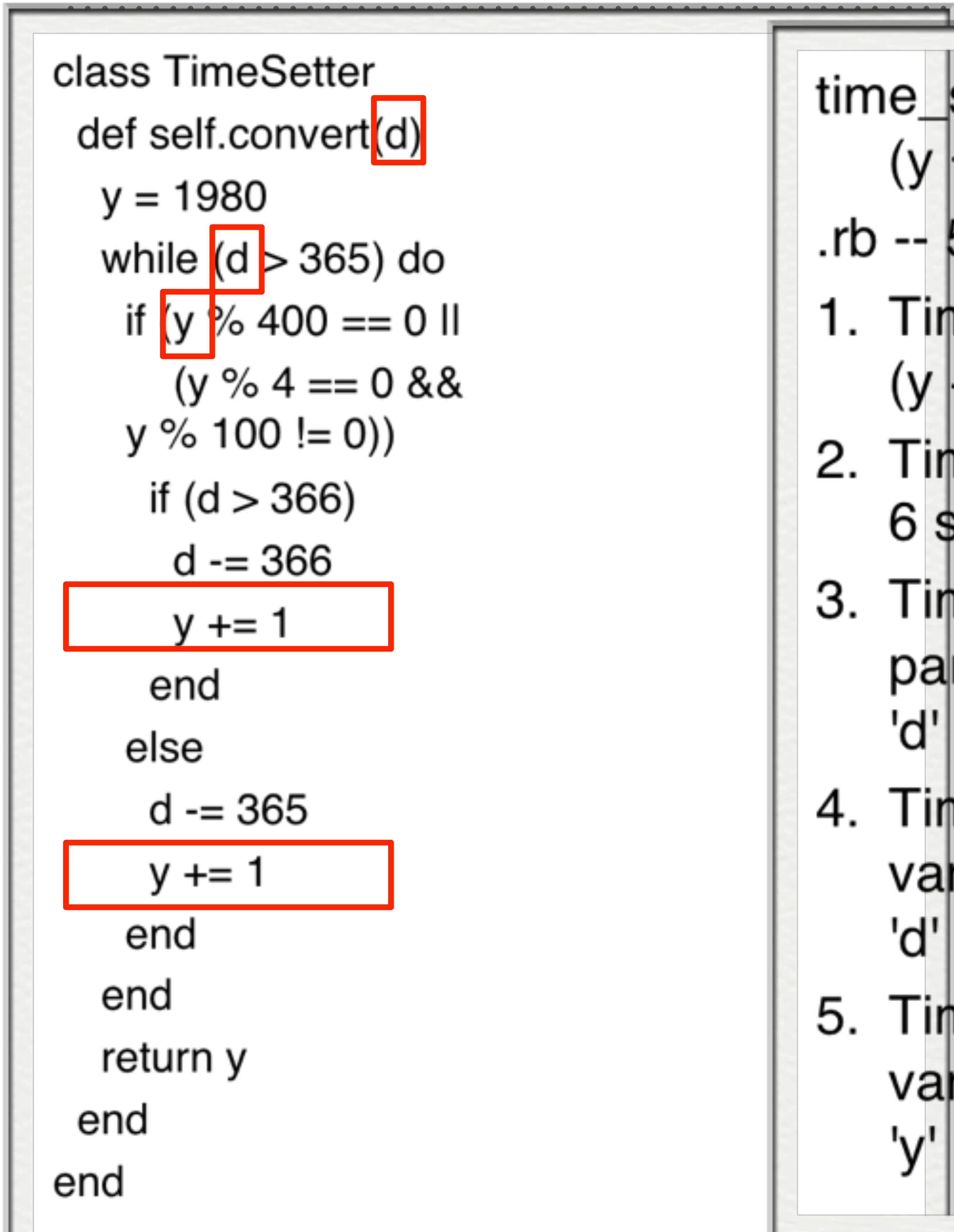
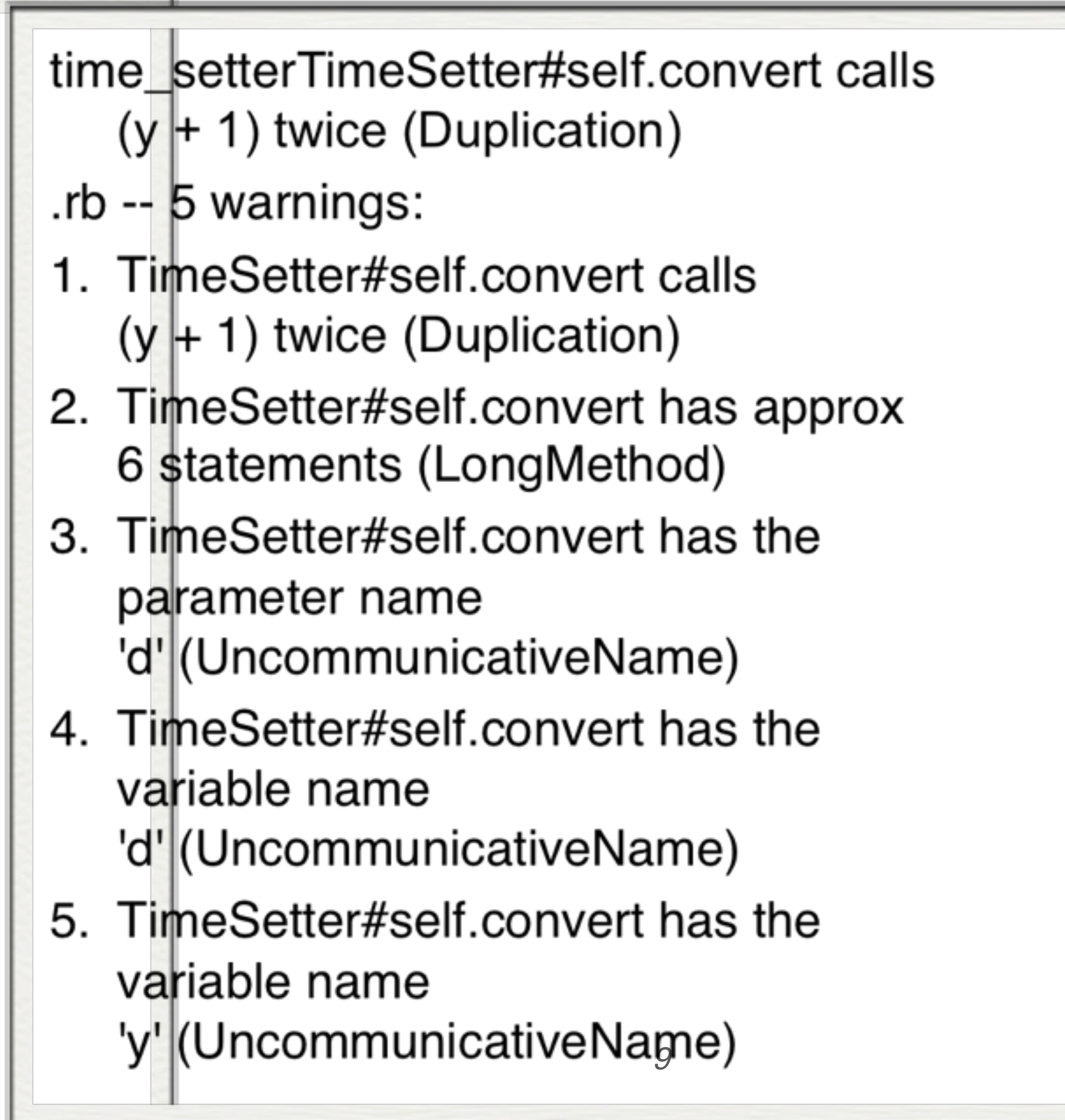
CODE SMELLS AND METRICS, REFACTORING, AND DESIGN PRINCIPLES

PROGRAM X & SMELLS



```
class TimeSetter
  def self.convert(d)
    y = 1980
    while (d > 365) do
      if (y % 400 == 0 ||
          (y % 4 == 0 &&
      y % 100 != 0))
        if (d > 366)
          d -= 366
          y += 1
        end
      else
        d -= 365
        y += 1
      end
    end
    return y
  end
end
```



```
time_setterTimeSetter#self.convert calls
    (y + 1) twice (Duplication)
.rb -- 5 warnings:
1.  TimeSetter#self.convert calls
    (y + 1) twice (Duplication)
2.  TimeSetter#self.convert has approx
    6 statements (LongMethod)
3.  TimeSetter#self.convert has the
    parameter name
    'd' (UncommunicativeName)
4.  TimeSetter#self.convert has the
    variable name
    'd' (UncommunicativeName)
5.  TimeSetter#self.convert has the
    variable name
    'y' (UncommunicativeName)
```

Quantitative: Metrics

- "Hotspots": places where *multiple metrics* raise red flags
  - *add require 'metric_fu' to **Rakefile***
  - ***rake metrics:all***
- Take metrics with a grain of salt
  - *Like coverage, better for identifying where improvement is needed than for signing off*

Metric	Tool	Target score
Code-to-test ratio	rake stats	≤ 1:2
C0 (statement) coverage	SimpleCov	90%+
Assignment-Branch-Condition score	flog	< 20 per method
Cyclomatic complexity	saikuro	< 10 per method (NIST)

https://www.ruby-toolbox.com/categories/

Qualitative: Code Smells

SOFA captures symptoms that often indicate code smells:

- Be short
- Do one thing
- Have few arguments
- Consistent level of abstraction

- Ruby tool: reek

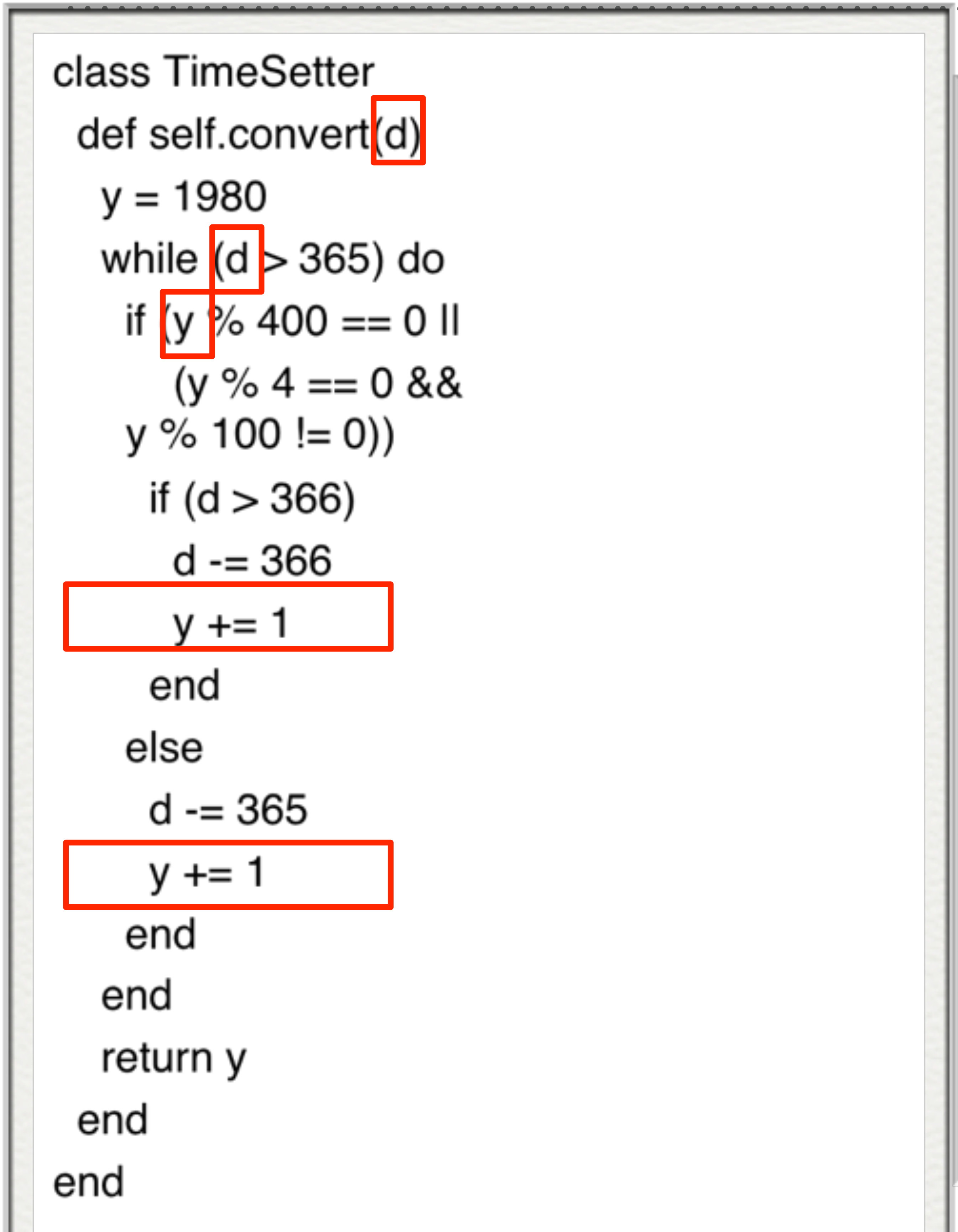
SINGLE LEVEL OF ABSTRACTION

- Complex tasks need divide & conquer
- Yellow flag for “encapsulate this task in a method”
- Like a good news story, classes & methods should read “top down”!
  - Good: start with a high level summary of key points, then go into each point in detail
  - Good: Each paragraph deals with 1 topic
  - Bad: ramble on, jumping between “levels of abstraction” rather than progressively refining

