The Cargo Book

The Cargo Book

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Getting started

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1.1 Getting started

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Installation

The easiest way to get Cargo is to get the current stable release of Rust by using the `rustup` script:

```
$ curl -sSf https://static.rust-lang.org/rustup.sh | sh
```

This will get you the current stable release of Rust for your platform along with the latest Cargo.

If you are on Windows, you can directly download the latest stable Rust and nightly Cargo:

- Rust (32-bit)
- Cargo (32-bit)
- Rust (64-bit)
- Cargo (64-bit)

Alternatively, you can build Cargo from source.

1.3

First steps with Cargo

To start a new project with Cargo, use `cargo new`:

```
$ cargo new hello_world --bin
```

We're passing `--bin` because we're making a binary program: if we were making a library, we'd leave it off.

Let's check out what Cargo has generated for us:

```
$ cd hello_world
$ tree .
.
  Cargo.toml
  src
      main.rs

1 directory, 2 files
```

This is all we need to get started. First, let's check out `Cargo.toml`:

```
[package]
name = "hello_world"
version = "0.1.0"
authors = ["Your Name <you@example.com>"]
```

This is called a **manifest**, and it contains all of the metadata that Cargo needs to compile your project.

Here's what's in `src/main.rs`:

```
fn main() {
    println!("Hello, world!");
}
```

Cargo generated a "hello world" for us. Let's compile it:

```
$ cargo build
   Compiling hello_world v0.1.0 (file:///path/to/project/hello_world)
```

And then run it:

```
$ ./target/debug/hello_world
Hello, world!
```

We can also use `cargo run` to compile and then run it, all in one step:

```
$ cargo run
     Fresh hello_world v0.1.0 (file:///path/to/project/hello_world)
   Running `target/hello_world`
Hello, world!
```

Going further

For more details on using Cargo, check out the Cargo Guide

Part II

Guide

Chapter 1

1.1 Cargo Guide

Welcome to the Cargo guide. This guide will give you all that you need to know about how to use Cargo to develop Rust projects.

- Why Cargo exists
- Creating a new project
- Working on an existing Cargo project
- Dependencies
- Project layout
- Tests
- Continuous Integration

Further reading

Now that you have an overview of how to use cargo and have created your first crate, you may be interested in:

- Publishing your crate on crates.io
- Reading about all the possible ways of specifying dependencies
- Learning more details about what you can specify in your `Cargo.toml` manifest

1.2

Why Cargo exists

Cargo is a tool that allows Rust projects to declare their various dependencies and ensure that you'll always get a repeatable build.

To accomplish this goal, Cargo does four things:

- Introduces two metadata files with various bits of project information.
- Fetches and builds your project's dependencies.
- Invokes `rustc` or another build tool with the correct parameters to build your project.
- Introduces conventions to make working with Rust projects easier.

1.3

Creating a new project

To start a new project with Cargo, use `cargo new`:

```
$ cargo new hello_world --bin
```

We're passing `--bin` because we're making a binary program: if we were making a library, we'd leave it off. This also initializes a new `git` repository by default. If you don't want it to do that, pass `--vcs none`.

Let's check out what Cargo has generated for us:

```
$ cd hello_world
$ tree .
.
   Cargo.toml
   src
       main.rs

1 directory, 2 files
```

If we had just used `cargo new hello_world` without the `--bin` flag, then we would have a `lib.rs` instead of a `main.rs`. For now, however, this is all we need to get started. First, let's check out `Cargo.toml`:

```
[package]
name = "hello_world"
version = "0.1.0"
authors = ["Your Name <you@example.com>"]
```

This is called a **manifest**, and it contains all of the metadata that Cargo needs to compile your project.

Here's what's in `src/main.rs`:

```
fn main() {
    println!("Hello, world!");
}
```

Cargo generated a "hello world" for us. Let's compile it:

```
$ cargo build
   Compiling hello_world v0.1.0 (file:///path/to/project/hello_world)
```

And then run it:

```
$ ./target/debug/hello_world
Hello, world!
```

We can also use `cargo run` to compile and then run it, all in one step (you won't see the `Compiling` line if you have not made any changes since you last compiled):

```
$ cargo run
   Compiling hello_world v0.1.0 (file:///path/to/project/hello_world)
     Running `target/debug/hello_world`
Hello, world!
```

You'll notice several new files and directories have been created:

```
$ tree .
.
   Cargo.lock
   Cargo.toml
   src
       main.rs
   target
       debug
           build
           deps
               hello_world-2386c2fd0156916f
           examples
           hello_world
```

```
            hello_world.d
            incremental
            native

8 directories, 6 files
```

The `Cargo.lock` file contains information about our dependencies. Since we don't have any yet, it's not very interesting. The `target` directory contains all the build products, and, as can be seen, Cargo produces debug builds by default. You can use `cargo build --release` to compile your files with optimizations turned on:

```
$ cargo build --release
   Compiling hello_world v0.1.0 (file:///path/to/project/hello_world)
```

`cargo build --release` puts the resulting binary in `target/release` instead of `target/debug`.

Compiling in debug mode is the default for development -- compilation time is shorter since the compiler doesn't do optimizations, but the code will run slower. Release mode takes longer to compile, but the code will run faster.

1.4

Working on an existing Cargo project

If you download an existing project that uses Cargo, it's really easy to get going.

First, get the project from somewhere. In this example, we'll use `rand` cloned from its repository on GitHub:

```
$ git clone https://github.com/rust-lang-nursery/rand.git
$ cd rand
```

To build, use `cargo build`:

```
$ cargo build
   Compiling rand v0.1.0 (file:///path/to/project/rand)
```

This will fetch all of the dependencies and then build them, along with the project.

1.5

Adding dependencies from crates.io

crates.io is the Rust community's central repository that serves as a location to discover and download packages. `cargo` is configured to use it by default to find requested packages.

To depend on a library hosted on crates.io, add it to your `Cargo.toml`.

Adding a dependency

If your `Cargo.toml` doesn't already have a `[dependencies]` section, add that, then list the crate name and version that you would like to use. This example adds a dependency of the `time` crate:

```
[dependencies]
time = "0.1.12"
```

The version string is a semver version requirement. The specifying dependencies docs have more information about the options you have here.

If we also wanted to add a dependency on the `regex` crate, we would not need to add `[dependencies]` for each crate listed. Here's what your whole `Cargo.toml` file would look like with dependencies on the `time` and `regex` crates:

```
[package]
name = "hello_world"
version = "0.1.0"
authors = ["Your Name <you@example.com>"]

[dependencies]
```

```
time = "0.1.12"
regex = "0.1.41"
```

Re-run `cargo build`, and Cargo will fetch the new dependencies and all of their dependencies, compile them all, and update the `Cargo.lock`:

```
$ cargo build
      Updating registry `https://github.com/rust-lang/crates.io-index`
   Downloading memchr v0.1.5
   Downloading libc v0.1.10
   Downloading regex-syntax v0.2.1
   Downloading memchr v0.1.5
   Downloading aho-corasick v0.3.0
   Downloading regex v0.1.41
     Compiling memchr v0.1.5
     Compiling libc v0.1.10
     Compiling regex-syntax v0.2.1
     Compiling memchr v0.1.5
     Compiling aho-corasick v0.3.0
     Compiling regex v0.1.41
     Compiling hello_world v0.1.0 (file:///path/to/project/hello_world)
```

Our `Cargo.lock` contains the exact information about which revision of all of these dependencies we used.

Now, if `regex` gets updated, we will still build with the same revision until we choose to `cargo update`.

You can now use the `regex` library using `extern crate` in `main.rs`.

```
extern crate regex;

use regex::Regex;

fn main() {
    let re = Regex::new(r"^\d{4}-\d{2}-\d{2}$").unwrap();
    println!("Did our date match? {}", re.is_match("2014-01-01"));
}
```

Running it will show:

```
$ cargo run
   Running `target/hello_world`
Did our date match? true
```

1.6

Project layout

Cargo uses conventions for file placement to make it easy to dive into a new Cargo project:

```
.
  Cargo.lock
  Cargo.toml
  benches
      large-input.rs
  examples
      simple.rs
  src
      bin
          another_executable.rs
      lib.rs
      main.rs
  tests
```

```
    some-integration-tests.rs
```

- `Cargo.toml` and `Cargo.lock` are stored in the root of your project.
- Source code goes in the `src` directory.
- The default library file is `src/lib.rs`.
- The default executable file is `src/main.rs`.
- Other executables can be placed in `src/bin/*.rs`.
- Integration tests go in the `tests` directory (unit tests go in each file they're testing).
- Examples go in the `examples` directory.
- Benchmarks go in the `benches` directory.

These are explained in more detail in the manifest description.

Cargo.toml vs Cargo.lock

`Cargo.toml` and `Cargo.lock` serve two different purposes. Before we talk about them, here's a summary:

- `Cargo.toml` is about describing your dependencies in a broad sense, and is written by you.
- `Cargo.lock` contains exact information about your dependencies. It is maintained by Cargo and should not be manually edited.

If you're building a library that other projects will depend on, put `Cargo.lock` in your `.gitignore`. If you're building an executable like a command-line tool or an application, check `Cargo.lock` into `git`. If you're curious about why that is, see "Why do binaries have `Cargo.lock` in version control, but not libraries?" in the FAQ.

Let's dig in a little bit more.

`Cargo.toml` is a **manifest** file in which we can specify a bunch of different metadata about our project. For example, we can say that we depend on another project:

```
[package]
name = "hello_world"
version = "0.1.0"
authors = ["Your Name <you@example.com>"]

[dependencies]
rand = { git = "https://github.com/rust-lang-nursery/rand.git" }
```

This project has a single dependency, on the `rand` library. We've stated in this case that we're relying on a particular Git repository that lives on GitHub. Since we haven't specified any other information, Cargo assumes that we intend to use the latest commit on the `master` branch to build our project.

Sound good? Well, there's one problem: If you build this project today, and then you send a copy to me, and I build this project tomorrow, something bad could happen. There could be more commits to `rand` in the meantime, and my build would include new commits while yours would not. Therefore, we would get different builds. This would be bad because we want reproducible builds.

We could fix this problem by putting a `rev` line in our `Cargo.toml`:

```
[dependencies]
rand = { git = "https://github.com/rust-lang-nursery/rand.git", rev = "9f35b8e" }
```

Now our builds will be the same. But there's a big drawback: now we have to manually think about SHA-1s every time we want to update our library. This is both tedious and error prone.

Enter the `Cargo.lock`. Because of its existence, we don't need to manually keep track of the exact revisions: Cargo will do it for us. When we have a manifest like this:

```
[package]
name = "hello_world"
version = "0.1.0"
authors = ["Your Name <you@example.com>"]

[dependencies]
rand = { git = "https://github.com/rust-lang-nursery/rand.git" }
```

Cargo will take the latest commit and write that information out into our `Cargo.lock` when we build for the first time. That file will look like this:

```
[root]
name = "hello_world"
version = "0.1.0"
dependencies = [
 "rand 0.1.0 (git+https://github.com/rust-lang-nursery/rand.git#9f35b8e439eeedd60b9414c58f389bdc6a3284f9
",
]

[[package]]
name = "rand"
version = "0.1.0"
source = "git+https://github.com/rust-lang-nursery/rand.git#9f35b8e439eeedd60b9414c58f389bdc6a3284f9"
```

You can see that there's a lot more information here, including the exact revision we used to build. Now when you give your project to someone else, they'll use the exact same SHA, even though we didn't specify it in our `Cargo.toml`.

When we're ready to opt in to a new version of the library, Cargo can re-calculate the dependencies and update things for us:

```
$ cargo update           # updates all dependencies
$ cargo update -p rand   # updates just "rand"
```

This will write out a new `Cargo.lock` with the new version information. Note that the argument to `cargo update` is actually a Package ID Specification and `rand` is just a short specification.

1.7

Tests

Cargo can run your tests with the `cargo test` command. Cargo looks for tests to run in two places: in each of your `src` files and any tests in `tests/`. Tests in your `src` files should be unit tests, and tests in `tests/` should be integration-style tests. As such, you'll need to import your crates into the files in `tests`.

Here's an example of running `cargo test` in our project, which currently has no tests:

```
$ cargo test
   Compiling rand v0.1.0 (https://github.com/rust-lang-nursery/rand.git#9f35b8e)
   Compiling hello_world v0.1.0 (file:///path/to/project/hello_world)
     Running target/test/hello_world-9c2b65bbb79eabce

running 0 tests

test result: ok. 0 passed; 0 failed; 0 ignored; 0 measured
```

If our project had tests, we would see more output with the correct number of tests.

