CMSC330

Summer 2009
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Introduction to Ruby

Previous Lecture

- Many types of programming languages
  - Imperative, functional, logical, OO, scripting
- Many programming language attributes
  - Clear, orthogonal, natural…
- Programming language implementation
  - Compiled, interpreted

This lecture

- Scripting languages
- Ruby language
  - Implicit variable declarations
  - Many control statements
  - Classes & objects
  - Strings

But first, from last time

- Higher-order functions:
  - take one or more functions as an input, or
  - output a function
  - ```
    let rec map f = function [] -> []
    | x::l -> (f x)::(map f l)
    ```
    - Takes function `f` as an argument, and returns a function
    - Same as

```
let rec map f somelist = match somelist with
| [] -> []
| x::xs -> (f x)::(map f xs)
```


What is Ruby?

- Ruby is an object-oriented, imperative scripting language
  - "Often people, especially computer engineers, focus on the machines. They think, "By doing this, the machine will run faster. By doing this, the machine will run more effectively. By doing this, the machine will something something something." They are focusing on machines. But in fact we need to focus on humans, on how humans care about doing programming or operating the application of the machines."

    –Yukihiro Matsumoto ("Matz")

Applications of Scripting Languages

- Scripting languages have many uses
  - Automating system administration
  - Automating user tasks
  - Quick-and-dirty development
- Major application :
  Text processing


```

Output from Command-Line Tool

```
% wc *
271      674     5323    AST.c
100      392     3219    AST.h
117      1459    238788  AST.o
1874     5428    47461   AST_defs.c
1375     6307    53667   AST_defs.h
371      884     9483    AST_parent.c
810      2328    24589   AST_print.c
640      3070    33530   AST_types.h
285      846     7081    AST_utils.c
59       274     2154    AST_utils.h
50       400     28756   AST_utils.o
866      2757    25873   Makefile
270      725     5578    Makefile.am
866      2743    27320   Makefile.in
38       175     1154    alloca.c
2035     4516    47721   aloctypes.c
86       350     3286    aloctypes.h
104      1051    66848   aloctypes.o
...
```


Climate Data for IAD in August, 2005

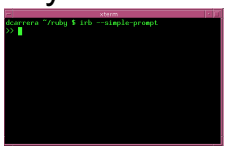
```
=================================================================================
1   2   3   4   5  6A  6B    7    8    9   10  11  12  13   14  15   16  17  18
                                          AVG MX 2MIN
DY MAX MIN AVG DEP HDD CDD  WTR  SNW DPTH SPD SPD DIR MIN PSBL S-S WX   SPD DR
=================================================================================


 1  87  66  77   1   0  12 0.00  0.0    0  2.5  9 200   M    M   7 18    12 210
 2  92  67  80   4   0  15 0.00  0.0    0  3.5 10  10   M    M   3 18    17 320
 3  93  69  81   5   0  16 0.00  0.0    0  4.1 13 360   M    M   2 18    17 360
 4  95  69  82   6   0  17 0.00  0.0    0  3.6  9 310   M    M   3 18    12 290
 5  94  73  84   8   0  19 0.00  0.0    0  5.9 18  10   M    M   3 18    25 360
 6  89  70  80   4   0  15 0.02  0.0    0  5.3 20 200   M    M   6 138   23 210
 7  89  69  79   3   0  14 0.00  0.0    0  3.6 14 200   M    M   7 1     16 210
 8  86  70  78   3   0  13 0.74  0.0    0  4.4 17 150   M    M  10 18    23 150
 9  76  70  73  -2   0   8 0.19  0.0    0  4.1  9  90   M    M   9 18    13  90
10  87  71  79   4   0  14 0.00  0.0    0  2.3  8 260   M    M   8 1     10 210
```


