CMSC 330: Organization of Programming Languages

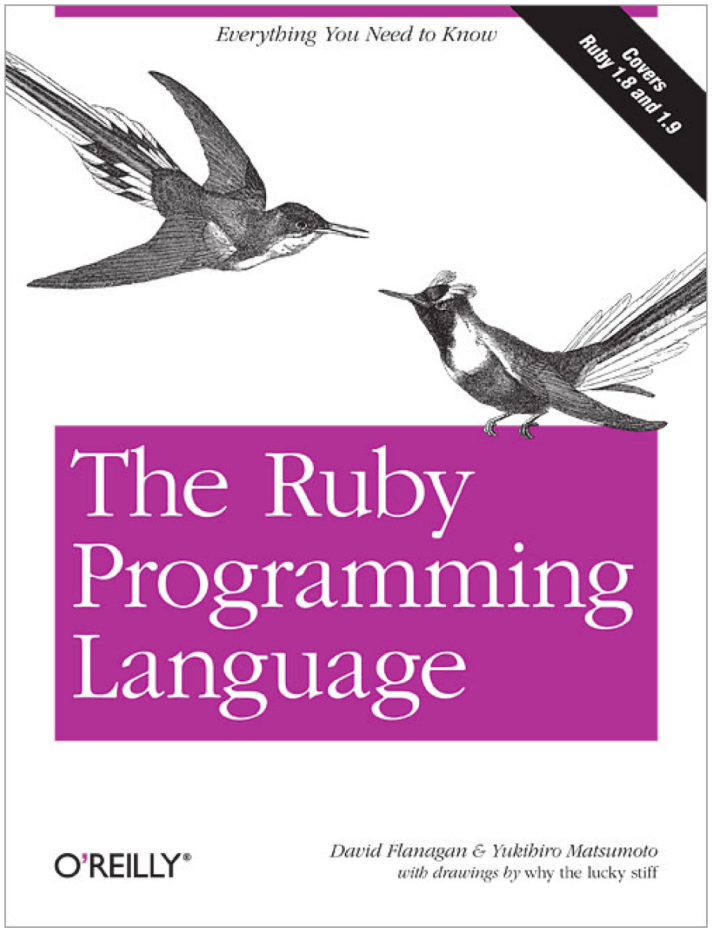
Introduction to Ruby:

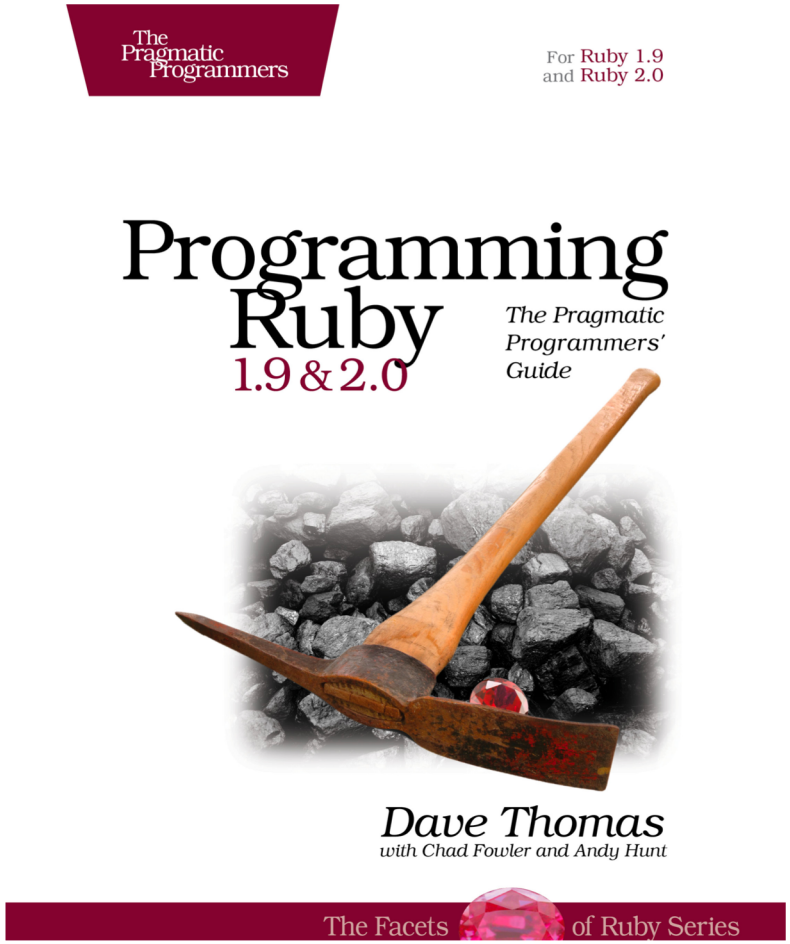
Declarations, Types, Control

Ruby

- An *object-oriented, imperative, dynamically typed (scripting) language*
  - Similar to other scripting languages (e.g., Python)
  - Notable in being **fully object-oriented**, and embracing **higher-order programming** style
    - Functions taking function(al code) as arguments
- Created in 1993 by Yukihiro Matsumoto (Matz)
  - "Ruby is designed to make programmers happy"
- Adopted by Ruby on Rails web programming framework in 2005 (a key to Ruby's popularity)

Books on Ruby





- Earlier version of Thomas book available on web
  - See course web page

Applications of Scripting Languages

- Scripting languages have many uses
  - Automating system administration
  - Automating user tasks
  - Quick-and-dirty development

- Motivating 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
...
```

Ruby is a ~~Scripting~~ Dynamic Language

- Ruby started with special purpose, but has grown into a general-purpose language
  - As have related languages, like Python and Perl
    - The Swedish pension system was once written in Perl!
- But Ruby has distinctive features when compared to traditional general-purpose languages
  - Such as lightweight syntax, dynamic typing, evaluating code in strings, …
- We will call them scripting languages, still, but also dynamic languages

A Simple Example

- Let's start with a simple Ruby program

ruby1.rb:

```
# This is a ruby program
x = 1
n = 5
while n > 0
  x = x * n
  n = n - 1
end
print(x)
print("\n")
```

```
% ruby -w ruby1.rb
120
%
```

Language Basics

comments begin with #, go to end of line

variables need not be declared

```
# This is a ruby program
x = 1
n = 5
while n > 0
  x = x * n
  n = n - 1
end
print(x)
print("\n")
```

line break separates expressions (can also use ";")

no special main() function or method

Run Ruby, Run

There are two basic ways to run a Ruby program

- ruby -w *filename* – execute script in *filename*
  - tip: the -w will cause Ruby to print a bit more if something bad happens
  - Ruby filenames should end with '.rb' extension
- irb – launch interactive Ruby shell
  - Can type in Ruby programs one line at a time, and watch as each line is executed

    irb(main):001:0> 3+4

    ⇒7
  - Can load Ruby programs via load command
    - Form: load *string*
    - String must be name of file containing Ruby program
    - E.g.: load 'foo.rb'

▸Ruby is installed on Grace cluster

Some Ruby Language Features

- Implicit declarations
  - Java, C have explicit declarations
- Dynamic typing
  - Java, C have (mostly) static typing
- Everything is an object
  - No distinction between objects and primitive data
  - Even “null” is an object (called *nil* in Ruby), as are classes
- No outside access to private object state
  - *Must* use getters, setters
- No method overloading
- Class-based and Mixin inheritance

Implicit vs. Explicit Declarations

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

```
x = 37;  // no declaration needed – created when assigned to
y = x + 5
```

    - x, y now exist, are integers

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

```
int x, y;   // declaration
x = 37;   // use
y = x + 5;  // use
```

Tradeoffs?

Explicit Declarations	Implicit Declarations
More text to type	Less text to type
Helps prevent typos	Easy to mistype variable name

