

Dependency Inversion Principle (DIP)

Dependency-Inversion Principle

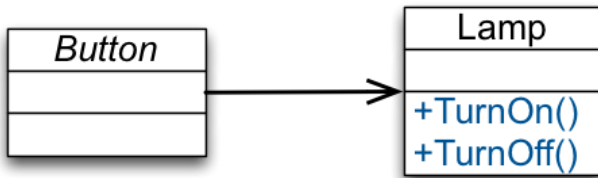
High-level modules should not depend on low-level modules. Both should depend on abstractions.

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

Example

Introduction by Example

A small design excerpt from the smart-home scenario:



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.

Do you see any problem with this design?

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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).

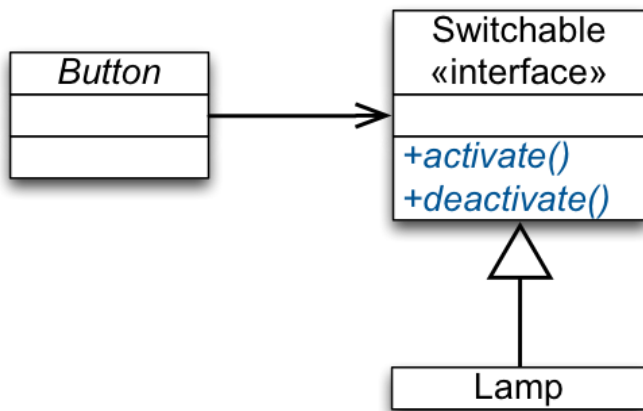
The **high-level policy** (detection of on/off gestures) underlying this (mini) design depends on the low-level details.

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



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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

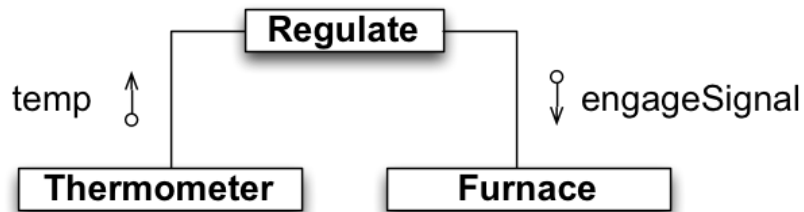
High-level, low-level modules. Good software designs are structured into modules.

- **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.

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.

Example - Regulating the Temperature



Is it compliant with the Dependency-Inversion Principle?

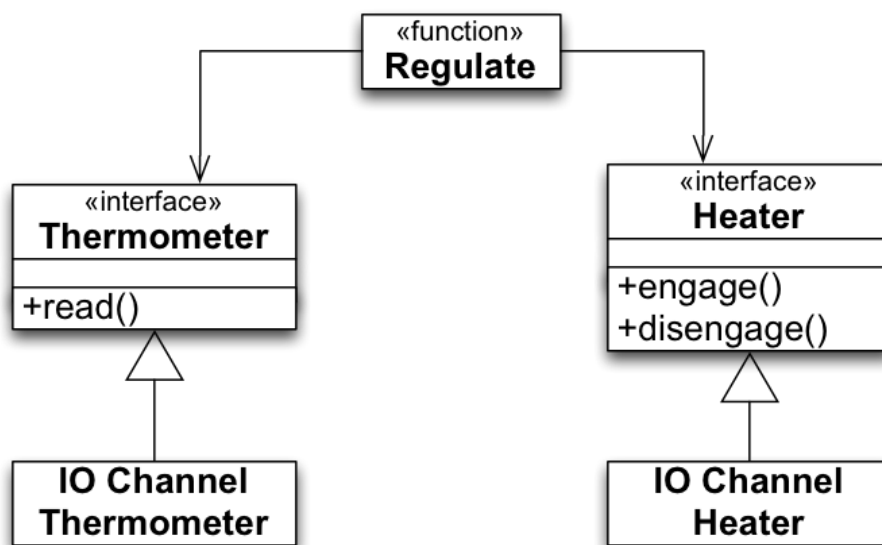
If not, what would you do?

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We have three modules where `Regulate` uses the other two:

- `Regulate` pulls data about the current temperature from the `Thermometer` component and
- `Regulate` signals the `Furnace` component to increase or decrease heat.

Example - Regulating the Temperature

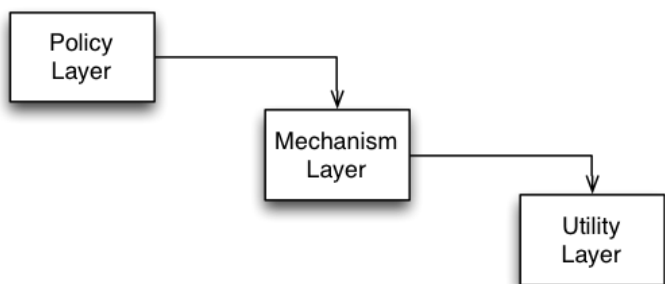


Layers and Dependencies

„...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

A possible 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.

What do you think of this interpretation?

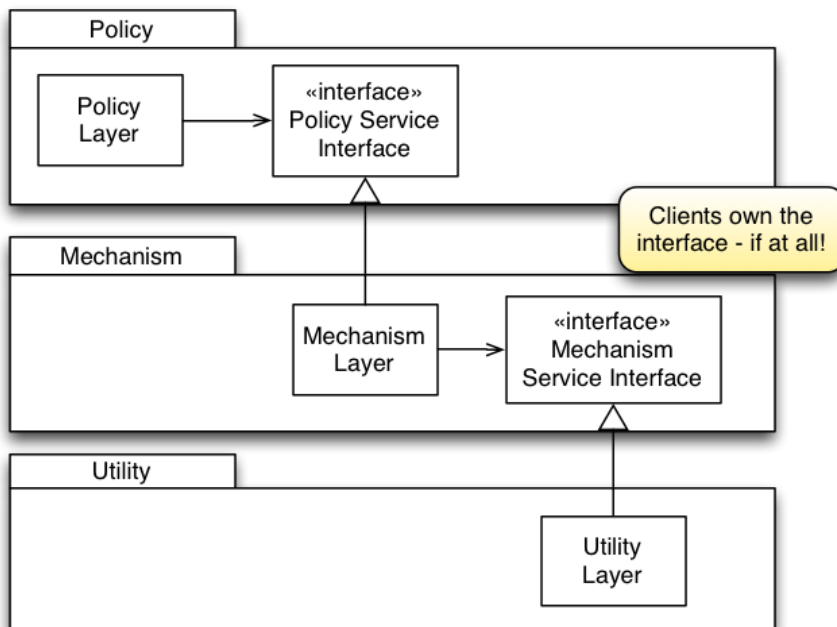
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This interpretation clearly **violates DIP**. Higher-level modules depend on lower-level modules.

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

Layers and Dependencies

Inverted Layer Dependencies



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- 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`.

Naive 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.

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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.

Takeaway

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

- 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.)