You can also run a specific test by passing a filter:

```
$ cargo test foo
```

This will run any test with `foo` in its name.

`cargo test` runs additional checks as well. For example, it will compile any examples you've included and will also test the examples in your documentation. Please see the testing guide in the Rust documentation for more details.

1.8

Continuous integration

Travis CI

To test your project on Travis CI, here is a sample `.travis.yml` file:

```
language: rust
rust:
  - stable
  - beta
  - nightly
matrix:
  allow_failures:
    - rust: nightly
```

This will test all three release channels, but any breakage in nightly will not fail your overall build. Please see the Travis CI Rust documentation for more information.

Part III

Cargo In Depth

Chapter 1

1.1 Cargo In Depth

- Specifying Dependencies
- Cargo.toml Format

1.2

Specifying Dependencies

Your crates can depend on other libraries from crates.io, `git` repositories, or subdirectories on your local file system. You can also temporarily override the location of a dependency— for example, to be able to test out a bug fix in the dependency that you are working on locally. You can have different dependencies for different platforms, and dependencies that are only used during development. Let's take a look at how to do each of these.

Specifying dependencies from crates.io

Cargo is configured to look for dependencies on crates.io by default. Only the name and a version string are required in this case. In the cargo guide, we specified a dependency on the `time` crate:

```
[dependencies]
time = "0.1.12"
```

The string `"0.1.12"` is a semver version requirement. Since this string does not have any operators in it, it is interpreted the same way as if we had specified `"^0.1.12"`, which is called a caret requirement.

Caret requirements

Caret requirements allow SemVer compatible updates to a specified version. An update is allowed if the new version number does not modify the left-most non-zero digit in the major, minor, patch grouping. In this case, if we ran `cargo update -p time`, cargo would update us to version `0.1.13` if it was available, but would not update us to `0.2.0`. If instead we had specified the version string as `^1.0`, cargo would update to `1.1` but not `2.0`. `0.0.x` is not considered compatible with any other version.

Here are some more examples of caret requirements and the versions that would be allowed with them:

```
^1.2.3 := >=1.2.3 <2.0.0
^1.2 := >=1.2.0 <2.0.0
^1 := >=1.0.0 <2.0.0
^0.2.3 := >=0.2.3 <0.3.0
^0.0.3 := >=0.0.3 <0.0.4
^0.0 := >=0.0.0 <0.1.0
^0 := >=0.0.0 <1.0.0
```

While SemVer says that there is no compatibility before 1.0.0, many programmers treat a `0.x.y` release in the same way as a `1.x.y` release: that is, `y` is incremented for bugfixes, and `x` is incremented for new features. As such, Cargo considers a `0.x.y` and `0.x.z` version, where `z > y`, to be compatible.

Tilde requirements

Tilde requirements specify a minimal version with some ability to update. If you specify a major, minor, and patch version or only a major and minor version, only patch-level changes are allowed. If you only specify a major version, then minor- and patch-level changes are allowed.

`~1.2.3` is an example of a tilde requirement.

```
~1.2.3 := >=1.2.3 <1.3.0
~1.2 := >=1.2.0 <1.3.0
~1 := >=1.0.0 <2.0.0
```

Wildcard requirements

Wildcard requirements allow for any version where the wildcard is positioned.

`*`, `1.*` and `1.2.*` are examples of wildcard requirements.

```
* := >=0.0.0
1.* := >=1.0.0 <2.0.0
1.2.* := >=1.2.0 <1.3.0
```

Inequality requirements

Inequality requirements allow manually specifying a version range or an exact version to depend on.

Here are some examples of inequality requirements:

```
>= 1.2.0
> 1
< 2
= 1.2.3
```

Multiple requirements

Multiple version requirements can also be separated with a comma, e.g. `>= 1.2, < 1.5`.

Specifying dependencies from `git` repositories

To depend on a library located in a `git` repository, the minimum information you need to specify is the location of the repository with the `git` key:

```
[dependencies]
rand = { git = "https://github.com/rust-lang-nursery/rand" }
```

Cargo will fetch the `git` repository at this location then look for a `Cargo.toml` for the requested crate anywhere inside the `git` repository (not necessarily at the root).

Since we haven't specified any other information, Cargo assumes that we intend to use the latest commit on the `master` branch to build our project. You can combine the `git` key with the `rev`, `tag`, or `branch` keys to specify something else. Here's an example of specifying that you want to use the latest commit on a branch named `next`:

```
[dependencies]
rand = { git = "https://github.com/rust-lang-nursery/rand", branch = "next" }
```

Specifying path dependencies

Over time, our `hello_world` project from the guide has grown significantly in size! It's gotten to the point that we probably want to split out a separate crate for others to use. To do this Cargo supports **path dependencies** which are typically sub-crates that live within one repository. Let's start off by making a new crate inside of our `hello_world` project:

```
# inside of hello_world/
$ cargo new hello_utils
```

This will create a new folder `hello_utils` inside of which a `Cargo.toml` and `src` folder are ready to be configured. In order to tell Cargo about this, open up `hello_world/Cargo.toml` and add `hello_utils` to your dependencies:

```
[dependencies]
hello_utils = { path = "hello_utils" }
```

This tells Cargo that we depend on a crate called `hello_utils` which is found in the `hello_utils` folder (relative to the `Cargo.toml` it's written in).

And that's it! The next `cargo build` will automatically build `hello_utils` and all of its own dependencies, and others can also start using the crate as well. However, crates that use dependencies specified with only a path are not permitted on crates.io. If we wanted to publish our `hello_world` crate, we would need to publish a version of `hello_utils` to crates.io (or specify a `git` repository location) and specify its version in the dependencies line as well:

```
[dependencies]
hello_utils = { path = "hello_utils", version = "0.1.0" }
```

Overriding dependencies

There are a number of methods in Cargo to support overriding dependencies and otherwise controlling the dependency graph. These options are typically, though, only available at the workspace level and aren't propagated through dependencies. In other words, "applications" have the ability to override dependencies but "libraries" do not.

The desire to override a dependency or otherwise alter some dependencies can arise through a number of scenarios. Most of them, however, boil down to the ability to to work with a crate before it's been published to crates.io. For example:

- A crate you're working on is also used in a much larger application you're working on, and you'd like to test a bug fix to the library inside of the larger application.
- An upstream crate you don't work on has a new feature or a bug fix on the master branch of its git repository which you'd like to test out.
- You're about to publish a new major version of your crate, but you'd like to do integration testing across an entire project to ensure the new major version works.
- You've submitted a fix to an upstream crate for a bug you found, but you'd like to immediately have your application start depending on the fixed version of the crate to avoid blocking on the bug fix getting merged.

These scenarios are currently all solved with the `[patch]` manifest section. Note that the `[patch]` feature is not yet currently stable and will be released on 2017-08-31. Historically some of these scenarios have been solved with the `[replace]` section, but we'll document the `[patch]` section here.

Testing a bugfix

Let's say you're working with the [`uuid`] crate but while you're working on it you discover a bug. You are, however, quite enterprising so you decide to also try out to fix the bug! Originally your manifest will look like:

`uuid`

```
[package]
name = "my-library"
version = "0.1.0"
authors = ["..."]

[dependencies]
uuid = "1.0"
```

First thing we'll do is to clone the `uuid` repository locally via:

```
$ git clone https://github.com/rust-lang-nursery/uuid
```

Next we'll edit the manifest of `my-library` to contain:

```
[patch.crates-io]
uuid = { path = "../path/to/uuid" }
```

Here we declare that we're *patching* the source `crates-io` with a new dependency. This will effectively add the local checked out version of `uuid` to the crates.io registry for our local project.

Next up we need to ensure that our lock file is updated to use this new version of `uuid` so our project uses the locally checked out copy instead of one from crates.io. The way `[patch]` works is that it'll load the dependency at `../path/to/uuid` and then whenever crates.io is queried for versions of `uuid` it'll *also* return the local version.

This means that the version number of the local checkout is significant and will affect whether the patch is used. Our manifest declared `uuid = "1.0"` which means we'll only resolve to `>= 1.0.0, < 2.0.0`, and Cargo's greedy resolution algorithm also means that we'll resolve to the maximum version within that range. Typically this doesn't matter as the version of the git repository will already be greater or match the maximum version published on crates.io, but it's important to keep this in mind!

In any case, typically all you need to do now is:

```
$ cargo build
   Compiling uuid v1.0.0 (file://.../uuid)
   Compiling my-library v0.1.0 (file://.../my-library)
    Finished dev [unoptimized + debuginfo] target(s) in 0.32 secs
```

And that's it! You're now building with the local version of `uuid` (note the `file://` in the build output). If you don't see the `file://` version getting built then you may need to run `cargo update -p uuid --precise $version` where `$version` is the version of the locally checked out copy of `uuid`.

Once you've fixed the bug you originally found the next thing you'll want to do is to likely submit that as a pull request to the `uuid` crate itself. Once you've done this then you can also update the `[patch]` section. The listing inside of `[patch]` is just like the `[dependencies]` section, so once your pull request is merged you could change your `path` dependency to:

```
[patch.crates-io]
uuid = { git = 'https://github.com/rust-lang-nursery/uuid' }
```

Working with an unpublished minor version

Let's now shift gears a bit from bug fixes to adding features. While working on `my-library` you discover that a whole new feature is needed in the `uuid` crate. You've implemented this feature, tested it locally above with `[patch]`, and submitted a pull request. Let's go over how you continue to use and test it before it's actually published.

Let's also say that the current version of `uuid` on crates.io is `1.0.0`, but since then the master branch of the git repository has updated to `1.0.1`. This branch includes your new feature you submitted previously. To use this repository we'll edit our `Cargo.toml` to look like

```
[package]
name = "my-library"
version = "0.1.0"
authors = ["..."]

[dependencies]
uuid = "1.0.1"

[patch.crates-io]
uuid = { git = 'https://github.com/rust-lang-nursery/uuid' }
```

Note that our local dependency on `uuid` has been updated to `1.0.1` as it's what we'll actually require once the crate is published. This version doesn't exist on crates.io, though, so we provide it with the `[patch]` section of the manifest.

Now when our library is built it'll fetch `uuid` from the git repository and resolve to 1.0.1 inside the repository instead of trying to download a version from crates.io. Once 1.0.1 is published on crates.io the `[patch]` section can be deleted.

It's also worth nothing that `[patch]` applies *transitively*. Let's say you use `my-library` in a larger project, such as:

```
[package]
name = "my-binary"
version = "0.1.0"
authors = ["..."]
```

```
[dependencies]
my-library = { git = 'https://example.com/git/my-library' }
uuid = "1.0"

[patch.crates-io]
uuid = { git = 'https://github.com/rust-lang-nursery/uuid' }
```

Remember that `[patch]` is only applicable at the *top level* so we consumers of `my-library` have to repeat the `[patch]` section if necessary. Here, though, the new `uuid` crate applies to *both* our dependency on `uuid` and the `my-library -> uuid` dependency. The `uuid` crate will be resolved to one version for this entire crate graph, 1.0.1, and it'll be pulled from the git repository.

Prepublishing a breaking change

As a final scenario, let's take a look at working with a new major version of a crate, typically accompanied with breaking changes. Sticking with our previous crates, this means that we're going to be creating version 2.0.0 of the `uuid` crate. After we've submitted all changes upstream we can update our manifest for `my-library` to look like:

```
[dependencies]
uuid = "2.0"

[patch.crates-io]
uuid = { git = "https://github.com/rust-lang-nursery/uuid", branch = "2.0.0" }
```

And that's it! Like with the previous example the 2.0.0 version doesn't actually exist on crates.io but we can still put it in through a git dependency through the usage of the `[patch]` section. As a thought exercise let's take another look at the `my-binary` manifest from above again as well:

```
[package]
name = "my-binary"
version = "0.1.0"
authors = ["..."]

[dependencies]
my-library = { git = 'https://example.com/git/my-library' }
uuid = "1.0"

[patch.crates-io]
uuid = { git = 'https://github.com/rust-lang-nursery/uuid', version = '2.0.0' }
```

Note that this will actually resolve to two versions of the `uuid` crate. The `my-binary` crate will continue to use the 1.x.y series of the `uuid` crate but the `my-library` crate will use the 2.0.0 version of `uuid`. This will allow you to gradually roll out breaking changes to a crate through a dependency graph without being force to update everything all at once.

Overriding with local dependencies

Sometimes you're only temporarily working on a crate and you don't want to have to modify `Cargo.toml` like with the `[patch]` section above. For this use case Cargo offers a much more limited version of overrides called **path overrides**.

