What is Domain Specific Language?

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DSL – Domain Specific Language

- DSL stands for domain specific language
- DSL is implemented in two ways:
  - External DSL: individual language implementation
    make, SQL, XSLT, etc.
  - Internal DSL: implemented as a library in a host language
    rake, rspec, etc.

My question:
What's the difference of internal DSL and library?

The Question (Concrete Version)

- rake is considered a DSL
- But Rakefile is just a Ruby program
- Why rake is DSL?

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The Question (Generalized Version)

- Internal DSL is just a library
- DSL description is just a program written in the host language
- Why internal DSL is considered a LANGUAGE?

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This Question is Important

- DSL empowers Ruby programmers
- Understanding what is DSL is important to design a new DSL

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My Answer:
DSL has its own semantics
DSL program is readable without Ruby semantics
This makes a program easier-to-read

External DSL is clear

- SQL is DSL for database
- XSLT is DSL for translating XML

They have own syntax and semantics

They are not general purpose language

So, they are DSL

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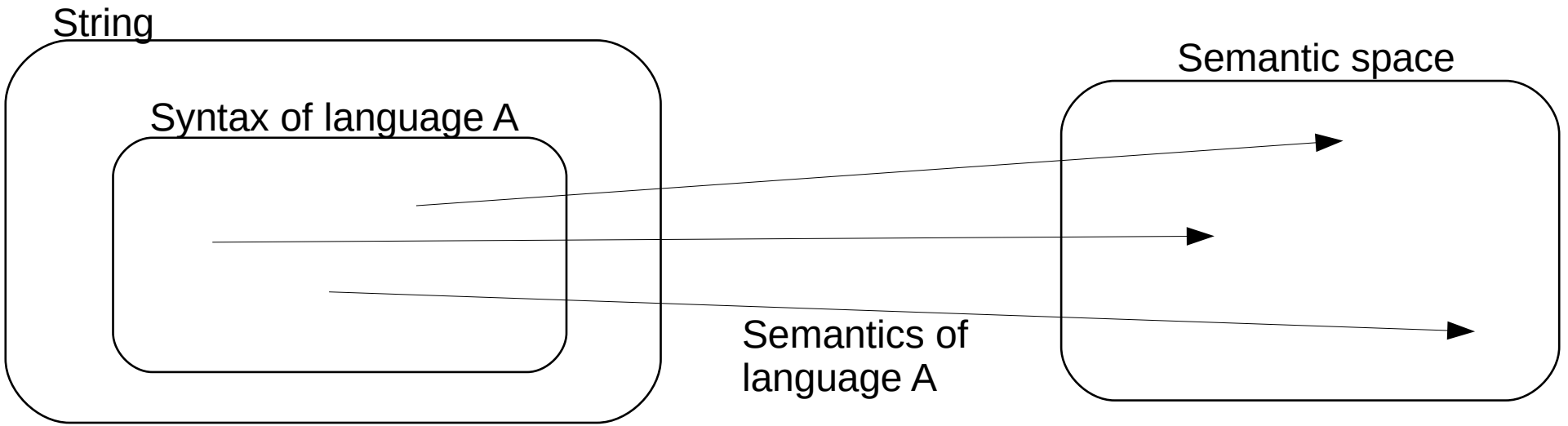
Internal DSL is not clear

- Many ruby libraries are considered DSL
  - rake is a DSL
  - rspec is a DSL
  - etc.
- Rakefile and foo_spec.rb is written in Ruby
- They are executed in Ruby semantics

