Design Patterns in Python

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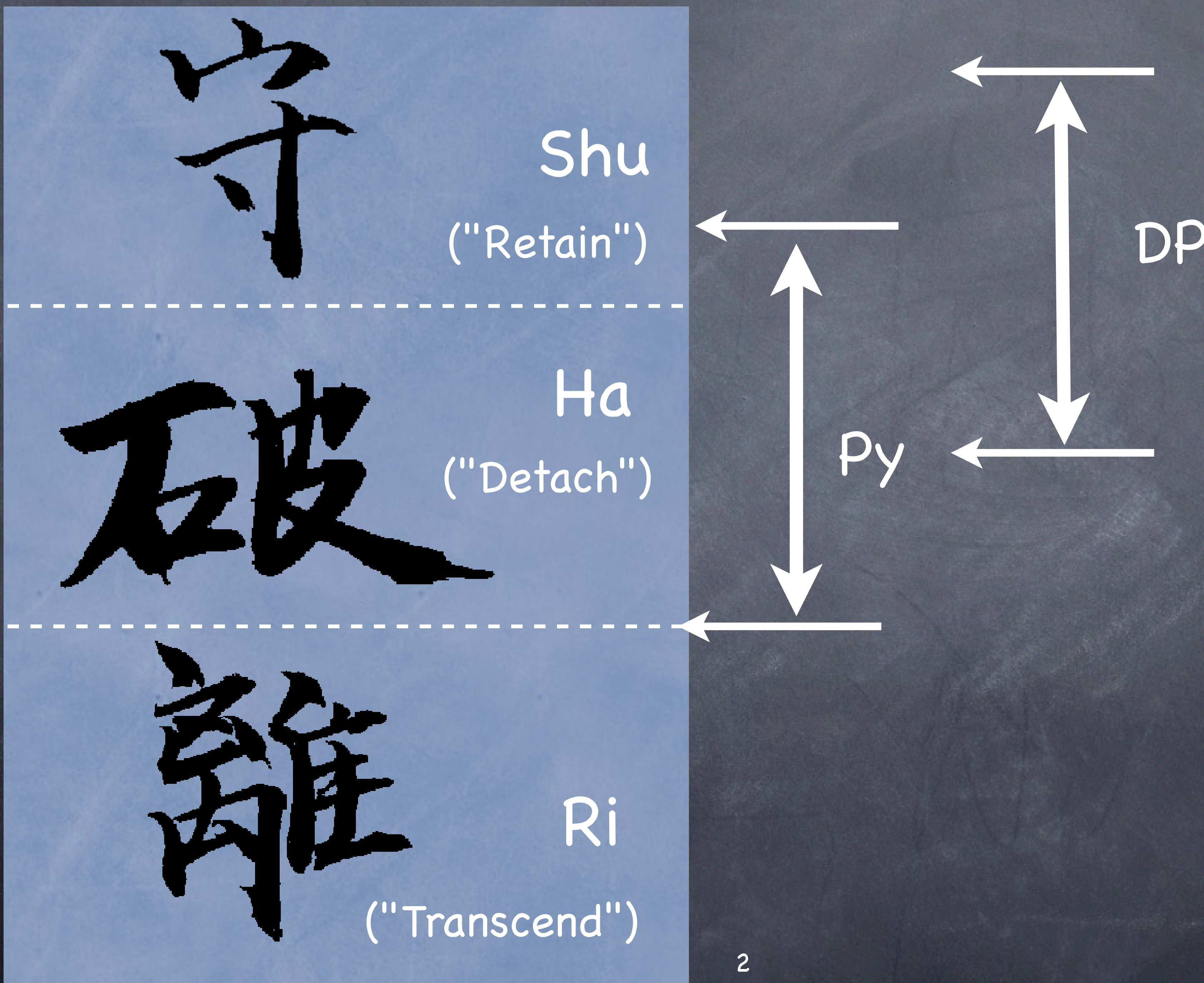
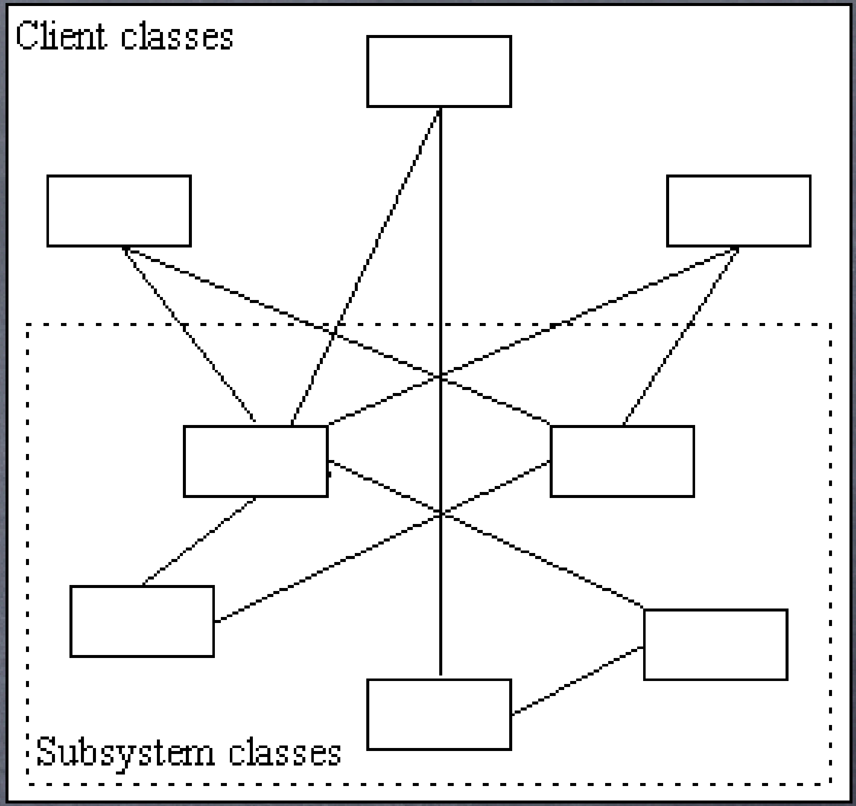
http://www.aleax.it/gdd_pydp.pdf