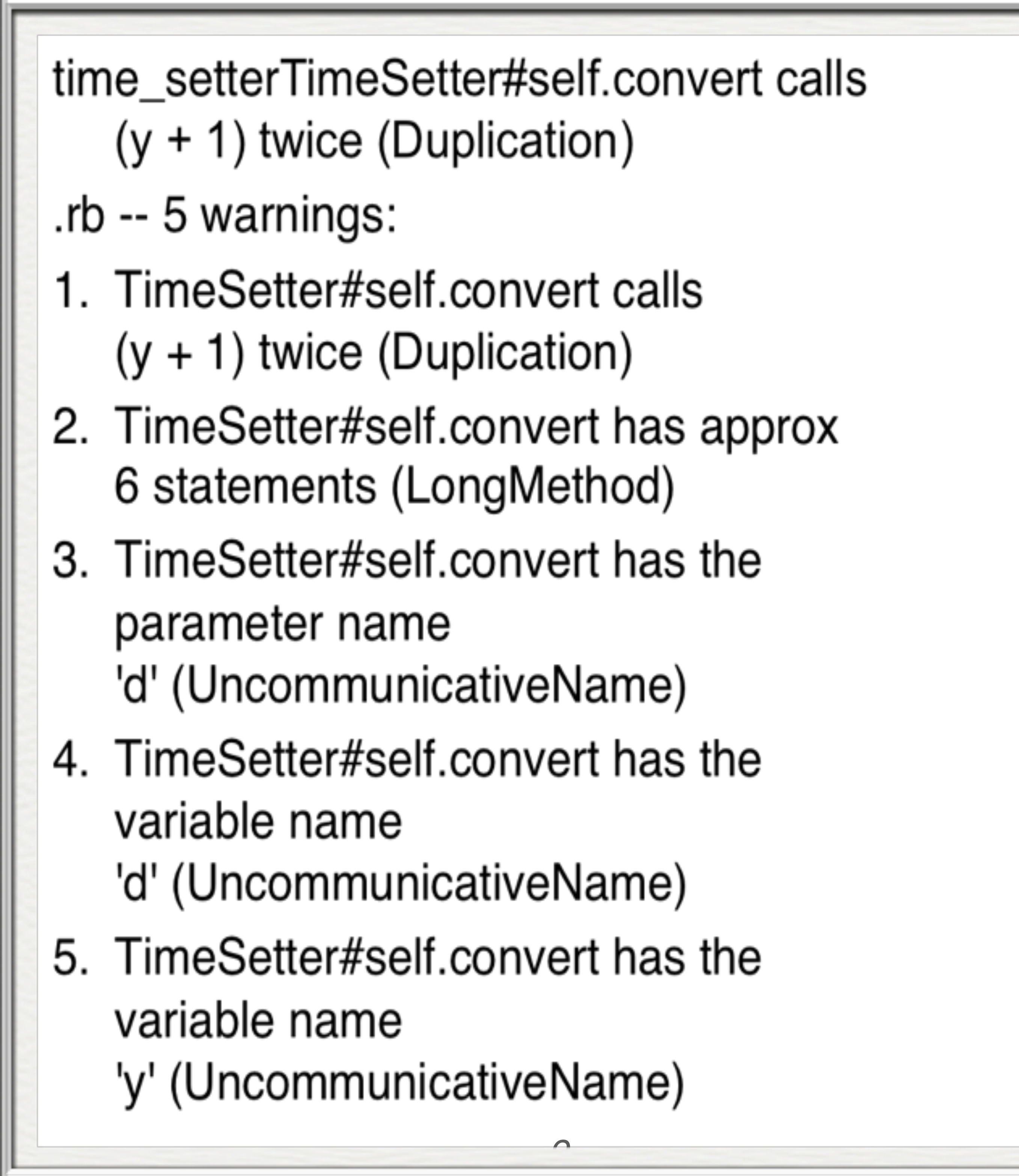
WHY LOTS OF ARGUMENTS IS BAD

- Hard to get good testing coverage
- Hard to mock/stub while testing
- Boolean arguments should be a yellow flag
  - If function behaves differently based on Boolean argument value, maybe should be 2 functions
- If arguments "travel in a pack", maybe you need to *extract a new class*
  - Same set of arguments for a lot of methods

PROGRAM X & SMELLS



```
class TimeSetter
 def self.convert(d)
  y = 1980
  while (d > 365) do
   if (y % 400 == 0 ||
      (y % 4 == 0 &&
   y % 100 != 0))
    if (d > 366)
     d -= 366
     y += 1
    end
   else
    d -= 365
    y += 1
   end
  end
  return y
 end
end
```



```
time_setterTimeSetter#self.convert calls
    (y + 1) twice (Duplication)
.rb -- 5 warnings:
1.  TimeSetter#self.convert calls
    (y + 1) twice (Duplication)
2.  TimeSetter#self.convert has approx
    6 statements (LongMethod)
3.  TimeSetter#self.convert has the
    parameter name
    'd' (UncommunicativeName)
4.  TimeSetter#self.convert has the
    variable name
    'd' (UncommunicativeName)
5.  TimeSetter#self.convert has the
    variable name
    'y' (UncommunicativeName)
```

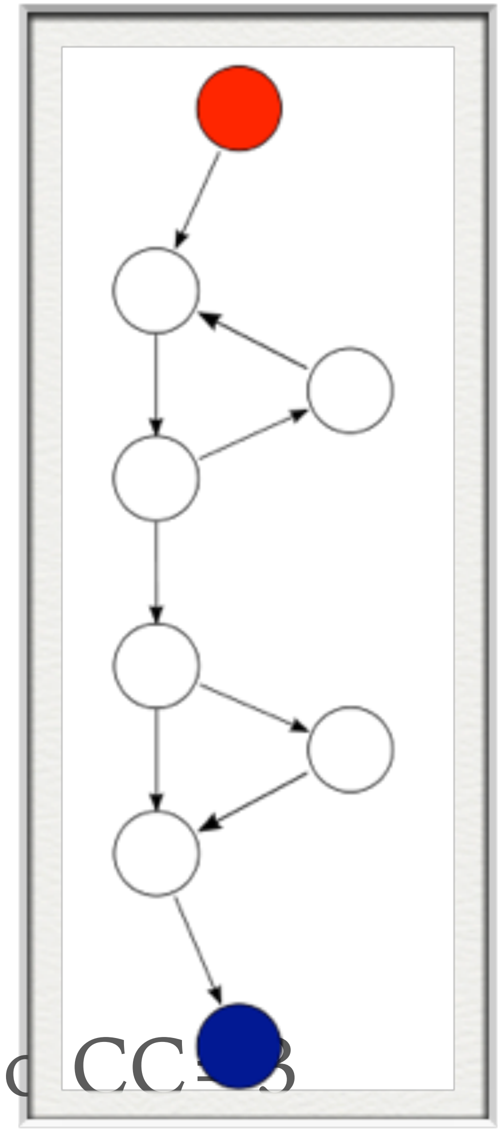
QUANTITATIVE: ABC COMPLEXITY

- Counts Assignments, Branches, Conditions
- Score = Square Root($A^2 + B^2 + C^2$)
- NIST (Natl. Inst. Stds. & Tech.): ≤20 /method
- Rails tool `flog` checks ABC complexity

QUANTITATIVE: CYCLOMATIC COMPLEXITY

- # of linearly-independent paths thru code = E– N+2P (edges, nodes, connected components)

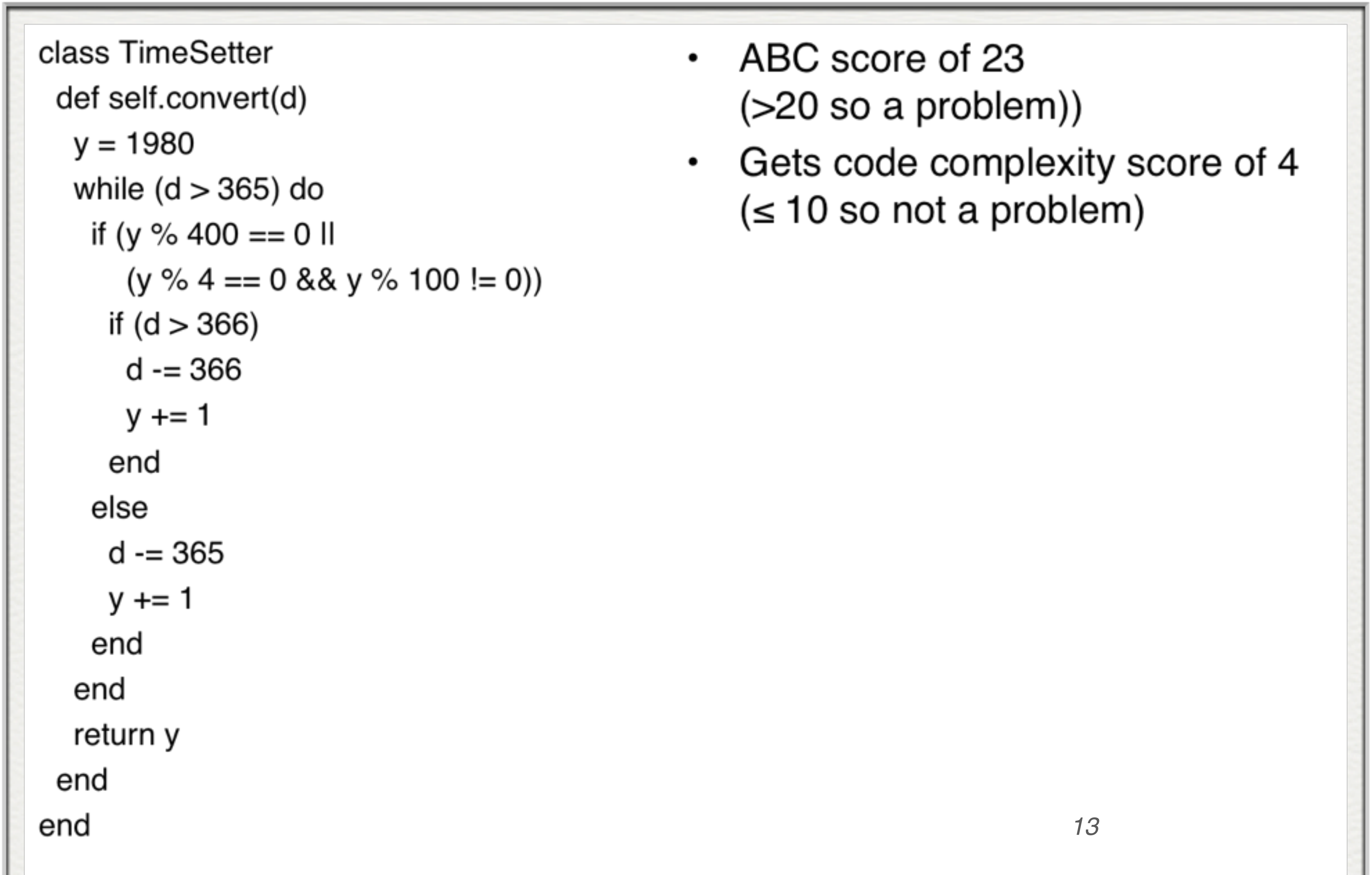
```
def mymeth
  while(...)
    ....
  end
  if (...)
    do_something
  end
end
```



Rails tool `saikuro` *calculates cyclomatic complexity*

- Here, E=9, N=8, P=1, so CC=3
- NIST (Natl. Inst. Stds. & Tech.): ≤10 /module

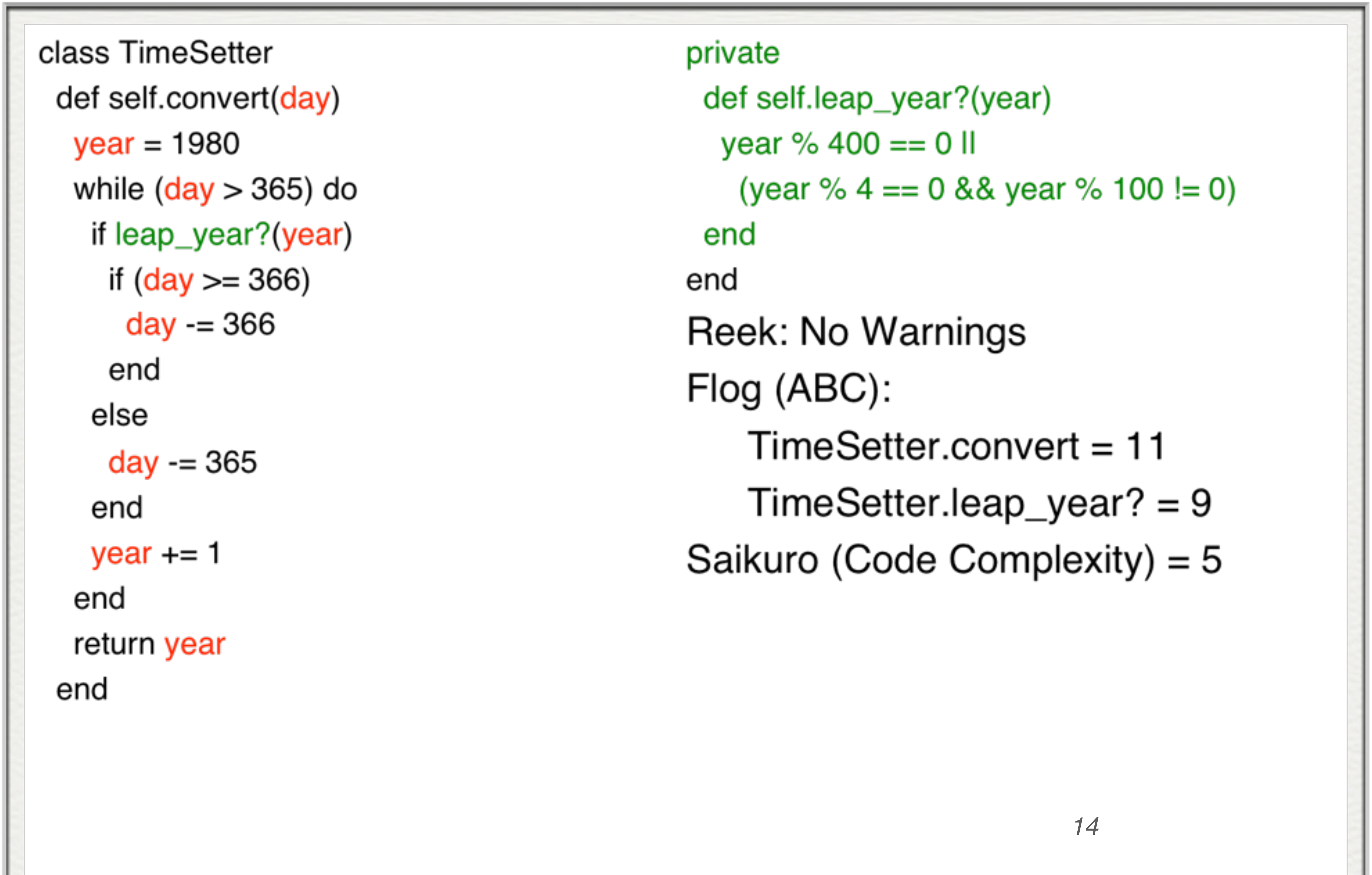
LEAP YEAR & QUANTITATIVE



```
class TimeSetter
  def self.convert(d)
    y = 1980
    while (d > 365) do
      if (y % 400 == 0 ||
          (y % 4 == 0 && y % 100 != 0))
        if (d > 366)
          d -= 366
          y += 1
        end
      else
        d -= 365
        y += 1
      end
    end
    return y
  end
end
```

- ABC score of 23 (>20 so a problem))
- Gets code complexity score of 4 (≤ 10 so not a problem)

REVISED LEAP YEAR & METRICS



```
class TimeSetter
  def self.convert(day)
    year = 1980
    while (day > 365) do
      if leap_year?(year)
        if (day >= 366)
          day -= 366
        end
      else
        day -= 365
      end
      year += 1
    end
    return year
  end
```

```
private
  def self.leap_year?(year)
    year % 400 == 0 ||
      (year % 4 == 0 && year % 100 != 0)
  end
end
```

Reek: No Warnings

Flog (ABC):

TimeSetter.convert = 11

TimeSetter.leap_year? = 9

Saikuro (Code Complexity) = 5

14

A good method is like a good news story

What makes a news article easy to read?