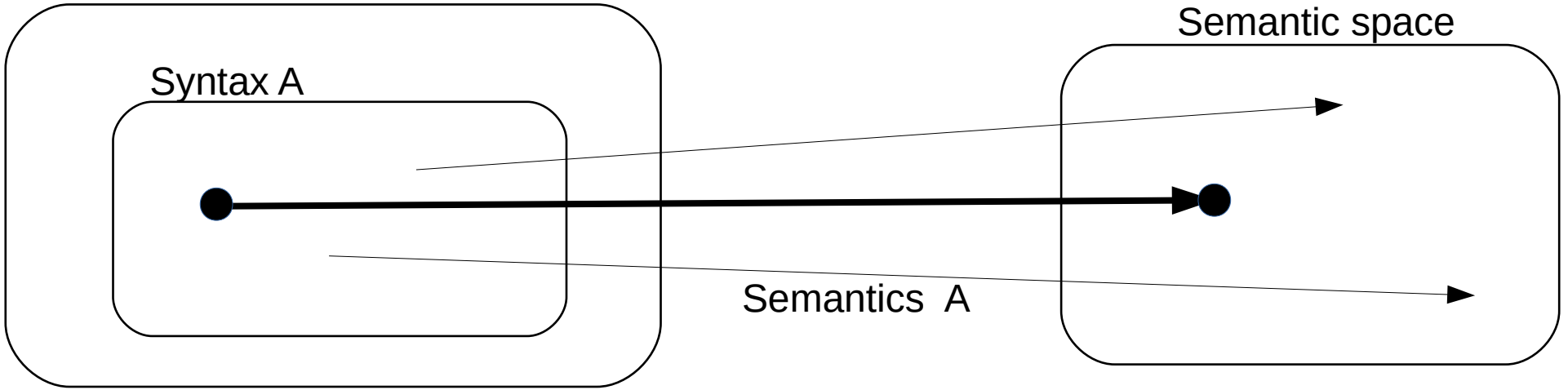
Syntax + Semantics = Language

- Syntax is a subset of string
- Semantics maps programs to semantic space



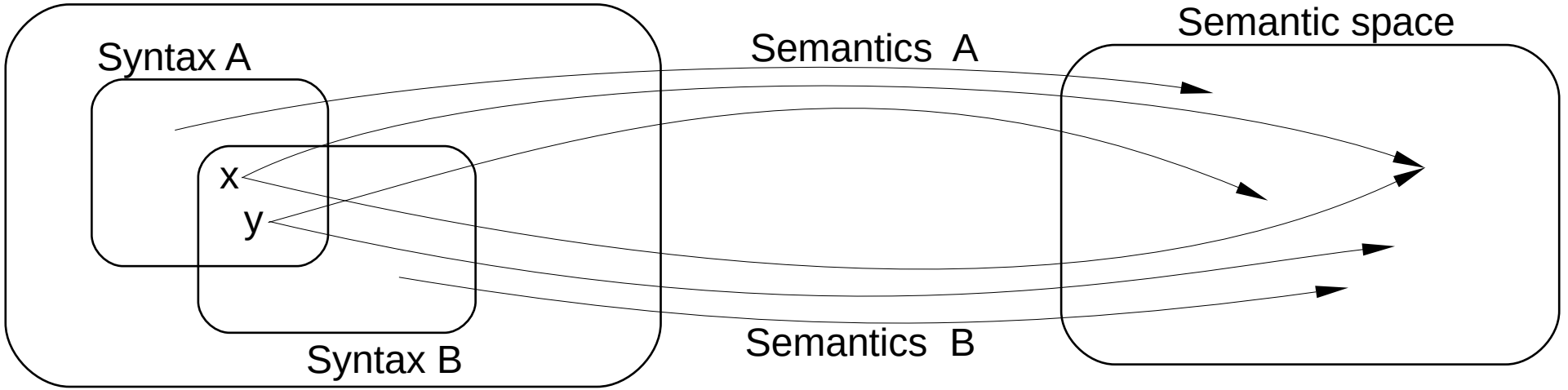
Reading a Program

- "reading a program" means "following a semantics arrow"
- We need to learn the semantics to read programs



Two Languages

- Lang. A and B has different syntax and semantics
- Some programs, such as x, has same meaning,
  Other programs, such as y, has different meaning



Two Language Semantics Examples

- One program has same meaning in two languages
- One program has different meaning in two languages

One Program Has Same Meaning in Two Languages

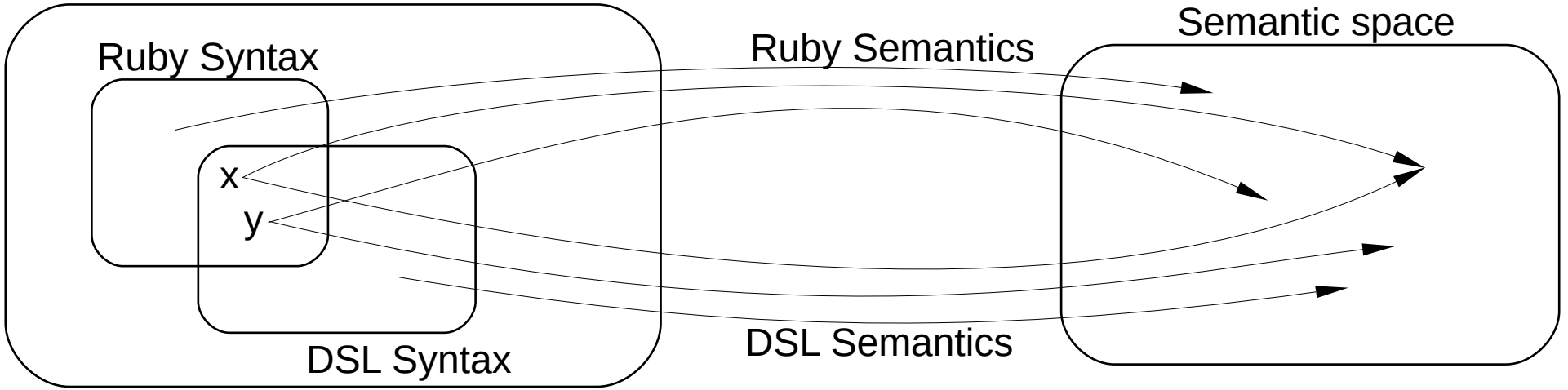
- Ruby
  - % ruby -e 'print "hello\n"'
    hello
- Perl
  - % perl -e 'print "hello\n"'
    hello
- 'print "hello\n"' has same meaning in Ruby and Perl.