Path overrides are specified through `.cargo/config` instead of `Cargo.toml`, and you can find more documentation about this configuration. Inside of `.cargo/config` you'll specify a key called `paths`:

```
paths = ["/path/to/uuid"]
```

This array should be filled with directories that contain a `Cargo.toml`. In this instance, we're just adding `uuid`, so it will be the only one that's overridden. This path can be either absolute or relative to the directory that contains the `.cargo` folder.

Path overrides are more restricted than the `[patch]` section, however, in that they cannot change the structure of the dependency graph. When a path replacement is used then the previous set of dependencies must all match exactly

to the new `Cargo.toml` specification. For example this means that path overrides cannot be used to test out adding a dependency to a crate, instead `[patch]` must be used in that situation. As a result usage of a path override is typically isolated to quick bug fixes rather than larger changes.

Note: using a local configuration to override paths will only work for crates that have been published to crates.io. You cannot use this feature to tell Cargo how to find local unpublished crates.

Platform specific dependencies

Platform-specific dependencies take the same format, but are listed under a `target` section. Normally Rust-like `#[cfg]` syntax will be used to define these sections:

```
[target.'cfg(windows)'.dependencies]
winhttp = "0.4.0"

[target.'cfg(unix)'.dependencies]
openssl = "1.0.1"

[target.'cfg(target_arch = "x86")'.dependencies]
native = { path = "native/i686" }

[target.'cfg(target_arch = "x86_64")'.dependencies]
native = { path = "native/x86_64" }
```

Like with Rust, the syntax here supports the `not`, `any`, and `all` operators to combine various cfg name/value pairs. Note that the `cfg` syntax has only been available since Cargo 0.9.0 (Rust 1.8.0).

In addition to `#[cfg]` syntax, Cargo also supports listing out the full target the dependencies would apply to:

```
[target.x86_64-pc-windows-gnu.dependencies]
winhttp = "0.4.0"

[target.i686-unknown-linux-gnu.dependencies]
openssl = "1.0.1"
```

If you're using a custom target specification, quote the full path and file name:

```
[target."x86_64/windows.json".dependencies]
winhttp = "0.4.0"

[target."i686/linux.json".dependencies]
openssl = "1.0.1"
native = { path = "native/i686" }

[target."x86_64/linux.json".dependencies]
openssl = "1.0.1"
native = { path = "native/x86_64" }
```

Development dependencies

You can add a `[dev-dependencies]` section to your `Cargo.toml` whose format is equivalent to `[dependencies]`:

```
[dev-dependencies]
tempdir = "0.3"
```

Dev-dependencies are not used when compiling a package for building, but are used for compiling tests, examples, and benchmarks.

These dependencies are *not* propagated to other packages which depend on this package.

You can also have target-specific development dependencies by using `dev-dependencies` in the target section header instead of `dependencies`. For example:

```
[target.'cfg(unix)'.dev-dependencies]
mio = "0.0.1"
```

Build dependencies

You can depend on other Cargo-based crates for use in your build scripts. Dependencies are declared through the `build-dependencies` section of the manifest:

```
[build-dependencies]
gcc = "0.3"
```

The build script **does not** have access to the dependencies listed in the `dependencies` or `dev-dependencies` section. Build dependencies will likewise not be available to the package itself unless listed under the `dependencies` section as well. A package itself and its build script are built separately, so their dependencies need not coincide. Cargo is kept simpler and cleaner by using independent dependencies for independent purposes.

Choosing features

If a package you depend on offers conditional features, you can specify which to use:

```
[dependencies.awesome]
version = "1.3.5"
default-features = false # do not include the default features, and optionally
                         # cherry-pick individual features
features = ["secure-password", "civet"]
```

More information about features can be found in the manifest documentation.

1.3

The Manifest Format

The `[package]` section

The first section in a `Cargo.toml` is `[package]`.

```
[package]
name = "hello_world" # the name of the package
version = "0.1.0"    # the current version, obeying semver
authors = ["you@example.com"]
```

All three of these fields are mandatory.

The `version` field Cargo bakes in the concept of Semantic Versioning, so make sure you follow some basic rules:

- Before you reach 1.0.0, anything goes, but if you make breaking changes, increment the minor version. In Rust, breaking changes include adding fields to structs or variants to enums.
- After 1.0.0, only make breaking changes when you increment the major version. Don't break the build.
- After 1.0.0, don't add any new public API (no new `pub` anything) in tiny versions. Always increment the minor version if you add any new `pub` structs, traits, fields, types, functions, methods or anything else.
- Use version numbers with three numeric parts such as 1.0.0 rather than 1.0.

The `build` field (optional) This field specifies a file in the repository which is a build script for building native code. More information can be found in the build script guide.

```
[package]
# ...
```

```
build = "build.rs"
```

The `documentation` field (optional) This field specifies a URL to a website hosting the crate's documentation. If no URL is specified in the manifest file, crates.io will automatically link your crate to the corresponding docs.rs page.

Documentation links from specific hosts are blacklisted. Hosts are added to the blacklist if they are known to not be hosting documentation and are possibly of malicious intent e.g. ad tracking networks. URLs from the following hosts are blacklisted:

- rust-ci.org

Documentation URLs from blacklisted hosts will not appear on crates.io, and may be replaced by docs.rs links.

The `exclude` and `include` fields (optional) You can explicitly specify to Cargo that a set of globs should be ignored or included for the purposes of packaging and rebuilding a package. The globs specified in the `exclude` field identify a set of files that are not included when a package is published as well as ignored for the purposes of detecting when to rebuild a package, and the globs in `include` specify files that are explicitly included.

If a VCS is being used for a package, the `exclude` field will be seeded with the VCS' ignore settings (`.gitignore` for git for example).

```
[package]
# ...
exclude = ["build/**/*.o", "doc/**/*.html"]
```

```
[package]
# ...
include = ["src/**/*", "Cargo.toml"]
```

The options are mutually exclusive: setting `include` will override an `exclude`. Note that `include` must be an exhaustive list of files as otherwise necessary source files may not be included.

Migrating to `gitignore`-like pattern matching The current interpretation of these configs is based on UNIX Globs, as implemented in the `glob` crate. We want Cargo's `include` and `exclude` configs to work as similar to `gitignore` as possible. The `gitignore` specification is also based on Globs, but has a bunch of additional features that enable easier pattern writing and more control. Therefore, we are migrating the interpretation for the rules of these configs to use the `ignore` crate, and treat them each rule as a single line in a `gitignore` file. See the tracking issue for more details on the migration.

The `publish` field (optional) The `publish` field can be used to prevent a package from being published to a repository by mistake.

```
[package]
# ...
publish = false
```

The `workspace` field (optional) The `workspace` field can be used to configure the workspace that this package will be a member of. If not specified this will be inferred as the first Cargo.toml with `[workspace]` upwards in the filesystem.

```
[package]
# ...
workspace = "path/to/root"
```

For more information, see the documentation for the workspace table below.

Package metadata There are a number of optional metadata fields also accepted under the `[package]` section:

```
[package]
# ...

# A short blurb about the package. This is not rendered in any format when
# uploaded to crates.io (aka this is not markdown).
description = "..."

# These URLs point to more information about the repository. These are
# intended to be webviews of the relevant data, not necessarily compatible
# with VCS tools and the like.
documentation = "..."
homepage = "..."
repository = "..."

# This points to a file in the repository (relative to this `Cargo.toml`). The
# contents of this file are stored and indexed in the registry.
readme = "..."

# This is a list of up to five keywords that describe this crate. Keywords
# are searchable on crates.io, and you may choose any words that would
# help someone find this crate.
keywords = ["...", "..."]

# This is a list of up to five categories where this crate would fit.
# Categories are a fixed list available at crates.io/category_slugs, and
# they must match exactly.
categories = ["...", "..."]

# This is a string description of the license for this package. Currently
# crates.io will validate the license provided against a whitelist of known
# license identifiers from http://spdx.org/licenses/. Multiple licenses can be
# separated with a `/`.
license = "..."

# If a project is using a nonstandard license, then this key may be specified in
# lieu of the above key and must point to a file relative to this manifest
# (similar to the readme key).
license-file = "..."

# Optional specification of badges to be displayed on crates.io. The badges
# currently available are Travis CI, Appveyor, and GitLab latest build status,
# specified using the following parameters:
[badges]
# Travis CI: `repository` in format "<user>/<project>" is required.
# `branch` is optional; default is `master`
travis-ci = { repository = "...", branch = "master" }
# Appveyor: `repository` is required. `branch` is optional; default is `master`
# `service` is optional; valid values are `github` (default), `bitbucket`, and
# `gitlab`.
appveyor = { repository = "...", branch = "master", service = "github" }
# GitLab: `repository` is required. `branch` is optional; default is `master`
gitlab = { repository = "...", branch = "master" }
# Circle CI: `repository` is required. `branch` is optional; default is `master`
circle-ci = { repository = "...", branch = "master" }
# Is it maintained resolution time: `repository` is required.
is-it-maintained-issue-resolution = { repository = "..." }
```

```
# Is it maintained percentage of open issues: `repository` is required.
is-it-maintained-open-issues = { repository = "..." }
# Codecov: `repository` is required. `branch` is optional; default is `master`
# `service` is optional; valid values are `github` (default), `bitbucket`, and
# `gitlab`.
codecov = { repository = "...", branch = "master", service = "github" }
# Coveralls: `repository` is required. `branch` is optional; default is `master`
# `service` is optional; valid values are `github` (default) and `bitbucket`.
coveralls = { repository = "...", branch = "master", service = "github" }
```

The crates.io registry will render the description, display the license, link to the three URLs and categorize by the keywords. These keys provide useful information to users of the registry and also influence the search ranking of a crate. It is highly discouraged to omit everything in a published crate.

The `metadata` table (optional) Cargo by default will warn about unused keys in `Cargo.toml` to assist in detecting typos and such. The `package.metadata` table, however, is completely ignored by Cargo and will not be warned about. This section can be used for tools which would like to store project configuration in `Cargo.toml`. For example:

```
[package]
name = "..."
# ...

# Metadata used when generating an Android APK, for example.
[package.metadata.android]
package-name = "my-awesome-android-app"
assets = "path/to/static"
```

Dependency sections

See the specifying dependencies page for information on the `[dependencies]`, `[dev-dependencies]`, `[build-dependencies]`, and target-specific `[target.*.dependencies]` sections.

The `[profile.*]` sections

Cargo supports custom configuration of how rustc is invoked through profiles at the top level. Any manifest may declare a profile, but only the top level project's profiles are actually read. All dependencies' profiles will be overridden. This is done so the top-level project has control over how its dependencies are compiled.

There are five currently supported profile names, all of which have the same configuration available to them. Listed below is the configuration available, along with the defaults for each profile.

```
# The development profile, used for `cargo build`.
[profile.dev]
opt-level = 0      # controls the `--opt-level` the compiler builds with.
                   # 0-1 is good for debugging. 2 is well-optimized. Max is 3.
debug = true       # include debug information (debug symbols). Equivalent to
                   # `-C debuginfo=2` compiler flag.
rpath = false      # controls whether compiler should set loader paths.
                   # If true, passes `-C rpath` flag to the compiler.
lto = false        # Link Time Optimization usually reduces size of binaries
                   # and static libraries. Increases compilation time.
                   # If true, passes `-C lto` flag to the compiler.
debug-assertions = true # controls whether debug assertions are enabled
                   # (e.g. debug_assert!() and arithmetic overflow checks)
codegen-units = 1  # if > 1 enables parallel code generation which improves
                   # compile times, but prevents some optimizations.
                   # Passes `-C codegen-units`. Ignored when `lto = true`.
panic = 'unwind'   # panic strategy (`-C panic=...`), can also be 'abort'
```

```
# The release profile, used for `cargo build --release`.
[profile.release]
opt-level = 3
debug = false
rpath = false
lto = false
debug-assertions = false
codegen-units = 1
panic = 'unwind'

# The testing profile, used for `cargo test`.
[profile.test]
opt-level = 0
debug = 2
rpath = false
lto = false
debug-assertions = true
codegen-units = 1
panic = 'unwind'

# The benchmarking profile, used for `cargo bench`.
[profile.bench]
opt-level = 3
debug = false
rpath = false
lto = false
debug-assertions = false
codegen-units = 1
panic = 'unwind'

# The documentation profile, used for `cargo doc`.
[profile.doc]
opt-level = 0
debug = 2
rpath = false
lto = false
debug-assertions = true
codegen-units = 1
panic = 'unwind'
```

The `[features]` section

Cargo supports features to allow expression of:

- conditional compilation options (usable through `cfg` attributes);
- optional dependencies, which enhance a package, but are not required; and
- clusters of optional dependencies, such as `postgres`, that would include the `postgres` package, the `postgres-macros` package, and possibly other packages (such as development-time mocking libraries, debugging tools, etc.).