Good: start with a high level summary of key points, then go into each point in detail

Good: each paragraph deals with 1 topic

Bad: ramble on, jumping between “levels of abstraction” rather than progressively refining

Intro to Method-Level Refactoring

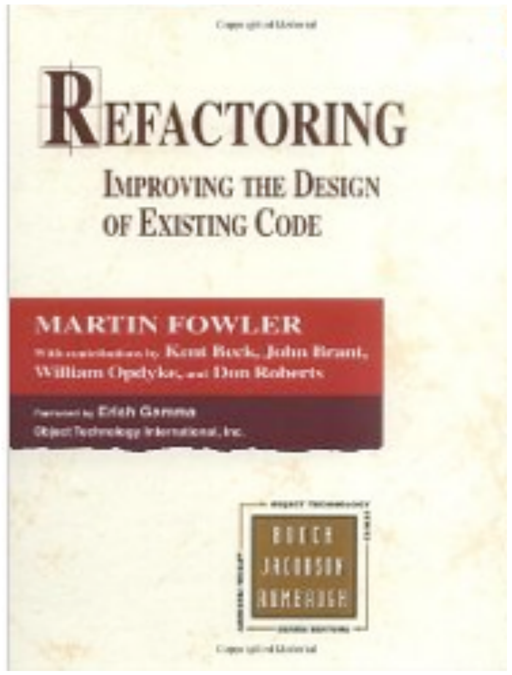
Refactoring: Idea

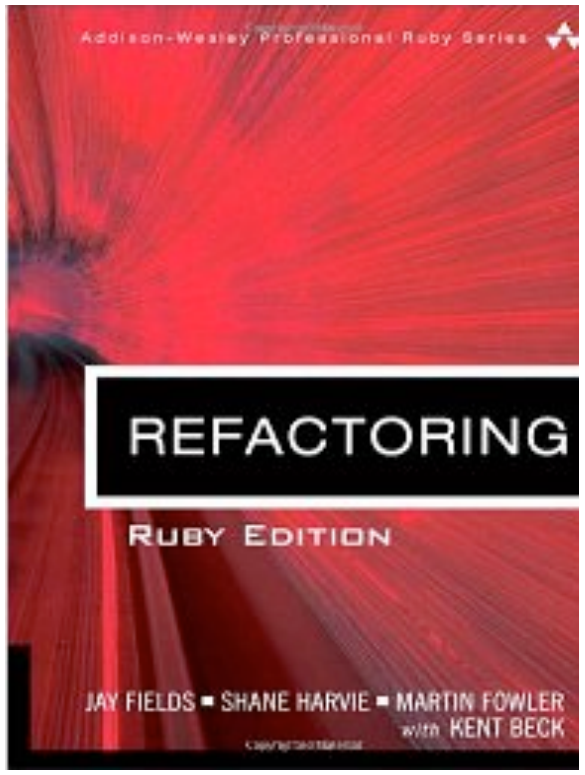
- ➤Start with code that has 1 or more problems/ smells
- ➤Through a series of *small steps*, transform to code from which those smells are absent
- ➤Protect each step with tests
- ➤*Minimize time during which tests are red*

*

History & Context

- Fowler et al. developed mostly definitive catalog of refactorings
    - *Adapted to various languages*
    - *Method- and class-level refactorings*
    - *Sidenote: Martin Fowler is awesome!!*
- Each refactoring consists of:
    - *Name*
    - *Summary of what it does/when to use*
    - *Motivation (what problem it solves)*
    - *Mechanics: step-by-step recipe*
    - *Example(s)*




Addison-Wesley Professional Ruby Series
REFACTORING
RUBY EDITION
JAY FIELDS ▪ SHANE HARVIE ▪ MARTIN FOWLER with KENT BECK

Refactoring TimeSetter

- Fix stupid names — http://pastebin.com/pYCfMQJp
- Extract method — http://pastebin.com/sXVDW9C6
- Extract method, encapsulate class — http://pastebin.com/zWM2ZqaW
- Test extracted methods — http://pastebin.com/DRpNPzpT
- Some thoughts on unit testing
  - *Glass-box testing can be useful while refactoring*
  - *Common approach: test critical values and representative noncritical values*

- Creating characterization tests and doing exploratory testing
  - *http://vimeo.com/47043669*

*

What did we do?

- ➤Made date calculator easier to read and understand using simple *refactorings*
- ➤Found a bug
- ➤Observation: if we had developed method using TDD, might have gone easier!
- ➤Improved our flog & reek scores

Refactored TimeSetter -> Date Calculator:

http://pastebin.com/0Bu6sMYi

*

Other Smells & Remedies

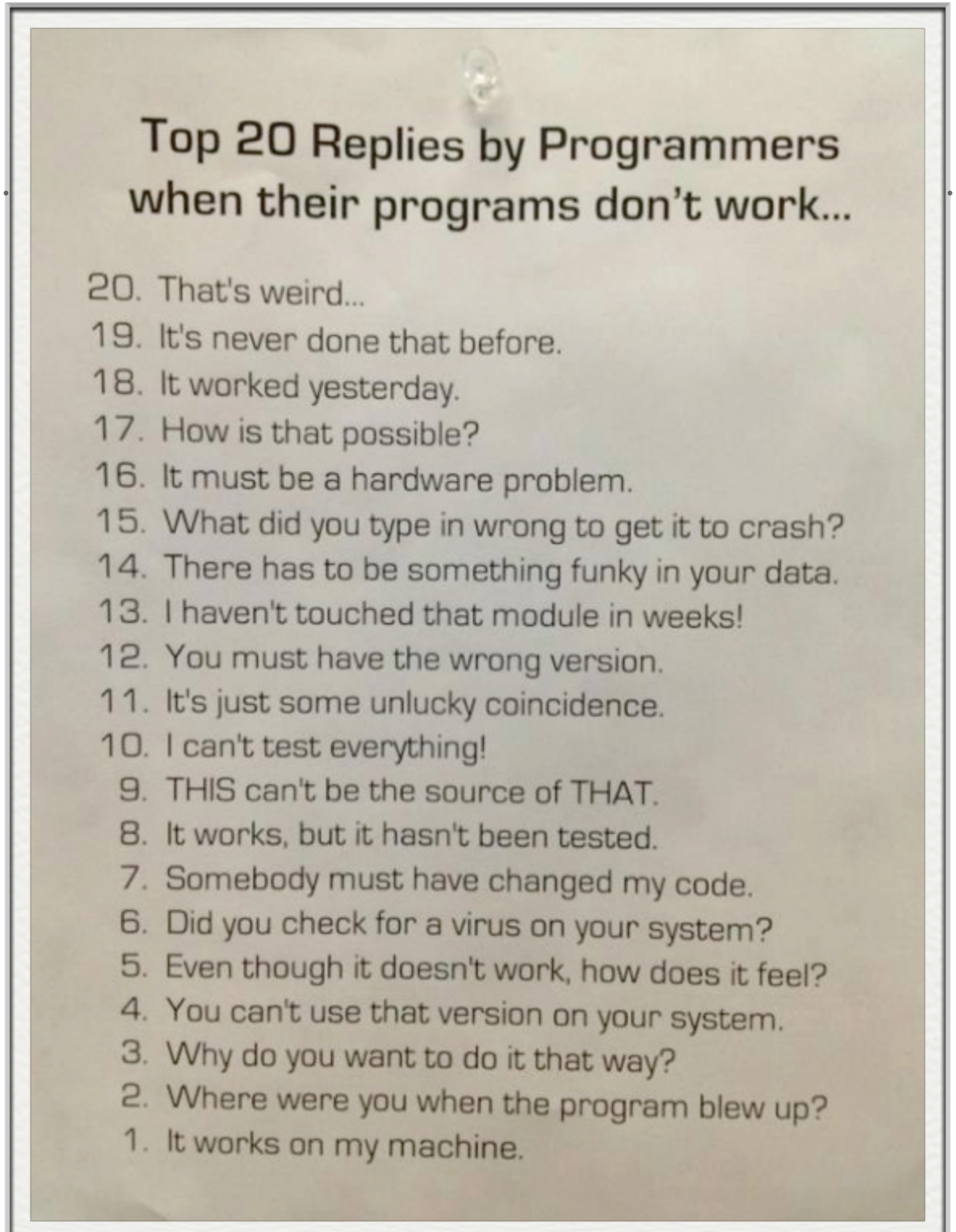
Smell	Refactoring that may resolve it
Large class	Extract class, subclass or module
Long method	*Decompose conditional* *Replace loop with collection method* *Extract method* *Extract enclosing method with yield()*
Long parameter list/data clump	Replace parameter with method call Extract class
Shotgun surgery; Inappropriate intimacy	Move method/move field to collect related items into one DRY place
Too many comments	Extract method introduce assertion replace with internal documentation
Inconsistent level of abstraction	*Extract methods & classes*

Fallacies & Pitfalls

Most of your design, coding, and testing time will be spent refactoring.

- ➤“We should just throw this out and start over”
- ➤Mixing refactoring with enhancement
- ➤Abuse of metrics
- ➤Waiting too long to do a “big refactor” (vs. continuous refactoring)

*



Top 20 Replies by Programmers when their programs don't work...

20. That's weird...
19. It's never done that before.
18. It worked yesterday.
17. How is that possible?
16. It must be a hardware problem.
15. What did you type in wrong to get it to crash?
14. There has to be something funky in your data.
13. I haven't touched that module in weeks!
12. You must have the wrong version.
11. It's just some unlucky coincidence.
10. I can't test everything!
9. THIS can't be the source of THAT.
8. It works, but it hasn't been tested.
7. Somebody must have changed my code.
6. Did you check for a virus on your system?
5. Even though it doesn't work, how does it feel?
4. You can't use that version on your system.
3. Why do you want to do it that way?
2. Where were you when the program blew up?
1. It works on my machine.

SOFTWARE DESIGN PRINCIPLES

Patterns, Antipatterns, and SOLID

Design Patterns Promote Reuse

"A pattern describes a problem that occurs often, along with a tried solution to the problem" - Christopher Alexander, 1977

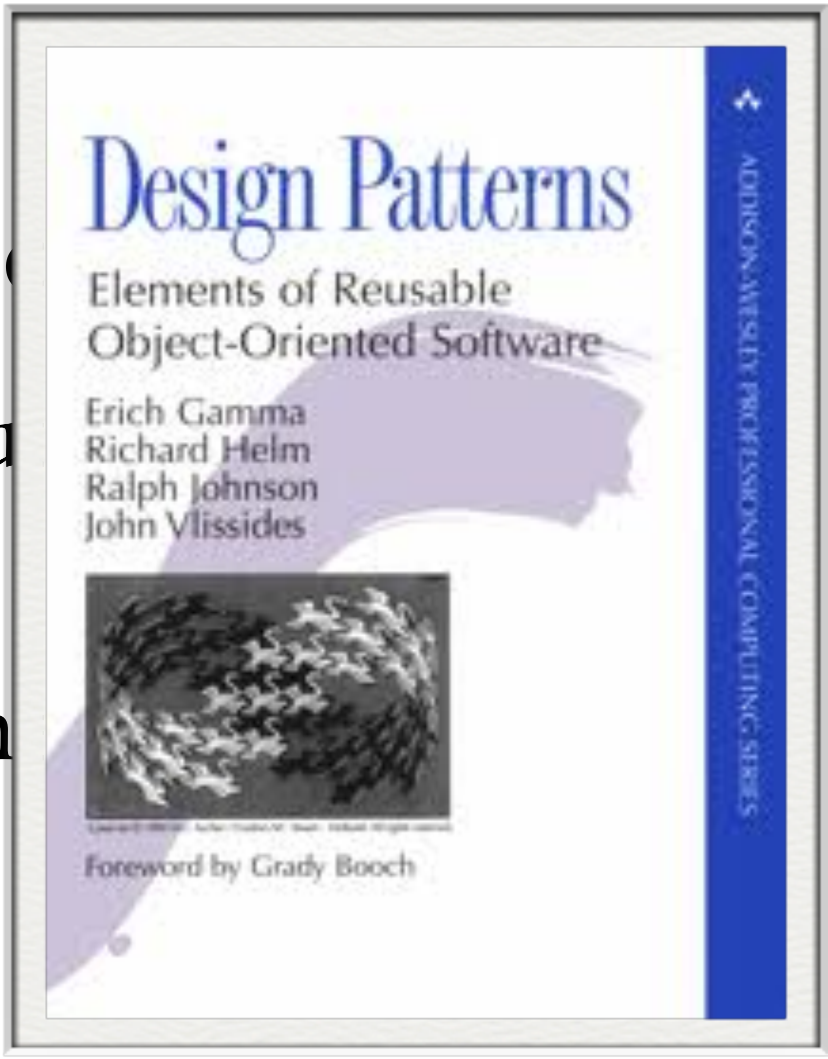
- Christopher Alexander's 253 (civil) architectural patterns range from the creation of cities (2. distribution of towns) to particular building problems (232. roof cap)
- A pattern language is an organized way of tackling an architectural problem using patterns

