nonessential associations

Associations

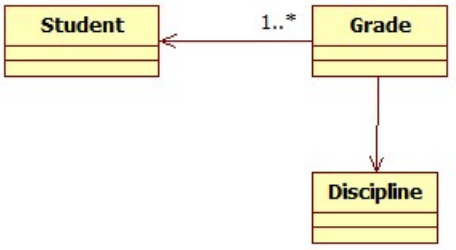
Catalog example

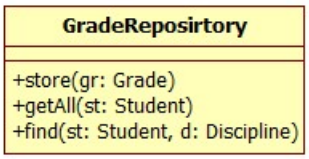



```
gr = ctr.assign("1", "FP", 10)
assert gr.getDiscipline()=="FP"
assert gr.getGrade()==10
assert gr.getStudent().getId()=="1"
assert
gr.getStudent().getName()=="Ion"
```

```
st = Student("1", "Ion",
       Address("Adr", 1, "Cluj"))

rep = GradeRepository()
grades = rep.getAll(st)
assert grades[0].getStudent()==st
assert grades[0].getGrade()==10
```

Client Code Ignores Repository Implementation; Developers Do Not

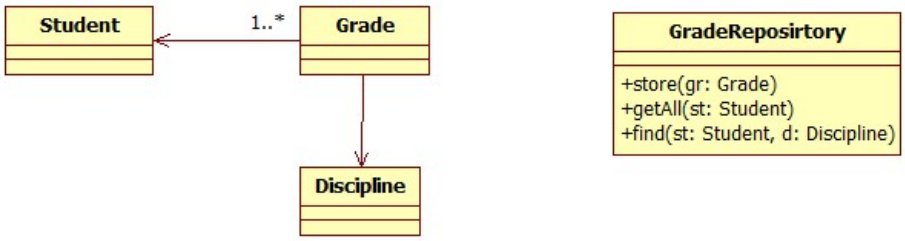




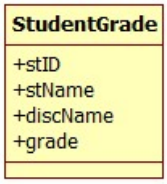

```
def store(self, gr):
        """
          Store a grade
          post: grade is in the repository
          raise GradeAlreadyAssigned exception if we already have a grade
                        for the student at the given discipline
          raise RepositoryException if there is an IO error when writing to
              the file
        """
        if self.find(gr.getStudent(), gr.getDiscipline())!=None:
            raise GradeAlreadyAssigned()

        #open the file for append
        try:
            f = open(self.__fname, "a")
            grStr = gr.getStudent().getId()+","+gr.getDiscipline()
            grStr =grStr+","+str(gr.getGrade())+"\n"
            f.write(grStr)
            f.close()
        except IOError:
            raise RepositorException("Unable to write a grade to the file")
```

Data transfer objects

Functionality: Show the best 5 students at a given discipline. Show a table containing the name of the student and his grade at the disicipline



Create a new class that contains just the needed information to implement the requested functionality



Program testing

Testing is observing the behavior of a program in many executions.
Execute the program for some input data and observe if the results are correct for these inputs.

Testing does not prove program correctness (only give us some confidence). On the contrary, it may prove its incorrectness if one execution give wrong results.

Testing can never completely identify all the defects within software.

Testing methods

Exhaustive testing

Check the program for all possible inputs.
Impractical so we need to choose a finite number of test cases.

Black box testing

The selection of input data for testing is decided by analyzing the specification. Distinct cases of the problem are decided and we use a test input data for each case

White box testing

Select the test data by analyzing the text of the program. We select test data such that all the execution paths are covered.
We test a function such that each statement is executed.

White box vs Black Box testing

```
def isPrime(nr):
    """
      Verify if a number is prime
      return True if nr is prime False if not
      raise ValueError if nr<=0
    """
    if nr<=0:
        raise ValueError("nr need to be positive")
    if nr==1:#1 is not a prime number
        return False
    if nr<=3:
        return True
    for i in range(2,nr):
        if nr%i==0:
            return False
    return True
```

Black Box

- test case for a prime/not prime
- test case for 0
- test case for negative number

White Box (cover all the paths)

- test case for 0
- test case fot negative
- test case for 1
- test case 3
- test case for prime (no divider)
- test case for not prime

```
def blackBoxPrimeTest():
    assert (isPrime(5)==True)
    assert (isPrime(9)==False)
    try:
        isPrime(-2)
        assert False
    except ValueError:
        assert True
    try:
        isPrime(0)
        assert False
    except ValueError:
        assert True
```

```
def whiteBoxPrimeTest():
    assert (isPrime(1)==False)
    assert (isPrime(3)==True)
    assert (isPrime(11)==True)
    assert (isPrime(9)==True)
    try:
        isPrime(-2)
        assert False
    except ValueError:
        assert True
    try:
        isPrime(0)
        assert False
    except ValueError:
        assert True
```

Testing levels

Tests are frequently grouped by where they are added in the software development process, or by the level of specificity of the test.