The "levels" of this talk



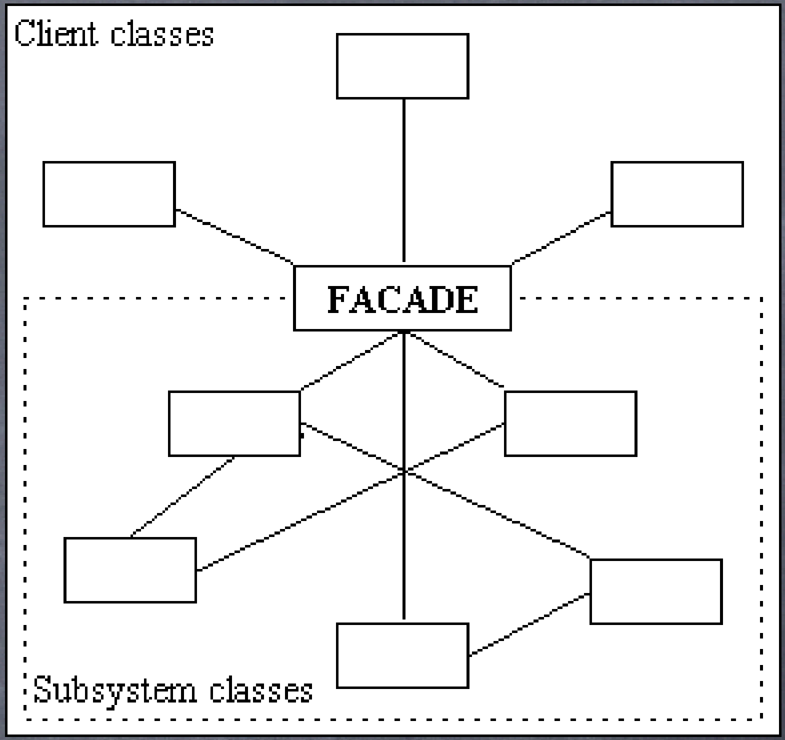
Hit the ground running...

- "Forces": some rich, complex subsystem offers a lot of useful functionality; client code interacts with several parts of this functionality in a way that's "out of control"
- this causes many problems for client-code programmers AND subsystem ones too (complexity + rigidity)



Solution: the "Facade" DP

- interpose a simpler "Facade" object/class exposing a controlled subset of functionality
  - client code now calls into the Facade, only
  - the Facade implements its simpler functionality via calls into the rich, complex subsystem
- subsystem implementation gains flexibility, clients gain simplicity