Kinds of Patterns in Software

- Architectural ("macroscale") patterns
  - *Model-view-controller*
  - *Pipe & Filter (e.g. compiler, Unix pipeline)*
  - *Event-based (e.g. interactive game)*
  - *Layering (e.g. SaaS technology stack)*
- Computation patterns
  - *Fast Fourier transform*
  - *Structured & unstructured grids*
  - *Dense linear algebra*
  - *Sparse linear algebra*
- *GoF (Gang of Four) Patterns: structural, creational, behavior*

The Gang of Four (GoF)

- ➤23 *structural* design patterns
  - ➤description of communicating obje
  - ➤captures common (and successful) solu of related problem instances
  - ➤can be customized to solve a specific (n that category


Design Patterns
Elements of Reusable Object-Oriented Software
Erich Gamma
Richard Helm
Ralph Johnson
John Vlissides
Foreword by Grady Booch
ADDISON-WESLEY PROFESSIONAL COMPUTING SERIES

- *Pattern ≠*
- *individual classes or libraries (list, hash, ...)*
- *full design—more like a blueprint for a design*

The GoF Pattern Zoo

1. Factory
2. ***Abstract factory***
3. Builder
4. Prototype
5. ***Singleton/Null obj***

Creation

6. ***Adapter***
7. ***Composite***
8. ***Proxy***
9. Bridge
10. Flyweight
11. ***Façade***
12. ***Decorator***

Structural

Behavioral

13. ***Observer***
14. *Mediator*
15. *Chain of responsibility*
16. *Command*
17. *Interpreter*
18. ***Iterator***
19. *Memento (memoization)*
20. *State*
21. ***Strategy***
22. ***Template***
23. *Visitor*

Meta-Patterns

Separate out the things that change from those that stay the same

1. Program to an Interface, not Implementation
2. Prefer composition & delegation over Inheritance
   - ➤delegation is about interface sharing, inheritance is about implementation sharing

Antipattern

- Code that looks like it should probably follow some design pattern, but it doesn't
- Symptoms:
    - *Viscosity (easier to do hack than Right Thing)*
    - *Immobility (can't DRY out functionality)*
    - *Needless repetition (comes from immobility)*
    - *Needless complexity from generality*

Motivation: minimize cost of change

- Single Responsibility principle
- Open/Closed principle
- Liskov substitution principle
- Injection of dependencies
  - *traditionally, Interface Segregation principle*
- Demeter principle

Refactoring & Design Patterns

Methods within a class	Relationships among classes
Code smells	Design smells
Many catalogs of code smells & refactorings	Many catalogs of design smells & design patterns
Some refactorings are superfluous in Ruby	Some design patterns are superfluous in Ruby
Metrics: ABC & Cyclomatic Complexity	Metrics: Lack of Cohesion of Methods (LCOM)
Refactor by extracting methods and moving around code within a class	Refactor by extracting classes and moving code between classes
SOFA: methods are **S**hort, do **O**ne thing, have **F**ew arguments, single level of **A**bstraction	SOLID: **S**ingle responsibility per class, **O**pen/closed principle, **L**iskov substitutability, **I**njection of dependencies, **D**emeter principle

Just Enough UML

Just Enough UML

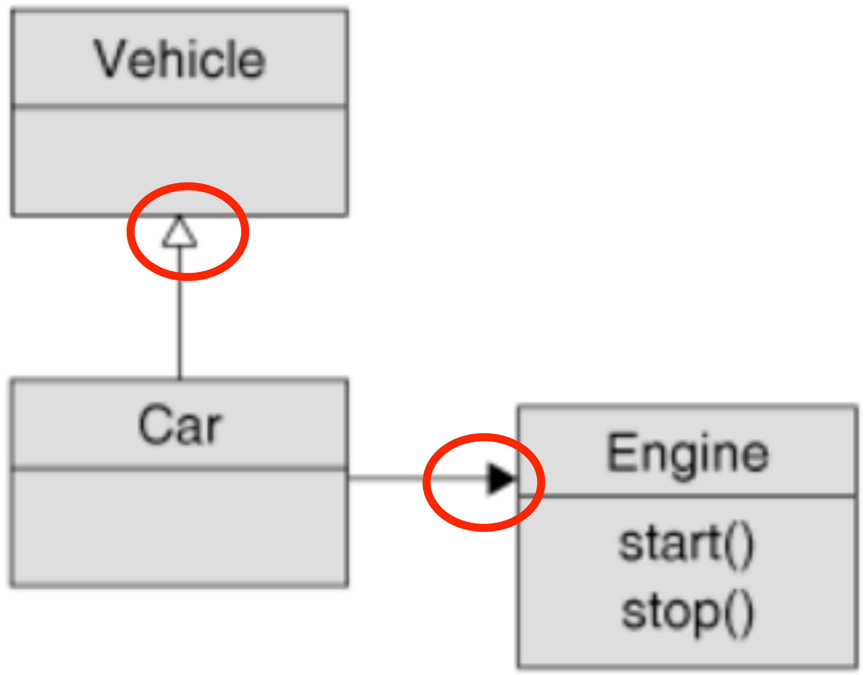
➤Unified Modeling Language: notation for describing various artifacts in OOP systems

➤One type of UML diagram is a *class diagram*, showing class relationships and principal methods:

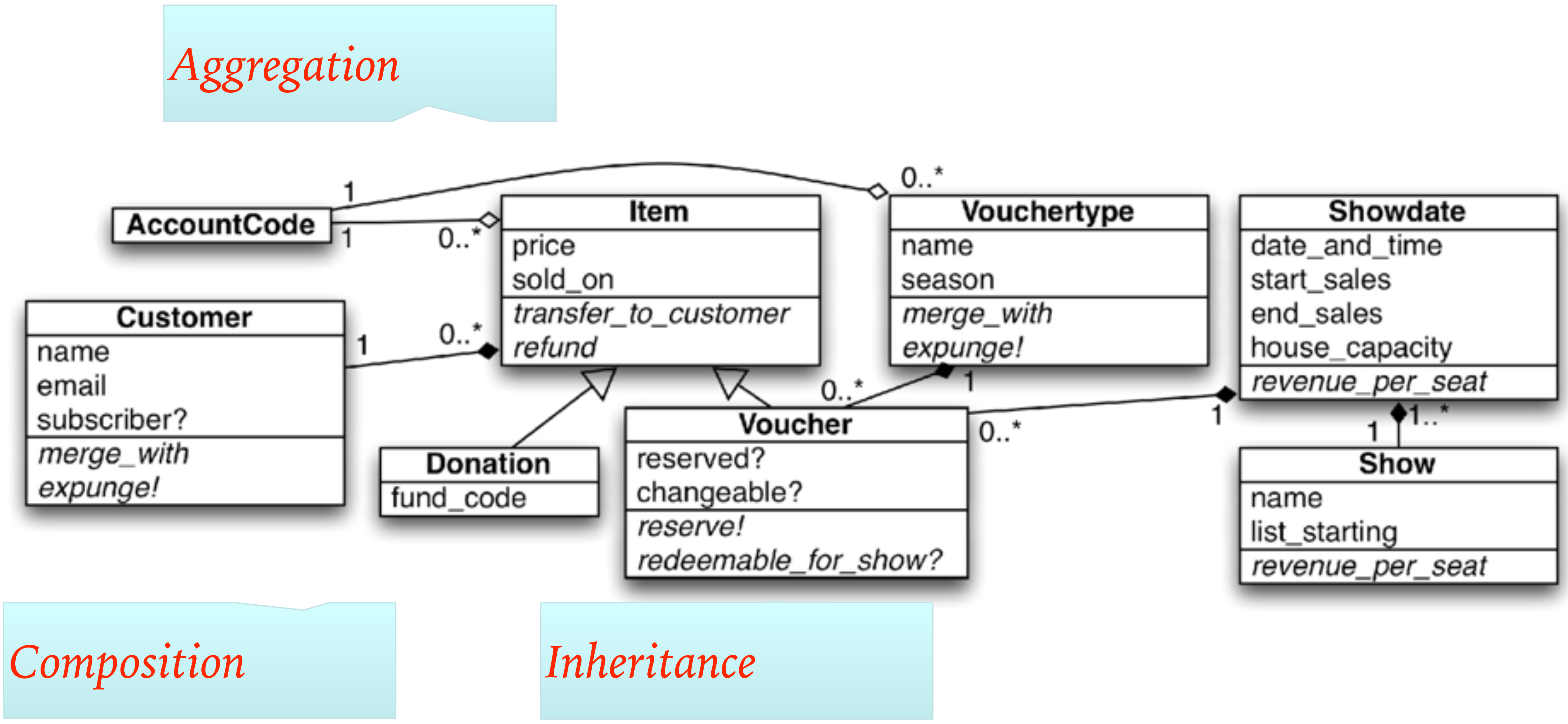
➤Car is a subclass of Vehicle

➤Engine is a *component* of Car

➤Engine class includes start(), stop() methods



Relationships



(Too Much UML)

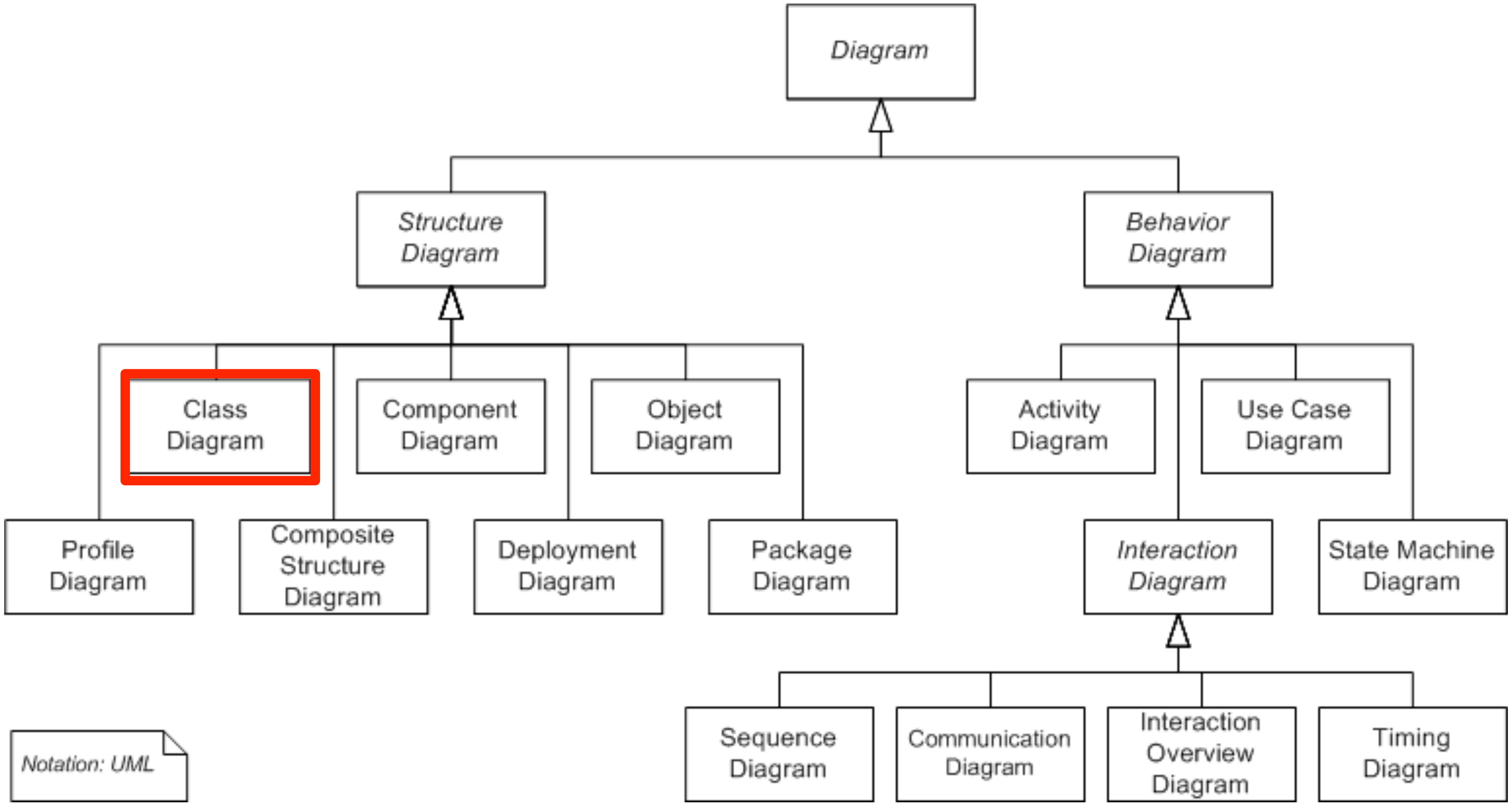


Diagram
Structure Diagram
Behavior Diagram
Class Diagram
Component Diagram
Object Diagram
Activity Diagram
Use Case Diagram
Profile Diagram
Composite Structure Diagram
Deployment Diagram
Package Diagram
Interaction Diagram
State Machine Diagram
Sequence Diagram
Communication Diagram
Interaction Overview Diagram
Timing Diagram
Notation: UML

Single Responsibility Principle

Single Responsibility Principle (SRP)

- A class should have *one and only one* reason to change
  - Each *responsibility* is a possible *axis of change*
  - Changes to one axis shouldn't affect others
- What is class's responsibility, in ≤25 words?
  - Part of the craft of OO design is *defining* responsibilities and then sticking to them
- Models with many sets of behaviors
  - eg a user is a moviegoer, and an authentication principal, and a social network member, ...etc.
  - really big class files are a tipoff