Raw Census 2000 Data for DC

```
u108_S,DC,000,01,0000001,572059,72264,572059,12.6,572059,572059,572059,0,0,
0,0,572059,175306,343213,2006,14762,383,21728,14661,572059,527044,15861
7,340061,1560,14605,291,1638,10272,45015,16689,3152,446,157,92,20090,43
89,572059,268827,3362,3048,3170,3241,3504,3286,3270,3475,3939,3647,3525
,3044,2928,2913,2769,2752,2933,2703,4056,5501,5217,4969,13555,24995,242
16,23726,20721,18802,16523,12318,4345,5810,3423,4690,7105,5739,3260,234
7,303232,3329,3057,2935,3429,3326,3456,3257,3754,3192,3523,3336,3276,29
89,2838,2824,2624,2807,2871,4941,6588,5625,5563,17177,27475,24377,22818
,21319,20851,19117,15260,5066,6708,4257,6117,10741,9427,6807,6175,57205
9,536373,370675,115963,55603,60360,57949,129440,122518,3754,3168,22448,
9967,4638,14110,16160,165698,61049,47694,13355,71578,60875,10703,33071,
35686,7573,28113,248590,108569,47694,60875,140021,115963,58050,21654,36
396,57913,10355,4065,6290,47558,25229,22329,24058,13355,10703,70088,657
37,37112,21742,12267,9475,9723,2573,2314,760,28625,8207,7469,738,19185,
18172,1013,1233,4351,3610,741,248590,199456,94221,46274,21443,24831,479
47,8705,3979,4726,39242,25175,14067,105235,82928,22307,49134,21742,1177
6,211,11565,9966,1650,86,1564,8316,54,8262,27392,25641,1751,248590,1159
63,4999,22466,26165,24062,16529,12409,7594,1739,132627,11670,32445,2322
5,21661,16234,12795,10563,4034,248590,115963,48738,28914,19259,10312,47
48,3992,132627,108569,19284,2713,1209,509,218,125
...
```


Running Ruby



- Execute script in file
  - `ruby -w filename.rb`
  - w option same as verbose
- Interactive Ruby shell
  - `irb` (image at right)
  - can type in Ruby programs one line at a time, and watch as each line is executed

```
irb(main):001:0> 3+4
=> 7
irb(main):002:0> print("hello\n")
hello
=> nil
```

- Executable

A Simple Example

- Let's start with a simple Ruby program `ruby1.rb`:

```
# This is a ruby program
x = 37
y = x + 5
print(y)
print("\n")
```

```
% ruby -w ruby1.rb
42
%
```


Language Basics

comments begin with #, go to end of line

variables need not be declared

```
# This is a ruby program
x = 37
y = x + 5
print(y)
print("\n")
```

line break separates expressions (can also use ";" to be safe)

no special main( ) function or method

Explicit vs. Implicit Declarations

- Java and C/C++ use explicit variable declarations
  - Variables are named and typed before they are used

```
int x, y; x = 37; y = x + 5;
```

- In Ruby, variables are implicitly declared
  - First use of a variable declares it and determines type

```
x = 37; y = x + 5;
x, y exist, will be integers
```


Tradeoffs?

Explicit Declarations	Implicit Declarations
Higher overhead	Lower overhead
Helps prevent typos	Easy to mistype variable names
Forces programmer to document types	Figures out types of variables automatically

Methods in Ruby

Methods are declared with def...end

List parameters at definition

May omit parens on call

Invoke method

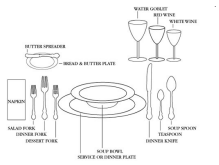
```
def sayN(message, n)
  i = 0
  while i < n
    puts message
    i = i + 1
  end
  return i
end

x = sayN("hello", 3)
puts(x)
```

(Methods should begin with lowercase letter and be defined before they are called)

Method terminology

- Formal parameters
  - Parameters used in the body of the method
  - `message`, `n` in our example
- Actual parameters
  - Arguments passed in to the method at a call
  - `"hello"`, `3` in our example



Control Statements

- A control statement is one that affects which instruction is executed next
  - We've seen two so far in Ruby
    - `while` and function call
- Ruby also has conditionals

```
if grade >= 90 then
  puts "You got an A"
elsif grade >= 80 then
  puts "You got a B"
elsif grade >= 70 then
  puts "You got a C"
else
  puts "You're not doing so well"
end
```


Guard Statements

- The guard of a conditional is the expression determines which branch is taken
  - `if grade >= 90 then …`
  - The true branch is taken if it does not evaluate to
    - `false`
    - `nil`
  - Warning: 0 is not false!

More Control Statements

```
unless grade < 90 then
puts "You got an A" unless grade < 90
until i >= n
  puts message
  i = i + 1
  end
```

- Why so many control statements?
  - Is this a good idea? Tradeoffs?

