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How resolve Gem dependencies in your code?

Hiroshi SHIBATA

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Self Introduction

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Hiroshi SHIBATA

@hsbt

Ruby core team

ANDPAD Fellow

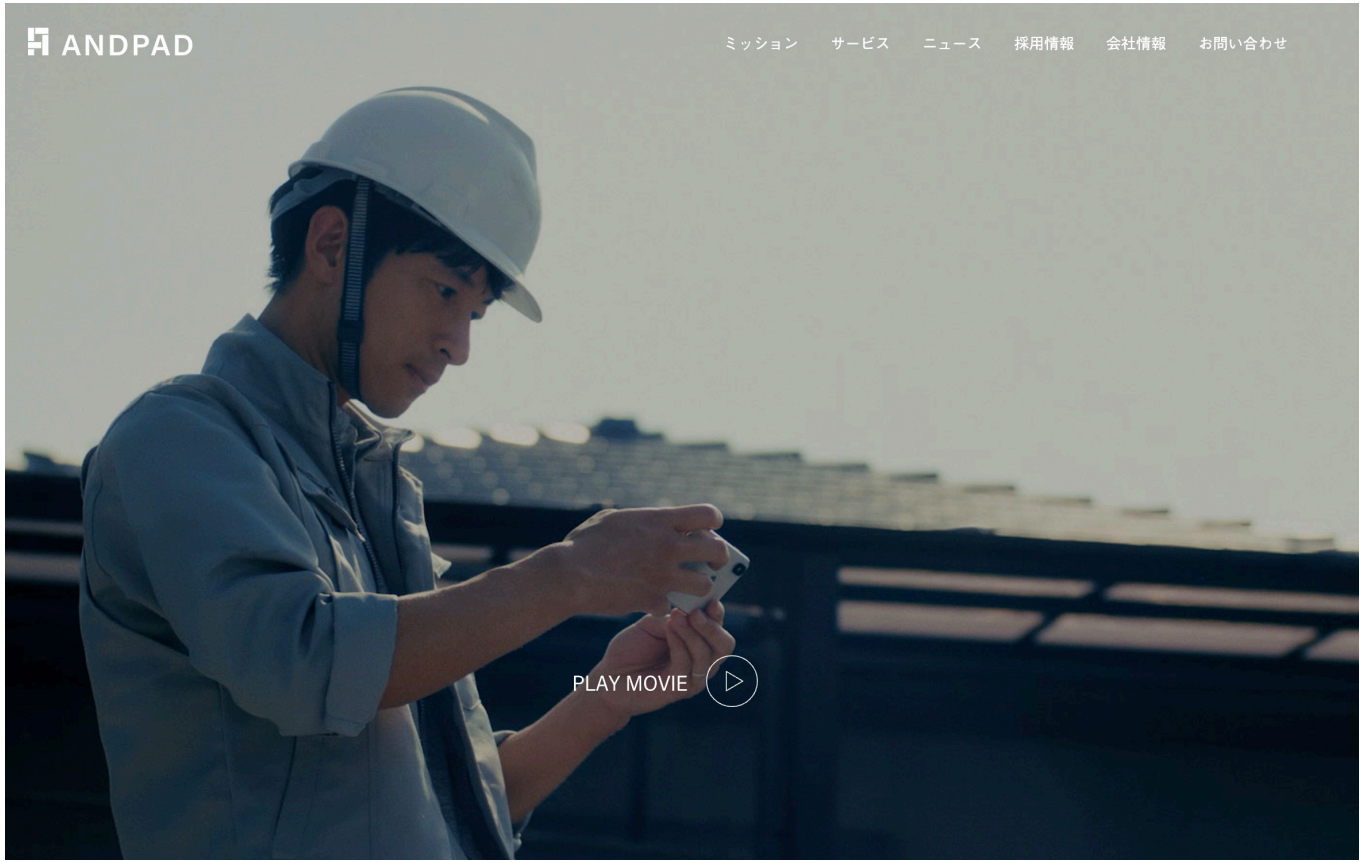
https://hsbt.org



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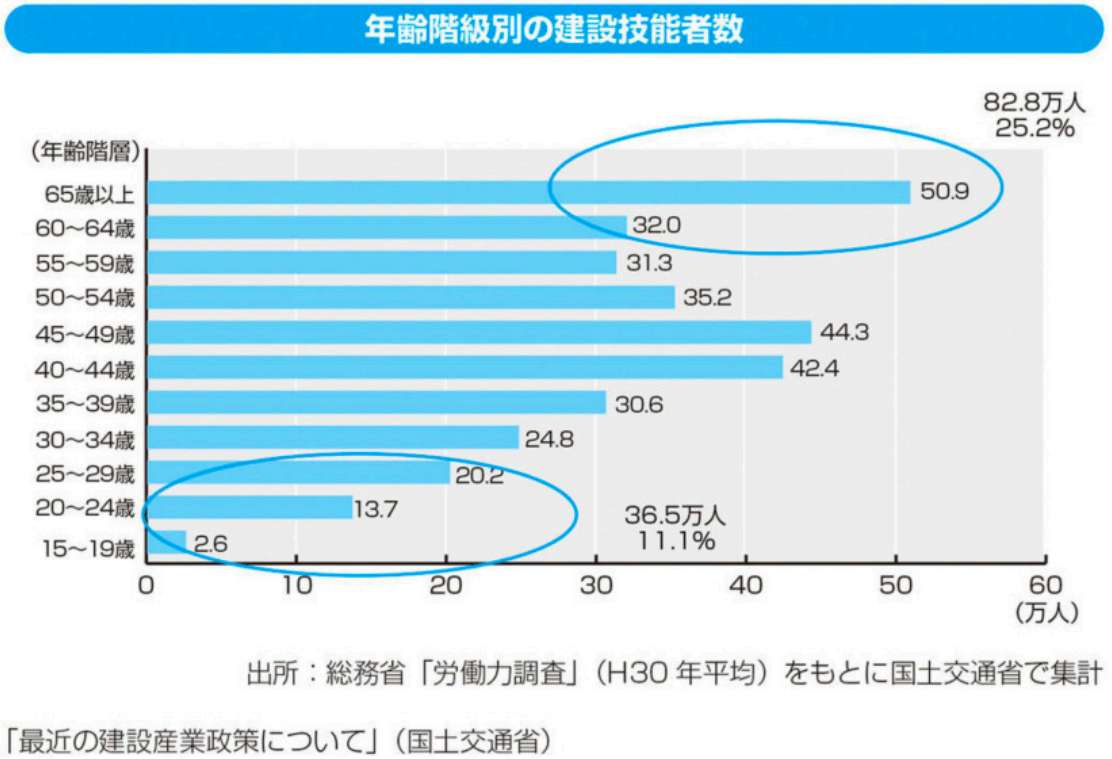


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Construction service in Japan have many many of problems in the future.

It’s time to provide DX experiences to them.



図解入門業界研究 最新建設業界の動向とカラクリがよ～くわかる本[第4版]

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What's Dependency Resolution with RubyGems/Bundler?

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Knowledge & Definition

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What's package manager?

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- User interface
  - Provide user interface to install package
- Dependency Resolution
  - Resolve dependencies of package and provide list of name and version of package
- Version locking (NEW!)
  - Provide environment to lock specified versions of package

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Terminology

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- Gem
  - A package/library for the Ruby programming language
- Gem::Specification
  - Class for defining metadata including name, version, platform, etc.
- gemspec
  - File describing the Gem::Specification in RubyGems/Bundler
    - This file is written by you for releasing gem
    - This file is created at gem install time by RubyGems

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Terminology

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- Resolution
  - Ensuring that the dependency constraint are satisfied the combinatorial constraints of multiple libraries.
- Resolver Engine
  - Performs dependency resolution with library name and version combinations and provides a list of libraries if resolved. RubyGems uses Mollinilo, Bundler uses PubGrub
- Resolver
  - Provides the Resolver Engine with the necessary data abstraction and library dependency resolution
  - Provides list of libraries including their names and versions to be installed.