One Program Has Different Meaning in Two Languages

- Ruby
  - irb> 1 + 2 * 3
    7
- Smalltalk:
  - gst> 1 + 2 * 3
    9
  - Smalltalk's binary operators have no precedence and always left-associative
    1 + 2 * 3 is interpreted as (1 + 2) * 3

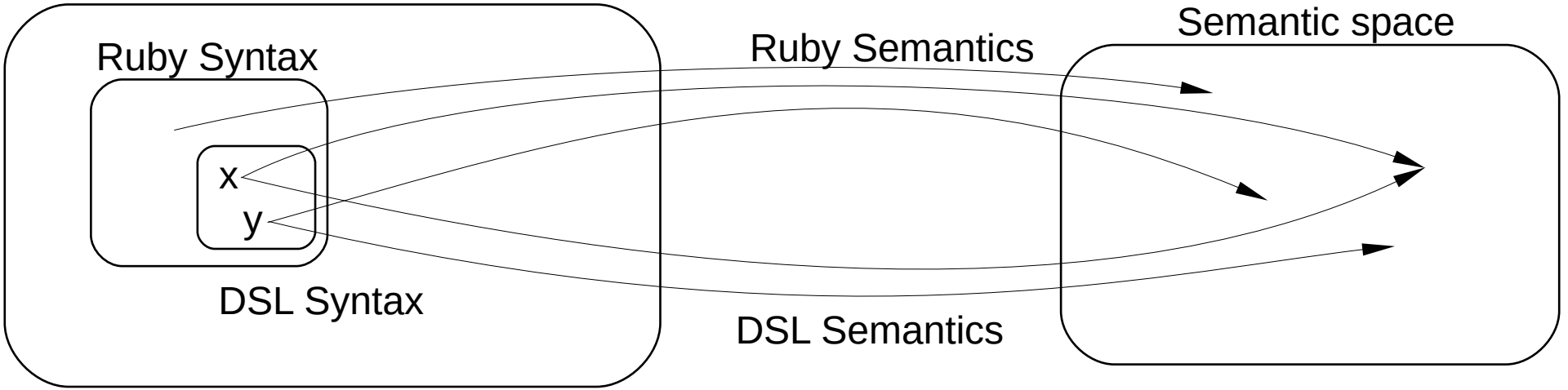
External DSL

- External DSL and Ruby are different languages
- Some programs, such as x, has same meaning,
  Other programs, such as y, has different meaning



