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Deep dive into Ruby's require

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Ruby core team

RubyGems/Bundler team

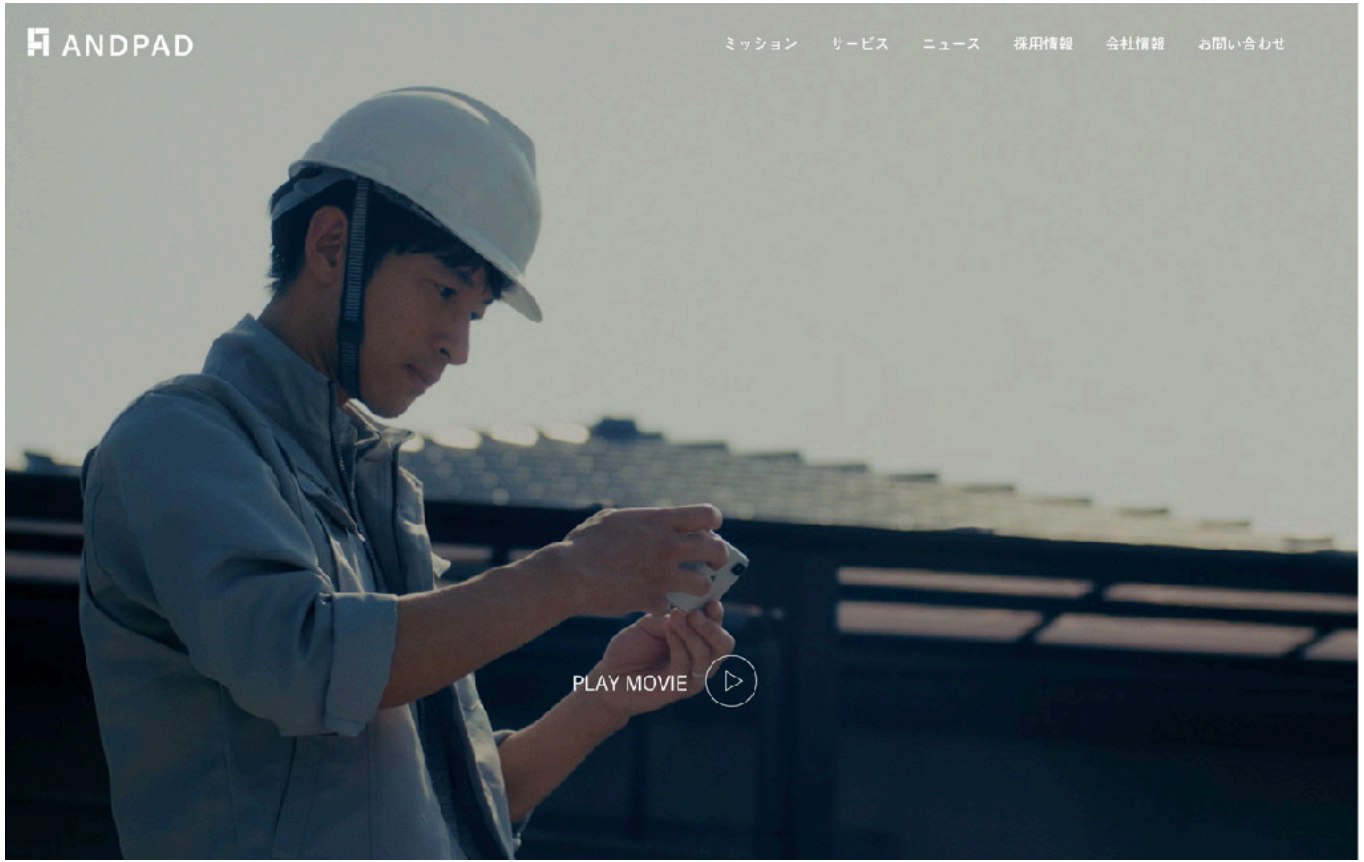
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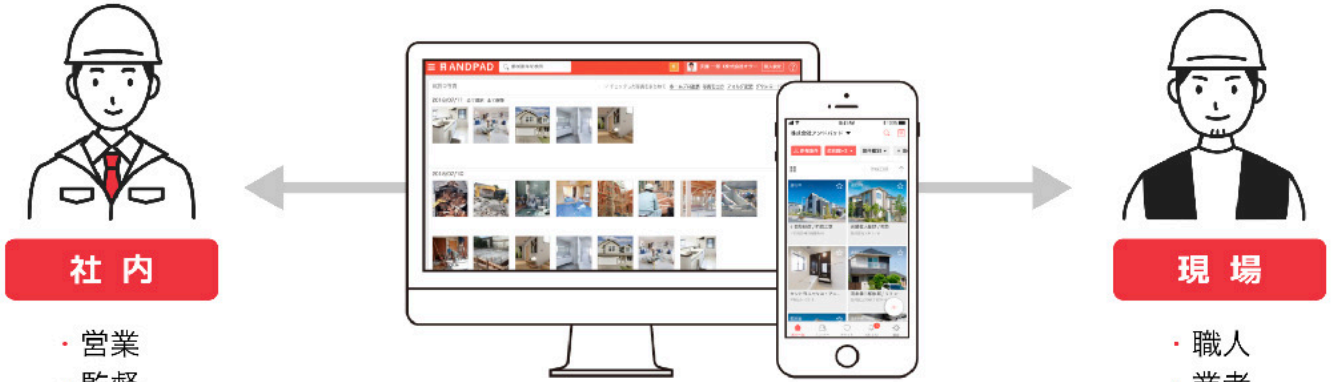