Even more control statements

```
for elt in [1, "math", 3] puts elt.to_s end
for i in (1..3) puts i end
(1..3).each{ |elt| puts elt }
IO.foreach(filename){ |x| puts x }
case x when 1, … when 2, … end
while i < n
  - break, next, redo
```

Practice Ruby Control Statements

- Ruby function to print all even numbers from 1 to some given value x

Classes and Objects

- Class names begin with an uppercase letter
- The "new" method creates an object
  - `s = String.new` creates a new `String` and makes `s` refer to it
- Every class inherits from `Object`

Everything is an Object

- In Ruby, everything is in fact an object
  - `(-4).abs`
    - integers are instances of `Fixnum`
  - `3 + 4`
    - infix notation for "invoke the `+` method of `3` on argument `4`"
  - `"programming".length`
    - strings are instances of `String`
  - `String.new`
    - classes are objects with a `new` method
  - `(4.13).class`
    - use the `class` method to get the class for an object
    - floating point numbers are instances of `Float`

Classes and Objects

- Objects are data
- Classes are types
- `Fixnum`, `Float`, `String`, etc., (including `Class`), are objects of type `Class`

Two cool things to do with classes

- Since classes are objects, you can manipulate them however you like
  - `if p then x = String else x = Time end`
    …
    `y = x.new # creates a String or a Time,`
    `# depending upon p`
- You can get names of all the methods of a class
  - `Object.methods`
  - `=> ["send", "name", "class_eval", "object_id", "new","autoload?", "singleton_methods", ... ]`

The `nil` object

- Ruby uses a special object `nil`
  - All uninitialized fields set to `nil` (`@` refers to a class field)
    ```
    irb(main):004:0> @x
    => nil
    ```
  - Like `NULL` or `0` in C/C++ and `null` in Java
- `nil` is an object of class `NilClass`
  - It's a *singleton object* – there is only one instance of it
- `NilClass` does *not* have a `new` method
  - `nil` has methods like `to_s`, but not other methods that don't make sense
    ```
    irb(main):006:0> @x + 2
    NoMethodError: undefined method `+' for
    nil:NilClass
    ```


What is a program?

- In Java, a program is...
  - A collection of class definitions
  - With a class `MyClass` that contains a method
    - `public static void main(String[] args)`
    - When you run `java MyClass`, the `main` method of class `MyClass` is invoked

A Ruby program is

- The class `Object`
  - When the class is loaded, any expression not in a method body is executed

defines a method of `Object`

Invokes `self.sayN`

Invokes `self.puts`

```
def sayN(message, n)
  i = 0
  while i < n
    puts message
    i = i + 1
  end
  return i
end

x = sayN("hello", 3)
puts(x)
```


Dynamic Typing

- Recall explicit versus implicit declarations
- We say that Ruby is dynamically typed
  - Types are determined and checked at run time
- Compare to C, which is statically typed

```
# Ruby
x = 3
x = "foo"  # gives x a
           # new type
```

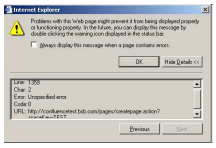
```
/* C */
int x;
x = 3;
x = "foo"; /* not allowed */
```


Types in Java and C++

- Are types in Java and C++ dynamic or static?
  - Answer: both
  - Many things are checked statically
    ```
    Vector v = new Vector();
    v.getZipcode();   //compile time error
    ```
  - Other things are checked at runtime
    ```
    Vector v = new Vector();
    Person p = (Person) v; //runtime error
    ```

"Now! That should clear up a few things around here!"

Tradeoffs?



Static Typing	Dynamic Typing
More work when writing code	Less work when writing code
Helps prevent some subtle errors	Can use objects incorrectly and not realize until exec.
Fewer program types to check	More program types to check

Classes and Objects in Ruby

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

  def addX(x)
    @x += x
  end

  def to_s
    return "(" + @x.to_s + "," + @y.to_s + ")"
  end
end

p = Point.new(3, 4)
p.addX(4)
puts(p.to_s)
```

class contains method/ constructor definitions

constructor definition

instance variables prefixed with "@"

method with no arguments

instantiation

invoking no-arg method

Notes to Java programmers

- Ruby does not support method overloading
  - A typical Java class might have two or more constructors
  - Since Ruby does not support method overloading there can only be one initialize method
- Ruby does issue an exception or warning if classes defines more than one initialize method
  - But last initialize method defined is the valid one

Classes and Objects in Ruby

- Recall classes begin with an uppercase letter
- `inspect` converts any instance to a string