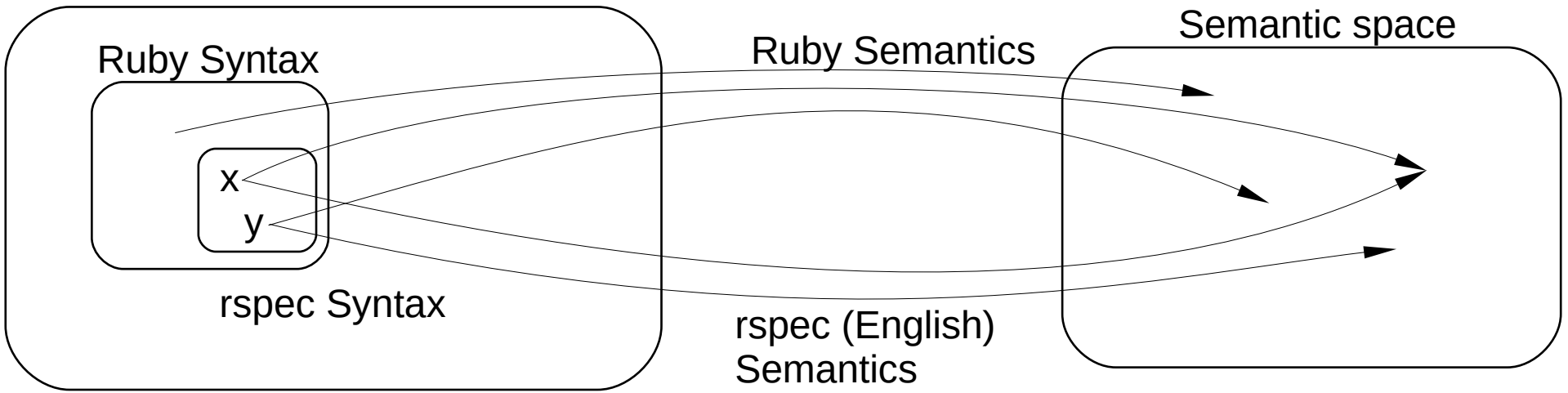
Internal DSL

- Internal DSL Syntax is subset of host language
- However, it has own semantics and some programs can have different meaning



Internal DSL has Different Semantics?

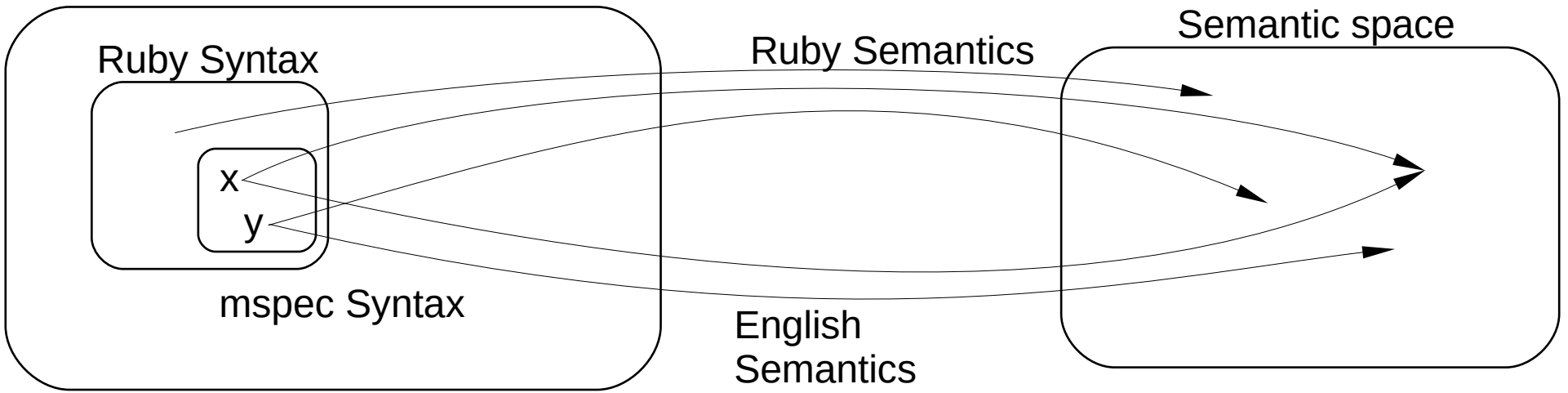
- rspec provides English-like language for BDD
- Ruby semantics and English semantics can differ



rubyspec (mspec) Example

- "should" method is implemented with "should" meaning in English
- spec/ruby/language/and_spec.rb:

```
it "evaluates to the last condition if all are true" do
  ("yes" && 1).should == 1
  (1 && "yes").should == "yes"
end
```



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Ruby and English

English is used everywhere in Ruby (not only DSL)

- class and method names
  matz rejects proposals until the name is appropriately means a feature
- English.rb
  alias $ERROR_INFO $!
- rspec

These make Ruby programs easier-to-read for English user

Internal DSL

- Internal DSL makes programs easier-to-read for domain-knowledgeable people who knows domain semantics
- Easier-to-read doesn't mean easier-to-write
  Programmers should make both meaning same
  I.e. Programmers must know both languages (DSL and host language)

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How to Design Good DSL

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DSL Design Principle

- Respect domain convention
  This makes DSL description easier for domain-knowledgeable people
- Reduce boilerplate
  - Preamble/Postamble
  - Frequent snippet
- Hide non-domain issue
  memory-management, etc.