A feature of a package is either an optional dependency, or a set of other features. The format for specifying features is:

```
[package]
name = "awesome"

[features]
# The default set of optional packages. Most people will want to use these
```

```
# packages, but they are strictly optional. Note that `session` is not a package
# but rather another feature listed in this manifest.
default = ["jquery", "uglifier", "session"]

# A feature with no dependencies is used mainly for conditional compilation,
# like `#[cfg(feature = "go-faster")]`.
go-faster = []

# The `secure-password` feature depends on the bcrypt package. This aliasing
# will allow people to talk about the feature in a higher-level way and allow
# this package to add more requirements to the feature in the future.
secure-password = ["bcrypt"]

# Features can be used to reexport features of other packages. The `session`
# feature of package `awesome` will ensure that the `session` feature of the
# package `cookie` is also enabled.
session = ["cookie/session"]

[dependencies]
# These packages are mandatory and form the core of this package's distribution.
cookie = "1.2.0"
oauth = "1.1.0"
route-recognizer = "=2.1.0"

# A list of all of the optional dependencies, some of which are included in the
# above `features`. They can be opted into by apps.
jquery = { version = "1.0.2", optional = true }
uglifier = { version = "1.5.3", optional = true }
bcrypt = { version = "*", optional = true }
civet = { version = "*", optional = true }
```

To use the package `awesome`:

```
[dependencies.awesome]
version = "1.3.5"
default-features = false # do not include the default features, and optionally
                         # cherry-pick individual features
features = ["secure-password", "civet"]
```

Rules The usage of features is subject to a few rules:

- Feature names must not conflict with other package names in the manifest. This is because they are opted into via `features = [...]`, which only has a single namespace.
- With the exception of the `default` feature, all features are opt-in. To opt out of the default feature, use `default-features = false` and cherry-pick individual features.
- Feature groups are not allowed to cyclically depend on one another.
- Dev-dependencies cannot be optional.
- Features groups can only reference optional dependencies.
- When a feature is selected, Cargo will call `rustc` with `--cfg feature="${feature_name}"`. If a feature group is included, it and all of its individual features will be included. This can be tested in code via `#[cfg(feature = "foo")]`.

Note that it is explicitly allowed for features to not actually activate any optional dependencies. This allows packages to internally enable/disable features without requiring a new dependency.

Usage in end products One major use-case for this feature is specifying optional features in end-products. For example, the Servo project may want to include optional features that people can enable or disable when they build it.

In that case, Servo will describe features in its `Cargo.toml` and they can be enabled using command-line flags:

```
$ cargo build --release --features "shumway pdf"
```

Default features could be excluded using `--no-default-features`.

Usage in packages In most cases, the concept of *optional dependency* in a library is best expressed as a separate package that the top-level application depends on.

However, high-level packages, like Iron or Piston, may want the ability to curate a number of packages for easy installation. The current Cargo system allows them to curate a number of mandatory dependencies into a single package for easy installation.

In some cases, packages may want to provide additional curation for optional dependencies:

- grouping a number of low-level optional dependencies together into a single high-level feature;
- specifying packages that are recommended (or suggested) to be included by users of the package; and
- including a feature (like `secure-password` in the motivating example) that will only work if an optional dependency is available, and would be difficult to implement as a separate package (for example, it may be overly difficult to design an IO package to be completely decoupled from OpenSSL, with opt-in via the inclusion of a separate package).

In almost all cases, it is an antipattern to use these features outside of high-level packages that are designed for curation. If a feature is optional, it can almost certainly be expressed as a separate package.

The `[workspace]` section

Projects can define a workspace which is a set of crates that will all share the same `Cargo.lock` and output directory. The `[workspace]` table can be defined as:

```
[workspace]

# Optional key, inferred if not present
members = ["path/to/member1", "path/to/member2", "path/to/member3/*"]

# Optional key, empty if not present
exclude = ["path1", "path/to/dir2"]
```

Workspaces were added to Cargo as part RFC 1525 and have a number of properties:

- A workspace can contain multiple crates where one of them is the root crate.
- The root crate's `Cargo.toml` contains the `[workspace]` table, but is not required to have other configuration.
- Whenever any crate in the workspace is compiled, output is placed next to the root crate's `Cargo.toml`.
- The lock file for all crates in the workspace resides next to the root crate's `Cargo.toml`.
- The `[patch]` and `[replace]` sections in `Cargo.toml` are only recognized at the workspace root crate, they are ignored in member crates' manifests.

The root crate of a workspace, indicated by the presence of `[workspace]` in its manifest, is responsible for defining the entire workspace. All `path` dependencies residing in the workspace directory become members. You can add additional packages to the workspace by listing them in the `members` key. Note that members of the workspaces listed explicitly will also have their path dependencies included in the workspace. Sometimes a project may have a lot of workspace members and it can be onerous to keep up to date. The path dependency can also use globs to match multiple paths. Finally, the `exclude` key can be used to blacklist paths from being included in a workspace. This can be useful if some path dependencies aren't desired to be in the workspace at all.

The `package.workspace` manifest key (described above) is used in member crates to point at a workspace's root crate. If this key is omitted then it is inferred to be the first crate whose manifest contains `[workspace]` upwards in the filesystem.

A crate may either specify `package.workspace` or specify `[workspace]`. That is, a crate cannot both be a root crate in a workspace (contain `[workspace]`) and also be a member crate of another workspace (contain `package.workspace`).

Most of the time workspaces will not need to be dealt with as `cargo new` and `cargo init` will handle workspace configuration automatically.

#TODO: move this to a more appropriate place

The project layout

If your project is an executable, name the main source file `src/main.rs`. If it is a library, name the main source file `src/lib.rs`.

Cargo will also treat any files located in `src/bin/*.rs` as executables. If your executable consists of more than just one source file, you might also use a directory inside `src/bin` containing a `main.rs` file which will be treated as an executable with a name of the parent directory. Do note, however, once you add a `[[bin]]` section (see below), Cargo will no longer automatically build files located in `src/bin/*.rs`. Instead you must create a `[[bin]]` section for each file you want to build.

Your project can optionally contain folders named `examples`, `tests`, and `benches`, which Cargo will treat as containing examples, integration tests, and benchmarks respectively.

```
src/           # directory containing source files
 lib.rs         # the main entry point for libraries and packages
 main.rs        # the main entry point for projects producing executables
   bin/         # (optional) directory containing additional executables
    *.rs
   */           # (optional) directories containing multi-file executables
    main.rs
examples/      # (optional) examples
 *.rs
tests/         # (optional) integration tests
 *.rs
benches/       # (optional) benchmarks
 *.rs
```

To structure your code after you've created the files and folders for your project, you should remember to use Rust's module system, which you can read about in the book.

Examples

Files located under `examples` are example uses of the functionality provided by the library. When compiled, they are placed in the `target/examples` directory.

They can compile either as executables (with a `main()` function) or libraries and pull in the library by using `extern crate <library-name>`. They are compiled when you run your tests to protect them from bitrotting.

You can run individual executable examples with the command `cargo run --example <example-name>`.

Specify `crate-type` to make an example be compiled as a library:

```
[[example]]
name = "foo"
crate-type = ["staticlib"]
```

You can build individual library examples with the command `cargo build --example <example-name>`.

Tests

When you run `cargo test`, Cargo will:

- compile and run your library's unit tests, which are in the files reachable from `lib.rs` (naturally, any sections marked with `#[cfg(test)]` will be considered at this stage);

- compile and run your library's documentation tests, which are embedded inside of documentation blocks;
- compile and run your library's integration tests; and
- compile your library's examples.

Integration tests Each file in `tests/*.rs` is an integration test. When you run `cargo test`, Cargo will compile each of these files as a separate crate. The crate can link to your library by using `extern crate <library-name>`, like any other code that depends on it.

Cargo will not automatically compile files inside subdirectories of `tests`, but an integration test can import modules from these directories as usual. For example, if you want several integration tests to share some code, you can put the shared code in `tests/common/mod.rs` and then put `mod common;` in each of the test files.

Configuring a target

All of the `[[bin]]`, `[lib]`, `[[bench]]`, `[[test]]`, and `[[example]]` sections support similar configuration for specifying how a target should be built. The double-bracket sections like `[[bin]]` are array-of-table of TOML, which means you can write more than one `[[bin]]` section to make several executables in your crate.

The example below uses `[lib]`, but it also applies to all other sections as well. All values listed are the defaults for that option unless otherwise specified.

```
[package]
# ...

[lib]
# The name of a target is the name of the library that will be generated. This
# is defaulted to the name of the package or project, with any dashes replaced
# with underscores. (Rust `extern crate` declarations reference this name;
# therefore the value must be a valid Rust identifier to be usable.)
name = "foo"

# This field points at where the crate is located, relative to the `Cargo.toml`.
path = "src/lib.rs"

# A flag for enabling unit tests for this target. This is used by `cargo test`.
test = true

# A flag for enabling documentation tests for this target. This is only relevant
# for libraries, it has no effect on other sections. This is used by
# `cargo test`.
doctest = true

# A flag for enabling benchmarks for this target. This is used by `cargo bench`.
bench = true

# A flag for enabling documentation of this target. This is used by `cargo doc`.
doc = true

# If the target is meant to be a compiler plugin, this field must be set to true
# for Cargo to correctly compile it and make it available for all dependencies.
plugin = false

# If the target is meant to be a "macros 1.1" procedural macro, this field must
# be set to true.
proc-macro = false

# If set to false, `cargo test` will omit the `--test` flag to rustc, which
# stops it from generating a test harness. This is useful when the binary being
```

```
# built manages the test runner itself.
harness = true
```

The `required-features` field (optional) The `required-features` field specifies which features the target needs in order to be built. If any of the required features are not selected, the target will be skipped. This is only relevant for the `[[bin]]`, `[[bench]]`, `[[test]]`, and `[[example]]` sections, it has no effect on `[lib]`.

```
[features]
# ...
postgres = []
sqlite = []
tools = []

[[bin]]
# ...
required-features = ["postgres", "tools"]
```

Building dynamic or static libraries If your project produces a library, you can specify which kind of library to build by explicitly listing the library in your `Cargo.toml`:

```
# ...

[lib]
name = "..."
crate-type = ["dylib"] # could be `staticlib` as well
```

The available options are `dylib`, `rlib`, `staticlib`, `cdylib`, and `proc-macro`. You should only use this option in a project. Cargo will always compile packages (dependencies) based on the requirements of the project that includes them.

You can read more about the different crate types in the Rust Reference Manual

The `[patch]` Section

This section of Cargo.toml can be used to override dependencies with other copies. The syntax is similar to the `[dependencies]` section:

```
[patch.crates-io]
foo = { git = 'https://github.com/example/foo' }
bar = { path = 'my/local/bar' }
```

The `[patch]` table is made of dependency-like sub-tables. Each key after `[patch]` is a URL of the source that's being patched, or `crates-io` if you're modifying the https://crates.io registry. In the example above `crates-io` could be replaced with a git URL such as `https://github.com/rust-lang-nursery/log`.

Each entry in these tables is a normal dependency specification, the same as found in the `[dependencies]` section of the manifest. The dependencies listed in the `[patch]` section are resolved and used to patch the source at the URL specified. The above manifest snippet patches the `crates-io` source (e.g. crates.io itself) with the `foo` crate and `bar` crate.

Sources can be patched with versions of crates that do not exist, and they can also be patched with versions of crates that already exist. If a source is patched with a crate version that already exists in the source, then the source's original crate is replaced.

More information about overriding dependencies can be found in the overriding dependencies section of the documentation and RFC 1969 for the technical specification of this feature. Note that the `[patch]` feature will first become available in Rust 1.20, set to be released on 2017-08-31.

The `[replace]` Section

This section of Cargo.toml can be used to override dependencies with other copies. The syntax is similar to the `[dependencies]` section:

```
[replace]
"foo:0.1.0" = { git = 'https://github.com/example/foo' }
"bar:1.0.2" = { path = 'my/local/bar' }
```

Each key in the `[replace]` table is a package id specification which allows arbitrarily choosing a node in the dependency graph to override. The value of each key is the same as the `[dependencies]` syntax for specifying dependencies, except that you can't specify features. Note that when a crate is overridden the copy it's overridden with must have both the same name and version, but it can come from a different source (e.g. git or a local path).

More information about overriding dependencies can be found in the overriding dependencies section of the documentation.

