Design Principles for Modular Programs

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Overview

Organizing source code

What does it mean to organize source code?

- Determine what code goes where ... d'uh!
- We split code into functions, classes and modules
- The purpose of this section is to discuss a few principles that help us do it correctly

Discussion

What do we mean by **organizing the code correctly?**

Organizing source code

We use a few key design principles that help determine how to organize source code

- Single responsibility principle
- Separation of concerns
- Dependency
- Coupling and cohesion

Single responsibility principle

- Each function should be responsible for one thing
- Each class should represent one entity
- Each module should address one aspect of the application

Single responsibility principle - functions

Let's take the function below as example

- Implements user interaction
- Implements computation
- Prints

```
def filter_score(scoreList):
  st = input("Start score:")
  end = input("End score:")
  for score in scoreList:
    if score.get_value() > st and score.get_value()
        < end:
      print(score)
```

Single responsibility principle - functions

Why could the **filter_score** function change?

- The program's input format or channel changes
  - e.g. menu/command based UI as in Assignment 2/3-4
  - How about GUI/web/mobile/voice-based UI?
- The filter has to be updated

NB!

The **filter_score** function has 2 responsibilities

Single responsibility principle - modules

How did we characterize a module?

[modules] ... each of which accomplishes one aspect within the program and contains everything necessary to accomplish this.

Single responsibility principle - modules

Discussion

Is there any similarity between how we design a function and a module?

Single responsibility principle

Multiple responsibilities are...

- Harder to understand and use
- Difficult/impossible to test
- Difficult/impossible to reuse
- Difficult to maintain and evolve

Separation of concerns

- Separate the program into distinct sections
- Each section addresses a particular concern
- **Concern** - information that affects the code of a computer program (e.g. computer hardware that runs the program, requirements, function and module names)
- Correctly implemented, leads to a program that is easy to test and from which parts can be reused

Separation of concerns - example

Let's take the function below as example **(again!)**

```
def filter_score(scoreList):
  st = input("Start score:")
  end = input("End score:")
  for score in scoreList:
    if score.get_value() > st and score.get_value()
        < end:
         print(score)
```

Separation of concerns - the UI

The refactored function below only addresses the UI, functionalities are delegated to the **filter_score** function

```
def filter_score_ui(scoreList):
    st = input("Start score:")
    end = input("End score:")
    result = filter_score(scoreList,st,end)
    for score in result:
        print(score)
```

Separation of concerns - the test

The **filter_score** function can be tested using a testing function such as the one below

```
def test_filter_score():
    lst = [person("Ana",100)]
    assert filter_score(l,10,30)==[]
    assert filter_score(l,1,30)==lst
    lst = [person("Anna",100), person("Ion",40),
           person("P",60)]
    assert filter_score(lst,3,50)==[person("Ion",40)]
```

Separation of concerns - the operation

The **filter_score** function only has one responsibility!

```
def filter_score(lst, st, end):
    '''
    Filter participants
    lst - list of participants
    st, end - integer scores
    return list of participants filtered by score
    '''
    rez = []
    for p in lst:
        if p.get_score() > st and p.get_score() < end:
            rez.append(p)
    return rez
```

Separation of concerns

NB!

These design principles are in many cases interwoven!

Dependency

What is a **dependency**?

- Function level - a function invokes another function
- Class level - a class method invokes a method of another class
- Module level - any function from one module invokes a function from another module

Example

Say we have functions **a**,**b**,**c** and **d**. **a** calls **b**, **b** calls **c** and **c** calls **d**.
What might happen if we change function **d** ?

Coupling

- **Coupling** - a measure of how strongly one element is connected to, has knowledge of, or relies on other elements
- More connections between one module and others, the harder to understand that module, the harder to re-use it in another situation, the harder to test it and isolate failures
- **Low coupling** - facilitates the development of programs that can handle change because they minimize the interdependency between functions/modules

Cohesion

- **Cohesion** - a measure of how strongly related and focused the responsibilities of an element are.
- A module may have:
  - **High Cohesion**: it is designed around a set of related functions
  - **Low Cohesion**: it is designed around a set of unrelated functions
- A cohesive module performs a single task within an application, requiring little interaction with code from other parts of the program.

Cohesion

- Modules with less tightly bound internal elements are more difficult to understand
- Higher cohesion is better

NB!

Cohesion is a more general concept than the single responsibility principle, but modules that follow the SRP tend to have high cohesion.

Cohesion

NB!

Simply put, a cohesive module should do just one thing - **now where have I heard that before... ?**

How to apply these design principles

- **Separate concerns** - divide the program into distinct sections, so that each addresses a separate concern
- Make sure the modules are **cohesive** and **loosely coupled**
- Make sure that each module, class have **one responsibility**, or that there is only one reason for change

Layered Architecture

We employ the layered architecture pattern keeping in mind the detailed design principles

Layered Architecture

Structure the application to:

- **Minimize module coupling** - modules don't know much about one another, makes future change easier
- **Maximize module cohesion** - each module consists of strongly inter-related code

Layered Architecture

Layered Architecture - an architectural pattern that allows you to design flexible systems using components

- Each layer communicates only with the one immediately below
- Each layer has a well-defined interface used by the layer immediately above (hide implementation details)

Layered Architecture

Common layers in an information system architecture

- **User interface, Presentation** - user interface related functions, classes, modules
- **Domain, Application Logic** - provide application functions determined by the use-cases
- **Infrastructure** - general, utility functions or modules
- **Application coordinator** - start and stop application, instantiate components

Layered Architecture

Demo

Examine **ex16_rationalCalculator**

Exceptions and layered architecture

How do we integrate exceptions into layered architecture programs?

NB!

- UI module(s) should not do a lot of processing
- Non-UI modules should not have any UI input/output

Our solution:

- We create an exception instance with an argument or error message
- We catch exceptions in the UI and display the corresponding message