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社内と現場をつなぐアプリ

施工管理に必要な情報を一元管理します

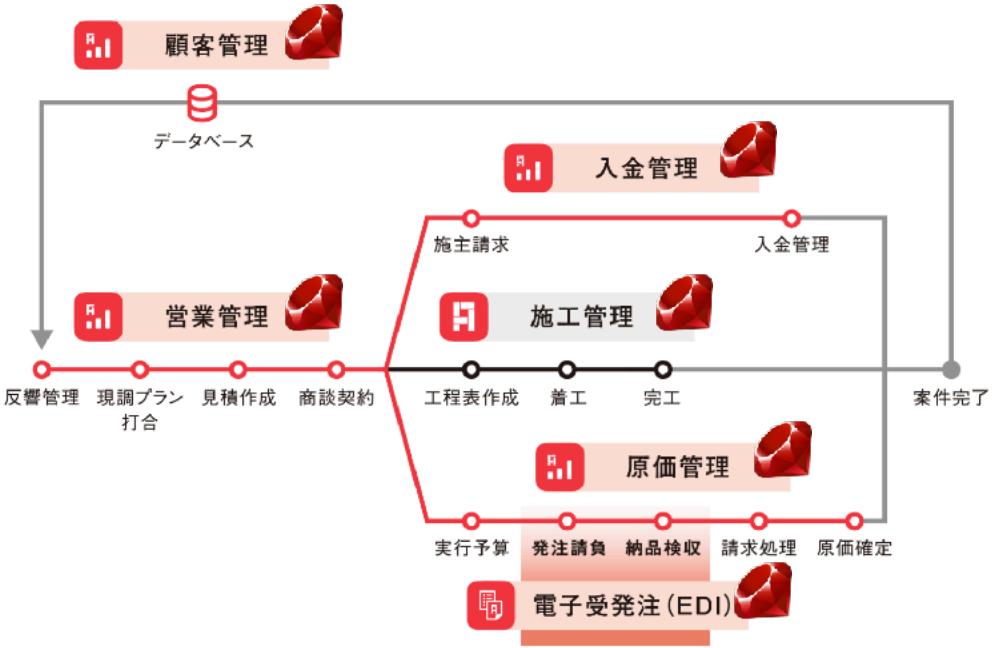


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想定されるユーザー

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顧客管理 / 受注管理

工事担当
施工管理 / 原価管理 / 電子受発注(EDI)

経理担当
入金管理 / 支払管理

経営者
業績分析

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Learning Ruby's require

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Inside of `require` of Ruby

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Basic knowlege of require

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- `require` is major method in Ruby.
  - `require` can handle Ruby and C/Rust extension with your platform like linux or macOS.
- `require` find $LOAD_PATH by your installation path originally.
  - `require_relative` find only current path.

```
>> require 'rss'
=> true
>> require 'rss'
=> false
>> require "bigdecimal"
=> true
#
>> require "bigdecimal.bundle"
=> true
#
>> require "bigdecimal.so"
=> true

>> require_relative "rss"
...cannot load such file -- ...
```

