The Cargo Book

Cargo is the Rust *package manager*. Cargo downloads your Rust package's dependencies, compiles your packages, makes distributable packages, and uploads them to crates.io, the Rust community's *package registry*. You can contribute to this book on GitHub.

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To get started with Cargo, install Cargo (and Rust) and set up your first *crate*.

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Getting Started

To get started with Cargo, install Cargo (and Rust) and set up your first *crate*.

- Installation
- First steps with Cargo

Installation

Install Rust and Cargo

The easiest way to get Cargo is to install the current stable release of Rust by using rustup. Installing Rust using `rustup` will also install `cargo`.

On Linux and macOS systems, this is done as follows:

```
curl https://sh.rustup.rs -sSf | sh
```

It will download a script, and start the installation. If everything goes well, you'll see this appear:

```
Rust is installed now. Great!
```

On Windows, download and run rustup-init.exe. It will start the installation in a console and present the above message on success.

After this, you can use the `rustup` command to also install `beta` or `nightly` channels for Rust and Cargo.

For other installation options and information, visit the install page of the Rust website.

Build and Install Cargo from Source

Alternatively, you can build Cargo from source.

First Steps with Cargo

This section provides a quick sense for the `cargo` command line tool. We demonstrate its ability to generate a new ***package*** for us, its ability to compile the ***crate*** within the package, and its ability to run the resulting program.

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

```
$ cargo new hello_world
```

Cargo defaults to `--bin` to make a binary program. To make a library, we would pass `--lib`, instead.

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"
edition = "2021"

[dependencies]
```

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

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

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

Cargo generated a "hello world" program for us, otherwise known as a ***binary crate***. Let's compile it:

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

Going further

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

Cargo Guide

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

- Why Cargo Exists
- Creating a New Package
- Working on an Existing Cargo Package
- Dependencies
- Package Layout
- Cargo.toml vs Cargo.lock
- Tests
- Continuous Integration
- Cargo Home
- Build Cache

Why Cargo Exists

Preliminaries

In Rust, as you may know, a library or executable program is called a *crate*. Crates are compiled using the Rust compiler, `rustc`. When starting with Rust, the first source code most people encounter is that of the venerable "hello world" program, which they compile by invoking `rustc` directly:

```
$ rustc hello.rs
$ ./hello
Hello, world!
```

Note that the above command required that we specify the file name explicitly. If we were to directly use `rustc` to compile a different program, a different command line invocation would be required. If we needed to specify any specific compiler flags or include external dependencies, then the needed command would be even more specific (and elaborate).

Furthermore, most non-trivial programs will likely have dependencies on external libraries, and will therefore also depend transitively on *their* dependencies. Obtaining the correct versions of all the necessary dependencies and keeping them up to date would be laborious and error-prone if done by hand.

Rather than work only with crates and `rustc`, we can avoid the manual tedium involved with performing the above tasks by introducing a higher-level *"package"* abstraction and by using a *package manager*.

Enter: Cargo

Cargo is the Rust package manager. It is a tool that allows Rust *packages* 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 package information.
- Fetches and builds your package's dependencies.
- Invokes `rustc` or another build tool with the correct parameters to build your package.
- Introduces conventions to make working with Rust packages easier.

To a large extent, Cargo normalizes the commands needed to build a given program or library; this is one aspect to the above mentioned conventions. As we show later, the same command can be used to build different *artifacts*, regardless of their names. Rather than invoke `rustc` directly, we can instead invoke something generic such as `cargo build` and let cargo worry about constructing the correct `rustc` invocation. Furthermore, Cargo will automatically fetch from a *registry* any dependencies we have defined for our artifact, and arrange for them to be incorporated into our build as needed.

It is only a slight exaggeration to say that once you know how to build one Cargo-based project, you know how to build *all* of them.

Creating a New Package

To start a new package 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 pass `--lib`. 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
```

Let's take a closer look at `Cargo.toml`:

```
[package]
name = "hello_world"
version = "0.1.0"
edition = "2021"

[dependencies]
```

This is called a ***manifest***, and it contains all of the metadata that Cargo needs to compile your package. This file is written in the TOML format (pronounced /tɑməl/).

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

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

Cargo generated a "hello world" program for us, otherwise known as a *binary crate*. Let's compile it:

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

You'll now notice a new file, `Cargo.lock`. It contains information about our dependencies. Since we don't have any yet, it's not very interesting.

Once you're ready for release, 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/package/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.

Working on an Existing Cargo Package

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

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

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

To build, use `cargo build`:

```
$ cargo build
   Compiling regex v1.5.0 (file:///path/to/package/regex)
```

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

Dependencies

crates.io is the Rust community's central *package registry* 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:

```toml
[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:

```toml
[package]
name = "hello_world"
version = "0.1.0"
edition = "2021"

[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 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/package/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 in `main.rs`.

```rust
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
```

Package Layout

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

```
.
├── Cargo.lock
├── Cargo.toml
├── src/
│   ├── lib.rs
│   ├── main.rs
│   └── bin/
│       ├── named-executable.rs
│       ├── another-executable.rs
│       └── multi-file-executable/
│           ├── main.rs
│           └── some_module.rs
├── benches/
│   ├── large-input.rs
│   └── multi-file-bench/
│       ├── main.rs
│       └── bench_module.rs
├── examples/
│   ├── simple.rs
│   └── multi-file-example/
│       ├── main.rs
│       └── ex_module.rs
└── tests/
    ├── some-integration-tests.rs
    └── multi-file-test/
        ├── main.rs
        └── test_module.rs
```

- `Cargo.toml` and `Cargo.lock` are stored in the root of your package (*package root*).
- 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/`.
- Benchmarks go in the `benches` directory.
- Examples go in the `examples` directory.
- Integration tests go in the `tests` directory.

If a binary, example, bench, or integration test consists of multiple source files, place a `main.rs` file along with the extra *modules* within a subdirectory of the `src/bin`, `examples`, `benches`, or `tests` directory. The name of the executable will be the directory name.

You can learn more about Rust's module system in the book.

See Configuring a target for more details on manually configuring targets. See Target auto-discovery for more information on controlling how Cargo automatically infers target names.

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 non-end product, such as a rust library that other rust packages will depend on, put `Cargo.lock` in your `.gitignore`. If you're building an end product, which are executable like command-line tool or an application, or a system library with crate-type of `staticlib` or `cdylib`, 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 package. For example, we can say that we depend on another package:

```
[package]
name = "hello_world"
version = "0.1.0"

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

This package has a single dependency, on the `regex` 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 package.

Sound good? Well, there's one problem: If you build this package today, and then you send a copy to me, and I build this package tomorrow, something bad could happen. There could be more commits to `regex` 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 defining a specific `rev` value in our `Cargo.toml`, so Cargo could know exactly which revision to use when building the package:

```
[dependencies]
regex = { git = "https://github.com/rust-lang/regex.git", rev = "9f9f693" }
```

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"

[dependencies]
regex = { git = "https://github.com/rust-lang/regex.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:

```
[[package]]
name = "hello_world"
version = "0.1.0"
dependencies = [
 "regex 1.5.0 (git+https://github.com/rust-lang/regex.git#9f9f693768c584971a4d53bc3c586c33ed3a6831)",
]

[[package]]
name = "regex"
version = "1.5.0"
source = "git+https://github.com/rust-lang/regex.git#9f9f693768c584971a4d53bc3c586c33ed3a6831"
```

You can see that there's a lot more information here, including the exact revision we used to build. Now when you give your package 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 regex  # updates just "regex"
```

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 `regex` is just a short specification.

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 documentation tests. 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 package, which currently has no tests:

```
$ cargo test
   Compiling regex v1.5.0 (https://github.com/rust-lang/regex.git#9f9f693)
   Compiling hello_world v0.1.0 (file:///path/to/package/hello_world)
     Running target/test/hello_world-9c2b65bbb79eabce

running 0 tests

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

If our package 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. It will compile any examples you've included to ensure they still compile. It also runs documentation tests to ensure your code samples from documentation comments compile. Please see the testing guide in the Rust documentation for a general view of writing and organizing tests. See Cargo Targets: Tests to learn more about different styles of tests in Cargo.

Continuous Integration

Travis CI

To test your package 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.

GitHub Actions

To test your package on GitHub Actions, here is a sample `.github/workflows/ci.yml` file:

```
name: Cargo Build & Test

on:
  push:
  pull_request:

env:
  CARGO_TERM_COLOR: always

jobs:
  build_and_test:
    name: Rust project - latest
    runs-on: ubuntu-latest
    strategy:
      matrix:
        toolchain:
          - stable
          - beta
          - nightly
    steps:
      - uses: actions/checkout@v3
      - run: rustup update ${{ matrix.toolchain }} && rustup default ${{ matrix.toolchain }}
      - run: cargo build --verbose
      - run: cargo test --verbose
```

This will test all three release channels (note a failure in any toolchain version will fail the entire job). You can also click `"Actions" > "new workflow"` in the GitHub UI and select Rust to add the default configuration to your repo. See GitHub Actions documentation for more information.

GitLab CI

To test your package on GitLab CI, here is a sample `.gitlab-ci.yml` file:

```
stages:
  - build

rust-latest:
  stage: build
  image: rust:latest
  script:
    - cargo build --verbose
    - cargo test --verbose

rust-nightly:
  stage: build
  image: rustlang/rust:nightly
  script:
    - cargo build --verbose
    - cargo test --verbose
  allow_failure: true
```

This will test on the stable channel and nightly channel, but any breakage in nightly will not fail your overall build. Please see the GitLab CI documentation for more information.

builds.sr.ht

To test your package on sr.ht, here is a sample `.build.yml` file. Be sure to change `<your repo>` and `<your project>` to the repo to clone and the directory where it was cloned.

```yaml
image: archlinux
packages:
  - rustup
sources:
  - <your repo>
tasks:
  - setup: |
      rustup toolchain install nightly stable
      cd <your project>/
      rustup run stable cargo fetch
  - stable: |
      rustup default stable
      cd <your project>/
      cargo build --verbose
      cargo test --verbose
  - nightly: |
      rustup default nightly
      cd <your project>/
      cargo build --verbose ||:
      cargo test --verbose  ||:
  - docs: |
      cd <your project>/
      rustup run stable cargo doc --no-deps
      rustup run nightly cargo doc --no-deps ||:
```

This will test and build documentation on the stable channel and nightly channel, but any breakage in nightly will not fail your overall build. Please see the builds.sr.ht documentation for more information.

Cargo Home

The "Cargo home" functions as a download and source cache. When building a crate, Cargo stores downloaded build dependencies in the Cargo home. You can alter the location of the Cargo home by setting the `CARGO_HOME` environmental variable. The home crate provides an API for getting this location if you need this information inside your Rust crate. By default, the Cargo home is located in `$HOME/.cargo/`.

Please note that the internal structure of the Cargo home is not stabilized and may be subject to change at any time.

The Cargo home consists of following components:

Files:

- `config.toml` Cargo's global configuration file, see the config entry in the reference.
- `credentials.toml` Private login credentials from `cargo login` in order to log in to a registry.
- `.crates.toml`, `.crates2.json` These hidden files contain package information of crates installed via `cargo install`. Do NOT edit by hand!

Directories:

- `bin` The bin directory contains executables of crates that were installed via `cargo install` or `rustup`. To be able to make these binaries accessible, add the path of the directory to your `$PATH` environment variable.
- `git` Git sources are stored here:
  - `git/db` When a crate depends on a git repository, Cargo clones the repo as a bare repo into this directory and updates it if necessary.
  - `git/checkouts` If a git source is used, the required commit of the repo is checked out from the bare repo inside `git/db` into this directory. This provides the compiler with the actual files contained in the repo of the commit specified for that dependency. Multiple checkouts of different commits of the same repo are possible.
- `registry` Packages and metadata of crate registries (such as crates.io) are located here.

- `registry/index` The index is a bare git repository which contains the metadata (versions, dependencies etc) of all available crates of a registry.
- `registry/cache` Downloaded dependencies are stored in the cache. The crates are compressed gzip archives named with a `.crate` extension.
- `registry/src` If a downloaded `.crate` archive is required by a package, it is unpacked into `registry/src` folder where rustc will find the `.rs` files.

Caching the Cargo home in CI

To avoid redownloading all crate dependencies during continuous integration, you can cache the `$CARGO_HOME` directory. However, caching the entire directory is often inefficient as it will contain downloaded sources twice. If we depend on a crate such as `serde 1.0.92` and cache the entire `$CARGO_HOME` we would actually cache the sources twice, the `serde-1.0.92.crate` inside `registry/cache` and the extracted `.rs` files of serde inside `registry/src`. That can unnecessarily slow down the build as downloading, extracting, recompressing and reuploading the cache to the CI servers can take some time.

If you wish to cache binaries installed with `cargo install`, you need to cache the `bin/` folder and the `.crates.toml` and `.crates2.json` files.

It should be sufficient to cache the following files and directories across builds:

- `.crates.toml`
- `.crates2.json`
- `bin/`
- `registry/index/`
- `registry/cache/`
- `git/db/`

Vendoring all dependencies of a project

See the `cargo vendor` subcommand.

Clearing the cache

In theory, you can always remove any part of the cache and Cargo will do its best to restore sources if a crate needs them either by reextracting an archive or checking out a bare repo or by simply redownloading the sources from the web.

Alternatively, the cargo-cache crate provides a simple CLI tool to only clear selected parts of the cache or show sizes of its components in your command-line.

Build cache

Cargo stores the output of a build into the “target” directory. By default, this is the directory named `target` in the root of your *workspace*. To change the location, you can set the `CARGO_TARGET_DIR` environment variable, the `build.target-dir` config value, or the `--target-dir` command-line flag.

The directory layout depends on whether or not you are using the `--target` flag to build for a specific platform. If `--target` is not specified, Cargo runs in a mode where it builds for the host architecture. The output goes into the root of the target directory, with each profile stored in a separate subdirectory:

Directory	Description
`target/debug/`	Contains output for the `dev` profile.
`target/release/`	Contains output for the `release` profile (with the `--release` option).
`target/foo/`	Contains build output for the `foo` profile (with the `--profile=foo` option).

For historical reasons, the `dev` and `test` profiles are stored in the `debug` directory, and the `release` and `bench` profiles are stored in the `release` directory. User-defined profiles are stored in a directory with the same name as the profile.

When building for another target with `--target`, the output is placed in a directory with the name of the target:

Directory	Example
`target/<triple>/debug/`	`target/thumbv7em-none-eabihf/debug/`
`target/<triple>/release/`	`target/thumbv7em-none-eabihf/release/`

> **Note**: When not using `--target`, this has a consequence that Cargo will share your dependencies with build scripts and proc macros. `RUSTFLAGS` will be shared with every `rustc` invocation. With the `--target` flag, build scripts and proc macros are built separately (for the host architecture), and do not share `RUSTFLAGS`.

Within the profile directory (such as `debug` or `release`), artifacts are placed into the following directories:

Directory	Description
`target/debug/`	Contains the output of the package being built (the binary executables and library targets).

Directory	Description
`target/debug/examples/`	Contains example targets.

Some commands place their output in dedicated directories in the top level of the `target` directory:

Directory	Description
`target/doc/`	Contains rustdoc documentation (`cargo doc`).
`target/package/`	Contains the output of the `cargo package` and `cargo publish` commands.

Cargo also creates several other directories and files needed for the build process. Their layout is considered internal to Cargo, and is subject to change. Some of these directories are:

Directory	Description
`target/debug/deps/`	Dependencies and other artifacts.
`target/debug/incremental/`	`rustc` incremental output, a cache used to speed up subsequent builds.
`target/debug/build/`	Output from build scripts.

Dep-info files

Next to each compiled artifact is a file called a “dep info” file with a `.d` suffix. This file is a Makefile-like syntax that indicates all of the file dependencies required to rebuild the artifact. These are intended to be used with external build systems so that they can detect if Cargo needs to be re-executed. The paths in the file are absolute by default. See the `build.dep-info-basedir` config option to use relative paths.

```
# Example dep-info file found in target/debug/foo.d
/path/to/myproj/target/debug/foo: /path/to/myproj/src/lib.rs /path/to/myproj/src/main.rs
```

Shared cache

A third party tool, sccache, can be used to share built dependencies across different workspaces.

To setup `sccache`, install it with `cargo install sccache` and set `RUSTC_WRAPPER` environmental variable to `sccache` before invoking Cargo. If you use bash, it makes sense to add `export RUSTC_WRAPPER=sccache` to `.bashrc`. Alternatively, you can set `build.rustc-wrapper` in the Cargo configuration. Refer to sccache documentation for more details.

Cargo Reference

The reference covers the details of various areas of Cargo.

Specifying Dependencies

Your crates can depend on other libraries from crates.io or other registries, `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 version requirement. Although it looks like a specific *version* of the `time` crate, it actually specifies a *range* of versions and allows SemVer compatible updates. 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 should update us to version `0.1.13` if it is the latest `0.1.z` release, but would not update us to `0.2.0`. If instead we had specified the version string as `1.0`, cargo should update to `1.1` if it is the latest `1.y` release, but not `2.0`. The version `0.0.x` is not considered compatible with any other version.

Here are some more examples of version 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
0.2    :=  >=0.2.0, <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
```

This compatibility convention is different from SemVer in the way it treats versions before 1.0.0. While SemVer says there is no compatibility before 1.0.0, Cargo considers `0.x.y` to be compatible with `0.x.z`, where `y ≥ z` and `x > 0`.

It is possible to further tweak the logic for selecting compatible versions using special operators, though it shouldn't be necessary most of the time.

Caret requirements

Caret requirements are an alternative syntax for the default strategy, `^1.2.3` is exactly equivalent to `1.2.3`.

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
```

> **Note**: crates.io does not allow bare `*` versions.

Comparison requirements

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

Here are some examples of comparison requirements:

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

Multiple requirements

As shown in the examples above, multiple version requirements can be separated with a comma, e.g., `>= 1.2, < 1.5`.

Specifying dependencies from other registries

To specify a dependency from a registry other than crates.io, first the registry must be configured in a `.cargo/config.toml` file. See the registries documentation for more information. In the dependency, set the `registry` key to the name of the registry to use.

```toml
[dependencies]
some-crate = { version = "1.0", registry = "my-registry" }
```

> **Note**: crates.io does not allow packages to be published with dependencies on other registries.

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:

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

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 — for example, specifying a member crate name of a workspace and setting `git` to the repository containing the workspace).

Since we haven’t specified any other information, Cargo assumes that we intend to use the latest commit on the main branch to build our package. 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`:

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

Anything that is not a branch or tag falls under `rev`. This can be a commit hash like `rev = "4c59b707"`, or a named reference exposed by the remote repository such as `rev = "refs/pull/493/head"`. What references are available varies by where the repo is hosted; GitHub in particular exposes a reference to the most recent commit of every pull request as shown, but other git hosts often provide something equivalent, possibly under a different naming scheme.

Once a `git` dependency has been added, Cargo will lock that dependency to the latest commit at the time. New commits will not be pulled down automatically once the lock is in place. However, they can be pulled down manually with `cargo update`.

See Git Authentication for help with git authentication for private repos.

> **Note**: crates.io does not allow packages to be published with `git` dependencies (`git` dev-dependencies are ignored). See the Multiple locations section for a fallback alternative.

Specifying path dependencies

Over time, our `hello_world` package 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` package:

```
# 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 and specify its version in the dependencies line as well:

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

> **Note**: crates.io does not allow packages to be published with `path` dependencies (`path` dev-dependencies are ignored). See the Multiple locations section for a fallback alternative.

Multiple locations

It is possible to specify both a registry version and a `git` or `path` location. The `git` or `path` dependency will be used locally (in which case the `version` is checked against the local copy), and when published to a registry like crates.io, it will use the registry version. Other combinations are not allowed. Examples:

```
[dependencies]
# Uses `my-bitflags` when used locally, and uses
# version 1.0 from crates.io when published.
bitflags = { path = "my-bitflags", version = "1.0" }

# Uses the given git repo when used locally, and uses
# version 1.0 from crates.io when published.
smallvec = { git = "https://github.com/servo/rust-smallvec.git", version = "1.0" }

# N.B. that if a version doesn't match, Cargo will fail to compile!
```

One example where this can be useful is when you have split up a library into multiple packages within the same workspace. You can then use `path` dependencies to point to the local packages within the workspace to use the local version during development, and then use the crates.io version once it is published. This is similar to specifying an override, but only applies to this one dependency declaration.

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-i686 = { path = "native/i686" }

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

Like with Rust, the syntax here supports the `not`, `any`, and `all` operators to combine various cfg name/value pairs.

If you want to know which cfg targets are available on your platform, run `rustc --print=cfg` from the command line. If you want to know which `cfg` targets are available for another platform, such as 64-bit Windows, run `rustc --print=cfg --target=x86_64-pc-windows-msvc`.

Unlike in your Rust source code, you cannot use `[target.'cfg(feature = "fancy-feature")'.dependencies]` to add dependencies based on optional features. Use the `[features]` section instead:

```
[dependencies]
foo = { version = "1.0", optional = true }
bar = { version = "1.0", optional = true }

[features]
fancy-feature = ["foo", "bar"]
```

The same applies to `cfg(debug_assertions)`, `cfg(test)` and `cfg(proc_macro)`. These values will not work as expected and will always have the default value returned by `rustc --print=cfg`. There is currently no way to add dependencies based on these configuration values.

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"
```

Custom target specifications

If you're using a custom target specification (such as `--target foo/bar.json`), use the base filename without the `.json` extension:

```
[target.bar.dependencies]
winhttp = "0.4.0"

[target.my-special-i686-platform.dependencies]
openssl = "1.0.1"
native = { path = "native/i686" }
```

> **Note**: Custom target specifications are not usable on the stable channel.

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"
```

> **Note**: When a package is published, only dev-dependencies that specify a `version` will be included in the published crate. For most use cases, dev-dependencies are not needed when published, though some users (like OS packagers) may want to run tests within a crate, so providing a `version` if possible can still be beneficial.

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]
cc = "1.0.3"
```

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

```
[target.'cfg(unix)'.build-dependencies]
cc = "1.0.3"
```

In this case, the dependency will only be built when the host platform matches the specified target.

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 features chapter.

Renaming dependencies in `Cargo.toml`

When writing a `[dependencies]` section in `Cargo.toml` the key you write for a dependency typically matches up to the name of the crate you import from in the code. For some projects, though, you may wish to reference the crate with a different name in the code regardless of how it's published on crates.io. For example you may wish to:

- Avoid the need to `use foo as bar` in Rust source.
- Depend on multiple versions of a crate.
- Depend on crates with the same name from different registries.

To support this Cargo supports a `package` key in the `[dependencies]` section of which package should be depended on:

```
[package]
name = "mypackage"
version = "0.0.1"

[dependencies]
foo = "0.1"
bar = { git = "https://github.com/example/project.git", package = "foo" }
baz = { version = "0.1", registry = "custom", package = "foo" }
```

In this example, three crates are now available in your Rust code:

```
extern crate foo; // crates.io
extern crate bar; // git repository
extern crate baz; // registry `custom`
```

All three of these crates have the package name of `foo` in their own `Cargo.toml`, so we're explicitly using the `package` key to inform Cargo that we want the `foo` package even though we're calling it something else locally. The `package` key, if not specified, defaults to the name of the dependency being requested.

Note that if you have an optional dependency like:

```
[dependencies]
bar = { version = "0.1", package = 'foo', optional = true }
```

you're depending on the crate `foo` from crates.io, but your crate has a `bar` feature instead of a `foo` feature. That is, names of features take after the name of the dependency, not the package name, when renamed.

Enabling transitive dependencies works similarly, for example we could add the following to the above manifest:

```
[features]
log-debug = ['bar/log-debug'] # using 'foo/log-debug' would be an error!
```

Inheriting a dependency from a workspace

Dependencies can be inherited from a workspace by specifying the dependency in the workspace's `[workspace.dependencies]` table. After that, add it to the `[dependencies]` table with `workspace = true`.

Along with the `workspace` key, dependencies can also include these keys:

- `optional`: Note that the `[workspace.dependencies]` table is not allowed to specify `optional`.
- `features`: These are additive with the features declared in the `[workspace.dependencies]`

Other than `optional` and `features`, inherited dependencies cannot use any other dependency key (such as `version` or `default-features`).

Dependencies in the `[dependencies]`, `[dev-dependencies]`, `[build-dependencies]`, and `[target."...".dependencies]` sections support the ability to reference the `[workspace.dependencies]` definition of dependencies.

```
[package]
name = "bar"
version = "0.2.0"

[dependencies]
regex = { workspace = true, features = ["unicode"] }

[build-dependencies]
cc.workspace = true

[dev-dependencies]
rand = { workspace = true, optional = true }
```

Overriding Dependencies

The desire to override a dependency can arise through a number of scenarios. Most of them, however, boil down to the ability 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 package 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 can be solved with the `[patch]` manifest section.

This chapter walks through a few different use cases, and includes details on the different ways to override a dependency.

> **Note**: See also specifying a dependency with multiple locations, which can be used to override the source for a single dependency declaration in a local package.

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 to fix the bug! Originally your manifest will look like:

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

[dependencies]
uuid = "1.0"
```

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

```
$ git clone https://github.com/uuid-rs/uuid.git
```

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 package.

Next up we need to ensure that our lock file is updated to use this new version of `uuid` so our package 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 (.../uuid)
   Compiling my-library v0.1.0 (.../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 path in parentheses in the build output). If you don't see the local path 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/uuid-rs/uuid.git' }
```

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"

[dependencies]
uuid = "1.0.1"

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

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 noting that `[patch]` applies *transitively*. Let's say you use `my-library` in a larger package, such as:

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

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

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

Remember that `[patch]` is applicable *transitively* but can only be defined 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.

Overriding repository URL

In case the dependency you want to override isn't loaded from `crates.io`, you'll have to change a bit how you use `[patch]`. For example, if the dependency is a git dependency, you can override it to a local path with:

```
[patch."https://github.com/your/repository"]
my-library = { path = "../my-library/path" }
```

And that's it!

Prepublishing a breaking change

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/uuid-rs/uuid.git", 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"

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

[patch.crates-io]
uuid = { git = 'https://github.com/uuid-rs/uuid.git', branch = '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 forced to update everything all at once.

Using `[patch]` with multiple versions

You can patch in multiple versions of the same crate with the `package` key used to rename dependencies. For example let's say that the `serde` crate has a bugfix that we'd like to use to its `1.*` series but we'd also like to prototype using a `2.0.0` version of serde we have in our git repository. To configure this we'd do:

```
[patch.crates-io]
serde = { git = 'https://github.com/serde-rs/serde.git' }
serde2 = { git = 'https://github.com/example/serde.git', package = 'serde', branch = 'v2' }
```

The first `serde = ...` directive indicates that serde `1.*` should be used from the git repository (pulling in the bugfix we need) and the second `serde2 = ...` directive indicates that the `serde` package should also be pulled from the `v2` branch of `https://github.com/example/serde`. We're assuming here that `Cargo.toml` on that branch mentions version `2.0.0`.

Note that when using the `package` key the `serde2` identifier here is actually ignored. We simply need a unique name which doesn't conflict with other patched crates.

The `[patch]` section

The `[patch]` 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.git' }
bar = { path = 'my/local/bar' }

[dependencies.baz]
git = 'https://github.com/example/baz.git'

[patch.'https://github.com/example/baz']
baz = { git = 'https://github.com/example/patched-baz.git', branch = 'my-branch' }
```

> **Note**: The `[patch]` table can also be specified as a configuration option, such as in a `.cargo/config.toml` file or a CLI option like `--config 'patch.crates-io.rand.path="rand"'`. This can be useful for local-only changes that you don't want to commit, or temporarily testing a patch.

The `[patch]` table is made of dependency-like sub-tables. Each key after `[patch]` is a URL of the source that is being patched, or the name of a registry. The name `crates-io` may be used to override the default registry crates.io. The first `[patch]` in the example above demonstrates overriding crates.io, and the second `[patch]` demonstrates overriding a git source.

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. It also patches the `https://github.com/example/baz` source with a `my-branch` that comes from elsewhere.

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.

Cargo only looks at the patch settings in the `Cargo.toml` manifest at the root of the workspace. Patch settings defined in dependencies will be ignored.

The `[replace]` section

> **Note:** `[replace]` is deprecated. You should use the `[patch]` table instead.

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.git' }
"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 3-part version number is required). 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).

Cargo only looks at the replace settings in the `Cargo.toml` manifest at the root of the workspace. Replace settings defined in dependencies will be ignored.

`paths` overrides

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.toml` instead of `Cargo.toml`. Inside of `.cargo/config.toml` 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.

The Manifest Format

The `Cargo.toml` file for each package is called its *manifest*. It is written in the TOML format. It contains metadata that is needed to compile the package. Checkout the `cargo locate-project` section for more detail on how cargo finds the manifest file.

Every manifest file consists of the following sections:

- `cargo-features` — Unstable, nightly-only features.
- `[package]` — Defines a package.
  - `name` — The name of the package.
  - `version` — The version of the package.
  - `authors` — The authors of the package.
  - `edition` — The Rust edition.
  - `rust-version` — The minimal supported Rust version.
  - `description` — A description of the package.
  - `documentation` — URL of the package documentation.
  - `readme` — Path to the package's README file.
  - `homepage` — URL of the package homepage.
  - `repository` — URL of the package source repository.
  - `license` — The package license.
  - `license-file` — Path to the text of the license.
  - `keywords` — Keywords for the package.
  - `categories` — Categories of the package.
  - `workspace` — Path to the workspace for the package.
  - `build` — Path to the package build script.
  - `links` — Name of the native library the package links with.
  - `exclude` — Files to exclude when publishing.
  - `include` — Files to include when publishing.
  - `publish` — Can be used to prevent publishing the package.
  - `metadata` — Extra settings for external tools.
  - `default-run` — The default binary to run by `cargo run`.
  - `autobins` — Disables binary auto discovery.
  - `autoexamples` — Disables example auto discovery.
  - `autotests` — Disables test auto discovery.
  - `autobenches` — Disables bench auto discovery.
  - `resolver` — Sets the dependency resolver to use.
- Target tables: (see configuration for settings)
  - `[lib]` — Library target settings.
  - `[[bin]]` — Binary target settings.
  - `[[example]]` — Example target settings.
  - `[[test]]` — Test target settings.
  - `[[bench]]` — Benchmark target settings.
- Dependency tables:

    - `[dependencies]` — Package library dependencies.
    - `[dev-dependencies]` — Dependencies for examples, tests, and benchmarks.
    - `[build-dependencies]` — Dependencies for build scripts.
    - `[target]` — Platform-specific dependencies.
- `[badges]` — Badges to display on a registry.
- `[features]` — Conditional compilation features.
- `[patch]` — Override dependencies.
- `[replace]` — Override dependencies (deprecated).
- `[profile]` — Compiler settings and optimizations.
- `[workspace]` — The workspace definition.

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 = ["Alice <a@example.com>", "Bob <b@example.com>"]
```

The only fields required by Cargo are `name` and `version`. If publishing to a registry, the registry may require additional fields. See the notes below and the publishing chapter for requirements for publishing to crates.io.

The `name` field

The package name is an identifier used to refer to the package. It is used when listed as a dependency in another package, and as the default name of inferred lib and bin targets.

The name must use only alphanumeric characters or `-` or `_`, and cannot be empty.

Note that `cargo new` and `cargo init` impose some additional restrictions on the package name, such as enforcing that it is a valid Rust identifier and not a keyword. crates.io imposes even more restrictions, such as:

- Only ASCII characters are allowed.
- Do not use reserved names.
- Do not use special Windows names such as "nul".
- Use a maximum of 64 characters of length.

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 patch-level 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.

See the Resolver chapter for more information on how Cargo uses versions to resolve dependencies, and for guidelines on setting your own version. See the SemVer compatibility chapter for more details on exactly what constitutes a breaking change.

The `authors` field

The optional `authors` field lists in an array the people or organizations that are considered the "authors" of the package. The exact meaning is open to interpretation — it may list the original or primary authors, current maintainers, or owners of the package. An optional email address may be included within angled brackets at the end of each author entry.