Unit testing

Unit testing refers to tests that verify the functionality of a specific section of code, usually at the function level.
Testing unit of code in isolation (functions). Test small parts of the program independently

Integration testing

Considers the way program works as a whole. After all modules have been tested and corrected we need to verify the overall behavior of the program.

Automated testing

Test automation is the process of writing a computer program to do testing that would otherwise need to be done manually.
use of software to control the execution of tests, the comparison of actual outcomes to predicted outcomes, the setting up of test preconditions

TDD:

TDD Steps:

- automated test cases
- writing specification (inv, pre/post)
    - throwing or not exceptions
- production code

Python unit testing framework (PyUnit)

unittest module supports:

- test automation
- sharing of setup and shutdown code for tests
- aggregation of tests into collections
- independence of the tests from the reporting framework

```
import unittest
class TestCase(unittest.TestCase):
    def setUp(self):
        #code executed before every testMethod
        val=StudentValidator()
        self.ctr=StudentController(val, StudentRepository())
        st = self.ctr.create("1", "Ion", "Adr", 1, "Cluj")

    def tearDown(self):
        #cleanup code executed after every testMethod

    def testCreate(self):
        self.assertTrue(self.ctr.getNrStudents()==1)
        #test for an invalid student
        self.assertRaises(ValidationEx,self.ctr.create,"1", "", "", 1, "Cj")

        #test for duplicated id
        self.assertRaises(DuplicatedIDException,self.ctr.create,"1", "I",
                                                                "A", 1, "j")

    def testRemove(self):
        #test for an invalid id
        self.assertRaises(ValueError,self.ctr.remove,"2")

        self.assertTrue(self.ctr.getNrStudents()==1)

        st = self.ctr.remove("1")
        self.assertTrue(self.ctr.getNrStudents()==0)
        self.assertEquals(st.getId(),"1")
        self.assertTrue(st.getName()=="Ion")
        self.assertTrue(st.getAdr().getStreet()=="Adr")


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

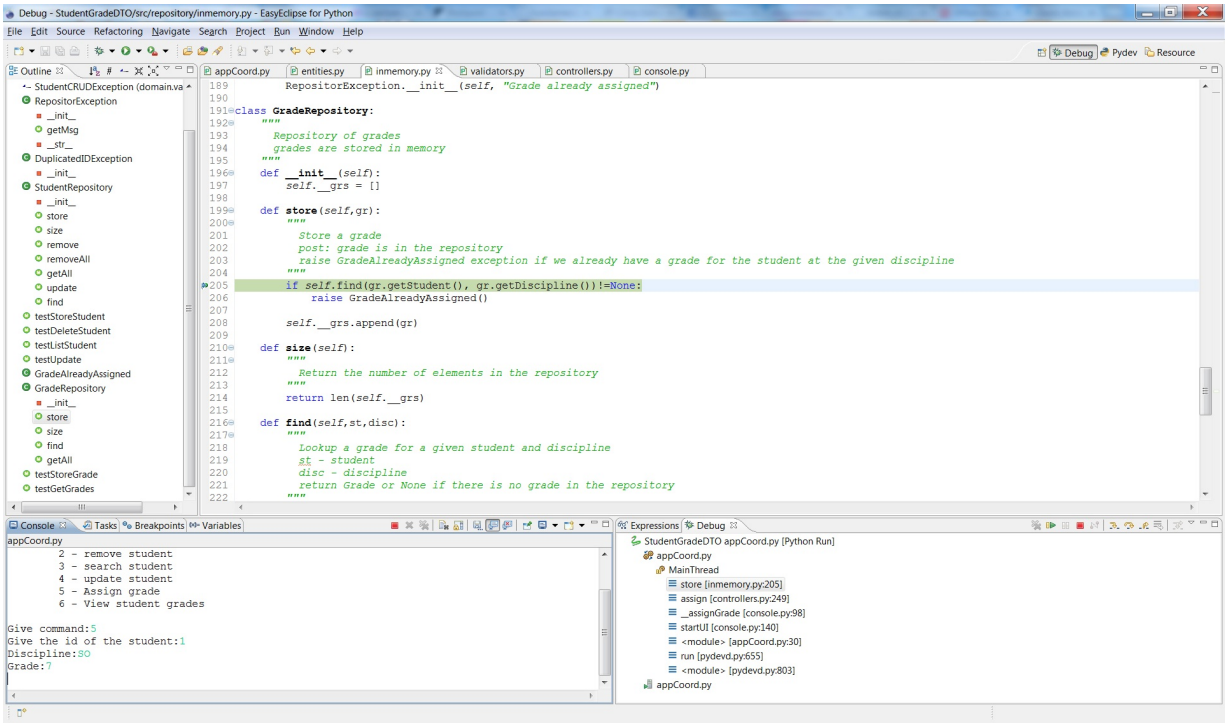
Debugging

Debugging is the activity that must be performed when testing indicates the presence of errors, to find errors, and rewrite the program with the purpose of eliminating the errors.

- using print statement
- using IDE

Debugging is the most unpleasant activity. Debugging must be **avoided.**

Eclipse debug perspective



Debug view

- wiew the current execution trace (stack trace)
- execute step by step, resume/pause execution

Variables view

- view variable values

Program inspection

Any fool can write code that a computer can understand. Good programmers write code that humans can understand

Programming style consist of all the activities made by a programmer for producing products easy to read, and easy to understand, and the way in which these qualities are achieved

Coding style (classes, functions)

Readability is considered the main attribute of style.
A program, like any publication, is a text must be read and understand by another programmer.
The element of coding style are:

- comments
- text formatting (indentation, white spaces)
- specification
- good names for entities (classes, functions, variables) of the program
    - meaningful names
    - use naming conventions

Naming conventions:

- class names: Student, StudentRepository
- variable names: student, nrElem (nr_elem)
- function names: getName, getAddress, storeStudent (get_name,get_address, store_student)