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load is a few different with require

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```
>> load "psych"
(irb):1:in `load': cannot load such file -- psych (LoadError)

>> load "psych.rb"
=> true

>> load "psych.rb"
...lib/psych.rb:236: warning: already initialized constant
Psych::LIBYAML_VERSION
(snip)
=> true
```

- Ruby also has `load`. It's alternative of require.
  - `load` didn't find your installation path. It find only current path.
  - `load` need to extension of file like “.rb”.
  - `load` can load ruby code many times.

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autoload is more Ruby'ish way

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```
module Bundler
  environment_preserver = EnvironmentPreserver.from_env
  ORIGINAL_ENV = environment_preserver.restore
  environment_preserver.replace_with_backup
  SUDO_MUTEX = Thread::Mutex.new

  autoload :Checksum,              File.expand_path("bundler/checksum", __dir__)
  autoload :Definition,            File.expand_path("bundler/definition", __dir__)
  autoload :Dependency,            File.expand_path("bundler/dependency", __dir__)

(snip)
```

- `require` and `load` are immediately evaluated by Ruby.
  - But `autoload` is only load Ruby code when constant is referenced.
- Ex. You call `Bundler::Definition`, Ruby will call `bundler/dependency.rb`

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How load Ruby code from outside of Ruby installation path?

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We have RubyGems

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- RubyGems is a package/library for the Ruby programming language
  - We can install gems from rubygems.org
- gemspec is a file describing Gem::Specification
  - This class for defining metadata including name, version, platform, etc.
- RubyGems provide extended `require` and `gem` method for loading gem for us.

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- You can see gemspec with `Gem.loaded_specs` like this:

```
>> Gem.loaded_specs["rack"]
=>
Gem::Specification.new do |s|
  s.name = "rack"
  s.version = Gem::Version.new("2.2.8")
  s.installed_by_version = Gem::Version.new("3.4.10")
  s.authors = ["Leah Neukirchen"]
  s.date = Time.utc(2023, 7, 31)
  s.dependencies = [Gem::Dependency.new("minitest", Gem::Requirement.new(["~> 5.0"]), :development),
   Gem::Dependency.new("minitest-sprint", Gem::Requirement.new([">= 0"]), :development),
   Gem::Dependency.new("minitest-global_expectations", Gem::Requirement.new([">= 0"]), :development),
   Gem::Dependency.new("rake", Gem::Requirement.new([">= 0"]), :development)]
  s.description = "Rack provides a minimal, modular and adaptable interface for developing web
applications in Ruby. By wrapping HTTP requests and responses in\nthe simplest way possible, it unifies
and distills the API for web\nservers, web frameworks, and software in between (the so-
called\nmiddleware) into a single method call.\n"
(...snip...)
end
```

- `Gem::Specification#dependencies` is important parts of your application.

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- RubyGems extends `require` in `kernel_require.rb`

```
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)
```

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

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- Find all of your gems: Gem::specification.find_by_path

```
def self.find_by_path(path)
  path = path.dup.freeze
  spec = @@spec_with_requirable_file[path] || stubs.find do |s|
    s.contains_requirable_file? path
  end || NOT_FOUND

  spec.to_spec
end
```

This returns all of your gemspec



- My environment have 2800+ gems. RubyGems search them.

```
$ ruby -ve "t = Time.now; require 'bigdecimal'; p Time.now - t"
0.272687

$ set -e GEM_HOME
$ ruby -ve "t = Time.now; require 'bigdecimal'; p Time.now - t"
0.000786

$ ruby --disable-gems -ve "t = Time.now; require 'bigdecimal'; p Time.now - t"
0.000512
```

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Introduce Kernel#gem method

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- RubyGems provide `gem` method to handle name and requirements.
  - It's different with gem method on Gemfile.
- This method inject gem path into your $LOAD_PATH with requirements

```
>> orig_paths = $LOAD_PATH.dup
>> gem "rake", "> 12", "< 13"
=> true
>> $LOAD_PATH - orig_paths
=> ["/Users/hsbt/.local/share/gem/gems/rake-12.3.3/lib"]
```

```
>> require "rake"
=> true
>> Rake::VERSION
=> "13.1.0"

#
>> gem "rake", "13.0.0"
=> true
>> require "rake"
=> true
>> Rake::VERSION
=> "13.0.0"

#
>> gem "rake", "> 12", "< 13"
=> true
>> require "rake"
=> true
>> Rake::VERSION
=> "12.3.3"
```