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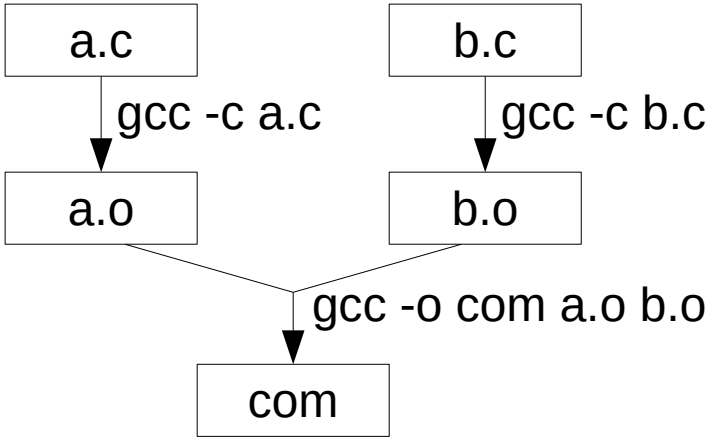
Several DSL Examples

- rake: DSL for build process
- erb: DSL for templates
- shell.rb: DSL for Unix-shell

Build Process

- There are many build tools using dependencies make, rake, cmake, SCons, Ant, ...
- build process = dependencies + actions

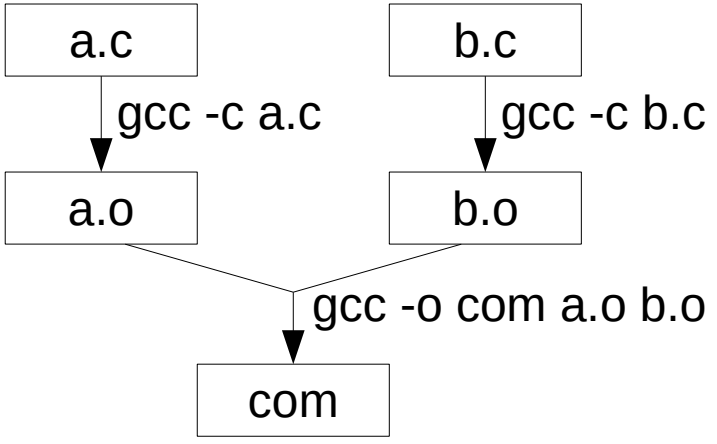


make

- Makefile:

```
a.o: a.c
        gcc -c a.c
b.o: b.c
        gcc -c b.c
com: a.o b.o
        gcc -o com a.o b.o
```

- Graphical Structure



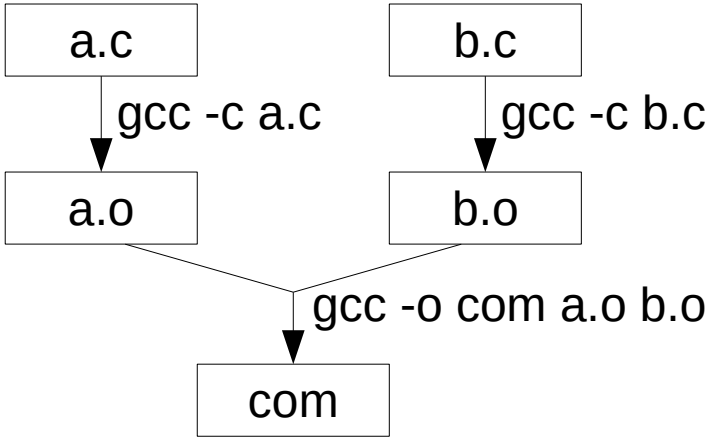
"make" is a famous build tool
Makefile represents the graphical structure succinctly

rake

- Rakefile:

```
file "a.o" => "a.c" do
  sh "gcc -c a.c" end
file "b.o" => "b.c" do
  sh "gcc -c b.c" end
file "com" => ["a.o", "b.o"] do
  sh "gcc -o com a.o b.o" end
```

- Graphical Structure



"rake" is build tool written in Ruby
Rakefile is similar to Makefile
Rakefile is bit more verbose than Makefile

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rake without DSL

- rake can be used without DSL
- Build script:

```
require 'rake'
Rake.application = Rake::Application.new
Rake.application.init("rake", ARGV)
Rake::FileTask.define_task("a.o" => "a.c") do system("gcc -c a.c") end
Rake::FileTask.define_task("b.o" => "b.c") do system("gcc -c b.c") end
Rake::FileTask.define_task("com" => ["a.o", "b.o"]) do system("gcc -o com a.o b.o") end
Rake.application.top_level
```