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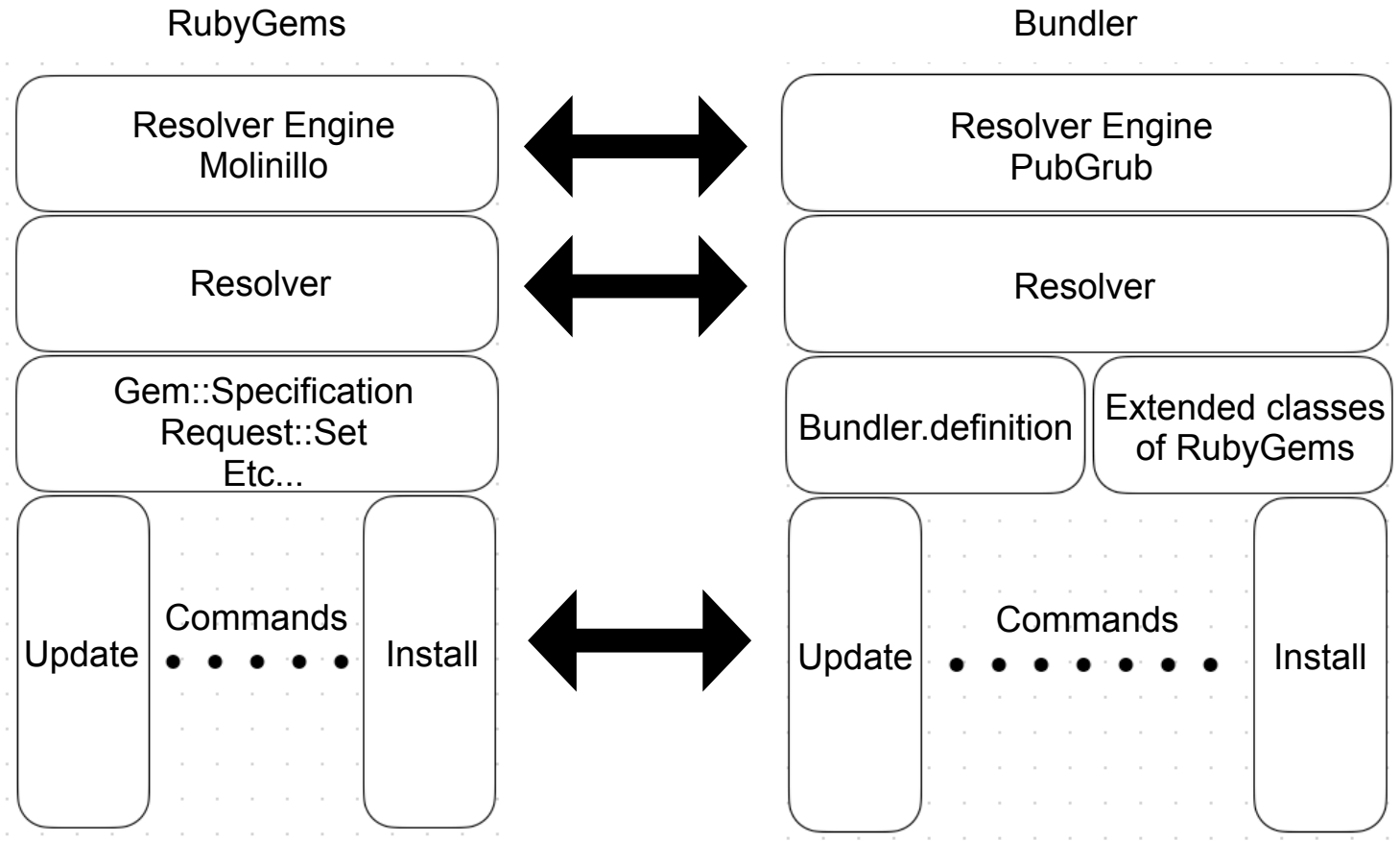
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The current issues of RubyGems and Bundler

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Architecture of RubyGems/Bundler

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Performance issues

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- Both RubyGems and Bundler are slow
- Ruby startup time is also slow with RubyGems
    - RubyGems extends `require`, `gem` and `warn`
- Users uses a trick that is `--disable-gems`

```
  def require(path) # :doc:
    return gem_original_require(path) unless
Gem.discover_gems_on_require

    begin
      RUBYGEMS_ACTIVATION_MONITOR.enter

      path = path.to_path if path.respond_to? :to_path

      if spec = Gem.find_unresolved_default_spec(path)
        # Ensure -I beats a default gem
        resolved_path = begin
          rp = nil
    (snip)
```

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Infinitely `bundle update`

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```
$ bundle update
Fetching gem metadata from https://rubygems.org/.....
Resolving
dependencies.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....^C
```

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Case Studies

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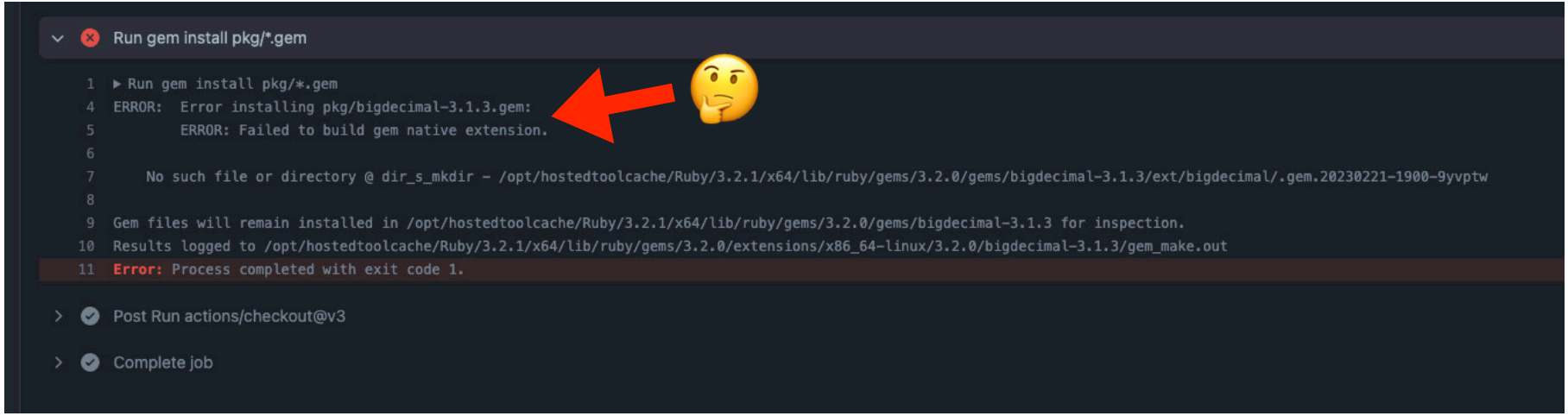
`gem install *.gem`
does not work as expected

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We are not sure why `gem install` is not working

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We can't install the same version of default gems with local install (`gem install pkg/foo.gem`) when default gems is the latest version.



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`install_command.rb` > `install_gem` > `Gem::RequestSet#install`