```
[package]
# ...
authors = ["Graydon Hoare", "Fnu Lnu <no-reply@rust-lang.org>"]
```

This field is only surfaced in package metadata and in the `CARGO_PKG_AUTHORS` environment variable within `build.rs`. It is not displayed in the crates.io user interface.

> **Warning**: Package manifests cannot be changed once published, so this field cannot be changed or removed in already-published versions of a package.

The `edition` field

The `edition` key is an optional key that affects which Rust Edition your package is compiled with. Setting the `edition` key in `[package]` will affect all targets/crates in the package, including test suites, benchmarks, binaries, examples, etc.

```
[package]
# ...
edition = '2021'
```

Most manifests have the `edition` field filled in automatically by `cargo new` with the latest stable edition. By default `cargo new` creates a manifest with the 2021 edition currently.

If the `edition` field is not present in `Cargo.toml`, then the 2015 edition is assumed for backwards compatibility. Note that all manifests created with `cargo new` will not use this historical fallback because they will have `edition` explicitly specified to a newer value.

The `rust-version` field

The `rust-version` field is an optional key that tells cargo what version of the Rust language and compiler your package can be compiled with. If the currently selected version of the Rust compiler is older than the stated version, cargo will exit with an error, telling the user what version is required.

The first version of Cargo that supports this field was released with Rust 1.56.0. In older releases, the field will be ignored, and Cargo will display a warning.

```
[package]
# ...
rust-version = "1.56"
```

The Rust version must be a bare version number with two or three components; it cannot include semver operators or pre-release identifiers. Compiler pre-release identifiers such as -nightly will be ignored while checking the Rust version. The `rust-version` must be equal to or newer than the version that first introduced the configured `edition`.

The `rust-version` may be ignored using the `--ignore-rust-version` option.

Setting the `rust-version` key in `[package]` will affect all targets/crates in the package, including test suites, benchmarks, binaries, examples, etc.

The `description` field

The description is a short blurb about the package. crates.io will display this with your package. This should be plain text (not Markdown).

```
[package]
# ...
description = "A short description of my package"
```

> **Note**: crates.io requires the `description` to be set.

The `documentation` field

The `documentation` 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.

```toml
[package]
# ...
documentation = "https://docs.rs/bitflags"
```

The `readme` field

The `readme` field should be the path to a file in the package root (relative to this `Cargo.toml`) that contains general information about the package. This file will be transferred to the registry when you publish. crates.io will interpret it as Markdown and render it on the crate's page.

```toml
[package]
# ...
readme = "README.md"
```

If no value is specified for this field, and a file named `README.md`, `README.txt` or `README` exists in the package root, then the name of that file will be used. You can suppress this behavior by setting this field to `false`. If the field is set to `true`, a default value of `README.md` will be assumed.

The `homepage` field

The `homepage` field should be a URL to a site that is the home page for your package.

```toml
[package]
# ...
homepage = "https://serde.rs/"
```

The `repository` field

The `repository` field should be a URL to the source repository for your package.

```toml
[package]
# ...
repository = "https://github.com/rust-lang/cargo/"
```

The `license` and `license-file` fields

The `license` field contains the name of the software license that the package is released under. The `license-file` field contains the path to a file containing the text of the license (relative to this `Cargo.toml`).

crates.io interprets the `license` field as an SPDX 2.1 license expression. The name must be a known license from the SPDX license list 3.11. Parentheses are not currently supported. See the SPDX site for more information.

SPDX license expressions support AND and OR operators to combine multiple licenses.[1]

```toml
[package]
# ...
license = "MIT OR Apache-2.0"
```

Using `OR` indicates the user may choose either license. Using `AND` indicates the user must comply with both licenses simultaneously. The `WITH` operator indicates a license with a special exception. Some examples:

- `MIT OR Apache-2.0`
- `LGPL-2.1-only AND MIT AND BSD-2-Clause`
- `GPL-2.0-or-later WITH Bison-exception-2.2`

If a package is using a nonstandard license, then the `license-file` field may be specified in lieu of the `license` field.

```toml
[package]
# ...
license-file = "LICENSE.txt"
```

> **Note**: crates.io requires either `license` or `license-file` to be set.

---

[1] Previously multiple licenses could be separated with a `/`, but that usage is deprecated.

The `keywords` field

The `keywords` field is an array of strings that describe this package. This can help when searching for the package on a registry, and you may choose any words that would help someone find this crate.

```toml
[package]
# ...
keywords = ["gamedev", "graphics"]
```

> **Note**: crates.io has a maximum of 5 keywords. Each keyword must be ASCII text, start with a letter, and only contain letters, numbers, `_` or `-`, and have at most 20 characters.

The `categories` field

The `categories` field is an array of strings of the categories this package belongs to.

```toml
categories = ["command-line-utilities", "development-tools::cargo-plugins"]
```

> **Note:** crates.io has a maximum of 5 categories. Each category should match one of the strings available at https://crates.io/category_slugs, and must match exactly.

The `workspace` field

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. Setting this is useful if the member is not inside a subdirectory of the workspace root.

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

This field cannot be specified if the manifest already has a `[workspace]` table defined. 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`).

For more information, see the workspaces chapter.

The `build` field

The `build` field specifies a file in the package root which is a build script for building native code. More information can be found in the build script guide.

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

The default is `"build.rs"`, which loads the script from a file named `build.rs` in the root of the package. Use `build = "custom_build_name.rs"` to specify a path to a different file or `build = false` to disable automatic detection of the build script.

The `links` field

The `links` field specifies the name of a native library that is being linked to. More information can be found in the `links` section of the build script guide.

For example, a crate that links a native library called “git2” (e.g. `libgit2.a` on Linux) may specify:

```
[package]
# ...
links = "git2"
```

The `exclude` and `include` fields

The `exclude` and `include` fields can be used to explicitly specify which files are included when packaging a project to be published, and certain kinds of change tracking (described below). The patterns specified in the `exclude` field identify a set of files that are not included, and the patterns in `include` specify files that are explicitly included. You may run `cargo package --list` to verify which files will be included in the package.

```toml
[package]
# ...
exclude = ["/ci", "images/", ".*"]
```

```toml
[package]
# ...
include = ["/src", "COPYRIGHT", "/examples", "!/examples/big_example"]
```

The default if neither field is specified is to include all files from the root of the package, except for the exclusions listed below.

If `include` is not specified, then the following files will be excluded:

- If the package is not in a git repository, all "hidden" files starting with a dot will be skipped.
- If the package is in a git repository, any files that are ignored by the gitignore rules of the repository and global git configuration will be skipped.

Regardless of whether `exclude` or `include` is specified, the following files are always excluded:

- Any sub-packages will be skipped (any subdirectory that contains a `Cargo.toml` file).
- A directory named `target` in the root of the package will be skipped.

The following files are always included:

- The `Cargo.toml` file of the package itself is always included, it does not need to be listed in `include`.
- A minimized `Cargo.lock` is automatically included if the package contains a binary or example target, see `cargo package` for more information.
- If a `license-file` is specified, it is always included.

The options are mutually exclusive; setting `include` will override an `exclude`. If you need to have exclusions to a set of `include` files, use the `!` operator described below.

The patterns should be gitignore-style patterns. Briefly:

- `foo` matches any file or directory with the name `foo` anywhere in the package. This is equivalent to the pattern `**/foo`.

- `/foo` matches any file or directory with the name `foo` only in the root of the package.
- `foo/` matches any *directory* with the name `foo` anywhere in the package.
- Common glob patterns like `*`, `?`, and `[]` are supported:
  - `*` matches zero or more characters except `/`. For example, `*.html` matches any file or directory with the `.html` extension anywhere in the package.
  - `?` matches any character except `/`. For example, `foo?` matches `food`, but not `foo`.
  - `[]` allows for matching a range of characters. For example, `[ab]` matches either `a` or `b`. `[a-z]` matches letters a through z.
- `**/` prefix matches in any directory. For example, `**/foo/bar` matches the file or directory `bar` anywhere that is directly under directory `foo`.
- `/**` suffix matches everything inside. For example, `foo/**` matches all files inside directory `foo`, including all files in subdirectories below `foo`.
- `/**/` matches zero or more directories. For example, `a/**/b` matches `a/b`, `a/x/b`, `a/x/y/b`, and so on.
- `!` prefix negates a pattern. For example, a pattern of `src/*.rs` and `!foo.rs` would match all files with the `.rs` extension inside the `src` directory, except for any file named `foo.rs`.

The include/exclude list is also used for change tracking in some situations. For targets built with `rustdoc`, it is used to determine the list of files to track to determine if the target should be rebuilt. If the package has a build script that does not emit any `rerun-if-*` directives, then the include/exclude list is used for tracking if the build script should be re-run if any of those files change.

The `publish` field

The `publish` field can be used to prevent a package from being published to a package registry (like *crates.io*) by mistake, for instance to keep a package private in a company.

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

The value may also be an array of strings which are registry names that are allowed to be published to.

```toml
[package]
# ...
publish = ["some-registry-name"]
```

If publish array contains a single registry, `cargo publish` command will use it when `--registry` flag is not specified.

The `metadata` table

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 package 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"
```

There is a similar table at the workspace level at `workspace.metadata`. While cargo does not specify a format for the content of either of these tables, it is suggested that external tools may wish to use them in a consistent fashion, such as referring to the data in `workspace.metadata` if data is missing from `package.metadata`, if that makes sense for the tool in question.

The `default-run` field

The `default-run` field in the `[package]` section of the manifest can be used to specify a default binary picked by `cargo run`. For example, when there is both `src/bin/a.rs` and `src/bin/b.rs`:

```
[package]
default-run = "a"
```

The `[badges]` section

The `[badges]` section is for specifying status badges that can be displayed on a registry website when the package is published.

> Note: crates.io previously displayed badges next to a crate on its website, but that functionality has been removed. Packages should place badges in its README file which will be displayed on crates.io (see the `readme` field).

```
[badges]
# The `maintenance` table indicates the status of the maintenance of
# the crate. This may be used by a registry, but is currently not
# used by crates.io. See https://github.com/rust-lang/crates.io/issues/2437
# and https://github.com/rust-lang/crates.io/issues/2438 for more details.
#
# The `status` field is required. Available options are:
# - `actively-developed`: New features are being added and bugs are being fixed.
# - `passively-maintained`: There are no plans for new features, but the maintainer intends to
#   respond to issues that get filed.
# - `as-is`: The crate is feature complete, the maintainer does not intend to continue working
on
#   it or providing support, but it works for the purposes it was designed for.
# - `experimental`: The author wants to share it with the community but is not intending to
meet
#   anyone's particular use case.
# - `looking-for-maintainer`: The current maintainer would like to transfer the crate to
someone
#   else.
# - `deprecated`: The maintainer does not recommend using this crate (the description of the
crate
#   can describe why, there could be a better solution available or there could be problems
with
#   the crate that the author does not want to fix).
# - `none`: Displays no badge on crates.io, since the maintainer has not chosen to specify
#   their intentions, potential crate users will need to investigate on their own.
maintenance = { status = "..." }
```

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

The `[profile]` tables provide a way to customize compiler settings such as optimizations and debug settings. See the Profiles chapter for more detail.

Cargo Targets

Cargo packages consist of *targets* which correspond to source files which can be compiled into a crate. Packages can have library, binary, example, test, and benchmark targets. The list of targets can be configured in the `Cargo.toml` manifest, often inferred automatically by the directory layout of the source files.

See Configuring a target below for details on configuring the settings for a target.

Library

The library target defines a "library" that can be used and linked by other libraries and executables. The filename defaults to `src/lib.rs`, and the name of the library defaults to the name of the package. A package can have only one library. The settings for the library can be customized in the `[lib]` table in `Cargo.toml`.

```
# Example of customizing the library in Cargo.toml.
[lib]
crate-type = ["cdylib"]
bench = false
```

Binaries

Binary targets are executable programs that can be run after being compiled. The default binary filename is `src/main.rs`, which defaults to the name of the package. Additional binaries are stored in the `src/bin/` directory. The settings for each binary can be customized in the `[[bin]]` tables in `Cargo.toml`.

Binaries can use the public API of the package's library. They are also linked with the `[dependencies]` defined in `Cargo.toml`.

You can run individual binaries with the `cargo run` command with the `--bin <bin-name>` option. `cargo install` can be used to copy the executable to a common location.

```
# Example of customizing binaries in Cargo.toml.
[[bin]]
name = "cool-tool"
test = false
bench = false

[[bin]]
name = "frobnicator"
required-features = ["frobnicate"]
```

Examples

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

Examples can use the public API of the package's library. They are also linked with the `[dependencies]` and `[dev-dependencies]` defined in `Cargo.toml`.

By default, examples are executable binaries (with a `main()` function). You can specify the `crate-type` field to make an example be compiled as a library:

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

You can run individual executable examples with the `cargo run` command with the `--example <example-name>` option. Library examples can be built with `cargo build` with the `--example <example-name>` option. `cargo install` with the `--example <example-name>` option can be used to copy executable binaries to a common location. Examples are compiled by `cargo test` by default to protect them from bit-rotting. Set the `test` field to `true` if you have `#[test]` functions in the example that you want to run with `cargo test`.

Tests

There are two styles of tests within a Cargo project:

- *Unit tests* which are functions marked with the `#[test]` attribute located within your library or binaries (or any target enabled with the `test` field). These tests have access to private APIs located within the target they are defined in.
- *Integration tests* which is a separate executable binary, also containing `#[test]` functions, which is linked with the project's library and has access to its *public* API.

Tests are run with the `cargo test` command. By default, Cargo and `rustc` use the libtest harness which is responsible for collecting functions annotated with the `#[test]` attribute and executing them in parallel, reporting the success and failure of each test. See the `harness` field if you want to use a different harness or test strategy.

> **Note**: There is another special style of test in Cargo: documentation tests. They are handled by `rustdoc` and have a slightly different execution model. For more information, please see `cargo test`.

Integration tests

Files located under the `tests` directory are integration tests. When you run `cargo test`, Cargo will compile each of these files as a separate crate, and execute them.

Integration tests can use the public API of the package's library. They are also linked with the `[dependencies]` and `[dev-dependencies]` defined in `Cargo.toml`.

If you want to share code among multiple integration tests, you can place it in a separate module such as `tests/common/mod.rs` and then put `mod common;` in each test to import it.

Each integration test results in a separate executable binary, and `cargo test` will run them serially. In some cases this can be inefficient, as it can take longer to compile, and may not make full use of multiple CPUs when running the tests. If you have a lot of integration tests, you may want to consider creating a single integration test, and split the tests into multiple modules. The libtest harness will automatically find all of the `#[test]` annotated functions and run them in parallel. You can pass module names to `cargo test` to only run the tests within that module.

Binary targets are automatically built if there is an integration test. This allows an integration test to execute the binary to exercise and test its behavior. The `CARGO_BIN_EXE_<name>` environment variable is set when the integration test is built so that it can use the `env` macro to locate the executable.

Benchmarks

Benchmarks provide a way to test the performance of your code using the `cargo bench` command. They follow the same structure as tests, with each benchmark function annotated with the `#[bench]` attribute. Similarly to tests:

- Benchmarks are placed in the `benches` directory.
- Benchmark functions defined in libraries and binaries have access to the *private* API within the target they are defined in. Benchmarks in the `benches` directory may use the *public* API.
- The `bench` field can be used to define which targets are benchmarked by default.
- The `harness` field can be used to disable the built-in harness.

> **Note**: The `#[bench]` attribute is currently unstable and only available on the nightly channel. There are some packages available on crates.io that may help with running benchmarks on the stable channel, such as Criterion.

Configuring a target

All of the `[lib]`, `[[bin]]`, `[[example]]`, `[[test]]`, and `[[bench]]` sections in `Cargo.toml` 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. You can only specify one library, so `[lib]` is a normal TOML table.

The following is an overview of the TOML settings for each target, with each field described in detail below.

```
[lib]
name = "foo"           # The name of the target.
path = "src/lib.rs"    # The source file of the target.
test = true            # Is tested by default.
doctest = true         # Documentation examples are tested by default.
bench = true           # Is benchmarked by default.
doc = true             # Is documented by default.
plugin = false         # Used as a compiler plugin (deprecated).
proc-macro = false     # Set to `true` for a proc-macro library.
harness = true         # Use libtest harness.
edition = "2015"       # The edition of the target.
crate-type = ["lib"]   # The crate types to generate.
required-features = [] # Features required to build this target (N/A for lib).
```

The `name` field

The `name` field specifies the name of the target, which corresponds to the filename of the artifact that will be generated. For a library, this is the crate name that dependencies will use to reference it.

For the `[lib]` and the default binary (`src/main.rs`), this defaults to the name of the package, with any dashes replaced with underscores. For other auto discovered targets, it defaults to the directory or file name.

This is required for all targets except `[lib]`.

The `path` field

The `path` field specifies where the source for the crate is located, relative to the `Cargo.toml` file.

If not specified, the inferred path is used based on the target name.

The `test` field

The `test` field indicates whether or not the target is tested by default by `cargo test`. The default is `true` for lib, bins, and tests.

> **Note**: Examples are built by `cargo test` by default to ensure they continue to compile, but they are not *tested* by default. Setting `test = true` for an example will also build it as a test and run any `#[test]` functions defined in the example.

The `doctest` field

The `doctest` field indicates whether or not documentation examples are tested by default by `cargo test`. This is only relevant for libraries, it has no effect on other sections. The default is `true` for the library.

The `bench` field

The `bench` field indicates whether or not the target is benchmarked by default by `cargo bench`. The default is `true` for lib, bins, and benchmarks.

The `doc` field

The `doc` field indicates whether or not the target is included in the documentation generated by `cargo doc` by default. The default is `true` for libraries and binaries.

> **Note**: The binary will be skipped if its name is the same as the lib target.

The `plugin` field

This field is used for `rustc` plugins, which are being deprecated.

The `proc-macro` field

The `proc-macro` field indicates that the library is a procedural macro (reference). This is only valid for the `[lib]` target.

The `harness` field

The `harness` field indicates that the `--test` flag will be passed to `rustc` which will automatically include the libtest library which is the driver for collecting and running tests marked with the `#[test]` attribute or benchmarks with the `#[bench]` attribute. The default is `true` for all targets.

If set to `false`, then you are responsible for defining a `main()` function to run tests and benchmarks.

Tests have the `cfg(test)` conditional expression enabled whether or not the harness is enabled.

The `edition` field

The `edition` field defines the Rust edition the target will use. If not specified, it defaults to the `edition` field for the `[package]`. This field should usually not be set, and is only intended for advanced scenarios such as incrementally transitioning a large package to a new edition.

The `crate-type` field

The `crate-type` field defines the crate types that will be generated by the target. It is an array of strings, allowing you to specify multiple crate types for a single target. This can only be specified for libraries and examples. Binaries, tests, and benchmarks are always the "bin" crate type. The defaults are:

Target	Crate Type
Normal library	`"lib"`
Proc-macro library	`"proc-macro"`
Example	`"bin"`

The available options are `bin`, `lib`, `rlib`, `dylib`, `cdylib`, `staticlib`, and `proc-macro`. You can read more about the different crate types in the Rust Reference Manual.

The `required-features` field

The `required-features` field specifies which features the target needs in order to be built. If any of the required features are not enabled, 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]]
name = "my-pg-tool"
required-features = ["postgres", "tools"]
```

Target auto-discovery

By default, Cargo automatically determines the targets to build based on the layout of the files on the filesystem. The target configuration tables, such as `[lib]`, `[[bin]]`, `[[test]]`, `[[bench]]`, or `[[example]]`, can be used to add additional targets that don't follow the standard directory layout.

The automatic target discovery can be disabled so that only manually configured targets will be built. Setting the keys `autobins`, `autoexamples`, `autotests`, or `autobenches` to `false` in the `[package]` section will disable auto-discovery of the corresponding target type.

```
[package]
# ...
autobins = false
autoexamples = false
autotests = false
autobenches = false
```

Disabling automatic discovery should only be needed for specialized situations. For example, if you have a library where you want a *module* named `bin`, this would present a problem because Cargo would usually attempt to compile anything in the `bin` directory as an executable. Here is a sample layout of this scenario:

```
├── Cargo.toml
└── src
    ├── lib.rs
    └── bin
        └── mod.rs
```

To prevent Cargo from inferring `src/bin/mod.rs` as an executable, set `autobins = false` in `Cargo.toml` to disable auto-discovery:

```
[package]
# …
autobins = false
```

> **Note**: For packages with the 2015 edition, the default for auto-discovery is `false` if at least one target is manually defined in `Cargo.toml`. Beginning with the 2018 edition, the default is always `true`.

Workspaces

A *workspace* is a collection of one or more packages, called *workspace members*, that are managed together.

The key points of workspaces are:

- Common commands can run across all workspace members, like `cargo check --workspace`.
- All packages share a common `Cargo.lock` file which resides in the *workspace root*.
- All packages share a common output directory, which defaults to a directory named `target` in the *workspace root*.
- Sharing package metadata, like with `workspace.package`.
- The `[patch]`, `[replace]` and `[profile.*]` sections in `Cargo.toml` are only recognized in the *root* manifest, and ignored in member crates' manifests.

In the `Cargo.toml`, the `[workspace]` table supports the following sections:

- `[workspace]` — Defines a workspace.
  - `resolver` — Sets the dependency resolver to use.
  - `members` — Packages to include in the workspace.
  - `exclude` — Packages to exclude from the workspace.
  - `default-members` — Packages to operate on when a specific package wasn't selected.
  - `package` — Keys for inheriting in packages.
  - `dependencies` — Keys for inheriting in package dependencies.
  - `metadata` — Extra settings for external tools.
- `[patch]` — Override dependencies.
- `[replace]` — Override dependencies (deprecated).
- `[profile]` — Compiler settings and optimizations.

The `[workspace]` section

To create a workspace, you add the `[workspace]` table to a `Cargo.toml`:

```
[workspace]
# ...
```

At minimum, a workspace has to have a member, either with a root package or as a virtual manifest.

Root package

If the `[workspace]` section is added to a `Cargo.toml` that already defines a `[package]`, the package is the *root package* of the workspace. The *workspace root* is the directory where the workspace's `Cargo.toml` is located.

```
[workspace]

[package]
name = "hello_world" # the name of the package
version = "0.1.0"    # the current version, obeying semver
authors = ["Alice <a@example.com>", "Bob <b@example.com>"]
```

Virtual workspace

Alternatively, a `Cargo.toml` file can be created with a `[workspace]` section but without a `[package]` section. This is called a *virtual manifest*. This is typically useful when there isn't a "primary" package, or you want to keep all the packages organized in separate directories.

```
# [PROJECT_DIR]/Cargo.toml
[workspace]
members = ["hello_world"]
```

```
# [PROJECT_DIR]/hello_world/Cargo.toml
[package]
name = "hello_world" # the name of the package
version = "0.1.0"    # the current version, obeying semver
authors = ["Alice <a@example.com>", "Bob <b@example.com>"]
```

The `members` and `exclude` fields

The `members` and `exclude` fields define which packages are members of the workspace:

```
[workspace]
members = ["member1", "path/to/member2", "crates/*"]
exclude = ["crates/foo", "path/to/other"]
```

All `path` dependencies residing in the workspace directory automatically become members. Additional members can be listed with the `members` key, which should be an array of strings containing directories with `Cargo.toml` files.

The `members` list also supports globs to match multiple paths, using typical filename glob patterns like `*` and `?`.

The `exclude` key can be used to prevent 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, or using a glob pattern and you want to remove a directory.

When inside a subdirectory within the workspace, Cargo will automatically search the parent directories for a `Cargo.toml` file with a `[workspace]` definition to determine which workspace to use. The `package.workspace` manifest key can be used in member crates to point at a workspace's root to override this automatic search. The manual setting can be useful if the member is not inside a subdirectory of the workspace root.

Package selection

In a workspace, package-related Cargo commands like `cargo build` can use the `-p` / `--package` or `--workspace` command-line flags to determine which packages to operate on. If neither of those flags are specified, Cargo will use the package in the current working directory. If the current directory is a virtual workspace, it will apply to all members (as if `--workspace` were specified on the command-line). See also `default-members`.

The `default-members` field

The optional `default-members` key can be specified to set the members to operate on when in the workspace root and the package selection flags are not used:

```
[workspace]
members = ["path/to/member1", "path/to/member2", "path/to/member3/*"]
default-members = ["path/to/member2", "path/to/member3/foo"]
```

When specified, `default-members` must expand to a subset of `members`.

The `package` table

The `workspace.package` table is where you define keys that can be inherited by members of a workspace. These keys can be inherited by defining them in the member package with `{key}.workspace = true`.

Keys that are supported:

`authors`	`categories`
`description`	`documentation`
`edition`	`exclude`
`homepage`	`include`
`keywords`	`license`
`license-file`	`publish`
`readme`	`repository`
`rust-version`	`version`

- `license-file` and `readme` are relative to the workspace root
- `include` and `exclude` are relative to your package root

Example:

```toml
# [PROJECT_DIR]/Cargo.toml
[workspace]
members = ["bar"]

[workspace.package]
version = "1.2.3"
authors = ["Nice Folks"]
description = "A short description of my package"
documentation = "https://example.com/bar"
```

```toml
# [PROJECT_DIR]/bar/Cargo.toml
[package]
name = "bar"
version.workspace = true
authors.workspace = true
description.workspace = true
documentation.workspace = true
```

The `dependencies` table

The `workspace.dependencies` table is where you define dependencies to be inherited by members of a workspace.

Specifying a workspace dependency is similar to package dependencies except:

- Dependencies from this table cannot be declared as `optional`
- `features` declared in this table are additive with the `features` from `[dependencies]`

You can then inherit the workspace dependency as a package dependency

Example:

```toml
# [PROJECT_DIR]/Cargo.toml
[workspace]
members = ["bar"]

[workspace.dependencies]
cc = "1.0.73"
rand = "0.8.5"
regex = { version = "1.6.0", default-features = false, features = ["std"] }
```

```toml
# [PROJECT_DIR]/bar/Cargo.toml
[package]
name = "bar"
version = "0.2.0"

[dependencies]
regex = { workspace = true, features = ["unicode"] }

[build-dependencies]
cc.workspace = true

[dev-dependencies]
rand.workspace = true
```

The `metadata` table

The `workspace.metadata` table is ignored by Cargo and will not be warned about. This section can be used for tools that would like to store workspace configuration in `Cargo.toml`. For example:

```toml
[workspace]
members = ["member1", "member2"]

[workspace.metadata.webcontents]
root = "path/to/webproject"
tool = ["npm", "run", "build"]
# ...
```

There is a similar set of tables at the package level at `package.metadata`. While cargo does not specify a format for the content of either of these tables, it is suggested that external tools may wish to use them in a consistent fashion, such as referring to the data in `workspace.metadata` if data is missing from `package.metadata`, if that makes sense for the tool in question.

Features

Cargo "features" provide a mechanism to express conditional compilation and optional dependencies. A package defines a set of named features in the `[features]` table of `Cargo.toml`, and each feature can either be enabled or disabled. Features for the package being built can be enabled on the command-line with flags such as `--features`. Features for dependencies can be enabled in the dependency declaration in `Cargo.toml`.

See also the Features Examples chapter for some examples of how features can be used.

The `[features]` section

Features are defined in the `[features]` table in `Cargo.toml`. Each feature specifies an array of other features or optional dependencies that it enables. The following examples illustrate how features could be used for a 2D image processing library where support for different image formats can be optionally included:

```
[features]
# Defines a feature named `webp` that does not enable any other features.
webp = []
```

With this feature defined, `cfg` expressions can be used to conditionally include code to support the requested feature at compile time. For example, inside `lib.rs` of the package could include this:

```
// This conditionally includes a module which implements WEBP support.
#[cfg(feature = "webp")]
pub mod webp;
```

Cargo sets features in the package using the `rustc` `--cfg` flag, and code can test for their presence with the `cfg` attribute or the `cfg` macro.

Features can list other features to enable. For example, the ICO image format can contain BMP and PNG images, so when it is enabled, it should make sure those other features are enabled, too:

```
[features]
bmp = []
png = []
ico = ["bmp", "png"]
webp = []
```

Feature names may include characters from the Unicode XID standard (which includes most letters), and additionally allows starting with `_` or digits `0` through `9`, and after the first character may also contain `-`, `+`, or `.`.

> **Note**: crates.io imposes additional constraints on feature name syntax that they must only be ASCII alphanumeric characters or `_`, `-`, or `+`.

The `default` feature

By default, all features are disabled unless explicitly enabled. This can be changed by specifying the `default` feature:

```
[features]
default = ["ico", "webp"]
bmp = []
png = []
ico = ["bmp", "png"]
webp = []
```

When the package is built, the `default` feature is enabled which in turn enables the listed features. This behavior can be changed by:

- The `--no-default-features` command-line flag disables the default features of the package.
- The `default-features = false` option can be specified in a dependency declaration.

> **Note**: Be careful about choosing the default feature set. The default features are a convenience that make it easier to use a package without forcing the user to carefully select which features to enable for common use, but there are some drawbacks. Dependencies automatically enable default features unless `default-features = false` is specified. This can make it difficult to ensure that the default features are not enabled, especially for a dependency that appears multiple times in the dependency graph. Every package must ensure that `default-features = false` is specified to avoid enabling them.
>
> Another issue is that it can be a SemVer incompatible change to remove a feature from the default set, so you should be confident that you will keep those features.

Optional dependencies

Dependencies can be marked "optional", which means they will not be compiled by default. For example, let's say that our 2D image processing library uses an external package to handle GIF images. This can be expressed like this:

```
[dependencies]
gif = { version = "0.11.1", optional = true }
```

By default, this optional dependency implicitly defines a feature that looks like this:

```
[features]
gif = ["dep:gif"]
```

This means that this dependency will only be included if the `gif` feature is enabled. The same `cfg(feature = "gif")` syntax can be used in the code, and the dependency can be enabled just like any feature such as `--features gif` (see Command-line feature options below).

In some cases, you may not want to expose a feature that has the same name as the optional dependency. For example, perhaps the optional dependency is an internal detail, or you want to group multiple optional dependencies together, or you just want to use a better name. If you specify the optional dependency with the `dep:` prefix anywhere in the `[features]` table, that disables the implicit feature.

> **Note**: The `dep:` syntax is only available starting with Rust 1.60. Previous versions can only use the implicit feature name.

For example, let's say in order to support the AVIF image format, our library needs two other dependencies to be enabled:

```
[dependencies]
ravif = { version = "0.6.3", optional = true }
rgb = { version = "0.8.25", optional = true }

[features]
avif = ["dep:ravif", "dep:rgb"]
```

In this example, the `avif` feature will enable the two listed dependencies. This also avoids creating the implicit `ravif` and `rgb` features, since we don't want users to enable those individually as they are internal details to our crate.

> **Note**: Another way to optionally include a dependency is to use platform-specific dependencies. Instead of using features, these are conditional based on the target platform.

Dependency features

Features of dependencies can be enabled within the dependency declaration. The `features` key indicates which features to enable:

```toml
[dependencies]
# Enables the `derive` feature of serde.
serde = { version = "1.0.118", features = ["derive"] }
```

The `default` features can be disabled using `default-features = false`:

```toml
[dependencies]
flate2 = { version = "1.0.3", default-features = false, features = ["zlib"] }
```

> **Note**: This may not ensure the default features are disabled. If another dependency includes `flate2` without specifying `default-features = false`, then the default features will be enabled. See feature unification below for more details.

Features of dependencies can also be enabled in the `[features]` table. The syntax is `"package-name/feature-name"`. For example:

```toml
[dependencies]
jpeg-decoder = { version = "0.1.20", default-features = false }

