Design Patterns and Test Driven Development

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The Book on Patterns: *Gang of Four (GoF)*

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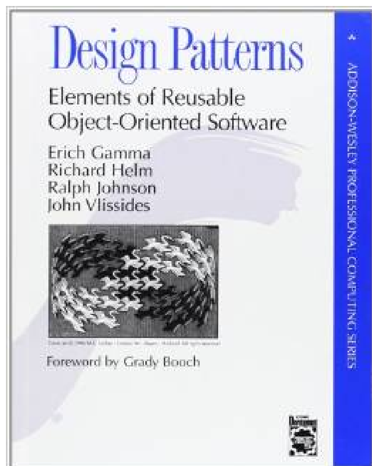

- Groundbreaking in 1995, until today
- Collection of then-existing patterns
- ... only giving them names
- Concise and to the point
- Well-structured
- (Relatively) easy to read
  - ... provided you understand the problems

The Other Books on Patterns

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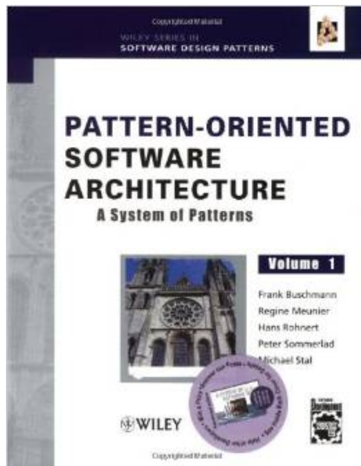

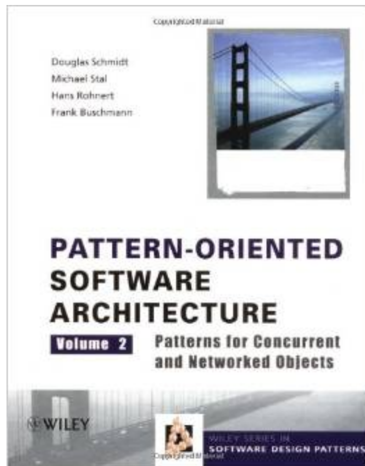

The Book on Test Driven Development

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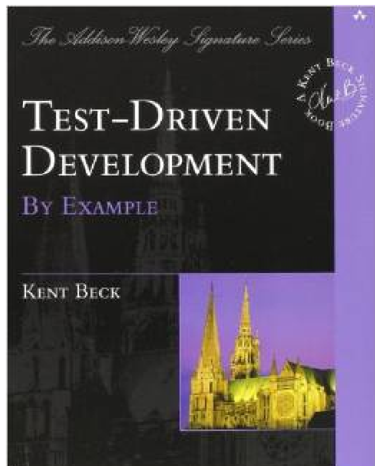

- Groundbreaking in 2003
- Revolutionary though simple (has only 200 pages)
- "New" methodologies
  - Test-first development
  - Refactoring, guided by automatic tests
  - ...
- Basis for all *agile* software development processes

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Design Patterns: What?

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What is a design pattern?

- A solution to a design problem
  - *Beware*: there is no solution without a problem
- "Design" means *Object Oriented Design*
  - Inheritance and polymorphism aren't patterns — at least not in OO
- There are many different problems
  - *Object creation*: objects are not always created directly
  - *Structure*: who knows who, and what does he look like?
  - *Behavior*: how do my objects talk to each other?

Design Patterns: Why?

Why use design patterns?

- Code is a solution to a problem
  - Solution/code needs to be readable and understandable
  - Solutions to similar problems tend to be similar
  - ... at least, should!
- Design patterns ...
  - Give names to solutions → important in communication
  - Encourage solution similarity
  - Are well understood → documentation need only give the pattern's name
  - Solutions become obvious

Non-Obvious Problem

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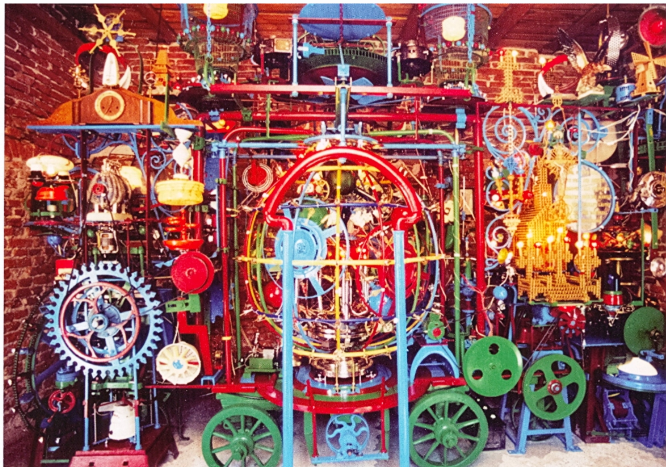
Gsellmann's Weltmaschine



Non-Obvious Solution

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Design Patterns: Caveats

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Design patterns are no silver bullet

- *Overengineering*: artificial/unnecessary code complexity
  - Solution without a problem
  - Not easy to understand — not at all obvious what's being solved
  - One of the biggest mistakes in software design
  - It's like the pest
- Pattern usage does not automatically ensure sound OO design

What is sound design?

- Nobody knows
- ... but fortunately there is *Test Driven Development*

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Test Driven Development

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A simple idea ... but first the problem ...

- New code is written and tested since ages
  - Bugs are fixed until it works
  - Testing mainly done manually
  - Standalone test programs, or ...
  - ... mostly the entire target application
- Existing code breaks once it is modified (law of nature)
  - Breakage not easily detected
  - *Fear!*
  - $\Longrightarrow$ nobody ever modifies existing code
  - $\Longrightarrow$ software starts to rot once it has been written

Development — Traditional Approach

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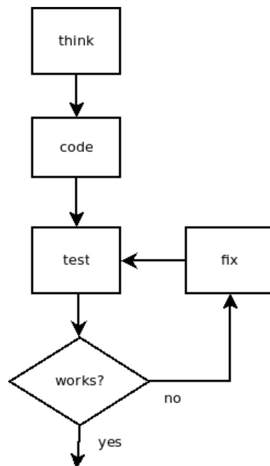
Traditional Approach

- Think about the design
- Come up with a decision
- Code it
- See if it works
- Fix
- (etc.)