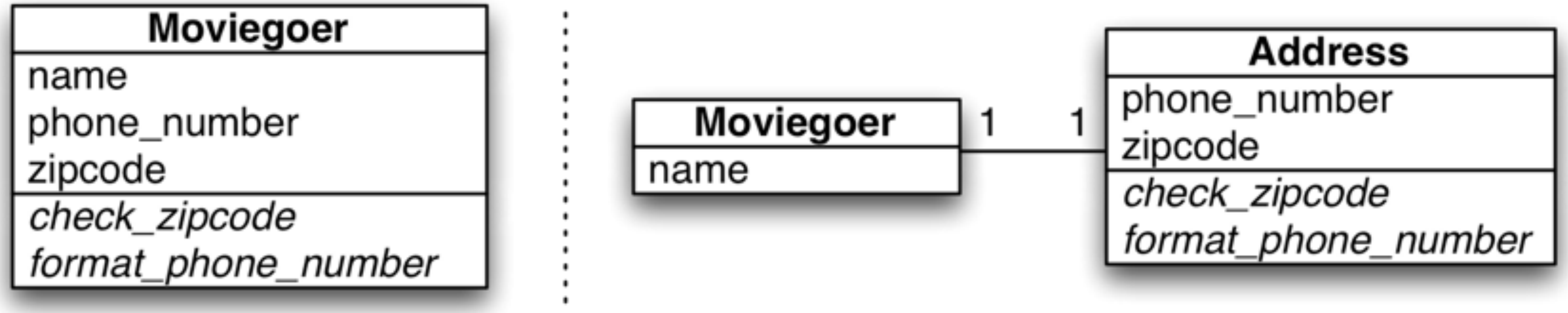
Lack of Cohesion of Methods

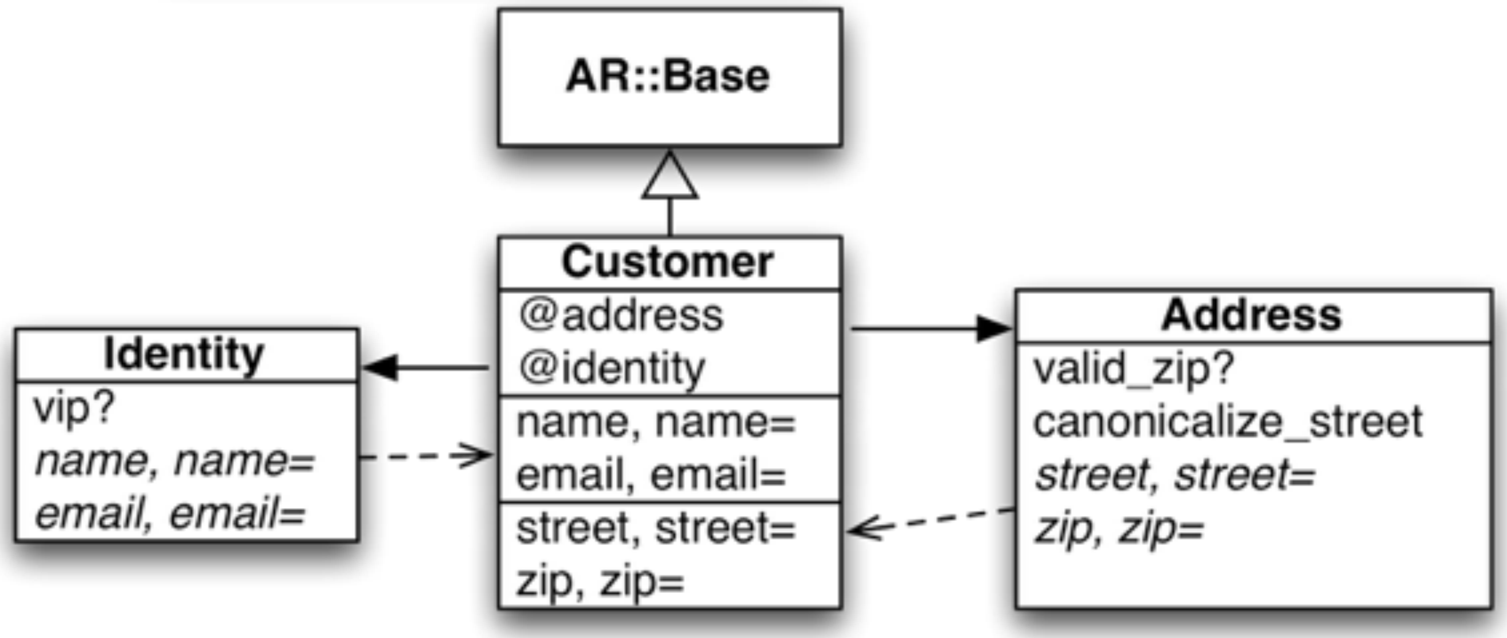
- Revised Henderson-Sellers
LCOM=1–(sum(MV_i) / M*V)   (between 0 and 1)
  - *M = # instance methods*
  - *V = # instance variables*
  - *MV_i = # instance methods that access the i'th instance variable (excluding "trivial" getters/setters)*
- LCOM-4 counts # of connected components in graph where related methods are connected by an edge
- High LCOM suggests possible SRP violation

Extract a module or class

- has_one or composed_of?
- Use composition & delegation?

http://pastebin.com/bjdaTWN8





http://pastebin.com/XESSSNb6

Open/Closed Principle

Open/Closed Principle

- Classes should be *open for extension*, but *closed for* ***source*** *modification*

```
class Report
  def output_report
    case @format
    when :html
      HtmlFormatter.new(self).output
    when :pdf
      PdfFormatter.new(self).output
```

- Can't extend (add new report types) without changing Report base class
- Not as bad as in statically typed language....but still ugly

Abstract Factory Pattern:

- ➤How to avoid OCP violation in Report constructor, if output type isn't known until runtime?
- ➤Statically typed language: *abstract factory* pattern
- ➤Ruby has a particularly simple implementation of this pattern…

```
class Report
  def output
    formatter_class =
      begin
        @format.to_s.classify.constantize
      rescue NameError
        # ...handle 'invalid formatter type'
      end
    formatter = formatter_class.send(:new, self)
    # etc
  end
end
```

http://pastebin.com/p3AHMqHZ

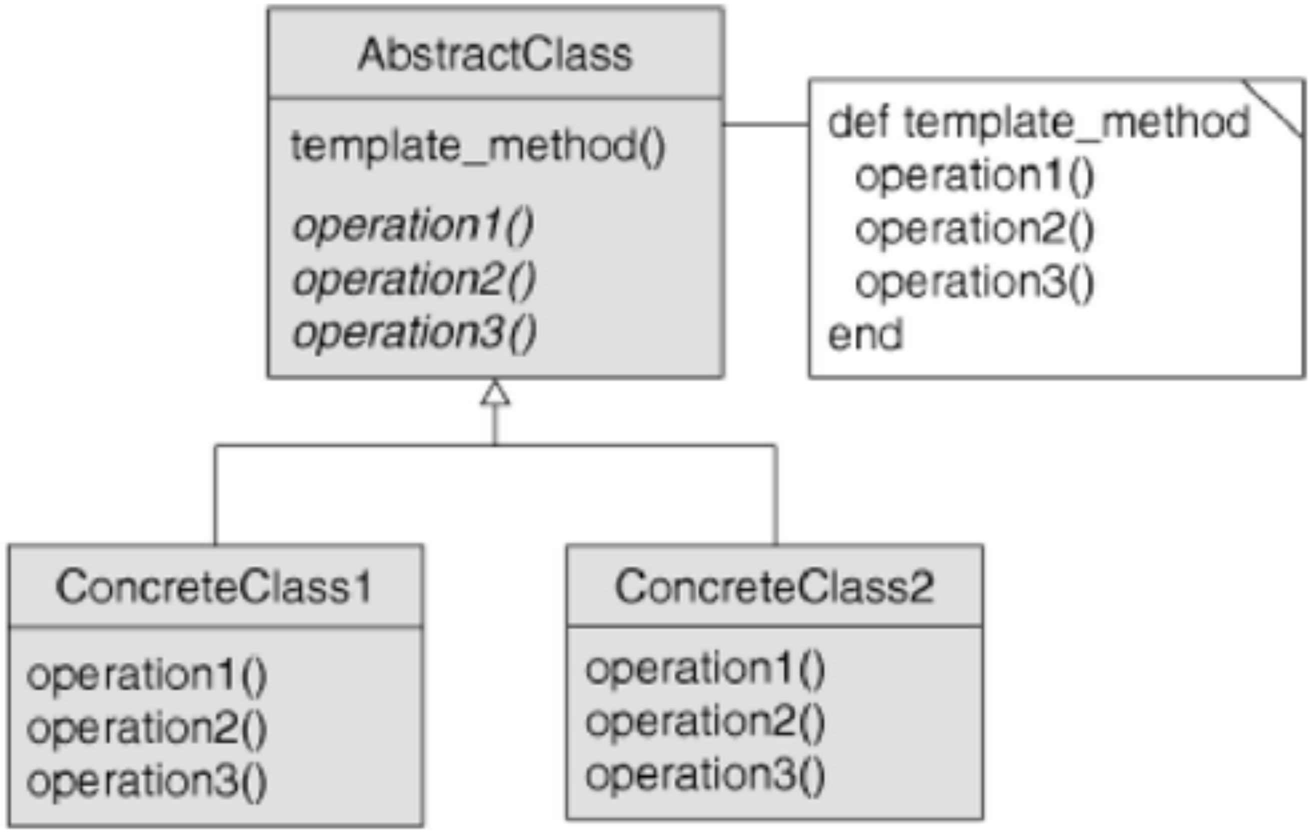
Template Method Pattern & Strategy Pattern

➤*Template method*: set of steps is the same, but implementation of steps different

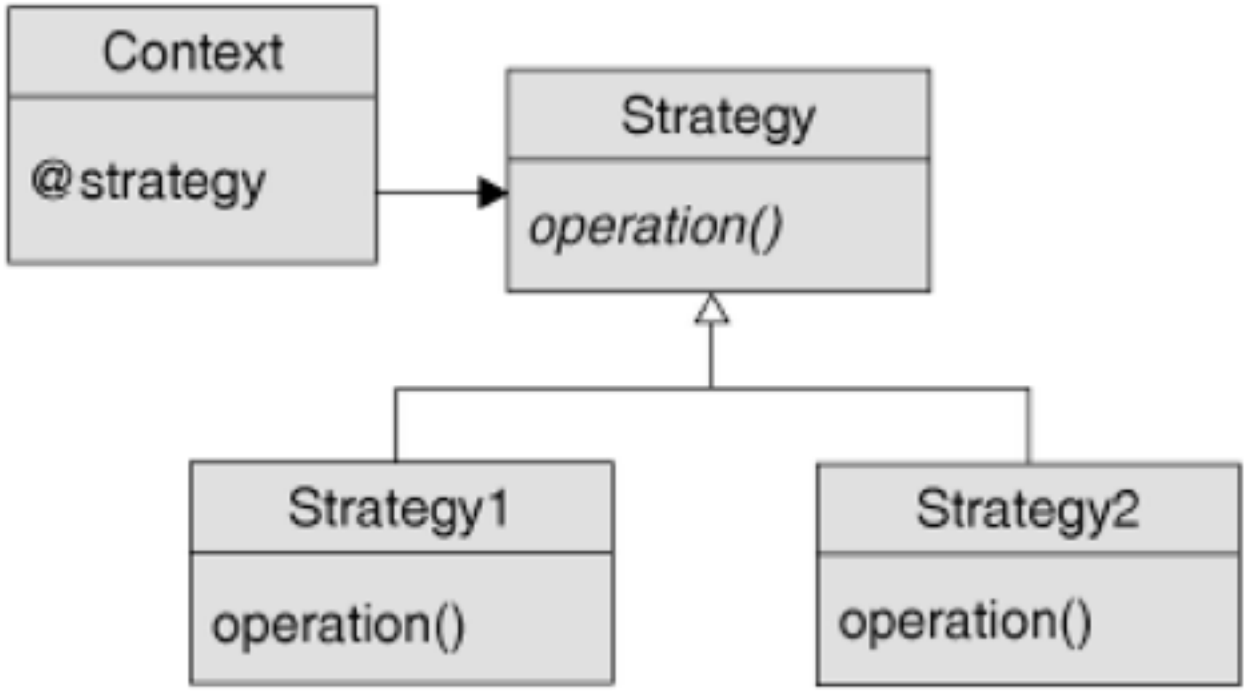
➤Typical implementation: inheritance, with subclasses overriding abstract methods

➤*Strategy*: task is the same, but many ways to do it

➤Typical implementation: composition



```
def template_method
  operation1()
  operation2()
  operation3()
end
```



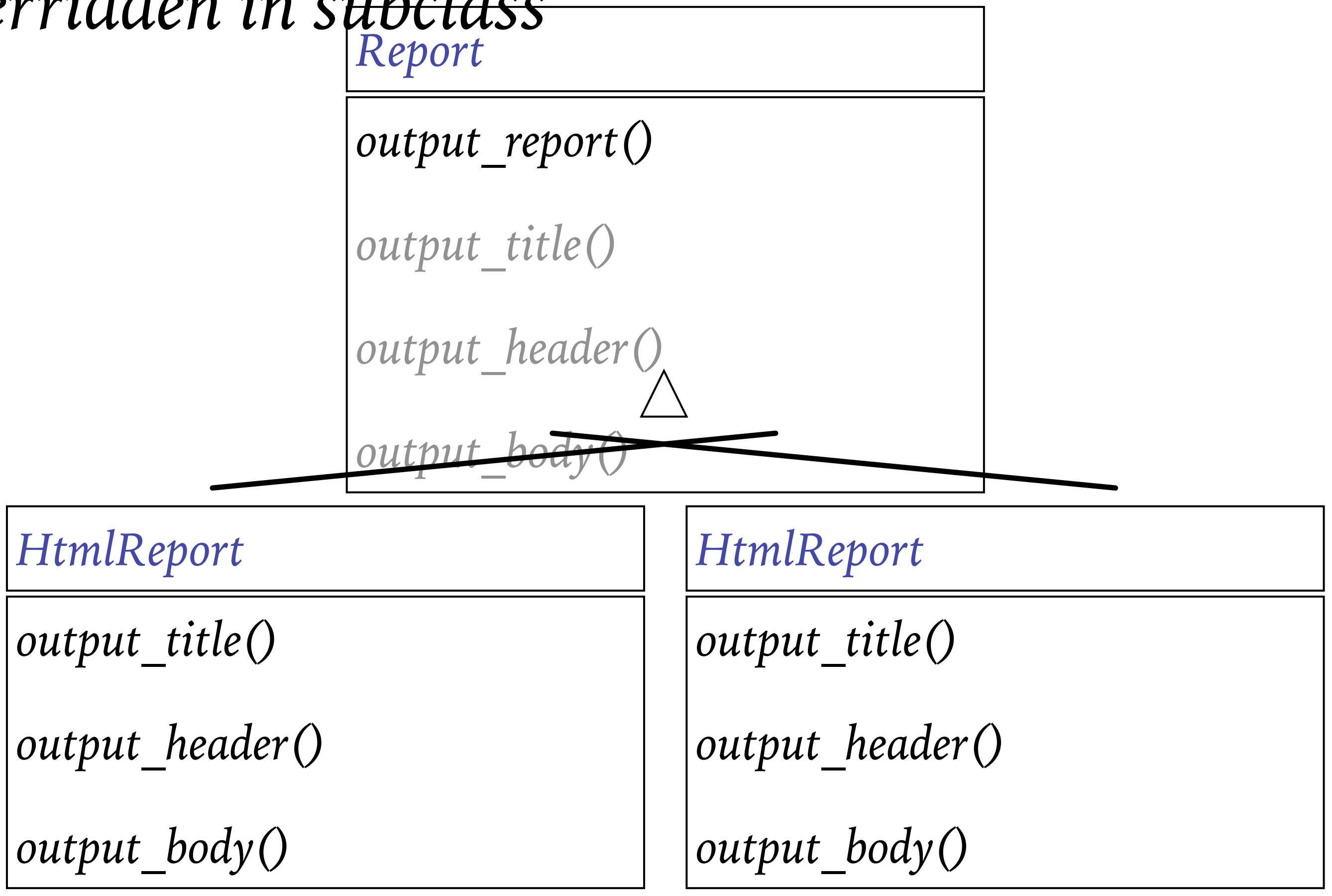
Report Generation Using Template

```
class Report
 attr_accessor :title, :text
 def output_report
  output_title
  output_header
  output_body
 end
end
```

