ÉCOLE
POLYTECHNIQUE
DE LOUVAIN

LSINF2335

Programming Paradigms: Theory, Practice and Applications

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Lecture 7

Reflection in Ruby

Partly inspired on :

- the pickaxe book “Programming Ruby” by Dave Thomas
- slides by Prof. Tom Mens (UMons)
- slides by Prof. Wolfgang De Meuter (VUB)

6.1 Higher-Order Programs

About blocks, procs and lambdas

Different ways of manipulating “chunks of code” in Ruby:

methods, blocks, arg& notation, procs, lambda

Blocks

Typical usage:

```
3.times { print "Ruby" }
```

But blocks are not first-class

Trying these in Ruby produces a syntax error:

```
{ print "Ruby" }
x = { print "Ruby" }
```

Blocks should always be associated to a method invocation,

and *`yield`* executes that block in the method

But blocks can be turned into first class objects...

The &arg notation


```
class ClosureTester
  def evaluate_block(arg1,arg2)
    yield(arg1,arg2)
  end
  def reify_block(arg1,arg2,&arg3)
    arg3
  end
end

c = ClosureTester.new
puts c.evaluate_block(1,2) { |a1,a2| a1 + a2 }
# prints 3
aClosure = c.reify_block(1,2) { |a1,a2| a1 + a2 }
# returns a “procedure” containing the block
puts aClosure.call(3,4)
# prints 7
aClosure.class
# => Proc
```

Blocks are the last argument of a message. &arg explicitly refers to that argument

The &arg notation


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```

Blocks are the last argument of a message. &arg explicitly refers to that argument

Note: yield produces an error when no block is passed with method

Proc and lambda

Procs are a more direct way of turning a block into a first class closure

```
aClosure = Proc.new { |a1,a2| a1+a2 }
puts aClosure.call(5,6)
# prints 11
```

Alternative: with proc or lambda:

```
aClosure = proc { |a1,a2| a1+a2 }
puts aClosure.call(5,6)
# prints 11
aClosure = lambda { |a1,a2| a1+a2 }
puts aClosure.call(5,6)
# prints 11
```

Proc and lambda

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Alternative: with proc or lambda:

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puts aClosure.call(5,6)
# prints 11
aClosure = lambda { |a1,a2| a1+a2 }
puts aClosure.call(5,6)
# prints 11
```

Note: `proc` and `lambda` are equivalent (but `proc` is mildly deprecated)

6.2 Singleton Methods

Singleton Methods

- Methods specific to a particular instance
- A form of dynamic object extension

```
class Student
  def reflection
    puts "I do not understand reflection"
  end
end

aStudent = Student.new
aStudent.reflection
# prints : I do not
  understand reflection
```

```
uclStudent = Student.new

def uclStudent.reflection
  puts "I understand reflection"
end

uclStudent.reflection
# prints : I understand reflection
```

Singleton Methods

- Methods specific to a particular instance
- A form of dynamic object extension

```
class Student
  def reflection
    puts "I do not understand reflection"
  end
end

aStudent = Student.new
aStudent.reflection
# prints : I do not
  understand reflection
```

no equivalent in Smalltalk (at language level)

```
uclStudent = Student.new

def uclStudent.reflection
  puts "I understand reflection"
end

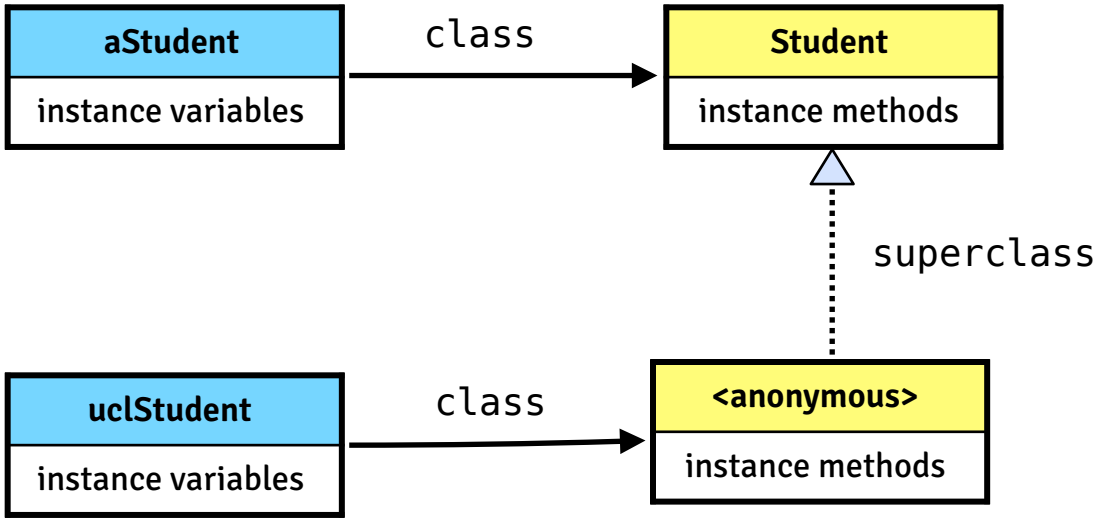
uclStudent.reflection
# prints : I understand reflection
```

Singleton Classes

If methods are stored in classes, then where are **singleton methods** stored?

Ruby creates an anonymous ***singleton class*** specific to the instance

This singleton class has the original class of the instance as superclass



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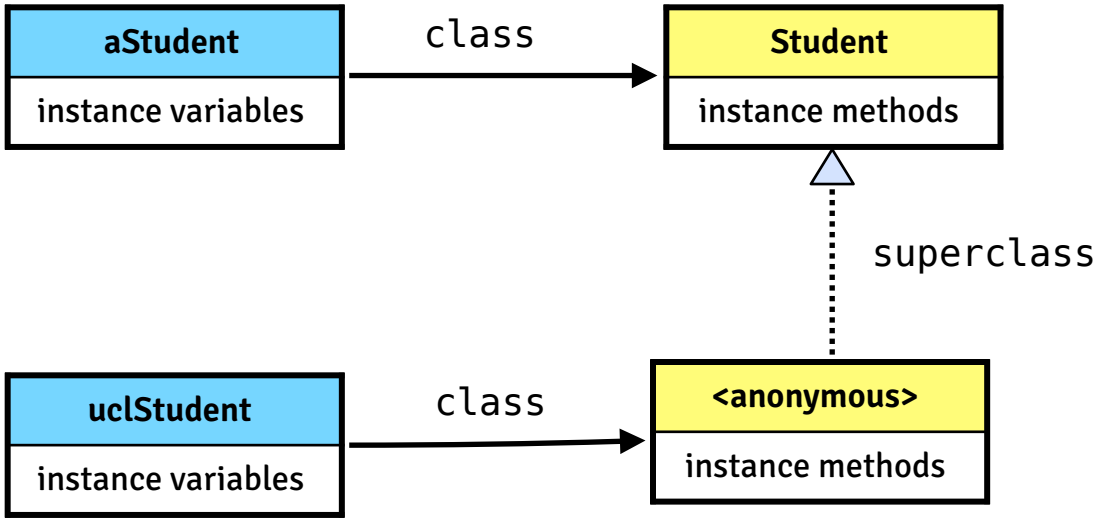
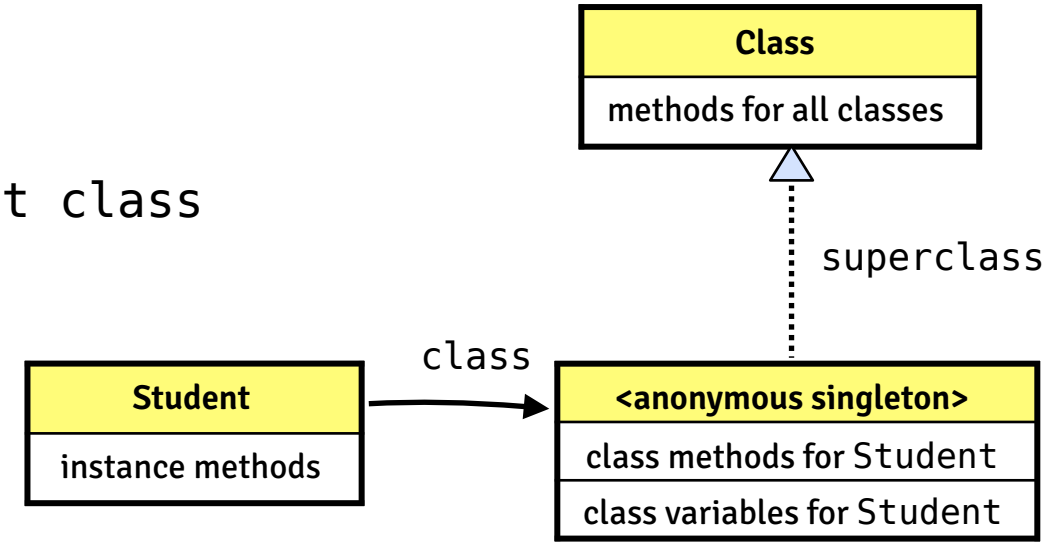


The anonymous singleton class is "hidden": `smartStudent.class` returns `Student`

Class Methods Are Singleton Methods