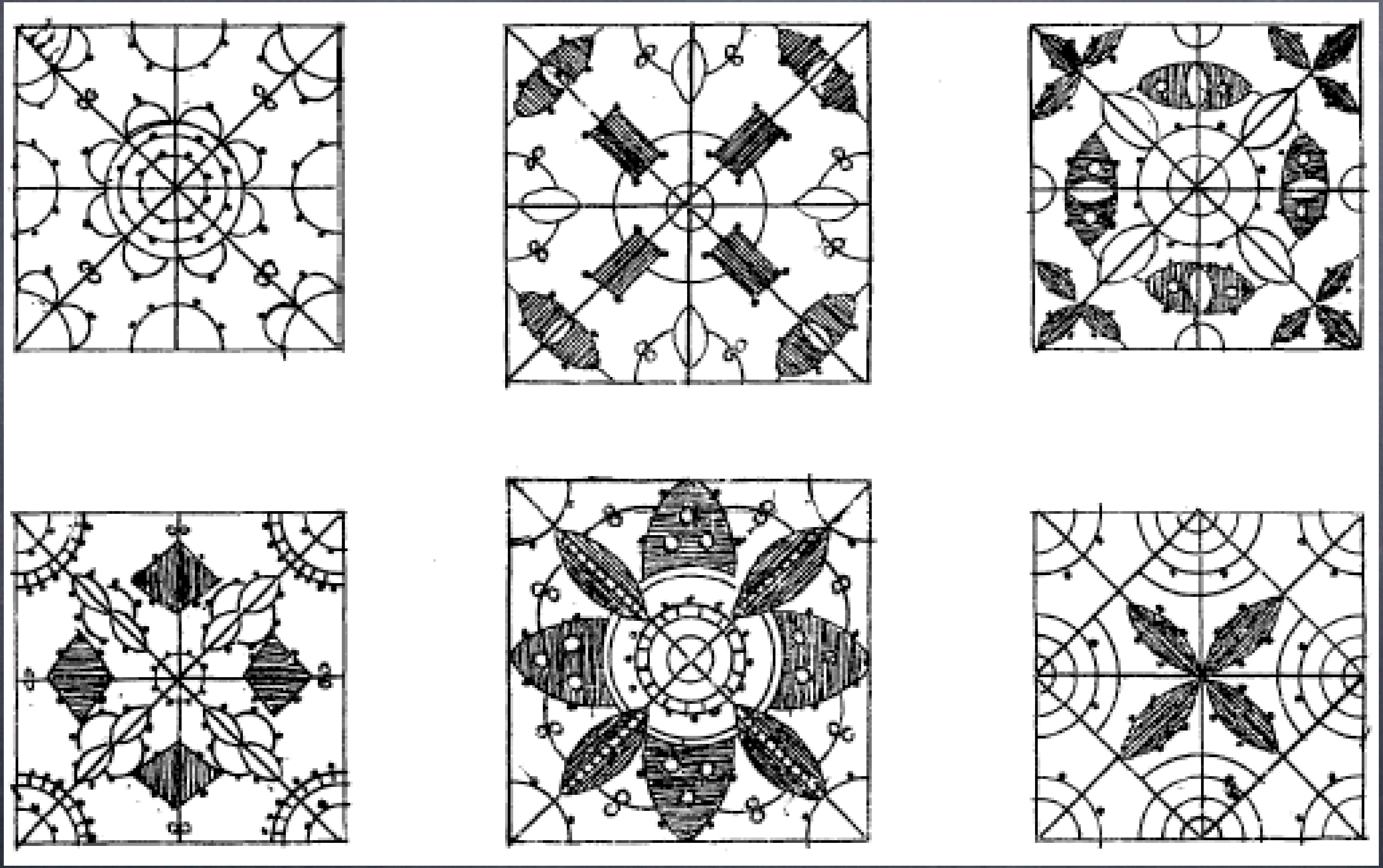
Facade is a Design Pattern

- summary of a frequent design problem + structure of a solution to that problem (+ pros and cons, alternatives, ...), and:
  - A NAME (much easier to retain/discuss!)
- "descriptions of communicating objects and classes customized to solve a general design problem in a particular context"
- that's NOT: a data structure, algorithm, domain-specific system architecture, programming-language/library feature
- MUST be studied in a language's context!
- MUST supply Known Uses ("KU")

Some Facade KUs

- ...in the Python standard library...:
  - dbhash facades for bsddb
    - highly simplified/subset access
    - also meets the "dbm" interface (thus, also an example of the Adapter DP)
  - os.path: basename, dirname facade for split + indexing; isdir (&c) facade for os.stat + stat.S_ISDIR (&c)
- Facade is a structural DP (we'll see another, Adapter, later; in dbhash, they "merge"!-)