- rake without DSL is not the supposed way to use rake
  "system" is used because no easy way to invoke "sh"
- The build script is much verbose than Rakefile

Thought Experiment: rake without DSL Improved

- Build script:

```
require 'rake'
r = Rake.new(ARGV)
r.define_file_task("a.o" => "a.c") do r.sh("gcc -c a.c") end
r.define_file_task("b.o" => "b.c") do r.sh("gcc -c b.c") end
r.define_file_task("com" => ["a.o", "b.o"]) do
  r.sh("gcc -o com a.o b.o") end
r.run
```

- It still verbose than Rakefile

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DSL Design in Rake

- Respect domain convention
  - Describe build graph using pair: target => dependencies
  - The arrow is inverse with build direction, unfortunately
- Reduce boilerplate
  - Preamble: require 'rake'; r = Rake.new
    Postamble: r.run
  - Frequent snippet
    "file" is shorter than "r.define_file_task"
    "sh" is shorter than "r.sh"

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DSL Implementation of Rake

- lib/rake/dsl_definition.rb
  This filename is definite reason that Rake is DSL
- Tricks for DSL
  - global methods
    "file" and "sh" is defined to "main" object
  - singleton pattern (global variable)
    The state is maintained at Rake.application
  - dedicated command, rake
    It makes preamble/postamble implicit

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ERB: template engine

- ERB source:
  foo
  <% 3.times do |i|
  %>bar<% end %>
  baz

- result:
  foo
  barbarbar
  baz

Template Engine can be considered as DSL for text generation

Text Generation with/without Template Engine

with ERB:

- foo
  <% 3.times do |i|
  %>bar<% end %>
  baz

without ERB:

- s = +""
  s << "foo\n".freeze
  3.times do |i|
  s << "bar".freeze end
  s << "\nbaz\n".freeze
  s

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DSL Design in ERB

- Respect domain convention
  - Use <% ... %> as SGML Processing Instruction and PHP
- Reduce boilerplate
  - Preamble: s = +""
    Postamble: s
  - Frequent snippet
    - string concatenations: s <<
    - quotes and escapes: "...\n"
- Hide non-domain issue
  - Destructive string concatenation (<<) is faster than non-destructive concatenation (+)
  - Avoid string allocations using .freeze

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shell.rb: Shell-like Tool in Ruby

- Bourne shell:
  ```
  cat /etc/hosts | grep localhost > /tmp/foo
  head -1 /tmp/foo
  ```
- shell.rb:
  ```
  irb> require 'shell'
  irb> Shell.new.transact {
  irb>   cat("/etc/hosts") | system("grep", "localhost") > "/tmp/foo"
  irb>   system("head", "-1", "/tmp/foo")
  irb> }
  shell(#<Th:0x000055da32f97178 run>): /bin/grep localhost
  shell(#<Th:0x000055da32f97178 run>): /bin/head -1 /tmp/foo
  => 127.0.0.1    localhost
  ```

shell.rb without Shell#transact

- shell.rb with transact:

```
Shell.new.transact {
  cat("/etc/hosts") |
  system("grep", "localhost") >
    "foo"
  system("head", "-1", "foo")
}
```

- shell.rb without transact

```
s = Shell.new
s.cat("/etc/hosts") |
s.system("grep", "localhost") >
 "/tmp/foo"
s.system("head", "-1", "foo")
```

transact method replaces self in the block to avoid frequent "s."
It uses instance_eval

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DSL Design in shell.rb

- Respect domain convention
  - Use "|" for pipe, ">" for redirection
  - cat method for cat command
- Reduce boilerplate
  - Frequent snippet
    - "cat" method instead of system("cat", ...)
      def_system_command provides a way to define such methods
    - "s." is removed using instance_eval

Internal DSL
or
External DSL

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Advantage of Internal DSL

Ruby and DSL can be mixed

- Ruby in DSL
  - Rake actions can be written in Ruby
- DSL in Ruby
  - generate Rake rules in Ruby loop

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Disadvantage of Internal DSL

- Ruby and DSL is mixed
  - DSL description is unusable except execution
    - make -n show actions
      rake -n doesn't show actions
- Tends to difficult to debug
  - DSL description: debugging at Ruby level, not DSL level
  - DSL implementation: dirty tricks makes debugging harder
- Tends to reach Ruby's limitation
  - The limitation may be changed by Ruby versions

