CSE341: Programming Languages

Lecture 20
Blocks & Procs;
Inheritance & Overriding

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Fall 2011

This lecture

Two separate topics

- Ruby's approach to almost-closures (blocks) and closures (Procs)
  - Convenient to use; unusual approach
  - Used throughout large standard library
    - Explicit loops rare
    - Instead of a loop, go find a useful iterator
- Subclasses, inheritance, and overriding
  - The essence of OOP
  - Not unlike in Java, but worth studying from PL perspective and in a more dynamic language

Blocks

Blocks are probably Ruby's strangest feature compared to other PLs

- Normal: easy way to pass anonymous functions for all the reasons we have been studying
- Normal: Blocks can take 0 or more arguments
- Strange: Can send 0 or 1 block with *any* message send
- Strange: Callee does not have a name for the block
  - Calls it with **`yield`**, **`yield 42`**, **`yield (3,5)`**, etc.
  - Can ask **`block_given?`** but rarely used in practice (usually assume a block is given if expected, or that a block's presence is implied by other arguments)

Examples

- Rampant use of blocks in standard library
  - Classes define iterators; don't write your own loops
  - Most of these examples happen to have 0 "regular" arguments

```
3.times { puts "hi" }
[4,6,8].each { puts "hi" }
[4,6,8].each { |x| puts x * 2 }
[4,6,8].map { |x| x * 2 }
[4,6,8].any? { |x| x > 7 } # block optional
[4,6,8].inject(foo) {|acc,elt| … }
```

- Easy to write your own methods that use blocks

```
def silly a
  (yield a) + (yield 42)
end
```

```
x.silly 5 { |b| b*2 }
```


Blocks are "second-class"

All a method can do with a block is **`yield`** to it (i.e., call it)

- Can't return it, store it in an object (e.g., for a callback), etc.
- But can also turn blocks into real closures (next slide)

But one block can call another block via **`yield`**

- From example **`MyList`** class in **`lec20.rb`** (though better in Ruby to use arrays as lists than define your own)

```
def map
  if @tail.nil?
    MyList.new(yield(@head), nil)
  else
    MyList.new(yield(@head),
               @tail.map {|x| yield x})
  end
end
```


First-class closures

- Implicit block arguments and **`yield`** is often sufficient
- But when you want a closure you can return, store, etc.:
  - The built-in **`Proc`** class
  - **`lambda`** method of **`Object`** takes a block and makes a **`Proc`**
    - Also can do it with "& arg", not shown here
  - Instances of **`Proc`** have a method **`call`**

```
def map_p proc
  if @tail.nil?
    MyList.new(proc.call(@head),
               nil)
  else
    MyList.new(proc.call(@head),
               @tail.map proc)
  end
end
```

```
xs.map_p
  (lambda{|x| … })
```

Subclassing

- A class definition has a *superclass* (`Object` if not specified)

```
class ColorPoint < Point  …
```

- The superclass affects the class definition:
  - Class *inherits* all method definitions from superclass
  - But class can *override* method definitions as desired

- Unlike Java:
  - No such thing as "inheriting fields" since all objects create instance variables by assigning to them
  - Subclassing has nothing to do with a (non-existent) type system: can still pass any object to any method

Example (to be continued)

```
class Point
  attr_reader  :x, :y
  attr_writer  :x, :y
  def initialize(x,y)
    @x = x
    @y = y
  end
  def distFromOrigin
    # direct field access
    Math.sqrt(@x*@x
              + @y*@y)
  end
  def distFromOrigin2
    # use getters
    Math.sqrt(x*x
              + y*y)
  end
end
```

```
class ColorPoint < Point
  attr_reader  :color
  attr_writer  :color
  def initialize(x,y,c)
    super(x,y)
    @color = c
  end
end
```


An object has a class

```
p  = Point.new(0,0)
cp = ColorPoint.new(0,0,"red")
p.class                          # Point
p.class.superclass               # Object
cp.class                         # ColorPoint
cp.class.superclass              # Point
cp.class.superclass.superclass   # Object
cp.is_a? Point                   # true
cp.instance_of? Point            # false
cp.is_a? ColorPoint              # true
cp.instance_of? ColorPoint       # true
```

- Using these methods is usually non-OOP style
  - Disallows other things that "act like a duck"
  - Nonetheless semantics is that an instance of `ColorPoint` "is a" `Point` but is not an "instance of" `Point`
  - Java's `instanceof` is like Ruby's `is_a?`

Why subclass

- Instead of creating `ColorPoint`, could add methods to `Point`
  - That could mess up other users and subclassers of `Point`

```
class Point
  attr_reader  :color
  attr_writer  :color
  def initialize(x,y,c="clear")
    @x = x
    @y = y
    @color = c
  end
end
```


Why subclass

- Instead of subclassing `Point`, could copy/paste the methods
  - Means the same thing *if* you don't use methods like `is_a?` and `superclass`, but of course code reuse is nice

```
class ColorPoint
  attr_reader :x, :y, :color
  attr_writer :x, :y, :color
  def initialize(x,y,c="clear")
    …
  end
  def distFromOrigin
    Math.sqrt(@x*@x + @y*@y)
  end
  def distFromOrigin2
    Math.sqrt(x*x + y*y)
  end
end
```


Why subclass

- Instead of subclassing `Point`, could use a `Point` instance variable
  - Define methods to send same message to the `Point`
  - Often OOP programmers overuse subclassing
  - But for `ColorPoint`, subclassing makes sense: less work and can use a `ColorPoint` wherever code expects a `Point`

```
class ColorPoint
  attr_reader :color
  attr_writer :color
  def initialize(x,y,c="clear")
    @pt = Point.new(x,y)
    @color = c
  end
  def x
    @pt.x
  end
  …
end
```

Overriding

- **ThreeDPoint** is more interesting than **ColorPoint** because it overrides **distFromOrigin** and **distFromOrigin2**
  - Gets code reuse, but highly disputable if it is appropriate to say a **ThreeDPoint** "is a" **Point**
  - Still just avoiding copy/paste

```
class ThreeDPoint < Point
  …
  def initialize(x,y,z)
    super(x,y)
    @z = z
  end
  def distFromOrigin # distFromOrigin2 similar
    d = super
    Math.sqrt(d*d + @z*@z)
  end
  …
end
```


So far…

- With examples so far, objects are not so different from closures
  - Multiple methods rather than just "call me"
  - Explicit instance variables rather than whatever is environment where function is defined
  - Inheritance avoids helper functions or code copying
  - "Simple" overriding just replaces methods
- But there is a big difference (that you learned in Java):

Overriding can make a method define in the superclass call a method in the subclass

  - The essential difference of OOP, studied carefully next lecture

Example: Equivalent except constructor

```
class PolarPoint < Point
  def initialize(r,theta)
    @r = r
    @theta = theta
  end
  def x
    @r * Math.cos(@theta)
  end
  def y
    @r * Math.sin(@theta)
  end
  def distFromOrigin
    @r
  end
  …
end
```

- Also need to define **x=** and **y=** (see lec20.rb)
- Key punchline: **distFromOrigin2**, defined in **Point**, "already works"

```
def distFromOrigin2
  Math.sqrt(x*x+y*y)
end
```

  - Why: calls to **self** are resolved in terms of the object's class