# Design Patterns: an Introduction

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27/08/2014

# Introduction

**Design Patterns**, what is all the fuss about?

- Mantra uttered over and over by old bearded gurus
- Scary diagrams
- Abstract, mysterious names
- universal magical answer to the spaghetti code I end up having at the end of my project

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Let's demystify...

# Outline

# History

- **Design Patterns**: invented by software Architect, *Christopher Alexander*.
- **Design Patterns: Elements of Reusable Object-Oriented Software** 1994,
  authored by the **Gang Of Four** (*Erich Gamma, Richard Helm, Ralph Johnson and John Vlissides*) popularised the concept in Computer science.
- Since then, countless books on how to apply many more patterns to many specific languages and problems.

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# Reusable techniques solving recurring problems

They are **not**:

- tools (tools are editors or IDEs)
- ready made one size fits all solutions

# Reusable techniques solving recurring problems

A Pattern is only complete if it comes with:

- a typical situation along with why it causes trouble
- a solution and the reason it is a good one.
- a context, when to apply it.
- limitations

# GoF Object Oriented Categories

In the book **Design Patterns**, the are the following categories:

- Creational: create resources instead of direct instantiation
- Structural: organise the structure of the data: hierarchy, composition
- Behavioral: drive the data flow, communication between objects

# GoF Creational Patterns

**Abstract Factory** groups object factories that have a common theme.

**Builder constructs** complex objects by separating construction and representation.

**Factory Method** creates objects without specifying the exact class to create.

**Prototype** creates objects by cloning an existing object.

**Singleton** restricts object creation for a class to only one instance.

# GoF Structural Patterns

**Adapter** allows classes with incompatible interfaces to work together by wrapping its own interface around that of an already existing class.

**Bridge** decouples an abstraction from its implementation so that the two can vary independently.

**Composite** composes zero-or-more similar objects so that they can be manipulated as one object.

**Decorator** dynamically adds/overrides behaviour in an existing method of an object.

**Facade** provides a simplified interface to a large body of code.

**Flyweight** reduces the cost of creating and manipulating a large number of similar objects.

**Proxy** provides a placeholder for another object to control access, reduce cost, and reduce complexity.

# GoF Behavioral Patterns

**Chain of responsibility** delegates commands to a chain of processing objects.

**Command** creates objects which encapsulate actions and parameters.

**Interpreter** implements a specialized language.

**Iterator** accesses the elements of an object sequentially without exposing its underlying representation.

**Mediator** allows loose coupling between classes by being the only class that has detailed knowledge of their methods.

**Memento** provides the ability to restore an object to its previous state (undo).

**Observer** is a publish/subscribe pattern which allows a number of observer objects to see an event.

**State** allows an object to alter its behavior when its internal state changes.

**Strategy** allows one of a family of algorithms to be selected on-the-fly at runtime.

**Template method** defines the skeleton of an algorithm as an abstract class, allowing its subclasses to provide concrete behavior.