Design Patterns



What's a Design Pattern

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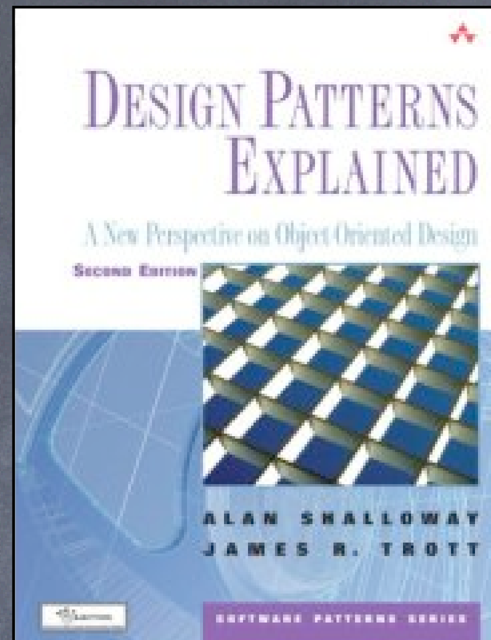
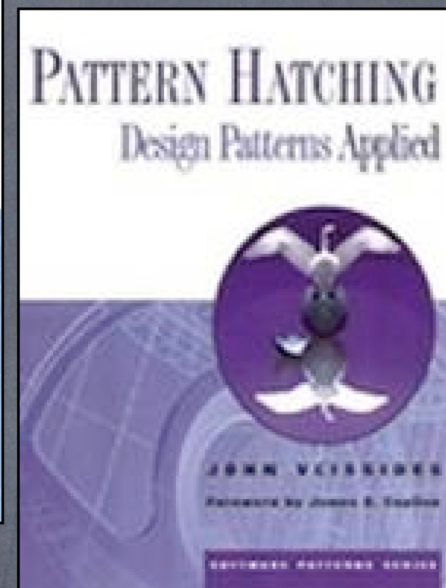
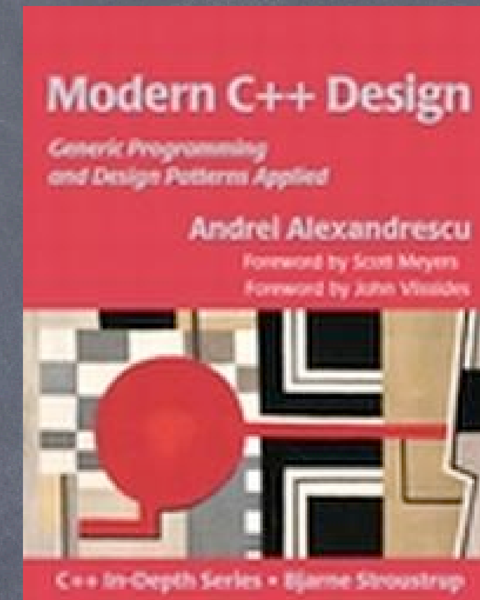
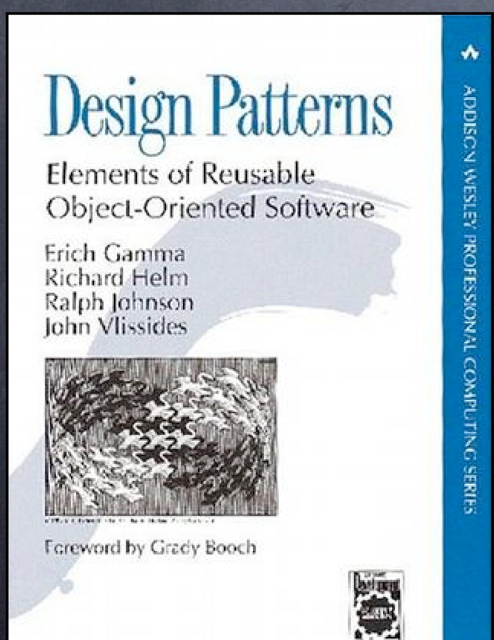
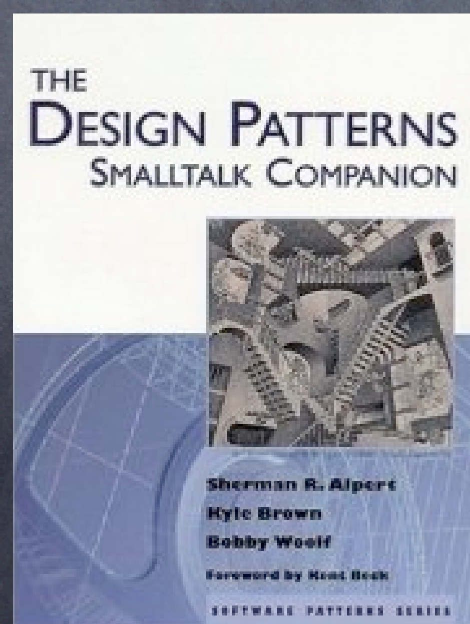
Many Good DP Books