```
def install(options, &block) # :yields: request, installer
(snip)
    sorted_requests.each do |req|
      if req.installed?
        req.spec.spec.build_extensions

        if @always_install.none? {|spec| spec == req.spec.spec }
          yield req, nil if block_given?
          next
        end
      end
```

Compared to the case where I just ran `gem install foo` and succeeded, it looks like this `req.spec.spec.build_extensions` is skipped.

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How works build_extensions

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```
def build_extensions # :nodoc:
  return if extensions.empty?
  return if default_gem?
  return if File.exist? gem_build_complete_path
  return if !File.writable?(base_dir)
  return if !File.exist?(File.join(base_dir, "extensions"))
(snip)
  ui = Gem::SilentUI.new
  Gem::DefaultUserInteraction.use_ui ui do
    builder = Gem::Ext::Builder.new self
    builder.build_extensions
  end
ensure
  ui&.close
  Gem::Specification.unresolved_deps.replace unresolved_deps
end
```



This case skipped all of guard conditions and raise build error

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Success/Failure cases of gem install

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- When you run `gem install foo`, the gemspec is `APISpecification` and it does not have `Gem::Specificaiton#extensions`.

```
[Activation request
  [APISpecification name: json version: 2.6.3 platform: ruby dependencies: [] set uri: https://index.rubygems.org/info/]
   for [Dependency request  json (= 2.6.3)  requested by nil]]
```

- When you run `gem i pkg/foo-x.y.z.gem`, gemspec is `LocalSpecification`, not `APISpecification`. This gemspec contains all the contents of foo.gemspec in the repository.

```
[Activation request
  [LocalSpecification name: json version: 2.6.3 platform: ruby dependencies: [] source: /Users/hsbt/path/to/pkg/json-2.6.3.gem]
   for [Dependency request  json (= 2.6.3)  requested by nil]]
```

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How resolve this issue?

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```
def build_extensions # :nodoc:
  return if extensions.empty?
  return if default_gem?
+  # we need to fresh build when same name and version of default gems
+  return if self.class.find_by_full_name(full_name)&.default_gem?
  return if File.exist? gem_build_complete_path
  return if !File.writable?(base_dir)
  return if !File.exist?(File.join(base_dir, "extensions"))
```

- I added additional condition for `build_extensions`.
  - RubyGems skipped the build if the same name and version of default gems exists system-wide.
- I'm sorry to add another condition about default gems.

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RubyGems is too complex and complicated

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- **gemspec has a complex tree of inherited relationships:**

```
Gem::BasicSpecification
Gem::StubSpecification < Gem::BasicSpecification
Gem::Specification < Gem::BasicSpecification
Gem::Resolver::Specification
Gem::Resolver::APISpecification < Gem::Resolver::Specification
Gem::Resolver::LocalSpecification < Gem::Resolver::SpecSpecification
Gem::Resolver::GitSpecification < Gem::Resolver::SpecSpecification
Gem::Resolver::LockSpecification < Gem::Resolver::Specification
Gem::Resolver::IndexSpecification < Gem::Resolver::Specification
Gem::Resolver::VendorSpecification < Gem::Resolver::SpecSpecification
...
and extended specification by Bundler
```

- **The install/build logic are located all over the place**

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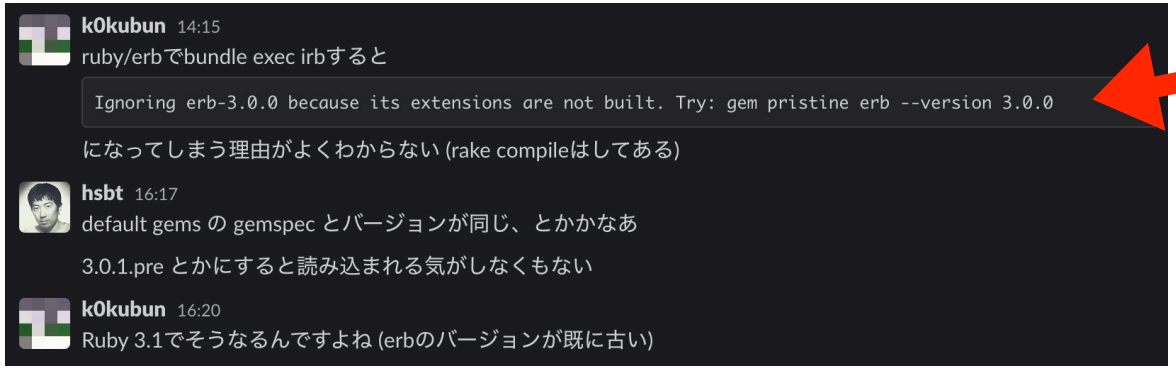
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Warnings of `bundle exec`

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I got the report from k0kubun

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k0kubun: I'm not sure why I got this warnings in spite of I already compile erb with rake-compiler.

hsbt: You can resolve it with bumping version like `3.0.1.pre` because it's default gems and latest version.

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Why did it show warning?

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- The rake-compiler build C extension properly.
  - `.bundle` or `.so` files exist under `lib` and `tmp` directory.