Template method stays the same;

helpers overridden in subclass

```
class HtmlReport < Report
 def output_title ... end
 def output_header ... end
end
class PdfReport < Report
 def output_title ... end
 def output_header ... end
end
```

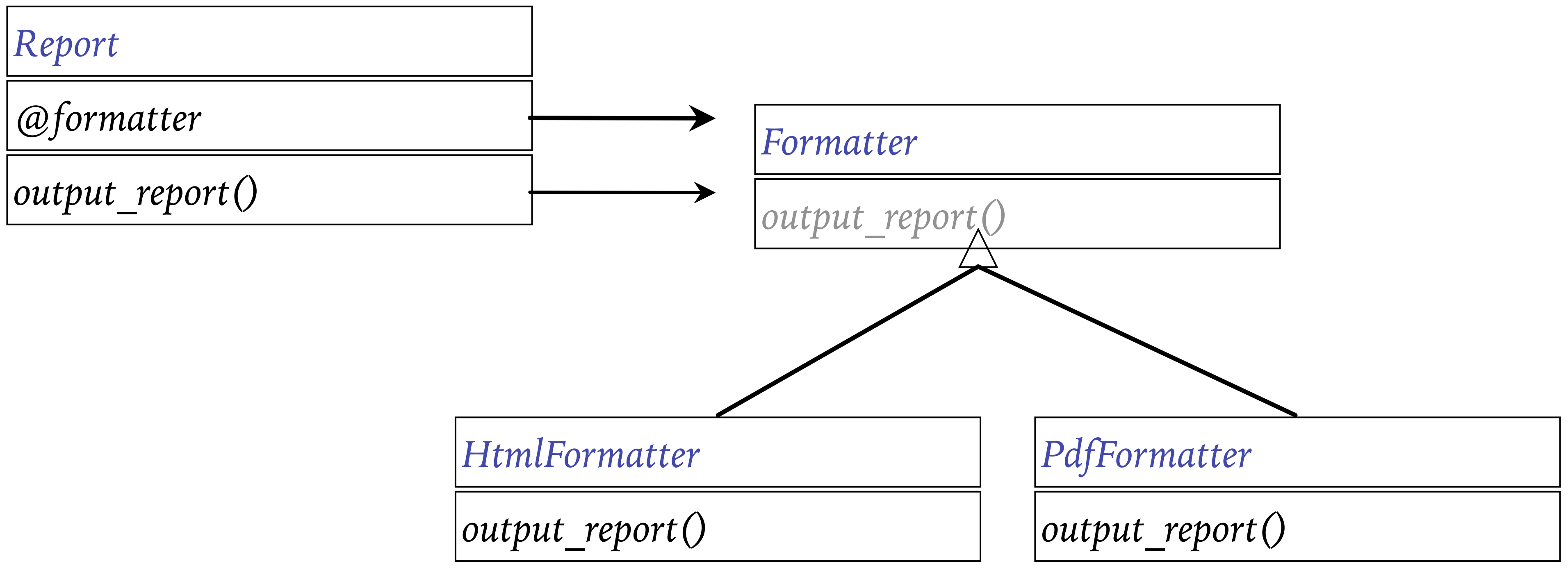


Report Generation Using Strategy

```
class Report
 attr_accessor :title, :text, :formatter
 def output_report
  @formatter.output_report
 end
end
```

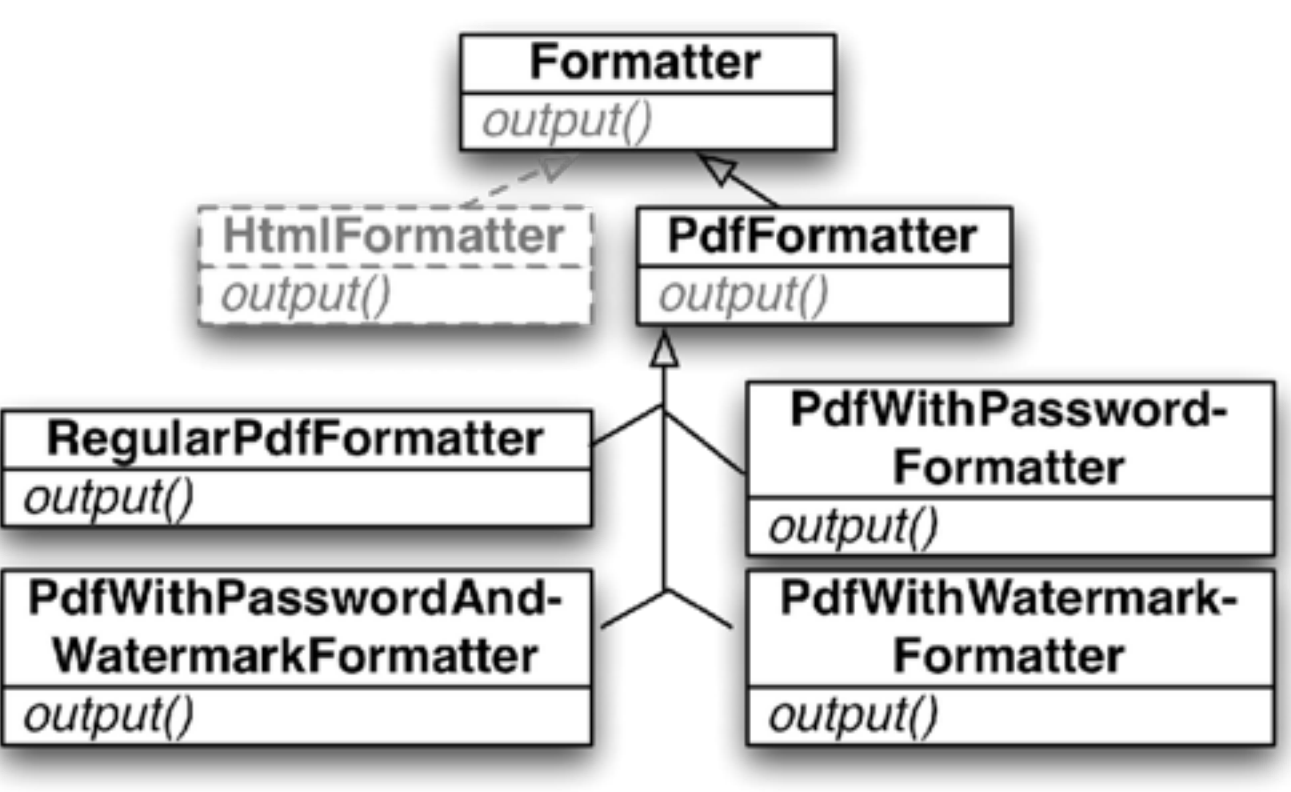
Delegation

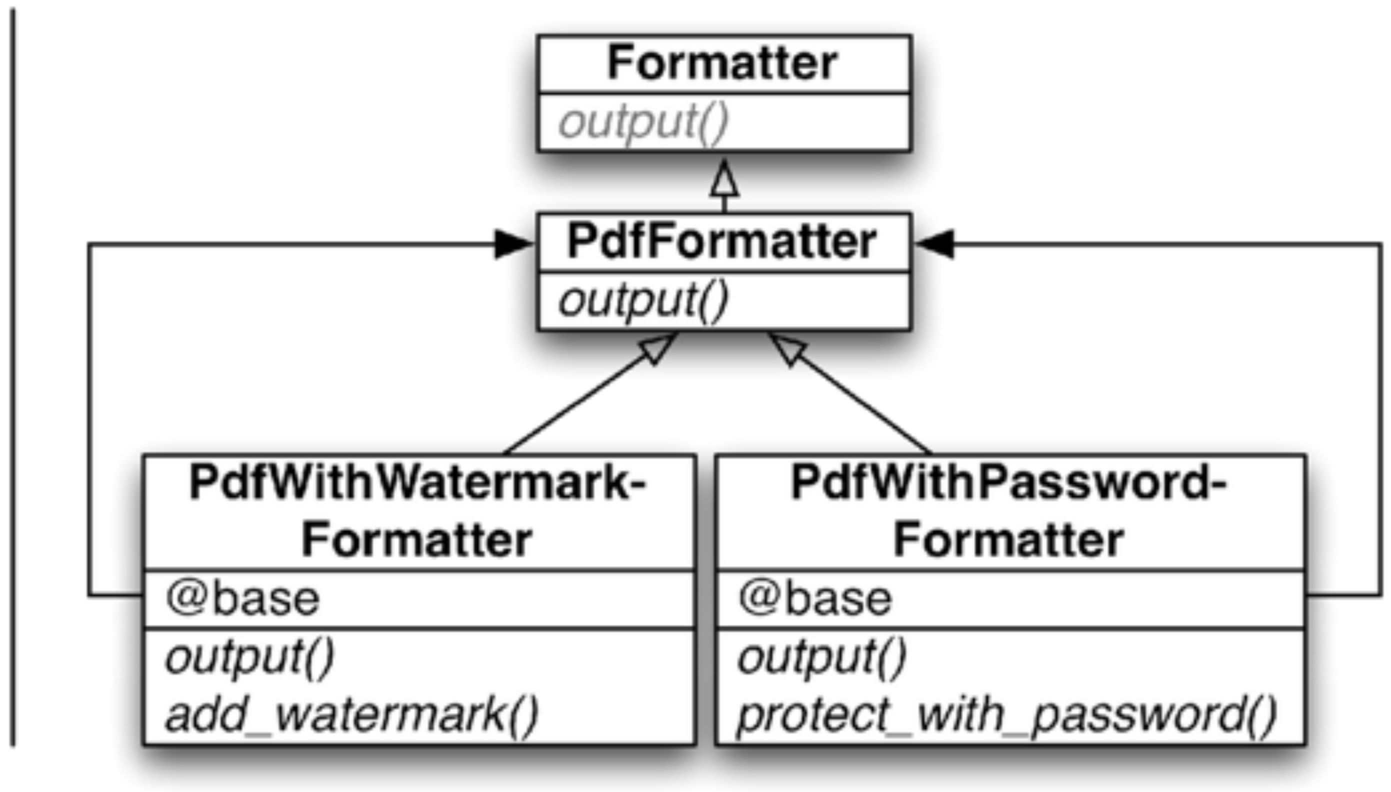
(vs. inheritance)



"Prefer composition over inheritance"

Decorator Pattern: DRYing Out Extension Points





Example in Rails: ActiveRecord scopes

Movie.for_kids.with_good_reviews(3)

Movie.with_many_fans.recently_reviewed

OCP In Practice

- Can’t close against *all* types of changes, so have to choose, and you might be wrong
- Agile methodology can help *expose important types of changes early*
    - *Scenario-driven design with prioritized features*
    - *Short iterations*
    - *Test-first development*
- Then you can try to close against *those types* of changes

Liskov Substitution Principle

Liskov Substitution: Subtypes can substitute for base types

➤Current formulation attributed to (Turing Award winner) Barbara Liskov

"A method that works on an instance of type T, should also work on any subtype of T"

- *Type/subtype != class/subclass*

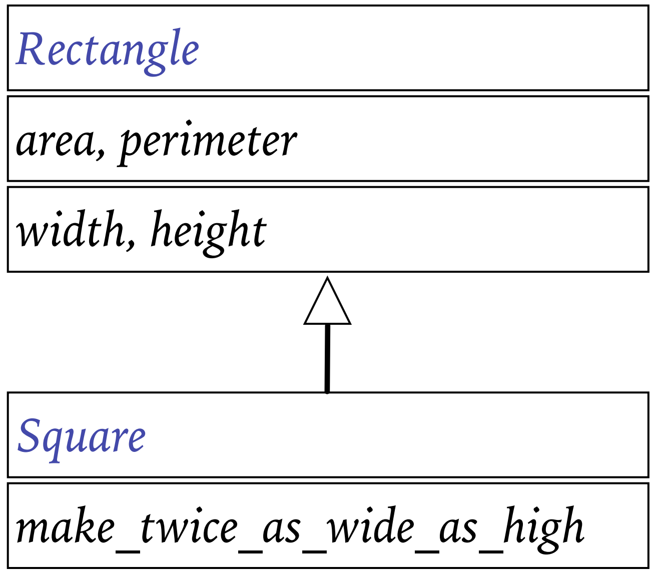
With duck typing, substitutability depends on how collaborators interact with object

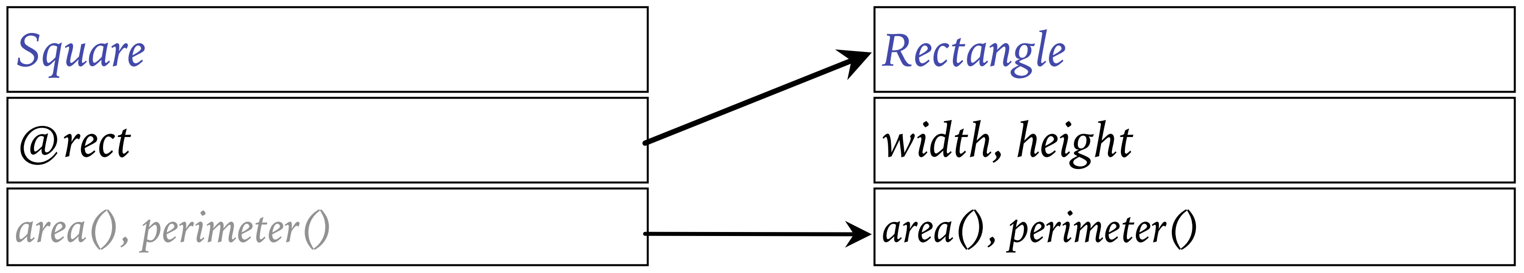
➤Let's see an example

http://pastebin.com/nf2D9RYj

Contracts

- "Prefer composition & delegation over inheritance"
- If can't express consistent assumptions about "contract" between class & collaborators, likely LSP violation
- Symptom: change to subclass requires change to superclass (shotgun surgery)