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Inside of gem method

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```
def gem(gem_name, *requirements) # :doc:

(snip)

    dep = Gem::Dependency.new(gem_name, *requirements)

    loaded = Gem.loaded_specs[gem_name]

    return false if loaded && dep.matches_spec?(loaded)

    spec = dep.to_spec

    if s
      if Gem::LOADED_SPECS_MUTEX.owned?
        spec.activate
      else
        Gem::LOADED_SPECS_MUTEX.synchronize { spec.activate }
      end
    end
```

- Kernel#gem create `Gem::Dependency` instance with name and requirements. After that activate it.

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RubyGems has some problems

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- RubyGems didn't have resolution mechanism with multiple libraries.
  - If you activated Rails 7, you should specify all of related libraries that support Rails 7.
  - It's difficult to resolve only `gem` method.
- Extended `require` is slow if you have a lot of gems like Rails application.

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How works bundler?

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Why Bundler come here?

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What's Bundler?

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- Bundler is also package manager of Ruby language
  - Bundler focused version locking feature
  - Bundler extends a lot of RubyGems resources like gemspec.
- Bundler works with Gemfile like:

```
# frozen_string_literal: true

source "https://rubygems.org"

gem "rake", ">= 11.1”
```

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Introduction of Lockfile

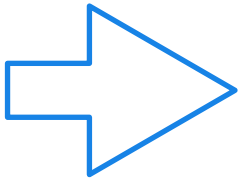
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- Bundler generates lockfile named Gemfile.lock from Gemfile with dependency resolution.
- Bundler use this lockfile for version locking in your applicaiton

```
# Gemfile
# frozen_string_literal: true

source "https://rubygems.org"

gem "rss"
```



```
# Gemfile.lock
GEM
  remote: https://rubygems.org/
  specs:
    rexml (3.2.5)
    rss (0.2.9)
      rexml

PLATFORMS
  arm64-darwin-23

DEPENDENCIES
  rss

BUNDLED WITH
   2.5.0.dev
```

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Performance issues

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- Bundler also extends RubyGems classes/methods. It's enabled when we used Bundler.
- `Gem::Specification#extension_dir` needs to handle git resource of Gemfile like this:

```
# for gem “rails”, git: “https://github.com/rails/rails"

alias_method :rg_extension_dir, :extension_dir
def extension_dir
  # following instance variable is already used in original method
  # and that is the reason to prefix it with bundler_ and add rubocop exception
  @bundler_extension_dir ||= if source.respond_to?(:extension_dir_name)
    unique_extension_dir = [source.extension_dir_name,
File.basename(full_gem_path)].uniq.join("-")
    File.expand_path(File.join(extensions_dir, unique_extension_dir))
  else
    rg_extension_dir
  end
end
```

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Basic case of Gemfile and bundle exec

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Basic case of Gemfile and Bundler

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- How Bundler resolve to slow down with RubyGems and Bundler?
  - I'll introduce it with `bundle exec` command with simple rss examples.

```
# Gemfile.lock
GEM
  remote: https://rubygems.org/
  specs:
    rexml (3.2.5)
    rss (0.2.9)
      rexml

PLATFORMS
  arm64-darwin-23

DEPENDENCIES
  rss

BUNDLED WITH
   2.5.0.dev
```

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What's Bundler.setup

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- `Bundler.setup` and `Bundler.require` is most important parts of Bundler
  - These methods defined at `runtime.rb`.
- `bundle exec` call `Bundler.setup` and `Kernel.exec`.

```ruby
def setup(*groups)
  @definition.ensure_equivalent_gemfile_and_lockfile if
Bundler.frozen_bundle?