```
def missing_extensions?
  return false if extensions.empty?
  return false if default_gem?
  return false if File.exist? gem_build_complete_path

  true
end
```



This case skipped all of guard conditions and show warning message

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What's gem.build_complete?

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- RubyGems has the following value as `Gem::Specification#extension_dir`.

```
>> Gem::Specification.find_by_name("json").extension_dir
=> "/Users/hsbt/.local/share/gem/extensions/arm64-darwin-22/3.3.0+0-static/json-2.6.3"
```

- Place a file `gem.build_complete` in the above directory when the build is complete.
  - RubyGems checks whether the file exists or not to determine whether the build is complete or not.
- However, the C extension files built by `rake-compiler` are not considered to be built by RubyGems because they do not take the above specification.

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The first try for resolving this issue

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- I fixed it by adding new conditions to this `missing_extensions?`.

```
def missing_extensions?
  (snip)
    return false if (full_require_paths - [extension_dir]).any? do |path|
      File.exist?(File.join(path, "#{name}.#{RbConfig::CONFIG['DLEXT']}")) ||
      !Dir.glob(File.join(path, name, "*.#{RbConfig::CONFIG['DLEXT']}")).empty?
    end
  (snip)
```

- We have to search for the names in directories other than extension_dir (erb.so or erb/erb.bundle).
- There is no way for RubyGems to know what rake-compiler is doing, so we need to search heuristic.

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But...

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- Review comment from Deivid who are one of primary maintainers
  - This method is called when a gem is required. It's very expensive to search all the full_require_paths in gemspec each time.
- We already extend many of logic like this.

```
$ wc -l *
  68 kernel_gem.rb
 165 kernel_require.rb
  49 kernel_warn.rb
```

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Final solution for this

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- I changed to use `rubygems_ext.rb` in Bundler. This file can extend RubyGems only when run with Bundler.
- When `gemspec` method is presented in the Gemfile, `source.root` is defined. We can handle some conditions under the only `bundle exec`

```
alias_method :rg_missing_extensions?, :missing_extensions?
def missing_extensions?
  if source.respond_to?(:root)
    return false if raw_require_paths.any? do |pathl
      ext_dir = File.join(full_gem_path, path)
      File.exist?(File.join(ext_dir, "#{name}.#{RbConfig::CONFIG["DLEXT"]}")) ||
      !Dir.glob(File.join(ext_dir, name, "*.#{RbConfig::CONFIG["DLEXT"]}")).empty?
    end
  end

  rg_missing_extensions?
end
```

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`bundle update --conservative` is not working as expected

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What's --conservative option?

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- What happens when you run `bundle update --conservative rails`
  - Only gems in the rails dependency tree and Gemfile will be updated
- `gem install/update --conservative rails` behaves a bit differently
  - Only install or update gems in the rails dependency tree

```
$ gem i rails
Successfully installed rails-7.0.4.3
1 gem installed
~
$ gem i rails --conservative
~
$
```

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Unexpected behavior of conservative option

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- When we run `bundle update --conservative rails` with following Gemfile

```
source "https://rubygems.org"

gem "rails", "7.0.4.3"
gem "importmap-rails"
```

- It updated `timeout` version.
  - I want only `activerecord`, `actionmailer` that are directly depends with `rails`.
  - Why are `rake` and other dependencies not updated, but only the above gems are?
- Is it a bug or something?

```
$ bundle up --conservative rails
Fetching gem metadata from https://rubygems.org/.....
Resolving dependencies...
Using rake 13.0.5
(snip)
Using crass 1.0.6
Using timeout 0.3.2 (was 0.3.1)
Using bundler 2.4.12
(snip)
Using net-imap 0.3.4
Using activesupport 7.0.4.3 (was 7.0.4.2)
Using rails-html-sanitizer 1.5.0
Using websocket-driver 0.7.5
Using mail 2.8.1
Using activemodel 7.0.4.3 (was 7.0.4.2)
Using rails-dom-testing 2.0.3
Using globalid 1.1.0
Using activerecord 7.0.4.3 (was 7.0.4.2)
Using actionview 7.0.4.3 (was 7.0.4.2)
Using activejob 7.0.4.3 (was 7.0.4.2)
Using actionpack 7.0.4.3 (was 7.0.4.2)
Using actioncable 7.0.4.3 (was 7.0.4.2)
Using activestorage 7.0.4.3 (was 7.0.4.2)
Using railties 7.0.4.3 (was 7.0.4.2)
Using actionmailer 7.0.4.3 (was 7.0.4.2)
Using actiontext 7.0.4.3 (was 7.0.4.2)
Using importmap-rails 1.1.5
Using actionmailbox 7.0.4.3 (was 7.0.4.2)
Using rails 7.0.4.3 (was 7.0.4.2)
Bundle updated!
```

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It's expected behavior of Bundler

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- Resolution conflicts occur when a dependent gem under rails, such as `railties`, is version-locked by referencing another gem. `PubGrub::SolveFailure` exception occurs and this gem is sent to the retry list.
- For example, importmap-rails depends on `railtie`. `importmap-rails was sent into retry list.
    - `railtie` and `activesupport` are used often as they are rails plugins, so they are almost always included