```
irb(main):033:0> p.inspect
=> "#<Point:0x54574 @y=4, @x=7>"
```

- Instance variables are prefixed with `@`
  - Compare to local variables with no prefix
  - *Cannot be accessed outside of class*

- The `to_s` method can be invoked implicitly
  - Like Java's `toString()` methods

Inheritance

- Recall that every class inherits from `Object`

```
class A
  def add(x)
    return x + 1
  end
end

class B < A
  def add(y)
    return (super(y) + 1)
  end
end

b = B.new
puts(b.add(3))
```

extend superclass

invoke add method of parent

`super()` in Ruby

- Within the body of a method
  - Call to `super()` acts just like a call to that original method
  - Except that search for method body starts in the superclass of the object that was found to contain the original method

Global Variables

- Ruby has two kinds of global variables
  - Class variables beginning with `@@` (`static` in Java)
  - Global variables across classes beginning with `$`

```
class Global
  @@x = 0

  def Global.inc
    @@x = @@x + 1; $x = $x + 1
  end

  def Global.get
    return @@x
  end
end
```

```
$x = 0
Global.inc
$x = $x + 1
Global.inc
puts(Global.get)
puts($x)
```

define a class ("singleton") method

Strings in Ruby

- Substitution in double-quoted strings with `#{ }`

```
course = "330"; msg = "Welcome to #{course}"
"It is now #{Time.new}"
```

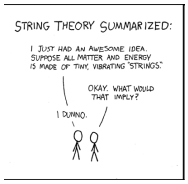
  - The contents of `#{ }` may be an arbitrary expression
  - Can also use single-quote as delimiter
    - No expression substitution, fewer escaping characters
- Here-documents

```
s = <<END
This is a text message on multiple lines and
typing \n is annoying
END
```

- Print with `printf`, `sprintf`, `to_s`

String library in Ruby

- `s.length`
- `s1 == s2`
- `s.chomp` and `s.chomp!`
  - `!` modifies the object
  - `?` observes the object
- `s.index('st',0)`, `s.sub('s','t')`, `s.gsub('s','t')`, `s.split("\t")`
- `s.each("\t"){ |x| puts x}`
  - Apply code to each tab-separated substring

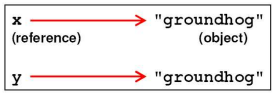


Object Copy vs. Reference Copy

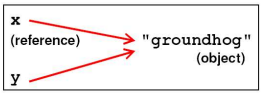
- Consider the following code
  - Assume an object/reference model like Java or Ruby
    - Or even two pointers pointing to the same structure

```
x = "groundhog" ; y = x
```

- Which of these occur?



Object copy



Reference copy

Object Copy vs. Reference Copy

- For

```
x = "groundhog" ; y = x
```

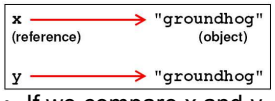
  - Ruby and Java would both do a reference copy
- But for

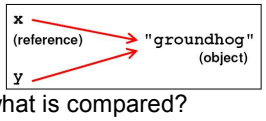
```
x = "groundhog"
y = String.new(x)
```

  - Ruby would cause an object copy
  - Unnecessary in Java since Strings are final

Physical vs. Structural Equality

- Consider these cases again:





- If we compare x and y, what is compared?
  - The references, or the contents of the objects they point to?
- If references are compared (physical equality) the first would return false but the second true
- If objects are compared both would return true

String Equality

- In Java, `x == y` is physical equality, always
  - Compares references, not string contents
- In Ruby, `x == y` for strings uses structural equality
  - Compares contents, not references
  - `==` is a method that can be overridden in Ruby!
  - To check physical equality, use the `equal?` method
    - Inherited from the `Object` class
- It's always important to know whether you're doing a reference or object copy
  - And physical or structural comparison

Summary

- Scripting languages
- Ruby language
  - Implicit variable declarations
  - Many control statements
  - Classes & objects
  - Strings

Reminders

- Discussion section tomorrow
  - Go over Ruby examples (available on webpage)
  - Go over Project 1 notes
    - Available on website
    - Ignore due date on slides; due Wednesday June 10
  - We will talk about regular expressions in Ruby on Thursday