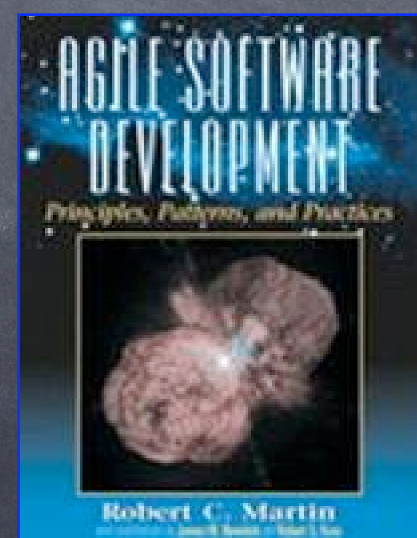


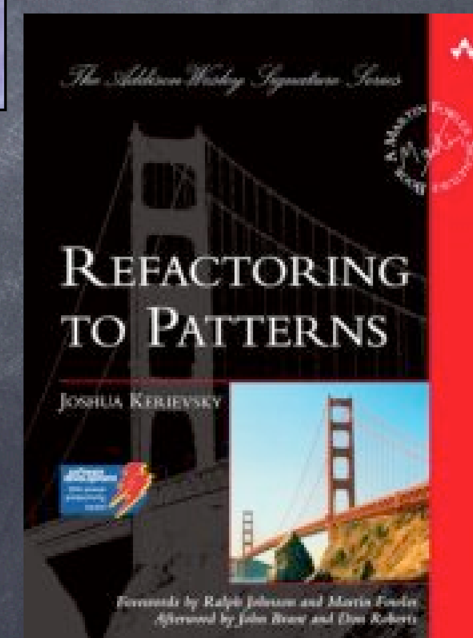












(biblio on the last slide)

Classic DP Categories

- Creational: ways and means of object instantiation
- Structural: mutual composition of classes or objects (the Facade DP is Structural)
- Behavioral: how classes or objects interact and distribute responsibilities among them
- Each can be class-level or object-level

Prolegomena to DPs

- "program to an interface, not to an implementation"
  - that's mostly done with "duck typing" in Python -- rarely w/"formal" interfaces
  - actually similar to "signature-based polymorphism" in C++ templates

Duck Typing Helps a Lot!

Teaching the ducks to type takes a while,
but saves you a lot of work afterwards!-)

Prolegomena to DPs

- "favor object composition over class inheritance"
  - in Python: hold, or wrap
  - inherit only when it's really convenient
    - expose all methods in base class (reuse + usually override + maybe extend)
    - but, it's a very strong coupling!

Python: hold or wrap?

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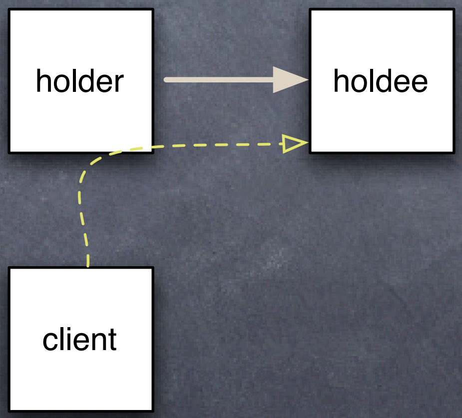
Python: hold or wrap?

- "Hold": object O has subobject S as an attribute (maybe property) -- that's all
  - use self.S.method or O.S.method
  - simple, direct, immediate, but... pretty strong coupling, often on the wrong axis



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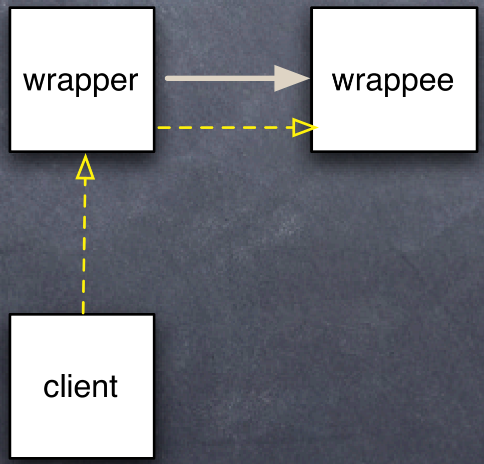
Python: hold or wrap?