```
def solve_versions(root:, logger:)
  solver = PubGrub::VersionSolver.new(:source => self, :root => root, :logger => logger)
  result = solver.solve
  result.map {|package, version| version.to_specs(package) }.flatten.uniq
rescue PubGrub::SolveFailure => e
  incompatibility = e.incompatibility

  names_to_unlock, names_to_allow_prereleases_for, extended_explanation = find_names_to_relax(incompatibility)

  names_to_relax = names_to_unlock + names_to_allow_prereleases_for

  if names_to_relax.any?
    if names_to_unlock.any?
      Bundler.ui.debug "Found conflicts with locked dependencies. Will retry with #{names_to_unlock.join(", ")} unlocked...", true

      @base.unlock_names(names_to_unlock)
    end
```

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This behavior is derivation of the following events frequently after running `bundle update` at Bundler 2.3 or before.

```
Bundler could not find compatible versions for gem "activesupport":
  In Gemfile:
    inherited_resources (= 1.6.0) was resolved to 1.6.0, which depends on
      has_scope (~> 0.6.0.rc) was resolved to 0.6.0, which depends on
        activesupport (>= 3.2, < 5)

    rails (= 4.2.0) was resolved to 4.2.0, which depends on
      activesupport (= 4.2.0)

Bundler could not find compatible versions for gem "railties":
  In Gemfile:
    inherited_resources (= 1.6.0) was resolved to 1.6.0, which depends on
      railties (>= 3.2, < 5)

    rails (= 4.2.0) was resolved to 4.2.0, which depends on
      railties (= 4.2.0)

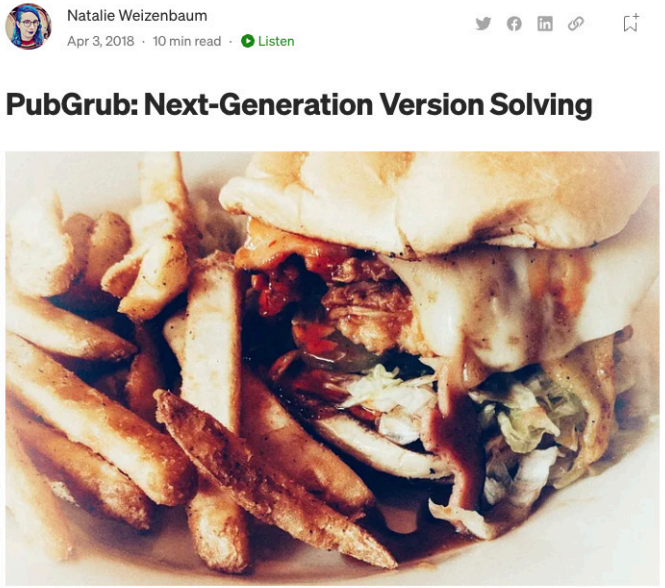
    inherited_resources (= 1.6.0) was resolved to 1.6.0, which depends on
      responders was resolved to 1.1.2, which depends on
        railties (>= 3.2, < 4.2)
```

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What's changed in Bundler 2.4?

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- If a resolution conflict occurs with PubGrub from Bundler 2.4, the logic is to give up immediately and ignore the end of the dependency tree. It only update target gems.
  - `activerecord`, `railties`, etc. are updated for this reason.
  - rake and others are unchanged.



Natalie Weizenbaum
Apr 3, 2018 · 10 min read · Listen

PubGrub: Next-Generation Version Solving

Image by @Th3RoadVirus

If you'd peeked in on me at work five months ago you'd find me with my nose in a textbook reading up on cutting-edge academic research on constraint-solving problems. Three months ago I was applying that knowledge to code, drafting and tweaking a new algorithm that united that research with a real-world tool. One month ago I was adding the last few features and polishing it up.

https://nex3.medium.com/pubgrub-2fb6470504f

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Tree swing cartoon

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- Running "bundle update --nanika rails" will update only rails and the gems directly under it.
  - This is difficult because Bundler does not keep the dependency hierarchy as data