```
class Student
  def self.some_class_method
    puts "I'm the Student class"
  end
end
aStudent = Student.new
aStudent.some_class_method
# NoMethodError
Student.some_class_method
# prints : I'm the Student class
```



Some Remarks

- Notice the analogy with Smalltalk
  - In Smalltalk, class methods (and variables) are stored in special meta-classes (one meta-class per class)
  - In Ruby, class methods (and variables) are stored in singleton classes, specific for each class
- Anonymous singleton classes are “hidden”
  - `smartStudent.class` returns `Student`
  - but there are ways of accessing the singleton class...

6.3 Mixin Modules

Mixin Modules

What if I want to inherit from multiple classes?

Mixin modules are an interesting alternative to multiple inheritance

- Rather than inheriting from multiple parent classes, you can "mix in" different modules

Mixins modules

- are like a partial class definition
- with late binding
  - use of `self` in a mixin method is late bound

Defining a Mixin Module


```
module Reflection
  def reflection
    puts "I understand reflection"
  end
end
```

a simple mixin module

```
module Debug
    def who_am_i
        print self.class.name + "(\#" +
              self.object_id.to_s + ")" +
              self.to_s
    end
end
```

another mixin module

Late binding of `self` in class where module will be mixed in

Including a Mixin In a Class


```
class Student
end
class ReflectionStudent < Student
  include Reflection
  include Debug
end

aStudent = ReflectionStudent.new
aStudent.reflection
# prints : “I understand reflection”

aStudent.who_am_i
# prints :
ReflectionStudent(#292320)#<ReflectionStudent:
0x8ebc0>
```

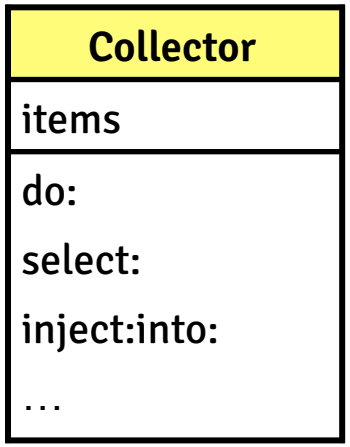
Implementing Iterators With the Enumerable Mixin


```
→ ri Enumerable


The Enumerable mixin provides collection classes with several traversal and
searching methods, and with the ability to sort. The class must provide a
method each, which yields successive members of the collection. If
Enumerable#max, #min, or #sort is used, the objects in the collection must
also implement a meaningful <=> operator, as these methods rely on an ordering
between members of the collection.
------------------------------------------------------------------------------
= Instance methods:

  all?, any?, chunk, collect, collect_concat, count, cycle, detect, drop,
  drop_while, each_cons, each_entry, each_slice, each_with_index,
  each_with_object, entries, find, find_all, find_index, first, flat_map,
  grep, group_by, include?, inject, lazy, map, max, max_by, member?, min,
  min_by, minmax, minmax_by, none?, one?, partition, reduce, reject,
  reverse_each, select, slice_before, sort, sort_by, take, take_while, to_a,
  to_set, zip
```

Class Collector In Smalltalk




```
do: aBlock
    ^items do: aBlock
select: aBlock
    ^items select: aBlock
inject: aValue into: aBlock
    ^items inject: aValue into: aBlock
…
```

How can we make such a Collector class in Ruby?

- which implements typical operators on collections like `collect`, `select`, `sort`, ...

Easy:

- implement the method each to iterate over the items
- including the `Enumerable` mixin does the rest

Using the Enumerable Mixin


```
class Collector



    attr_reader :items
    def initialize(collection)
        @items = collection
    end









end
```

Using the Enumerable Mixin


```
class Collector

    include Enumerable

    attr_reader :items
    def initialize(collection)
        @items = collection
    end

    def each
        @items.each do |item|
            yield item
        end
    end



end
```

Using the Enumerable Mixin


```
class Collector

    include Enumerable
    include Debug
    attr_reader :items
    def initialize(collection)
        @items = collection
    end

    def each
        @items.each do |item|
            yield item
        end
    end
    def to_s
        @items.to_s + "\n"
    end
end
```

Let's Try It Out…


```
myCollector = Collector.new([1,3,2])
  => #<Collector:0x321dc4 @items=[1, 3, 2]>

myCollector.who_am_i
  Collector (#1642210): 132
  => nil

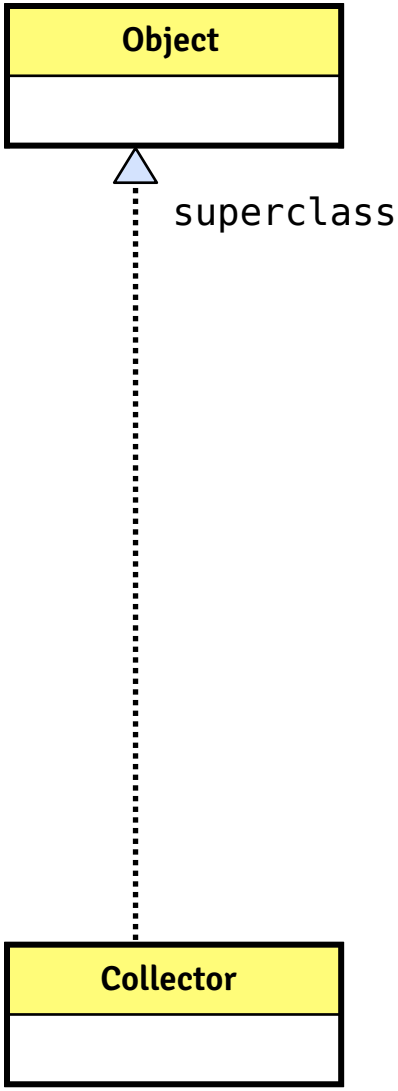
myCollector.each { |el| print " Value: "+el.to_s }
   Value: 1 Value: 3 Value: 2
  => [1, 3, 2]

newCollector = Collector.new(myCollector.sort)

  => #<Collector:0x31aa38 @items=[1, 2, 3]> newCollector.who_am_i
  Collector (#1627420): 123