**Visitor** separates an algorithm from an object structure by moving the hierarchy of methods into one object.

# Other known categories

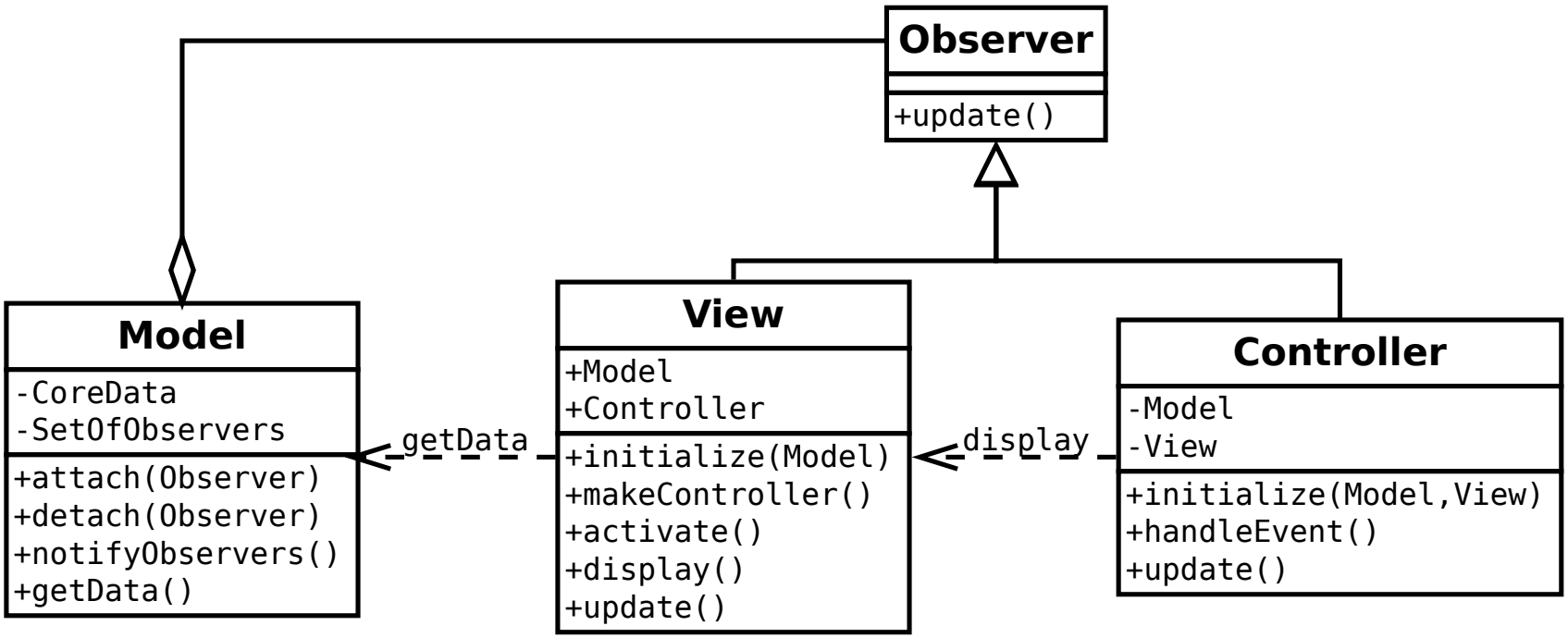
**Architectural** Large application scale patterns: core/plugin, data stores...