Traditional Approach — Problems

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So what are the core problems?

- Before a modification ...
  - How do I know my solution will be ok?
  - How will it feel? Will it be usable?
  - Am I (and others) comfortable with it?
- After a modification ...
  - It is impossible to decide if everything still works
  - What is the definition of *everything*?
  - What is the definition of *works*?
  - What are the costs to decide that?
  - *What are the costs if we do only manual testing*?
  - *What is the state of the code? What about refactoring?*
- After the release ...
  - We curse at the testers that they do a bad job!

Test Driven Development — Principles (1)

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What if we were able to test everything automatically?

- Modifications could be done *without any fear*
  - *"Regression"*: new term for that kind of bug
  - Something that worked before a modification but doesn't afterwards
- Ongoing refactoring possible → no code smells
- New features would bring new tests
  - The *Everything* grows over time

But: the Everything is now defined as ...

- Production code
- Test code

Test Driven Development — Principles (2)

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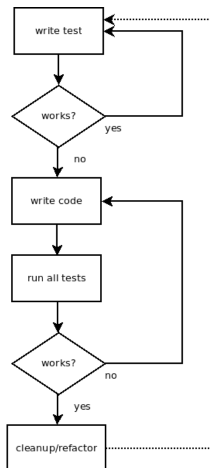
Test Driven Development

- New “development process”
- Tests come first
- → “Requirements phase”
- Have you ever read a requirements document *after* coding was done?
- → Tests fail initially



Test Driven Development — Benefits? Caveats?

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What does it bring, what does it cost?

- More work initially — so much for sure
- Investment into the future
- More code can be done
- Not at all easy to convince people of it

Big caveat

- Tests belong to the code
- *No way* moving on without!
- $\Longrightarrow$ Have to take care of the tests

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Origins

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Unittest frameworks — where they come from

- `SUnit`, 1998. By Kent Beck in Smalltalk.
- `JUnit`, 2001. Ported from Smalltalk to Java, by Kent Beck and Erich Gamma.
  - Gained wide popularity by Kent Beck's book
- From then on ported to almost every language — commonly known as `xUnit`
  - Python: `PyUnit`, then became part of the Python library, module `unittest`
  - C++: `Boost.Test`, `CppUnit`, Google Test, ...
  - All the newer languages: Ruby, Rust, Go, ...
  - COBOL

xUnit Structure — Overview

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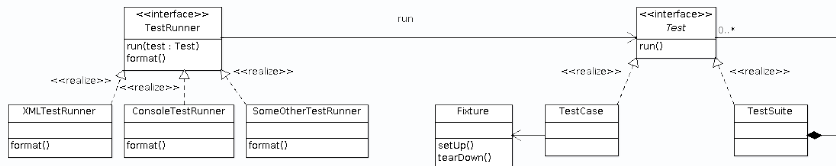

- TestCase: one test that is written. Here's the most code.
- TestSuite: composition of many test cases, for structural purposes.
- Fixture: defined environment of a TestCase
- TestRunner: runs a Test (Suite or Case), collects and presents results.

xUnit: TestCase and TestSuite

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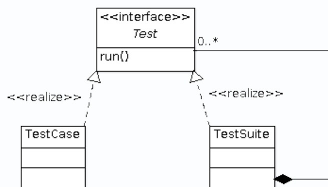
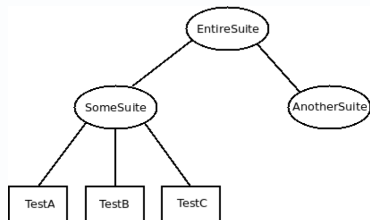
Suites: recursive test structure

- Derive from `TestCase` to *implement* tests
- Use `TestSuite` objects to structure tests hierarchically
- Run a subset of all tests
- The *Composite Pattern* in use ...
- Not available in every xUnit incarnation





xUnit: TestCase and Fixture

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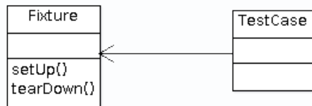
Fixture: defined test environment

- Multiple tests start from the same state → common *Fixture*
- Method `setUp()` — establishes known state to start tests from. Examples: well-known/required database content, files have to be present, ...
- Method `tearDown()` — deallocates resources. For example: cleanup database, remove files, ...



Implementation:

- Python: class that contains test methods
- C/C++: weird macros to setup objects and associations

xUnit: TestCase and *Assertions*

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Test code checks for failure: Assertions

- Varying multitude of assertions to draw from
- Records test failure in some test result, for later reporting
- Abort the test case → failure
- Variation: *non-fatal* assertions

```
container.insert(100)
container.insert(200)
self.assertEqual(len(container), 2)
```

```
self.assertAlmostEqual(1/3, 0.333, 2)
```

xUnit: TestRunner

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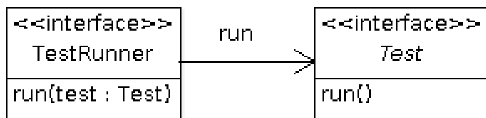
Running all tests: `TestRunner`

- `TestRunner` usually instantiated in main programs
- During running a test ...
  - Fixtures are prepared (`setup()`, `tearDown()`)
  - Results are collected
  - Failure or success
- After all tests have run ...
  - The result has to be presented
- (Sidenote: do you know the *Strategy Pattern*?)



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The “Process”

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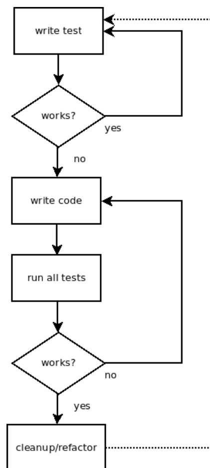
Test Driven Development is … well …

- Not a full process
- The basis of all “agile” processes
  - Anybody doing Scrum these days?
- It’s *Software done right*
- It’s about continuous investment and taking out



The “Requirements Phase”, New Code

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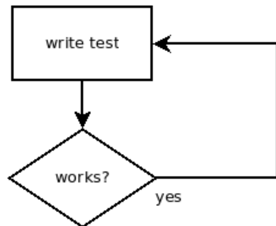
Writing new code in a test driven way ...