[features]
# Enables parallel processing support by enabling the "rayon" feature of jpeg-decoder.
parallel = ["jpeg-decoder/rayon"]
```

The `"package-name/feature-name"` syntax will also enable `package-name` if it is an optional dependency. Often this is not what you want. You can add a `?` as in `"package-name?/feature-name"` which will only enable the given feature if something else enables the optional dependency.

> **Note**: The `?` syntax is only available starting with Rust 1.60.

For example, let's say we have added some serialization support to our library, and it requires enabling a corresponding feature in some optional dependencies. That can be done like this:

```toml
[dependencies]
serde = { version = "1.0.133", optional = true }
rgb = { version = "0.8.25", optional = true }

[features]
serde = ["dep:serde", "rgb?/serde"]
```

In this example, enabling the `serde` feature will enable the serde dependency. It will also enable the `serde` feature for the `rgb` dependency, but only if something else has enabled the `rgb` dependency.

Command-line feature options

The following command-line flags can be used to control which features are enabled:

- `--features` *FEATURES*: Enables the listed features. Multiple features may be separated with commas or spaces. If using spaces, be sure to use quotes around all the features if running Cargo from a shell (such as `--features "foo bar"`). If building multiple packages in a workspace, the `package-name/feature-name` syntax can be used to specify features for specific workspace members.

- `--all-features`: Activates all features of all packages selected on the command-line.

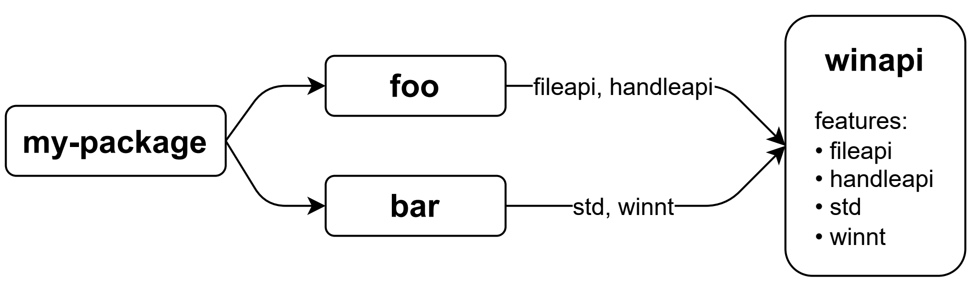
- `--no-default-features`: Does not activate the `default` feature of the selected packages.

Feature unification

Features are unique to the package that defines them. Enabling a feature on a package does not enable a feature of the same name on other packages.

When a dependency is used by multiple packages, Cargo will use the union of all features enabled on that dependency when building it. This helps ensure that only a single copy of the dependency is used. See the features section of the resolver documentation for more details.

For example, let's look at the `winapi` package which uses a large number of features. If your package depends on a package `foo` which enables the "fileapi" and "handleapi" features of `winapi`, and another dependency `bar` which enables the "std" and "winnt" features of `winapi`, then `winapi` will be built with all four of those features enabled.



A consequence of this is that features should be *additive*. That is, enabling a feature should not disable functionality, and it should usually be safe to enable any combination of features. A feature should not introduce a SemVer-incompatible change.

For example, if you want to optionally support `no_std` environments, **do not** use a `no_std` feature. Instead, use a `std` feature that *enables* `std`. For example:

```
#![no_std]

#[cfg(feature = "std")]
extern crate std;

#[cfg(feature = "std")]
pub fn function_that_requires_std() {
    // ...
}
```

Mutually exclusive features

There are rare cases where features may be mutually incompatible with one another. This should be avoided if at all possible, because it requires coordinating all uses of the package in the dependency graph to cooperate to avoid enabling them together. If it is not possible, consider adding a compile error to detect this scenario. For example:

```
#[cfg(all(feature = "foo", feature = "bar"))]
compile_error!("feature \"foo\" and feature \"bar\" cannot be enabled at the same time");
```

Instead of using mutually exclusive features, consider some other options:

- Split the functionality into separate packages.
- When there is a conflict, choose one feature over another. The `cfg-if` package can help with writing more complex `cfg` expressions.
- Architect the code to allow the features to be enabled concurrently, and use runtime options to control which is used. For example, use a config file, command-line argument, or environment variable to choose which behavior to enable.

Inspecting resolved features

In complex dependency graphs, it can sometimes be difficult to understand how different features get enabled on various packages. The `cargo tree` command offers several options to help inspect and visualize which features are enabled. Some options to try:

- `cargo tree -e features`: This will show features in the dependency graph. Each feature will appear showing which package enabled it.
- `cargo tree -f "{p} {f}"`: This is a more compact view that shows a comma-separated list of features enabled on each package.
- `cargo tree -e features -i foo`: This will invert the tree, showing how features flow into the given package “foo”. This can be useful because viewing the entire graph can be quite large and overwhelming. Use this when you are trying to figure out which features are enabled on a specific package and why. See the example at the bottom of the `cargo tree` page on how to read this.

Feature resolver version 2

A different feature resolver can be specified with the `resolver` field in `Cargo.toml`, like this:

```
[package]
name = "my-package"
version = "1.0.0"
resolver = "2"
```

See the resolver versions section for more detail on specifying resolver versions.

The version `"2"` resolver avoids unifying features in a few situations where that unification can be unwanted. The exact situations are described in the resolver chapter, but in short, it avoids unifying in these situations:

- Features enabled on platform-specific dependencies for targets not currently being built are ignored.
- Build-dependencies and proc-macros do not share features with normal dependencies.
- Dev-dependencies do not activate features unless building a target that needs them (like tests or examples).

Avoiding the unification is necessary for some situations. For example, if a build-dependency enables a `std` feature, and the same dependency is used as a normal dependency for a `no_std` environment, enabling `std` would break the build.

However, one drawback is that this can increase build times because the dependency is built multiple times (each with different features). When using the version `"2"` resolver, it is recommended to check for dependencies that are built multiple times to reduce overall build time. If it is not *required* to build those duplicated packages with separate features, consider adding features to the `features` list in the dependency declaration so that the duplicates end up with the same features (and thus Cargo will build it only once). You can detect these duplicate dependencies with the `cargo tree --duplicates` command. It will show which packages are built multiple times; look for any entries listed with the same version. See Inspecting resolved features for more on fetching information on the resolved features. For build dependencies, this is not necessary if you are cross-compiling with the `--target` flag because build dependencies are always built separately from normal dependencies in that scenario.

Resolver version 2 command-line flags

The `resolver = "2"` setting also changes the behavior of the `--features` and `--no-default-features` command-line options.

With version `"1"`, you can only enable features for the package in the current working directory. For example, in a workspace with packages `foo` and `bar`, and you are in the directory for package `foo`, and ran the command `cargo build -p bar --features` `bar-feat`, this would fail because the `--features` flag only allowed enabling features on `foo`.

With `resolver = "2"`, the features flags allow enabling features for any of the packages selected on the command-line with `-p` and `--workspace` flags. For example:

```
# This command is allowed with resolver = "2", regardless of which directory
# you are in.
cargo build -p foo -p bar --features foo-feat,bar-feat

# This explicit equivalent works with any resolver version:
cargo build -p foo -p bar --features foo/foo-feat,bar/bar-feat
```

Additionally, with `resolver = "1"`, the `--no-default-features` flag only disables the default feature for the package in the current directory. With version “2”, it will disable the default features for all workspace members.

Build scripts

Build scripts can detect which features are enabled on the package by inspecting the `CARGO_FEATURE_<name>` environment variable, where `<name>` is the feature name converted to uppercase and `-` converted to `_`.

Required features

The `required-features` field can be used to disable specific Cargo targets if a feature is not enabled. See the linked documentation for more details.

SemVer compatibility

Enabling a feature should not introduce a SemVer-incompatible change. For example, the feature shouldn’t change an existing API in a way that could break existing uses. More details about what changes are compatible can be found in the SemVer Compatibility chapter.

Care should be taken when adding and removing feature definitions and optional dependencies, as these can sometimes be backwards-incompatible changes. More details can be found in the Cargo section of the SemVer Compatibility chapter. In short, follow these rules:

- The following is usually safe to do in a minor release:
  - Add a new feature or optional dependency.
  - Change the features used on a dependency.
- The following should usually **not** be done in a minor release:
  - Remove a feature or optional dependency.
  - Moving existing public code behind a feature.
  - Remove a feature from a feature list.

See the links for caveats and examples.

Feature documentation and discovery

You are encouraged to document which features are available in your package. This can be done by adding doc comments at the top of `lib.rs`. As an example, see the regex crate source, which when rendered can be viewed on docs.rs. If you have other documentation, such as a user guide, consider adding the documentation there (for example, see serde.rs). If you have a binary project, consider documenting the features in the README or other documentation for the project (for example, see sccache).

Clearly documenting the features can set expectations about features that are considered "unstable" or otherwise shouldn't be used. For example, if there is an optional dependency, but you don't want users to explicitly list that optional dependency as a feature, exclude it from the documented list.

Documentation published on docs.rs can use metadata in `Cargo.toml` to control which features are enabled when the documentation is built. See docs.rs metadata documentation for more details.

> **Note**: Rustdoc has experimental support for annotating the documentation to indicate which features are required to use certain APIs. See the `doc_cfg` documentation for more details. An example is the `syn` documentation, where you can see colored boxes which note which features are required to use it.

Discovering features

When features are documented in the library API, this can make it easier for your users to discover which features are available and what they do. If the feature documentation for a package isn't readily available, you can look at the `Cargo.toml` file, but sometimes it can be hard to track it down. The crate page on crates.io has a link to the source repository if available. Tools like `cargo vendor` or cargo-clone-crate can be used to download the source and inspect it.

Feature combinations

Because features are a form of conditional compilation, they require an exponential number of configurations and test cases to be 100% covered. By default, tests, docs, and other tooling such as Clippy will only run with the default set of features.

We encourage you to consider your strategy and tooling in regards to different feature combinations — Every project will have different requirements in conjunction with time, resources, and the cost-benefit of covering specific scenarios. Common configurations may be with / without default features, specific combinations of features, or all combinations of features.

Features Examples

The following illustrates some real-world examples of features in action.

Minimizing build times and file sizes

Some packages use features so that if the features are not enabled, it reduces the size of the crate and reduces compile time. Some examples are:

- `syn` is a popular crate for parsing Rust code. Since it is so popular, it is helpful to reduce compile times since it affects so many projects. It has a clearly documented list of features which can be used to minimize the amount of code it contains.
- `regex` has a several features that are well documented. Cutting out Unicode support can reduce the resulting file size as it can remove some large tables.
- `winapi` has a large number of features that limit which Windows API bindings it supports.
- `web-sys` is another example similar to `winapi` that provides a huge surface area of API bindings that are limited by using features.

Extending behavior

The `serde_json` package has a `preserve_order` feature which changes the behavior of JSON maps to preserve the order that keys are inserted. Notice that it enables an optional dependency `indexmap` to implement the new behavior.

When changing behavior like this, be careful to make sure the changes are SemVer compatible. That is, enabling the feature should not break code that usually builds with the feature off.

`no_std` support

Some packages want to support both `no_std` and `std` environments. This is useful for supporting embedded and resource-constrained platforms, but still allowing extended capabilities for platforms that support the full standard library.

The `wasm-bindgen` package defines a `std` feature that is enabled by default. At the top of the library, it unconditionally enables the `no_std` attribute. This ensures that `std` and the `std` prelude are not automatically in scope. Then, in various places in the code (example1, example2), it uses `#[cfg(feature = "std")]` attributes to conditionally enable extra functionality that requires `std`.

Re-exporting dependency features

It can be convenient to re-export the features from a dependency. This allows the user depending on the crate to control those features without needing to specify those dependencies directly. For example, `regex` re-exports the features from the `regex_syntax` package. Users of `regex` don't need to know about the `regex_syntax` package, but they can still access the features it contains.

Vendoring of C libraries

Some packages provide bindings to common C libraries (sometimes referred to as "sys" crates). Sometimes these packages give you the choice to use the C library installed on the system, or to build it from source. For example, the `openssl` package has a `vendored` feature which enables the corresponding `vendored` feature of `openssl-sys`. The `openssl-sys` build script has some conditional logic which causes it to build from a local copy of the OpenSSL source code instead of using the version from the system.

The `curl-sys` package is another example where the `static-curl` feature causes it to build libcurl from source. Notice that it also has a `force-system-lib-on-osx` feature which forces it to use the system libcurl, overriding the static-curl setting.

Feature precedence

Some packages may have mutually-exclusive features. One option to handle this is to prefer one feature over another. The `log` package is an example. It has several features for choosing the maximum logging level at compile-time described here. It uses `cfg-if` to choose a precedence. If multiple features are enabled, the higher "max" levels will be preferred over the lower levels.

Proc-macro companion package

Some packages have a proc-macro that is intimately tied with it. However, not all users will need to use the proc-macro. By making the proc-macro an optional-dependency, this allows you to conveniently choose whether or not it is included. This is helpful, because sometimes the proc-macro version must stay in sync with the parent package, and you don't want to force the users to have to specify both dependencies and keep them in sync.

An example is `serde` which has a `derive` feature which enables the `serde_derive` proc-macro. The `serde_derive` crate is very tightly tied to `serde`, so it uses an equals version requirement to ensure they stay in sync.

Nightly-only features

Some packages want to experiment with APIs or language features that are only available on the Rust nightly channel. However, they may not want to require their users to also use the nightly channel. An example is `wasm-bindgen` which has a `nightly` feature which enables an extended API that uses the `Unsize` marker trait that is only available on the nightly channel at the time of this writing.

Note that at the root of the crate it uses `cfg_attr` to enable the nightly feature. Keep in mind that the `feature` attribute is unrelated to Cargo features, and is used to opt-in to experimental language features.

The `simd_support` feature of the `rand` package is another example, which relies on a dependency that only builds on the nightly channel.

Experimental features

Some packages have new functionality that they may want to experiment with, without having to commit to the stability of those APIs. The features are usually documented that they are experimental, and thus may change or break in the future, even during a minor release. An example is the `async-std` package, which has an `unstable` feature, which gates new APIs that people can opt-in to using, but may not be completely ready to be relied upon.

Profiles

Profiles provide a way to alter the compiler settings, influencing things like optimizations and debugging symbols.

Cargo has 4 built-in profiles: `dev`, `release`, `test`, and `bench`. The profile is automatically chosen based on which command is being run if a profile is not specified on the command-line. In addition to the built-in profiles, custom user-defined profiles can also be specified.

Profile settings can be changed in `Cargo.toml` with the `[profile]` table. Within each named profile, individual settings can be changed with key/value pairs like this:

```
[profile.dev]
opt-level = 1               # Use slightly better optimizations.
overflow-checks = false     # Disable integer overflow checks.
```

Cargo only looks at the profile settings in the `Cargo.toml` manifest at the root of the workspace. Profile settings defined in dependencies will be ignored.

Additionally, profiles can be overridden from a config definition. Specifying a profile in a config file or environment variable will override the settings from `Cargo.toml`.

Profile settings

The following is a list of settings that can be controlled in a profile.

opt-level

The `opt-level` setting controls the `-C opt-level` flag which controls the level of optimization. Higher optimization levels may produce faster runtime code at the expense of longer compiler times. Higher levels may also change and rearrange the compiled code which may make it harder to use with a debugger.

The valid options are:

- `0`: no optimizations
- `1`: basic optimizations
- `2`: some optimizations
- `3`: all optimizations
- `"s"`: optimize for binary size
- `"z"`: optimize for binary size, but also turn off loop vectorization.

It is recommended to experiment with different levels to find the right balance for your project. There may be surprising results, such as level `3` being slower than `2`, or the `"s"` and `"z"` levels not being necessarily smaller. You may also want to reevaluate your settings over time as newer versions of `rustc` changes optimization behavior.

See also Profile Guided Optimization for more advanced optimization techniques.

debug

The `debug` setting controls the `-C debuginfo` flag which controls the amount of debug information included in the compiled binary.

The valid options are:

- `0` or `false`: no debug info at all
- `1`: line tables only
- `2` or `true`: full debug info

You may wish to also configure the `split-debuginfo` option depending on your needs as well.

split-debuginfo

The `split-debuginfo` setting controls the `-C split-debuginfo` flag which controls whether debug information, if generated, is either placed in the executable itself or adjacent to it.

This option is a string and acceptable values are the same as those the compiler accepts. The default value for this option is `unpacked` on macOS for profiles that have debug information otherwise enabled. Otherwise the default for this option is documented with rustc and is platform-specific. Some options are only available on the nightly channel. The Cargo default may change in the future once more testing has been performed, and support for DWARF is stabilized.

strip

The `strip` option controls the `-C strip` flag, which directs rustc to strip either symbols or debuginfo from a binary. This can be enabled like so:

```
[package]
# ...

[profile.release]
strip = "debuginfo"
```

Possible string values of `strip` are `"none"`, `"debuginfo"`, and `"symbols"`. The default is `"none"`.

You can also configure this option with the boolean values `true` or `false`. `strip = true` is equivalent to `strip = "symbols"`. `strip = false` is equivalent to `strip = "none"` and disables `strip` completely.

debug-assertions

The `debug-assertions` setting controls the `-C debug-assertions` flag which turns `cfg(debug_assertions)` conditional compilation on or off. Debug assertions are intended to include runtime validation which is only available in debug/development builds. These may be things that are too expensive or otherwise undesirable in a release build. Debug assertions enables the `debug_assert!` macro in the standard library.

The valid options are:

- `true`: enabled
- `false`: disabled

overflow-checks

The `overflow-checks` setting controls the `-C overflow-checks` flag which controls the behavior of runtime integer overflow. When overflow-checks are enabled, a panic will occur on overflow.

The valid options are:

- `true`: enabled
- `false`: disabled

lto

The `lto` setting controls the `-C lto` flag which controls LLVM's link time optimizations. LTO can produce better optimized code, using whole-program analysis, at the cost of longer linking time.

The valid options are:

- `false`: Performs "thin local LTO" which performs "thin" LTO on the local crate only across its codegen units. No LTO is performed if codegen units is 1 or opt-level is 0.
- `true` or `"fat"`: Performs "fat" LTO which attempts to perform optimizations across all crates within the dependency graph.
- `"thin"`: Performs "thin" LTO. This is similar to "fat", but takes substantially less time to run while still achieving performance gains similar to "fat".
- `"off"`: Disables LTO.

See also the `-C linker-plugin-lto` `rustc` flag for cross-language LTO.

panic

The `panic` setting controls the `-C panic` flag which controls which panic strategy to use.

The valid options are:

- `"unwind"`: Unwind the stack upon panic.
- `"abort"`: Terminate the process upon panic.

When set to `"unwind"`, the actual value depends on the default of the target platform. For example, the NVPTX platform does not support unwinding, so it always uses `"abort"`.

Tests, benchmarks, build scripts, and proc macros ignore the `panic` setting. The `rustc` test harness currently requires `unwind` behavior. See the `panic-abort-tests` unstable flag which enables `abort` behavior.

Additionally, when using the `abort` strategy and building a test, all of the dependencies will also be forced to build with the `unwind` strategy.

incremental

The `incremental` setting controls the `-C incremental` flag which controls whether or not incremental compilation is enabled. Incremental compilation causes `rustc` to save additional information to disk which will be reused when recompiling the crate, improving re-compile times. The additional information is stored in the `target` directory.

The valid options are:

- `true`: enabled
- `false`: disabled

Incremental compilation is only used for workspace members and “path” dependencies.

The incremental value can be overridden globally with the `CARGO_INCREMENTAL` environment variable or the `build.incremental` config variable.

codegen-units

The `codegen-units` setting controls the `-C codegen-units` flag which controls how many “code generation units” a crate will be split into. More code generation units allows more of a crate to be processed in parallel possibly reducing compile time, but may produce slower code.

This option takes an integer greater than 0.

The default is 256 for incremental builds, and 16 for non-incremental builds.

rpath

The `rpath` setting controls the `-C rpath` flag which controls whether or not `rpath` is enabled.

Default profiles

dev

The `dev` profile is used for normal development and debugging. It is the default for build commands like `cargo build`, and is used for `cargo install --debug`.

The default settings for the `dev` profile are:

```
[profile.dev]
opt-level = 0
debug = true
split-debuginfo = '...'  # Platform-specific.
debug-assertions = true
overflow-checks = true
lto = false
panic = 'unwind'
incremental = true
codegen-units = 256
rpath = false
```

release

The `release` profile is intended for optimized artifacts used for releases and in production. This profile is used when the `--release` flag is used, and is the default for `cargo install`.

The default settings for the `release` profile are:

```
[profile.release]
opt-level = 3
debug = false
split-debuginfo = '...'  # Platform-specific.
debug-assertions = false
overflow-checks = false
lto = false
panic = 'unwind'
incremental = false
codegen-units = 16
rpath = false
```

test

The `test` profile is the default profile used by `cargo test`. The `test` profile inherits the settings from the `dev` profile.

bench

The `bench` profile is the default profile used by `cargo bench`. The `bench` profile inherits the settings from the `release` profile.

Build Dependencies

To compile quickly, all profiles, by default, do not optimize build dependencies (build scripts, proc macros, and their dependencies), and avoid computing debug info when a build dependency is not used as a runtime dependency. The default settings for build overrides are:

```
[profile.dev.build-override]
opt-level = 0
codegen-units = 256
debug = false # when possible

[profile.release.build-override]
opt-level = 0
codegen-units = 256
```

However, if errors occur while running build dependencies, turning full debug info on will improve backtraces and debuggability when needed:

```
debug = true
```

Build dependencies otherwise inherit settings from the active profile in use, as described in Profile selection.

Custom profiles

In addition to the built-in profiles, additional custom profiles can be defined. These may be useful for setting up multiple workflows and build modes. When defining a custom profile, you must specify the `inherits` key to specify which profile the custom profile inherits settings from when the setting is not specified.

For example, let's say you want to compare a normal release build with a release build with LTO optimizations, you can specify something like the following in `Cargo.toml`:

```
[profile.release-lto]
inherits = "release"
lto = true
```

The `--profile` flag can then be used to choose this custom profile:

```
cargo build --profile release-lto
```

The output for each profile will be placed in a directory of the same name as the profile in the `target` directory. As in the example above, the output would go into the `target/release-lto` directory.

Profile selection

The profile used depends on the command, the command-line flags like `--release` or `--profile`, and the package (in the case of overrides). The default profile if none is specified is:

Command	Default Profile
`cargo run`, `cargo build`, `cargo check`, `cargo rustc`	`dev` profile
`cargo test`	`test` profile
`cargo bench`	`bench` profile
`cargo install`	`release` profile

You can switch to a different profile using the `--profile=NAME` option which will used the given profile. The `--release` flag is equivalent to `--profile=release`.

The selected profile applies to all Cargo targets, including library, binary, example, test, and benchmark.

The profile for specific packages can be specified with overrides, described below.

Overrides

Profile settings can be overridden for specific packages and build-time crates. To override the settings for a specific package, use the `package` table to change the settings for the named package:

```
# The `foo` package will use the -Copt-level=3 flag.
[profile.dev.package.foo]
opt-level = 3
```

The package name is actually a Package ID Spec, so you can target individual versions of a package with syntax such as `[profile.dev.package."foo:2.1.0"]`.

To override the settings for all dependencies (but not any workspace member), use the `"*"` package name:

```
# Set the default for dependencies.
[profile.dev.package."*"]
opt-level = 2
```

To override the settings for build scripts, proc macros, and their dependencies, use the `build-override` table:

```toml
# Set the settings for build scripts and proc-macros.
[profile.dev.build-override]
opt-level = 3
```

> Note: When a dependency is both a normal dependency and a build dependency, Cargo will try to only build it once when `--target` is not specified. When using `build-override`, the dependency may need to be built twice, once as a normal dependency and once with the overridden build settings. This may increase initial build times.

The precedence for which value is used is done in the following order (first match wins):

1. `[profile.dev.package.name]` — A named package.
2. `[profile.dev.package."*"]` — For any non-workspace member.
3. `[profile.dev.build-override]` — Only for build scripts, proc macros, and their dependencies.
4. `[profile.dev]` — Settings in `Cargo.toml`.
5. Default values built-in to Cargo.

Overrides cannot specify the `panic`, `lto`, or `rpath` settings.

Overrides and generics

The location where generic code is instantiated will influence the optimization settings used for that generic code. This can cause subtle interactions when using profile overrides to change the optimization level of a specific crate. If you attempt to raise the optimization level of a dependency which defines generic functions, those generic functions may not be optimized when used in your local crate. This is because the code may be generated in the crate where it is instantiated, and thus may use the optimization settings of that crate.

For example, nalgebra is a library which defines vectors and matrices making heavy use of generic parameters. If your local code defines concrete nalgebra types like `Vector4<f64>` and uses their methods, the corresponding nalgebra code will be instantiated and built within your crate. Thus, if you attempt to increase the optimization level of `nalgebra` using a profile override, it may not result in faster performance.

Further complicating the issue, `rustc` has some optimizations where it will attempt to share monomorphized generics between crates. If the opt-level is 2 or 3, then a crate will not use monomorphized generics from other crates, nor will it export locally defined monomorphized items to be shared with other crates. When experimenting with optimizing dependencies for development, consider trying opt-level 1, which will apply some optimizations while still allowing monomorphized items to be shared.

Configuration

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

Hierarchical structure

Cargo allows local configuration for a particular package as well as global configuration. It looks for configuration files in the current directory and all parent directories. If, for example, Cargo were invoked in `/projects/foo/bar/baz`, then the following configuration files would be probed for and unified in this order:

- `/projects/foo/bar/baz/.cargo/config.toml`
- `/projects/foo/bar/.cargo/config.toml`
- `/projects/foo/.cargo/config.toml`
- `/projects/.cargo/config.toml`
- `/.cargo/config.toml`
- `$CARGO_HOME/config.toml` which defaults to:
  - Windows: `%USERPROFILE%\.cargo\config.toml`
  - Unix: `$HOME/.cargo/config.toml`

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

If a key is specified in multiple config files, the values will get merged together. Numbers, strings, and booleans will use the value in the deeper config directory taking precedence over ancestor directories, where the home directory is the lowest priority. Arrays will be joined together.

At present, when being invoked from a workspace, Cargo does not read config files from crates within the workspace. i.e. if a workspace has two crates in it, named `/projects/foo/bar/baz/mylib` and `/projects/foo/bar/baz/mybin`, and there are Cargo configs at `/projects/foo/bar/baz/mylib/.cargo/config.toml` and `/projects/foo/bar/baz/mybin/.cargo/config.toml`, Cargo does not read those configuration files if it is invoked from the workspace root (`/projects/foo/bar/baz/`).

> **Note:** Cargo also reads config files without the `.toml` extension, such as `.cargo/config`. Support for the `.toml` extension was added in version 1.39 and is the preferred form. If both files exist, Cargo will use the file without the extension.

Configuration format

Configuration files are written in the TOML format (like the manifest), with simple key-value pairs inside of sections (tables). The following is a quick overview of all settings, with detailed descriptions found below.

```toml
paths = ["/path/to/override"] # path dependency overrides

[alias]     # command aliases
b = "build"
c = "check"
t = "test"
r = "run"
rr = "run --release"
recursive_example = "rr --example recursions"
space_example = ["run", "--release", "--", "\"command list\""]

[build]
jobs = 1                      # number of parallel jobs, defaults to # of CPUs
rustc = "rustc"               # the rust compiler tool
rustc-wrapper = "…"           # run this wrapper instead of `rustc`
rustc-workspace-wrapper = "…" # run this wrapper instead of `rustc` for workspace members
rustdoc = "rustdoc"           # the doc generator tool
target = "triple"             # build for the target triple (ignored by `cargo install`)
target-dir = "target"         # path of where to place all generated artifacts
rustflags = ["…", "…"]        # custom flags to pass to all compiler invocations
rustdocflags = ["…", "…"]     # custom flags to pass to rustdoc
incremental = true            # whether or not to enable incremental compilation
dep-info-basedir = "…"        # path for the base directory for targets in depfiles

[doc]
browser = "chromium"          # browser to use with `cargo doc --open`,
                              # overrides the `BROWSER` environment variable

[env]
# Set ENV_VAR_NAME=value for any process run by Cargo
ENV_VAR_NAME = "value"
# Set even if already present in environment
ENV_VAR_NAME_2 = { value = "value", force = true }
# Value is relative to .cargo directory containing `config.toml`, make absolute
ENV_VAR_NAME_3 = { value = "relative/path", relative = true }

[future-incompat-report]
frequency = 'always' # when to display a notification about a future incompat report

[cargo-new]
vcs = "none"              # VCS to use ('git', 'hg', 'pijul', 'fossil', 'none')

[http]
debug = false               # HTTP debugging
proxy = "host:port"         # HTTP proxy in libcurl format
ssl-version = "tlsv1.3"     # TLS version to use
ssl-version.max = "tlsv1.3" # maximum TLS version
ssl-version.min = "tlsv1.1" # minimum TLS version
timeout = 30                # timeout for each HTTP request, in seconds
low-speed-limit = 10        # network timeout threshold (bytes/sec)
cainfo = "cert.pem"         # path to Certificate Authority (CA) bundle
check-revoke = true         # check for SSL certificate revocation
multiplexing = true         # HTTP/2 multiplexing
user-agent = "…"            # the user-agent header

[install]
root = "/some/path"         # `cargo install` destination directory

[net]
retry = 3                   # network retries
git-fetch-with-cli = true   # use the `git` executable for git operations
```

```toml
offline = true              # do not access the network

[net.ssh]
known-hosts = ["..."]       # known SSH host keys

[patch.<registry>]
# Same keys as for [patch] in Cargo.toml

[profile.<name>]         # Modify profile settings via config.
inherits = "dev"         # Inherits settings from [profile.dev].
opt-level = 0            # Optimization level.
debug = true             # Include debug info.
split-debuginfo = '...'  # Debug info splitting behavior.
debug-assertions = true  # Enables debug assertions.
overflow-checks = true   # Enables runtime integer overflow checks.
lto = false              # Sets link-time optimization.
panic = 'unwind'         # The panic strategy.
incremental = true       # Incremental compilation.
codegen-units = 16       # Number of code generation units.
rpath = false            # Sets the rpath linking option.
[profile.<name>.build-override]  # Overrides build-script settings.
# Same keys for a normal profile.
[profile.<name>.package.<name>]  # Override profile for a package.
# Same keys for a normal profile (minus `panic`, `lto`, and `rpath`).