**Concurrency** concurrent programming techniques, including locking mechanisms, thread pooling...

**Testing** code testing patterns: mock objects, set-up/tear-down...

**Domain specific** Some patterns are very much domain specific

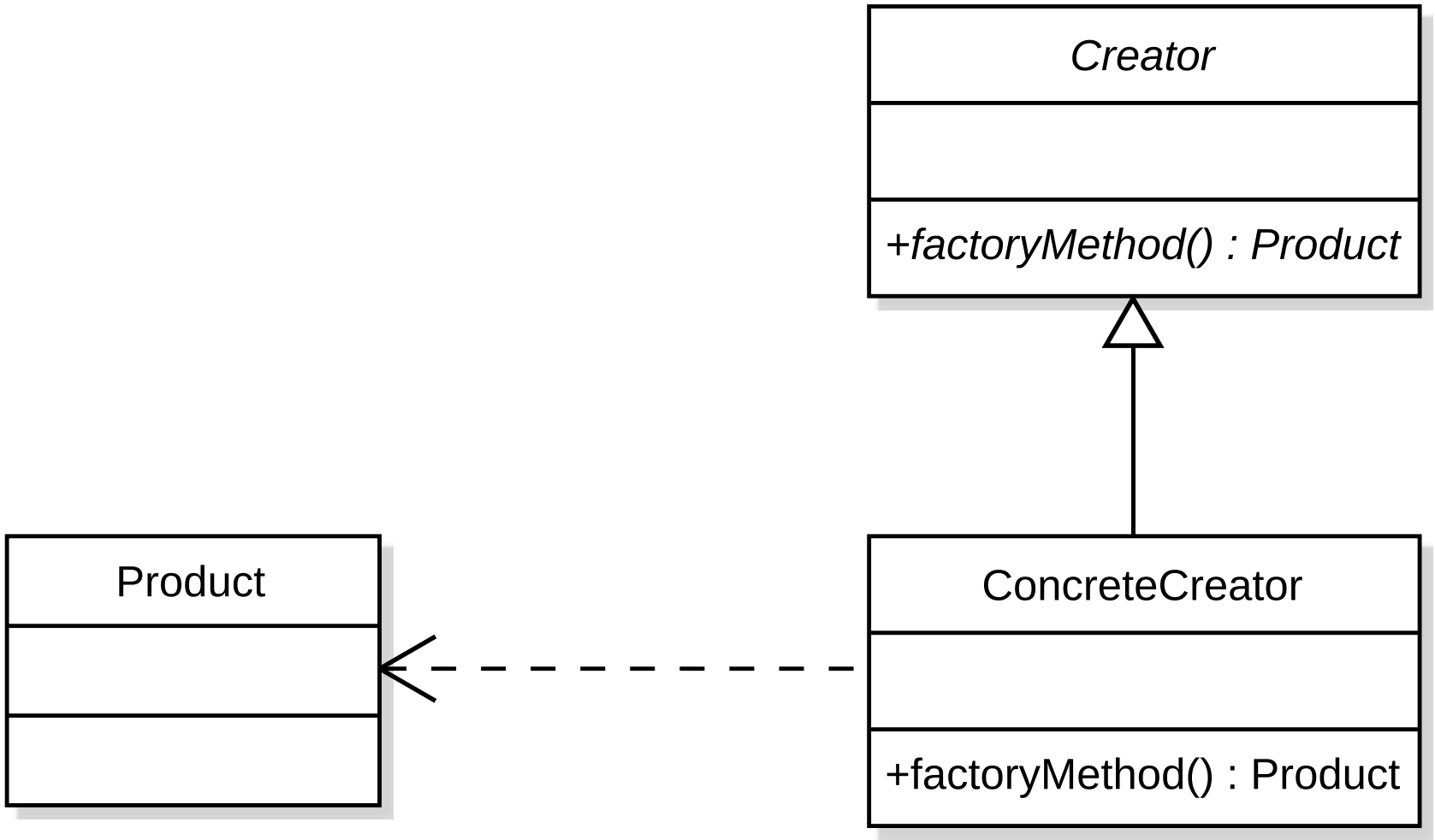
# MVC: Principle



# MVC: Variations

- Qt uses **MV** pattern
- Django uses **MVT** pattern
- Everybody's loose interpretation of "where do my controller stops and my view starts"