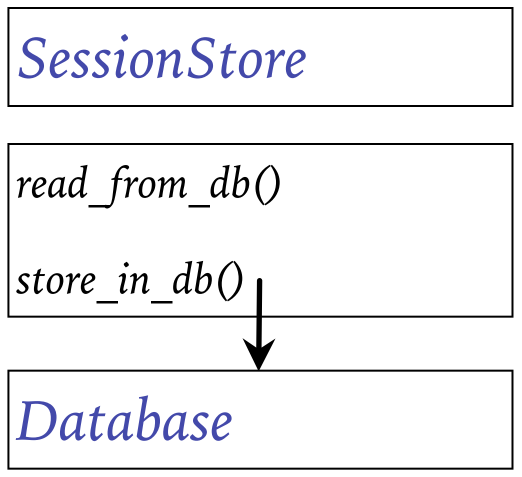


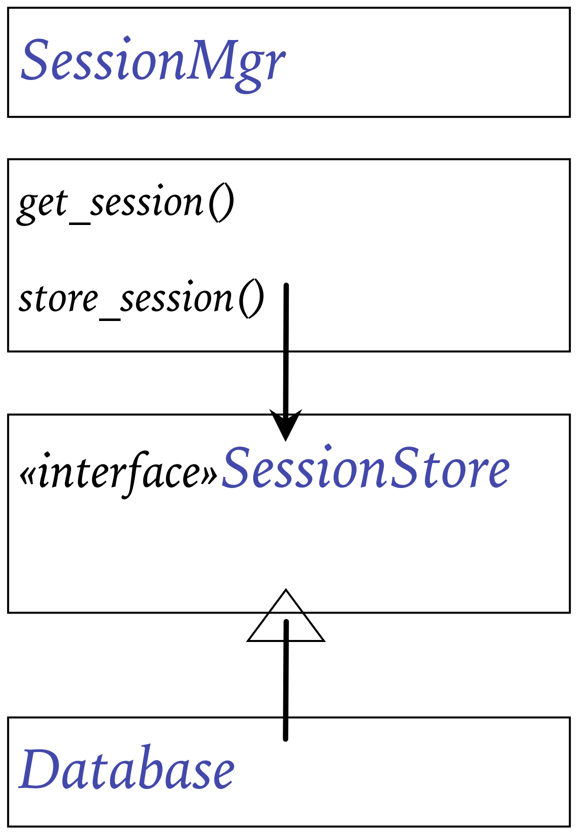


Dependency Injection

Dependency Inversion

- Problem: *a* depends on *b*, but *b* interface & implementation can change, even if *functionality* stable
- Solution: “inject” an *abstract interface* that *a* & *b* depend on
  - If not exact match, Adapter/Façade
  - “inversion”: now b (and a) depend on interface, vs. a depending on b
- Ruby equivalent: Extract Module to isolate the interface

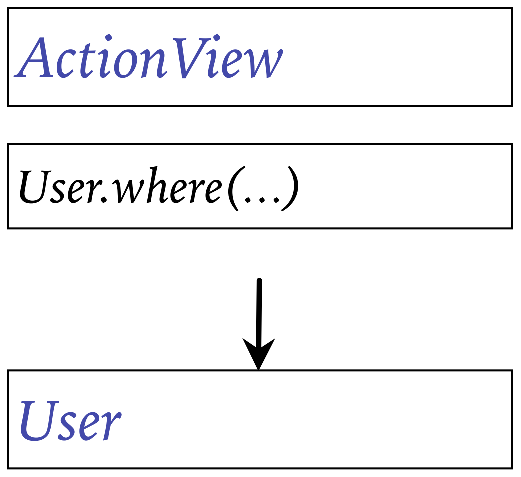




DIP in Rails: example

- What's wrong with this in a *view*:

```
- @vips = User.where('group="VIP"')
```

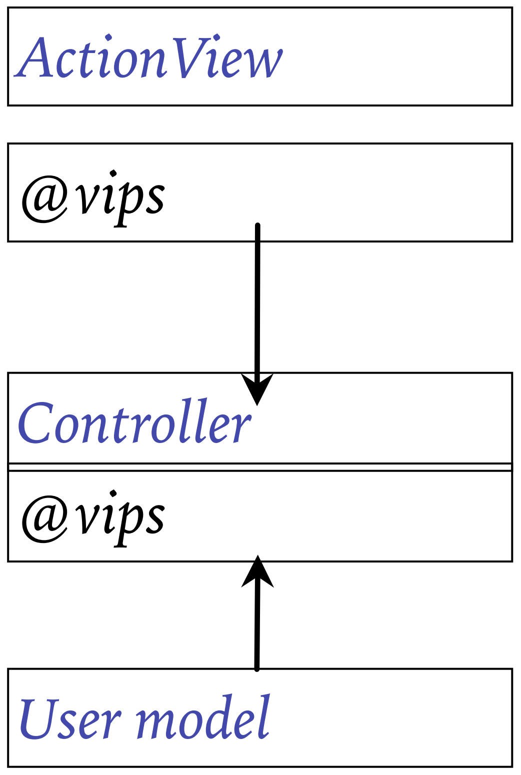


- A little better:

```
- @vips = User.find_vips
```

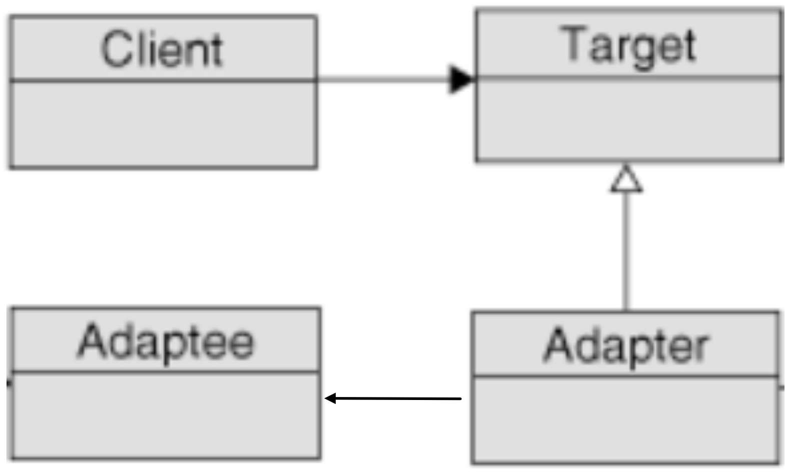
- Happiness:

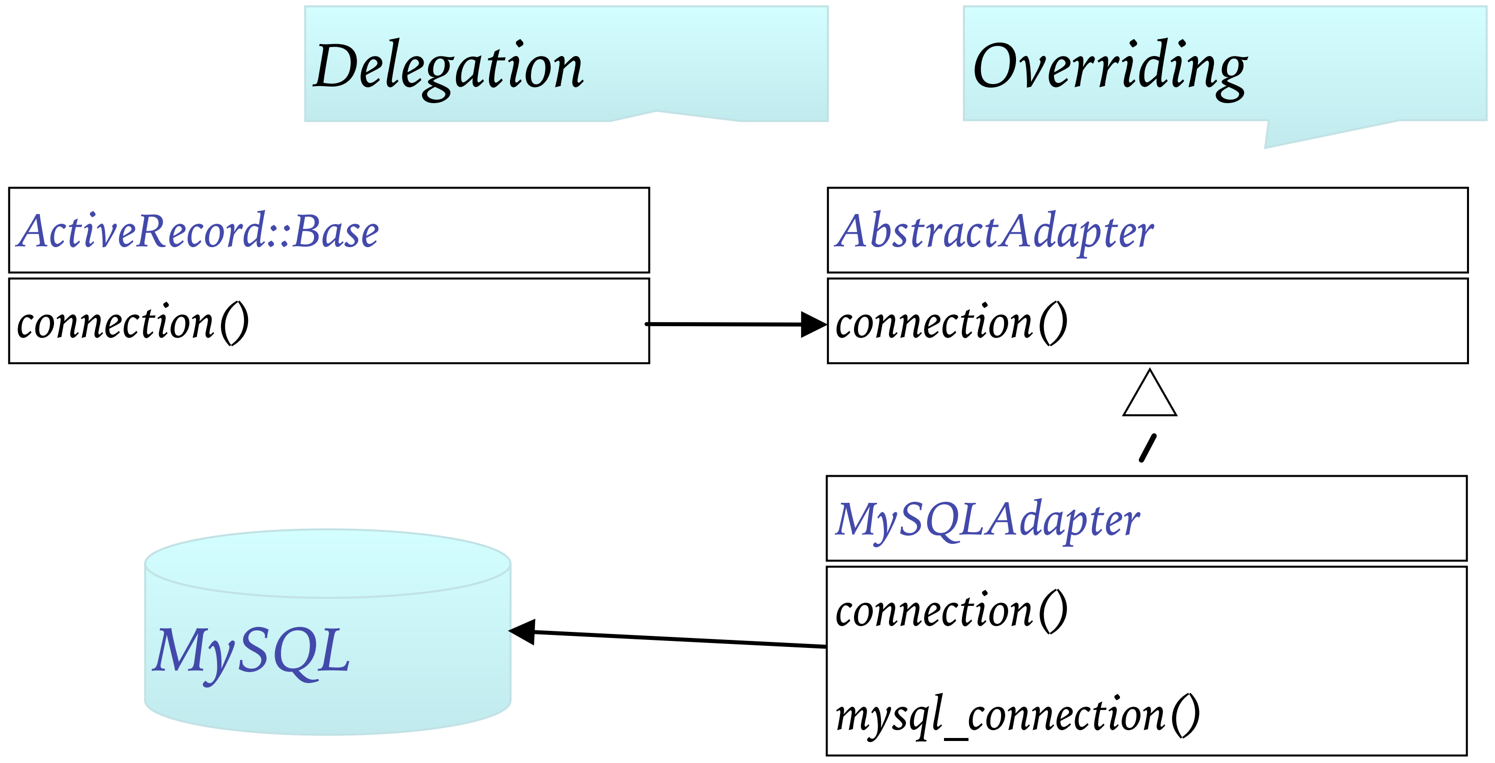
```
# in controller
@vips = User.find_vips
```



Injecting Dependencies with the Adapter pattern

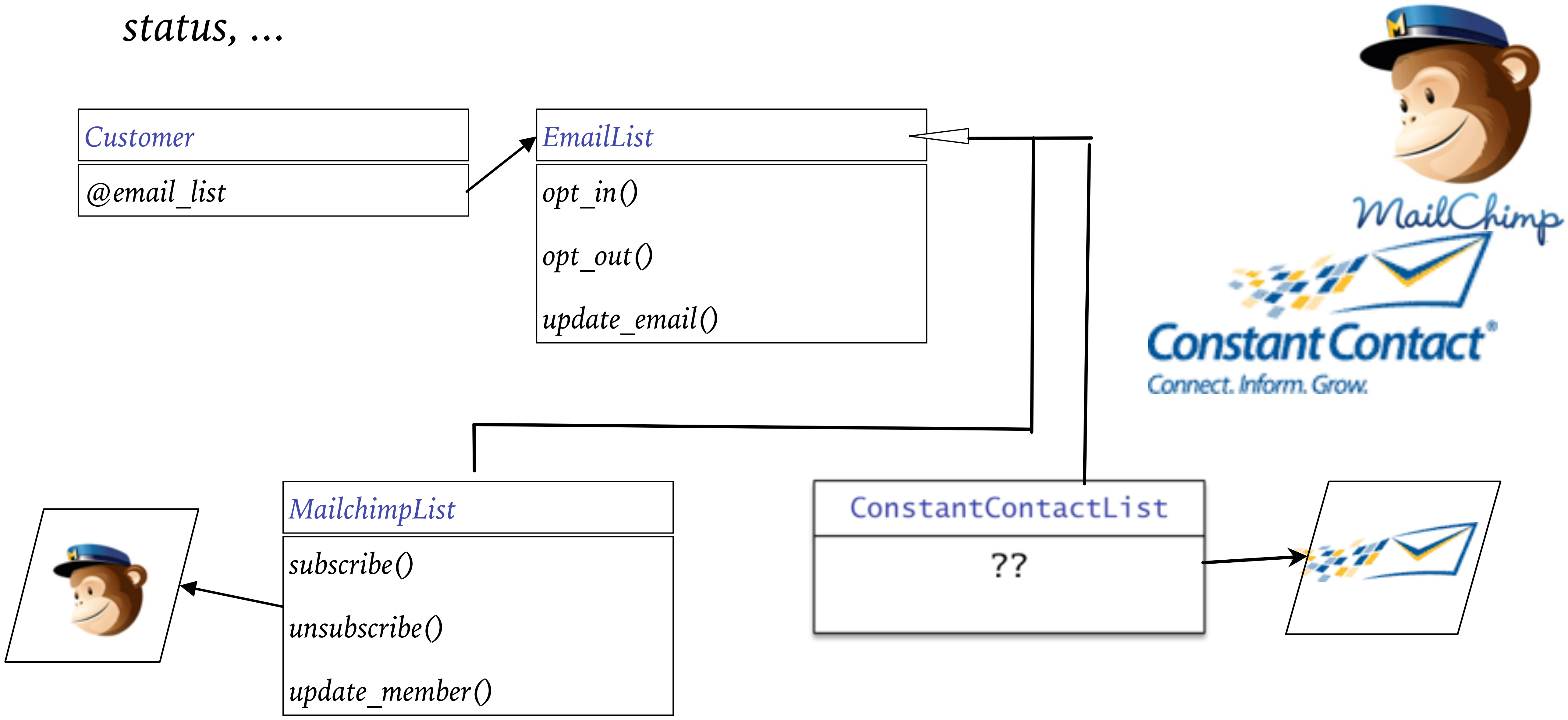
- Problem: client wants to use a "service"...
    - *service generally supports desired operations*
    - *but the API's don't match what client expects*
    - *and/or client must interoperate transparently with multiple slightly-different services*
- Rails example: database "adapters" for MySQL, Oracle, PostgreSQL, ...