[registries.<name>]  # registries other than crates.io
index = "…"          # URL of the registry index
token = "…"          # authentication token for the registry

[registry]
default = "…"        # name of the default registry
token = "…"          # authentication token for crates.io

[source.<name>]      # source definition and replacement
replace-with = "…"   # replace this source with the given named source
directory = "…"      # path to a directory source
registry = "…"       # URL to a registry source
local-registry = "…" # path to a local registry source
git = "…"            # URL of a git repository source
branch = "…"         # branch name for the git repository
tag = "…"            # tag name for the git repository
rev = "…"            # revision for the git repository

[target.<triple>]
linker = "…"            # linker to use
runner = "…"            # wrapper to run executables
rustflags = ["…", "…"]  # custom flags for `rustc`

[target.<cfg>]
runner = "…"            # wrapper to run executables
rustflags = ["…", "…"]  # custom flags for `rustc`

[target.<triple>.<links>] # `links` build script override
rustc-link-lib = ["foo"]
rustc-link-search = ["/path/to/foo"]
rustc-flags = ["-L", "/some/path"]
rustc-cfg = ['key="value"']
rustc-env = {key = "value"}
rustc-cdylib-link-arg = ["…"]
metadata_key1 = "value"
metadata_key2 = "value"
```

```
[term]
quiet = false           # whether cargo output is quiet
verbose = false         # whether cargo provides verbose output
color = 'auto'          # whether cargo colorizes output
progress.when = 'auto' # whether cargo shows progress bar
progress.width = 80     # width of progress bar
```

Environment variables

Cargo can also be configured through environment variables in addition to the TOML configuration files. For each configuration key of the form `foo.bar` the environment variable `CARGO_FOO_BAR` can also be used to define the value. Keys are converted to uppercase, dots and dashes are converted to underscores. For example the `target.x86_64-unknown-linux-gnu.runner` key can also be defined by the `CARGO_TARGET_X86_64_UNKNOWN_LINUX_GNU_RUNNER` environment variable.

Environment variables will take precedence over TOML configuration files. Currently only integer, boolean, string and some array values are supported to be defined by environment variables. Descriptions below indicate which keys support environment variables and otherwise they are not supported due to technical issues.

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

Command-line overrides

Cargo also accepts arbitrary configuration overrides through the `--config` command-line option. The argument should be in TOML syntax of `KEY=VALUE`:

```
cargo --config net.git-fetch-with-cli=true fetch
```

The `--config` option may be specified multiple times, in which case the values are merged in left-to-right order, using the same merging logic that is used when multiple configuration files apply. Configuration values specified this way take precedence over environment variables, which take precedence over configuration files.

Some examples of what it looks like using Bourne shell syntax:

```
# Most shells will require escaping.
cargo --config http.proxy=\"http://example.com\" …

# Spaces may be used.
cargo --config "net.git-fetch-with-cli = true" …

# TOML array example. Single quotes make it easier to read and write.
cargo --config 'build.rustdocflags = ["--html-in-header", "header.html"]' …

# Example of a complex TOML key.
cargo --config "target.'cfg(all(target_arch = \"arm\", target_os = \"none\"))'.runner = 'my-
runner'" …

# Example of overriding a profile setting.
cargo --config profile.dev.package.image.opt-level=3 …
```

The `--config` option can also be used to pass paths to extra configuration files that Cargo should use for a specific invocation. Options from configuration files loaded this way follow the same precedence rules as other options specified directly with `--config`.

Config-relative paths

Paths in config files may be absolute, relative, or a bare name without any path separators. Paths for executables without a path separator will use the `PATH` environment variable to search for the executable. Paths for non-executables will be relative to where the config value is defined.

In particular, rules are:

- For environment variables, paths are relative to the current working directory.
- For config values loaded directly from the `--config KEY=VALUE` option, paths are relative to the current working directory.
- For config files, paths are relative to the parent directory of the directory where the config files were defined, no matter those files are from either the hierarchical probing or the `--config <path>` option.

> **Note:** To maintain consistency with existing `.cargo/config.toml` probing behavior, it is by design that a path in a config file passed via `--config <path>` is also relative to two levels up from the config file itself.
>
> To avoid unexpected results, the rule of thumb is putting your extra config files at the same level of discovered `.cargo/config.toml` in your project. For instance, given a project `/my/project`, it is recommended to put config files under `/my/project/.cargo` or a new directory at the same level, such as `/my/project/.config`.

```
# Relative path examples.

[target.x86_64-unknown-linux-gnu]
runner = "foo"  # Searches `PATH` for `foo`.

[source.vendored-sources]
# Directory is relative to the parent where `.cargo/config.toml` is located.
# For example, `/my/project/.cargo/config.toml` would result in `/my/project/vendor`.
directory = "vendor"
```

Executable paths with arguments

Some Cargo commands invoke external programs, which can be configured as a path and some number of arguments.

The value may be an array of strings like `['/path/to/program', 'somearg']` or a space-separated string like `'/path/to/program somearg'`. If the path to the executable contains a space, the list form must be used.

If Cargo is passing other arguments to the program such as a path to open or run, they will be passed after the last specified argument in the value of an option of this format. If the specified program does not have path separators, Cargo will search `PATH` for its executable.

Credentials

Configuration values with sensitive information are stored in the `$CARGO_HOME/credentials.toml` file. This file is automatically created and updated by `cargo login` and `cargo logout`. It follows the same format as Cargo config files.

```
[registry]
token = "…"   # Access token for crates.io

[registries.<name>]
token = "…"   # Access token for the named registry
```

Tokens are used by some Cargo commands such as `cargo publish` for authenticating with remote registries. Care should be taken to protect the tokens and to keep them secret.

As with most other config values, tokens may be specified with environment variables. The token for crates.io may be specified with the `CARGO_REGISTRY_TOKEN` environment variable. Tokens for other registries may be specified with environment variables of the form `CARGO_REGISTRIES_<name>_TOKEN` where `<name>` is the name of the registry in all capital letters.

Configuration keys

This section documents all configuration keys. The description for keys with variable parts are annotated with angled brackets like `target.<triple>` where the `<triple>` part can be any target triple like `target.x86_64-pc-windows-msvc`.

`paths`

- Type: array of strings (paths)
- Default: none
- Environment: not supported

An array of paths to local packages which are to be used as overrides for dependencies. For more information see the Overriding Dependencies guide.

`[alias]`

- Type: string or array of strings
- Default: see below
- Environment: `CARGO_ALIAS_<name>`

The `[alias]` table defines CLI command aliases. For example, running `cargo b` is an alias for running `cargo build`. Each key in the table is the subcommand, and the value is the actual command to run. The value may be an array of strings, where the first element is the command and the following are arguments. It may also be a string, which will be split on spaces into subcommand and arguments. The following aliases are built-in to Cargo:

```
[alias]
b = "build"
c = "check"
d = "doc"
t = "test"
r = "run"
rm = "remove"
```

Aliases are not allowed to redefine existing built-in commands.

Aliases are recursive:

```
[alias]
rr = "run --release"
recursive_example = "rr --example recursions"
```

`[build]`

The `[build]` table controls build-time operations and compiler settings.

`build.jobs`

- Type: integer
- Default: number of logical CPUs
- Environment: `CARGO_BUILD_JOBS`

Sets the maximum number of compiler processes to run in parallel. If negative, it sets the maximum number of compiler processes to the number of logical CPUs plus provided value. Should not be 0.

Can be overridden with the `--jobs` CLI option.

`build.rustc`

- Type: string (program path)
- Default: “rustc”
- Environment: `CARGO_BUILD_RUSTC` or `RUSTC`

Sets the executable to use for `rustc`.

`build.rustc-wrapper`

- Type: string (program path)
- Default: none
- Environment: `CARGO_BUILD_RUSTC_WRAPPER` or `RUSTC_WRAPPER`

Sets a wrapper to execute instead of `rustc`. The first argument passed to the wrapper is the path to the actual executable to use (i.e., `build.rustc`, if that is set, or `"rustc"` otherwise).

`build.rustc-workspace-wrapper`

- Type: string (program path)
- Default: none
- Environment: `CARGO_BUILD_RUSTC_WORKSPACE_WRAPPER` or `RUSTC_WORKSPACE_WRAPPER`

Sets a wrapper to execute instead of `rustc`, for workspace members only. The first argument passed to the wrapper is the path to the actual executable to use (i.e., `build.rustc`, if that is set, or `"rustc"` otherwise). It affects the filename hash so that artifacts produced by the wrapper are cached separately.

`build.rustdoc`

- Type: string (program path)
- Default: “rustdoc”
- Environment: `CARGO_BUILD_RUSTDOC` or `RUSTDOC`

Sets the executable to use for `rustdoc`.

`build.target`

- Type: string or array of strings
- Default: host platform
- Environment: `CARGO_BUILD_TARGET`

The default target platform triples to compile to.

This allows passing either a string or an array of strings. Each string value is a target platform triple. The selected build targets will be built for each of the selected architectures.

The string value may also be a relative path to a `.json` target spec file.

Can be overridden with the `--target` CLI option.

```
[build]
target = ["x86_64-unknown-linux-gnu", "i686-unknown-linux-gnu"]
```

`build.target-dir`

- Type: string (path)
- Default: “target”
- Environment: `CARGO_BUILD_TARGET_DIR` or `CARGO_TARGET_DIR`

The path to where all compiler output is placed. The default if not specified is a directory named `target` located at the root of the workspace.

Can be overridden with the `--target-dir` CLI option.

`build.rustflags`

- Type: string or array of strings
- Default: none
- Environment: `CARGO_BUILD_RUSTFLAGS` or `CARGO_ENCODED_RUSTFLAGS` or `RUSTFLAGS`

Extra command-line flags to pass to `rustc`. The value may be an array of strings or a space-separated string.

There are four mutually exclusive sources of extra flags. They are checked in order, with the first one being used:

1. `CARGO_ENCODED_RUSTFLAGS` environment variable.
2. `RUSTFLAGS` environment variable.
3. All matching `target.<triple>.rustflags` and `target.<cfg>.rustflags` config entries joined together.
4. `build.rustflags` config value.

Additional flags may also be passed with the `cargo rustc` command.

If the `--target` flag (or `build.target`) is used, then the flags will only be passed to the compiler for the target. Things being built for the host, such as build scripts or proc macros, will not receive the args. Without `--target`, the flags will be passed to all compiler invocations (including build scripts and proc macros) because dependencies are shared. If you have args that you do not want to pass to build scripts or proc macros and are building for the host, pass `--target` with the host triple.

It is not recommended to pass in flags that Cargo itself usually manages. For example, the flags driven by profiles are best handled by setting the appropriate profile setting.

> **Caution**: Due to the low-level nature of passing flags directly to the compiler, this may cause a conflict with future versions of Cargo which may issue the same or similar flags on its own which may interfere with the flags you specify. This is an area where Cargo may not always be backwards compatible.

`build.rustdocflags`

- Type: string or array of strings
- Default: none
- Environment: `CARGO_BUILD_RUSTDOCFLAGS` or `CARGO_ENCODED_RUSTDOCFLAGS` or `RUSTDOCFLAGS`

Extra command-line flags to pass to `rustdoc`. The value may be an array of strings or a space-separated string.

There are three mutually exclusive sources of extra flags. They are checked in order, with the first one being used:

1. `CARGO_ENCODED_RUSTDOCFLAGS` environment variable.
2. `RUSTDOCFLAGS` environment variable.
3. `build.rustdocflags` config value.

Additional flags may also be passed with the `cargo rustdoc` command.

`build.incremental`

- Type: bool
- Default: from profile
- Environment: `CARGO_BUILD_INCREMENTAL` or `CARGO_INCREMENTAL`

Whether or not to perform incremental compilation. The default if not set is to use the value from the profile. Otherwise this overrides the setting of all profiles.

The `CARGO_INCREMENTAL` environment variable can be set to `1` to force enable incremental compilation for all profiles, or `0` to disable it. This env var overrides the config setting.

`build.dep-info-basedir`

- Type: string (path)
- Default: none
- Environment: `CARGO_BUILD_DEP_INFO_BASEDIR`

Strips the given path prefix from dep info file paths. This config setting is intended to convert absolute paths to relative paths for tools that require relative paths.

The setting itself is a config-relative path. So, for example, a value of `"."` would strip all paths starting with the parent directory of the `.cargo` directory.

`build.pipelining`

This option is deprecated and unused. Cargo always has pipelining enabled.

`[doc]`

The `[doc]` table defines options for the `cargo doc` command.

`doc.browser`

- Type: string or array of strings (program path with args)
- Default: `BROWSER` environment variable, or, if that is missing, opening the link in a system specific way

This option sets the browser to be used by `cargo doc`, overriding the `BROWSER` environment variable when opening documentation with the `--open` option.

`[cargo-new]`

The `[cargo-new]` table defines defaults for the `cargo new` command.

`cargo-new.name`

This option is deprecated and unused.

`cargo-new.email`

This option is deprecated and unused.

`cargo-new.vcs`

- Type: string
- Default: “git” or “none”
- Environment: `CARGO_CARGO_NEW_VCS`

Specifies the source control system to use for initializing a new repository. Valid values are `git`, `hg` (for Mercurial), `pijul`, `fossil` or `none` to disable this behavior. Defaults to `git`, or `none` if already inside a VCS repository. Can be overridden with the `--vcs` CLI option.

[env]

The `[env]` section allows you to set additional environment variables for build scripts, rustc invocations, `cargo run` and `cargo build`.

```
[env]
OPENSSL_DIR = "/opt/openssl"
```

By default, the variables specified will not override values that already exist in the environment. This behavior can be changed by setting the `force` flag.

Setting the `relative` flag evaluates the value as a config-relative path that is relative to the parent directory of the `.cargo` directory that contains the `config.toml` file. The value of the environment variable will be the full absolute path.

```
[env]
TMPDIR = { value = "/home/tmp", force = true }
OPENSSL_DIR = { value = "vendor/openssl", relative = true }
```

[future-incompat-report]

The `[future-incompat-report]` table controls setting for future incompat reporting

future-incompat-report.frequency

- Type: string
- Default: “always”
- Environment: `CARGO_FUTURE_INCOMPAT_REPORT_FREQUENCY`

Controls how often we display a notification to the terminal when a future incompat report is available. Possible values:

- `always` (default): Always display a notification when a command (e.g. `cargo build`) produces a future incompat report
- `never`: Never display a notification

[http]

The `[http]` table defines settings for HTTP behavior. This includes fetching crate dependencies and accessing remote git repositories.

`http.debug`

- Type: boolean
- Default: false
- Environment: `CARGO_HTTP_DEBUG`

If `true`, enables debugging of HTTP requests. The debug information can be seen by setting the `CARGO_LOG=cargo::ops::registry=debug` environment variable (or use `trace` for even more information).

Be wary when posting logs from this output in a public location. The output may include headers with authentication tokens which you don't want to leak! Be sure to review logs before posting them.

`http.proxy`

- Type: string
- Default: none
- Environment: `CARGO_HTTP_PROXY` or `HTTPS_PROXY` or `https_proxy` or `http_proxy`

Sets an HTTP and HTTPS proxy to use. The format is in libcurl format as in `[protocol://]host[:port]`. If not set, Cargo will also check the `http.proxy` setting in your global git configuration. If none of those are set, the `HTTPS_PROXY` or `https_proxy` environment variables set the proxy for HTTPS requests, and `http_proxy` sets it for HTTP requests.

`http.timeout`

- Type: integer
- Default: 30
- Environment: `CARGO_HTTP_TIMEOUT` or `HTTP_TIMEOUT`

Sets the timeout for each HTTP request, in seconds.

`http.cainfo`

- Type: string (path)
- Default: none
- Environment: `CARGO_HTTP_CAINFO`

Path to a Certificate Authority (CA) bundle file, used to verify TLS certificates. If not specified, Cargo attempts to use the system certificates.

`http.check-revoke`

- Type: boolean
- Default: true (Windows) false (all others)
- Environment: `CARGO_HTTP_CHECK_REVOKE`

This determines whether or not TLS certificate revocation checks should be performed. This only works on Windows.

`http.ssl-version`

- Type: string or min/max table
- Default: none
- Environment: `CARGO_HTTP_SSL_VERSION`

This sets the minimum TLS version to use. It takes a string, with one of the possible values of "default", "tlsv1", "tlsv1.0", "tlsv1.1", "tlsv1.2", or "tlsv1.3".

This may alternatively take a table with two keys, `min` and `max`, which each take a string value of the same kind that specifies the minimum and maximum range of TLS versions to use.

The default is a minimum version of "tlsv1.0" and a max of the newest version supported on your platform, typically "tlsv1.3".

`http.low-speed-limit`

- Type: integer
- Default: 10
- Environment: `CARGO_HTTP_LOW_SPEED_LIMIT`

This setting controls timeout behavior for slow connections. If the average transfer speed in bytes per second is below the given value for `http.timeout` seconds (default 30 seconds), then the connection is considered too slow and Cargo will abort and retry.

`http.multiplexing`

- Type: boolean
- Default: true
- Environment: `CARGO_HTTP_MULTIPLEXING`

When `true`, Cargo will attempt to use the HTTP2 protocol with multiplexing. This allows multiple requests to use the same connection, usually improving performance when fetching multiple files. If `false`, Cargo will use HTTP 1.1 without pipelining.

`http.user-agent`

- Type: string
- Default: Cargo's version
- Environment: `CARGO_HTTP_USER_AGENT`

Specifies a custom user-agent header to use. The default if not specified is a string that includes Cargo's version.

`[install]`

The `[install]` table defines defaults for the `cargo install` command.

`install.root`

- Type: string (path)
- Default: Cargo's home directory
- Environment: `CARGO_INSTALL_ROOT`

Sets the path to the root directory for installing executables for `cargo install`. Executables go into a `bin` directory underneath the root.

To track information of installed executables, some extra files, such as `.crates.toml` and `.crates2.json`, are also created under this root.

The default if not specified is Cargo's home directory (default `.cargo` in your home directory).

Can be overridden with the `--root` command-line option.

`[net]`

The `[net]` table controls networking configuration.

`net.retry`

- Type: integer
- Default: 3
- Environment: `CARGO_NET_RETRY`

Number of times to retry possibly spurious network errors.

`net.git-fetch-with-cli`

- Type: boolean
- Default: false
- Environment: `CARGO_NET_GIT_FETCH_WITH_CLI`

If this is `true`, then Cargo will use the `git` executable to fetch registry indexes and git dependencies. If `false`, then it uses a built-in `git` library.

Setting this to `true` can be helpful if you have special authentication requirements that Cargo does not support. See Git Authentication for more information about setting up git authentication.

`net.offline`

- Type: boolean
- Default: false

- Environment: `CARGO_NET_OFFLINE`

If this is `true`, then Cargo will avoid accessing the network, and attempt to proceed with locally cached data. If `false`, Cargo will access the network as needed, and generate an error if it encounters a network error.

Can be overridden with the `--offline` command-line option.

`net.ssh`

The `[net.ssh]` table contains settings for SSH connections.

`net.ssh.known-hosts`

- Type: array of strings
- Default: see description
- Environment: not supported

The `known-hosts` array contains a list of SSH host keys that should be accepted as valid when connecting to an SSH server (such as for SSH git dependencies). Each entry should be a string in a format similar to OpenSSH `known_hosts` files. Each string should start with one or more hostnames separated by commas, a space, the key type name, a space, and the base64-encoded key. For example:

```
[net.ssh]
known-hosts = [
    "example.com ssh-ed25519 AAAAC3NzaC1lZDI1NTE5AAAAIFO4Q5T0UV0SQevair9PFwoxY9dl4pQl3u5phoqJH3cF"
]
```

Cargo will attempt to load known hosts keys from common locations supported in OpenSSH, and will join those with any listed in a Cargo configuration file. If any matching entry has the correct key, the connection will be allowed.

Cargo comes with the host keys for github.com built-in. If those ever change, you can add the new keys to the config or known_hosts file.

See Git Authentication for more details.

`[patch]`

Just as you can override dependencies using `[patch]` in `Cargo.toml`, you can override them in the cargo configuration file to apply those patches to any affected build. The format is identical to the one used in `Cargo.toml`.

Since `.cargo/config.toml` files are not usually checked into source control, you should prefer patching using `Cargo.toml` where possible to ensure that other developers can compile your crate in their own environments. Patching through cargo configuration files is generally only appropriate when the patch section is automatically generated by an external build tool.

If a given dependency is patched both in a cargo configuration file and a `Cargo.toml` file, the patch in the configuration file is used. If multiple configuration files patch the same dependency, standard cargo configuration merging is used, which prefers the value defined closest to the current directory, with `$HOME/.cargo/config.toml` taking the lowest precedence.

Relative `path` dependencies in such a `[patch]` section are resolved relative to the configuration file they appear in.

`[profile]`

The `[profile]` table can be used to globally change profile settings, and override settings specified in `Cargo.toml`. It has the same syntax and options as profiles specified in `Cargo.toml`. See the Profiles chapter for details about the options.

`[profile.<name>.build-override]`

- Environment: `CARGO_PROFILE_<name>_BUILD_OVERRIDE_<key>`

The build-override table overrides settings for build scripts, proc macros, and their dependencies. It has the same keys as a normal profile. See the overrides section for more details.

`[profile.<name>.package.<name>]`

- Environment: not supported

The package table overrides settings for specific packages. It has the same keys as a normal profile, minus the `panic`, `lto`, and `rpath` settings. See the overrides section for more details.

`profile.<name>.codegen-units`

- Type: integer
- Default: See profile docs.
- Environment: `CARGO_PROFILE_<name>_CODEGEN_UNITS`

See codegen-units.

`profile.<name>.debug`

- Type: integer or boolean
- Default: See profile docs.
- Environment: `CARGO_PROFILE_<name>_DEBUG`

See debug.

`profile.<name>.split-debuginfo`

- Type: string
- Default: See profile docs.
- Environment: `CARGO_PROFILE_<name>_SPLIT_DEBUGINFO`

See split-debuginfo.

`profile.<name>.debug-assertions`

- Type: boolean
- Default: See profile docs.
- Environment: `CARGO_PROFILE_<name>_DEBUG_ASSERTIONS`

See debug-assertions.

`profile.<name>.incremental`

- Type: boolean
- Default: See profile docs.
- Environment: `CARGO_PROFILE_<name>_INCREMENTAL`

See incremental.

`profile.<name>.lto`

- Type: string or boolean
- Default: See profile docs.
- Environment: `CARGO_PROFILE_<name>_LTO`

See lto.

`profile.<name>.overflow-checks`

- Type: boolean
- Default: See profile docs.
- Environment: `CARGO_PROFILE_<name>_OVERFLOW_CHECKS`

See overflow-checks.

`profile.<name>.opt-level`

- Type: integer or string
- Default: See profile docs.
- Environment: `CARGO_PROFILE_<name>_OPT_LEVEL`

See opt-level.

`profile.<name>.panic`

- Type: string
- default: See profile docs.
- Environment: `CARGO_PROFILE_<name>_PANIC`

See panic.

`profile.<name>.rpath`

- Type: boolean
- default: See profile docs.
- Environment: `CARGO_PROFILE_<name>_RPATH`

See rpath.

`[registries]`

The `[registries]` table is used for specifying additional registries. It consists of a sub-table for each named registry.

`registries.<name>.index`

- Type: string (url)
- Default: none
- Environment: `CARGO_REGISTRIES_<name>_INDEX`

Specifies the URL of the index for the registry.

`registries.<name>.token`

- Type: string
- Default: none
- Environment: `CARGO_REGISTRIES_<name>_TOKEN`

Specifies the authentication token for the given registry. This value should only appear in the credentials file. This is used for registry commands like `cargo publish` that require authentication.

Can be overridden with the `--token` command-line option.

`registries.crates-io.protocol`

- Type: string
- Default: `sparse`
- Environment: `CARGO_REGISTRIES_CRATES_IO_PROTOCOL`

Specifies the protocol used to access crates.io. Allowed values are `git` or `sparse`.

`git` causes Cargo to clone the entire index of all packages ever published to crates.io from https://github.com/rust-lang/crates.io-index/. This can have performance implications due to the size of the index. `sparse` is a newer protocol which uses HTTPS to download only what is necessary from https://index.crates.io/. This can result in a significant performance improvement for resolving new dependencies in most situations.

More information about registry protocols may be found in the Registries chapter.

`[registry]`

The `[registry]` table controls the default registry used when one is not specified.

`registry.index`

This value is no longer accepted and should not be used.

`registry.default`

- Type: string
- Default: `"crates-io"`
- Environment: `CARGO_REGISTRY_DEFAULT`

The name of the registry (from the `registries` table) to use by default for registry commands like `cargo publish`.

Can be overridden with the `--registry` command-line option.

`registry.token`

- Type: string
- Default: none
- Environment: `CARGO_REGISTRY_TOKEN`

Specifies the authentication token for crates.io. This value should only appear in the credentials file. This is used for registry commands like `cargo publish` that require authentication.

Can be overridden with the `--token` command-line option.

`[source]`

The `[source]` table defines the registry sources available. See Source Replacement for more information. It consists of a sub-table for each named source. A source should only define one kind (directory, registry, local-registry, or git).

`source.<name>.replace-with`

- Type: string

- Default: none
- Environment: not supported

If set, replace this source with the given named source or named registry.

`source.<name>.directory`

- Type: string (path)
- Default: none
- Environment: not supported

Sets the path to a directory to use as a directory source.

`source.<name>.registry`

- Type: string (url)
- Default: none
- Environment: not supported

Sets the URL to use for a registry source.

`source.<name>.local-registry`

- Type: string (path)
- Default: none
- Environment: not supported

Sets the path to a directory to use as a local registry source.

`source.<name>.git`

- Type: string (url)
- Default: none
- Environment: not supported

Sets the URL to use for a git repository source.

`source.<name>.branch`

- Type: string
- Default: none
- Environment: not supported

Sets the branch name to use for a git repository.

If none of `branch`, `tag`, or `rev` is set, defaults to the `master` branch.

`source.<name>.tag`

- Type: string
- Default: none

- Environment: not supported

Sets the tag name to use for a git repository.

If none of `branch`, `tag`, or `rev` is set, defaults to the `master` branch.

`source.<name>.rev`

- Type: string
- Default: none
- Environment: not supported

Sets the revision to use for a git repository.

If none of `branch`, `tag`, or `rev` is set, defaults to the `master` branch.

`[target]`

The `[target]` table is used for specifying settings for specific platform targets. It consists of a sub-table which is either a platform triple or a `cfg()` expression. The given values will be used if the target platform matches either the `<triple>` value or the `<cfg>` expression.

```
[target.thumbv7m-none-eabi]
linker = "arm-none-eabi-gcc"
runner = "my-emulator"
rustflags = ["…", "…"]

[target.'cfg(all(target_arch = "arm", target_os = "none"))']
runner = "my-arm-wrapper"
rustflags = ["…", "…"]
```

`cfg` values come from those built-in to the compiler (run `rustc --print=cfg` to view), values set by build scripts, and extra `--cfg` flags passed to `rustc` (such as those defined in `RUSTFLAGS`). Do not try to match on `debug_assertions` or Cargo features like `feature="foo"`.

If using a target spec JSON file, the `<triple>` value is the filename stem. For example `--target foo/bar.json` would match `[target.bar]`.

`target.<triple>.ar`

This option is deprecated and unused.

`target.<triple>.linker`

- Type: string (program path)
- Default: none
- Environment: `CARGO_TARGET_<triple>_LINKER`

Specifies the linker which is passed to `rustc` (via `-C linker`) when the `<triple>` is being compiled for. By default, the linker is not overridden.

`target.<triple>.runner`

- Type: string or array of strings (program path with args)
- Default: none
- Environment: `CARGO_TARGET_<triple>_RUNNER`

If a runner is provided, executables for the target `<triple>` will be executed by invoking the specified runner with the actual executable passed as an argument. This applies to `cargo run`, `cargo test` and `cargo bench` commands. By default, compiled executables are executed directly.

`target.<cfg>.runner`

This is similar to the target runner, but using a `cfg()` expression. If both a `<triple>` and `<cfg>` runner match, the `<triple>` will take precedence. It is an error if more than one `<cfg>` runner matches the current target.

`target.<triple>.rustflags`

- Type: string or array of strings
- Default: none
- Environment: `CARGO_TARGET_<triple>_RUSTFLAGS`

Passes a set of custom flags to the compiler for this `<triple>`. The value may be an array of strings or a space-separated string.

See `build.rustflags` for more details on the different ways to specific extra flags.

`target.<cfg>.rustflags`

This is similar to the target rustflags, but using a `cfg()` expression. If several `<cfg>` and `<triple>` entries match the current target, the flags are joined together.

`target.<triple>.<links>`

The links sub-table provides a way to override a build script. When specified, the build script for the given `links` library will not be run, and the given values will be used instead.