- Nothing is clear from the beginning
- ... not even the problem

To get hold of the problem ...

- Write code that wouldn’t compile (there’s no solution yet)
- ... but gives you an impression of how a solution could look like
- Talk to people about proposed solution
- $\rightarrow$ “Finding the interface”
- *This is the first test*
- “Test First Development”



The "Requirements Phase", Existing Code

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Modifying existing code, to add features or change behavior ...

- Find the test suite for the module in question
    - $\rightarrow$ *structure* is important
- Add a new test for the new feature, making clear exactly what is wanted
    - The new test naturally fails, as always
- Modify code
- Run *all* tests
- Repeat

Caveats (1)

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Take care of your tests! If your tests are suddenly gone, your code is alone ...

Caveats (2)

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- Tests are what ensure your code's value
- *You can do more valuable code with tests and TDD*
- Test code is no different from "real" code
  - → Subject to bitrot
- *"Lost Tests Syndrome"*: keep your hands off manual test suite arrangement
  - → Varying support from frameworks

 Test Driven Development

Caveats (3)

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But:

- Nobody tests the tests
  - *false impression*: "it's only tests"
- *Structure* is important
- *Easy running* is important — everybody has to know how
- *Easy running*: avoid big dependencies — nobody will want to setup database infrastructure

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Object Oriented Programming and Design (1)

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> “Perfection is attained not when there is nothing more to add, but when there is nothing more to remove”
>
> Antoine de Saint-Exupéry

- To adhere to this principle is possible even in assembly code
- ... it’s just that it’s a bit harder

Object Oriented Programming and Design (2)

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What OO does for us:

- *Things can be programmed like we talk about them*
- Enforces encapsulation
  - Members (private)
  - Methods
- Lets us separate out dependencies
  - Interfaces
  - Inheritance

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Example: Members and Methods

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Encoding and decoding: the *Julius Caesar* “Encryption” method

UML

JuliusCaesarCodec
shift : Integer
encode(data : String) : String decode(data : String) : String

C++ Code

```
class JuliusCaesarCodec
{
public:
    string encode(string data);
    string decode(string data);
private:
    int shift;
};
```

Example: Constructor and Destructor

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Constructor (and Destructor): controlled initialization

- There's only one way to do it — unlike in C
- `struct` initialization
- Explicit assignment
- Define a function `init_jc_codec(int shift)`
- (literally hundreds more)

C++ Code

```
class JuliusCaesarCodec
{
public:
    JuliusCaesarCodec(int shift);
    ~JuliusCaesarCodec();
// ...
};
```

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Motivation: Interfaces

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What if ...

- There were multiple such codecs available (Base64?)
- I don't care which one I am using
- I want to write code that just makes use of *any* codec

Solution: Interfaces

- Define the *interface* of an entire set of implementations
- Implementations *implement* interfaces
- User code is then written against *interfaces* rather than concrete implementations

Example: Interfaces (1)

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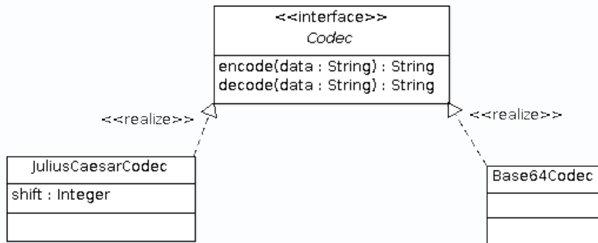
Interfaces ...

- Don't implement anything
- Only force implementors into a corset for uniform usage

UML



Example: Interfaces (2)

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Interfaces don't implement ...

- C++: no dedicated `interface` keyword (as there is in Java)
- *Abstract Methods*

Codec *Interface*: C++ Code

```
class Codec
{
public:
    virtual ~Codec() {}

    virtual string encode(string data) = 0;
    virtual string decode(string data) = 0;
};
```

Example: Interfaces (3)

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Concrete code implements ...

- C++: no dedicated `implements` keyword (as there is in Java)
- Plain inheritance

Implementing an Interface: C++ Code

```
class JuliusCaesarCodec : public Codec
{
public:
    // ...
    virtual string encode(string data);
    virtual string decode(string data);
};
```

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Design Principles

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Principle vs. Dogma

- Every handcraft has rules, on every single level, which everybody agrees upon
- Our handcraft is no exception
- On the *design level*: Design Principles
  - **S**ingle Responsibility
  - **O**pen/Closed
  - **L**iskov Substitution
  - **I**nterface Segregation
  - **D**ependency Inversion
- → SOLID (for people who find it hard to remember rules)
- *Antipattern*: a pattern that violates any of these principles

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Single Responsibility Principle

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> "Every class must have responsibility over a single part of the program"
>
> Robert C. Martin, at around 2000

> "Every class must do one thing and should do that well."
>
> Jörg Faschingbauer, all the time

Consequences:

- Defining/writing tests is easier
- Documenting is easier
- Understanding is easier

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Open/Closed Principle

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> "Software entities must be open for extension, but closed for modification."
>
> Bertrand Meyer, 1988

Interpretations/consequences:

- Adding functionality not by modifying but by adding (e.g. "plugins")
- Heavy use of an *interface*

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Liskov Substitution Principle (1)

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> "It must be possible in a program to exchange two implementations of an interface *without* compromising the correctness of the program."
>
> Barbara Liskov, 1995

Is this true for our Codec "design"?

Liskov Substitution Principle (2)

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Classical violation of Liskow's principle: square/rectangle

- A rectangle is defined as a pair (width, height), each of which is modifiable separately
- Can a square be seen as a rectangle then?

Consequences:

- No special cases in user code
- Polished interfaces

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Interface Segregation Principle

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> "No client of an interface should be forced to depend on methods it does not use."
>
> Robert C. Martin (again), at around 2000

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Dependency Inversion Principle (1)

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1. High-level modules should not depend on low-level modules. Both should depend on abstractions.
2. Abstractions should not depend upon details. Details should depend upon abstractions.