1.4

Configuration

This document will explain how Cargo's configuration system works, as well as available keys or configuration. For configuration of a project through its manifest, see the manifest format.

Hierarchical structure

Cargo allows to have local configuration for a particular project or global configuration (like git). Cargo also extends this ability to a hierarchical strategy. If, for example, Cargo were invoked in `/home/foo/bar/baz`, then the following configuration files would be probed for:

- `/home/foo/bar/baz/.cargo/config`
- `/home/foo/bar/.cargo/config`
- `/home/foo/.cargo/config`
- `/home/.cargo/config`
- `/.cargo/config`

With this structure you can specify local configuration per-project, and even possibly check it into version control. You can also specify personal default with a configuration file in your home directory.

Configuration format

All configuration is currently in the TOML format (like the manifest), with simple key-value pairs inside of sections (tables) which all get merged together.

Configuration keys

All of the following keys are optional, and their defaults are listed as their value unless otherwise noted.

Key values that specify a tool may be given as an absolute path, a relative path or as a pathless tool name. Absolute paths and pathless tool names are used as given. Relative paths are resolved relative to the parent directory of the `.cargo` directory of the config file that the value resides within.

```
# An array of paths to local repositories which are to be used as overrides for
# dependencies. For more information see the Specifying Dependencies guide.
paths = ["/path/to/override"]

[cargo-new]
# This is your name/email to place in the `authors` section of a new Cargo.toml
# that is generated. If not present, then `git` will be probed, and if that is
# not present then `$USER` and `$EMAIL` will be used.
name = "..."
email = "..."

# By default `cargo new` will initialize a new Git repository. This key can be
```

```
# set to `hg` to create a Mercurial repository, or `none` to disable this
# behavior.
vcs = "none"

# For the following sections, $triple refers to any valid target triple, not the
# literal string "$triple", and it will apply whenever that target triple is
# being compiled to. 'cfg(...)' refers to the Rust-like `#[cfg]` syntax for
# conditional compilation.
[target]
# For Cargo builds which do not mention --target, this is the linker
# which is passed to rustc (via `-C linker=`). By default this flag is not
# passed to the compiler.
linker = ".."

[target.$triple]
# Similar to the above linker configuration, but this only applies to
# when the `$triple` is being compiled for.
linker = ".."
# custom flags to pass to all compiler invocations that target $triple
# this value overrides build.rustflags when both are present
rustflags = ["..", ".."]

[target.'cfg(...)']
# Similar for the $triple configuration, but using the `cfg` syntax.
# If several `cfg` and $triple targets are candidates, then the rustflags
# are concatenated. The `cfg` syntax only applies to rustflags, and not to
# linker.
rustflags = ["..", ".."]

# Configuration keys related to the registry
[registry]
index = "..."   # URL of the registry index (defaults to the central repository)
token = "..."   # Access token (found on the central repo's website)

[http]
proxy = "host:port" # HTTP proxy to use for HTTP requests (defaults to none)
                    # in libcurl format, e.g. "socks5h://host:port"
timeout = 60000     # Timeout for each HTTP request, in milliseconds
cainfo = "cert.pem" # Path to Certificate Authority (CA) bundle (optional)
check-revoke = true # Indicates whether SSL certs are checked for revocation

[build]
jobs = 1                  # number of parallel jobs, defaults to # of CPUs
rustc = "rustc"           # the rust compiler tool
rustdoc = "rustdoc"       # the doc generator tool
target = "triple"         # build for the target triple
target-dir = "target"     # path of where to place all generated artifacts
rustflags = ["..", ".."]  # custom flags to pass to all compiler invocations

[term]
verbose = false        # whether cargo provides verbose output
color = 'auto'         # whether cargo colorizes output

# Network configuration
[net]
retry = 2 # number of times a network call will automatically retried
```

```
# Alias cargo commands. The first 3 aliases are built in. If your
# command requires grouped whitespace use the list format.
[alias]
b = "build"
t = "test"
r = "run"
rr = "run --release"
space_example = ["run", "--release", "--", "\"command list\""]
```

Environment variables

Cargo can also be configured through environment variables in addition to the TOML syntax above. For each configuration key above of the form `foo.bar` the environment variable `CARGO_FOO_BAR` can also be used to define the value. For example the `build.jobs` key can also be defined by `CARGO_BUILD_JOBS`.

Environment variables will take precedent over TOML configuration, and currently only integer, boolean, and string keys are supported to be defined by environment variables.

In addition to the system above, Cargo recognizes a few other specific environment variables.

1.5

Environment Variables

Cargo sets and reads a number of environment variables which your code can detect or override. Here is a list of the variables Cargo sets, organized by when it interacts with them:

Environment variables Cargo reads

You can override these environment variables to change Cargo's behavior on your system:

- `CARGO_HOME` - Cargo maintains a local cache of the registry index and of git checkouts of crates. By default these are stored under `$HOME/.cargo`, but this variable overrides the location of this directory. Once a crate is cached it is not removed by the clean command.
- `CARGO_TARGET_DIR` - Location of where to place all generated artifacts, relative to the current working directory.
- `RUSTC` - Instead of running `rustc`, Cargo will execute this specified compiler instead.
- `RUSTC_WRAPPER` - Instead of simply running `rustc`, Cargo will execute this specified wrapper instead, passing as its commandline arguments the rustc invocation, with the first argument being rustc.
- `RUSTDOC` - Instead of running `rustdoc`, Cargo will execute this specified `rustdoc` instance instead.
- `RUSTFLAGS` - A space-separated list of custom flags to pass to all compiler invocations that Cargo performs. In contrast with `cargo rustc`, this is useful for passing a flag to *all* compiler instances.

Note that Cargo will also read environment variables for `.cargo/config` configuration values, as described in that documentation

Environment variables Cargo sets for crates

Cargo exposes these environment variables to your crate when it is compiled. Note that this applies for test binaries as well. To get the value of any of these variables in a Rust program, you can use the `env!` macro:

```
let version = env!("CARGO_PKG_VERSION");
```

`version` will now contain the value of `CARGO_PKG_VERSION`.

- `CARGO` - Path to the `cargo` binary performing the build.
- `CARGO_MANIFEST_DIR` - The directory containing the manifest of your package.
- `CARGO_PKG_VERSION` - The full version of your package.

- `CARGO_PKG_VERSION_MAJOR` - The major version of your package.
- `CARGO_PKG_VERSION_MINOR` - The minor version of your package.
- `CARGO_PKG_VERSION_PATCH` - The patch version of your package.
- `CARGO_PKG_VERSION_PRE` - The pre-release version of your package.
- `CARGO_PKG_AUTHORS` - Colon separated list of authors from the manifest of your package.
- `CARGO_PKG_NAME` - The name of your package.
- `CARGO_PKG_DESCRIPTION` - The description of your package.
- `CARGO_PKG_HOMEPAGE` - The home page of your package.
- `OUT_DIR` - If the package has a build script, this is set to the folder where the build script should place its output. See below for more information.

Environment variables Cargo sets for build scripts

Cargo sets several environment variables when build scripts are run. Because these variables are not yet set when the build script is compiled, the above example using `env!` won't work and instead you'll need to retrieve the values when the build script is run:

```
use std::env;
let out_dir = env::var("OUT_DIR").unwrap();
```

`out_dir` will now contain the value of `OUT_DIR`.

- `CARGO_MANIFEST_DIR` - The directory containing the manifest for the package being built (the package containing the build script). Also note that this is the value of the current working directory of the build script when it starts.
- `CARGO_MANIFEST_LINKS` - the manifest `links` value.
- `CARGO_FEATURE_<name>` - For each activated feature of the package being built, this environment variable will be present where `<name>` is the name of the feature uppercased and having `-` translated to `_`.
- `CARGO_CFG_<cfg>` - For each configuration option of the package being built, this environment variable will contain the value of the configuration, where `<cfg>` is the name of the configuration uppercased and having `-` translated to `_`. Boolean configurations are present if they are set, and not present otherwise. Configurations with multiple values are joined to a single variable with the values delimited by `,`.
- `OUT_DIR` - the folder in which all output should be placed. This folder is inside the build directory for the package being built, and it is unique for the package in question.
- `TARGET` - the target triple that is being compiled for. Native code should be compiled for this triple. Some more information about target triples can be found in clang's own documentation.
- `HOST` - the host triple of the rust compiler.
- `NUM_JOBS` - the parallelism specified as the top-level parallelism. This can be useful to pass a `-j` parameter to a system like `make`.
- `OPT_LEVEL`, `DEBUG` - values of the corresponding variables for the profile currently being built.
- `PROFILE` - `release` for release builds, `debug` for other builds.
- `DEP_<name>_<key>` - For more information about this set of environment variables, see build script documentation about `links`.
- `RUSTC`, `RUSTDOC` - the compiler and documentation generator that Cargo has resolved to use, passed to the build script so it might use it as well.

Environment variables Cargo sets for 3rd party subcommands

Cargo exposes this environment variable to 3rd party subcommands (ie. programs named `cargo-foobar` placed in `$PATH`):

- `CARGO` - Path to the `cargo` binary performing the build.

1.6

Build Script Support

Some packages need to compile third-party non-Rust code, for example C libraries. Other packages need to link to C libraries which can either be located on the system or possibly need to be built from source. Others still need facilities for functionality such as code generation before building (think parser generators).

Cargo does not aim to replace other tools that are well-optimized for these tasks, but it does integrate with them with the `build` configuration option.

```
[package]
# ...
build = "build.rs"
```

The Rust file designated by the `build` command (relative to the package root) will be compiled and invoked before anything else is compiled in the package, allowing your Rust code to depend on the built or generated artifacts. Note that there is no default value for `build`, it must be explicitly specified if required.

Some example use cases of the build command are:

- Building a bundled C library.
- Finding a C library on the host system.
- Generating a Rust module from a specification.
- Performing any platform-specific configuration needed for the crate.

Each of these use cases will be detailed in full below to give examples of how the build command works.

Inputs to the Build Script

When the build script is run, there are a number of inputs to the build script, all passed in the form of environment variables.

In addition to environment variables, the build script's current directory is the source directory of the build script's package.

Outputs of the Build Script

All the lines printed to stdout by a build script are written to a file like `target/debug/build/<pkg>/output` (the precise location may depend on your configuration). Any line that starts with `cargo:` is interpreted directly by Cargo. This line must be of the form `cargo:key=value`, like the examples below:

```
# specially recognized by Cargo
cargo:rustc-link-lib=static=foo
cargo:rustc-link-search=native=/path/to/foo
cargo:rustc-cfg=foo
# arbitrary user-defined metadata
cargo:root=/path/to/foo
cargo:libdir=/path/to/foo/lib
cargo:include=/path/to/foo/include
```

There are a few special keys that Cargo recognizes, some affecting how the crate is built:

- `rustc-link-lib=[KIND=]NAME` indicates that the specified value is a library name and should be passed to the compiler as a `-l` flag. The optional `KIND` can be one of `static`, `dylib` (the default), or `framework`, see `rustc --help` for more details.
- `rustc-link-search=[KIND=]PATH` indicates the specified value is a library search path and should be passed to the compiler as a `-L` flag. The optional `KIND` can be one of `dependency`, `crate`, `native`, `framework` or `all` (the default), see `rustc --help` for more details.
- `rustc-flags=FLAGS` is a set of flags passed to the compiler, only `-l` and `-L` flags are supported.
- `rustc-cfg=FEATURE` indicates that the specified feature will be passed as a `--cfg` flag to the compiler. This is often useful for performing compile-time detection of various features.
- `rerun-if-changed=PATH` is a path to a file or directory which indicates that the build script should be re-run if it changes (detected by a more-recent last-modified timestamp on the file). Normally build scripts are re-run if any file inside the crate root changes, but this can be used to scope changes to just a small set of files. (If this path points to a directory the entire directory will not be traversed for changes -- only changes to the timestamp of the directory itself (which corresponds to some types of changes within the directory, depending on platform) will trigger a rebuild. To request a re-run on any changes within an entire directory, print a line for the directory and another line for everything inside it, recursively.)
  Note that if the build script itself (or one of its dependencies) changes, then it's rebuilt and rerun unconditionally, so `cargo:rerun-if-changed=build.rs` is almost always redundant (unless you want to ignore changes in all other files except for `build.rs`).
- `warning=MESSAGE` is a message that will be printed to the main console after a build script has finished running. Warnings are only shown for path dependencies (that is, those you're working on locally), so for example warnings printed out in crates.io crates are not emitted by default.

Any other element is a user-defined metadata that will be passed to dependents. More information about this can be found in the links section.

