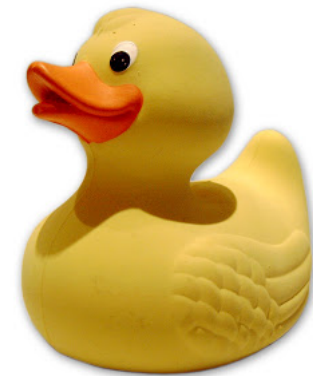# CSE 413
Programming Languages & Implementation

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Autumn 2016

Ruby: Duck Typing, Inheritance, and Modules

The plan…

Several related topics:

- "Duck typing" – dynamic typing in Ruby
- Inheritance and classes
- Modularity and mixins

Later:

- Multiple inheritance, interfaces, and mixins

And then:

- Start on grammars, scanners, parsers

Types in Ruby

- Ruby is dynamically typed – everything is an object
- Only notion of an object's "type" is what messages it can respond to
  - i.e., whether it has methods for a particular message
  - This can change dynamically for either all objects of a class or for individual objects

Duck Typing

- "If it walks like a duck and talks like a duck, it must be a duck"
  - Even if it isn't
  - All that matters is how an object behaves
    - (i.e, what messages it understands)

  - Maybe more accurate: it might as well be a duck if you can't tell the difference

Thought Experiment (1)

- What must be true about x for this method to work?

```
def foo x
  x.m + x.n
end
```

Thought Experiment (2)

- What is true about x?

   x.m + x.n

- Less than you might think
  - x must have 0-argument methods m and n
  - The object returned by x.m must have a + method that takes one argument
  - The object returned by x.n must have whatever methods are needed by x.m.+ (!)

Duck Typing Tradeoffs

- Plus
  - Convenient, promotes code reuse
  - All that matters is what messages an object can receive

- Minus
  - "Obvious" equivalences don't hold: x+x, 2*x, x*2
  - May expose more about an object than might be desirable (more coupling in code)
  - May allow objects to "work" in unintended / inappropriate contexts

Classes & Inheritance

- Ruby vs Java:
  - Subclassing in Ruby is not about type checking – it is not subtyping (because of dynamic typing)
  - Subclassing in Ruby is about inheriting methods
- Can use `super` to refer to inherited code
- See examples in `Points.rb`
  - `ThreeDPoint` inherits methods `x` and `y`
  - `ColorPoint` inherits `distance` methods

Overriding

- With dynamic typing, inheritance alone is just avoiding cut/paste

- Overriding is the key difference
  - When a method in a superclass makes a **self** call, it resolves to a method defined in the subclass if there is one
  - Example: **distFromOrigin2** in **PolarPoint**

Ruby – Why Subclasses?

- Since we can add/change methods on the fly, why use a subclass?

- Instead of class **ColorPoint**, why not just add a color field to **Point**?
  – Can't do this in Java

  – Can do it in Ruby, but it changes all **Point** instances (including subclasses), even existing ones

  – Pro: now all **Point** classes have a color

  – Con: Maybe that breaks something else or is the wrong abstraction for some **Point** clients

Organizing Large(r) Programs

- Issues
  - Idea: divide code into manageable components
  - Also: want to take advantage of reusable chunks of code (libraries, classes, etc.)
- Strategy: Split code into separate files
  - Typically, one or more classes per file
  - Use "require" (or sometimes "load") to access in Ruby
  - What about components that aren't classes?

Namespaces & Modules

- Idea: Want to break larger programs into pieces where names can be reused independently

  - Avoids clashes when combining libraries written by different organizations or at different times

- Ruby solution: modules

  - Separate source files that define namespaces, but not necessarily classes

Example (from Programming Ruby)

```ruby
module Trig
  PI = 3.14
  def Trig.sin(x)
   # …
  end
  def Trig.cos(x)
   # …
  end
end
```

```ruby
module Moral
  VERY_BAD = 0
  BAD          = 1
  def Moral.sin(badness)
   # …
  end
end
```

Using Modules

…

require 'trig'

require 'moral'

y = Trig.sin(Trig::PI/4)

penance = Moral.sin(

Moral::VERY_BAD)

…

- Key point: Each module defines a namespace

  – No clashes with same names in other modules

- Module methods are a lot like class methods

Mixins

- Modules can be used to add behavior to classes – *mixins*
  - Define instance methods and data in module

  - "include" the module in a class – incorporates the module definitions into the class
    - Now the class has its original behavior plus whatever was added in the mixin

  - Provides most of the capabilities of multiple inheritance and/or Java interfaces

Example

```
module Debug
  def trace
    # …
  end
end


class Something
  include debug
  # …
end
```

```
class SomethingElse
  include debug
  # …
end
```

- Both classes have the trace method defined, and it can interact with other methods and data in the host class as if it was defined there
  - (trace is not "shared" by the classes and can't pass information back and forth)

Exploiting Mixins – Comparable

- The real power of this is when mixins build on or interact with code in the classes that use them

- Example: library mixin **Comparable**
  - Class must define operator <=>

    (a <=> b returns -1, 0, +1 if a<b, a==b, a>b)
  - **Comparable** mixin uses "client" <=> to define <, <=, ==, >=, >, and **between?** for that class

Another example – Enumerable

- Container/collection class provides an **`each`** method to call a block for each item in the collection

- Enumerable module builds many mapping-like operations on top of this
  - **`map`**, **`include?`**, **`find_all`**, …
  - If items in the collection implement <=> you also get **`sort`**, **`min`**, **`max`**, …

Iterator Example

- Suppose we want to define a class of `Sequence` objects that have a `from`, `to`, and `step`, and contain numbers `x` such that

  - `from <= x <= to`, and

  - `x = from + n*step` for integer value `n`

(Credit: *Ruby Programming Language*, Flanagan & Matsumoto)

Sequence Class & Constructor

```
class Sequence
  # mixin all of the methods in Enumerable
  include Enumerable

  def initialize(from, to, step)
    @from, @to, @step = from, to, step
  end
  …
```

Sequence each method

- To add an iterator to Sequence and make it also work with Enumerable, all we need is this:

```
def each
  x = @from
  while x <= @to
    yield x
    x += @step
  end
end
```