  # Has to happen first
  clean_load_path

  specs = @definition.specs_for(groups)

  SharedHelpers.set_bundle_environment
  Bundler.rubygems.replace_entrypoints(specs)

  # Activate the specs
  load_paths = specs.map do |spec|
    check_for_activated_spec!(spec)

    Bundler.rubygems.mark_loaded(spec)
    spec.load_paths.reject {|path| $LOAD_PATH.include?(path) }
  end.reverse.flatten

  Bundler.rubygems.add_to_load_path(load_paths)

  setup_manpath

  lock(:preserve_unknown_sections => true)

  self
end
```

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Reset your environment with Bundler

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- At first, Bundler update your lockfile and install new versions if it's needed. After that, Reject gem paths that are not `require` yet.

```ruby
@definition.ensure_equivalent_gemfile_and_lockfile if Bundler.frozen_bundle?

# Has to happen first
clean_load_path
```

```ruby
  def clean_load_path
    loaded_gem_paths = Bundler.rubygems.loaded_gem_paths

    $LOAD_PATH.reject! do |p|
      resolved_path = resolve_path(p)
      next if $LOADED_FEATURES.any? {|lf| lf.start_with?(resolved_path) }
      loaded_gem_paths.delete(p)
    end
    $LOAD_PATH.uniq!
  end
```

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How select dependencies by Bundler.definition

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- `Bundler.definition` and `Bundler::Resolver` is core parts for this.
  - Bundler.definition create instance of `Bundler::Resolver` and call resolution methods inside `specs_for`.

```
specs = @definition.specs_for(groups)
SharedHelpers.set_bundle_environment
Bundler.rubygems.replace_entrypoints(specs)
```

This method revert extended require by rubygems

- `specs` is instance of Bundler::SpecSet.
  - Bundler inject `bundler` as dependency into Gemfile.

```
>> specs.map(&:name)
=> ["bundler", "rexml", "rss"]
```

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Update your LOAD_PATH with scratch

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```
  # Activate the specs
  load_paths = specs.map do |spec|
    check_for_activated_spec!(spec)

    Bundler.rubygems.mark_loaded(spec)
    spec.load_paths.reject {|path| $LOAD_PATH.include?(path) }
  end.reverse.flatten

  Bundler.rubygems.add_to_load_path(load_paths)
  setup_manpath
  lock(:preserve_unknown_sections => true)
  self
```

- These logic is easy to understand. We generate paths generated by resolved gemspec.

  `Gem::Specification#load_paths` returns load paths from gemspec.

- `load_paths` returns like this:

```
~/.rbenv/versions/master/lib/ruby/gems/3.3.0+0/gems/rss-0.2.9/lib
~/.rbenv/versions/master/lib/ruby/gems/3.3.0+0/gems/rexml-3.2.5/lib
~/.rbenv/versions/master/lib/ruby/gems/3.3.0+0/gems/bundler-2.5.0.dev/lib
```

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Future of standard libraries

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What are default and bundled gems?

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- The Ruby core team released "Default gems" to the rubygems.org.
  - You can install standard libraries of Ruby via RubyGems.
  - Default gems are openssl, psych, json, etc… You can see all of default gems at https://stdgems.org/
- Rubygems have a detection method for default gems.

```
>> require 'rss'
=> true
>> Gem.loaded_specs["rss"].default_gem?
=> false
>> require 'openssl'
=> true
>> Gem.loaded_specs["openssl"].default_gem?
=> true
```

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Basic scenario of Bundler resolution

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- `Bundler.rubygems.replace_entrypoints` inject gemspecs of default gems into dependencies of Gemfile.

```
Bundler.rubygems.default_stubs.each do |stub|
  default_spec = stub.to_spec
  default_spec_name = default_spec.name
  next if specs_by_name.key?(default_spec_name)

  specs << default_spec
  specs_by_name[default_spec_name] = default_spec
end
```

specs = Declared in Gemfile: rails, nokogiri, sidekiq, etc...

+

default_spec = Default gems: csv, psych, json, etc...

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What's Bundled gems

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- We bundled *.gem and unpacked files to tarball package for Bundled gems with `gems/bundled_gems` in ruby/ruby repository like this:



nobu Update test-unit

8 contributors

8 lines (7 sloc) | 361 Bytes

```
1  did_you_mean 1.3.0 https://github.com/yuki24/did_you_mean
2  minitest 5.11.3 https://github.com/seattlerb/minitest
3  net-telnet 0.2.0 https://github.com/ruby/net-telnet
4  power_assert 1.1.4 https://github.com/k-tsj/power_assert
5  rake 12.3.2 https://github.com/ruby/rake
6  test-unit 3.3.3 https://github.com/test-unit/test-unit
7  xmlrpc 0.3.0 https://github.com/ruby/xmlrpc
```

- `make install` installed Bundled gem your box.