Build Dependencies

Build scripts are also allowed to have dependencies on other Cargo-based crates. Dependencies are declared through the `build-dependencies` section of the manifest.

```
[build-dependencies]
foo = { git = "https://github.com/your-packages/foo" }
```

The build script **does not** have access to the dependencies listed in the `dependencies` or `dev-dependencies` section (they're not built yet!). All build dependencies will also not be available to the package itself unless explicitly stated as so.

The `links` Manifest Key

In addition to the manifest key `build`, Cargo also supports a `links` manifest key to declare the name of a native library that is being linked to:

```
[package]
# ...
links = "foo"
build = "build.rs"
```

This manifest states that the package links to the `libfoo` native library, and it also has a build script for locating and/or building the library. Cargo requires that a `build` command is specified if a `links` entry is also specified.

The purpose of this manifest key is to give Cargo an understanding about the set of native dependencies that a package has, as well as providing a principled system of passing metadata between package build scripts.

Primarily, Cargo requires that there is at most one package per `links` value. In other words, it's forbidden to have two packages link to the same native library. Note, however, that there are conventions in place to alleviate this.

As mentioned above in the output format, each build script can generate an arbitrary set of metadata in the form of key-value pairs. This metadata is passed to the build scripts of **dependent** packages. For example, if `libbar` depends

on `libfoo`, then if `libfoo` generates `key=value` as part of its metadata, then the build script of `libbar` will have the environment variables `DEP_FOO_KEY=value`.

Note that metadata is only passed to immediate dependents, not transitive dependents. The motivation for this metadata passing is outlined in the linking to system libraries case study below.

Overriding Build Scripts

If a manifest contains a `links` key, then Cargo supports overriding the build script specified with a custom library. The purpose of this functionality is to prevent running the build script in question altogether and instead supply the metadata ahead of time.

To override a build script, place the following configuration in any acceptable Cargo configuration location.

```
[target.x86_64-unknown-linux-gnu.foo]
rustc-link-search = ["/path/to/foo"]
rustc-link-lib = ["foo"]
root = "/path/to/foo"
key = "value"
```

This section states that for the target `x86_64-unknown-linux-gnu` the library named `foo` has the metadata specified. This metadata is the same as the metadata generated as if the build script had run, providing a number of key/value pairs where the `rustc-flags`, `rustc-link-search`, and `rustc-link-lib` keys are slightly special.

With this configuration, if a package declares that it links to `foo` then the build script will **not** be compiled or run, and the metadata specified will instead be used.

Case study: Code generation

Some Cargo packages need to have code generated just before they are compiled for various reasons. Here we'll walk through a simple example which generates a library call as part of the build script.

First, let's take a look at the directory structure of this package:

```
.
  Cargo.toml
  build.rs
  src
      main.rs

1 directory, 3 files
```

Here we can see that we have a `build.rs` build script and our binary in `main.rs`. Next, let's take a look at the manifest:

```
# Cargo.toml

[package]
name = "hello-from-generated-code"
version = "0.1.0"
authors = ["you@example.com"]
build = "build.rs"
```

Here we can see we've got a build script specified which we'll use to generate some code. Let's see what's inside the build script:

```
// build.rs

use std::env;
use std::fs::File;
use std::io::Write;
use std::path::Path;

fn main() {
    let out_dir = env::var("OUT_DIR").unwrap();
```

```
    let dest_path = Path::new(&out_dir).join("hello.rs");
    let mut f = File::create(&dest_path).unwrap();

    f.write_all(b"
        pub fn message() -> &'static str {
            \"Hello, World!\"
        }
    ").unwrap();
}
```

There's a couple of points of note here:

- The script uses the `OUT_DIR` environment variable to discover where the output files should be located. It can use the process' current working directory to find where the input files should be located, but in this case we don't have any input files.
- This script is relatively simple as it just writes out a small generated file. One could imagine that other more fanciful operations could take place such as generating a Rust module from a C header file or another language definition, for example.

Next, let's peek at the library itself:

```
// src/main.rs

include!(concat!(env!("OUT_DIR"), "/hello.rs"));

fn main() {
    println!("{}", message());
}
```

This is where the real magic happens. The library is using the rustc-defined `include!` macro in combination with the `concat!` and `env!` macros to include the generated file (`hello.rs`) into the crate's compilation.

Using the structure shown here, crates can include any number of generated files from the build script itself.

Case study: Building some native code

Sometimes it's necessary to build some native C or C++ code as part of a package. This is another excellent use case of leveraging the build script to build a native library before the Rust crate itself. As an example, we'll create a Rust library which calls into C to print "Hello, World!".

Like above, let's first take a look at the project layout:

```
.
  Cargo.toml
  build.rs
  src
      hello.c
      main.rs

1 directory, 4 files
```

Pretty similar to before! Next, the manifest:

```
# Cargo.toml

[package]
name = "hello-world-from-c"
version = "0.1.0"
authors = ["you@example.com"]
build = "build.rs"
```

For now we're not going to use any build dependencies, so let's take a look at the build script now:

```
// build.rs

use std::process::Command;
use std::env;
use std::path::Path;

fn main() {
    let out_dir = env::var("OUT_DIR").unwrap();

    // note that there are a number of downsides to this approach, the comments
    // below detail how to improve the portability of these commands.
    Command::new("gcc").args(&["src/hello.c", "-c", "-fPIC", "-o"])
                       .arg(&format!("{}/hello.o", out_dir))
                       .status().unwrap();
    Command::new("ar").args(&["crus", "libhello.a", "hello.o"])
                      .current_dir(&Path::new(&out_dir))
                      .status().unwrap();

    println!("cargo:rustc-link-search=native={}", out_dir);
    println!("cargo:rustc-link-lib=static=hello");
}
```

This build script starts out by compiling our C file into an object file (by invoking `gcc`) and then converting this object file into a static library (by invoking `ar`). The final step is feedback to Cargo itself to say that our output was in `out_dir` and the compiler should link the crate to `libhello.a` statically via the `-l static=hello` flag.

Note that there are a number of drawbacks to this hardcoded approach:

- The `gcc` command itself is not portable across platforms. For example it's unlikely that Windows platforms have `gcc`, and not even all Unix platforms may have `gcc`. The `ar` command is also in a similar situation.
- These commands do not take cross-compilation into account. If we're cross compiling for a platform such as Android it's unlikely that `gcc` will produce an ARM executable.

Not to fear, though, this is where a `build-dependencies` entry would help! The Cargo ecosystem has a number of packages to make this sort of task much easier, portable, and standardized. For example, the build script could be written as:

```
// build.rs

// Bring in a dependency on an externally maintained `gcc` package which manages
// invoking the C compiler.
extern crate gcc;

fn main() {
    gcc::compile_library("libhello.a", &["src/hello.c"]);
}
```

Add a build time dependency on the `gcc` crate with the following addition to your `Cargo.toml`:

```
[build-dependencies]
gcc = "0.3"
```

The gcc crate abstracts a range of build script requirements for C code:

- It invokes the appropriate compiler (MSVC for windows, `gcc` for MinGW, `cc` for Unix platforms, etc.).
- It takes the `TARGET` variable into account by passing appropriate flags to the compiler being used.
- Other environment variables, such as `OPT_LEVEL`, `DEBUG`, etc., are all handled automatically.
- The stdout output and `OUT_DIR` locations are also handled by the `gcc` library.

Here we can start to see some of the major benefits of farming as much functionality as possible out to common build dependencies rather than duplicating logic across all build scripts!

Back to the case study though, let's take a quick look at the contents of the `src` directory:

```
// src/hello.c

#include <stdio.h>

void hello() {
    printf("Hello, World!\n");
}
```

```
// src/main.rs

// Note the lack of the `#[link]` attribute. We're delegating the responsibility
// of selecting what to link to over to the build script rather than hardcoding
// it in the source file.
extern { fn hello(); }

fn main() {
    unsafe { hello(); }
}
```

And there we go! This should complete our example of building some C code from a Cargo package using the build script itself. This also shows why using a build dependency can be crucial in many situations and even much more concise!

We've also seen a brief example of how a build script can use a crate as a dependency purely for the build process and not for the crate itself at runtime.

Case study: Linking to system libraries

The final case study here will be investigating how a Cargo library links to a system library and how the build script is leveraged to support this use case.

Quite frequently a Rust crate wants to link to a native library often provided on the system to bind its functionality or just use it as part of an implementation detail. This is quite a nuanced problem when it comes to performing this in a platform-agnostic fashion, and the purpose of a build script is again to farm out as much of this as possible to make this as easy as possible for consumers.

As an example to follow, let's take a look at one of Cargo's own dependencies, libgit2. This library has a number of constraints:

- It has an optional dependency on OpenSSL on Unix to implement the https transport.
- It has an optional dependency on libssh2 on all platforms to implement the ssh transport.
- It is often not installed on all systems by default.
- It can be built from source using `cmake`.

To visualize what's going on here, let's take a look at the manifest for the relevant Cargo package.

```
[package]
name = "libgit2-sys"
version = "0.1.0"
authors = ["..."]
links = "git2"
build = "build.rs"

[dependencies]
libssh2-sys = { git = "https://github.com/alexcrichton/ssh2-rs" }

[target.'cfg(unix)'.dependencies]
```

```
openssl-sys = { git = "https://github.com/alexcrichton/openssl-sys" }

# ...
```

As the above manifests show, we've got a `build` script specified, but it's worth noting that this example has a `links` entry which indicates that the crate (`libgit2-sys`) links to the `git2` native library.

Here we also see the unconditional dependency on `libssh2` via the `libssh2-sys` crate, as well as a platform-specific dependency on `openssl-sys` for *nix (other variants elided for now). It may seem a little counterintuitive to express *C dependencies* in the *Cargo manifest*, but this is actually using one of Cargo's conventions in this space.

`*-sys` Packages

To alleviate linking to system libraries, Cargo has a *convention* of package naming and functionality. Any package named `foo-sys` will provide two major pieces of functionality:

- The library crate will link to the native library `libfoo`. This will often probe the current system for `libfoo` before resorting to building from source.
- The library crate will provide **declarations** for functions in `libfoo`, but it does **not** provide bindings or higher-level abstractions.

The set of `*-sys` packages provides a common set of dependencies for linking to native libraries. There are a number of benefits earned from having this convention of native-library-related packages:

- Common dependencies on `foo-sys` alleviates the above rule about one package per value of `links`.
- A common dependency allows centralizing logic on discovering `libfoo` itself (or building it from source).
- These dependencies are easily overridable.

Building libgit2

Now that we've got libgit2's dependencies sorted out, we need to actually write the build script. We're not going to look at specific snippets of code here and instead only take a look at the high-level details of the build script of `libgit2-sys`. This is not recommending all packages follow this strategy, but rather just outlining one specific strategy.

The first step of the build script should do is to query whether libgit2 is already installed on the host system. To do this we'll leverage the preexisting tool `pkg-config` (when its available). We'll also use a `build-dependencies` section to refactor out all the `pkg-config` related code (or someone's already done that!).

If `pkg-config` failed to find libgit2, or if `pkg-config` just wasn't installed, the next step is to build libgit2 from bundled source code (distributed as part of `libgit2-sys` itself). There are a few nuances when doing so that we need to take into account, however:

- The build system of libgit2, `cmake`, needs to be able to find libgit2's optional dependency of libssh2. We're sure we've already built it (it's a Cargo dependency), we just need to communicate this information. To do this we leverage the metadata format to communicate information between build scripts. In this example the libssh2 package printed out `cargo:root=...` to tell us where libssh2 is installed at, and we can then pass this along to cmake with the `CMAKE_PREFIX_PATH` environment variable.
- We'll need to handle some `CFLAGS` values when compiling C code (and tell `cmake` about this). Some flags we may want to pass are `-m64` for 64-bit code, `-m32` for 32-bit code, or `-fPIC` for 64-bit code as well.
- Finally, we'll invoke `cmake` to place all output into the `OUT_DIR` environment variable, and then we'll print the necessary metadata to instruct rustc how to link to libgit2.

Most of the functionality of this build script is easily refactorable into common dependencies, so our build script isn't quite as intimidating as this description! In reality it's expected that build scripts are quite succinct by farming logic such as above to build dependencies.

1.7

Publishing on crates.io

Once you've got a library that you'd like to share with the world, it's time to publish it on crates.io! Publishing a crate is when a specific version is uploaded to be hosted on crates.io.

Take care when publishing a crate, because a publish is **permanent**. The version can never be overwritten, and the code cannot be deleted. There is no limit to the number of versions which can be published, however.

