Winter Semester 16/17

Software Engineering Design & Construction

Dr. Michael Eichberg
Fachgebiet Softwaretechnik
Technische Universität Darmstadt

Dependency-Inversion Principle

***D**ependency-**I**nversion **P**rinciple*

High-level modules should not depend on low-level modules. Both should depend on abstractions.

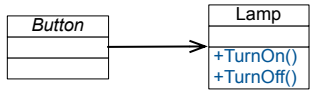
Abstractions should not depend on details. Details should depend on abstractions.

–Agile Software Development; Robert C. Martin; Prentice Hall, 2003

Introduction by Example

A Small Design Exercise

- Behavior of `Button`:
  - The button is capable of "sensing" whether it has been activated/ deactivated by the user.
  - Once a change is detected, it turns the Lamp on, respectively off.



Issues?

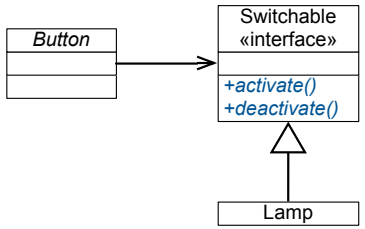
Assessment

- We cannot reuse Button since it depends directly on Lamp. (But there are plenty of other uses for Button.)
- Button should not depend on the details represented by Lamp.

These are symptoms of the real problem (Violation of the Dependency-Inversion Principle). The high-level policy (detection of on/off gestures) underlying this (mini) design depends on the low-level details.
The underlying abstraction is the detection of on/off gestures and their delegation to a server object that can handle them.

If the interface of `Lamp` is changed, `Button` has to be at least tested or even adjusted, even though the policy that `Button` represents is not changed!
To make the high-level policy independent of details we should be able to define it independent of the details of `Lamp` or any other specific device.

A Dependency-Inversion Principle Compliant Solution



Now `Button` only depends on abstractions; it can be reused with various classes that implement `Switchable`.

Changes in `Lamp` will not affect `Button`.

The dependencies have been inverted: `Lamp` now has to conform to the interface defined by `Button`.

Actually: both depend on an abstraction!

The Rationale behind the Dependency-Inversion Principle

- Good software designs are structured into modules.
  - **High-level modules** contain the important policy decisions and business models of an application – The identity of the application.
  - **Low-level modules** contain detailed implementations of individual mechanisms needed to realize the policy.

5

"Here", policy means *what to do when*.

The Rationale behind the Dependency-Inversion Principle

- Good software designs are structured into modules.
  - High-level modules contain the important policy decisions and business models of an application – The identity of the application.
  - Low-level modules contain detailed implementations of individual mechanisms needed to realize the policy.

High-level Policy
The abstraction that underlies the application; the truth that does not vary when details are changed; the system inside the system; the metaphor.

6

High-level policies and business processes is what we want to reuse. If high-level modules depend on the low-level modules changes to the lower level details will force high-level modules to be tested again/to be changed. Additionally, it becomes harder if not practically impossible to use them in other contexts. It is the high-level modules that should influence the low-level details.

„…all well-structured object-oriented architectures ***have clearly defined layers****, with each layer providing some coherent set of services* ***through a well-defined and controlled interface…****“*

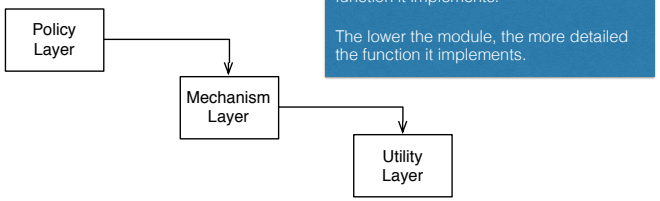
-Grady Booch

„…all well-structured object-oriented architectures ***have clearly defined layers****, with each layer providing some coherent set of services* ***through a well-defined and controlled interface…****“*

An Interpretation

The higher the module is positioned in a layered architecture, the more general the function it implements.

The lower the module, the more detailed the function it implements.



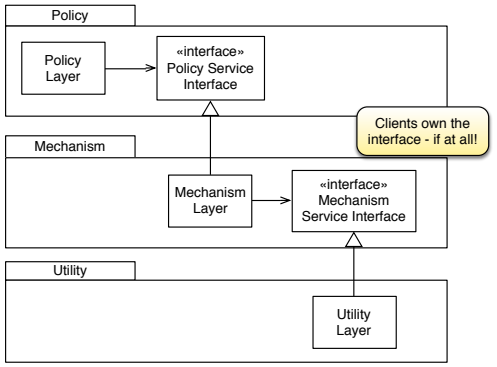
-Grady Booch

This interpretation clearly violates DIP. Higher-level modules depend on lower-level modules.

This is actually a typical structure of a layered architecture realized with structured programming (e.g., using "C").

Layers and Dependencies

Inverted Layer Dependencies



9

- An upper-layer declares (owns) interfaces for services it needs.
- Lower-layer implements these interfaces.
- Upper-layer uses lower-layer by the interface.
  The upper layer does not depend on the lower-layer.
- Lower-layer depends on the interface declared by the upper-layer.

Usually, we think of utility libraries as owning their own interfaces. (A relict from structured programming era.) Due to ownership inversion, Policy is unaffected by changes in Mechanism or Utility.

(Such as design also greatly facilitates test-driven development.)

Naïve Heuristic for Ensuring DIP

DO NOT DEPEND ON A CONCRETE CLASS.

All relationships in a program should terminate on an abstract class or an interface.

- No class should hold a reference to a concrete class.
- No class should derive from a concrete class.
- No method should override an implemented method of any of its base classes.

10

This heuristic is usually violated at least once in every program:

- Some class will have to create concrete classes.
- Subclass relationships do often terminate at a concrete class.

The heuristic seems **naive for concrete stable classes,** e.g., `String` in Java. But, concrete application classes are generally volatile and you should not depend on them. Their volatility can be isolated by keeping them behind abstract *interfaces owned by clients*.

Dependency-Inversion Principle

- Traditional structural programming creates a dependency structure in which policies depend on details.
  (Policies become vulnerable to changes in the details.)
- Object-orientation enables to invert the dependency:
  - Policy and details depend on abstractions.
  - Service interfaces are owned by their clients.
  - Inversion of dependency is the hallmark of good object-oriented design.
    (Implies an inversion of interface ownership.)

Which kind of refactoring is strongly related to the DIP?

Answer: Extract Interface