- "Wrap": hold (often via private name) plus delegation (so you directly use O.method)
  - explicit (def method(self...)...self.S.method)
  - automatic (delegation in __getattr__)
  - gets coupling right (Law of Demeter)



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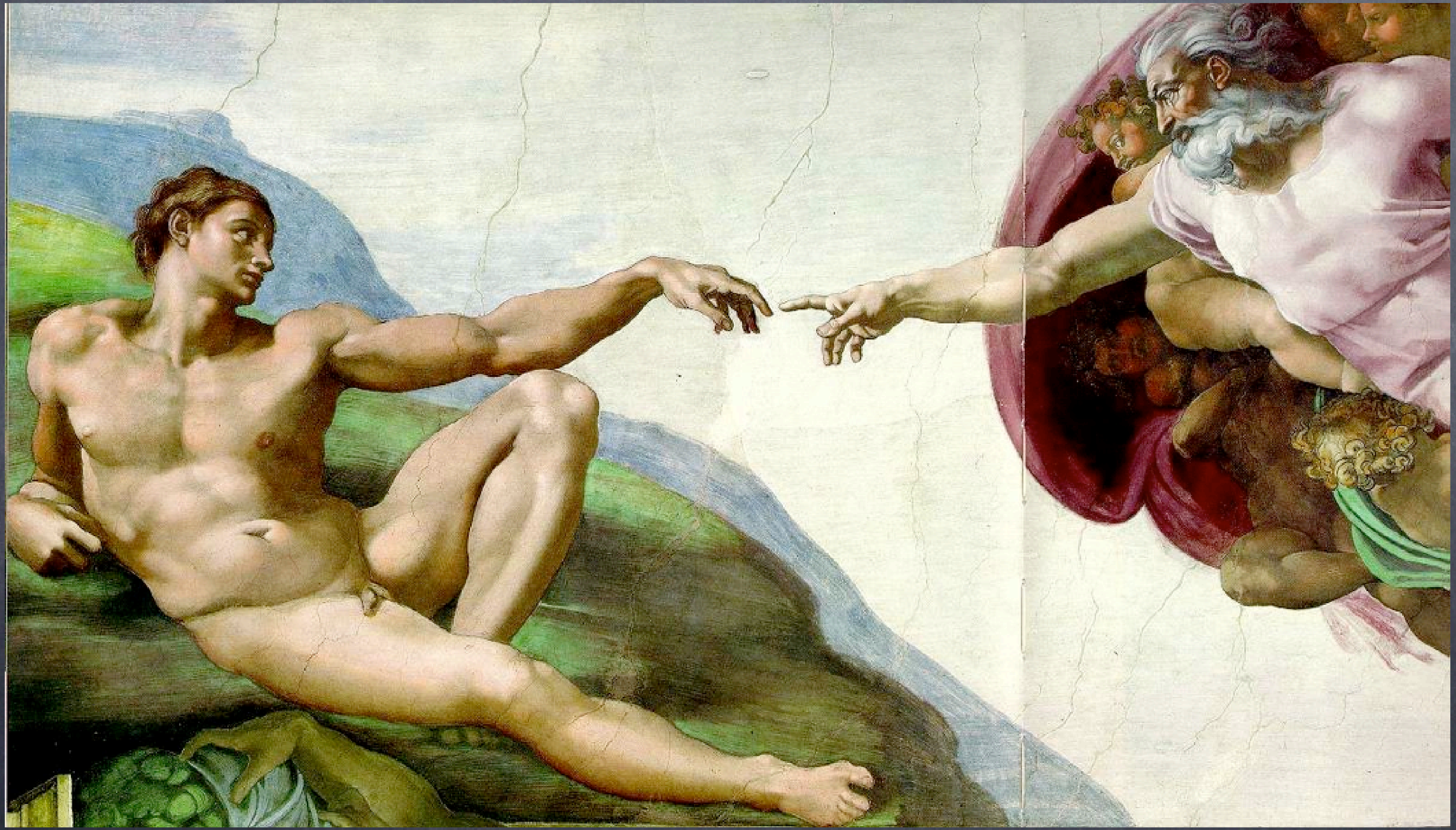
E.g: wrap to "restrict"

```
class RestrictingWrapper(object):
  def __init__(self, w, block):
    self._w = w
    self._block = block
  def __getattr__(self, n):
    if n in self._block:
      raise AttributeError, n
    return getattr(self._w, n)
  ...
```

Inheritance cannot restrict!