myCollector.max
  => 3
```

How Do Mixin Modules Work?



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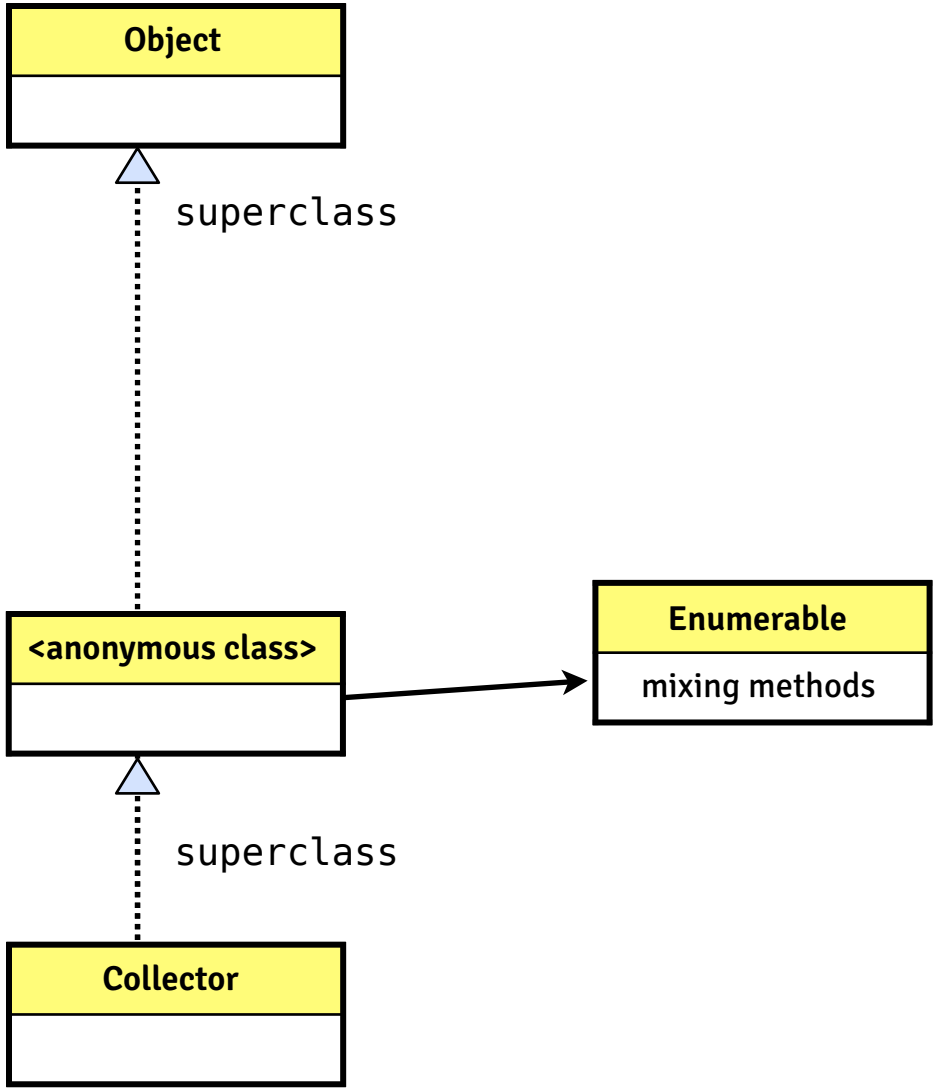

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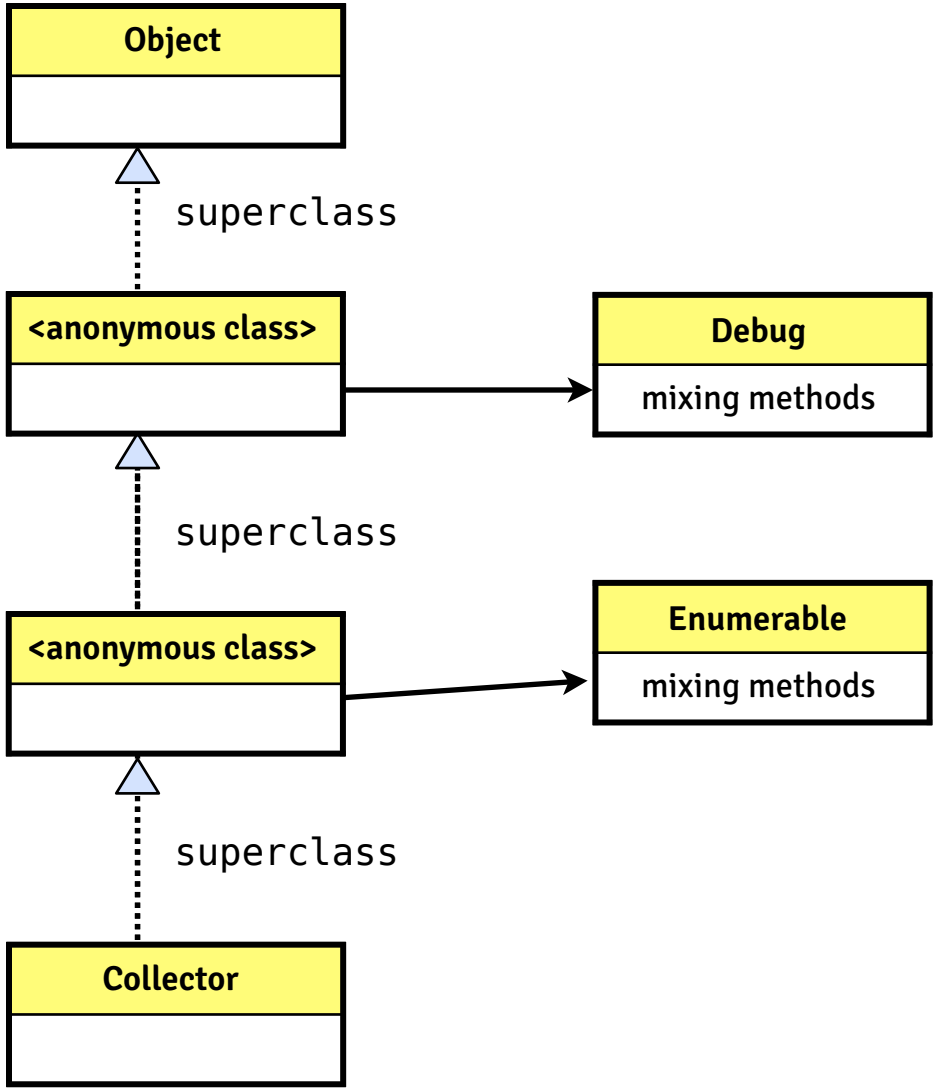

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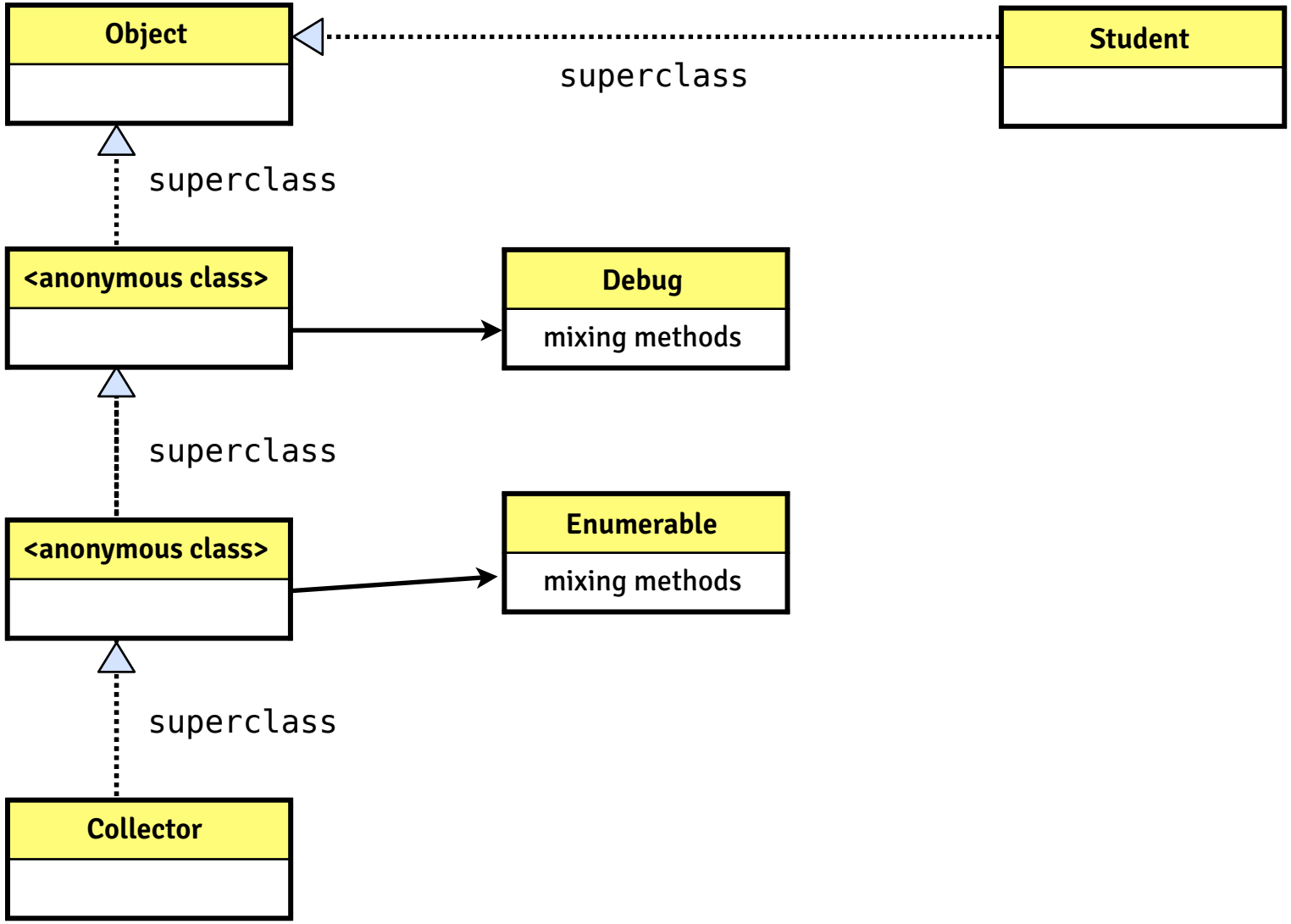