Robert C. Martin (again), at around 2000

Dependency Inversion Principle (2)

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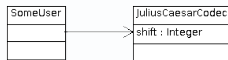
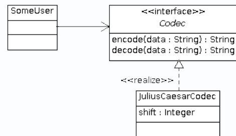
Bad



Good



Does that really pay off?

- There is only one concrete implementation
- With *dependency inversion* applied there's one more class
- Not easily readable

Dependency Inversion Principle (3)

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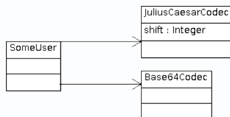
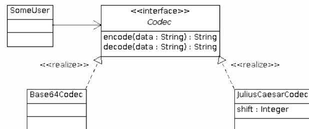
Really Bad



- Typical scenario: long `if-else-if-...` chains
- Each association used based on, say, the value of an integer variable

Really Good



- Shorter code — no long chains
- (Ideally) does exactly one thing, and *delegates* encoding

Does anybody know the Strategy Pattern?

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Design Patterns — The Legend

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> "Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice."
>
> Christopher Alexander, 1977

- Christopher Alexander is an *architect*
- *Gang of Four* got heavily inspired by his work

Design Patterns — Definition

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A Design Pattern has the following attributes:

- **Name.** We use it to identify and talk about problems and their solutions.
- **Problem.** A pattern is a solution, and there is no solution without a problem. The problem must be clearly defined.
- **Solution.** A description of the solution — design, responsibilities, collaborations, ...
- **Consequences.** Benefits, trade-offs. Needed for evaluation/selection.

Design Patterns — *The Book*

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Creational Patterns

- Factory Method
- Abstract Factory
- Builder
- Prototype
- Singleton

Structural Patterns

- Adapter
- Bridge
- Composite
- Decorator
- Facade
- Flyweight
- Proxy

Behavioral Patterns

- Interpreter
- Template Method
- Chain of Responsibility
- Command
- Iterator
- Mediator
- Memento
- Observer
- State
- Strategy
- Visitor

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Creational Patterns — What for? (1)

Direct object creation ...

Using concrete type

```
void use_codec(JuliusCaesarCodec *codec) { /*...*/ }

JuliusCaesarCodec *codec = new JuliusCaesarCodec(5);
use_codec(codec);
```

- Hard dependency on `JuliusCaesarCodec`, introduced by
  1. codec being of *concrete* type
  2. Instantiation of concrete type
- *Is it necessary to use concrete type?*
- *Does `use_codec()` care?*

Creational Patterns — What for? (2)

Using interface type

```
void use_codec(Codec *codec) { /*...*/ }

Codec *codec = new JuliusCaesarCodec(5);
use_codec(codec);
```

- Still hard dependency on `JuliusCaesarCodec`, introduced by
  1. Instantiation of concrete type

Creational Patterns — What for? (3)

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Naive solution: external function

```
Codec *create_codec();
void use_codec(Codec *codec) { /*...*/ }

Codec *codec = create_codec();
use_codec(codec);
```

- Dependency has been moved to `create_codec()`
- We don't care which `Codec` incarnation we use → *Liskow Substitution Principle*
- Decided externally, by the implementation of `create_codec()`

Creational Patterns — What for? (4)

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Now how could `create_codec()` **look like?**

```
enum CodecType {
  JULIUS_CAESAR,
  BASE64
};
int jc_shift = 5;
// modify if you want different type
CodecType type_instantiated = BASE64;

Codec *create_codec() {
  switch (type_instantiated) {
    case JULIUS_CAESAR: return new JuliusCaesarCodec(jc_shift)
    case BASE64: return new Base64Codec;
  }
}
```

Creational Patterns — What for? (5)

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There are prettier solutions!

→ Creational Patterns

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Abstract Factory

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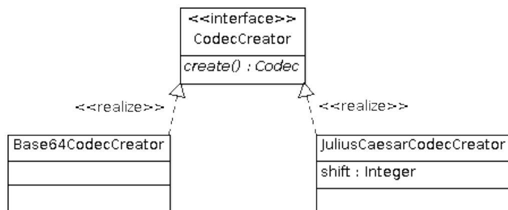

Setup (near `main()` function?)

```
codec_factory = new JuliusCaesarCodecFactory(5);
```

Usage

```
Codec *codec = codec_factory->create();
use_codec(codec);
```

Abstract Factory — Discussion

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How does using (instantiating) code get to the factory?

- Pass factory in
  - Explicit: everyone can see that module makes use of it
  - $\rightarrow$ Dependency is obvious
- Global Variable $\rightarrow$ bad smell
  - Hidden dependency
- Singleton ...

Pass via Constructor

```
class SomeCodecUser
{
public:
    SomeCodecUser(CodecFactory *codec_factory);
};
```

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Singleton

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Ensure a class has only one instance,
and provide a global access point to it.

SomeClassWithOneInstance
get_instance() : SomeClassWithOneInstance do_something() do_more()

- `get_instance()` is not called on an instance
- C++, Java: `static`

Singleton — Example

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Example: `Base64Codec` ...

- Everybody needs it
  - Email attachments
  - HTTP transport
  - ...
- There need not be multiple instances
  - It has no data of its own
  - Only the algorithm (`encode()`, `decode()`)

Singleton — Example, Class Definition (1)

base64.h

```
class Base64Codec
{
public:
    // return (and on-demand instantiate)
    // the only Base64Codec object in the world
    static Base64Codec &get_instance();

    string encode(string data);
    string decode(string data);

private:
    ...
};
```

Singleton — Example, Class Definition (2)

base64.h

```
class Base64Codec
{
public:
    ...
private:
    // THE object
    static Base64Codec *instance;

    // inhibit public instantiation
    Base64Codec();
};
```

Singleton — Example, Class Implementation

base64.cc

```
Base64Codec *Base64Codec::instance;

Base64Codec &Base64Codec::get_instance()
{
    if (instance == NULL)
        instance = new Base64Codec;
    return *instance;
}
```

Singleton — Example, User Code

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user.cc

```
string binary_data = ...;
string email_attachment =
    Base64Codec::get_instance().encode(binary_data);
```

Singleton — Discussion

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Singleton: Pros

- Nicely encapsulates global data
- Saves one from passing parameters instead

Singleton: Cons

- Nicely encapsulates global data
- Saves one from passing parameters instead
- It's still *global*
    - Unit testing?
- Makes the design less obvious
    - Singleton access hidden deep in implementation
    - *Hidden dependency!*
- Anti-Pattern?