Internal DSL
or
Library

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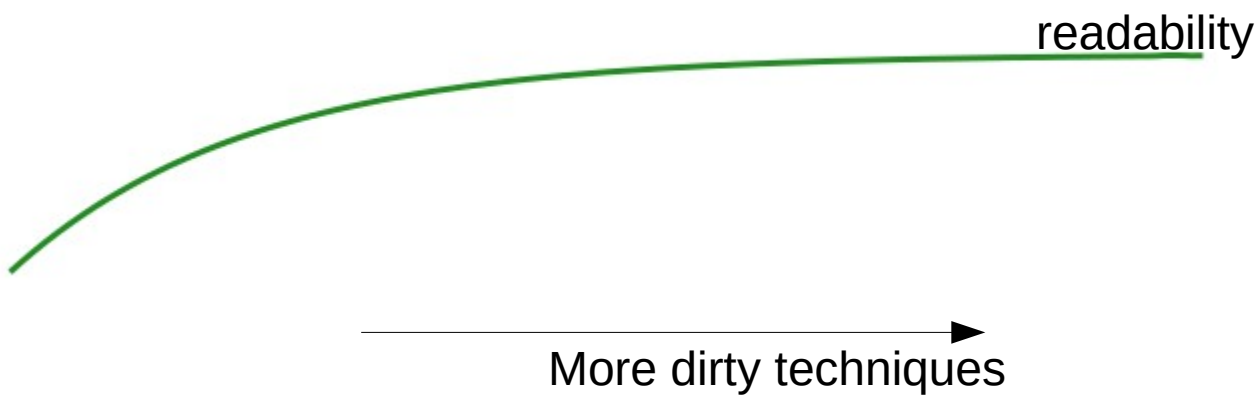
Between DSL and Library

- Many techniques to respect domain knowledge and reduce boilerplate
- Some techniques are cleaner and others are more dirty
- Clean techniques (Not so DSL-ish)
  - Good names (English words)
  - Appropriate use of operators
- Dirty techniques (DSL-ish)
  - singleton pattern (global variable)
  - instance_eval
  - individual command
  - TracePoint
  - RubyVM::AbstractSyntaxTree

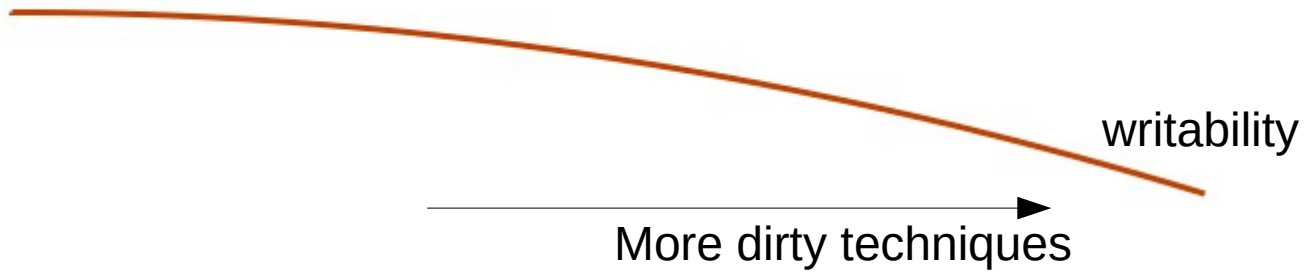
Readability of DSL

- Dirty techniques may improve readability
  But it cannot improve endlessly
- Readability of DSL must saturate