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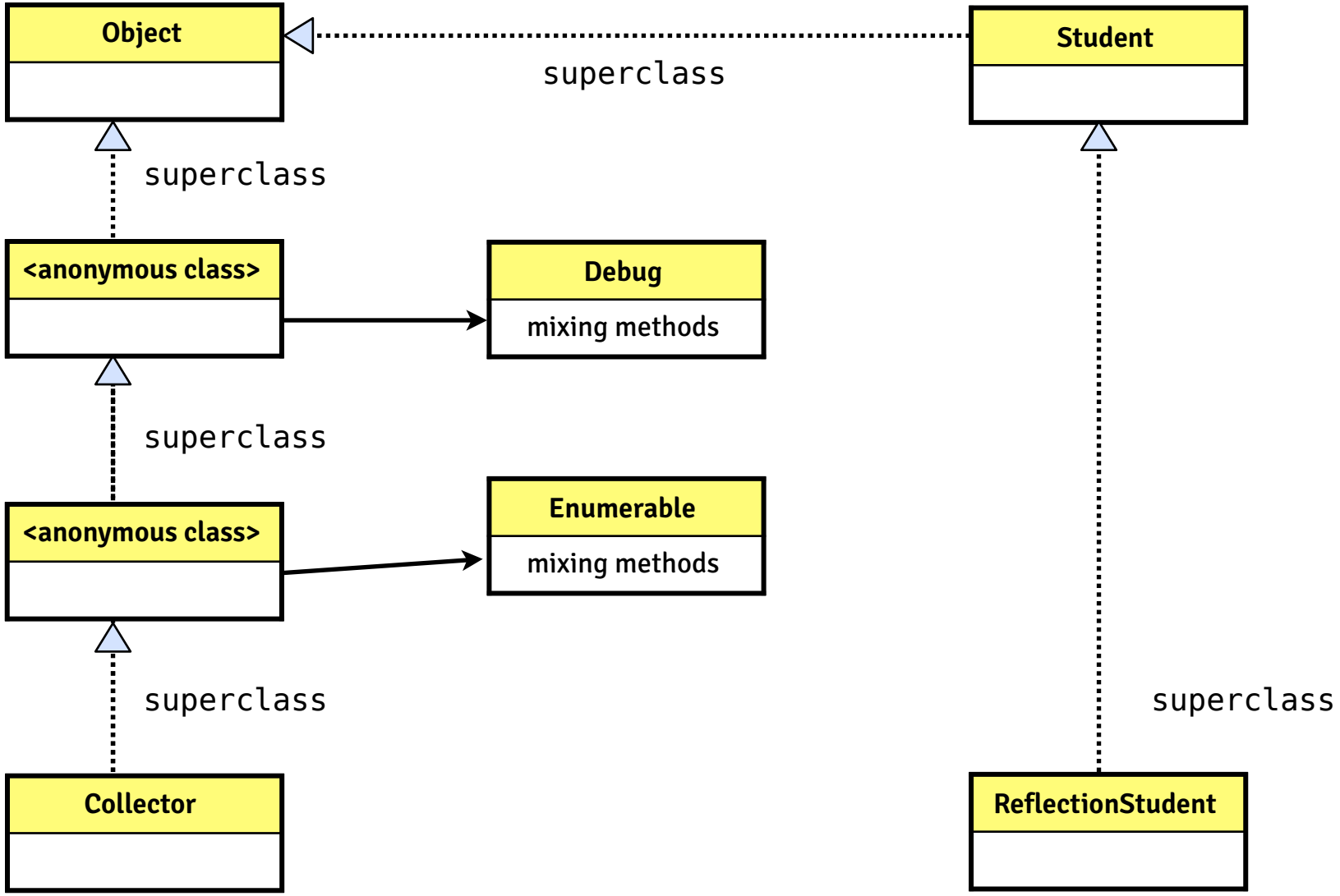

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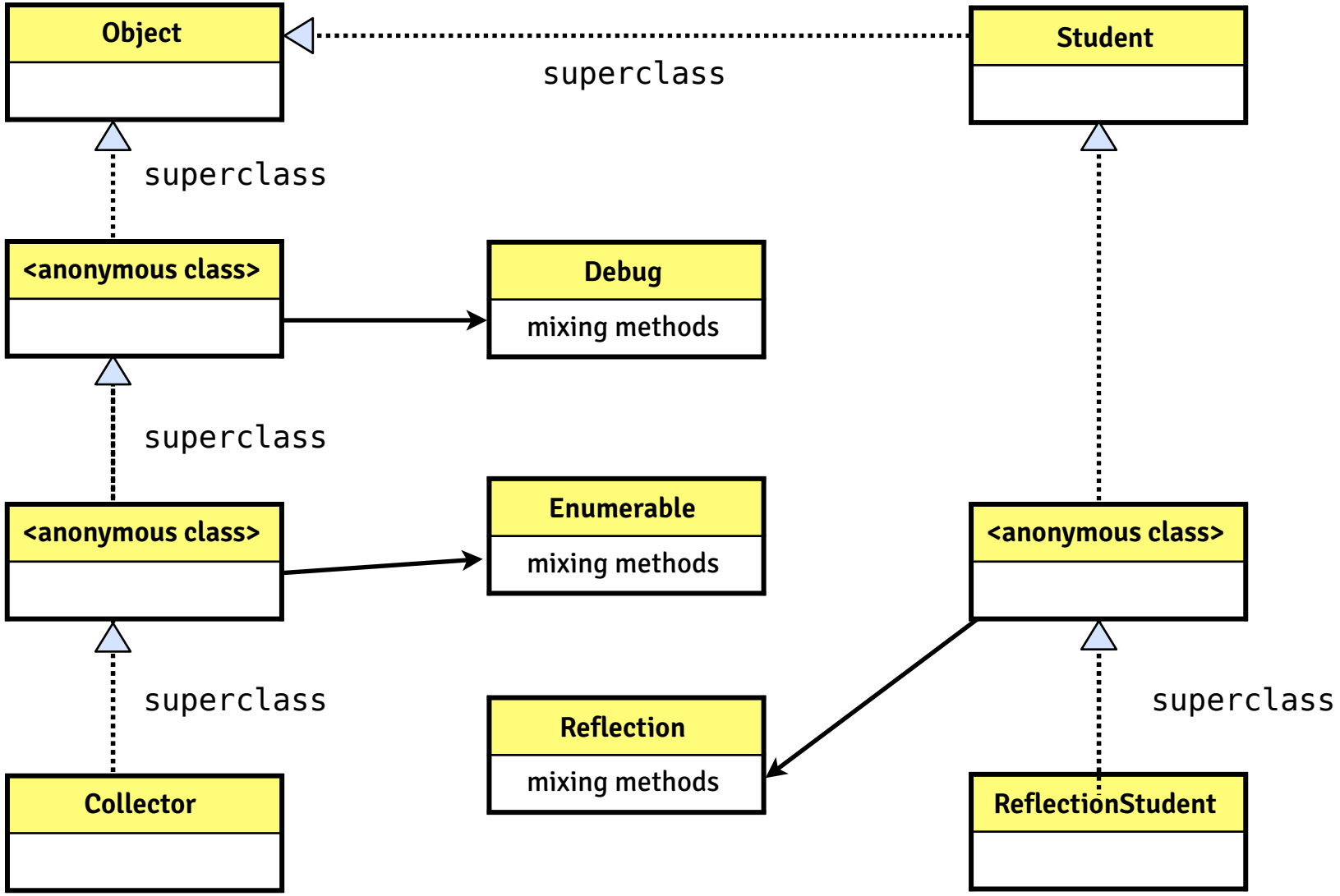

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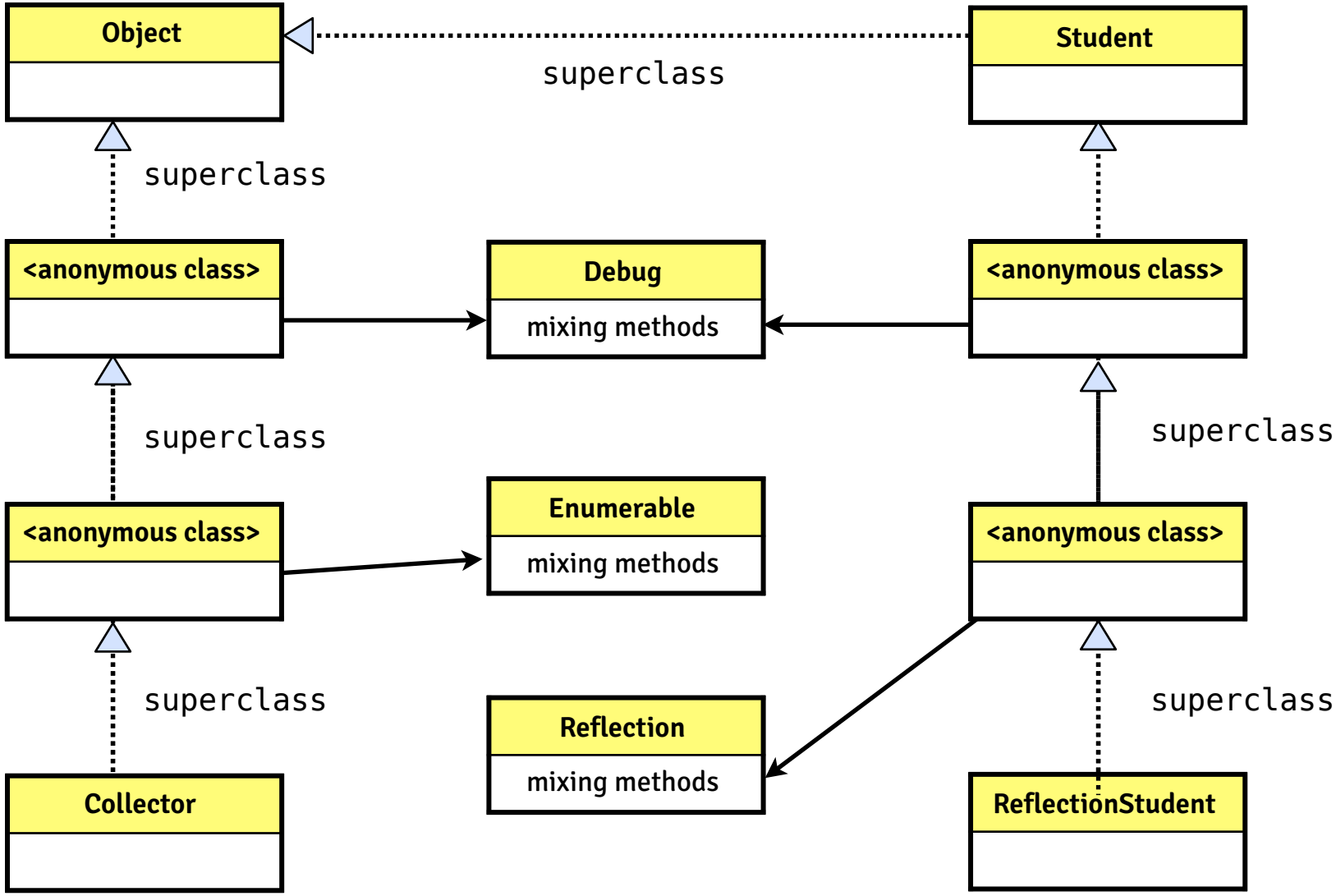

Extending An Object With a Mixin