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Structural Patterns — What for?

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Any non-trivial program has an object structure ...

- Multiple objects are combined → structure
- Some structures *and motivations* are immediately obvious
- ... others aren't
- There are no billions of different motivations
- → A handful of *Patterns* is sufficient to describe most

Combining Objects — Multiple Inheritance (1)

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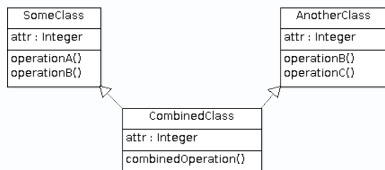

Issues:

- `CombinedClass` is a *union* of both of its bases
- *Contains* boths methods and data, *without* “namespace” qualification
    - Conflicts
    - Ambiguities
    - Prone to bugs
- Situation very similar to global variable usage

Combining Objects — Multiple Inheritance (2)

Massacre in C++

```
class CombinedClass : public SomeClass, public AnotherClass
{
public:
    void combinedOperation() {
        attr = SomeClass::attr + AnotherClass::attr;
        operationA();
        SomeClass::operationB();
        AnotherClass::operationB();
        operationC();
    }

private:
    int attr;
};
```

Combining Objects — Composition (1)

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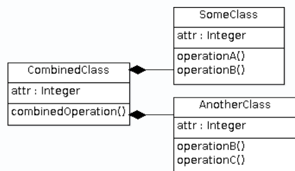

Better, because ...

- Relationships are more obvious
- No ambiguities
- **Speech is clear**: "*Uses* `SomeClass` and `AnotherClass` to implement its operations" (if anybody cares at all)
- **And not**: "*Is both a* `SomeClass` and a `AnotherClass`, and adds a little to both"

Combining Objects — Composition (2)

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```
class CombinedClass
{
public:
    void combinedOperation() {
        attr = Some.attr + another.attr;
        some.operationA();
        some.operationB();
        another.operationB();
        another.operationC();
    }
private:
    SomeClass some;
    AnotherClass another;
    int attr;
};
```

Combining Objects — There's More To It

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So much for trivial object combinations

$\rightarrow$ Structural Patterns

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Adapter — Sample Problem

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Sample Problem: `Base64Codec` **(again) ...**

- I have an implementation based on C++ `iostream`
- Want to implement C++ `string` based interface
    - ... as dictated by interface `Codec`

```
class Base64Codec
  : public Codec
{
public:
  string encode(string);
  string decode(string);
};
```

```
class IOBase64Codec
{
public:
  static void encode(
    istream&, ostream&);
  static void decode(
    istream&, ostream&);
};
```

Adapter — Motivation

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Pattern: apply ultralight glue ...

- Interfaces are similar
  - It is obvious that their *intention* is the same
- Interfaces are incompatible, compiler-wise
- *Adapt* the `iostream` implementation into our `string` based `Codec` hierarchy
- Fortunately there's C++'s `istringstream` and `ostringstream` which turns a string into a stream and back

Adapter — Graphics

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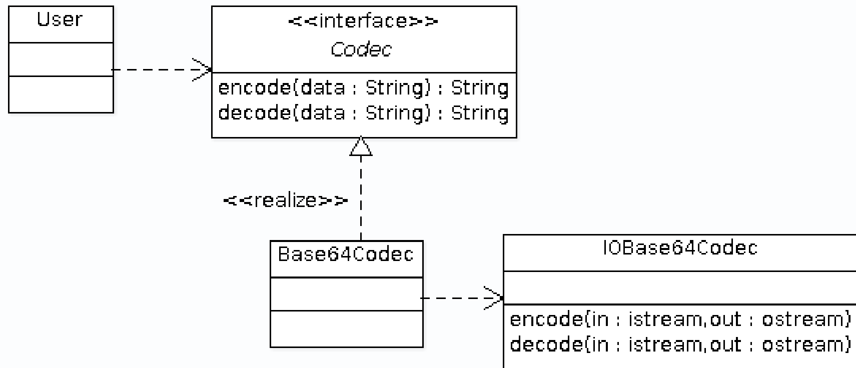

Adapter — Implementation

A typical adapter implementation ...

- Usually very short, to the point, obvious
- Inlineable in most cases
- No big deal — it's the *name* that is important for communication