```toml
[target.x86_64-unknown-linux-gnu.foo]
rustc-link-lib = ["foo"]
rustc-link-search = ["/path/to/foo"]
rustc-flags = "-L /some/path"
rustc-cfg = ['key="value"']
rustc-env = {key = "value"}
rustc-cdylib-link-arg = ["…"]
metadata_key1 = "value"
metadata_key2 = "value"
```

`[term]`

The `[term]` table controls terminal output and interaction.

`term.quiet`

- Type: boolean
- Default: false
- Environment: `CARGO_TERM_QUIET`

Controls whether or not log messages are displayed by Cargo.

Specifying the `--quiet` flag will override and force quiet output. Specifying the `--verbose` flag will override and disable quiet output.

`term.verbose`

- Type: boolean
- Default: false
- Environment: `CARGO_TERM_VERBOSE`

Controls whether or not extra detailed messages are displayed by Cargo.

Specifying the `--quiet` flag will override and disable verbose output. Specifying the `--verbose` flag will override and force verbose output.

`term.color`

- Type: string
- Default: "auto"
- Environment: `CARGO_TERM_COLOR`

Controls whether or not colored output is used in the terminal. Possible values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

Can be overridden with the `--color` command-line option.

`term.progress.when`

- Type: string
- Default: “auto”
- Environment: `CARGO_TERM_PROGRESS_WHEN`

Controls whether or not progress bar is shown in the terminal. Possible values:

- `auto` (default): Intelligently guess whether to show progress bar.
- `always`: Always show progress bar.
- `never`: Never show progress bar.

`term.progress.width`

- Type: integer
- Default: none
- Environment: `CARGO_TERM_PROGRESS_WIDTH`

Sets the width for progress bar.

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_LOG` — Cargo uses the `env_logger` crate to display debug log messages. The `CARGO_LOG` environment variable can be set to enable debug logging, with a value such as `trace`, `debug`, or `warn`. Usually it is only used during debugging. For more details refer to the Debug logging.
- `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` (`%USERPROFILE%\.cargo` on Windows), but this variable overrides the location of this directory. Once a crate is cached it is not removed by the clean command. For more details refer to the guide.
- `CARGO_TARGET_DIR` — Location of where to place all generated artifacts, relative to the current working directory. See `build.target-dir` to set via config.
- `CARGO` — If set, Cargo will forward this value instead of setting it to its own auto-detected path when it builds crates and when it executes build scripts and external subcommands. This value is not directly executed by Cargo, and should always point at a command that behaves exactly like `cargo`, as that's what users of the variable will be expecting.
- `RUSTC` — Instead of running `rustc`, Cargo will execute this specified compiler instead. See `build.rustc` to set via config.
- `RUSTC_WRAPPER` — Instead of simply running `rustc`, Cargo will execute this specified wrapper, passing as its command-line arguments the rustc invocation, with the first argument being the path to the actual rustc. Useful to set up a build cache tool such as `sccache`. See `build.rustc-wrapper` to set via config. Setting this to the empty string overwrites the config and resets cargo to not use a wrapper.
- `RUSTC_WORKSPACE_WRAPPER` — Instead of simply running `rustc`, for workspace members Cargo will execute this specified wrapper, passing as its command-line arguments the rustc invocation, with the first argument being the path to the actual rustc. It affects the filename hash so that artifacts produced by the wrapper are cached separately. See `build.rustc-workspace-wrapper` to set via config. Setting this to the empty string overwrites the config and resets cargo to not use a wrapper for workspace members.
- `RUSTDOC` — Instead of running `rustdoc`, Cargo will execute this specified `rustdoc` instance instead. See `build.rustdoc` to set via config.

- `RUSTDOCFLAGS` — A space-separated list of custom flags to pass to all `rustdoc` invocations that Cargo performs. In contrast with `cargo rustdoc`, this is useful for passing a flag to *all* `rustdoc` instances. See `build.rustdocflags` for some more ways to set flags. This string is split by whitespace; for a more robust encoding of multiple arguments, see `CARGO_ENCODED_RUSTDOCFLAGS`.
- `CARGO_ENCODED_RUSTDOCFLAGS` — A list of custom flags separated by `0x1f` (ASCII Unit Separator) to pass to all `rustdoc` invocations that Cargo performs.
- `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. See `build.rustflags` for some more ways to set flags. This string is split by whitespace; for a more robust encoding of multiple arguments, see `CARGO_ENCODED_RUSTFLAGS`.
- `CARGO_ENCODED_RUSTFLAGS` — A list of custom flags separated by `0x1f` (ASCII Unit Separator) to pass to all compiler invocations that Cargo performs.
- `CARGO_INCREMENTAL` — If this is set to 1 then Cargo will force incremental compilation to be enabled for the current compilation, and when set to 0 it will force disabling it. If this env var isn't present then cargo's defaults will otherwise be used. See also `build.incremental` config value.
- `CARGO_CACHE_RUSTC_INFO` — If this is set to 0 then Cargo will not try to cache compiler version information.
- `HTTPS_PROXY` or `https_proxy` or `http_proxy` — The HTTP proxy to use, see `http.proxy` for more detail.
- `HTTP_TIMEOUT` — The HTTP timeout in seconds, see `http.timeout` for more detail.
- `TERM` — If this is set to `dumb`, it disables the progress bar.
- `BROWSER` — The web browser to execute to open documentation with `cargo doc`'s' `--open` flag, see `doc.browser` for more details.
- `RUSTFMT` — Instead of running `rustfmt`, `cargo fmt` will execute this specified `rustfmt` instance instead.

Configuration environment variables

Cargo reads environment variables for some configuration values. See the configuration chapter for more details. In summary, the supported environment variables are:

- `CARGO_ALIAS_<name>` — Command aliases, see `alias`.
- `CARGO_BUILD_JOBS` — Number of parallel jobs, see `build.jobs`.
- `CARGO_BUILD_RUSTC` — The `rustc` executable, see `build.rustc`.
- `CARGO_BUILD_RUSTC_WRAPPER` — The `rustc` wrapper, see `build.rustc-wrapper`.
- `CARGO_BUILD_RUSTC_WORKSPACE_WRAPPER` — The `rustc` wrapper for workspace members only, see `build.rustc-workspace-wrapper`.
- `CARGO_BUILD_RUSTDOC` — The `rustdoc` executable, see `build.rustdoc`.
- `CARGO_BUILD_TARGET` — The default target platform, see `build.target`.
- `CARGO_BUILD_TARGET_DIR` — The default output directory, see `build.target-dir`.
- `CARGO_BUILD_RUSTFLAGS` — Extra `rustc` flags, see `build.rustflags`.
- `CARGO_BUILD_RUSTDOCFLAGS` — Extra `rustdoc` flags, see `build.rustdocflags`.

- `CARGO_BUILD_INCREMENTAL` — Incremental compilation, see `build.incremental`.
- `CARGO_BUILD_DEP_INFO_BASEDIR` — Dep-info relative directory, see `build.dep-info-basedir`.
- `CARGO_CARGO_NEW_VCS` — The default source control system with `cargo new`, see `cargo-new.vcs`.
- `CARGO_FUTURE_INCOMPAT_REPORT_FREQUENCY` — How often we should generate a future incompat report notification, see `future-incompat-report.frequency`.
- `CARGO_HTTP_DEBUG` — Enables HTTP debugging, see `http.debug`.
- `CARGO_HTTP_PROXY` — Enables HTTP proxy, see `http.proxy`.
- `CARGO_HTTP_TIMEOUT` — The HTTP timeout, see `http.timeout`.
- `CARGO_HTTP_CAINFO` — The TLS certificate Certificate Authority file, see `http.cainfo`.
- `CARGO_HTTP_CHECK_REVOKE` — Disables TLS certificate revocation checks, see `http.check-revoke`.
- `CARGO_HTTP_SSL_VERSION` — The TLS version to use, see `http.ssl-version`.
- `CARGO_HTTP_LOW_SPEED_LIMIT` — The HTTP low-speed limit, see `http.low-speed-limit`.
- `CARGO_HTTP_MULTIPLEXING` — Whether HTTP/2 multiplexing is used, see `http.multiplexing`.
- `CARGO_HTTP_USER_AGENT` — The HTTP user-agent header, see `http.user-agent`.
- `CARGO_INSTALL_ROOT` — The default directory for `cargo install`, see `install.root`.
- `CARGO_NET_RETRY` — Number of times to retry network errors, see `net.retry`.
- `CARGO_NET_GIT_FETCH_WITH_CLI` — Enables the use of the `git` executable to fetch, see `net.git-fetch-with-cli`.
- `CARGO_NET_OFFLINE` — Offline mode, see `net.offline`.
- `CARGO_PROFILE_<name>_BUILD_OVERRIDE_<key>` — Override build script profile, see `profile.<name>.build-override`.
- `CARGO_PROFILE_<name>_CODEGEN_UNITS` — Set code generation units, see `profile.<name>.codegen-units`.
- `CARGO_PROFILE_<name>_DEBUG` — What kind of debug info to include, see `profile.<name>.debug`.
- `CARGO_PROFILE_<name>_DEBUG_ASSERTIONS` — Enable/disable debug assertions, see `profile.<name>.debug-assertions`.
- `CARGO_PROFILE_<name>_INCREMENTAL` — Enable/disable incremental compilation, see `profile.<name>.incremental`.
- `CARGO_PROFILE_<name>_LTO` — Link-time optimization, see `profile.<name>.lto`.
- `CARGO_PROFILE_<name>_OVERFLOW_CHECKS` — Enable/disable overflow checks, see `profile.<name>.overflow-checks`.
- `CARGO_PROFILE_<name>_OPT_LEVEL` — Set the optimization level, see `profile.<name>.opt-level`.
- `CARGO_PROFILE_<name>_PANIC` — The panic strategy to use, see `profile.<name>.panic`.
- `CARGO_PROFILE_<name>_RPATH` — The rpath linking option, see `profile.<name>.rpath`.
- `CARGO_PROFILE_<name>_SPLIT_DEBUGINFO` — Controls debug file output behavior, see `profile.<name>.split-debuginfo`.
- `CARGO_REGISTRIES_<name>_INDEX` — URL of a registry index, see `registries.<name>.index`.

- `CARGO_REGISTRIES_<name>_TOKEN` — Authentication token of a registry, see `registries.<name>.token`.
- `CARGO_REGISTRY_DEFAULT` — Default registry for the `--registry` flag, see `registry.default`.
- `CARGO_REGISTRY_TOKEN` — Authentication token for crates.io, see `registry.token`.
- `CARGO_TARGET_<triple>_LINKER` — The linker to use, see `target.<triple>.linker`. The triple must be converted to uppercase and underscores.
- `CARGO_TARGET_<triple>_RUNNER` — The executable runner, see `target.<triple>.runner`.
- `CARGO_TARGET_<triple>_RUSTFLAGS` — Extra `rustc` flags for a target, see `target.<triple>.rustflags`.
- `CARGO_TERM_QUIET` — Quiet mode, see `term.quiet`.
- `CARGO_TERM_VERBOSE` — The default terminal verbosity, see `term.verbose`.
- `CARGO_TERM_COLOR` — The default color mode, see `term.color`.
- `CARGO_TERM_PROGRESS_WHEN` — The default progress bar showing mode, see `term.progress.when`.
- `CARGO_TERM_PROGRESS_WIDTH` — The default progress bar width, see `term.progress.width`.

Environment variables Cargo sets for crates

Cargo exposes these environment variables to your crate when it is compiled. Note that this applies for running binaries with `cargo run` and `cargo test` as well. To get the value of any of these variables in a Rust program, do this:

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

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

Note that if one of these values is not provided in the manifest, the corresponding environment variable is set to the empty string, `""`.

- `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 from the manifest of your package.
- `CARGO_PKG_HOMEPAGE` — The home page from the manifest of your package.
- `CARGO_PKG_REPOSITORY` — The repository from the manifest of your package.
- `CARGO_PKG_LICENSE` — The license from the manifest of your package.
- `CARGO_PKG_LICENSE_FILE` — The license file from the manifest of your package.

- `CARGO_PKG_RUST_VERSION` — The Rust version from the manifest of your package. Note that this is the minimum Rust version supported by the package, not the current Rust version.
- `CARGO_PKG_README` — Path to the README file of your package.
- `CARGO_CRATE_NAME` — The name of the crate that is currently being compiled. It is the name of the Cargo target with `-` converted to `_`, such as the name of the library, binary, example, integration test, or benchmark.
- `CARGO_BIN_NAME` — The name of the binary that is currently being compiled. Only set for binaries or binary examples. This name does not include any file extension, such as `.exe`.
- `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. (Only set during compilation.)
- `CARGO_BIN_EXE_<name>` — The absolute path to a binary target's executable. This is only set when building an integration test or benchmark. This may be used with the `env` macro to find the executable to run for testing purposes. The `<name>` is the name of the binary target, exactly as-is. For example, `CARGO_BIN_EXE_my-program` for a binary named `my-program`. Binaries are automatically built when the test is built, unless the binary has required features that are not enabled.
- `CARGO_PRIMARY_PACKAGE` — This environment variable will be set if the package being built is primary. Primary packages are the ones the user selected on the command-line, either with `-p` flags or the defaults based on the current directory and the default workspace members. This environment variable will not be set when building dependencies. This is only set when compiling the package (not when running binaries or tests).
- `CARGO_TARGET_TMPDIR` — Only set when building integration test or benchmark code. This is a path to a directory inside the target directory where integration tests or benchmarks are free to put any data needed by the tests/benches. Cargo initially creates this directory but doesn't manage its content in any way, this is the responsibility of the test code.

Dynamic library paths

Cargo also sets the dynamic library path when compiling and running binaries with commands like `cargo run` and `cargo test`. This helps with locating shared libraries that are part of the build process. The variable name depends on the platform:

- Windows: `PATH`
- macOS: `DYLD_FALLBACK_LIBRARY_PATH`
- Unix: `LD_LIBRARY_PATH`

The value is extended from the existing value when Cargo starts. macOS has special consideration where if `DYLD_FALLBACK_LIBRARY_PATH` is not already set, it will add the default `$HOME/lib:/usr/local/lib:/usr/lib`.

Cargo includes the following paths:

- Search paths included from any build script with the `rustc-link-search` instruction. Paths outside of the `target` directory are removed. It is the responsibility of the user running Cargo to properly set the environment if additional libraries on the system are needed in the search path.
- The base output directory, such as `target/debug`, and the "deps" directory. This is mostly for legacy support of `rustc` compiler plugins.
- The rustc sysroot library path. This generally is not important to most users.

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` — Path to the `cargo` binary performing the build.
- `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_MAKEFLAGS` — Contains parameters needed for Cargo's jobserver implementation to parallelize subprocesses. Rustc or cargo invocations from build.rs can already read `CARGO_MAKEFLAGS`, but GNU Make requires the flags to be specified either directly as arguments, or through the `MAKEFLAGS` environment variable. Currently Cargo doesn't set the `MAKEFLAGS` variable, but it's free for build scripts invoking GNU Make to set it to the contents of `CARGO_MAKEFLAGS`.
- `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 `,`. This includes values built-in to the compiler (which can be seen with `rustc --print=cfg`) and values set by build scripts and extra flags passed to `rustc` (such as those defined in `RUSTFLAGS`). Some examples of what these variables are:
  - `CARGO_CFG_UNIX` — Set on unix-like platforms.
  - `CARGO_CFG_WINDOWS` — Set on windows-like platforms.
  - `CARGO_CFG_TARGET_FAMILY=unix` — The target family.

    - `CARGO_CFG_TARGET_OS=macos` — The target operating system.
    - `CARGO_CFG_TARGET_ARCH=x86_64` — The CPU target architecture.
    - `CARGO_CFG_TARGET_VENDOR=apple` — The target vendor.
    - `CARGO_CFG_TARGET_ENV=gnu` — The target environment ABI.
    - `CARGO_CFG_TARGET_POINTER_WIDTH=64` — The CPU pointer width.
    - `CARGO_CFG_TARGET_ENDIAN=little` — The CPU target endianness.
    - `CARGO_CFG_TARGET_FEATURE=mmx,sse` — List of CPU target features enabled.
- `OUT_DIR` — the folder in which all output and intermediate artifacts 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. See the Target Triple description for more information.
- `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`. Note that care should be taken when interpreting this environment variable. For historical purposes this is still provided but recent versions of Cargo, for example, do not need to run `make -j`, and instead can set the `MAKEFLAGS` env var to the content of `CARGO_MAKEFLAGS` to activate the use of Cargo's GNU Make compatible jobserver for sub-make invocations.
- `OPT_LEVEL`, `DEBUG` — values of the corresponding variables for the profile currently being built.
- `PROFILE` — `release` for release builds, `debug` for other builds. This is determined based on if the profile inherits from the `dev` or `release` profile. Using this environment variable is not recommended. Using other environment variables like `OPT_LEVEL` provide a more correct view of the actual settings being used.
- `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.
- `RUSTC_WRAPPER` — the `rustc` wrapper, if any, that Cargo is using. See `build.rustc-wrapper`.
- `RUSTC_WORKSPACE_WRAPPER` — the `rustc` wrapper, if any, that Cargo is using for workspace members. See `build.rustc-workspace-wrapper`.
- `RUSTC_LINKER` — The path to the linker binary that Cargo has resolved to use for the current target, if specified. The linker can be changed by editing `.cargo/config.toml`; see the documentation about cargo configuration for more information.
- `CARGO_ENCODED_RUSTFLAGS` — extra flags that Cargo invokes `rustc` with, separated by a `0x1f` character (ASCII Unit Separator). See `build.rustflags`. Note that since Rust 1.55, `RUSTFLAGS` is removed from the environment; scripts should use `CARGO_ENCODED_RUSTFLAGS` instead.
- `CARGO_PKG_<var>` — The package information variables, with the same names and values as are provided during crate building.

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.

For extended information about your environment you may run `cargo metadata`.

Build Scripts

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 custom build scripts. Placing a file named `build.rs` in the root of a package will cause Cargo to compile that script and execute it just before building the package.

```rust
// Example custom build script.
fn main() {
    // Tell Cargo that if the given file changes, to rerun this build script.
    println!("cargo:rerun-if-changed=src/hello.c");
    // Use the `cc` crate to build a C file and statically link it.
    cc::Build::new()
        .file("src/hello.c")
        .compile("hello");
}
```

Some example use cases of build scripts 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.

The sections below describe how build scripts work, and the examples chapter shows a variety of examples on how to write scripts.

> Note: The `package.build` manifest key can be used to change the name of the build script, or disable it entirely.

Life Cycle of a Build Script

Just before a package is built, Cargo will compile a build script into an executable (if it has not already been built). It will then run the script, which may perform any number of tasks. The script may communicate with Cargo by printing specially formatted commands prefixed with `cargo:` to stdout.

The build script will be rebuilt if any of its source files or dependencies change.

By default, Cargo will re-run the build script if any of the files in the package changes. Typically it is best to use the `rerun-if` commands, described in the change detection section below, to narrow the focus of what triggers a build script to run again.

Once the build script successfully finishes executing, the rest of the package will be compiled. Scripts should exit with a non-zero exit code to halt the build if there is an error, in which case the build script's output will be displayed on the terminal.

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

Build scripts may save any output files or intermediate artifacts in the directory specified in the `OUT_DIR` environment variable. Scripts should not modify any files outside of that directory.

Build scripts communicate with Cargo by printing to stdout. Cargo will interpret each line that starts with `cargo:` as an instruction that will influence compilation of the package. All other lines are ignored.

> Note: The order of `cargo:` instructions printed by the build script *may* affect the order of arguments that `cargo` passes to `rustc`. In turn, the order of arguments passed to `rustc` may affect the order of arguments passed to the linker. Therefore, you will want to pay attention to the order of the build script's instructions. For example, if object `foo` needs to link against library `bar`, you may want to make sure that library `bar`'s `cargo:rustc-link-lib` instruction appears *after* instructions to link object `foo`.

The output of the script is hidden from the terminal during normal compilation. If you would like to see the output directly in your terminal, invoke Cargo as "very verbose" with the `-vv` flag. This only happens when the build script is run. If Cargo determines nothing has changed, it will not re-run the script, see change detection below for more.

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). The stderr output is also saved in that same directory.

The following is a summary of the instructions that Cargo recognizes, with each one detailed below.

- `cargo:rerun-if-changed=PATH` — Tells Cargo when to re-run the script.
- `cargo:rerun-if-env-changed=VAR` — Tells Cargo when to re-run the script.
- `cargo:rustc-link-arg=FLAG` — Passes custom flags to a linker for benchmarks, binaries, `cdylib` crates, examples, and tests.
- `cargo:rustc-link-arg-bin=BIN=FLAG` — Passes custom flags to a linker for the binary `BIN`.
- `cargo:rustc-link-arg-bins=FLAG` — Passes custom flags to a linker for binaries.
- `cargo:rustc-link-arg-tests=FLAG` — Passes custom flags to a linker for tests.
- `cargo:rustc-link-arg-examples=FLAG` — Passes custom flags to a linker for examples.
- `cargo:rustc-link-arg-benches=FLAG` — Passes custom flags to a linker for benchmarks.
- `cargo:rustc-link-lib=LIB` — Adds a library to link.
- `cargo:rustc-link-search=[KIND=]PATH` — Adds to the library search path.
- `cargo:rustc-flags=FLAGS` — Passes certain flags to the compiler.
- `cargo:rustc-cfg=KEY[="VALUE"]` — Enables compile-time `cfg` settings.
- `cargo:rustc-env=VAR=VALUE` — Sets an environment variable.
- `cargo:rustc-cdylib-link-arg=FLAG` — Passes custom flags to a linker for cdylib crates.
- `cargo:warning=MESSAGE` — Displays a warning on the terminal.
- `cargo:KEY=VALUE` — Metadata, used by `links` scripts.

`cargo:rustc-link-arg=FLAG`

The `rustc-link-arg` instruction tells Cargo to pass the `-C link-arg=FLAG` option to the compiler, but only when building supported targets (benchmarks, binaries, `cdylib` crates, examples, and tests). Its usage is highly platform specific. It is useful to set the shared library version or linker script.

`cargo:rustc-link-arg-bin=BIN=FLAG`

The `rustc-link-arg-bin` instruction tells Cargo to pass the `-C link-arg=FLAG` option to the compiler, but only when building the binary target with name `BIN`. Its usage is highly platform specific. It is useful to set a linker script or other linker options.

`cargo:rustc-link-arg-bins=FLAG`

The `rustc-link-arg-bins` instruction tells Cargo to pass the `-C link-arg=FLAG` option to the compiler, but only when building a binary target. Its usage is highly platform specific. It is useful to set a linker script or other linker options.

`cargo:rustc-link-lib=LIB`

The `rustc-link-lib` instruction tells Cargo to link the given library using the compiler's `-l` flag. This is typically used to link a native library using FFI.

The `LIB` string is passed directly to rustc, so it supports any syntax that `-l` does. Currently the full supported syntax for `LIB` is `[KIND[:MODIFIERS]=]NAME[:RENAME]`.

The `-l` flag is only passed to the library target of the package, unless there is no library target, in which case it is passed to all targets. This is done because all other targets have an implicit dependency on the library target, and the given library to link should only be included once. This means that if a package has both a library and a binary target, the *library* has access to the symbols from the given lib, and the binary should access them through the library target's public API.

The optional `KIND` may be one of `dylib`, `static`, or `framework`. See the rustc book for more detail.

`cargo:rustc-link-arg-tests=FLAG`

The `rustc-link-arg-tests` instruction tells Cargo to pass the `-C link-arg=FLAG` option to the compiler, but only when building a tests target.

`cargo:rustc-link-arg-examples=FLAG`

The `rustc-link-arg-examples` instruction tells Cargo to pass the `-C link-arg=FLAG` option to the compiler, but only when building an examples target.

`cargo:rustc-link-arg-benches=FLAG`

The `rustc-link-arg-benches` instruction tells Cargo to pass the `-C link-arg=FLAG` option to the compiler, but only when building a benchmark target.

`cargo:rustc-link-search=[KIND=]PATH`

The `rustc-link-search` instruction tells Cargo to pass the `-L` flag to the compiler to add a directory to the library search path.

The optional `KIND` may be one of `dependency`, `crate`, `native`, `framework`, or `all`. See the rustc book for more detail.

These paths are also added to the dynamic library search path environment variable if they are within the `OUT_DIR`. Depending on this behavior is discouraged since this makes it difficult to use the resulting binary. In general, it is best to avoid creating dynamic libraries in a build script (using existing system libraries is fine).

`cargo:rustc-flags=FLAGS`

The `rustc-flags` instruction tells Cargo to pass the given space-separated flags to the compiler. This only allows the `-l` and `-L` flags, and is equivalent to using `rustc-link-lib` and `rustc-link-search`.

`cargo:rustc-cfg=KEY[="VALUE"]`

The `rustc-cfg` instruction tells Cargo to pass the given value to the `--cfg` flag to the compiler. This may be used for compile-time detection of features to enable conditional compilation.

Note that this does *not* affect Cargo's dependency resolution. This cannot be used to enable an optional dependency, or enable other Cargo features.

Be aware that Cargo features use the form `feature="foo"`. `cfg` values passed with this flag are not restricted to that form, and may provide just a single identifier, or any arbitrary key/value pair. For example, emitting `cargo:rustc-cfg=abc` will then allow code to use `#[cfg(abc)]` (note the lack of `feature=`). Or an arbitrary key/value pair may be used with an `=` symbol like `cargo:rustc-cfg=my_component="foo"`. The key should be a Rust identifier, the value should be a string.

`cargo:rustc-env=VAR=VALUE`

The `rustc-env` instruction tells Cargo to set the given environment variable when compiling the package. The value can be then retrieved by the `env!` macro in the compiled crate. This is useful for embedding additional metadata in crate's code, such as the hash of git HEAD or the unique identifier of a continuous integration server.

See also the environment variables automatically included by Cargo.

> **Note**: These environment variables are also set when running an executable with `cargo run` or `cargo test`. However, this usage is discouraged since it ties the executable to Cargo's execution environment. Normally, these environment variables should only be checked at compile-time with the `env!` macro.

`cargo:rustc-cdylib-link-arg=FLAG`

The `rustc-cdylib-link-arg` instruction tells Cargo to pass the `-C link-arg=FLAG` option to the compiler, but only when building a `cdylib` library target. Its usage is highly platform specific. It is useful to set the shared library version or the runtime-path.

`cargo:warning=MESSAGE`

The `warning` instruction tells Cargo to display a warning after the 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. The `-vv` "very verbose" flag may be used to have Cargo display warnings for all crates.

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]
cc = "1.0.46"
```

The build script **does not** have access to the dependencies listed in the `dependencies` or `dev-dependencies` section (they're not built yet!). Also, build dependencies are not available to the package itself unless also explicitly added in the `[dependencies]` table.

It is recommended to carefully consider each dependency you add, weighing against the impact on compile time, licensing, maintenance, etc. Cargo will attempt to reuse a dependency if it is shared between build dependencies and normal dependencies. However, this is not always possible, for example when cross-compiling, so keep that in consideration of the impact on compile time.

Change Detection

When rebuilding a package, Cargo does not necessarily know if the build script needs to be run again. By default, it takes a conservative approach of always re-running the build script if any file within the package is changed (or the list of files controlled by the `exclude` and `include` fields). For most cases, this is not a good choice, so it is recommended that every build script emit at least one of the `rerun-if` instructions (described below). If these are emitted, then Cargo will only re-run the script if the given value has changed. If Cargo is re-running the build scripts of your own crate or a dependency and you don't know why, see "Why is Cargo rebuilding my code?" in the FAQ.

`cargo:rerun-if-changed=PATH`

The `rerun-if-changed` instruction tells Cargo to re-run the build script if the file at the given path has changed. Currently, Cargo only uses the filesystem last-modified "mtime" timestamp to determine if the file has changed. It compares against an internal cached timestamp of when the build script last ran.

If the path points to a directory, it will scan the entire directory for any modifications.

If the build script inherently does not need to re-run under any circumstance, then emitting `cargo:rerun-if-changed=build.rs` is a simple way to prevent it from being re-run (otherwise, the default if no `rerun-if` instructions are emitted is to scan the entire package directory for changes). Cargo automatically handles whether or not the script itself needs to be recompiled, and of course the script will be re-run after it has been recompiled. Otherwise, specifying `build.rs` is redundant and unnecessary.

`cargo:rerun-if-env-changed=NAME`

The `rerun-if-env-changed` instruction tells Cargo to re-run the build script if the value of an environment variable of the given name has changed.

Note that the environment variables here are intended for global environment variables like `CC` and such, it is not necessary to use this for environment variables like `TARGET` that Cargo sets.

The `links` Manifest Key

The `package.links` key may be set in the `Cargo.toml` manifest to declare that the package links with the given native library. 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.

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

This manifest states that the package links to the `libfoo` native library. When using the `links` key, the package must have a build script, and the build script should use the `rustc-link-lib` instruction to link the library.

Primarily, Cargo requires that there is at most one package per `links` value. In other words, it is forbidden to have two packages link to the same native library. This helps prevent duplicate symbols between crates. 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 the package `bar` depends on `foo`, then if `foo` generates `key=value` as part of its build script metadata, then the build script of `bar` will have the environment variables `DEP_FOO_KEY=value`. See the "Using another `sys` crate" for an example of how this can be used.

Note that metadata is only passed to immediate dependents, not transitive dependents.

`*-sys` Packages

Some Cargo packages that link to system libraries have a naming convention of having a `-sys` suffix. Any package named `foo-sys` should provide two major pieces of functionality:

- The library crate should link to the native library `libfoo`. This will often probe the current system for `libfoo` before resorting to building from source.
- The library crate should provide **declarations** for types and functions in `libfoo`, but **not** 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 rule about one package per value of `links`.
- Other `-sys` packages can take advantage of the `DEP_NAME_KEY=value` environment variables to better integrate with other packages. See the "Using another `sys` crate" example.
- A common dependency allows centralizing logic on discovering `libfoo` itself (or building it from source).
- These dependencies are easily overridable.

It is common to have a companion package without the `-sys` suffix that provides a safe, high-level abstractions on top of the sys package. For example, the `git2` crate provides a high-level interface to the `libgit2-sys` crate.

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 `config.toml` file.

```
[target.x86_64-unknown-linux-gnu.foo]
rustc-link-lib = ["foo"]
rustc-link-search = ["/path/to/foo"]
rustc-flags = "-L /some/path"
rustc-cfg = ['key="value"']
rustc-env = {key = "value"}
rustc-cdylib-link-arg = ["…"]
metadata_key1 = "value"
metadata_key2 = "value"
```

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 be used instead.

The `warning`, `rerun-if-changed`, and `rerun-if-env-changed` keys should not be used and will be ignored.

Jobserver

Cargo and `rustc` use the jobserver protocol, developed for GNU make, to coordinate concurrency across processes. It is essentially a semaphore that controls the number of jobs running concurrently. The concurrency may be set with the `--jobs` flag, which defaults to the number of logical CPUs.

Each build script inherits one job slot from Cargo, and should endeavor to only use one CPU while it runs. If the script wants to use more CPUs in parallel, it should use the `jobserver` crate to coordinate with Cargo.

As an example, the `cc` crate may enable the optional `parallel` feature which will use the jobserver protocol to attempt to build multiple C files at the same time.

Build Script Examples

The following sections illustrate some examples of writing build scripts.

Some common build script functionality can be found via crates on crates.io. Check out the `build-dependencies` keyword to see what is available. The following is a sample of some popular crates[1]:

- `bindgen` — Automatically generate Rust FFI bindings to C libraries.
- `cc` — Compiles C/C++/assembly.
- `pkg-config` — Detect system libraries using the `pkg-config` utility.
- `cmake` — Runs the `cmake` build tool to build a native library.
- `autocfg`, `rustc_version`, `version_check` — These crates provide ways to implement conditional compilation based on the current `rustc` such as the version of the compiler.

[1] This list is not an endorsement. Evaluate your dependencies to see which is right for your project.

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`. This package has a basic manifest:

```
# Cargo.toml

[package]
name = "hello-from-generated-code"
version = "0.1.0"
edition = "2021"
```

Let's see what's inside the build script:

```
// build.rs

use std::env;
use std::fs;
use std::path::Path;

fn main() {
    let out_dir = env::var_os("OUT_DIR").unwrap();
    let dest_path = Path::new(&out_dir).join("hello.rs");
    fs::write(
        &dest_path,
        "pub fn message() -> &'static str {
            \"Hello, World!\"
        }
        "
    ).unwrap();
    println!("cargo:rerun-if-changed=build.rs");
}
```

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.
- In general, build scripts should not modify any files outside of `OUT_DIR`. It may seem fine on the first blush, but it does cause problems when you use such crate as a dependency, because there’s an *implicit* invariant that sources in `.cargo/registry` should be immutable. `cargo` won’t allow such scripts when packaging.
- 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.
- The `rerun-if-changed` instruction tells Cargo that the build script only needs to re-run if the build script itself changes. Without this line, Cargo will automatically run the build script if any file in the package changes. If your code generation uses some input files, this is where you would print a list of each of those files.

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.

Building a native library

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 package 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"
edition = "2021"
```

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

```rust
// 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");
    println!("cargo:rerun-if-changed=src/hello.c");
}
```

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 hard-coded 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. Let's try the `cc` crate from crates.io. First, add it to the `build-dependencies` in `Cargo.toml`:

```toml
[build-dependencies]
cc = "1.0"
```

And rewrite the build script to use this crate:

```rust
// build.rs

fn main() {
    cc::Build::new()
        .file("src/hello.c")
        .compile("hello");
    println!("cargo:rerun-if-changed=src/hello.c");
}
```

The `cc` 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 `cc` 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:

```c
// src/hello.c

#include <stdio.h>

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

```rust
// src/main.rs

// Note the lack of the `#[link]` attribute. We're delegating the responsibility
// of selecting what to link over to the build script rather than hard-coding
// 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.

Linking to system libraries

This example demonstrates how to link a system library and how the build script is used to support this use case.

Quite frequently a Rust crate wants to link to a native library 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. It is best, if possible, to farm out as much of this as possible to make this as easy as possible for consumers.

For this example, we will be creating a binding to the system's zlib library. This is a library that is commonly found on most Unix-like systems that provides data compression. This is already wrapped up in the `libz-sys` crate, but for this example, we'll do an extremely simplified version. Check out the source code for the full example.

To make it easy to find the location of the library, we will use the `pkg-config` crate. This crate uses the system's `pkg-config` utility to discover information about a library. It will automatically tell Cargo what is needed to link the library. This will likely only work on Unix-like systems with `pkg-config` installed. Let's start by setting up the manifest:

```
# Cargo.toml

[package]
name = "libz-sys"
version = "0.1.0"
edition = "2021"
links = "z"

[build-dependencies]
pkg-config = "0.3.16"
```

Take note that we included the `links` key in the `package` table. This tells Cargo that we are linking to the `libz` library. See "Using another sys crate" for an example that will leverage this.

The build script is fairly simple:

```
// build.rs

fn main() {
    pkg_config::Config::new().probe("zlib").unwrap();
    println!("cargo:rerun-if-changed=build.rs");
}
```

Let's round out the example with a basic FFI binding:

```
// src/lib.rs

use std::os::raw::{c_uint, c_ulong};

extern "C" {
    pub fn crc32(crc: c_ulong, buf: *const u8, len: c_uint) -> c_ulong;
}

#[test]
fn test_crc32() {
    let s = "hello";
    unsafe {
        assert_eq!(crc32(0, s.as_ptr(), s.len() as c_uint), 0x3610a686);
    }
}
```

Run `cargo build -vv` to see the output from the build script. On a system with `libz` already installed, it may look something like this:

```
[libz-sys 0.1.0] cargo:rustc-link-search=native=/usr/lib
[libz-sys 0.1.0] cargo:rustc-link-lib=z
[libz-sys 0.1.0] cargo:rerun-if-changed=build.rs
```

Nice! `pkg-config` did all the work of finding the library and telling Cargo where it is.

It is not unusual for packages to include the source for the library, and build it statically if it is not found on the system, or if a feature or environment variable is set. For example, the real `libz-sys` crate checks the environment variable `LIBZ_SYS_STATIC` or the `static` feature to build it from source instead of using the system library. Check out the source for a more complete example.

Using another `sys` crate

When using the `links` key, crates may set metadata that can be read by other crates that depend on it. This provides a mechanism to communicate information between crates. In this example, we'll be creating a C library that makes use of zlib from the real `libz-sys` crate.

If you have a C library that depends on zlib, you can leverage the `libz-sys` crate to automatically find it or build it. This is great for cross-platform support, such as Windows where zlib is not usually installed. `libz-sys` sets the `include` metadata to tell other packages where to find the header files for zlib. Our build script can read that metadata with the `DEP_Z_INCLUDE` environment variable. Here's an example:

```toml
# Cargo.toml

[package]
name = "zuser"
version = "0.1.0"
edition = "2021"

[dependencies]
libz-sys = "1.0.25"

[build-dependencies]
cc = "1.0.46"
```

Here we have included `libz-sys` which will ensure that there is only one `libz` used in the final library, and give us access to it from our build script:

```rust
// build.rs

fn main() {
    let mut cfg = cc::Build::new();
    cfg.file("src/zuser.c");
    if let Some(include) = std::env::var_os("DEP_Z_INCLUDE") {
        cfg.include(include);
    }
    cfg.compile("zuser");
    println!("cargo:rerun-if-changed=src/zuser.c");
}
```

With `libz-sys` doing all the heavy lifting, the C source code may now include the zlib header, and it should find the header, even on systems where it isn't already installed.