Before your first publish

First thing's first, you'll need an account on crates.io to acquire an API token. To do so, visit the home page and log in via a GitHub account (required for now). After this, visit your Account Settings page and run the `cargo login` command specified.

```
$ cargo login abcdefghijklmnopqrstuvwxyz012345
```

This command will inform Cargo of your API token and store it locally in your `~/.cargo/config`. Note that this token is a **secret** and should not be shared with anyone else. If it leaks for any reason, you should regenerate it immediately.

Before publishing a new crate

Keep in mind that crate names on crates.io are allocated on a first-come-first- serve basis. Once a crate name is taken, it cannot be used for another crate.

Packaging a crate The next step is to package up your crate into a format that can be uploaded to crates.io. For this we'll use the `cargo package` subcommand. This will take our entire crate and package it all up into a `*.crate` file in the `target/package` directory.

```
$ cargo package
```

As an added bonus, the `*.crate` will be verified independently of the current source tree. After the `*.crate` is created, it's unpacked into `target/package` and then built from scratch to ensure that all necessary files are there for the build to succeed. This behavior can be disabled with the `--no-verify` flag.

Now's a good time to take a look at the `*.crate` file to make sure you didn't accidentally package up that 2GB video asset, or large data files used for code generation, integration tests, or benchmarking. There is currently a 10MB upload size limit on `*.crate` files. So, if the size of `tests` and `benches` directories and their dependencies are up to a couple of MBs, you can keep them in your package; otherwsie, better to exclude them.

Cargo will automatically ignore files ignored by your version control system when packaging, but if you want to specify an extra set of files to ignore you can use the `exclude` key in the manifest:

```
[package]
# ...
exclude = [
    "public/assets/*",
    "videos/*",
]
```

The syntax of each element in this array is what rust-lang/glob accepts. If you'd rather roll with a whitelist instead of a blacklist, Cargo also supports an `include` key, which if set, overrides the `exclude` key:

```
[package]
# ...
include = [
    "**/*.rs",
    "Cargo.toml",
]
```

Uploading the crate

Now that we've got a `*.crate` file ready to go, it can be uploaded to crates.io with the `cargo publish` command. And that's it, you've now published your first crate!

```
$ cargo publish
```

If you'd like to skip the `cargo package` step, the `cargo publish` subcommand will automatically package up the local crate if a copy isn't found already.

Be sure to check out the metadata you can specify to ensure your crate can be discovered more easily!

Publishing a new version of an existing crate

In order to release a new version, change the `version` value specified in your `Cargo.toml` manifest. Keep in mind the semver rules. Then optionally run `cargo package` if you want to inspect the `*.crate` file for the new version before publishing, and run `cargo publish` to upload the new version.

Managing a crates.io-based crate

Management of crates is primarily done through the command line `cargo` tool rather than the crates.io web interface. For this, there are a few subcommands to manage a crate.

`cargo yank` Occasions may arise where you publish a version of a crate that actually ends up being broken for one reason or another (syntax error, forgot to include a file, etc.). For situations such as this, Cargo supports a "yank" of a version of a crate.

```
$ cargo yank --vers 1.0.1
$ cargo yank --vers 1.0.1 --undo
```

A yank **does not** delete any code. This feature is not intended for deleting accidentally uploaded secrets, for example. If that happens, you must reset those secrets immediately.

The semantics of a yanked version are that no new dependencies can be created against that version, but all existing dependencies continue to work. One of the major goals of crates.io is to act as a permanent archive of crates that does not change over time, and allowing deletion of a version would go against this goal. Essentially a yank means that all projects with a `Cargo.lock` will not break, while any future `Cargo.lock` files generated will not list the yanked version.

`cargo owner` A crate is often developed by more than one person, or the primary maintainer may change over time! The owner of a crate is the only person allowed to publish new versions of the crate, but an owner may designate additional owners.

```
$ cargo owner --add my-buddy
$ cargo owner --remove my-buddy
$ cargo owner --add github:rust-lang:owners
$ cargo owner --remove github:rust-lang:owners
```

The owner IDs given to these commands must be GitHub user names or GitHub teams.

If a user name is given to `--add`, that user becomes a "named" owner, with full rights to the crate. In addition to being able to publish or yank versions of the crate, they have the ability to add or remove owners, *including* the owner that made *them* an owner. Needless to say, you shouldn't make people you don't fully trust into a named owner. In order to become a named owner, a user must have logged into crates.io previously.

If a team name is given to `--add`, that team becomes a "team" owner, with restricted right to the crate. While they have permission to publish or yank versions of the crate, they *do not* have the ability to add or remove owners. In addition to being more convenient for managing groups of owners, teams are just a bit more secure against owners becoming malicious.

The syntax for teams is currently `github:org:team` (see examples above). In order to add a team as an owner one must be a member of that team. No such restriction applies to removing a team as an owner.

GitHub permissions

Team membership is not something GitHub provides simple public access to, and it is likely for you to encounter the following message when working with them:

> *It looks like you don't have permission to query a necessary property from GitHub to complete this request. You may need to re-authenticate on crates.io to grant permission to read GitHub org memberships. Just go to https://crates.io/login*

This is basically a catch-all for "you tried to query a team, and one of the five levels of membership access control denied this". That is not an exaggeration. GitHub's support for team access control is Enterprise Grade.

The most likely cause of this is simply that you last logged in before this feature was added. We originally requested *no* permissions from GitHub when authenticating users, because we didn't actually ever use the user's token for anything other than logging them in. However to query team membership on your behalf, we now require the `read:org` scope.

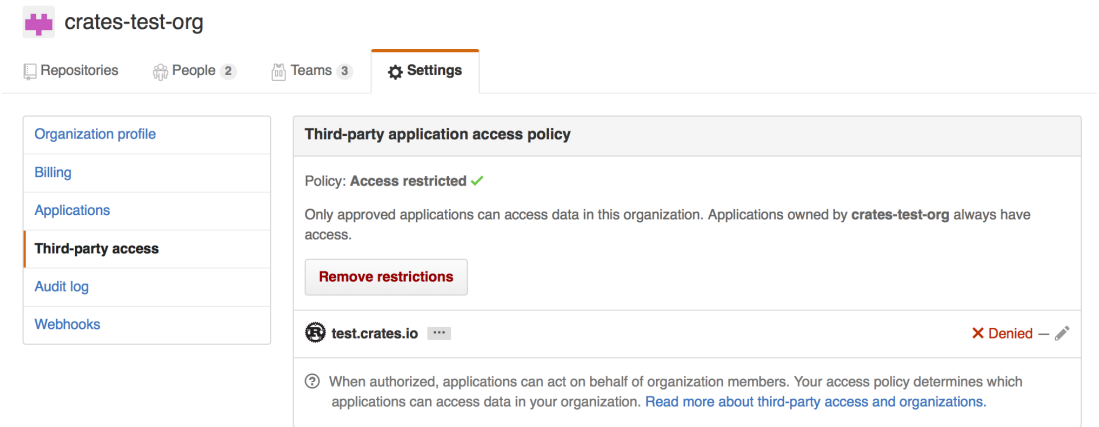
You are free to deny us this scope, and everything that worked before teams were introduced will keep working. However you will never be able to add a team as an owner, or publish a crate as a team owner. If you ever attempt to do this, you will get the error above. You may also see this error if you ever try to publish a crate that you don't own at all, but otherwise happens to have a team.

If you ever change your mind, or just aren't sure if crates.io has sufficient permission, you can always go to https://crates.io/login, which will prompt you for permission if crates.io doesn't have all the scopes it would like to.

An additional barrier to querying GitHub is that the organization may be actively denying third party access. To check this, you can go to:

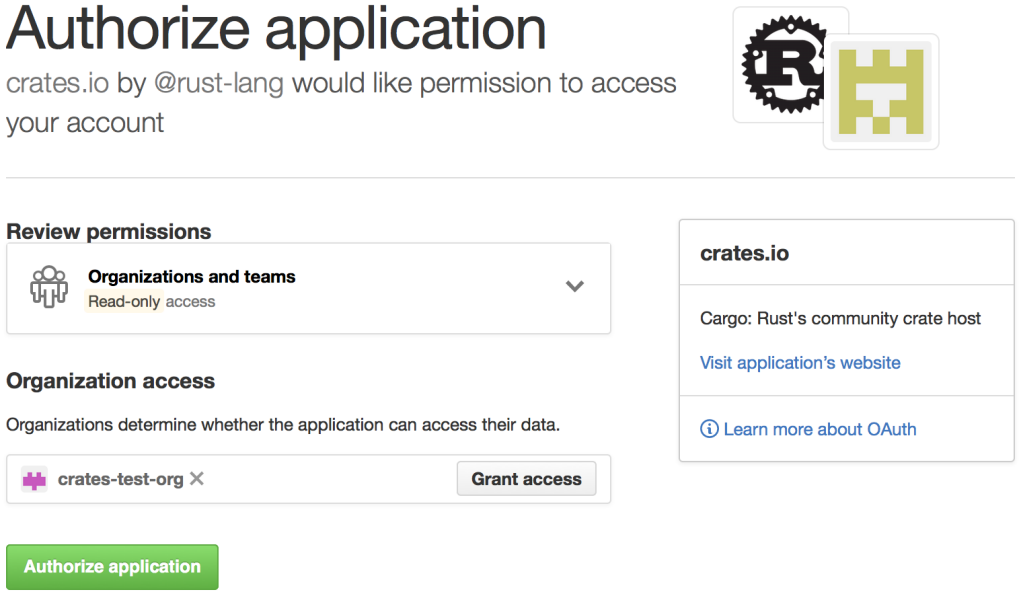
```
https://github.com/organizations/:org/settings/oauth_application_policy
```

where `:org` is the name of the organization (e.g. rust-lang). You may see something like:



Where you may choose to explicitly remove crates.io from your organization's blacklist, or simply press the "Remove Restrictions" button to allow all third party applications to access this data.

Alternatively, when crates.io requested the `read:org` scope, you could have explicitly whitelisted crates.io querying the org in question by pressing the "Grant Access" button next to its name:



1.8

Package ID Specifications

Package ID specifications

Subcommands of Cargo frequently need to refer to a particular package within a dependency graph for various operations like updating, cleaning, building, etc. To solve this problem, Cargo supports Package ID Specifications. A specification is a string which is used to uniquely refer to one package within a graph of packages.

Specification grammar The formal grammar for a Package Id Specification is:

```
pkgid := pkgname
       | [ proto "://" ] hostname-and-path [ "#" ( pkgname | semver ) ]
pkgname := name [ ":" semver ]

proto := "http" | "git" | ...
```

Here, brackets indicate that the contents are optional.

Example specifications These could all be references to a package `foo` version `1.2.3` from the registry at `crates.io`

pkgid	name	version	url
`foo`	foo	*	*
`foo:1.2.3`	foo	1.2.3	*
`crates.io/foo`	foo	*	*://crates.io/foo
`crates.io/foo#1.2.3`	foo	1.2.3	*://crates.io/foo
`crates.io/bar#foo:1.2.3`	foo	1.2.3	*://crates.io/bar
`http://crates.io/foo#1.2.3`	foo	1.2.3	http://crates.io/foo

Brevity of specifications The goal of this is to enable both succinct and exhaustive syntaxes for referring to packages in a dependency graph. Ambiguous references may refer to one or more packages. Most commands generate an error if more than one package could be referred to with the same specification.

1.9

Replacing sources

Cargo supports the ability to **replace one source with another** to express strategies along the lines of mirrors or vendoring dependencies. Configuration is currently done through the `.cargo/config` configuration mechanism, like so:

```
# The `source` table is where all keys related to source-replacement
# are stored.
[source]

# Under the `source` table are a number of other tables whose keys are a
# name for the relevant source. For example this section defines a new
# source, called `my-awesome-source`, which comes from a directory
# located at `vendor` relative to the directory containing this `.cargo/config`
# file
[source.my-awesome-source]
directory = "vendor"

# The crates.io default source for crates is available under the name
# "crates-io", and here we use the `replace-with` key to indicate that it's
# replaced with our source above.
[source.crates-io]
replace-with = "my-awesome-source"
```

With this configuration Cargo attempts to look up all crates in the directory "vendor" rather than querying the online registry at crates.io. Using source replacement Cargo can express:

- Vendoring - custom sources can be defined which represent crates on the local filesystem. These sources are subsets of the source that they're replacing and can be checked into projects if necessary.
- Mirroring - sources can be replaced with an equivalent version which acts as a cache for crates.io itself.