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The major problem for the bundled gems

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If you use Bundler, you need to add the bundled gems into your Gemfile.

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

gem “rss”
gem "bigdecimal" # You need to this always after Ruby 3.4
…
```

I need to consider to transition and migration plan for this.
But I have no idea yet. Maybe, I will add the some mechanism to Bundler internal to care about this.

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Warning feature of bundled gems

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- I added warning feature about bundled gems.
- You can see how handle bundled gems like this.

```
$ cat -p Gemfile
source "https://rubygems.org"

gem "rss"

$ bundle exec irb
>> require "csv"
(irb):1: warning: csv which will no longer be part of
the default gems since Ruby 3.4.0. Add csv to your
Gemfile or gemspec.
=> true
```

```
module Gem::BUNDLED_GEMS
  SINCE = {
    "rexml" => "3.0.0",
    "rss" => "3.0.0",
    "webrick" => "3.0.0",
    "matrix" => "3.1.0",
    "net-ftp" => "3.1.0",
    "net-imap" => "3.1.0",
    "net-pop" => "3.1.0",
    "net-smtp" => "3.1.0",
    "prime" => "3.1.0",
    "abbrev" => "3.4.0",
    "base64" => "3.4.0",
    "bigdecimal" => "3.4.0",
    "csv" => "3.4.0",
    "drb" => "3.4.0",
    "getoptlong" => "3.4.0",
    "mutex_m" => "3.4.0",
    "nkf" => "3.4.0",
    "observer" => "3.4.0",
    "racc" => "3.4.0",
    "resolv-replace" => "3.4.0",
    "rinda" => "3.4.0",
    "syslog" => "3.4.0",
  }.freeze
```

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How extend require in your use case?

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```
def replace_require(specs)
  return if [::Kernel.singleton_class, ::Kernel].any? {|klass| klass.respond_to?(:no_warning_require) }

  [::Kernel.singleton_class, ::Kernel].each do |kernel_class|
    kernel_class.send(:alias_method, :no_warning_require, :require)
    [illegible]
      if message = ::Gem::BUNDLED_GEMS.warning?(name, specs: specs)
        warn message, :uplevel => 1
      end
      kernel_class.send(:no_warning_require, name)
    end
    if kernel_class == ::Kernel
      kernel_class.send(:private, :require)
    else
      kernel_class.send(:public, :require)
    end
  end
end
```

We easily extend `require` like this. I only enabled this extension under the bundler. I added this to monkey patch collection of bundler.

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We want Namespace feature

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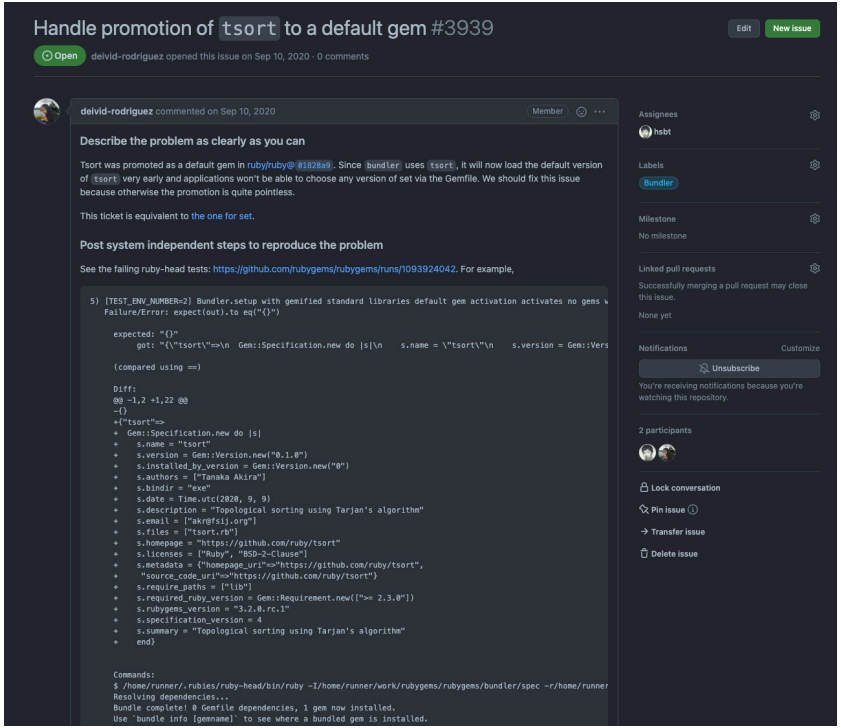
Activation issue of default gems