```c
// src/zuser.c

#include "zlib.h"

// … rest of code that makes use of zlib.
```

Conditional compilation

A build script may emit `rustc-cfg` instructions which can enable conditions that can be checked at compile time. In this example, we'll take a look at how the `openssl` crate uses this to support multiple versions of the OpenSSL library.

The `openssl-sys` crate implements building and linking the OpenSSL library. It supports multiple different implementations (like LibreSSL) and multiple versions. It makes use of the `links` key so that it may pass information to other build scripts. One of the things it passes is the `version_number` key, which is the version of OpenSSL that was detected. The code in the build script looks something like this:

```
println!("cargo:version_number={:x}", openssl_version);
```

This instruction causes the `DEP_OPENSSL_VERSION_NUMBER` environment variable to be set in any crates that directly depend on `openssl-sys`.

The `openssl` crate, which provides the higher-level interface, specifies `openssl-sys` as a dependency. The `openssl` build script can read the version information generated by the `openssl-sys` build script with the `DEP_OPENSSL_VERSION_NUMBER` environment variable. It uses this to generate some `cfg` values:

```
// (portion of build.rs)

if let Ok(version) = env::var("DEP_OPENSSL_VERSION_NUMBER") {
    let version = u64::from_str_radix(&version, 16).unwrap();

    if version >= 0x1_00_01_00_0 {
        println!("cargo:rustc-cfg=ossl101");
    }
    if version >= 0x1_00_02_00_0 {
        println!("cargo:rustc-cfg=ossl102");
    }
    if version >= 0x1_01_00_00_0 {
        println!("cargo:rustc-cfg=ossl110");
    }
    if version >= 0x1_01_00_07_0 {
        println!("cargo:rustc-cfg=ossl110g");
    }
    if version >= 0x1_01_01_00_0 {
        println!("cargo:rustc-cfg=ossl111");
    }
}
```

These `cfg` values can then be used with the `cfg` attribute or the `cfg` macro to conditionally include code. For example, SHA3 support was added in OpenSSL 1.1.1, so it is conditionally excluded for older versions:

```
// (portion of openssl crate)

#[cfg(ossl111)]
pub fn sha3_224() -> MessageDigest {
    unsafe { MessageDigest(ffi::EVP_sha3_224()) }
}
```

Of course, one should be careful when using this, since it makes the resulting binary even more dependent on the build environment. In this example, if the binary is distributed to another system, it may not have the exact same shared libraries, which could cause problems.

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 things 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). You will also need to verify your email address on the Account Settings page. Once that is done create an API token, make sure you copy it. Once you leave the page you will not be able to see it again.

Then run the `cargo login` command.

```
$ cargo login
```

Then at the prompt put in the token specified.

```
please paste the API Token found on https://crates.io/me below
abcdefghijklmnopqrstuvwxyz012345
```

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

> **Note**: The `cargo logout` command can be used to remove the token from `credentials.toml`. This can be useful if you no longer need it stored on the local machine.

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.

Check out the metadata you can specify in `Cargo.toml` to ensure your crate can be discovered more easily! Before publishing, make sure you have filled out the following fields:

- `license` or `license-file`
- `description`
- `homepage`
- `documentation`
- `repository`
- `readme`

It would also be a good idea to include some `keywords` and `categories`, though they are not required.

If you are publishing a library, you may also want to consult the Rust API Guidelines.

Packaging a crate

The next step is to package up your crate and upload it to crates.io. For this we'll use the `cargo publish` subcommand. This command performs the following steps:

1. Perform some verification checks on your package.
2. Compress your source code into a `.crate` file.
3. Extract the `.crate` file into a temporary directory and verify that it compiles.
4. Upload the `.crate` file to crates.io.
5. The registry will perform some additional checks on the uploaded package before adding it.

It is recommended that you first run `cargo publish --dry-run` (or `cargo package` which is equivalent) to ensure there aren't any warnings or errors before publishing. This will perform the first three steps listed above.

```
$ cargo publish --dry-run
```

You can inspect the generated `.crate` file in the `target/package` directory. crates.io currently has a 10MB size limit on the `.crate` file. You may want to check the size of the `.crate` file to ensure you didn't accidentally package up large assets that are not required to build your package, such as test data, website documentation, or code generation. You can check which files are included with the following command:

```
$ cargo package --list
```

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/*",
]
```

If you'd rather explicitly list the files to include, Cargo also supports an `include` key, which if set, overrides the `exclude` key:

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

Uploading the crate

When you are ready to publish, use the `cargo publish` command to upload to crates.io:

```
$ cargo publish
```

And that's it, you've now published your first crate!

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 which provide guidelines on what is a compatible change. Then run `cargo publish` as described above 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 --version 1.0.1
$ cargo yank --version 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 packages 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 github-handle
$ cargo owner --remove github-handle
$ 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 is invited as 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 is invited as 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 invite 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.

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.

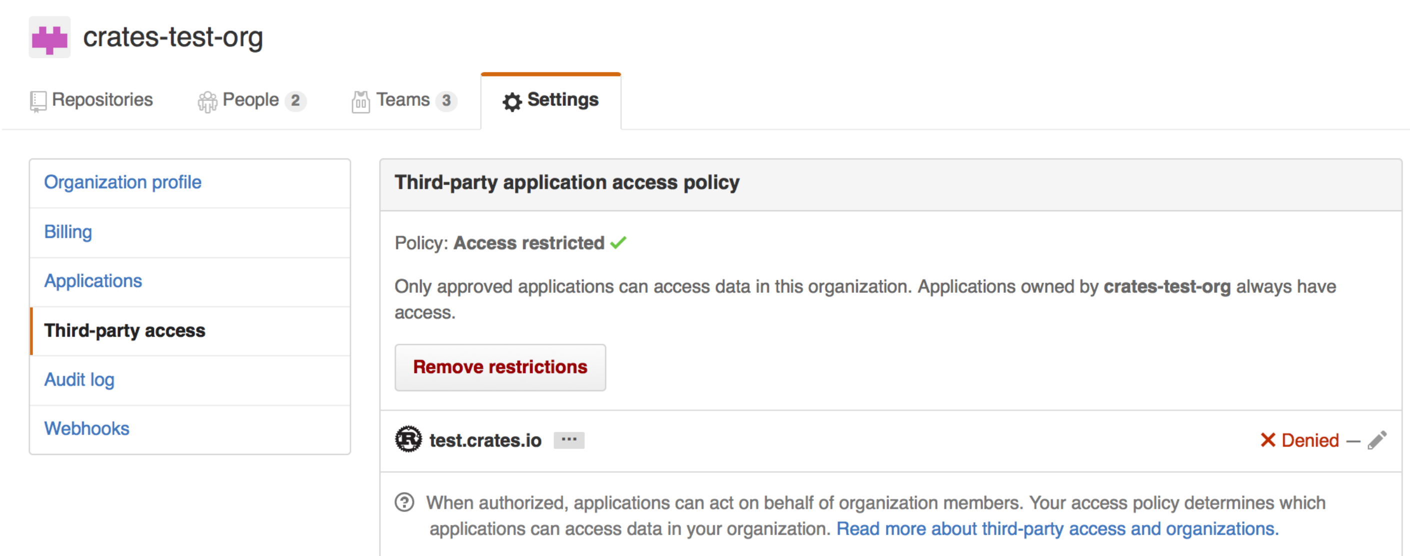
You are free to deny us this scope, and everything that worked before teams were introduced will keep working. However you will never be able to add a team as an owner, or publish a crate as a team owner. If you ever attempt to do this, you will get the error above. You may also see this error if you 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/ and re-authenticate, 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:

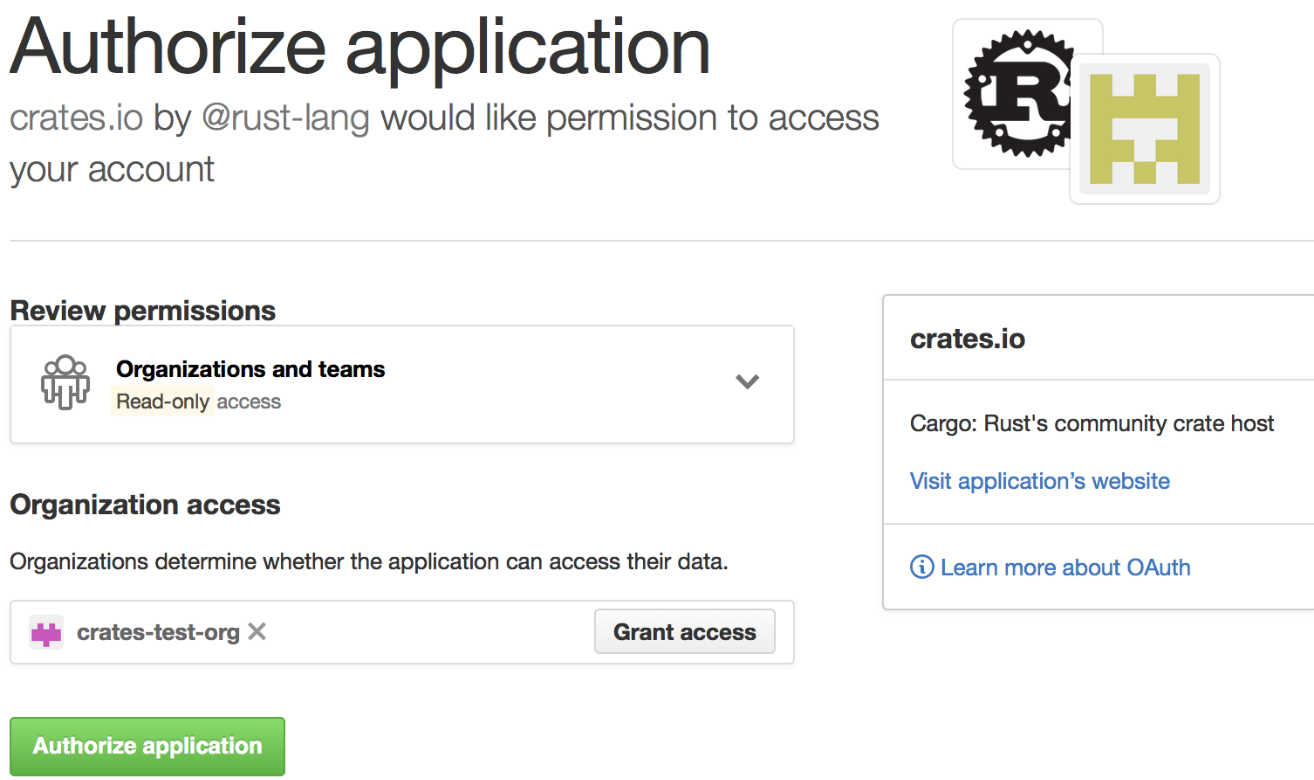
```
https://github.com/organizations/:org/settings/oauth_application_policy
```

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:



Troubleshooting GitHub team access errors

When trying to add a GitHub team as crate owner, you may see an error like:

```
error: failed to invite owners to crate <crate_name>: api errors (status 200 OK): could not
find the github team org/repo
```

In that case, you should go to the GitHub Application settings page and check if crates.io is listed in the `Authorized OAuth Apps` tab. If it isn't, you should go to https://crates.io/ and authorize it. Then go back to the Application Settings page on GitHub, click on the crates.io application in the list, and make sure you or your organization is listed in the "Organization access" list with a green check mark. If there's a button labeled `Grant` or `Request`, you should grant the access or request the org owner to do so.

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.

The specification may be fully qualified, such as `https://github.com/rust-lang/crates.io-index#regex@1.4.3` or it may be abbreviated, such as `regex`. The abbreviated form may be used as long as it uniquely identifies a single package in the dependency graph. If there is ambiguity, additional qualifiers can be added to make it unique. For example, if there are two versions of the `regex` package in the graph, then it can be qualified with a version to make it unique, such as `regex@1.4.3`.

Specification grammar

The formal grammar for a Package Id Specification is:

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

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

Here, brackets indicate that the contents are optional.

The URL form can be used for git dependencies, or to differentiate packages that come from different sources such as different registries.

Example specifications

The following are references to the `regex` package on `crates.io`:

Spec	Name	Version
`regex`	`regex`	`*`
`regex@1.4.3`	`regex`	`1.4.3`
`https://github.com/rust-lang/crates.io-index#regex`	`regex`	`*`
`https://github.com/rust-lang/crates.io-index#regex@1.4.3`	`regex`	`1.4.3`

The following are some examples of specs for several different git dependencies:

Spec	Name	Version
`https://github.com/rust-lang/cargo#0.52.0`	`cargo`	`0.52.0`
`https://github.com/rust-lang/cargo#cargo-platform@0.1.2`	`cargo-platform`	`0.1.2`
`ssh://git@github.com/rust-lang/regex.git#regex@1.4.3`	`regex`	`1.4.3`

Local packages on the filesystem can use `file://` URLs to reference them:

Spec	Name	Version
`file:///path/to/my/project/foo`	`foo`	`*`
`file:///path/to/my/project/foo#1.1.8`	`foo`	`1.1.8`

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.

Source Replacement

This document is about replacing the crate index. You can read about overriding dependencies in the overriding dependencies section of this documentation.

A *source* is a provider that contains crates that may be included as dependencies for a package. Cargo supports the ability to **replace one source with another** to express strategies such as:

- 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 packages 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. Note that this also means that a replacement source is not allowed to have crates which are not present in the original 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 `[patch]` key, and private registry support is described in the Registries chapter.

When using source replacement, running commands like `cargo publish` that need to contact the registry require passing the `--registry` option. This helps avoid any ambiguity about which registry to contact, and will use the authentication token for the specified registry.

Configuration

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

```toml
# 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-vendor-source`, which comes from a directory
# located at `vendor` relative to the directory containing this `.cargo/config.toml`
# file
[source.my-vendor-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.
#
# The `replace-with` key can also reference an alternative registry name
# defined in the `[registries]` table.
[source.crates-io]
replace-with = "my-vendor-source"

# 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"

# Several kinds of sources can be specified (described in more detail below):
registry = "https://example.com/path/to/index"
local-registry = "path/to/registry"
directory = "path/to/vendor"

# Git sources can optionally specify a branch/tag/rev as well
git = "https://example.com/path/to/repo"
# branch = "master"
# tag = "v1.0.1"
# rev = "313f44e8"
```

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 create 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. Directory sources are primarily managed by the `cargo vendor` subcommand.

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.

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:

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

Information about package structure

You can use `cargo metadata` command to get information about package structure and dependencies. See the `cargo metadata` documentation for details on the format of the output.

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, the cargo_metadata crate can be used to parse the output.

JSON messages

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.

The `--message-format` option can also take additional formatting values which alter the way the JSON messages are computed and rendered. See the description of the `--message-format` option in the build command documentation for more details.

If you are using Rust, the cargo_metadata crate can be used to parse these messages.

Compiler messages

The "compiler-message" message includes output from the compiler, such as warnings and errors. See the rustc JSON chapter for details on `rustc`'s message format, which is embedded in the following structure:

```
{
    /* The "reason" indicates the kind of message. */
    "reason": "compiler-message",
    /* The Package ID, a unique identifier for referring to the package. */
    "package_id": "my-package 0.1.0 (path+file:///path/to/my-package)",
    /* Absolute path to the package manifest. */
    "manifest_path": "/path/to/my-package/Cargo.toml",
    /* The Cargo target (lib, bin, example, etc.) that generated the message. */
    "target": {
        /* Array of target kinds.
           - lib targets list the `crate-type` values from the
             manifest such as "lib", "rlib", "dylib",
             "proc-macro", etc. (default ["lib"])
           - binary is ["bin"]
           - example is ["example"]
           - integration test is ["test"]
           - benchmark is ["bench"]
           - build script is ["custom-build"]
        */
        "kind": [
            "lib"
        ],
        /* Array of crate types.
           - lib and example libraries list the `crate-type` values
             from the manifest such as "lib", "rlib", "dylib",
             "proc-macro", etc. (default ["lib"])
           - all other target kinds are ["bin"]
        */
        "crate_types": [
            "lib"
        ],
        /* The name of the target. */
        "name": "my-package",
        /* Absolute path to the root source file of the target. */
        "src_path": "/path/to/my-package/src/lib.rs",
        /* The Rust edition of the target.
           Defaults to the package edition.
        */
        "edition": "2018",
        /* Array of required features.
           This property is not included if no required features are set.
        */
        "required-features": ["feat1"],
        /* Whether the target should be documented by `cargo doc`. */
        "doc": true,
        /* Whether or not this target has doc tests enabled, and
           the target is compatible with doc testing.
        */
        "doctest": true
        /* Whether or not this target should be built and run with `--test`
        */
        "test": true
    },
    /* The message emitted by the compiler.

    See https://doc.rust-lang.org/rustc/json.html for details.
    */
    "message": {
        /* ... */
```

```
    }
}
```

Artifact messages

For every compilation step, a “compiler-artifact” message is emitted with the following structure:

```
{
    /* The "reason" indicates the kind of message. */
    "reason": "compiler-artifact",
    /* The Package ID, a unique identifier for referring to the package. */
    "package_id": "my-package 0.1.0 (path+file:///path/to/my-package)",
    /* Absolute path to the package manifest. */
    "manifest_path": "/path/to/my-package/Cargo.toml",
    /* The Cargo target (lib, bin, example, etc.) that generated the artifacts.
       See the definition above for `compiler-message` for details.
    */
    "target": {
        "kind": [
            "lib"
        ],
        "crate_types": [
            "lib"
        ],
        "name": "my-package",
        "src_path": "/path/to/my-package/src/lib.rs",
        "edition": "2018",
        "doc": true,
        "doctest": true,
        "test": true
    },
    /* The profile indicates which compiler settings were used. */
    "profile": {
        /* The optimization level. */
        "opt_level": "0",
        /* The debug level, an integer of 0, 1, or 2. If `null`, it implies
           rustc's default of 0.
        */
        "debuginfo": 2,
        /* Whether or not debug assertions are enabled. */
        "debug_assertions": true,
        /* Whether or not overflow checks are enabled. */
        "overflow_checks": true,
        /* Whether or not the `--test` flag is used. */
        "test": false
    },
    /* Array of features enabled. */
    "features": ["feat1", "feat2"],
    /* Array of files generated by this step. */
    "filenames": [
        "/path/to/my-package/target/debug/libmy_package.rlib",
        "/path/to/my-package/target/debug/deps/libmy_package-be9f3faac0a26ef0.rmeta"
    ],
    /* A string of the path to the executable that was created, or null if
       this step did not generate an executable.
    */
    "executable": null,
    /* Whether or not this step was actually executed.
       When `true`, this means that the pre-existing artifacts were
       up-to-date, and `rustc` was not executed. When `false`, this means that
       `rustc` was run to generate the artifacts.
    */
    "fresh": true
}
```

Build script output

The “build-script-executed” message includes the parsed output of a build script. Note that this is emitted even if the build script is not run; it will display the previously cached value. More details about build script output may be found in the chapter on build scripts.

```
{
    /* The "reason" indicates the kind of message. */
    "reason": "build-script-executed",
    /* The Package ID, a unique identifier for referring to the package. */
    "package_id": "my-package 0.1.0 (path+file:///path/to/my-package)",
    /* Array of libraries to link, as indicated by the `cargo:rustc-link-lib`
       instruction. Note that this may include a "KIND=" prefix in the string
       where KIND is the library kind.
    */
    "linked_libs": ["foo", "static=bar"],
    /* Array of paths to include in the library search path, as indicated by
       the `cargo:rustc-link-search` instruction. Note that this may include a
       "KIND=" prefix in the string where KIND is the library kind.
    */
    "linked_paths": ["/some/path", "native=/another/path"],
    /* Array of cfg values to enable, as indicated by the `cargo:rustc-cfg`
       instruction.
    */
    "cfgs": ["cfg1", "cfg2=\"string\""],
    /* Array of [KEY, VALUE] arrays of environment variables to set, as
       indicated by the `cargo:rustc-env` instruction.
    */
    "env": [
        ["SOME_KEY", "some value"],
        ["ANOTHER_KEY", "another value"]
    ],
    /* An absolute path which is used as a value of `OUT_DIR` environmental
       variable when compiling current package.
    */
    "out_dir": "/some/path/in/target/dir"
}
```

Build finished

The “build-finished” message is emitted at the end of the build.

```
{
    /* The "reason" indicates the kind of message. */
    "reason": "build-finished",
    /* Whether or not the build finished successfully. */
    "success": true,
}
```

This message can be helpful for tools to know when to stop reading JSON messages. Commands such as `cargo test` or `cargo run` can produce additional output after the build has finished. This message lets a tool know that Cargo will not produce additional JSON messages, but there may be additional output that may be generated afterwards (such as the output generated by the program executed by `cargo run`).

> Note: There is experimental nightly-only support for JSON output for tests, so additional test-specific JSON messages may begin arriving after the “build-finished” message if that is enabled.

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-${command}`. The external tool must be present in one of the user’s `$PATH` directories.

When Cargo invokes a custom subcommand, the first argument to the subcommand will be the filename of the custom subcommand, as usual. The second argument will be the subcommand name itself. For example, the second argument would be `${command}` when invoking `cargo-${command}`. Any additional arguments on the command line will be forwarded unchanged.

Cargo can also display the help output of a custom subcommand with `cargo help ${command}`. Cargo assumes that the subcommand will print a help message if its third argument is `--help`. So, `cargo help ${command}` would invoke `cargo-${command} ${command} --help`.

Custom subcommands may use the `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: the API may change without deprecation
- versions of the linked Cargo library may be different from the Cargo binary

Instead, it is encouraged to use the CLI interface to drive Cargo. The `cargo metadata` command can be used to obtain information about the current project (the `cargo_metadata` crate provides a Rust interface to this command).

Registries

Cargo installs crates and fetches dependencies from a "registry". The default registry is crates.io. A registry contains an "index" which contains a searchable list of available crates. A registry may also provide a web API to support publishing new crates directly from Cargo.

> Note: If you are interested in mirroring or vendoring an existing registry, take a look at Source Replacement.

If you are implementing a registry server, see Running a Registry for more details about the protocol between Cargo and a registry.

Using an Alternate Registry

To use a registry other than crates.io, the name and index URL of the registry must be added to a `.cargo/config.toml` file. The `registries` table has a key for each registry, for example:

```
[registries]
my-registry = { index = "https://my-intranet:8080/git/index" }
```

The `index` key should be a URL to a git repository with the registry's index or a Cargo sparse registry URL with the `sparse+` prefix.

A crate can then depend on a crate from another registry by specifying the `registry` key and a value of the registry's name in that dependency's entry in `Cargo.toml`:

```
# Sample Cargo.toml
[package]
name = "my-project"
version = "0.1.0"
edition = "2021"

[dependencies]
other-crate = { version = "1.0", registry = "my-registry" }
```

As with most config values, the index may be specified with an environment variable instead of a config file. For example, setting the following environment variable will accomplish the same thing as defining a config file:

```
CARGO_REGISTRIES_MY_REGISTRY_INDEX=https://my-intranet:8080/git/index
```

> Note: crates.io does not accept packages that depend on crates from other registries.

Publishing to an Alternate Registry

If the registry supports web API access, then packages can be published directly to the registry from Cargo. Several of Cargo's commands such as `cargo publish` take a `--registry` command-line flag to indicate which registry to use. For example, to publish the package in the current directory:

1. `cargo login --registry=my-registry`

   This only needs to be done once. You must enter the secret API token retrieved from the registry's website. Alternatively the token may be passed directly to the `publish` command with the `--token` command-line flag or an environment variable with the name of the registry such as `CARGO_REGISTRIES_MY_REGISTRY_TOKEN`.

2. `cargo publish --registry=my-registry`

Instead of always passing the `--registry` command-line option, the default registry may be set in `.cargo/config.toml` with the `registry.default` key. For example:

```
[registry]
default = "my-registry"
```

Setting the `package.publish` key in the `Cargo.toml` manifest restricts which registries the package is allowed to be published to. This is useful to prevent accidentally publishing a closed-source package to crates.io. The value may be a list of registry names, for example:

```
[package]
# ...
publish = ["my-registry"]
```

The `publish` value may also be `false` to restrict all publishing, which is the same as an empty list.

The authentication information saved by `cargo login` is stored in the `credentials.toml` file in the Cargo home directory (default `$HOME/.cargo`). It has a separate table for each registry, for example:

```
[registries.my-registry]
token = "854DvwSlUwEHtIo3kWy6x7UCPKHfzCmy"
```

Registry Protocols

Cargo supports two remote registry protocols: `git` and `sparse`. If the registry index URL starts with `sparse+`, Cargo uses the sparse protocol. Otherwise Cargo uses the `git` protocol.

The `git` protocol stores index metadata in a git repository and requires Cargo to clone the entire repo.

The `sparse` protocol fetches individual metadata files using plain HTTP requests. Since Cargo only downloads the metadata for relevant crates, the `sparse` protocol can save significant time and bandwidth.

The crates.io registry supports both protocols. The protocol for crates.io is controlled via the `registries.crates-io.protocol` config key.

Running a Registry

A minimal registry can be implemented by having a git repository that contains an index, and a server that contains the compressed `.crate` files created by `cargo package`. Users won't be able to use Cargo to publish to it, but this may be sufficient for closed environments. The index format is described in Registry Index.

A full-featured registry that supports publishing will additionally need to have a web API service that conforms to the API used by Cargo. The web API is described in Registry Web API.

Commercial and community projects are available for building and running a registry. See https://github.com/rust-lang/cargo/wiki/Third-party-registries for a list of what is available.

Index Format

The following defines the format of the index. New features are occasionally added, which are only understood starting with the version of Cargo that introduced them. Older versions of Cargo may not be able to use packages that make use of new features. However, the format for older packages should not change, so older versions of Cargo should be able to use them.

Index Configuration

The root of the index contains a file named `config.json` which contains JSON information used by Cargo for accessing the registry. This is an example of what the crates.io config file looks like:

```
{
    "dl": "https://crates.io/api/v1/crates",
    "api": "https://crates.io"
}
```

The keys are:

- `dl`: This is the URL for downloading crates listed in the index. The value may have the following markers which will be replaced with their corresponding value:
    - `{crate}`: The name of crate.
    - `{version}`: The crate version.
    - `{prefix}`: A directory prefix computed from the crate name. For example, a crate named `cargo` has a prefix of `ca/rg`. See below for details.
    - `{lowerprefix}`: Lowercase variant of `{prefix}`.
    - `{sha256-checksum}`: The crate's sha256 checksum.

  If none of the markers are present, then the value `/{crate}/{version}/download` is appended to the end.
- `api`: This is the base URL for the web API. This key is optional, but if it is not specified, commands such as `cargo publish` will not work. The web API is described below.

Download Endpoint

The download endpoint should send the `.crate` file for the requested package. Cargo supports https, http, and file URLs, HTTP redirects, HTTP1 and HTTP2. The exact specifics of TLS support depend on the platform that Cargo is running on, the version of Cargo, and how it was compiled.

Index files

The rest of the index repository contains one file for each package, where the filename is the name of the package in lowercase. Each version of the package has a separate line in the file. The files are organized in a tier of directories:

- Packages with 1 character names are placed in a directory named `1`.
- Packages with 2 character names are placed in a directory named `2`.
- Packages with 3 character names are placed in the directory `3/{first-character}` where `{first-character}` is the first character of the package name.
- All other packages are stored in directories named `{first-two}/{second-two}` where the top directory is the first two characters of the package name, and the next subdirectory is the third and fourth characters of the package name. For example, `cargo` would be stored in a file named `ca/rg/cargo`.

> Note: Although the index filenames are in lowercase, the fields that contain package names in `Cargo.toml` and the index JSON data are case-sensitive and may contain upper and lower case characters.

The directory name above is calculated based on the package name converted to lowercase; it is represented by the marker `{lowerprefix}`. When the original package name is used without case conversion, the resulting directory name is represented by the marker `{prefix}`. For example, the package `MyCrate` would have a `{prefix}` of `My/Cr` and a `{lowerprefix}` of `my/cr`. In general, using `{prefix}` is recommended over `{lowerprefix}`, but there are pros and cons to each choice. Using `{prefix}` on case-insensitive filesystems results in (harmless-but-inelegant) directory aliasing. For example, `crate` and `CrateTwo` have `{prefix}` values of `cr/at` and `Cr/at`; these are distinct on Unix machines but alias to the same directory on Windows. Using directories with normalized case avoids aliasing, but on case-sensitive filesystems it's harder to support older versions of Cargo that lack `{prefix}`/`{lowerprefix}`. For example, nginx rewrite rules can easily construct `{prefix}` but can't perform case-conversion to construct `{lowerprefix}`.

Registries should consider enforcing limitations on package names added to their index. Cargo itself allows names with any alphanumeric, `-`, or `_` characters. crates.io imposes its own limitations, including the following:

- Only allows ASCII characters.
- Only alphanumeric, `-`, and `_` characters.
- First character must be alphabetic.
- Case-insensitive collision detection.
- Prevent differences of `-` vs `_`.
- Under a specific length (max 64).
- Rejects reserved names, such as Windows special filenames like “nul”.

Registries should consider incorporating similar restrictions, and consider the security implications, such as IDN homograph attacks and other concerns in UTR36 and

UTS39.

Each line in a package file contains a JSON object that describes a published version of the package. The following is a pretty-printed example with comments explaining the format of the entry.

```
{
    // The name of the package.
    // This must only contain alphanumeric, `-`, or `_` characters.
    "name": "foo",
    // The version of the package this row is describing.
    // This must be a valid version number according to the Semantic
    // Versioning 2.0.0 spec at https://semver.org/.
    "vers": "0.1.0",
    // Array of direct dependencies of the package.
    "deps": [
        {
            // Name of the dependency.
            // If the dependency is renamed from the original package name,
            // this is the new name. The original package name is stored in
            // the `package` field.
            "name": "rand",
            // The SemVer requirement for this dependency.
            // This must be a valid version requirement defined at
            // https://doc.rust-lang.org/cargo/reference/specifying-dependencies.html.
            "req": "^0.6",
            // Array of features (as strings) enabled for this dependency.
            "features": ["i128_support"],
            // Boolean of whether or not this is an optional dependency.
            "optional": false,
            // Boolean of whether or not default features are enabled.
            "default_features": true,
            // The target platform for the dependency.
            // null if not a target dependency.
            // Otherwise, a string such as "cfg(windows)".
            "target": null,
            // The dependency kind.
            // "dev", "build", or "normal".
            // Note: this is a required field, but a small number of entries
            // exist in the crates.io index with either a missing or null
            // `kind` field due to implementation bugs.
            "kind": "normal",
            // The URL of the index of the registry where this dependency is
            // from as a string. If not specified or null, it is assumed the
            // dependency is in the current registry.
            "registry": null,
            // If the dependency is renamed, this is a string of the actual
            // package name. If not specified or null, this dependency is not
            // renamed.
            "package": null,
        }
    ],
    // A SHA256 checksum of the `.crate` file.
    "cksum": "d867001db0e2b6e0496f9fac96930e2d42233ecd3ca0413e0753d4c7695d289c",
    // Set of features defined for the package.
    // Each feature maps to an array of features or dependencies it enables.
    "features": {
        "extras": ["rand/simd_support"]
    },
    // Boolean of whether or not this version has been yanked.
    "yanked": false,
    // The `links` string value from the package's manifest, or null if not
    // specified. This field is optional and defaults to null.
    "links": null,
    // An unsigned 32-bit integer value indicating the schema version of this
    // entry.
    //
```

```
    // If this not specified, it should be interpreted as the default of 1.
    //
    // Cargo (starting with version 1.51) will ignore versions it does not
    // recognize. This provides a method to safely introduce changes to index
    // entries and allow older versions of cargo to ignore newer entries it
    // doesn't understand. Versions older than 1.51 ignore this field, and
    // thus may misinterpret the meaning of the index entry.
    //
    // The current values are:
    //
    // * 1: The schema as documented here, not including newer additions.
    //      This is honored in Rust version 1.51 and newer.
    // * 2: The addition of the `features2` field.
    //      This is honored in Rust version 1.60 and newer.
    "v": 2,
    // This optional field contains features with new, extended syntax.
    // Specifically, namespaced features (`dep:`) and weak dependencies
    // (`pkg?/feat`).
    //
    // This is separated from `features` because versions older than 1.19
    // will fail to load due to not being able to parse the new syntax, even
    // with a `Cargo.lock` file.
    //
    // Cargo will merge any values listed here with the "features" field.
    //
    // If this field is included, the "v" field should be set to at least 2.
    //
    // Registries are not required to use this field for extended feature
    // syntax, they are allowed to include those in the "features" field.
    // Using this is only necessary if the registry wants to support cargo
    // versions older than 1.19, which in practice is only crates.io since
    // those older versions do not support other registries.
    "features2": {
        "serde": ["dep:serde", "chrono?/serde"]
    }
}
```

The JSON objects should not be modified after they are added except for the `yanked` field whose value may change at any time.