Cargo has a core assumption about source replacement that the source code is exactly the same from both sources. In our above example Cargo assumes that all of the crates coming from `my-awesome-source` are the exact same as the copies from `crates-io`. Note that this also means that `my-awesome-source` is not allowed to have crates which are not present in the `crates-io` source.

As a consequence, source replacement is not appropriate for situations such as patching a dependency or a private registry. Cargo supports patching dependencies through the usage of the `[replace]` key, and private registry support is planned for a future version of Cargo.

Configuration

Configuration of replacement sources is done through `.cargo/config` and the full set of available keys are:

```
# Each source has its own table where the key is the name of the source
[source.the-source-name]

# Indicate that `the-source-name` will be replaced with `another-source`,
# defined elsewhere
replace-with = "another-source"

# Available kinds of sources that can be specified (described below)
registry = "https://example.com/path/to/index"
local-registry = "path/to/registry"
directory = "path/to/vendor"
```

The `crates-io` represents the crates.io online registry (default source of crates) and can be replaced with:

```
[source.crates-io]
replace-with = 'another-source'
```

Registry Sources

A "registry source" is one that is the same as crates.io itself. That is, it has an index served in a git repository which matches the format of the crates.io index. That repository then has configuration indicating where to download crates from.

Currently there is not an already-available project for setting up a mirror of crates.io. Stay tuned though!

Local Registry Sources

A "local registry source" is intended to be a subset of another registry source, but available on the local filesystem (aka vendoring). Local registries are downloaded ahead of time, typically sync'd with a `Cargo.lock`, and are made up of a set of `*.crate` files and an index like the normal registry is.

The primary way to manage and crate local registry sources is through the `cargo-local-registry` subcommand, available on crates.io and can be installed with `cargo install cargo-local-registry`.

Local registries are contained within one directory and contain a number of `*.crate` files downloaded from crates.io as well as an `index` directory with the same format as the crates.io-index project (populated with just entries for the crates that are present).

Directory Sources

A "directory source" is similar to a local registry source where it contains a number of crates available on the local filesystem, suitable for vendoring dependencies. Also like local registries, directory sources can primarily be managed by an external subcommand, `cargo-vendor`, which can be installed with `cargo install cargo-vendor`.

Directory sources are distinct from local registries though in that they contain the unpacked version of `*.crate` files, making it more suitable in some situations to check everything into source control. A directory source is just a directory containing a number of other directories which contain the source code for crates (the unpacked version of `*.crate` files). Currently no restriction is placed on the name of each directory.

Each crate in a directory source also has an associated metadata file indicating the checksum of each file in the crate to protect against accidental modifications.

1.10

External tools

One of the goals of Cargo is simple integration with third-party tools, like IDEs and other build systems. To make integration easier, Cargo has several facilities:

- `cargo metadata` command, which outputs project structure and dependencies information in JSON,
- `--message-format` flag, which outputs information about a particular build,
- support for custom subcommands.

Information about project structure

You can use `cargo metadata` command to get information about project structure and dependencies. The output of the command looks like this:

```
{
  // Integer version number of the format.
  "version": integer,

  // List of packages for this workspace, including dependencies.
  "packages": [
    {
      // Opaque package identifier.
```

```
      "id": PackageId,

      "name": string,

      "version": string,

      "source": SourceId,

      // A list of declared dependencies, see `resolve` field for actual dependencies.
      "dependencies": [ Dependency ],

      "targets: [ Target ],

      // Path to Cargo.toml
      "manifest_path": string,
    }
  ],

  "workspace_members": [ PackageId ],

  // Dependencies graph.
  "resolve": {
     "nodes": [
       {
         "id": PackageId,
         "dependencies": [ PackageId ]
       }
     ]
  }
}
```

The format is stable and versioned. When calling `cargo metadata`, you should pass `--format-version` flag explicitly to avoid forward incompatibility hazard.

If you are using Rust, there is cargo_metadata crate.

Information about build

When passing `--message=format=json`, Cargo will output the following information during the build:

- compiler errors and warnings,
- produced artifacts,
- results of the build scripts (for example, native dependencies).

The output goes to stdout in the JSON object per line format. The `reason` field distinguishes different kinds of messages.

Information about dependencies in the Makefile-compatible format is stored in the `.d` files alongside the artifacts.

Custom subcommands.

Cargo is designed to be extensible with new subcommands without having to modify Cargo itself. This is achieved by translating a cargo invocation of the form cargo `(?<command>[^ ]+)` into an invocation of an external tool `cargo-${command}` that then needs to be present in one of the user's `$PATH` directories.

Custom subcommand may use `CARGO` environment variable to call back to Cargo. Alternatively, it can link to `cargo` crate as a library, but this approach has drawbacks:

- Cargo as a library is unstable, API changes without deprecation,
- versions of Cargo library and Cargo binary may be different.

1.11

Crates.io package policies

In general, these policies are guidelines. Problems are often contextual, and exceptional circumstances sometimes require exceptional measures. We plan to continue to clarify and expand these rules over time as new circumstances arise. If your problem is not described below, consider sending us an email.

Package Ownership

We have a first-come, first-served policy on crate names. Upon publishing a package, the publisher will be made owner of the package on Crates.io.

If someone wants to take over a package, and the previous owner agrees, the existing maintainer can add them as an owner, and the new maintainer can remove them. If necessary, the team may reach out to inactive maintainers and help mediate the process of ownership transfer.

Removal

Many questions are specialized instances of a more general form: "Under what circumstances can a package be removed from Crates.io?"

The short version is that packages are first-come, first-served, and we won't attempt to get into policing what exactly makes a legitimate package. We will do what the law requires us to do, and address flagrant violations of the Rust Code of Conduct.

Squatting

We do not have any policies to define 'squatting', and so will not hand over ownership of a package for that reason.

The Law

For issues such as DMCA violations, trademark and copyright infringement, Crates.io will respect Mozilla Legal's decisions with regards to content that is hosted.

Code of Conduct

The Rust project has a Code of Conduct which governs appropriate conduct for the Rust community. In general, any content on Crates.io that violates the Code of Conduct may be removed. There are two important, related aspects:

- We will not be pro-actively monitoring the site for these kinds of violations, but relying on the community to draw them to our attention.
- "Does this violate the Code of Conduct" is a contextual question that cannot be directly answered in the hypothetical sense. All of the details must be taken into consideration in these kinds of situations.

Part IV

FAQ

Chapter 1

1.1 Frequently Asked Questions

Is the plan to use GitHub as a package repository?

No. The plan for Cargo is to use crates.io, like npm or Rubygems do with npmjs.org and rubygems.org.

We plan to support git repositories as a source of packages forever, because they can be used for early development and temporary patches, even when people use the registry as the primary source of packages.

Why build crates.io rather than use GitHub as a registry?

We think that it's very important to support multiple ways to download packages, including downloading from GitHub and copying packages into your project itself.

That said, we think that crates.io offers a number of important benefits, and will likely become the primary way that people download packages in Cargo.

For precedent, both Node.js's npm and Ruby's bundler support both a central registry model as well as a Git-based model, and most packages are downloaded through the registry in those ecosystems, with an important minority of packages making use of git-based packages.

Some of the advantages that make a central registry popular in other languages include:

- **Discoverability**. A central registry provides an easy place to look for existing packages. Combined with tagging, this also makes it possible for a registry to provide ecosystem-wide information, such as a list of the most popular or most-depended-on packages.

- **Speed**. A central registry makes it possible to easily fetch just the metadata for packages quickly and efficiently, and then to efficiently download just the published package, and not other bloat that happens to exist in the repository. This adds up to a significant improvement in the speed of dependency resolution and fetching. As dependency graphs scale up, downloading all of the git repositories bogs down fast. Also remember that not everybody has a high-speed, low-latency Internet connection.

Will Cargo work with C code (or other languages)?

Yes!

Cargo handles compiling Rust code, but we know that many Rust projects link against C code. We also know that there are decades of tooling built up around compiling languages other than Rust.

Our solution: Cargo allows a package to specify a script (written in Rust) to run before invoking `rustc`. Rust is leveraged to implement platform-specific configuration and refactor out common build functionality among packages.

Can Cargo be used inside of `make` (or `ninja`, or ...)

Indeed. While we intend Cargo to be useful as a standalone way to compile Rust projects at the top-level, we know that some people will want to invoke Cargo from other build tools.

We have designed Cargo to work well in those contexts, paying attention to things like error codes and machine-readable output modes. We still have some work to do on those fronts, but using Cargo in the context of conventional scripts is something we designed for from the beginning and will continue to prioritize.

Does Cargo handle multi-platform projects or cross-compilation?

Rust itself provides facilities for configuring sections of code based on the platform. Cargo also supports platform-specific dependencies, and we plan to support more per-platform configuration in `Cargo.toml` in the future.

In the longer-term, we're looking at ways to conveniently cross-compile projects using Cargo.

Does Cargo support environments, like `production` or `test`?

We support environments through the use of profiles to support:

- environment-specific flags (like `-g --opt-level=0` for development and `--opt-level=3` for production).
- environment-specific dependencies (like `hamcrest` for test assertions).
- environment-specific `#[cfg]`
- a `cargo test` command

Does Cargo work on Windows?

Yes!

All commits to Cargo are required to pass the local test suite on Windows. If, however, you find a Windows issue, we consider it a bug, so please file an issue.

Why do binaries have `Cargo.lock` in version control, but not libraries?

The purpose of a `Cargo.lock` is to describe the state of the world at the time of a successful build. It is then used to provide deterministic builds across whatever machine is building the project by ensuring that the exact same dependencies are being compiled.

This property is most desirable from applications and projects which are at the very end of the dependency chain (binaries). As a result, it is recommended that all binaries check in their `Cargo.lock`.

For libraries the situation is somewhat different. A library is not only used by the library developers, but also any downstream consumers of the library. Users dependent on the library will not inspect the library's `Cargo.lock` (even if it exists). This is precisely because a library should **not** be deterministically recompiled for all users of the library.

If a library ends up being used transitively by several dependencies, it's likely that just a single copy of the library is desired (based on semver compatibility). If all libraries were to check in their `Cargo.lock`, then multiple copies of the library would be used, and perhaps even a version conflict.

In other words, libraries specify semver requirements for their dependencies but cannot see the full picture. Only end products like binaries have a full picture to decide what versions of dependencies should be used.

Can libraries use `*` as a version for their dependencies?

As of January 22nd, 2016, crates.io rejects all packages (not just libraries) with wildcard dependency constraints.

While libraries *can*, strictly speaking, they should not. A version requirement of `*` says "This will work with every version ever," which is never going to be true. Libraries should always specify the range that they do work with, even if it's something as general as "every 1.x.y version."

Why `Cargo.toml`?

As one of the most frequent interactions with Cargo, the question of why the configuration file is named `Cargo.toml` arises from time to time. The leading capital-`C` was chosen to ensure that the manifest was grouped with other similar configuration files in directory listings. Sorting files often puts capital letters before lowercase letters, ensuring files like `Makefile` and `Cargo.toml` are placed together. The trailing `.toml` was chosen to emphasize the fact that the file is in the TOML configuration format.

Cargo does not allow other names such as `cargo.toml` or `Cargofile` to emphasize the ease of how a Cargo repository can be identified. An option of many possible names has historically led to confusion where one case was handled but others were accidentally forgotten.

How can Cargo work offline?

Cargo is often used in situations with limited or no network access such as airplanes, CI environments, or embedded in large production deployments. Users are often surprised when Cargo attempts to fetch resources from the network, and hence the request for Cargo to work offline comes up frequently.

Cargo, at its heart, will not attempt to access the network unless told to do so. That is, if no crates comes from crates.io, a git repository, or some other network location, Cargo will never attempt to make a network connection. As a result, if Cargo attempts to touch the network, then it's because it needs to fetch a required resource.

Cargo is also quite aggressive about caching information to minimize the amount of network activity. It will guarantee, for example, that if `cargo build` (or an equivalent) is run to completion then the next `cargo build` is guaranteed to not touch the network so long as `Cargo.toml` has not been modified in the meantime. This avoidance of the network boils down to a `Cargo.lock` existing and a populated cache of the crates reflected in the lock file. If either of these components are missing, then they're required for the build to succeed and must be fetched remotely.

As of Rust 1.11.0 Cargo understands a new flag, `--frozen`, which is an assertion that it shouldn't touch the network. When passed, Cargo will immediately return an error if it would otherwise attempt a network request. The error should include contextual information about why the network request is being made in the first place to help debug as well. Note that this flag *does not change the behavior of Cargo*, it simply asserts that Cargo shouldn't touch the network as a previous command has been run to ensure that network activity shouldn't be necessary.

For more information about vendoring, see documentation on source replacement.