```
string Base64Codec::encode(string in)
{
    istringstream sin(in);
    ostringstream sout;
    IOBase64Codec::encode(sin, sout);
    return sout.str();
}
```

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Bridge — Example: String (1)

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Straightforward bridge example: String

- Goal: *transparent* sharing of objects
- User code has an innocent looking object $\rightarrow$ *bridge*
  - *Handle* to the real stuff
  - ... possibly augmented with some additional higher level methods
- E.g. a naive String class
  - Implementation: reference counting, low level memory management
  - Bridge: cute methods *find*, *cut*, *splice*, ...

Bridge — Example: String (2)

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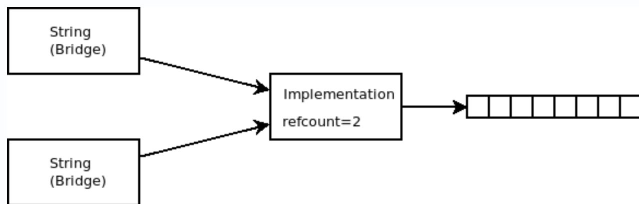
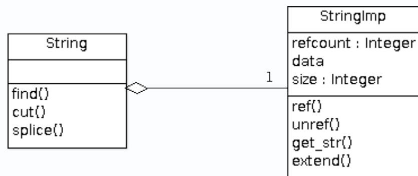
String: Object Diagram



String: Class Diagram



Bridge — Definition

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Bridge: GoF Definition

Decouple an abstraction from its implementation so that the two can vary independently.

So what could that mean?

- `String` is an easy application of the Bridge pattern
  - `String` is an abstraction: nobody sees low level memory issues, but rather useful methods
- Definition leaves much more room for interpretation
  - Abstraction side can vary
  - Implementation side can vary

Bridge — General Case

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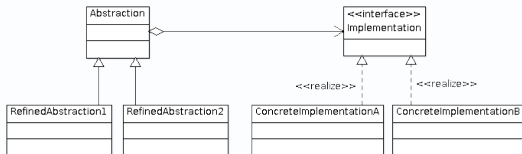

- Focus is more on independent evolution of both sides
- *Abstract Factory* can be used to setup bridges

As for the `String` example ...

- Abstractions: `ASCIIString`, `UTF8String`, ...
- Implementations: `StringImpMalloc`, `StringImpChunked`

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Composite — Example: Unix Filesystem (1)

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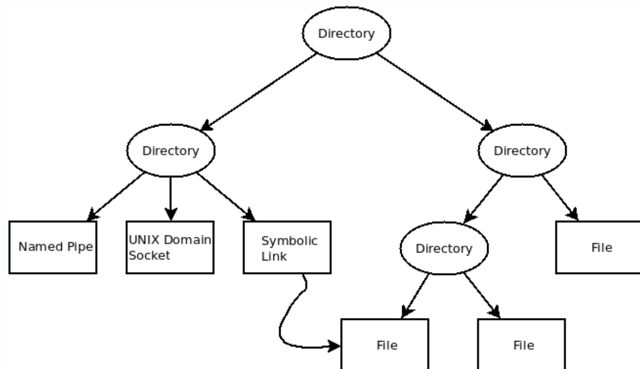

Composite — Example: Unix Filesystem (2)

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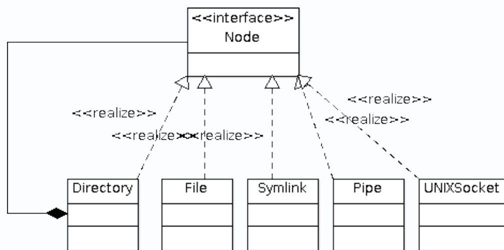

- Hierarchy is in place with this design
- But there is more which is lacking from this example
  - Directory is different
  - Application (`tar`, `tree`, ...) needs to *know* the concrete types
  - → Complexity

Composite — Example: Graphics

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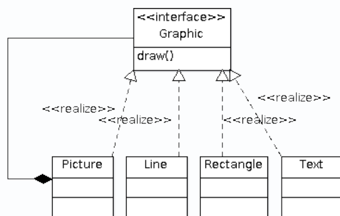

- *Common interface*
- Composite `Graphic` draws all it contains
- *Recursive*: `Graphic` can contain `Graphic` can contain ...

Composite — Example: Thermometer

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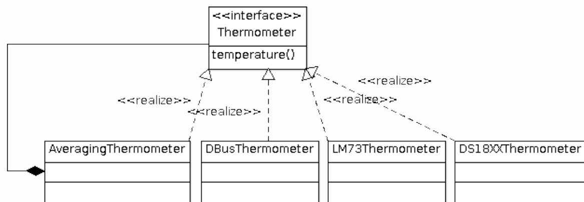

- `AveragingThermometer`: average out of several temperatures
- Design variation: *weighted* average

Composite — Example: Boolean Expression

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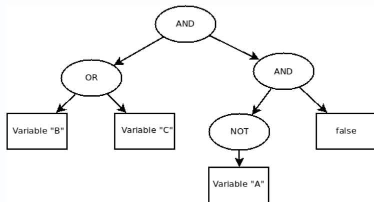
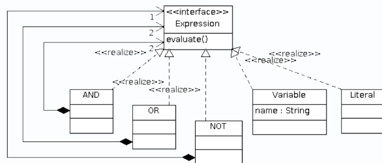
- Abstract Syntax Trees (AST)
- Simple AST: Boolean Expression
- Evaluating (executing) ASTs is a different story
- *Interpreter Pattern*

Object Structure



Class Diagram



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Proxy — Definition

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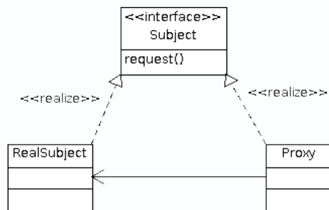
GoF Definition

Provide a surrogate or placeholder for another object to control access to it.

GoF Diagram



A-ha ...

Proxy — GoF Example: Image in Text

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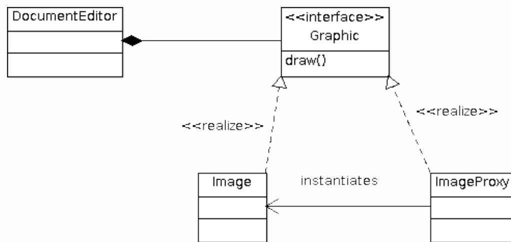
- Image should not be loaded/calculated when not in visible area
- $\rightarrow$ Demand loading