```
module Reflection
  def reflection
    puts "I understand reflection"
  end
end
```

```
aStudent = Student.new
aStudent.extend Reflection
aStudent.reflection
# prints : “I understand reflection”
otherStudent = Student.new
otherStudent.reflection
# NoMethodError
```

6.4 Reflective Features in Ruby

Before Starting…

- A bit of introspection at the prompt
- Use ri to read ruby documentation:

  `ri Fixnum` for documentation of a class

  `ri Fixnum#meth` for documentation on an instance method

  `ri Fixnum::meth` for documentation on a class method

  `ri -l` for documentation on all classes

Reflective Features in Ruby

1. The Class `Class`
2. Meta-Object Protocol
3. Class-Level Macros
4. Eval
5. Hook Methods

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Going Meta

Everything is an object; you can ask any object for its class:

```
42.class => Fixnum
:foo.class => Symbol
“Ruby”.class => String
true.class     => TrueClass
[1,2,3].class  => Array
{ :a => 1 }.class => Hash
```

Even a class is an object; its class is a special class called `Class`

```
Fixnum.class   => Class
42.class.class   => Class
```

`Class` is an object too; the class of `Class` is `Class` itself

```
Class.class   => Class
```

The Class `Class`

All classes are an instance of the class `Class`

`Class` implements some interesting introspection methods:

- `instance_variables, instance_variable_get, class_variables, …`
- `methods, public_methods, private_instance_methods, …`
- `superclass, class, …`
- and many more.

And some intercession methods too:

- `instance_variable_set`

If you forgot what reflective methods are available, use introspection :-)

```
Class.public_methods.sort
```

Manipulating An Instance Reflectively


```
class Example
end

ex = Example.new

ex.instance_variables                # => []

ex.instance_variable_set(:@x,1)      # => 1

ex.instance_variables                # => ["@x"]

ex.instance_variable_defined?(:@x) # => true

ex.instance_variable_defined?(:@y) # => false

ex.instance_variable_get(:@x)        # => 1
```

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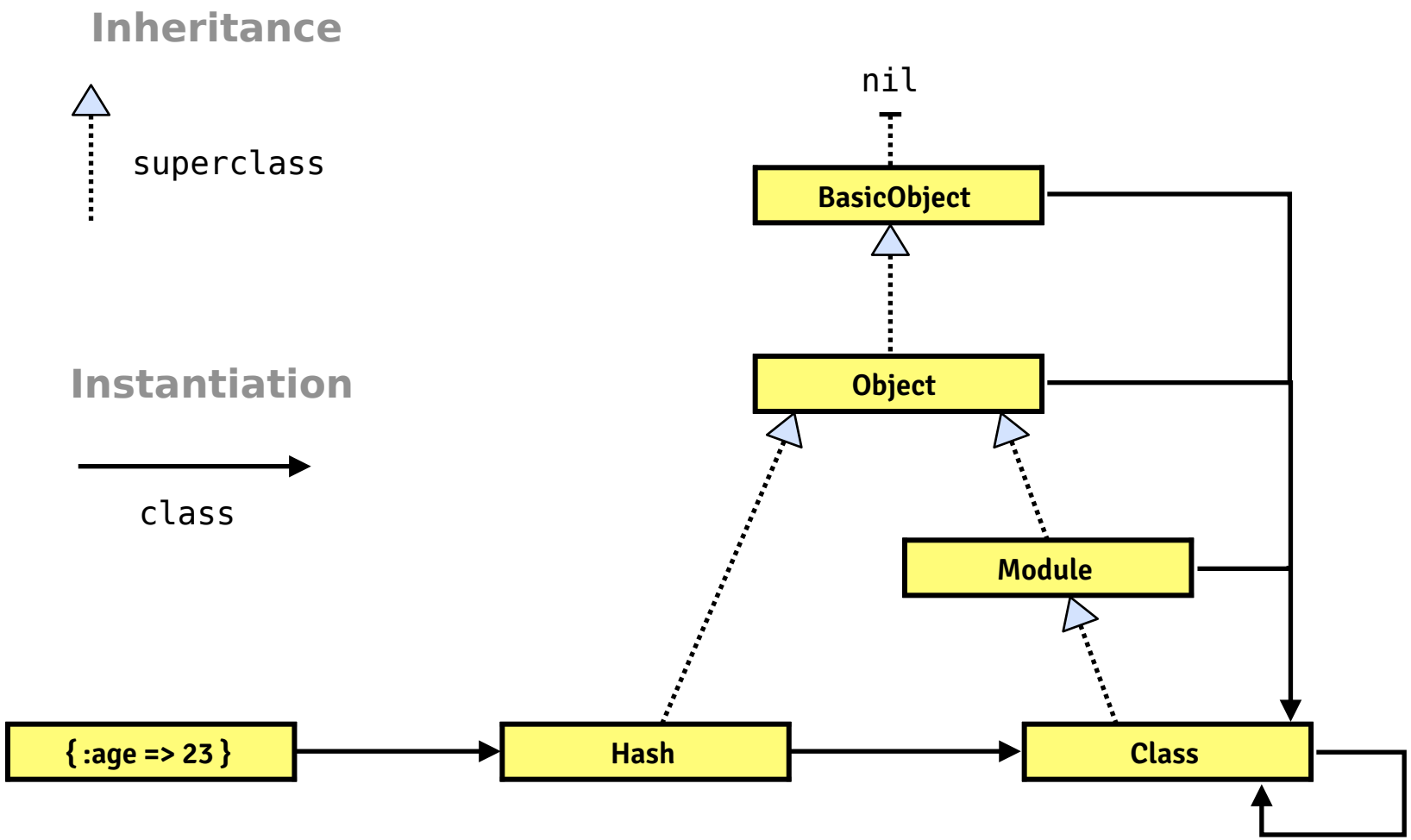
Ruby's Meta-Object Protocol



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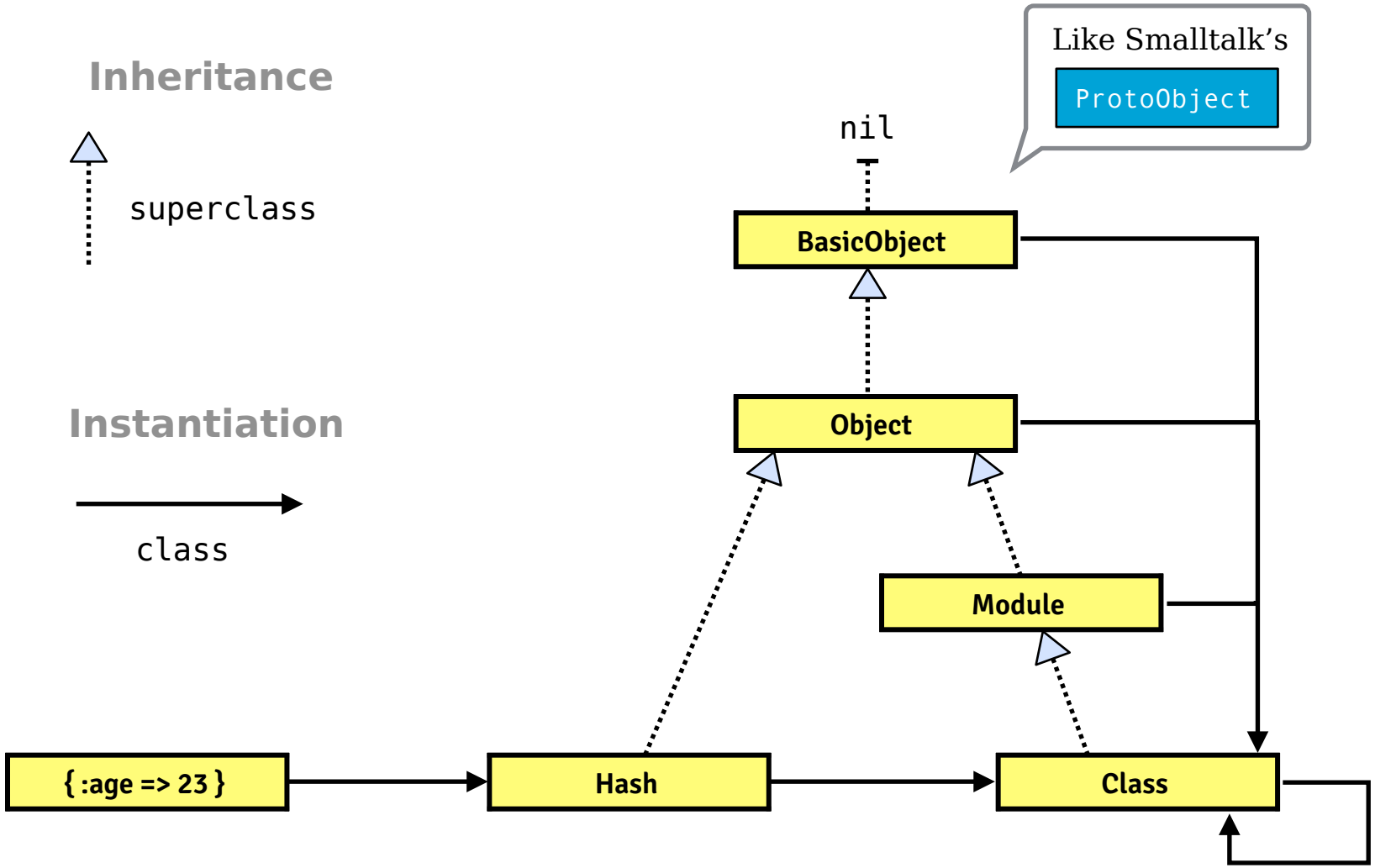
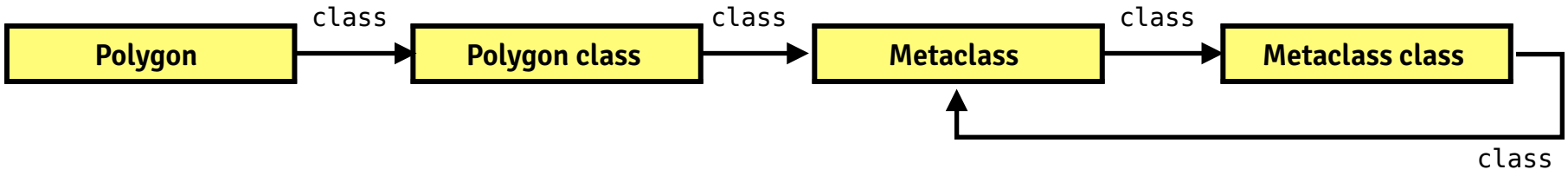
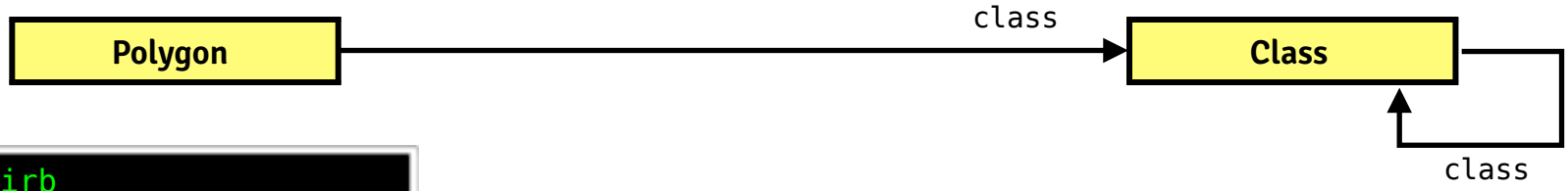


Ruby's Absorbed Metaclasses

Smalltalk ✓ metaclasses are first class



Ruby