# Factory Method Pattern: Principle



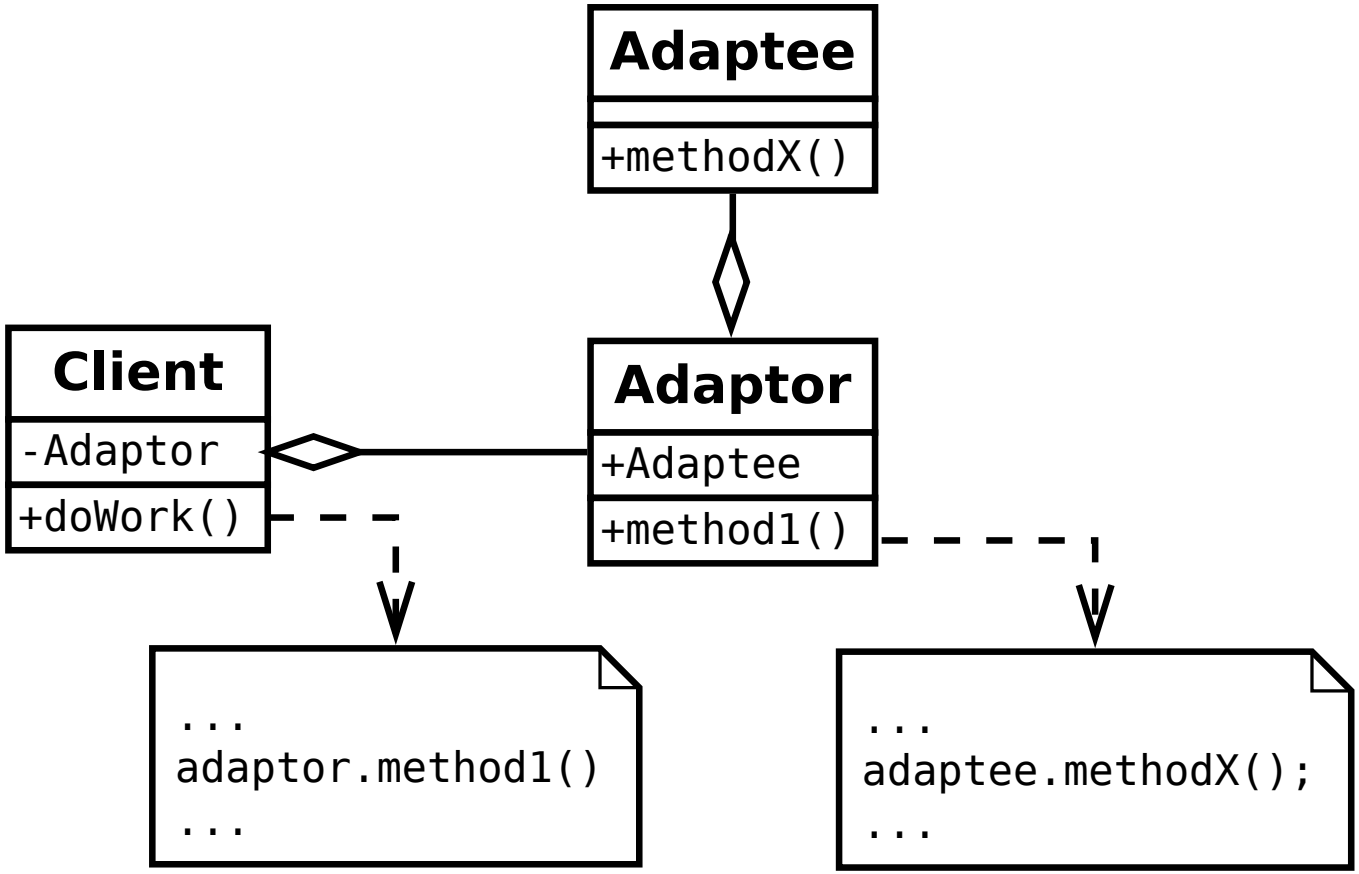
# Factory Method Pattern: Code

```
root = etree.Element('body')
h1 = etree.Element('h1')
h1.text = 'The Title'
root.append(h1)
p = etree.Element('p')
p.text = 'Always write Python'
root.append(p)

from lmxl.builder import E

doc = E('body',
        E('h1', 'The Title'),
        E('p', 'Always write Python'))
```