Creational Patterns

- not very common in Python...
- ...because "factory" is essentially built-in!-)



Creational Patterns [1]

- "we want just one instance to exist"
  - use a module instead of a class
    - no subclassing, no special methods, ...
  - make just 1 instance (no enforcement)
    - need to commit to "when" to make it
  - singleton ("highlander")
    - subclassing not really smooth
  - monostate ("borg")
    - Guido dislikes it

Singleton ("Highlander")

```
class Singleton(object):
  def __new__(cls, *a, **k):
    if not hasattr(cls, '_inst'):
      cls._inst = super(Singleton, cls
                ).__new__(cls, *a, **k)
    return cls._inst
```

subclassing is a problem, though:

```
class Foo(Singleton): pass
class Bar(Foo): pass
f = Foo(); b = Bar(); # ...???...
```

problem is intrinsic to Singleton

Monostate ("Borg")

```
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
```

subclassing is no problem, just:

```
class Foo(Borg): pass
class Bar(Foo): pass
class Baz(Foo): _shared_state = {}
```

data overriding to the rescue!

Creational Patterns [2]

- "we don't want to commit to instantiating a specific concrete class"
  - "Dependency Injection" DP
    - no creation except "outside"
    - what if multiple creations are needed?
  - "Factory" subcategory of DPs
    - may create w/ever or reuse existing
    - factory functions (& other callables)
    - factory methods (overridable)
    - abstract factory classes

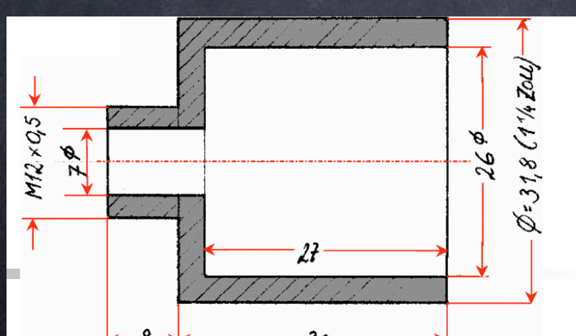
Structural Patterns

"Masquerading/Adaptation" subcategory:

- Adapter: tweak an interface (both class and object variants exist)
- Facade: simplify a subsystem's interface
- ...and many others I don't cover, such as:
  - Bridge: many implementations of an abstraction, many implementations of a functionality, no repetitive coding
  - Decorator: reuse+tweak w/o inheritance
  - Proxy: decouple from access/location

Adapter

- client code γ requires a protocol C
- supplier code σ provides different protocol S (with a superset of C's functionality)
- adapter code α "sneaks in the middle":
  - to γ, α is a supplier (produces protocol C)
  - to σ, α is a client (consumes protocol S)
  - "inside", α implements C (by means of appropriate calls to S on σ)



Toy-example Adapter

- C requires method foobar(foo, bar)
- S supplies method barfoo(bar, foo)
- e.g., σ could be:

```
class Barfooer(object):
    def barfoo(self, bar, foo):
        ...
```

Object Adapter

- per-instance, with wrapping delegation:

```
class FoobarWrapper(object):
  def __init__(self, wrappee):
    self.w = wrappee
  def foobar(self, foo, bar):
    return self.w.barfoo(bar, foo)

foobarer=FoobarWrapper(barfooer)
```

Class Adapter (direct)

- per-class, w/subclasing & self-delegation:

```
class Foobarer(Barfooer):
  def foobar(self, foo, bar):
    return self.barfoo(bar, foo)

foobarer=Foobarer(...w/ever...)
```

Class Adapter (mixin)

- flexible, good use of multiple inheritance:

```
class BF2FB:
  def foobar(self, foo, bar):
    return self.barfoo(bar, foo)

class Foobarer(BF2FB, Barfooer):
  pass

foobarer=Foobarer(...w/ever...)
```

Adapter KU

- socket._fileobject: from sockets to file-like objects (w/much code for buffering)
- doctest.DocTestSuite: adapts doctest tests to unittest.TestSuite
- dbhash: adapt bsddb to dbm
- StringIO: adapt str or unicode to file-like
- shelve: adapt "limited dict" (str keys and values, basic methods) to complete mapping
  - via pickle for any <-> string
  - + UserDict.DictMixin

Adapter observations

- some RL adapters may require much code
- mixin classes are a great way to help adapt to rich protocols (implement advanced methods on top of fundamental ones)
- Adapter occurs at all levels of complexity
- in Python, it's _not_ just about classes and their instances (by a long shot!-) -- often _callables_ are adapted (via decorators and other HOFs, closures, functools, ...)