```
$ irb
> class Polygon; end
> Polygon.class
Class
> Polygon.new
=> #<Polygon:0x007fe4…>
```

"an instance of Polygon"

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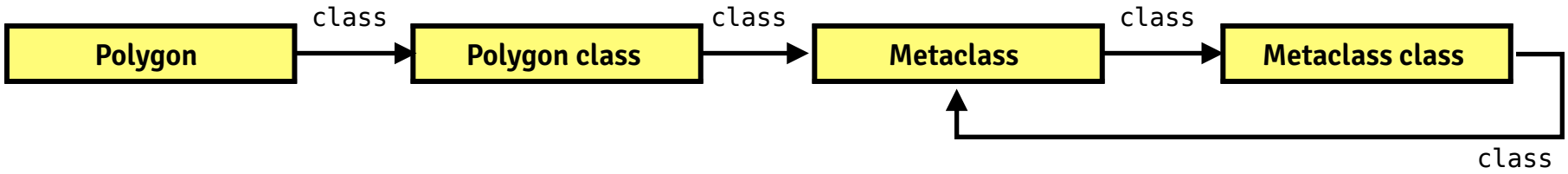

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```

"an instance of Polygon"

```
$ irb
> class Polygon
>   def self.metaclass
>     class << self
>       self
>     end
>   end
> end
=> nil
> Polygon.metaclass
=> #<Class:Polygon>
```

"an instance of Class for the Polygon class"
= metaclass for Polygon

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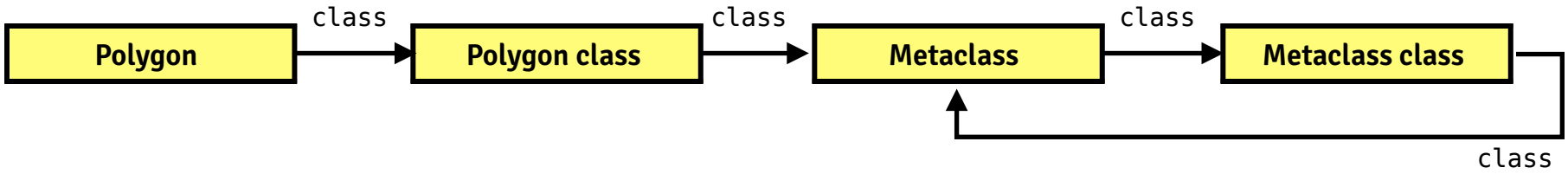

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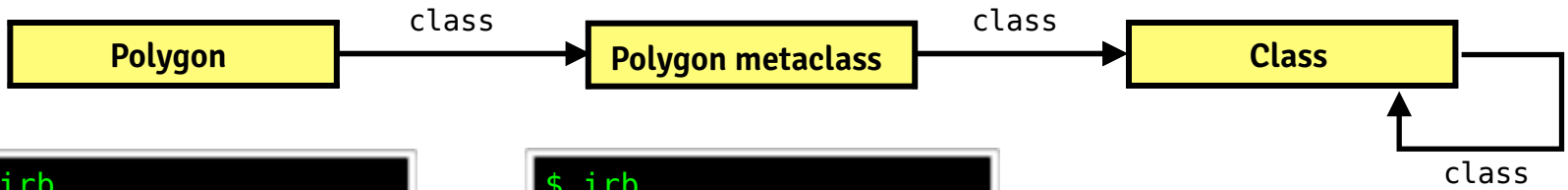


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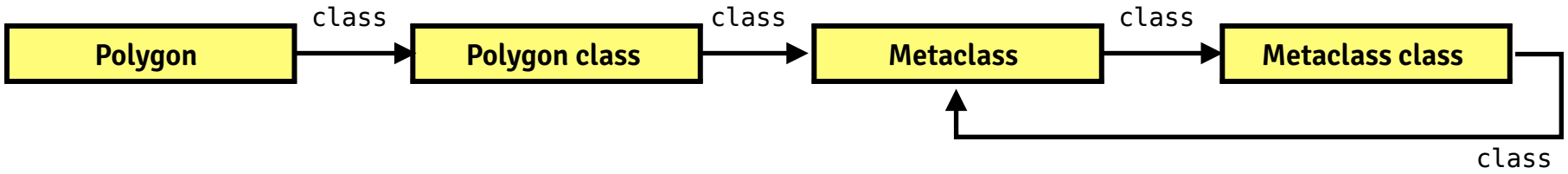
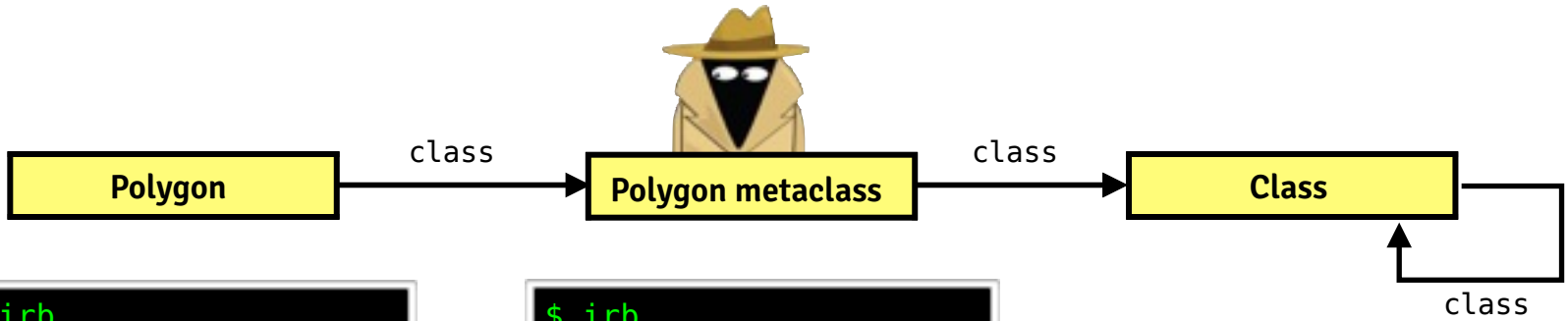


Ruby ~ metaclasses are an absorbed (hidden) concept

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"an instance of Polygon"

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> class Polygon
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>     class << self
>       self
>     end
>   end
> end
=> nil
> Polygon.metaclass
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"an instance of Class for the Polygon class"
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Remember These?