# Adapter Pattern: Principle



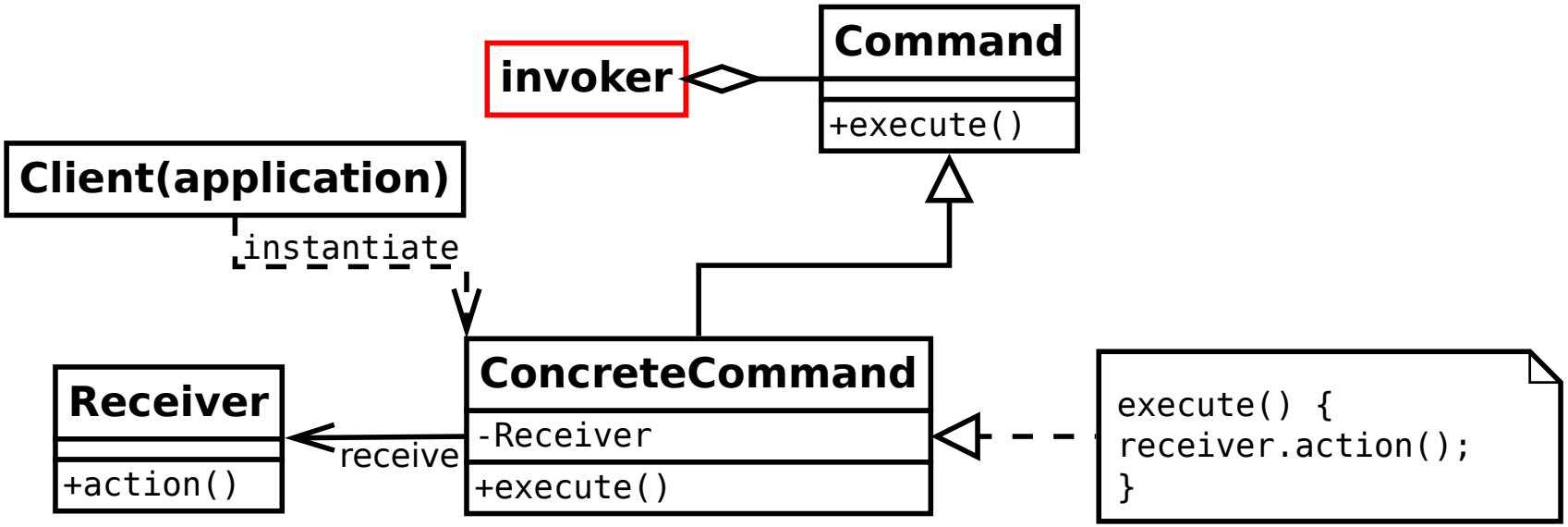
# Adapter Pattern: Code

Python has the concept of a "file-like" object, which has read() and write(). Examples are `file` and `StringIO`, but **not** `socket` (it has `send()` and `recv()` instead). Luckily, we can get an Adapter from `socket` with `makefile()`:

```
import socket

s = socket.socket(socket.AF_INET)
s.connect(...)
s.send('hello there')
file_like_socket = s.makefile()
file_like_socket.write('hi again')
```

# Command Pattern: Principle



# Command Pattern: Code

```
def paint_line(x1, y1, x2, y2): pass

class PaintLineCommand(object):
  def __init__(self, x1, y1, x2, y2):
      self.x1, self.y1 = x1, y1
      self.x2, self.y2 = x2, y2

  def __call__(self):
      paint_line(self.x1, self.y1, self.x2, self.y2)

  def __str__(self):
      return 'paint_line from {}/{} to {}/{}'.format(
          self.x1, self.y1, self.x2, self.y2)

cmd = PaintLineCommand(5, 23, 42, 123)
cmd()
logging.debug(cmd)
```

# Command Pattern: Code

```
class PaintLineCommand(object):
  # ...

  def undo(self):
      erase_line(self.x1, self.y1, self.x2, self.y2)


cmd = PaintLineCommand(5, 23, 42, 123)
cmd()
command_history.append(cmd)
command_history[-1].undo()
```

# Python Perspective

Patterns don't have to be about object-oriented design. They can be something very simple.

```
if 'page' in params:
    page = params['page']
else:
    page = 1
```

Can be written as

```
page = params.get('page', 1)
```

# Limitations

- Language specific patterns
- Trends
- Technical advances, obsolescence

# Singleton Pattern: Principle

- One instance shared all over the code: "global object"
- Examples: config managers, Factories, Facade objects

# Singleton Pattern: Python

There are many ways to implement it in Python.

- a module instead of a class
- a class method instance() (does not enforce single instance)
- implement __new__()
- metaclass
- ...
- use the Monostate Pattern instead

# Singleton Pattern: IOLoop in Tornado

```
@staticmethod
def instance():
    """Returns a global `IOLoop` instance.
       ...
    """
    if not hasattr(IOLoop, "_instance"):
        with IOLoop._instance_lock:
            if not hasattr(IOLoop, "_instance"):
                # New instance after double check
                IOLoop._instance = IOLoop()
    return IOLoop._instance
```

Q: But is it thread-safe?

# Singleton Pattern: Metaclass

```
class Singleton(type):
    def __init__(cls, name, bases, attrs):
        super(Singleton, cls).__init__(
            cls, bases, attrs)

        cls._instance = None

    def __call__(cls, *a, **k):
        if cls._instance is None:
            cls._instance = super(
                Singleton, cls).__call__(*a, **k)

        return cls._instance
```

# Singleton Pattern: Using the metaclass

```
class EventCounter(object):
    __metaclass__ = Singleton

    def __init__(self):
        self.count = 0

    def register_event(self):
        self.count += 1
```

```
>>> a, b = EventCounter(), EventCounter()
>>> b.count
0
>>> a.register_event()
>>> b.count
1
```

# Singleton Pattern: Alternative "Monostate"

```
class Borg(object):
    _shared_state = {}

    def __new__(cls, *a, **k):
        obj = super(Borg, cls).__new__(cls, *a, **k)
        obj.__dict__ = cls._shared_state
        return obj


class SevenOfNine(Borg): pass
```

# Singleton Pattern: Controversies

- very much used, BUT
- introducing global state never encouraged
- tricky thread safety at initialisation (ultimately flawed in c++ due to uncertainty of dynamic loading order)
- overused: situations REALLY needing a singleton are rare

# Conclusions

There is so much more we can show...

# Links

- Many Python examples from here: https://www.youtube.com/watch?v=Er5K_nR5IDQ
- Good talk by Alex Martelli at EuroPython: https://www.youtube.com/watch?v=bPJKYrZjq10

# Questions?