```
$ bundle up --nanika rails
Fetching gem metadata from https://rubygems.org/.....
Resolving dependencies...
Using rake 13.0.5
(snip)
Using crass 1.0.6
Using timeout 0.3.1
Using bundler 2.4.12
(snip)
Using net-imap 0.3.4
Using activesupport 7.0.4.3 (was 7.0.4.2)
Using rails-html-sanitizer 1.5.0
Using websocket-driver 0.7.5
Using mail 2.8.1
Using activemodel 7.0.4.3 (was 7.0.4.2)
Using rails-dom-testing 2.0.3
Using globalid 1.1.0
Using activerecord 7.0.4.3 (was 7.0.4.2)
Using actionview 7.0.4.3 (was 7.0.4.2)
Using activejob 7.0.4.3 (was 7.0.4.2)
Using actionpack 7.0.4.3 (was 7.0.4.2)
Using actioncable 7.0.4.3 (was 7.0.4.2)
Using activestorage 7.0.4.3 (was 7.0.4.2)
Using railties 7.0.4.3 (was 7.0.4.2)
Using actionmailer 7.0.4.3 (was 7.0.4.2)
Using actiontext 7.0.4.3 (was 7.0.4.2)
Using importmap-rails 1.1.5
Using actionmailbox 7.0.4.3 (was 7.0.4.2)
Using rails 7.0.4.3 (was 7.0.4.2)
Bundle updated!
```

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Proposals for the future

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Duplicates and redundant of code and commands

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What's I worked?

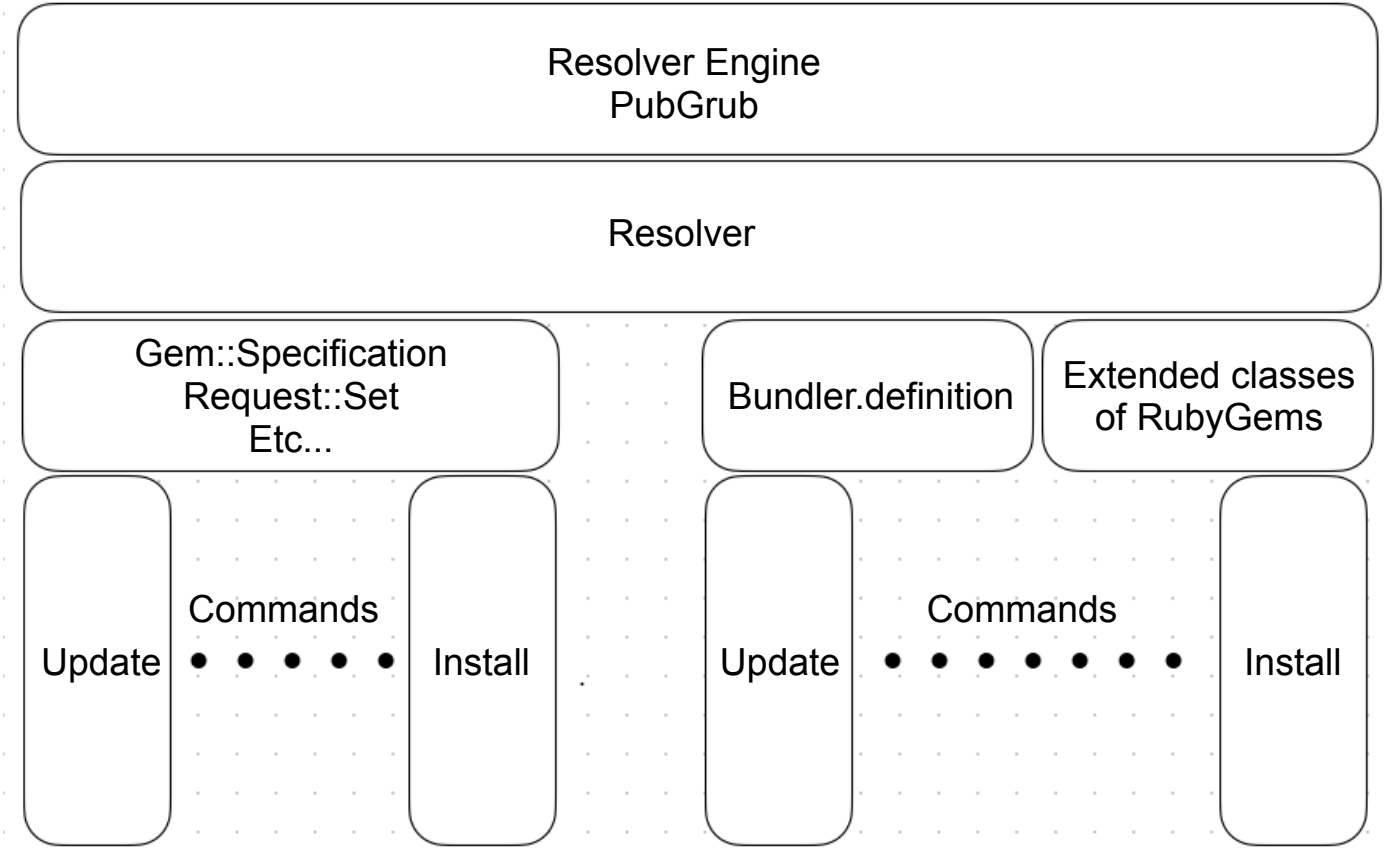
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- I started to unify toolchains in rubygems repository
  - Rake task(rubocop, test/spec, release...)
  - The migration of Rubocop Rules(almost done)
- I want to unify commands and their code-base
  - Merge to either `gem` and `bundle`
  - Share the same Resolver Engine that is PubGrub

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A difficult way for them

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Rubygems/Bundler is too slow

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Refactor and re-organizing code about core extension

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- Refactor require and gem methods on RubyGems. It's too complex with historical reason.
  - We avoid to scan all gemspecs in your system. In this fact, RubyGems and Bundler is too slow with your largely rails monolith.
  - Ideally, it should be fast without caching tools like `bootsnap`.

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Impromovement about Resolver and its engine

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- Resolver improvements in RubyGems and Bundler
  - PubGrub is fast enough
  - Complexity of passing data to PubGrub/Molinillo and receiving results from PubGrub/Molinillo
    - There appears to be duplicate data and repeated runs.
    - I'm wondering if it's unnecessary to simply use `bundle update rails` to run `rails` dependencies 3 times...?
- I still don't understand it well enough, so I'll work on it!

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Conclusion

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Conclusion

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- I talked about some issues and recent fixes. What should be RubyGems and Bundler by maintainer's view.
  - I will do my best to make the experience even better!
- Thanks to ANDPAD, I am able to spend more time focusing
  - Also Thanks to attend my talk.

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Appendix

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Example of mixing C extensions in multiple Ruby versions

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Ignoring .... の Warning は何か

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- The following message is displayed when RubyGems does not determine that the C extension is already installed