```
class ComplexCartesian
    ...
    attr_reader :x, :y
    attr_writer :x, :y
    ...
end
```

or, alternatively:

```
class ComplexCartesian
    ...
    attr_accessor :x, :y
    ...
end
```

These are examples of **class-level macros**

i.e., class-level methods that generate code behind the scenes

Creating a Class-Level Macro

Example: define accessor methods that not only read/write a variable, but also log access to the variable.

Example of intended usage:

```
>> ex = Example.new
=> #<Example:0x352208>
>> ex.value=6
Assigning 6 to value
=> 6
>> ex.value
Reading value
=> 6
```

Let's Start Simply


```
class Logger

  def self.add_logging

    def log(msg)

      STDERR.puts Time.now.strftime("%H:%M:%S: ")
                    + "#{self} (#{msg})"

    end
  end
end

class Example < Logger
  add_logging
end
ex = Example.new
ex.log("hello")
```

Let's Start Simply


```
class Logger

  def self.add_logging

    def log(msg)

      STDERR.puts Time.now.strftime("%H:%M:%S: ")
                    + "#{self} (#{msg})"

    end
  end
end

class Example < Logger
  add_logging
end
ex = Example.new
ex.log("hello")
```

```
>> ex.log("hello")
10:11:51: #<Example:0x35ad04> (hello)
=> nil
```

Let's Start Simply

```
class Logger

  def self.add_logging

    def log(msg)

      STDERR.puts Time.now.strftime("%H:%M:%S: ")
                    + "#{self} (#{msg})"

    end
  end
end
```

This is a **class method**

```
>> ex.log("hello")
10:11:51: #<Example:0x35ad04> (hello)
=> nil
```

```
class Example < Logger
  add_logging
end
ex = Example.new
ex.log("hello")
```

Let's Start Simply


```
class Logger

  def self.add_logging

    def log(msg)

      STDERR.puts Time.now.strftime("%H:%M:%S: ")
                    + "#{self} (#{msg})"

    end
  end
end
```

This is a **class method**

This instance method will get installed when executing the class method

```
>> ex.log("hello")
10:11:51: #<Example:0x35ad04> (hello)
=> nil
```

```
class Example < Logger
  add_logging
end
ex = Example.new
ex.log("hello")
```

Let's Start Simply


```
class Logger

  def self.add_logging

    def log(msg)

      STDERR.puts Time.now.strftime("%H:%M:%S: ")
                    + "#{self} (#{msg})"

    end
  end
end
```

This is a **class method**

This instance method will get installed when executing the class method

```
>> ex.log("hello")
10:11:51: #<Example:0x35ad04> (hello)
=> nil
```

```
class Example < Logger
  add_logging
end
ex = Example.new
ex.log("hello")
```

Install logging method for instances of class `Example`

Let's Start Simply

```
class Logger

  def self.add_logging

    def log(msg)

      STDERR.puts Time.now.strftime("%H:%M:%S: ")
                    + "#{self} (#{msg})"

    end
  end
end
```

This is a **class method**

This instance method will get installed when executing the class method

```
>> ex.log("hello")
10:11:51: #<Example:0x35ad04> (hello)
=> nil
```

```
class Example < Logger
  add_logging
end
ex = Example.new
ex.log("hello")
```

Install logging method for instances of class `Example`

Instances of `Example` now understand the log method

A Logged Getter And Setter


```
class AttrLogger

  def self.add_logged_accessors
    def set(newval)
      puts "Assigning #{newval}"
      @val = newval
    end
    def get
      puts "Reading"
      @val
    end
  end

end

class Example < AttrLogger
  add_logged_accessors
end
```

```
ex = Example.new
=> #<Example:0x3534c8>
>> ex.set 6
Assigning 6
=> 6
>> ex.get
Reading
=> 6
```

A Logged Getter And Setter


```
class AttrLogger

  def self.add_logged_accessors
    def set(newval)
      puts "Assigning #{newval}"
      @val = newval
    end
    def get
      puts "Reading"
      @val
    end
  end

end

class Example < AttrLogger
  add_logged_accessors
end
```

Class method

```
ex = Example.new
=> #<Example:0x3534c8>
>> ex.set 6
Assigning 6
=> 6
>> ex.get
Reading
=> 6
```

A Logged Getter And Setter


```
class AttrLogger

  def self.add_logged_accessors
    def set(newval)
      puts "Assigning #{newval}"
      @val = newval
    end
    def get
      puts "Reading"
      @val
    end
  end

end

class Example < AttrLogger
  add_logged_accessors
end
```

Class method

Instance method to set value

```
ex = Example.new
=> #<Example:0x3534c8>
>> ex.set 6
Assigning 6
=> 6
>> ex.get
Reading
=> 6
```

A Logged Getter And Setter


```
class AttrLogger

  def self.add_logged_accessors
    def set(newval)
      puts "Assigning #{newval}"
      @val = newval
    end
    def get
      puts "Reading"
      @val
    end
  end

end

class Example < AttrLogger
  add_logged_accessors
end
```

Class method

Instance method to set value

Instance method to get value

```
ex = Example.new
=> #<Example:0x3534c8>
>> ex.set 6
Assigning 6
=> 6
>> ex.get
Reading
=> 6
```

A Logged Getter And Setter


```
class AttrLogger

  def self.add_logged_accessors
    def set(newval)
      puts "Assigning #{newval}"
      @val = newval
    end
    def get
      puts "Reading"
      @val
    end
  end

end

class Example < AttrLogger
  add_logged_accessors
end
```

Class method

Instance method to set value

with logging

Instance method to get value

with logging

```
ex = Example.new
=> #<Example:0x3534c8>
>> ex.set 6
Assigning 6
=> 6
>> ex.get
Reading
=> 6
```

Method `define_method`

- But how can I create a method of which also the name is parameterized?

  for example, for a given symbol `:value` I want to generate
  - an instance variable `@value`
  - a logged reader method named `value`
  - a logged writer method named `value=(newvalue)`

- Use **`define_method`**

```
define_method(name) do |param1 ... paramn|
  body
end
```

Becomes the method name

Becomes the method parameters

Becomes the method body

Putting Everything Together


```
class AttrLogger
  def self.attr_logger(name)
    define_method("#{name}=") do |val|
      puts "Assigning #{val.inspect} to #{name}"
      instance_variable_set("@#{name}", val)
    end
    define_method("#{name}") do
      puts "Reading #{name}"
      instance_variable_get("@#{name}")
    end
  end
end

class Example < AttrLogger
  attr_logger :value
end
```

```
ex = Example.new
=> #<Example:0x3534c8>
>> ex.value=6
Assigning 6 to value
=> 6
>> ex.value
Reading value
=> 6
```

Class-Level Macros In RoR

Class-level macros are used heavily in Ruby on Rails

```
class Project < ActiveRecord::Base
    belongs_to                :portfolio
    has_one                   :project_manager
    has_many                  :milestones
    has_and_belongs_to_many :categories
  end
```

Reflective Features in Ruby

1. The Class `Class`
2. Meta-Object Protocol
3. Class-Level Macros
4. Eval
5. Hook Methods

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eval

Methods `instance_eval` and `class_eval`

- defined on `Object`
- allow you to temporarily set `self` to some arbitrary object
- evaluates the block, passed with eval, in that context
- then resets `self` to its original value

`class_eval`

sets `self` as if you were in the body of the class definition of the receiver

`instance_eval`

sets `self` as if you were working inside the singleton class of the receiver

class_eval: Adding An Instance Method


```
class TestClass
end

test = TestClass.new
test.testMethod
# NoMethodError

TestClass.class_eval do
    def testMethod
      puts "I exist"
    end
end
# instance method testMethod has now been added

test.testMethod
# prints: I exist
```

class_eval: Adding An Instance Method


```
class TestClass
end

test = TestClass.new
test.testMethod
# NoMethodError

TestClass.class_eval do
    def testMethod
      puts "I exist"
    end
end
# instance method testMethod has now been added

test.testMethod
# prints: I exist
```

Define a class

class_eval: Adding An Instance Method