> **Note**: The index JSON format has subtle differences from the JSON format of the Publish API and `cargo metadata`. If you are using one of those as a source to generate index entries, you are encouraged to carefully inspect the documentation differences between them.
>
> For the Publish API, the differences are:
>
> - `deps`
>   - `name` — When the dependency is renamed in `Cargo.toml`, the publish API puts the original package name in the `name` field and the aliased name in the `explicit_name_in_toml` field. The index places the aliased name in the `name` field, and the original package name in the `package` field.
>   - `req` — The Publish API field is called `version_req`.

- `cksum` — The publish API does not specify the checksum, it must be computed by the registry before adding to the index.
- `features` — Some features may be placed in the `features2` field. Note: This is only a legacy requirement for crates.io; other registries should not need to bother with modifying the features map. The `v` field indicates the presence of the `features2` field.
- The publish API includes several other fields, such as `description` and `readme`, which don't appear in the index. These are intended to make it easier for a registry to obtain the metadata about the crate to display on a website without needing to extract and parse the `.crate` file. This additional information is typically added to a database on the registry server.

For `cargo metadata`, the differences are:

- `vers` — The `cargo metadata` field is called `version`.
- `deps`
  - `name` — When the dependency is renamed in `Cargo.toml`, `cargo metadata` puts the original package name in the `name` field and the aliased name in the `rename` field. The index places the aliased name in the `name` field, and the original package name in the `package` field.
  - `default_features` — The `cargo metadata` field is called `uses_default_features`.
  - `registry` — `cargo metadata` uses a value of `null` to indicate that the dependency comes from crates.io. The index uses a value of `null` to indicate that the dependency comes from the same registry as the index. When creating an index entry, a registry other than crates.io should translate a value of `null` to be `https://github.com/rust-lang/crates.io-index` and translate a URL that matches the current index to be `null`.
  - `cargo metadata` includes some extra fields, such as `source` and `path`.
- The index includes additional fields such as `yanked`, `cksum`, and `v`.

Index Protocols

Cargo supports two remote registry protocols: `git` and `sparse`. The `git` protocol stores index files in a git repository and the `sparse` protocol fetches individual files over HTTP.

Git Protocol

The git protocol has no protocol prefix in the index url. For example the git index URL for crates.io is `https://github.com/rust-lang/crates.io-index`.

Cargo caches the git repository on disk so that it can efficiently incrementally fetch updates.

Sparse Protocol

The sparse protocol uses the `sparse+` protocol prefix in the registry URL. For example, the sparse index URL for crates.io is `sparse+https://index.crates.io/`.

The sparse protocol downloads each index file using an individual HTTP request. Since this results in a large number of small HTTP requests, performance is significantly improved with a server that supports pipelining and HTTP/2.

Caching

Cargo caches the crate metadata files, and captures the `ETag` or `Last-Modified` HTTP header from the server for each entry. When refreshing crate metadata, Cargo sends the `If-None-Match` or `If-Modified-Since` header to allow the server to respond with HTTP 304 "Not Modified" if the local cache is valid, saving time and bandwidth. If both `ETag` and `Last-Modified` headers are present, Cargo uses the `ETag` only.

Cache Invalidation

If a registry is using some kind of CDN or proxy which caches access to the index files, then it is recommended that registries implement some form of cache invalidation when the files are updated. If these caches are not updated, then users may not be able to access new crates until the cache is cleared.

Nonexistent Crates

For crates that do not exist, the registry should respond with a 404 "Not Found", 410 "Gone" or 451 "Unavailable For Legal Reasons" code.

Sparse Limitations

Since the URL of the registry is stored in the lockfile, it's not recommended to offer a registry with both protocols. Discussion about a transition plan is ongoing in issue #10964. The crates.io registry is an exception, since Cargo internally substitutes the equivalent git URL when the sparse protocol is used.

If a registry does offer both protocols, it's currently recommended to choose one protocol as the canonical protocol and use source replacement for the other protocol.

Web API

A registry may host a web API at the location defined in `config.json` to support any of the actions listed below.

Cargo includes the `Authorization` header for requests that require authentication. The header value is the API token. The server should respond with a 403 response code if the token is not valid. Users are expected to visit the registry's website to obtain a token, and Cargo can store the token using the `cargo login` command, or by passing the token on the command-line.

Responses use the 200 response code for success. Errors should use an appropriate response code, such as 404. Failure responses should have a JSON object with the following structure:

```
{
    // Array of errors to display to the user.
    "errors": [
        {
            // The error message as a string.
            "detail": "error message text"
        }
    ]
}
```

If the response has this structure Cargo will display the detailed message to the user, even if the response code is 200. If the response code indicates an error and the content does not have this structure, Cargo will display to the user a message intended to help debugging the server error. A server returning an `errors` object allows a registry to provide a more detailed or user-centric error message.

For backwards compatibility, servers should ignore any unexpected query parameters or JSON fields. If a JSON field is missing, it should be assumed to be null. The endpoints are versioned with the `v1` component of the path, and Cargo is responsible for handling backwards compatibility fallbacks should any be required in the future.

Cargo sets the following headers for all requests:

- `Content-Type`: `application/json`
- `Accept`: `application/json`
- `User-Agent`: The Cargo version such as `cargo 1.32.0 (8610973aa 2019-01-02)`. This may be modified by the user in a configuration value. Added in 1.29.

Publish

- Endpoint: `/api/v1/crates/new`
- Method: PUT

- Authorization: Included

The publish endpoint is used to publish a new version of a crate. The server should validate the crate, make it available for download, and add it to the index.

It is not required for the index to be updated before the successful response is sent. After a successful response, Cargo will poll the index for a short period of time to identify that the new crate has been added. If the crate does not appear in the index after a short period of time, then Cargo will display a warning letting the user know that the new crate is not yet available.

The body of the data sent by Cargo is:

- 32-bit unsigned little-endian integer of the length of JSON data.
- Metadata of the package as a JSON object.
- 32-bit unsigned little-endian integer of the length of the `.crate` file.
- The `.crate` file.

The following is a commented example of the JSON object. Some notes of some restrictions imposed by crates.io are included only to illustrate some suggestions on types of validation that may be done, and should not be considered as an exhaustive list of restrictions crates.io imposes.

```
{
    // The name of the package.
    "name": "foo",
    // The version of the package being published.
    "vers": "0.1.0",
    // Array of direct dependencies of the package.
    "deps": [
        {
            // Name of the dependency.
            // If the dependency is renamed from the original package name,
            // this is the original name. The new package name is stored in
            // the `explicit_name_in_toml` field.
            "name": "rand",
            // The semver requirement for this dependency.
            "version_req": "^0.6",
            // Array of features (as strings) enabled for this dependency.
            "features": ["i128_support"],
            // Boolean of whether or not this is an optional dependency.
            "optional": false,
            // Boolean of whether or not default features are enabled.
            "default_features": true,
            // The target platform for the dependency.
            // null if not a target dependency.
            // Otherwise, a string such as "cfg(windows)".
            "target": null,
            // The dependency kind.
            // "dev", "build", or "normal".
            "kind": "normal",
            // The URL of the index of the registry where this dependency is
            // from as a string. If not specified or null, it is assumed the
            // dependency is in the current registry.
            "registry": null,
            // If the dependency is renamed, this is a string of the new
            // package name. If not specified or null, this dependency is not
            // renamed.
            "explicit_name_in_toml": null,
        }
    ],
    // Set of features defined for the package.
    // Each feature maps to an array of features or dependencies it enables.
    // Cargo does not impose limitations on feature names, but crates.io
    // requires alphanumeric ASCII, `_` or `-` characters.
    "features": {
        "extras": ["rand/simd_support"]
    },
    // List of strings of the authors.
    // May be empty.
    "authors": ["Alice <a@example.com>"],
    // Description field from the manifest.
    // May be null. crates.io requires at least some content.
    "description": null,
    // String of the URL to the website for this package's documentation.
    // May be null.
    "documentation": null,
    // String of the URL to the website for this package's home page.
    // May be null.
    "homepage": null,
    // String of the content of the README file.
    // May be null.
    "readme": null,
    // String of a relative path to a README file in the crate.
```

```
    // May be null.
    "readme_file": null,
    // Array of strings of keywords for the package.
    "keywords": [],
    // Array of strings of categories for the package.
    "categories": [],
    // String of the license for the package.
    // May be null. crates.io requires either `license` or `license_file` to be set.
    "license": null,
    // String of a relative path to a license file in the crate.
    // May be null.
    "license_file": null,
    // String of the URL to the website for the source repository of this package.
    // May be null.
    "repository": null,
    // Optional object of "status" badges. Each value is an object of
    // arbitrary string to string mappings.
    // crates.io has special interpretation of the format of the badges.
    "badges": {
        "travis-ci": {
            "branch": "master",
            "repository": "rust-lang/cargo"
        }
    },
    // The `links` string value from the package's manifest, or null if not
    // specified. This field is optional and defaults to null.
    "links": null
}
```

A successful response includes the JSON object:

```
{
    // Optional object of warnings to display to the user.
    "warnings": {
        // Array of strings of categories that are invalid and ignored.
        "invalid_categories": [],
        // Array of strings of badge names that are invalid and ignored.
        "invalid_badges": [],
        // Array of strings of arbitrary warnings to display to the user.
        "other": []
    }
}
```

Yank

- Endpoint: `/api/v1/crates/{crate_name}/{version}/yank`
- Method: DELETE
- Authorization: Included

The yank endpoint will set the `yank` field of the given version of a crate to `true` in the index.

A successful response includes the JSON object:

```
{
    // Indicates the delete succeeded, always true.
    "ok": true,
}
```

Unyank

- Endpoint: `/api/v1/crates/{crate_name}/{version}/unyank`
- Method: PUT
- Authorization: Included

The unyank endpoint will set the `yank` field of the given version of a crate to `false` in the index.

A successful response includes the JSON object:

```
{
    // Indicates the delete succeeded, always true.
    "ok": true,
}
```

Owners

Cargo does not have an inherent notion of users and owners, but it does provide the `owner` command to assist managing who has authorization to control a crate. It is up to the registry to decide exactly how users and owners are handled. See the publishing documentation for a description of how crates.io handles owners via GitHub users and teams.

Owners: List

- Endpoint: `/api/v1/crates/{crate_name}/owners`
- Method: GET
- Authorization: Included

The owners endpoint returns a list of owners of the crate.

A successful response includes the JSON object:

```
{
    // Array of owners of the crate.
    "users": [
        {
            // Unique unsigned 32-bit integer of the owner.
            "id": 70,
            // The unique username of the owner.
            "login": "github:rust-lang:core",
            // Name of the owner.
            // This is optional and may be null.
            "name": "Core",
        }
    ]
}
```

Owners: Add

- Endpoint: `/api/v1/crates/{crate_name}/owners`
- Method: PUT
- Authorization: Included

A PUT request will send a request to the registry to add a new owner to a crate. It is up to the registry how to handle the request. For example, crates.io sends an invite to the user that they must accept before being added.

The request should include the following JSON object:

```
{
    // Array of `login` strings of owners to add.
    "users": ["login_name"]
}
```

A successful response includes the JSON object:

```
{
    // Indicates the add succeeded, always true.
    "ok": true,
    // A string to be displayed to the user.
    "msg": "user ehuss has been invited to be an owner of crate cargo"
}
```

Owners: Remove

- Endpoint: `/api/v1/crates/{crate_name}/owners`
- Method: DELETE
- Authorization: Included

A DELETE request will remove an owner from a crate. The request should include the following JSON object:

```
{
    // Array of `login` strings of owners to remove.
    "users": ["login_name"]
}
```

A successful response includes the JSON object:

```
{
    // Indicates the remove succeeded, always true.
    "ok": true
}
```

Search

- Endpoint: `/api/v1/crates`
- Method: GET
- Query Parameters:
    - `q`: The search query string.
    - `per_page`: Number of results, default 10, max 100.

The search request will perform a search for crates, using criteria defined on the server.

A successful response includes the JSON object:

```
{
    // Array of results.
    "crates": [
        {
            // Name of the crate.
            "name": "rand",
            // The highest version available.
            "max_version": "0.6.1",
            // Textual description of the crate.
            "description": "Random number generators and other randomness functionality.\n",
        }
    ],
    "meta": {
        // Total number of results available on the server.
        "total": 119
    }
}
```

Login

- Endpoint: `/me`

The “login” endpoint is not an actual API request. It exists solely for the `cargo login` command to display a URL to instruct a user to visit in a web browser to log in and retrieve an API token.

Dependency Resolution

One of Cargo's primary tasks is to determine the versions of dependencies to use based on the version requirements specified in each package. This process is called "dependency resolution" and is performed by the "resolver". The result of the resolution is stored in the `Cargo.lock` file which "locks" the dependencies to specific versions, and keeps them fixed over time.

The resolver attempts to unify common dependencies while considering possibly conflicting requirements. It turns out, however, that in many cases there is no single "best" dependency resolution, and so the resolver must use heuristics to choose a preferred solution. The sections below provide some details on how requirements are handled, and how to work with the resolver.

See the chapter Specifying Dependencies for more details about how dependency requirements are specified.

The `cargo tree` command can be used to visualize the result of the resolver.

SemVer compatibility

Cargo uses SemVer for specifying version numbers. This establishes a common convention for what is compatible between different versions of a package. See the SemVer Compatibility chapter for guidance on what is considered a "compatible" change. This notion of "compatibility" is important because Cargo assumes it should be safe to update a dependency within a compatibility range without breaking the build.

Versions are considered compatible if their left-most non-zero major/minor/patch component is the same. For example, `1.0.3` and `1.1.0` are considered compatible, and thus it should be safe to update from the older release to the newer one. However, an update from `1.1.0` to `2.0.0` would not be allowed to be made automatically. This convention also applies to versions with leading zeros. For example, `0.1.0` and `0.1.2` are compatible, but `0.1.0` and `0.2.0` are not. Similarly, `0.0.1` and `0.0.2` are not compatible.

As a quick refresher, the *version requirement* syntax Cargo uses for dependencies is:

Requirement	Example	Equivalence	Description
Caret	`1.2.3` or `^1.2.3`	`>=1.2.3, <2.0.0`	Any SemVer-compatible version of at least the given value.
Tilde	`~1.2`	`>=1.2.0, <1.3.0`	Minimum version, with restricted compatibility range.

Requirement	Example	Equivalence	Description
Wildcard	`1.*`	`>=1.0.0, <2.0.0`	Any version in the `*` position.
Equals	`=1.2.3`	`=1.2.3`	Exactly the specified version only.
Comparison	`>1.1`	`>=1.2.0`	Naive numeric comparison of specified digits.
Compound	`>=1.2, <1.5`	`>1.2.0, <1.5.0`	Multiple requirements that must be simultaneously satisfied.

When multiple packages specify a dependency for a common package, the resolver attempts to ensure that they use the same version of that common package, as long as they are within a SemVer compatibility range. It also attempts to use the greatest version currently available within that compatibility range. For example, if there are two packages in the resolve graph with the following requirements:

```
# Package A
[dependencies]
bitflags = "1.0"

# Package B
[dependencies]
bitflags = "1.1"
```

If at the time the `Cargo.lock` file is generated, the greatest version of `bitflags` is `1.2.1`, then both packages will use `1.2.1` because it is the greatest within the compatibility range. If `2.0.0` is published, it will still use `1.2.1` because `2.0.0` is considered incompatible.

If multiple packages have a common dependency with semver-incompatible versions, then Cargo will allow this, but will build two separate copies of the dependency. For example:

```
# Package A
[dependencies]
rand = "0.7"

# Package B
[dependencies]
rand = "0.6"
```

The above will result in Package A using the greatest `0.7` release (`0.7.3` at the time of this writing) and Package B will use the greatest `0.6` release (`0.6.5` for example). This can lead to potential problems, see the Version-incompatibility hazards section for more details.

Multiple versions within the same compatibility range are not allowed and will result in a resolver error if it is constrained to two different versions within a compatibility range. For example, if there are two packages in the resolve graph with the following requirements:

```
# Package A
[dependencies]
log = "=0.4.11"

# Package B
[dependencies]
log = "=0.4.8"
```

The above will fail because it is not allowed to have two separate copies of the `0.4` release of the `log` package.

Version-incompatibility hazards

When multiple versions of a crate appear in the resolve graph, this can cause problems when types from those crates are exposed by the crates using them. This is because the types and items are considered different by the Rust compiler, even if they have the same name. Libraries should take care when publishing a SemVer-incompatible version (for example, publishing `2.0.0` after `1.0.0` has been in use), particularly for libraries that are widely used.

The "semver trick" is a workaround for this problem of publishing a breaking change while retaining compatibility with older versions. The linked page goes into detail about what the problem is and how to address it. In short, when a library wants to publish a SemVer-breaking release, publish the new release, and also publish a point release of the previous version that reexports the types from the newer version.

These incompatibilities usually manifest as a compile-time error, but sometimes they will only appear as a runtime misbehavior. For example, let's say there is a common library named `foo` that ends up appearing with both version `1.0.0` and `2.0.0` in the resolve graph. If `downcast_ref` is used on a object created by a library using version `1.0.0`, and the code calling `downcast_ref` is downcasting to a type from version `2.0.0`, the downcast will fail at runtime.

It is important to make sure that if you have multiple versions of a library that you are properly using them, especially if it is ever possible for the types from different versions to be used together. The `cargo tree -d` command can be used to identify duplicate versions and where they come from. Similarly, it is important to consider the impact on the ecosystem if you publish a SemVer-incompatible version of a popular library.

Pre-releases

SemVer has the concept of "pre-releases" with a dash in the version, such as `1.0.0-alpha`, or `1.0.0-beta`. Cargo will avoid automatically using pre-releases unless explicitly asked. For example, if `1.0.0-alpha` of package `foo` is published, then a requirement of `foo = "1.0"` will *not* match, and will return an error. The pre-release must be specified, such as `foo = "1.0.0-alpha"`. Similarly `cargo install` will avoid pre-releases unless explicitly asked to install one.

Cargo allows "newer" pre-releases to be used automatically. For example, if `1.0.0-beta` is published, then a requirement `foo = "1.0.0-alpha"` will allow updating to the `beta` version. Beware that pre-release versions can be unstable, and as such care should be taken when using them. Some projects may choose to publish breaking changes between pre-release versions. It is recommended to not use pre-release dependencies in a library if your library is not also a pre-release. Care should also be taken when updating your `Cargo.lock`, and be prepared if a pre-release update causes issues.

The pre-release tag may be separated with periods to distinguish separate components. Numeric components will use numeric comparison. For example, `1.0.0-alpha.4` will use numeric comparison for the `4` component. That means that if `1.0.0-alpha.11` is published, that will be chosen as the greatest release. Non-numeric components are compared lexicographically.

Version metadata

SemVer has the concept of "version metadata" with a plus in the version, such as `1.0.0+21AF26D3`. This metadata is usually ignored, and should not be used in a version requirement. You should never publish multiple versions that differ only in the metadata tag (note, this is a known issue with crates.io that currently permits this).

Other constraints

Version requirements aren't the only constraint that the resolver considers when selecting and unifying dependencies. The following sections cover some of the other constraints that can affect resolution.

Features

For the purpose of generating `Cargo.lock`, the resolver builds the dependency graph as-if all features of all workspace members are enabled. This ensures that any optional dependencies are available and properly resolved with the rest of the graph when features are added or removed with the `--features` command-line flag. The resolver runs a second time to determine the actual features used when *compiling* a crate, based on the features selected on the command-line.

Dependencies are resolved with the union of all features enabled on them. For example, if one package depends on the `im` package with the `serde` dependency enabled and another package depends on it with the `rayon` dependency enabled, then `im` will be built with both features enabled, and the `serde` and `rayon` crates will be included in the resolve graph. If no packages depend on `im` with those features, then those optional dependencies will be ignored, and they will not affect resolution.

When building multiple packages in a workspace (such as with `--workspace` or multiple `-p` flags), the features of the dependencies of all of those packages are unified. If you have a circumstance where you want to avoid that unification for different workspace members, you will need to build them via separate `cargo` invocations.

The resolver will skip over versions of packages that are missing required features. For example, if a package depends on version `^1` of `regex` with the `perf` feature, then the oldest version it can select is `1.3.0`, because versions prior to that did not contain the `perf` feature. Similarly, if a feature is removed from a new release, then packages that require that feature will be stuck on the older releases that contain that feature. It is discouraged to remove features in a SemVer-compatible release. Beware that optional dependencies also define an implicit feature, so removing an optional dependency or making it non-optional can cause problems, see removing an optional dependency.

Feature resolver version 2

When `resolver = "2"` is specified in `Cargo.toml` (see resolver versions below), a different feature resolver is used which uses a different algorithm for unifying features. The version `"1"` resolver will unify features for a package no matter where it is specified. The version `"2"` resolver will avoid unifying features in the following situations:

- Features for target-specific dependencies are not enabled if the target is not currently being built. For example:

  ```toml
  [dependencies.common]
  version = "1.0"
  features = ["f1"]

  [target.'cfg(windows)'.dependencies.common]
  version = "1.0"
  features = ["f2"]
  ```

  When building this example for a non-Windows platform, the `f2` feature will *not* be enabled.

- Features enabled on build-dependencies or proc-macros will not be unified when those same dependencies are used as a normal dependency. For example:

```
[dependencies]
log = "0.4"

[build-dependencies]
log = {version = "0.4", features=['std']}
```

When building the build script, the `log` crate will be built with the `std` feature. When building the library of your package, it will not enable the feature.

- Features enabled on dev-dependencies will not be unified when those same dependencies are used as a normal dependency, unless those dev-dependencies are currently being built. For example:

```
[dependencies]
serde = {version = "1.0", default-features = false}

[dev-dependencies]
serde = {version = "1.0", features = ["std"]}
```

In this example, the library will normally link against `serde` without the `std` feature. However, when built as a test or example, it will include the `std` feature. For example, `cargo test` or `cargo build --all-targets` will unify these features. Note that dev-dependencies in dependencies are always ignored, this is only relevant for the top-level package or workspace members.

`links`

The `links` field is used to ensure only one copy of a native library is linked into a binary. The resolver will attempt to find a graph where there is only one instance of each `links` name. If it is unable to find a graph that satisfies that constraint, it will return an error.

For example, it is an error if one package depends on `libgit2-sys` version `0.11` and another depends on `0.12`, because Cargo is unable to unify those, but they both link to the `git2` native library. Due to this requirement, it is encouraged to be very careful when making SemVer-incompatible releases with the `links` field if your library is in common use.

Yanked versions

Yanked releases are those that are marked that they should not be used. When the resolver is building the graph, it will ignore all yanked releases unless they already exist in the `Cargo.lock` file.

Dependency updates

Dependency resolution is automatically performed by all Cargo commands that need to know about the dependency graph. For example, `cargo build` will run the resolver to discover all the dependencies to build. After the first time it runs, the result is stored in the `Cargo.lock` file. Subsequent commands will run the resolver, keeping dependencies locked to the versions in `Cargo.lock` *if it can*.

If the dependency list in `Cargo.toml` has been modified, for example changing the version of a dependency from `1.0` to `2.0`, then the resolver will select a new version for that dependency that matches the new requirements. If that new dependency introduces new requirements, those new requirements may also trigger additional updates. The `Cargo.lock` file will be updated with the new result. The `--locked` or `--frozen` flags can be used to change this behavior to prevent automatic updates when requirements change, and return an error instead.

`cargo update` can be used to update the entries in `Cargo.lock` when new versions are published. Without any options, it will attempt to update all packages in the lock file. The `-p` flag can be used to target the update for a specific package, and other flags such as `--aggressive` or `--precise` can be used to control how versions are selected.

Overrides

Cargo has several mechanisms to override dependencies within the graph. The Overriding Dependencies chapter goes into detail on how to use overrides. The overrides appear as an overlay to a registry, replacing the patched version with the new entry. Otherwise, resolution is performed like normal.

Dependency kinds

There are three kinds of dependencies in a package: normal, build, and dev. For the most part these are all treated the same from the perspective of the resolver. One difference is that dev-dependencies for non-workspace members are always ignored, and do not influence resolution.

Platform-specific dependencies with the `[target]` table are resolved as-if all platforms are enabled. In other words, the resolver ignores the platform or `cfg` expression.

dev-dependency cycles

Usually the resolver does not allow cycles in the graph, but it does allow them for dev-dependencies. For example, project “foo” has a dev-dependency on “bar”, which has a normal dependency on “foo” (usually as a “path” dependency). This is allowed because there isn’t really a cycle from the perspective of the build artifacts. In this example, the “foo” library is built (which does not need “bar” because “bar” is only used for tests), and then “bar” can be built depending on “foo”, then the “foo” tests can be built linking to “bar”.

Beware that this can lead to confusing errors. In the case of building library unit tests, there are actually two copies of the library linked into the final test binary: the one that was linked with “bar”, and the one built that contains the unit tests. Similar to the issues highlighted in the Version-incompatibility hazards section, the types between the two are not compatible. Be careful when exposing types of “foo” from “bar” in this situation, since the “foo” unit tests won’t treat them the same as the local types.

If possible, try to split your package into multiple packages and restructure it so that it remains strictly acyclic.

Resolver versions

A different feature resolver algorithm can be used by specifying the resolver version in `Cargo.toml` like this:

```
[package]
name = "my-package"
version = "1.0.0"
resolver = "2"
```

The version `"1"` resolver is the original resolver that shipped with Cargo up to version 1.50. The default is `"2"` if the root package specifies `edition = "2021"` or a newer edition. Otherwise the default is `"1"`.

The version `"2"` resolver introduces changes in feature unification. See the features chapter for more details.

The resolver is a global option that affects the entire workspace. The `resolver` version in dependencies is ignored, only the value in the top-level package will be used. If using a virtual workspace, the version should be specified in the `[workspace]` table, for example:

```
[workspace]
members = ["member1", "member2"]
resolver = "2"
```

Recommendations

The following are some recommendations for setting the version within your package, and for specifying dependency requirements. These are general guidelines that should apply to common situations, but of course some situations may require specifying unusual requirements.

- Follow the SemVer guidelines when deciding how to update your version number, and whether or not you will need to make a SemVer-incompatible version change.
- Use caret requirements for dependencies, such as `"1.2.3"`, for most situations. This ensures that the resolver can be maximally flexible in choosing a version while maintaining build compatibility.
    - Specify all three components with the version you are currently using. This helps set the minimum version that will be used, and ensures that other users won't end up with an older version of the dependency that might be missing something that your package requires.
    - Avoid `*` requirements, as they are not allowed on crates.io, and they can pull in SemVer-breaking changes during a normal `cargo update`.
    - Avoid overly broad version requirements. For example, `>=2.0.0` can pull in any SemVer-incompatible version, like version `5.0.0`, which can result in broken builds in the future.
    - Avoid overly narrow version requirements if possible. For example, if you specify a tilde requirement like `bar="~1.3"`, and another package specifies a requirement of `bar="1.4"`, this will fail to resolve, even though minor releases should be compatible.
- Try to keep the dependency versions up-to-date with the actual minimum versions that your library requires. For example, if you have a requirement of `bar="1.0.12"`, and then in a future release you start using new features added in the `1.1.0` release of "bar", update your dependency requirement to `bar="1.1.0"`.

  If you fail to do this, it may not be immediately obvious because Cargo can opportunistically choose the newest version when you run a blanket `cargo update`. However, if another user depends on your library, and runs `cargo update -p your-library`, it will *not* automatically update "bar" if it is locked in their `Cargo.lock`. It will only update "bar" in that situation if the dependency declaration is also updated. Failure to do so can cause confusing build errors for the user using `cargo update -p`.
- If two packages are tightly coupled, then an `=` dependency requirement may help ensure that they stay in sync. For example, a library with a companion proc-macro library will sometimes make assumptions between the two libraries that won't work well if the two are out of sync (and it is never expected to use the two libraries independently). The parent library can use an `=` requirement on the proc-macro, and re-export the macros for easy access.
- `0.0.x` versions can be used for packages that are permanently unstable.

In general, the stricter you make the dependency requirements, the more likely it will be for the resolver to fail. Conversely, if you use requirements that are too loose, it may be possible for new versions to be published that will break the build.

Troubleshooting

The following illustrates some problems you may experience, and some possible solutions.

Unexpected dependency duplication

The resolver algorithm may converge on a solution that includes two copies of a dependency when one would suffice. For example:

```
# Package A
[dependencies]
rand = "0.7"

# Package B
[dependencies]
rand = ">=0.6"  # note: open requirements such as this are discouraged
```

In this example, Cargo may build two copies of the `rand` crate, even though a single copy at version `0.7.3` would meet all requirements. This is because the resolver's algorithm favors building the latest available version of `rand` for Package B, which is `0.8.5` at the time of this writing, and that is incompatible with Package A's specification. The resolver's algorithm does not currently attempt to "deduplicate" in this situation.

The use of open-ended version requirements like `>=0.6` is discouraged in Cargo. But, if you run into this situation, the `cargo update` command with the `--precise` flag can be used to manually remove such duplications.

SemVer-breaking patch release breaks the build

Sometimes a project may inadvertently publish a point release with a SemVer-breaking change. When users update with `cargo update`, they will pick up this new release, and then their build may break. In this situation, it is recommended that the project should yank the release, and either remove the SemVer-breaking change, or publish it as a new SemVer-major version increase.

If the change happened in a third-party project, if possible try to (politely!) work with the project to resolve the issue.

While waiting for the release to be yanked, some workarounds depend on the circumstances:

- If your project is the end product (such as a binary executable), just avoid updating the offending package in `Cargo.lock`. This can be done with the `--precise` flag in `cargo update`.
- If you publish a binary on crates.io, then you can temporarily add an `=` requirement to force the dependency to a specific good version.
  - Binary projects can alternatively recommend users to use the `--locked` flag with `cargo install` to use the original `Cargo.lock` that contains the known good version.
- Libraries may also consider publishing a temporary new release with stricter requirements that avoid the troublesome dependency. You may want to consider using range requirements (instead of `=`) to avoid overly-strict requirements that may conflict with other packages using the same dependency. Once the problem has been resolved, you can publish another point release that relaxes the dependency back to a caret requirement.
- If it looks like the third-party project is unable or unwilling to yank the release, then one option is to update your code to be compatible with the changes, and update the dependency requirement to set the minimum version to the new release. You will also need to consider if this is a SemVer-breaking change of your own library, for example if it exposes types from the dependency.