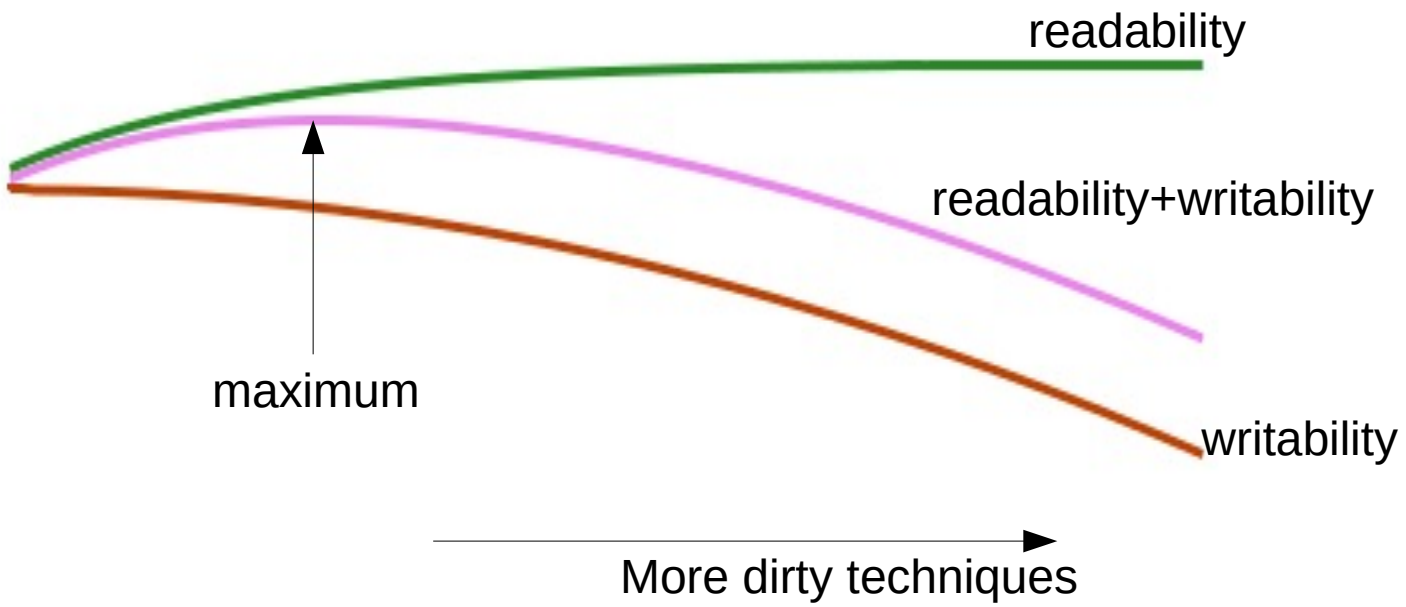
Writability of DSL

- Dirty techniques degrades writability (maintainability, debug) of DSL descriptions and implementations
- Disadvantage would be bigger endlessly



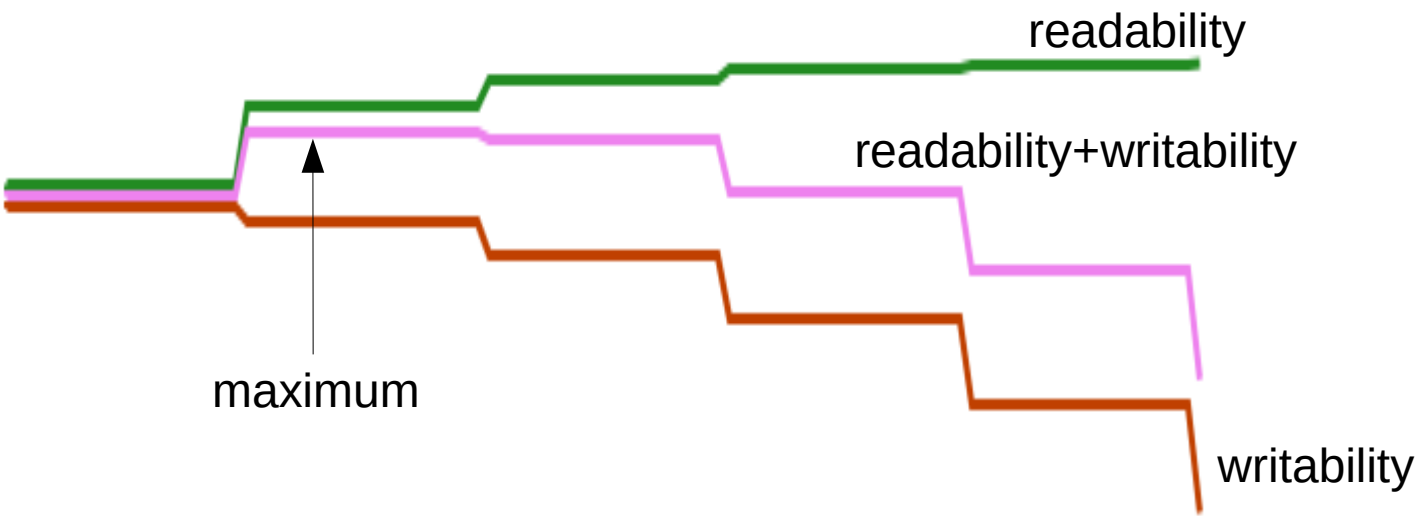
Readability + Writability

- readability + writability would have maximum



Dirty Techniques are Discrete

- There are not so many dirty techniques



In this image,
only one dirty technique is enough

Summary

- Why internal DSL is a language?
  - It has own semantics
- Why DSL is easier-to-read?
  - Programmers (or domain experts) can use domain knowledge (domain semantics)
- How to design good DSL?
  - Moderate use of dirty techniques