```
class TestClass
end

test = TestClass.new
test.testMethod
# NoMethodError

TestClass.class_eval do
    def testMethod
      puts "I exist"
    end
end
# instance method testMethod has now been added

test.testMethod
# prints: I exist
```

Define a class

Do this as if inside the class definition

instance_eval: Adding A Singleton Method


```
class TestClass
end

test = TestClass.new
test.testMethod
#NoMethodError

test.instance_eval do
    def testMethod
      puts "I exist"
    end
end
# singleton method testMethod has been added to test

test.testMethod
# prints: I exist
test2 = TestClass.new
test2.testMethod
#NoMethodError
```

instance_eval: Adding a Class Method


```
class TestClass
end

TestClass.instance_eval do
    def testMethod
      puts "I exist"
    end
end
# class method testMethod has now been added

test = TestClass.new
test.testMethod
#NoMethodError
TestClass.testMethod
# prints: I exist
```

instance_eval: Adding a Class Method


```
class TestClass
end

TestClass.instance_eval do
    def testMethod
      puts "I exist"
    end
end
# class method testMethod has now been added

test = TestClass.new
test.testMethod
#NoMethodError
TestClass.testMethod
# prints: I exist
```

Define a class

instance_eval: Adding a Class Method


```
class TestClass
end

TestClass.instance_eval do
    def testMethod
      puts "I exist"
    end
end
# class method testMethod has now been added

test = TestClass.new
test.testMethod
#NoMethodError
TestClass.testMethod
# prints: I exist
```

Define a class

Do this as if inside the singleton class

instance_eval: Adding a Class Method


```
class TestClass
end

TestClass.instance_eval do
    def testMethod
      puts "I exist"
    end
end
# class method testMethod has now been added

test = TestClass.new
test.testMethod
#NoMethodError
TestClass.testMethod
# prints: I exist
```

Define a class

Do this as if inside the singleton class

Confusing terminology:

- `class_eval` can be used to define instance methods
- `instance-eval` can be used to define class methods

Reflective Features in Ruby

1. The Class `Class`
2. Meta-Object Protocol
3. Class-Level Macros
4. Eval
5. Hook Methods

Reflective Features in Ruby

1. The Class `Class`
2. Meta-Object Protocol
3. Class-Level Macros
4. Eval
5. Hook Methods

Hook Method Example 1: Missing Methods


```
class Student
  def method_missing(name)
    puts "I do not understand " + name.to_s
  end
end

aStudent = Student.new

aStudent.reflection
# prints : “I do not understand reflection”
=> nil
```

Hook Method Example 1: Missing Methods


```
class Student
  def method_missing(name)
    puts "I do not understand " + name.to_s
  end
end

aStudent = Student.new

aStudent.reflection
# prints : “I do not understand reflection”
=> nil
```

If Ruby couldn't find a method after having looked it up in the object's class hierarchy, Ruby looks for a method called `method_missing` on the original receiver, starting back at the class of `self` and then looking up the superclass chain again.

Hook Method Example 1: Missing Methods

Like Smalltalk's `doesNotUnderstand`

```
class Student
  def method_missing(name)
    puts "I do not understand " + name.to_s
  end
end

aStudent = Student.new

aStudent.reflection
# prints : "I do not understand reflection"
=> nil
```

If Ruby couldn't find a method after having looked it up in the object's class hierarchy, Ruby looks for a method called `method_missing` on the original receiver, starting back at the class of `self` and then looking up the superclass chain again.

Hook Method Example 1: Missing Methods (ctd.)


```
class MethodCatcher
  def method_missing(name, *args, &block)
    puts "Name of missing method is #{name.to_s}."
    puts "Method arguments are #{args.to_s}."
    puts “Method body is #{block.inspect}."
  end
end

catch = MethodCatcher.new
catch.someMethod(1,2){puts "something"}
# prints :
   Name of missing method is someMethod.
   Method arguments are 12.
   Method body is #<Proc:0x0033b2ec@(irb):30>.
```

Hook Methods

`method_missing(name, *args, &block)`

is a hook method called by Ruby when some method is not found during method lookup

In general, hook methods (also called callbacks)

- are methods you write
- but that get called by the Ruby interpreter at run-time when some particular event occurs

Other Hook Methods

Method-related hooks

- adding an instance method: `method_added`
- adding a singleton method: `singleton_method_added`
- and many more: `method_removed`, `singleton_method_removed`, `method_undefined`, `singleton_method_undefined`

Class and module-related hooks

- subclassing: `inherited`
- mixing in a module: `extend_object`
- and many more: `append_features, included, extended, initialize_copy, const_missing`

Object marshaling hooks

- `marshal_dump, marshal_load`

Coercion hooks

- `coerce, induced_from, to_xxx`

Hook Method Example 2: Adding Methods


```
class MyClass
  def self.method_added(name)
    puts "Adding Method #{name}"
  end
  def new_method
    # blabla
  end
end

Adding Method new_method
=> nil
```

Hook Method Example 2: Adding Methods


```
class MyClass
  def self.method_added(name)
    puts "Adding Method #{name}"
  end
  def new_method
    # blabla
  end
end

Adding Method new_method
=> nil
```

Hook **method**

Hook Method Example 2: Adding Methods


```
class MyClass
  def self.method_added(name)
    puts "Adding Method #{name}"
  end
  def new_method
    # blabla
  end
end

Adding Method new_method
=> nil
```

Hook **method**

Instance **method**

Hook Method Example 2: Adding Methods


```
class MyClass
  def self.method_added(name)
    puts "Adding Method #{name}"
  end
  def new_method
    # blabla
  end
end

Adding Method new_method
=> nil
```

Hook **method**

Instance **method**

Hook method is executed when Ruby adds the instance **method**

6.5 Meta-Programming With Methods

Meta-Programming With Methods

1. Dynamic class extension
2. Calling methods dynamically
3. Removing methods dynamically
4. Method aliasing

Dynamically Add Methods To A Class


```
class Point
  def initialize(x,y)
    @x,@y = x,y
  end
end
```

a simple class

```
origin = Point.new(0,0)
point = Point.new(0,0)
origin == point      # => false
```

```
class Point
  attr_reader :x, :y
  def ==(p)
    @x==p.x
  end
end
```

extending the class (classes are "open")

```
origin == point      # => true
newpoint = Point.new(1,0)
origin == newpoint   # => false
```

old instances see the new methos too

Even Built-In Classes Are Open


```
[1,2,3].myfind  { | entry | entry == 2 }
# => NoMethodError: undefined method ‘myfind’ ...
```

```
class Array
  def myfind
    for i in 0...size
      value = self[i]
      return value if yield(value)
    end
    return nil
  end
end
```

```
[1,2,3].myfind  { | entry | true }          # => 1
[1,2,3].myfind  { | entry | entry == 2 }    # => 2
[1,2,3].myfind  { | entry | entry > 2 }     # => 3
```

Even Built-In Classes Are Open


```
[1,2,3].myfind  { | entry | entry == 2 }
# => NoMethodError: undefined method ‘myfind’ ...
```

```
class Array
  def myfind
    for i in 0...size
      value = self[i]
      return value if yield(value)
    end
    return nil
  end
end
```

Sidenote: actually the method `find` is already implemented on collection classes

```
[1,2,3].myfind  { | entry | true }          # => 1
[1,2,3].myfind  { | entry | entry == 2 }   # => 2
[1,2,3].myfind  { | entry | entry > 2 }    # => 3
```

Calling Methods Dynamically


```
class TestClass
  def testMethod
    puts "I exist"
  end
  def testMethod2(arg)
    puts "I also exist with argument #{arg}"
  end
  def method_missing(methodid)
      puts "#{methodid} does not exist"
  end
end

test = TestClass.new
selector = :testMethod
test.send(:testMethod)
value = 2
test.send("#{selector}2".to_s,value)
```

Removing Methods From a Class or Module


```
class TestClass
  def testMethod
    puts "I exist"
  end
  def method_missing(methodid)
      puts "#{methodid} does not exist"
  end
end

test = TestClass.new
test.testMethod  # prints: I exist
class TestClass
  remove_method(:testMethod)
end
test.testMethod
# prints: testMethod does not exist
```

Method Aliasing


```
class Object
  def timestamp
    return @timestamp
  end
  def timestamp=(aTime)
   @timestamp = aTime
  end
end

class Class
  alias_method :old_new, :new
  def new(*args)
    result = old_new(*args)
    result.timestamp = Time.now
    return result
  end
end
```

```
class Test
end
obj1 = Test.new
sleep 2
obj2 = Test.new

puts obj1.timestamp
# 2016-03-20 15:56:44 +0100
puts obj2.timestamp
# 2016-03-20 15:56:46 +0100
```

Conclusion

This was only an introduction to some of the powerful metaprogramming and reflective features offered by Ruby...

... but there exist many more

Just try them out for yourself !