Facade vs Adapter

- Adapter's about supplying a given protocol required by client-code
  - or, gain polymorphism via homogeneity
- Facade is about simplifying a rich interface when just a subset is often needed
- Facade most often "fronts" for a subsystem made up of many classes/objects, Adapter "front" for just one single object or class

Behavioral Patterns

- Template Method: self-delegation
  - ..."the essence of OOP"...
  - some of its many Python-specific variants

Template Method

- great pattern, lousy name
  - "template" very overloaded
    - generic programming in C++
    - generation of document from skeleton
    - ...
- a better name: self-delegation
  - directly descriptive!-)

Classic TM

- abstract base class offers "organizing method" which calls "hook methods"
- in ABC, hook methods stay abstract
- concrete subclasses implement the hooks
- client code calls organizing method
  - on some reference to ABC (injecter, or...)
  - which of course refers to a concrete SC

TM skeleton

```
class AbstractBase(object):
  def orgMethod(self):
    self.doThis()
    self.doThat()

class Concrete(AbstractBase):
  def doThis(self): ...
  def doThat(self): ...
```

KU: cmd.Cmd.cmdloop

```
def cmdloop(self):
  self.preloop()
  while True:
    s = self.doinput()
    s = self.precmd(s)
    finis = self.docmd(s)
    finis = self.postcmd(finis,s)
    if finis: break
  self.postloop()
```

Classic TM Rationale

- the "organizing method" provides "structural logic" (sequencing &c)
- the "hook methods" perform "actual ``elementary" actions"
- it's an often-appropriate factorization of commonality and variation
  - focuses on objects' (classes') responsibilities and collaborations: base class calls hooks, subclass supplies them
  - applies the "Hollywood Principle": "don't call us, we'll call you"

A choice for hooks

```
class TheBase(object):
  def doThis(self):
    # provide a default (often a no-op)
    pass
  def doThat(self):
    # or, force subclass to implement
    # (might also just be missing...)
    raise NotImplementedError
```

Default implementations often handier, when sensible; but "mandatory" may be good docs.

KU: Queue.Queue

```
class Queue:
  ...
  def put(self, item):
    self.not_full.acquire()
    try:
      while self._full():
        self.not_full.wait()
      self._put(item)
      self.not_empty.notify()
    finally:
      self.not_full.release()
  def _put(self, item): ...
```

Queue's TMDP

- Not abstract, often used as-is
  - thus, implements all hook-methods
- subclass can customize queueing discipline
  - with no worry about locking, timing, ...
  - default discipline is simple, useful FIFO
  - can override hook methods (_init, _qsize, _empty, _full, _put, _get) AND...
  - ...data (maxsize, queue), a Python special

Customizing Queue

```
class LifoQueueA(Queue):
  def _put(self, item):
    self.queue.appendleft(item)

class LifoQueueB(Queue):
  def _init(self, maxsize):
    self.maxsize = maxsize
    self.queue = list()
  def _get(self):
    return self.queue.pop()
```

"Factoring out" the hooks

- "organizing method" in one class
- "hook methods" in another
- KU: HTML formatter vs writer
- KU: SAX parser vs handler
- adds one axis of variability/flexibility
- shades towards the Strategy DP:
  - Strategy: 1 abstract class per decision point, independent concrete classes
  - Factored TM: abstract/concrete classes more "grouped"

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TM + introspection

- "organizing" class can snoop into "hook" class (maybe descendant) at runtime
  - find out what hook methods exist
  - dispatch appropriately (including "catch-all" and/or other error-handling)

KU: cmd.Cmd.docmd

```
def docmd(self, cmd, a):
  ...
  try:
    fn = getattr(self, 'do_' + cmd)
  except AttributeError:
    return self.dodefault(cmd, a)
  return fn(a)
```

Questions & Answers

Q?

A!

1. Design Patterns: Elements of Reusable Object-Oriented Software -- Gamma, Helms, Johnson, Vlissides -- advanced, very deep, THE classic "Gang of 4" book that started it all (C++)
2. Head First Design Patterns -- Freeman -- introductory, fast-paced, very hands-on (Java)
3. Design Patterns Explained -- Shalloway, Trott -- introductory, mix of examples, reasoning and explanation (Java)
4. The Design Patterns Smalltalk Companion -- Alpert, Brown, Woolf -- intermediate, very language-specific (Smalltalk)
5. Agile Software Development, Principles, Patterns and Practices -- Martin -- intermediate, extremely practical, great mix of theory and practice (Java, C++)
6. Refactoring to Patterns -- Kerievsky -- introductory, strong emphasis on refactoring existing code (Java)
7. Pattern Hatching, Design Patterns Applied -- Vlissides -- advanced, anecdotal, specific applications of idea from the Gof4 book (C++)
8. Modern C++ Design: Generic Programming and Design Patterns Applied -- Alexandrescu -- advanced, very language specific (C++)