- constants: MAX

Whatever convention you use, use them **consistently**.

Refactoring

Refactoring is the process of changing the software system in such a way that it does not alter the external behavior of the code yet improves its internal structure.
It is a disciplined way to clean up the code that minimizes the chances of introducing bugs.

When you need to add a new feature to the program, and the program's code is not structured in a convenient way for adding the new feature, first refactor the code to make it easy to add a feature, then add the feature

Why to refactor

- Refactoring improves the design of the software
- Refactoring makes software easier to understand
- Refactoring helps you find bugs
- Refactoring helps you program faster

Bad smells

When we need to refactor the code

- **Duplicated code**
- **Long method**
- **Large class**
- **Long parameter list**
- **Comments**
- **Divergent change**

    One class is commonly changed in different ways for different reasons

Refactoring - Methods

Rename Method

The name of a method does not reveal its purpose.

Consolidate Conditional Expression

You have a sequence of conditional tests with the same result.
Combine them into a single conditional expression and extract it.

Consolidate Duplicate Conditional Fragments

The same fragment of code is in all branches of a conditional expression.
Move it outside of the expression.

Decompose Conditional

You have a complicated conditional (if-then-else) statement.
Extract methods from the condition, then part, and else parts.

Inline Temp

You have a temp that is assigned to once with a simple expression, and the temp is getting in the way of other refactorings.
Replace all references to that temp with the expression.

Introduce Explaining Variable

You have a complicated expression.
Put the result of the expression, or parts of the expression, in a temporary variable with a name that explains the purpose.

Refactoring - Methods

Remove Assignments to Parameters

The code assigns to a parameter.
Use a temporary variable instead.

Remove Control Flag

You have a variable that is acting as a control flag for a series of boolean expressions.
Use a break or return instead.

Remove Double Negative

You have a double negative conditional.

Make it a single positive conditional

Replace Nested Conditional with Guard Clauses

A method has conditional behavior that does not make clear what the normal path of execution is
Use Guard Clauses for all the special cases

Replace Temp with Query

You are using a temporary variable to hold the result of an expression.
Extract the expression into a method. Replace all references to the temp with the expression. The new method can then be used in other methods.

Refactoring - Class

Encapsulate Field

There is a public field.
Make it private and provide accessors.

Replace Magic Number with Symbolic Constant

You have a literal number with a particular meaning.
Create a constant, name it after the meaning, and replace the number with it.

Extract Method

You have a code fragment that can be grouped together.
Turn the fragment into a method whose name explains the purpose of the method.

Move Method

A method is, or will be, using or used by more features of another class than the class on which it is defined.
Create a new method with a similar body in the class it uses most. Either turn the old method into a simple delegation, or remove it altogether.

Move Field

A field is, or will be, used by another class more than the class on which it is defined.
Create a new field in the target class, and change all its users.