```
ImageProxy::draw()
{
    if (image == NULL)
        image = Image(filename);
    image->draw();
}
```

Proxy — Example: Plugin Interface

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Loading code from a file ...

- Unix/Linux: `dlopen()`, `dlsym()`
- Windows: `LoadLibraryEx()`, `GetProcAddress()`

Defining a plugin scheme: `Codec` **...**

- A plugin (DLL, sharded library) brings one `Codec` object
  - Well defined name: `the_object`
  - We only know the interface (implementation buried in plugin)
- Proxy `Codec` ...
  - Load library
  - Use `dlsym()` to find `the_object`
  - Use that as `RealSubject`

Proxy — Remoting (1)

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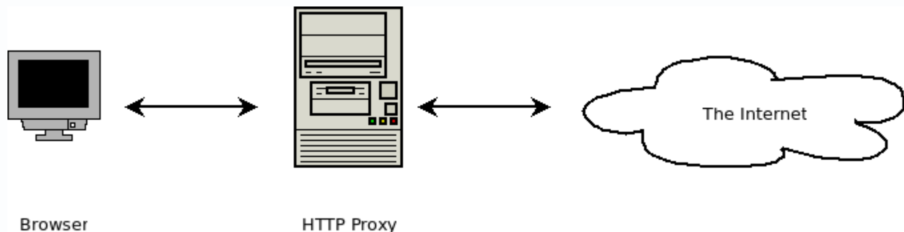
The word Proxy as everybody knows it ...



Proxy — Remoting (2)

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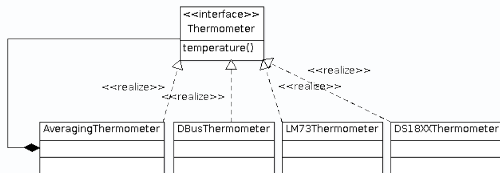
Distributed applications ...

- Use a remote object as if it were remote
- Local *Proxy* object — satisfying the interface
- Remote concrete implementation
- Wire protocol in between

DBusThermometer



Proxy — Remoting (3)

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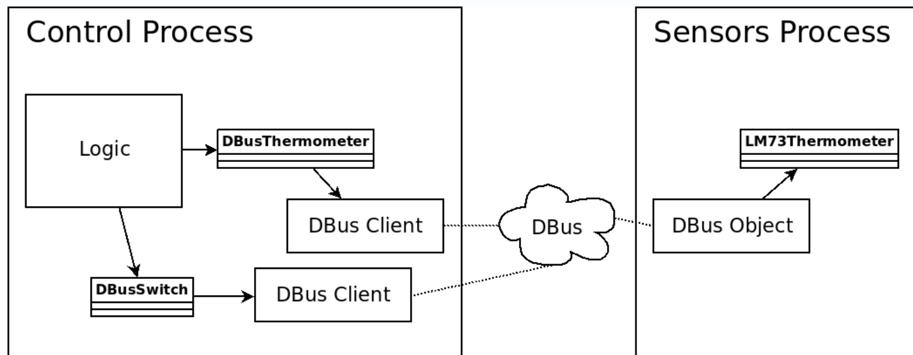
Distributed Application



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Behavioral Patterns

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Structure versus Functionality

- Structure implies functionality (sometimes)
  - Composite: boolean expressions
- Structure implies only little functionality (sometimes)
  - Adapter
  - Bridge
- Functionality implies structure (mostly)

Behavioral Patterns:

- Focus on object interactions
- Parameters, return values
- $\rightarrow$ Semantics

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Command

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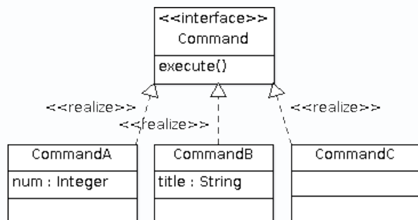
Command: the problem ...

- Imagine a large framework, passing and executing requests of some sort
- Requests are not fixed, but rather extensible/anonymous

- Request $\iff$ function call
- Variable parameters
- $\rightarrow$ Encapsulate parameters in object



Command — Example: Remote Requests

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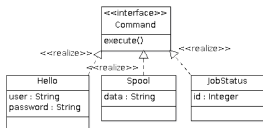
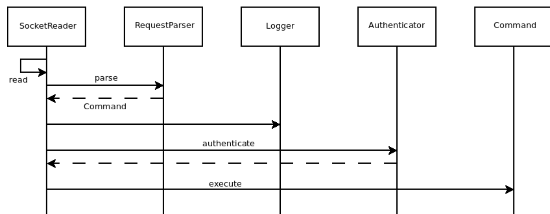
Large framework, handling remote requests ...





- Which pattern is used for `RequestParser`?
- Command's execution maximally decoupled from the rest
- $\rightarrow$ *Highly dynamic*

Command — Problems

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Command has problems (as everything) ...

- Non-uniform return value — `Hello`, `Spool`, `JobStatus` are quite different
  - How is that serialized back onto the line?
  - → Probably not appropriate!
- `Command` classes are largely unrelated (→ structural problems)
- Many `Command` classes
- `Command` implementation tend to become complex
- Gets unhandy *really soon* if applied unappropriately → watch out, and change!

Command — Example: Shell

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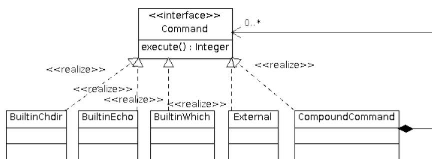
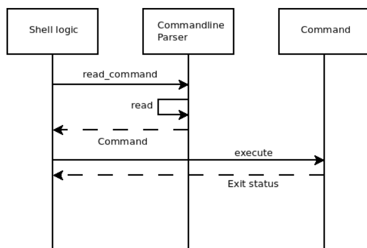
UNIX Shell: parsing and executing user's command line ...





- Uniform outcome (exit status) → *perfect!*
- GoF example: menu items (no outcome at all)

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Interpreter — Example: Boolean Expression (1)

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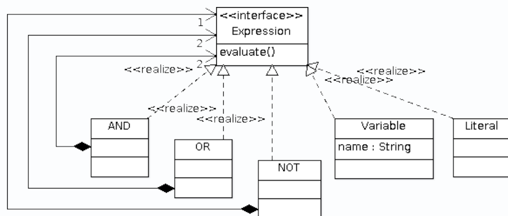

- *Composite* structure
- *Evaluation* is not so simple
- Storage of variable's values → *Context*

Interpreter — Example: Boolean Expression (2)

Interpreter vs. Composite: hard to tell the difference ...

- Languages are best represented by trees
- Trees are best represented using Composite
- $\Longrightarrow$ Interpreter likely is Composite
- Not necessarily vice versa