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We still have a activation issue with RubyGems and the default gems like `json`.

```
You have already activated timeout 0.3.1, but
your Gemfile requires timeout 0.3.2. Since
timeout is a default gem, you can either remove
your dependency on it or try updating to a
newer version of bundler that supports timeout
as a default gem.
```

How handle this problem?



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How handle activation problem?

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1. Rewrite default gems to simple Ruby code

   → 😆

2. Vendoring approach when RubyGems uses only pure ruby libraries like URI.

   → 😩

3. Rewrite default gems written by C extension to pure ruby code.

   → 😩

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Example for rewrite C to Ruby

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You can use any versions of Psych. Because RubyGems and Bundler use the original Ruby implementation for YAML serializer.

When RubyGems uses json-2.1.0, You couldn't use json 1.8.x. Because ruby gems and rubygems.org never uses JSON format.

master ▾ rubygems / bundler / lib / bundler / yaml_serializer.rb / <> Jump to ▾

deivid-rodriguez Normalize bundler's access modifier indentations ... ✓

3 contributors

89 lines (80 sloc) | 2.36 KB

```ruby
# frozen_string_literal: true

module Bundler
  # A stub yaml serializer that can handle only hashes and strings (as of now).
  module YAMLSerializer
    module_function

    def dump(hash)
      yaml = String.new("---")
      yaml << dump_hash(hash)
    end

    def dump_hash(hash)
      yaml = String.new("\n")
      hash.each do |k, v|
        yaml << k << ":"
        if v.is_a?(Hash)
          yaml << dump_hash(v).gsub(/^(?!$)/, "  ") # indent all non-empty lines
        elsif v.is_a?(Array) # Expected to be array of strings
          yaml << "\n- " << v.map {|s| s.to_s.gsub(/\s+/, " ").inspect }.join("\n- ") << "\n"
        else
          yaml << " " << v.to_s.gsub(/\s+/, " ").inspect << "\n"
        end
      end
      yaml
    end
```

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We considered namespace feature with RubyGems and Bundler

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tagomoris-san proposed namespace feature for package system of Ruby.

It may help our activation problem.

Ex. RubyGems and Bundler will use JSON under only their namespace. You can activate any version of JSON on your application.

Feature #19744 OPEN



Namespace on read

Added by tagomoris (Satoshi Tagomori) 5 months ago. Updated 1 day ago.

Status: Open
Priority: Normal
Assignee: -
Target version: -
[ruby-core:114025]

Description

What is the "Namespace on read"

This proposes a new feature to define virtual top-level namespaces in Ruby. Those namespaces can require/load libraries (either .rb or native extension) separately from the gl
also required/loaded in the namespace.

Motivation

The "namespace on read" can solve the 2 problems below, and can make a path to solve another problem:
The details of those motivations are described in the below section ("Motivation details").

Avoiding name conflicts between libraries

Applications can require two different libraries safely which use the same module name.

Avoiding unexpected globally shared modules/objects

Applications can make an independent/unshared module instance.

(In the future) Multiple versions of gems can be required

Application developers will have fewer version conflicts between gem dependencies if rubygems/bundler will support the namespace on read.