```
var = 37
If (rare-condition)
  y = vsr + 5
```

Typo!

Only caught when this line is actually run.

Bug could be latent for quite a while

Static Type Checking (Static Typing)

- Before program is run
  - Types of all expressions are determined
  - Disallowed operations cause compile-time error
    - Cannot run the program

- Static types are often explicit (*aka* manifest)
  - Specified in text (at variable declaration)
    - C, C++, Java, C#
  - But may also be inferred – compiler determines type based on usage
    - OCaml, C# and Go (limited)

Dynamic Type Checking

- During program execution
  - Can determine type from run-time value
  - Type is checked before use
  - Disallowed operations cause run-time exception
    - Type errors may be latent in code for a long time
- Dynamic types are *not* manifest
  - Variables are just introduced/used without types
  - Examples
    - **Ruby**, Python, Javascript, Lisp

Static and Dynamic Typing

- Ruby is dynamically typed, C is statically typed

```ruby
# Ruby
x = 3
x = "foo"   # gives x a
            # new type
x.foo       # NoMethodError
            # at runtime
```

```c
/* C */
int x;
x = 3;
x = "foo"; /* not allowed */
/* program doesn't compile */
```

- Notes
  - Can always run the Ruby program; may fail when run
  - C variables declared, with types
    - Ruby variables declared *implicitly*
    - Implicit declarations most natural with dynamic typing

Tradeoffs?

- Static type checking
  - More work for programmer (at first)
    - Catches more (and subtle) errors at compile time
  - Precludes some correct programs
    - May require a contorted rewrite
  - More efficient code (fewer run-time checks)
- Dynamic type checking
  - Less work for programmer (at first)
    - Delays some errors to run time
  - Allows more programs
    - Including ones that will fail
  - Less efficient code (more run-time checks)

Java: *Mostly* Static Typing

- In Java, types are mostly checked statically

```
Object x = new Object();
x.println("hello");   // No such method error at compile time
```

- But sometimes checks occur at run-time

```
Object o = new Object();
String s = (String) o;  // No compiler warning, fails at run time
// (Some Java compilers may be smart enough to warn about
   above cast)
```

Quiz 1: Get out your clickers!

- True or false: This program has a type error

```
# Ruby
x = 3
y = "foo"
x = y
```

A. True
B. False

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B. False

- True or false: This program has a type error

```
/* C */
void foo() {
  int x = 3;
  char *y = "foo";
  x = y;
}
```

A. True
B. False

Quiz 1: Get out your clickers!

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Control Statements in Ruby

- A control statement is one that affects which instruction is executed next
  - While loops
  - Conditionals

```
i = 0
while i < n
  i = i + 1
end
```

```
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
```

Conditionals and Loops Must End!

- All Ruby conditional and looping statements must be terminated with the end keyword.
- Examples

```
if grade >= 90 then
  puts "You got an A"
end
```

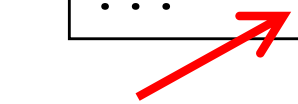
```
if grade >= 90 then
  puts "You got an A"
else
  puts “No A, sorry"
end
```

```
i = 0
while i < n
  i = i + 1
end
```

What is True?

- The guard of a conditional is the expression that determines which branch is taken

```
if grade >= 90 then
...
```



Guard

- The true branch is taken if the guard evaluates to anything except
  - false
  - nil
- Warning to C programmers: **0 is not false!**

Quiz 2: What is the output?

```
x = 0
if x then
  puts "true"
elsif x == 0 then
  puts "== 0"
else
  puts "false"
end
```

A. Nothing – there's an error
B. "true"
C. "== 0"
D. "false"

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```

A. Nothing – there's an error

B. "true"

C. "== 0"

D. "false"

x is neither **false** nor **nil** so the first guard is satisfied