```
Ignoring erb-4.0.2 because its extensions are not built. Try: gem pristine erb --version 4.0.2
```

- This message often appears when using chruby or setting your own GEM_HOME.
- If the three conditions of `missing_extension?` (especially gem.build_complete) are not met, the extension is not considered to be built.

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とりあえず解決するには?

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- Run `gem pristine --extension
  - Run reinstallation with the gem files already downloaded
  - Note that this command will run all the C extension gems you have installed (even different versions).
- You must have about 50-100 C extension gems at your disposal...?

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流石に使いにくいのでちょっとした改善をいれた

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- Added `--only-missing` option to RubyGems 3.5 (Ruby 3.3 or later)
- This option rebuilds only C extensions with `missing_extensions?

```
elsif options[:extensions_set] &&
      options[:extensions] && options[:args].empty?
  Gem::Specification.select do |spec|
    spec.extensions && !spec.extensions.empty?
  end
elsif options[:only_missing_extensions]
  Gem::Specification.select do |spec|
    spec.missing_extensions?
  end
else
```

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C 拡張の gem における Warning 以上の問題点

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- If you are using multiple Ruby versions and have a common GEM_HOME, you may have problems above Warning.
  - gemspec and lib are not separated by Ruby version.
    - Therefore, reuqire of C extensions built/installed with different Ruby versions will cause SEGV.
  - C extension directories (extension_dir) are separated
- Should we use extension_dir instead of lib to require C extensions?

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更に一歩進んだ提案

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- In theory, all Ruby versions can share Gem files
  - Pure Ruby libraries can be shared by nature
    - GEM_HOME is also a common philosophy.
  - extension_dir is originally in full_require_paths, so it can be required naively, and there are no accidents because it is separated by Ruby version.
- This can be achieved by not putting C extensions under lib.
  - When you change Ruby version, you can't say "Oh.... I need to bundle install again..." when changing Ruby versions. This is very eco-friendly and productive.

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lib の下から C 拡張をすべて消すスクリプト

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```
require "rbconfig"
require "pathname"

gems = Gem::Specification.select { |spec|
  spec.platform == RUBY_ENGINE && !spec.extensions.empty?
}.compact.uniq.map { |spec|
  [spec.name, spec.version]
}

gems.each do |n, v|
  s = Gem::Specification.find_all_by_full_name("#{n}-#{v}").first
  (s.full_require_paths - [s.extension_dir]).each do |path|
    Dir.glob(File.join(path, "**/*")).each do |file|
      if Pathname(file).extname == ".#{RbConfig::CONFIG["DLEXT"]}"
        puts "Deleting #{file}"
        File.delete(file)
      end
    end
  end
end
```

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歴史的な経緯もあって難航中

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- RubyGems 3.4 now does make clean after building C extensions
  - Some gems required or passed to ffi C extensions that were built in the build directory and not in extension_dir or lib...
    - Fixed it all.
- Bundler also seems to have code that expects to be under lib...

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今後に向けて

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- In the meantime, I created a pull-req that can be turned off at the configuration level.
  - https://github.com/rubygems/rubygems/pull/6463
  - Someone please try it.
- Putting `install_extension_in_lib: false` in gemrc will not install C extensions under lib. Eco.

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