Example code with this feature

```
# your_module.rb
module YourModule
end

# my_module.rb
require 'your_module'

module MyModule
end

# example.rb
namespace1 = NameSpace.new
namespace1.require('my_module') #=> true

namespace1::MyModule #=> #<Module:0x00000001027ea650>::MyModule (or #<NameSpace:0x00...>::MyModule ?)
namespace1::YourModule # similar to the above

MyModule # NameError
YourModule # NameError

namespace2 = NameSpace.new      # Any number of namespaces can be defined
namespace2.require('my_module') # Different library "instance" from namespace1

require 'my_module' # require in the global namespace

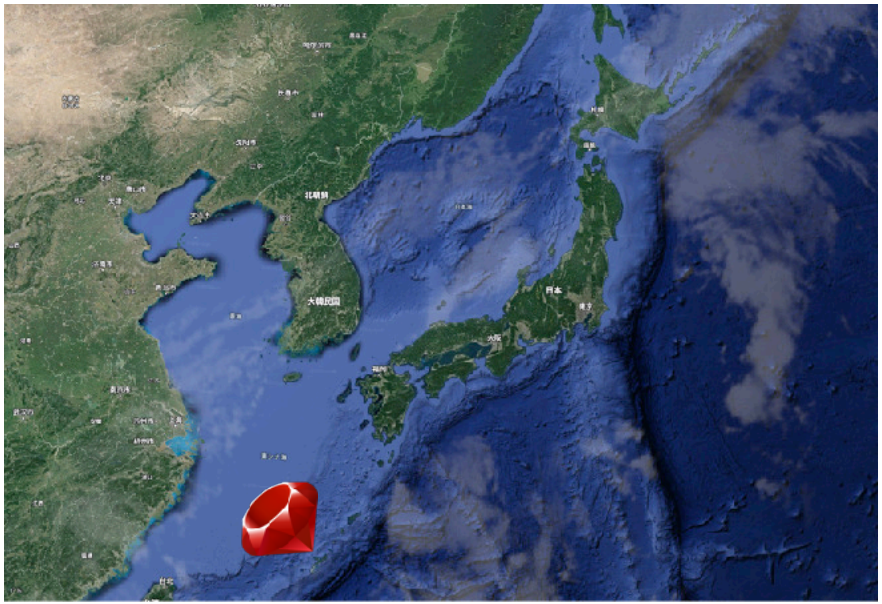
MyModule.object_id != namespace1::MyModule.object_id #=> true
namespace1::MyModule.object_id != namespace2::MyModule.object_id
```

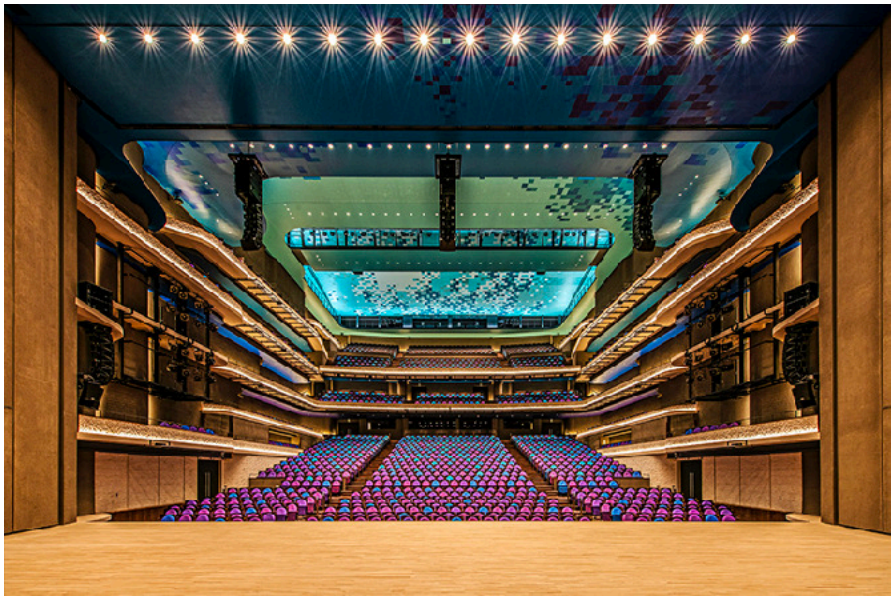
The required/loaded libraries will define different "instances" of modules/classes in those namespaces (just like the "wrapper" 2nd argument of `Kernel.load`). This doesn't intr
resolution (without forced top-level reference like `::Name`).

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RubyKaigi 2024 will be coming Okinawa island in Japan at May, 2024.

Looking forward seeing you again at RubyKaigi 2024 :wave:





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Wrap up

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- I talked about...
  - Knowledge require, RubyGems, Bundler
  - How works Bundler modify LOAD_PATH of Ruby
  - How works extends require for use-cases



< Ruby is a programmer's best friend

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