```
class Context {
public:
  bool lookup_value(string);
};
class Expression
{
public:
  virtual bool
    evaluate(Context&) = 0;
};
```

Interpreter — Discussion

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Ups

- Grammar is easy to extend
- Easily implemented

Downs

- Complex grammars hard to maintain
- $\rightarrow$ Parser generators probably a better alternative

See also

- Visitor pattern, to extend functionality

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Observer — Model-View-Controller (MVC) (1)

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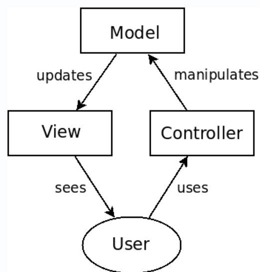
Model-View-Controller: revolution in GUI design in the late 70s

- *Model*: application data, business logic
- *View*: visible representation
  - *observes* the model → callback
- *Controller*: specifies actions to manipulate the model
  - Triggered by button clicks, for example



Observer — Model-View-Controller (MVC) (2)

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MVC is not among the GoF patterns ...

- Subdivided into more generalized patterns
    - MVC was discovered for GUI design
    - Integrated into Smalltalk
    - Adopted by Apple for their GUIs
- *Controller* → *Strategy*
    - "Do something!", and not caring what
- *View* → *Composite*
    - Recursive decomposition of graphics
- Interaction (notification) between *Model* and *View* → *Observer*

Observer — Collaborations (1)

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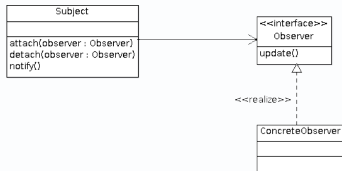
- Subject has zero or more Observers registered
- On modification, all of them are notified
- On notifications, they update their ... whatever



Observer — Collaborations (2)

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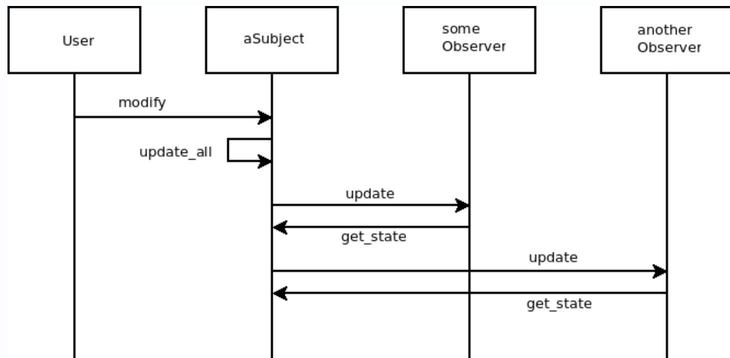

Observer — Discussion (1)

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- Observing multiple subjects
  - `update()` needs to pass a reference to changed subject
- *When* is the update triggered?
  - Every single modification?
  - → Inconsistent state
  - "Transactional integrity"?
- *Who* triggers the update?
  - User after *he* is done? → unhandy
  - Subject? Transactional integrity?
  - → Be careful during design! Change if smell detected!

Observer — Discussion (2)

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- *Push* versus *pull*
  - Does subject push modification information?
  - Or does observer query for it?
- Multithreading
  - *pull* has to *lock* into subject
  - → Deadlock danger during callback (?)

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Strategy — Example: TestRunner (1)

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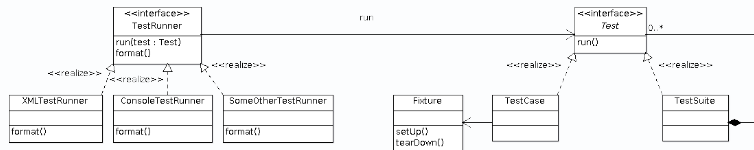
The **Template Method** pattern, as applied to `xUnit` ...



- **Template Method** doesn't scale (as everybody knows)
  - It is a straightforward solution to long `if-else` chains
  - One dimension of variability (here, `format()`) is manageable
  - Number of implementors grows exponentially with the number of variations
  - Extension is not reusable
- Different solution necessary

Strategy — Example: `TestRunner` (2)

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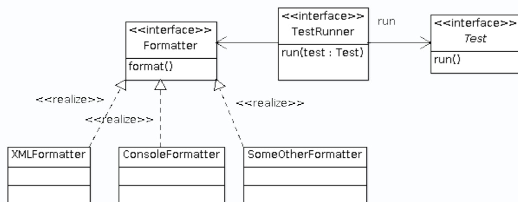

Consequences ...

- `TestRunner` instances are parameterizeable
  - `TestRunner` is a *concrete* class
  - Receives a `Formatter` during construction (or at runtime, or ...)
- Formatting is Unit-testable *without prior test run*

Strategy — Final Words

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Strategy is one of the most important patterns, because ...

- *Delegation* is perfectly/clearly/cleanly expressed
- Runtime parameterization possible
  - Delegee need not be passed to constructor — can also be done dynamically
- Perfect alternative to most long `if-else` chains where functionality is chosen

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Visitor — Extending Boolean Expressions (1)

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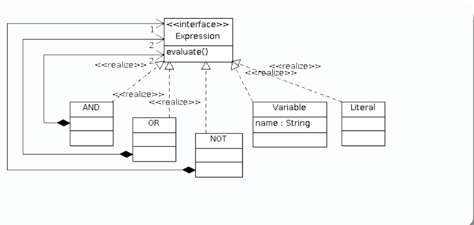
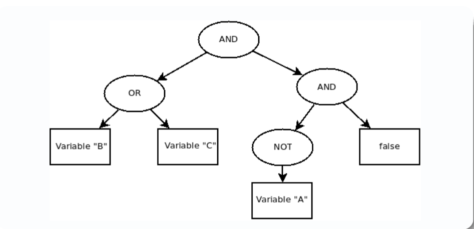
- Main method: `evaluate()`
- What about `prettyprint()`?
- What about `myfavoritemethod()`?
- Add all to `Expression`?
- → Unhandiness, uncovered by the *Interface Segregation Principle*





Visitor — Extending Boolean Expressions (2)

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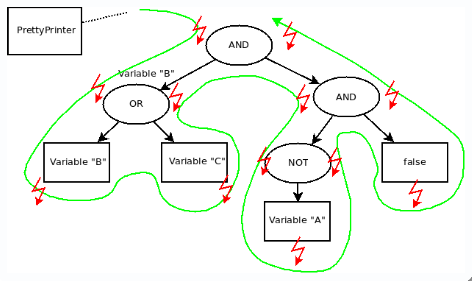
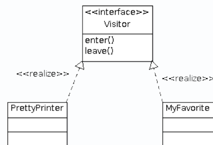
- Add `visit()` to `Expression`
- Nodes: `enter()`, walk children, `leave()`
- Leaves: `enter()`, `leave()`
- ... or so





Notes

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