Example: Supporting External Services

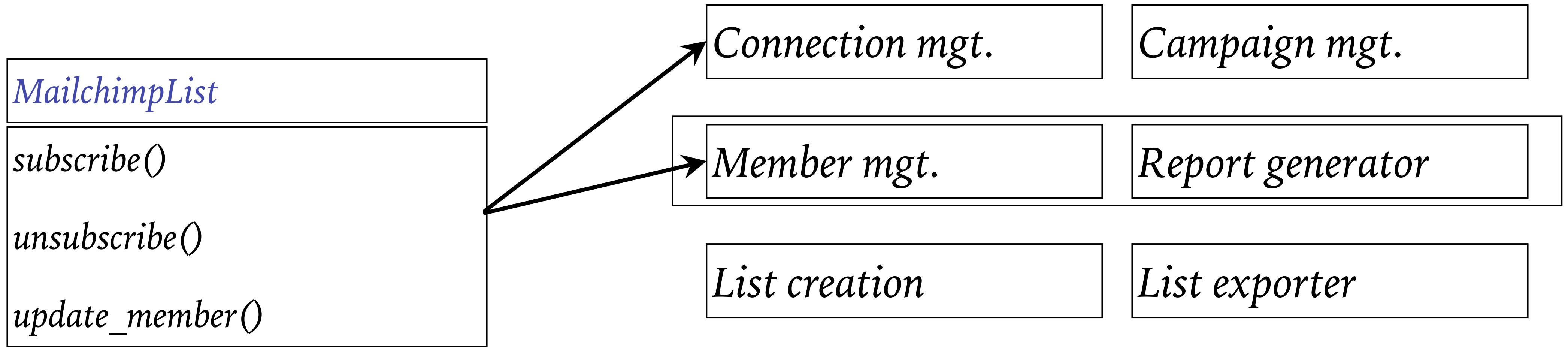
- External services for email marketing, both have RESTful API's
- Similar features
  - *Maintain multiple lists, add/remove user(s) from list(s), change user's opt-in status, ...*



* *Disclaimer: logos © or ™ their respective holders. This example is for education only and doesn't imply endorsement, etc.—duh.*

Related: Façade

- In fact, we only use a *subset* of much more elaborate API's
  - Initialization, list management, start/stop campaign…
- So our adapter is also a *façade*
  - may *unify* distinct underlying API's into a single, simplified API

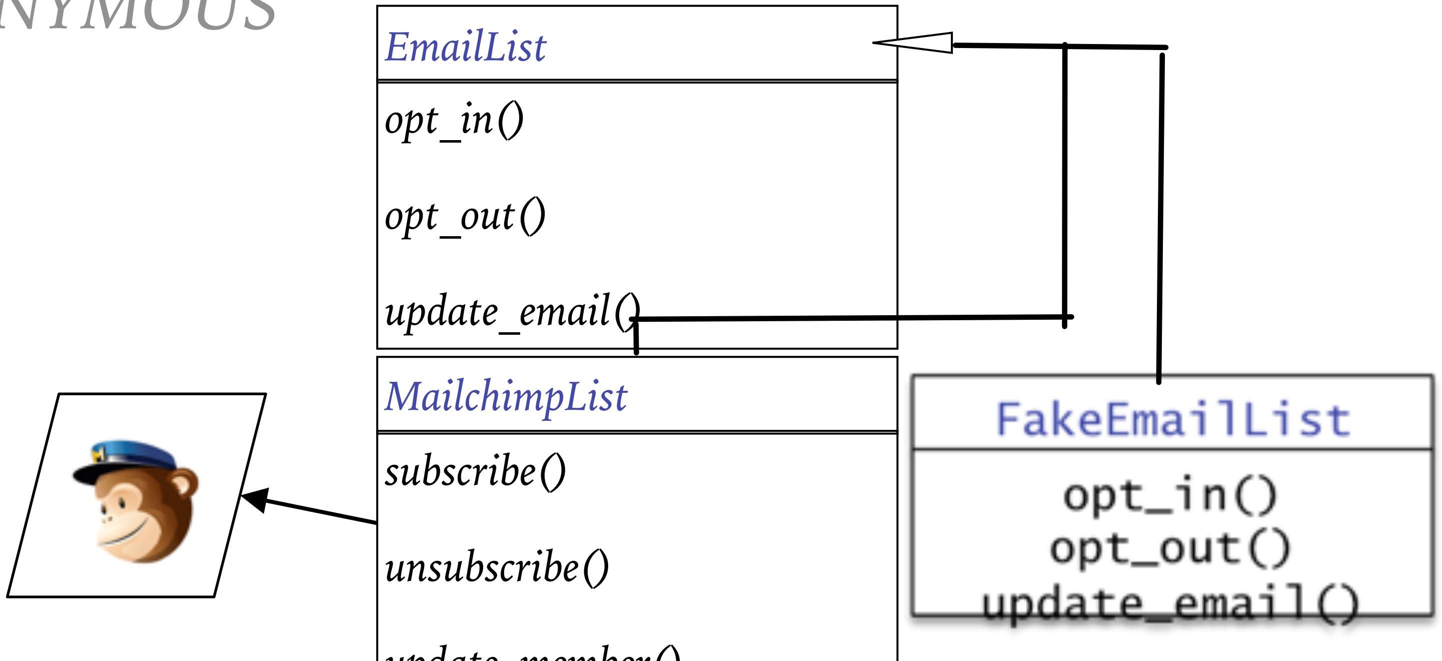


Related: Null object

- ➤Problem: want *invariants* to simplify design, but app requirements seem to break this
- ➤*Null object:* stand-in on which "important" methods can be called

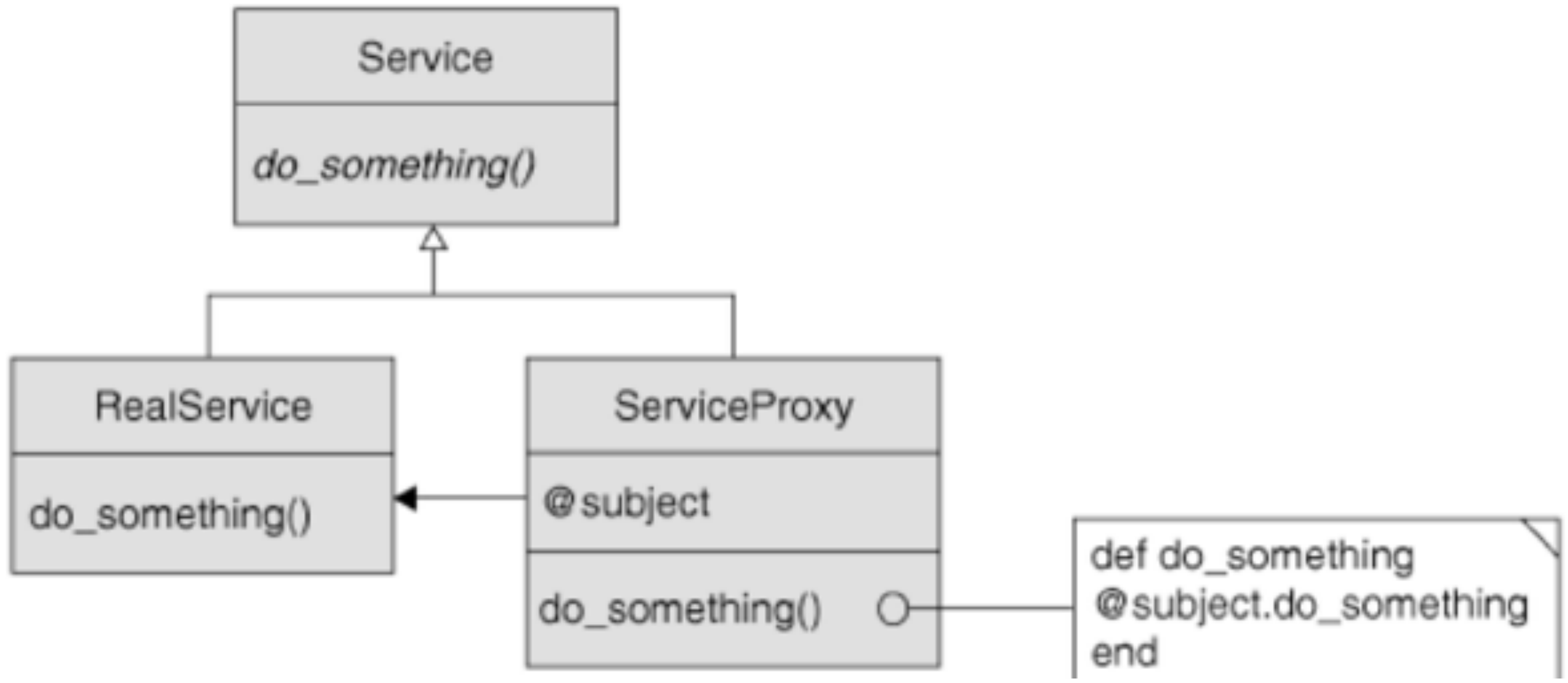
http://pastebin.com/RBuvPMkR

```
@customer = Customer.null_customer

@customer.logged_in?  # => false

@customer.last_name   # => "ANONYMOUS"

@customer.is_vip?     # => false
```



Related: Proxy

- Proxy implements *same methods* as “real” service object, but “intercepts” each call
- do authentication/protect access
- hide remote-ness of a service
- defer work (be lazy)
- Rails example: association proxies (eg Movie.reviews)



Demeter Principle

Demeter Principle + Example

- Only talk to your friends...not strangers.
- You can call methods on
  - yourself
  - your own instance variables, if applicable
- But not on *the results returned by* them.
- Solutions:
  - replace method with delegate
  - Separate traversal from computation (Visitor)
  - Be aware of important events without knowing implementation details (Observer)

http://pastebin.com/NRSkHstN

Observer

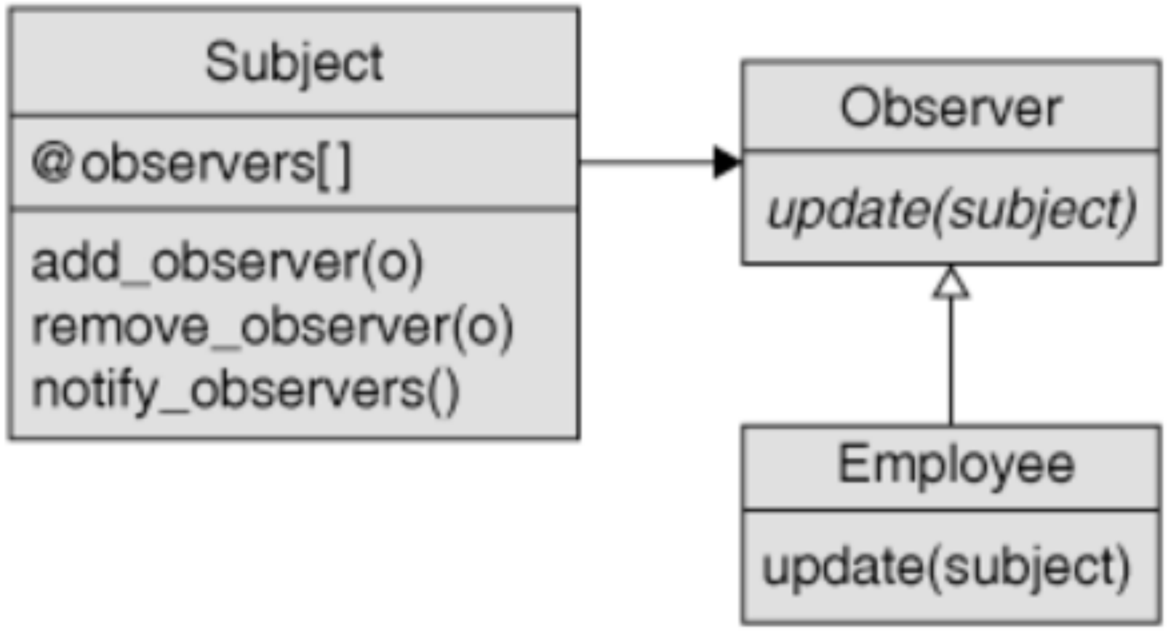
➤Problem: entity O (“observer”) wants to know when certain things happen to entity S (“subject”)

➤Design issues

➤acting on events is O’s concern—don’t want to pollute S

➤any type of object could be an observer or subject—inheritance is awkward

- *Example use cases*
- *full-text indexer wants to know about new post (e.g. eBay, Craigslist)*
- *auditor wants to know whenever “sensitive” actions are performed by an admin*



Example: Maintaining Relational Integrity

- Problem: delete a customer who “owns” previous transactions (i.e., foreign keys point to her)
- My solution: merge with “the unknown customer”
- ActiveRecord provides built-in hooks for Observer design pattern

```
class CustomerObserver < ActiveRecord::Observer
  observe :customer # actually not needed (convention)
  def before_destroy ... end
end

# in config/environment.rb
config.active_record.observers = :customer_observer
```

Design Patterns & SOLID wrapup

A Few Patterns Seen in Rails

- Adapter (database connection)
- Abstract Factory (database connection)
- Observer (caching)
- Proxy (AR association collections)
- Singleton (Inflector)
- Decorator (AR scopes, alias_method_chain)
- Command (migrations)
- Iterator (everywhere)
- Duck typing simplifies expressing and "plumbing" most of these by "weakening" the relative coupling of inheritance

SOLID Caveat

- Designed for statically typed languages, so some principles have more impact there
  - "avoid changes that modify type signature" (often implies contract change)—but Ruby doesn't really use types
  - "avoid changes that require gratuitous recompiling"—but Ruby isn't compiled
- Use judgment: goal is *deliver working & maintainable code quickly*

Summary

- Design patterns represent *successful solutions* to classes of problems
- Reuse of design rather than code/classes
- A few patterns “redefined” in Rails since useful to SaaS
- Can apply at many levels: architecture, design (GoF patterns), computation
- Separate what changes from what stays the same
    - *program to interface, not implementation*
    - *prefer composition over inheritance*
    - *delegate!*
    - *all 3 are made easier by duck typing*
- Much more to read & know—this is just an intro