SemVer Compatibility

This chapter provides details on what is conventionally considered a compatible or breaking SemVer change for new releases of a package. See the SemVer compatibility section for details on what SemVer is, and how Cargo uses it to ensure compatibility of libraries.

These are only *guidelines*, and not necessarily hard-and-fast rules that all projects will obey. The Change categories section details how this guide classifies the level and severity of a change. Most of this guide focuses on changes that will cause `cargo` and `rustc` to fail to build something that previously worked. Almost every change carries some risk that it will negatively affect the runtime behavior, and for those cases it is usually a judgment call by the project maintainers whether or not it is a SemVer-incompatible change.

See also rust-semverver, which is an experimental tool that attempts to programmatically check compatibility rules.

Change categories

All of the policies listed below are categorized by the level of change:

- **Major change**: a change that requires a major SemVer bump.
- **Minor change**: a change that requires only a minor SemVer bump.
- **Possibly-breaking change**: a change that some projects may consider major and others consider minor.

The "Possibly-breaking" category covers changes that have the *potential* to break during an update, but may not necessarily cause a breakage. The impact of these changes should be considered carefully. The exact nature will depend on the change and the principles of the project maintainers.

Some projects may choose to only bump the patch number on a minor change. It is encouraged to follow the SemVer spec, and only apply bug fixes in patch releases. However, a bug fix may require an API change that is marked as a "minor change", and shouldn't affect compatibility. This guide does not take a stance on how each individual "minor change" should be treated, as the difference between minor and patch changes are conventions that depend on the nature of the change.

Some changes are marked as "minor", even though they carry the potential risk of breaking a build. This is for situations where the potential is extremely low, and the potentially breaking code is unlikely to be written in idiomatic Rust, or is specifically discouraged from use.

This guide uses the terms "major" and "minor" assuming this relates to a "1.0.0" release or later. Initial development releases starting with "0.y.z" can treat changes in "y" as a major release, and "z" as a minor release. "0.0.z" releases are always major changes. This is because Cargo uses the convention that only changes in the left-most non-zero component are considered incompatible.

- API compatibility
  - Items
    - Major: renaming/moving/removing any public items
    - Minor: adding new public items
  - Structs
    - Major: adding a private struct field when all current fields are public
    - Major: adding a public field when no private field exists
    - Minor: adding or removing private fields when at least one already exists
    - Minor: going from a tuple struct with all private fields (with at least one field) to a normal struct, or vice versa
  - Enums
    - Major: adding new enum variants (without `non_exhaustive`)
    - Major: adding new fields to an enum variant
  - Traits
    - Major: adding a non-defaulted trait item
    - Major: any change to trait item signatures
    - Possibly-breaking: adding a defaulted trait item
    - Major: adding a trait item that makes the trait non-object safe
    - Major: adding a type parameter without a default
    - Minor: adding a defaulted trait type parameter
  - Implementations
    - Possibly-breaking change: adding any inherent items
  - Generics
    - Major: tightening generic bounds
    - Minor: loosening generic bounds
    - Minor: adding defaulted type parameters
    - Minor: generalizing a type to use generics (with identical types)
    - Major: generalizing a type to use generics (with possibly different types)
    - Minor: changing a generic type to a more generic type
  - Functions
    - Major: adding/removing function parameters
    - Possibly-breaking: introducing a new function type parameter
    - Minor: generalizing a function to use generics (supporting original type)
    - Major: generalizing a function to use generics with type mismatch
  - Attributes
    - Major: switching from `no_std` support to requiring `std`
- Tooling and environment compatibility
  - Possibly-breaking: changing the minimum version of Rust required
  - Possibly-breaking: changing the platform and environment requirements
  - Minor: introducing new lints

API compatibility

All of the examples below contain three parts: the original code, the code after it has been modified, and an example usage of the code that could appear in another project. In a minor change, the example usage should successfully build with both the before and after versions.

Major: renaming/moving/removing any public items

The absence of a publicly exposed item will cause any uses of that item to fail to compile.

```
// MAJOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub fn foo() {}

///////////////////////////////////////////////////////////
// After
// ... item has been removed

///////////////////////////////////////////////////////////
// Example usage that will break.
fn main() {
    updated_crate::foo(); // Error: cannot find function `foo`
}
```

This includes adding any sort of `cfg` attribute which can change which items or behavior is available based on conditional compilation.

Mitigating strategies:

- Mark items to be removed as deprecated, and then remove them at a later date in a SemVer-breaking release.
- Mark renamed items as deprecated, and use a `pub use` item to re-export to the old name.

Minor: adding new public items

Adding new, public items is a minor change.

```
// MINOR CHANGE

///////////////////////////////////////////////////////////
// Before
// ... absence of item

///////////////////////////////////////////////////////////
// After
pub fn foo() {}

///////////////////////////////////////////////////////////
// Example use of the library that will safely work.
// `foo` is not used since it didn't previously exist.
```

Note that in some rare cases this can be a **breaking change** due to glob imports. For example, if you add a new trait, and a project has used a glob import that brings that trait into scope, and the new trait introduces an associated item that conflicts with any types it is implemented on, this can cause a compile-time error due to the ambiguity. Example:

```
// Breaking change example

///////////////////////////////////////////////////////////
// Before
// ... absence of trait

///////////////////////////////////////////////////////////
// After
pub trait NewTrait {
    fn foo(&self) {}
}

impl NewTrait for i32 {}

///////////////////////////////////////////////////////////
// Example usage that will break.
use updated_crate::*;

pub trait LocalTrait {
    fn foo(&self) {}
}

impl LocalTrait for i32 {}

fn main() {
    123i32.foo(); // Error:  multiple applicable items in scope
}
```

This is not considered a major change because conventionally glob imports are a known forwards-compatibility hazard. Glob imports of items from external crates should be avoided.

Major: adding a private struct field when all current fields are public

When a private field is added to a struct that previously had all public fields, this will break any code that attempts to construct it with a struct literal.

```
// MAJOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub struct Foo {
    pub f1: i32,
}

///////////////////////////////////////////////////////////
// After
pub struct Foo {
    pub f1: i32,
    f2: i32,
}

///////////////////////////////////////////////////////////
// Example usage that will break.
fn main() {
    let x = updated_crate::Foo { f1: 123 }; // Error: cannot construct `Foo`
}
```

Mitigation strategies:

- Do not add new fields to all-public field structs.
- Mark structs as `#[non_exhaustive]` when first introducing a struct to prevent users from using struct literal syntax, and instead provide a constructor method and/or Default implementation.

Major: adding a public field when no private field exists

When a public field is added to a struct that has all public fields, this will break any code that attempts to construct it with a struct literal.

```
// MAJOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub struct Foo {
    pub f1: i32,
}

///////////////////////////////////////////////////////////
// After
pub struct Foo {
    pub f1: i32,
    pub f2: i32,
}

///////////////////////////////////////////////////////////
// Example usage that will break.
fn main() {
    let x = updated_crate::Foo { f1: 123 }; // Error: missing field `f2`
}
```

Mitigation strategies:

- Do not add new new fields to all-public field structs.
- Mark structs as `#[non_exhaustive]` when first introducing a struct to prevent users from using struct literal syntax, and instead provide a constructor method and/or Default implementation.

Minor: adding or removing private fields when at least one already exists

It is safe to add or remove private fields from a struct when the struct already has at least one private field.

```
// MINOR CHANGE

///////////////////////////////////////////////////////////
// Before
#[derive(Default)]
pub struct Foo {
    f1: i32,
}

///////////////////////////////////////////////////////////
// After
#[derive(Default)]
pub struct Foo {
    f2: f64,
}

///////////////////////////////////////////////////////////
// Example use of the library that will safely work.
fn main() {
    // Cannot access private fields.
    let x = updated_crate::Foo::default();
}
```

This is safe because existing code cannot use a struct literal to construct it, nor exhaustively match its contents.

Note that for tuple structs, this is a **major change** if the tuple contains public fields, and the addition or removal of a private field changes the index of any public field.

```
// MAJOR CHANGE

///////////////////////////////////////////////////////////
// Before
#[derive(Default)]
pub struct Foo(pub i32, i32);

///////////////////////////////////////////////////////////
// After
#[derive(Default)]
pub struct Foo(f64, pub i32, i32);

///////////////////////////////////////////////////////////
// Example usage that will break.
fn main() {
    let x = updated_crate::Foo::default();
    let y = x.0; // Error: is private
}
```

Minor: going from a tuple struct with all private fields (with at least one field) to a normal struct, or vice versa

Changing a tuple struct to a normal struct (or vice-versa) is safe if all fields are private.

```
// MINOR CHANGE

///////////////////////////////////////////////////////////
// Before
#[derive(Default)]
pub struct Foo(i32);

///////////////////////////////////////////////////////////
// After
#[derive(Default)]
pub struct Foo {
    f1: i32,
}

///////////////////////////////////////////////////////////
// Example use of the library that will safely work.
fn main() {
    // Cannot access private fields.
    let x = updated_crate::Foo::default();
}
```

This is safe because existing code cannot use a struct literal to construct it, nor match its contents.

Major: adding new enum variants (without `non_exhaustive`)

It is a breaking change to add a new enum variant if the enum does not use the `#[non_exhaustive]` attribute.

```
// MAJOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub enum E {
    Variant1,
}

///////////////////////////////////////////////////////////
// After
pub enum E {
    Variant1,
    Variant2,
}

///////////////////////////////////////////////////////////
// Example usage that will break.
fn main() {
    use updated_crate::E;
    let x = E::Variant1;
    match x { // Error: `E::Variant2` not covered
        E::Variant1 => {}
    }
}
```

Mitigation strategies:

- When introducing the enum, mark it as `#[non_exhaustive]` to force users to use wildcard patterns to catch new variants.

Major: adding new fields to an enum variant

It is a breaking change to add new fields to an enum variant because all fields are public, and constructors and matching will fail to compile.

```
// MAJOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub enum E {
    Variant1 { f1: i32 },
}

///////////////////////////////////////////////////////////
// After
pub enum E {
    Variant1 { f1: i32, f2: i32 },
}

///////////////////////////////////////////////////////////
// Example usage that will break.
fn main() {
    use updated_crate::E;
    let x = E::Variant1 { f1: 1 }; // Error: missing f2
    match x {
        E::Variant1 { f1 } => {} // Error: missing f2
    }
}
```

Mitigation strategies:

- When introducing the enum, mark the variant as `non_exhaustive` so that it cannot be constructed or matched without wildcards.

```
pub enum E {
    #[non_exhaustive]
    Variant1{f1: i32}
}
```

- When introducing the enum, use an explicit struct as a value, where you can have control over the field visibility.

```rust
pub struct Foo {
   f1: i32,
   f2: i32,
}
pub enum E {
    Variant1(Foo)
}
```

Major: adding a non-defaulted trait item

It is a breaking change to add a non-defaulted item to a trait. This will break any implementors of the trait.

```rust
// MAJOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub trait Trait {}

///////////////////////////////////////////////////////////
// After
pub trait Trait {
    fn foo(&self);
}

///////////////////////////////////////////////////////////
// Example usage that will break.
use updated_crate::Trait;
struct Foo;

impl Trait for Foo {}  // Error: not all trait items implemented
```

Mitigation strategies:

- Always provide a default implementation or value for new associated trait items.
- When introducing the trait, use the sealed trait technique to prevent users outside of the crate from implementing the trait.

Major: any change to trait item signatures

It is a breaking change to make any change to a trait item signature. This can break external implementors of the trait.

```rust
// MAJOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub trait Trait {
    fn f(&self, x: i32) {}
}

///////////////////////////////////////////////////////////
// After
pub trait Trait {
    // For sealed traits or normal functions, this would be a minor change
    // because generalizing with generics strictly expands the possible uses.
    // But in this case, trait implementations must use the same signature.
    fn f<V>(&self, x: V) {}
}

///////////////////////////////////////////////////////////
// Example usage that will break.
use updated_crate::Trait;
struct Foo;

impl Trait for Foo {
    fn f(&self, x: i32) {}  // Error: trait declaration has 1 type parameter
}
```

Mitigation strategies:

- Introduce new items with default implementations to cover the new functionality instead of modifying existing items.
- When introducing the trait, use the sealed trait technique to prevent users outside of the crate from implementing the trait.

Possibly-breaking: adding a defaulted trait item

It is usually safe to add a defaulted trait item. However, this can sometimes cause a compile error. For example, this can introduce an ambiguity if a method of the same name exists in another trait.

```rust
// Breaking change example

///////////////////////////////////////////////////////////
// Before
pub trait Trait {}

///////////////////////////////////////////////////////////
// After
pub trait Trait {
    fn foo(&self) {}
}

///////////////////////////////////////////////////////////
// Example usage that will break.
use updated_crate::Trait;
struct Foo;

trait LocalTrait {
    fn foo(&self) {}
}

impl Trait for Foo {}
impl LocalTrait for Foo {}

fn main() {
    let x = Foo;
    x.foo(); // Error: multiple applicable items in scope
}
```

Note that this ambiguity does *not* exist for name collisions on inherent implementations, as they take priority over trait items.

See trait-object-safety for a special case to consider when adding trait items.

Mitigation strategies:

- Some projects may deem this acceptable breakage, particularly if the new item name is unlikely to collide with any existing code. Choose names carefully to help avoid these collisions. Additionally, it may be acceptable to require downstream users to add disambiguation syntax to select the correct function when updating the dependency.

Major: adding a trait item that makes the trait non-object safe

It is a breaking change to add a trait item that changes the trait to not be object safe.

```rust
// MAJOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub trait Trait {}

///////////////////////////////////////////////////////////
// After
pub trait Trait {
    // An associated const makes the trait not object-safe.
    const CONST: i32 = 123;
}

///////////////////////////////////////////////////////////
// Example usage that will break.
use updated_crate::Trait;
struct Foo;

impl Trait for Foo {}

fn main() {
    let obj: Box<dyn Trait> = Box::new(Foo); // Error: cannot be made into an object
}
```

It is safe to do the converse (making a non-object safe trait into a safe one).

Major: adding a type parameter without a default

It is a breaking change to add a type parameter without a default to a trait.

```rust
// MAJOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub trait Trait {}

///////////////////////////////////////////////////////////
// After
pub trait Trait<T> {}

///////////////////////////////////////////////////////////
// Example usage that will break.
use updated_crate::Trait;
struct Foo;

impl Trait for Foo {}  // Error: missing generics
```

Mitigating strategies:

- See adding a defaulted trait type parameter.

Minor: adding a defaulted trait type parameter

It is safe to add a type parameter to a trait as long as it has a default. External implementors will use the default without needing to specify the parameter.

```
// MINOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub trait Trait {}

///////////////////////////////////////////////////////////
// After
pub trait Trait<T = i32> {}

///////////////////////////////////////////////////////////
// Example use of the library that will safely work.
use updated_crate::Trait;
struct Foo;

impl Trait for Foo {}
```

Possibly-breaking change: adding any inherent items

Usually adding inherent items to an implementation should be safe because inherent items take priority over trait items. However, in some cases the collision can cause problems if the name is the same as an implemented trait item with a different signature.

```rust
// Breaking change example

///////////////////////////////////////////////////////////
// Before
pub struct Foo;

///////////////////////////////////////////////////////////
// After
pub struct Foo;

impl Foo {
    pub fn foo(&self) {}
}

///////////////////////////////////////////////////////////
// Example usage that will break.
use updated_crate::Foo;

trait Trait {
    fn foo(&self, x: i32) {}
}

impl Trait for Foo {}

fn main() {
    let x = Foo;
    x.foo(1); // Error: this method takes 0 arguments but 1 argument was supplied
}
```

Note that if the signatures match, there would not be a compile-time error, but possibly a silent change in runtime behavior (because it is now executing a different function).

Mitigation strategies:

- Some projects may deem this acceptable breakage, particularly if the new item name is unlikely to collide with any existing code. Choose names carefully to help avoid these collisions. Additionally, it may be acceptable to require downstream users to add disambiguation syntax to select the correct function when updating the dependency.

Major: tightening generic bounds

It is a breaking change to tighten generic bounds on a type since this can break users expecting the looser bounds.

```rust
// MAJOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub struct Foo<A> {
    pub f1: A,
}

///////////////////////////////////////////////////////////
// After
pub struct Foo<A: Eq> {
    pub f1: A,
}

///////////////////////////////////////////////////////////
// Example usage that will break.
use updated_crate::Foo;

fn main() {
    let s = Foo { f1: 1.23 }; // Error: the trait bound `{float}: Eq` is not satisfied
}
```

Minor: loosening generic bounds

It is safe to loosen the generic bounds on a type, as it only expands what is allowed.

```rust
// MINOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub struct Foo<A: Clone> {
    pub f1: A,
}

///////////////////////////////////////////////////////////
// After
pub struct Foo<A> {
    pub f1: A,
}

///////////////////////////////////////////////////////////
// Example use of the library that will safely work.
use updated_crate::Foo;

fn main() {
    let s = Foo { f1: 123 };
}
```

Minor: adding defaulted type parameters

It is safe to add a type parameter to a type as long as it has a default. All existing references will use the default without needing to specify the parameter.

```rust
// MINOR CHANGE

///////////////////////////////////////////////////////////
// Before
#[derive(Default)]
pub struct Foo {}

///////////////////////////////////////////////////////////
// After
#[derive(Default)]
pub struct Foo<A = i32> {
    f1: A,
}

///////////////////////////////////////////////////////////
// Example use of the library that will safely work.
use updated_crate::Foo;

fn main() {
    let s: Foo = Default::default();
}
```

Minor: generalizing a type to use generics (with identical types)

A struct or enum field can change from a concrete type to a generic type parameter, provided that the change results in an identical type for all existing use cases. For example, the following change is permitted:

```rust
// MINOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub struct Foo(pub u8);

///////////////////////////////////////////////////////////
// After
pub struct Foo<T = u8>(pub T);

///////////////////////////////////////////////////////////
// Example use of the library that will safely work.
use updated_crate::Foo;

fn main() {
    let s: Foo = Foo(123);
}
```

because existing uses of `Foo` are shorthand for `Foo<u8>` which yields the identical field type.

Major: generalizing a type to use generics (with possibly different types)

Changing a struct or enum field from a concrete type to a generic type parameter can break if the type can change.

```
// MAJOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub struct Foo<T = u8>(pub T, pub u8);

///////////////////////////////////////////////////////////
// After
pub struct Foo<T = u8>(pub T, pub T);

///////////////////////////////////////////////////////////
// Example usage that will break.
use updated_crate::Foo;

fn main() {
    let s: Foo<f32> = Foo(3.14, 123); // Error: mismatched types
}
```

Minor: changing a generic type to a more generic type

It is safe to change a generic type to a more generic one. For example, the following adds a generic parameter that defaults to the original type, which is safe because all existing users will be using the same type for both fields, the the defaulted parameter does not need to be specified.

```
// MINOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub struct Foo<T>(pub T, pub T);

///////////////////////////////////////////////////////////
// After
pub struct Foo<T, U = T>(pub T, pub U);

///////////////////////////////////////////////////////////
// Example use of the library that will safely work.
use updated_crate::Foo;

fn main() {
    let s: Foo<f32> = Foo(1.0, 2.0);
}
```

Major: adding/removing function parameters

Changing the arity of a function is a breaking change.

```rust
// MAJOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub fn foo() {}

///////////////////////////////////////////////////////////
// After
pub fn foo(x: i32) {}

///////////////////////////////////////////////////////////
// Example usage that will break.
fn main() {
    updated_crate::foo(); // Error: this function takes 1 argument
}
```

Mitigating strategies:

- Introduce a new function with the new signature and possibly deprecate the old one.
- Introduce functions that take a struct argument, where the struct is built with the builder pattern. This allows new fields to be added to the struct in the future.

Possibly-breaking: introducing a new function type parameter

Usually, adding a non-defaulted type parameter is safe, but in some cases it can be a breaking change:

```rust
// Breaking change example

///////////////////////////////////////////////////////////
// Before
pub fn foo<T>() {}

///////////////////////////////////////////////////////////
// After
pub fn foo<T, U>() {}

///////////////////////////////////////////////////////////
// Example usage that will break.
use updated_crate::foo;

fn main() {
    foo::<u8>(); // Error: function takes 2 generic arguments but 1 generic argument was
supplied
}
```

However, such explicit calls are rare enough (and can usually be written in other ways) that this breakage is usually acceptable. One should take into account how likely it is that the function in question is being called with explicit type arguments.

Minor: generalizing a function to use generics (supporting original type)

The type of a parameter to a function, or its return value, can be *generalized* to use generics, including by introducing a new type parameter, as long as it can be instantiated to the original type. For example, the following changes are allowed:

```
// MINOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub fn foo(x: u8) -> u8 {
    x
}
pub fn bar<T: Iterator<Item = u8>>(t: T) {}

///////////////////////////////////////////////////////////
// After
use std::ops::Add;
pub fn foo<T: Add>(x: T) -> T {
    x
}
pub fn bar<T: IntoIterator<Item = u8>>(t: T) {}

///////////////////////////////////////////////////////////
// Example use of the library that will safely work.
use updated_crate::{bar, foo};

fn main() {
    foo(1);
    bar(vec![1, 2, 3].into_iter());
}
```

because all existing uses are instantiations of the new signature.

Perhaps somewhat surprisingly, generalization applies to trait objects as well, given that every trait implements itself:

```rust
// MINOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub trait Trait {}
pub fn foo(t: &dyn Trait) {}

///////////////////////////////////////////////////////////
// After
pub trait Trait {}
pub fn foo<T: Trait + ?Sized>(t: &T) {}

///////////////////////////////////////////////////////////
// Example use of the library that will safely work.
use updated_crate::{foo, Trait};

struct Foo;
impl Trait for Foo {}

fn main() {
    let obj = Foo;
    foo(&obj);
}
```

(The use of `?Sized` is essential; otherwise you couldn't recover the original signature.)

Introducing generics in this way can potentially create type inference failures. These are usually rare, and may be acceptable breakage for some projects, as this can be fixed with additional type annotations.

```rust
// Breaking change example

///////////////////////////////////////////////////////////
// Before
pub fn foo() -> i32 {
    0
}

///////////////////////////////////////////////////////////
// After
pub fn foo<T: Default>() -> T {
    Default::default()
}

///////////////////////////////////////////////////////////
// Example usage that will break.
use updated_crate::foo;

fn main() {
    let x = foo(); // Error: type annotations needed
}
```

Major: generalizing a function to use generics with type mismatch

It is a breaking change to change a function parameter or return type if the generic type constrains or changes the types previously allowed. For example, the following adds a generic constraint that may not be satisfied by existing code:

```
// MAJOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub fn foo(x: Vec<u8>) {}

///////////////////////////////////////////////////////////
// After
pub fn foo<T: Copy + IntoIterator<Item = u8>>(x: T) {}

///////////////////////////////////////////////////////////
// Example usage that will break.
use updated_crate::foo;

fn main() {
    foo(vec![1, 2, 3]); // Error: `Copy` is not implemented for `Vec<u8>`
}
```

Major: switching from `no_std` support to requiring `std`

If your library specifically supports a `no_std` environment, it is a breaking change to make a new release that requires `std`.

```
// MAJOR CHANGE

///////////////////////////////////////////////////////////
// Before
#![no_std]
pub fn foo() {}

///////////////////////////////////////////////////////////
// After
pub fn foo() {
    std::time::SystemTime::now();
}

///////////////////////////////////////////////////////////
// Example usage that will break.
// This will fail to link for no_std targets because they don't have a `std` crate.
#![no_std]
use updated_crate::foo;

fn example() {
    foo();
}
```

Mitigation strategies:

- A common idiom to avoid this is to include a `std` Cargo feature that optionally enables `std` support, and when the feature is off, the library can be used in a `no_std` environment.

Tooling and environment compatibility

Possibly-breaking: changing the minimum version of Rust required

Introducing the use of new features in a new release of Rust can break projects that are using older versions of Rust. This also includes using new features in a new release of Cargo, and requiring the use of a nightly-only feature in a crate that previously worked on stable.

Some projects choose to allow this in a minor release for various reasons. It is usually relatively easy to update to a newer version of Rust. Rust also has a rapid 6-week release cycle, and some projects will provide compatibility within a window of releases (such as the current stable release plus N previous releases). Just keep in mind that some large projects may not be able to update their Rust toolchain rapidly.

Mitigation strategies:

- Use Cargo features to make the new features opt-in.
- Provide a large window of support for older releases.
- Copy the source of new standard library items if possible so that you can continue to use an older version but take advantage of the new feature.
- Provide a separate branch of older minor releases that can receive backports of important bugfixes.
- Keep an eye out for the `[cfg(version(..))]` and `#[cfg(accessible(..))]` features which provide an opt-in mechanism for new features. These are currently unstable and only available in the nightly channel.

Possibly-breaking: changing the platform and environment requirements

There is a very wide range of assumptions a library makes about the environment that it runs in, such as the host platform, operating system version, available services, filesystem support, etc. It can be a breaking change if you make a new release that restricts what was previously supported, for example requiring a newer version of an operating system. These changes can be difficult to track, since you may not always know if a change breaks in an environment that is not automatically tested.

Some projects may deem this acceptable breakage, particularly if the breakage is unlikely for most users, or the project doesn't have the resources to support all environments. Another notable situation is when a vendor discontinues support for some hardware or OS, the project may deem it reasonable to also discontinue support.

Mitigation strategies:

- Document the platforms and environments you specifically support.
- Test your code on a wide range of environments in CI.

Minor: introducing new lints

Some changes to a library may cause new lints to be triggered in users of that library. This should generally be considered a compatible change.

```
// MINOR CHANGE

///////////////////////////////////////////////////////////
// Before
pub fn foo() {}

///////////////////////////////////////////////////////////
// After
#[deprecated]
pub fn foo() {}

///////////////////////////////////////////////////////////
// Example use of the library that will safely work.

fn main() {
    updated_crate::foo(); // Warning: use of deprecated function
}
```

Beware that it may be possible for this to technically cause a project to fail if they have explicitly denied the warning, and the updated crate is a direct dependency. Denying warnings should be done with care and the understanding that new lints may be introduced over time. However, library authors should be cautious about introducing new warnings and may want to consider the potential impact on their users.

The following lints are examples of those that may be introduced when updating a dependency:

- `deprecated` — Introduced when a dependency adds the `#[deprecated]` attribute to an item you are using.
- `unused_must_use` — Introduced when a dependency adds the `#[must_use]` attribute to an item where you are not consuming the result.
- `unused_unsafe` — Introduced when a dependency *removes* the `unsafe` qualifier from a function, and that is the only unsafe function called in an unsafe block.

Additionally, updating `rustc` to a new version may introduce new lints.

Transitive dependencies which introduce new lints should not usually cause a failure because Cargo uses `--cap-lints` to suppress all lints in dependencies.

Mitigating strategies:

- If you build with warnings denied, understand you may need to deal with resolving new warnings whenever you update your dependencies. If using RUSTFLAGS to pass `-Dwarnings`, also add the `-A` flag to allow lints that are likely to cause issues, such as `-Adeprecated`.
- Introduce deprecations behind a feature. For example `#[cfg_attr(feature = "deprecated", deprecated="use bar instead")]`. Then, when you plan to remove an item in a future SemVer breaking change, you can communicate with your users that they should enable the `deprecated` feature *before* updating to remove the use of the deprecated items. This allows users to choose when to respond to deprecations without needing to immediately respond to them. A downside is that it can be difficult to communicate to users that they need to take these manual steps to prepare for a major update.

Cargo

Minor: adding a new Cargo feature

It is usually safe to add new Cargo features. If the feature introduces new changes that cause a breaking change, this can cause difficulties for projects that have stricter backwards-compatibility needs. In that scenario, avoid adding the feature to the "default" list, and possibly document the consequences of enabling the feature.

```toml
# MINOR CHANGE

###########################################################
# Before
[features]
# ..empty

###########################################################
# After
[features]
std = []
```

Major: removing a Cargo feature

It is usually a breaking change to remove Cargo features. This will cause an error for any project that enabled the feature.

```toml
# MAJOR CHANGE

###########################################################
# Before
[features]
logging = []

###########################################################
# After
[dependencies]
# ..logging removed
```

Mitigation strategies:

- Clearly document your features. If there is an internal or experimental feature, mark it as such, so that users know the status of the feature.
- Leave the old feature in `Cargo.toml`, but otherwise remove its functionality. Document that the feature is deprecated, and remove it in a future major SemVer release.

Major: removing a feature from a feature list if that changes functionality or public items

If removing a feature from another feature, this can break existing users if they are expecting that functionality to be available through that feature.

```toml
# Breaking change example

###########################################################
# Before
[features]
default = ["std"]
std = []

###########################################################
# After
[features]
default = []  # This may cause packages to fail if they are expecting std to be enabled.
std = []
```

Possibly-breaking: removing an optional dependency

Removing an optional dependency can break a project using your library because another project may be enabling that dependency via Cargo features.

```
# Breaking change example

###########################################################
# Before
[dependencies]
curl = { version = "0.4.31", optional = true }

###########################################################
# After
[dependencies]
# ..curl removed
```

Mitigation strategies:

- Clearly document your features. If the optional dependency is not included in the documented list of features, then you may decide to consider it safe to change undocumented entries.
- Leave the optional dependency, and just don't use it within your library.
- Replace the optional dependency with a Cargo feature that does nothing, and document that it is deprecated.
- Use high-level features which enable optional dependencies, and document those as the preferred way to enable the extended functionality. For example, if your library has optional support for something like "networking", create a generic feature name "networking" that enables the optional dependencies necessary to implement "networking". Then document the "networking" feature.

Minor: changing dependency features

It is usually safe to change the features on a dependency, as long as the feature does not introduce a breaking change.

```
# MINOR CHANGE

###########################################################
# Before
[dependencies]
rand = { version = "0.7.3", features = ["small_rng"] }


###########################################################
# After
[dependencies]
rand = "0.7.3"
```

Minor: adding dependencies

It is usually safe to add new dependencies, as long as the new dependency does not introduce new requirements that result in a breaking change. For example, adding a new dependency that requires nightly in a project that previously worked on stable is a major change.

```
# MINOR CHANGE

###########################################################
# Before
[dependencies]
# ..empty

###########################################################
# After
[dependencies]
log = "0.4.11"
```

Application compatibility

Cargo projects may also include executable binaries which have their own interfaces (such as a CLI interface, OS-level interaction, etc.). Since these are part of the Cargo package, they often use and share the same version as the package. You will need to decide if and how you want to employ a SemVer contract with your users in the changes you make to your application. The potential breaking and compatible changes to an application are too numerous to list, so you are encouraged to use the spirit of the SemVer spec to guide your decisions on how to apply versioning to your application, or at least document what your commitments are.

Future incompat report

Cargo checks for future-incompatible warnings in all dependencies. These are warnings for changes that may become hard errors in the future, causing the dependency to stop building in a future version of rustc. If any warnings are found, a small notice is displayed indicating that the warnings were found, and provides instructions on how to display a full report.

For example, you may see something like this at the end of a build:

```
warning: the following packages contain code that will be rejected by a future
         version of Rust: rental v0.5.5
note: to see what the problems were, use the option `--future-incompat-report`,
      or run `cargo report future-incompatibilities --id 1`
```

A full report can be displayed with the `cargo report future-incompatibilities --id ID` command, or by running the build again with the `--future-incompat-report` flag. The developer should then update their dependencies to a version where the issue is fixed, or work with the developers of the dependencies to help resolve the issue.

Configuration

This feature can be configured through a `[future-incompat-report]` section in `.cargo/config.toml`. Currently, the supported options are:

```
[future-incompat-report]
frequency = "always"
```

The supported values for the frequency are `"always"` and `"never"`, which control whether or not a message is printed out at the end of `cargo build` / `cargo check`.

Reporting build timings

The `--timings` option gives some information about how long each compilation takes, and tracks concurrency information over time.

```
cargo build --timings
```

This writes an HTML report in `target/cargo-timings/cargo-timing.html`. This also writes a copy of the report to the same directory with a timestamp in the filename, if you want to look at older runs.

Reading the graphs

There are two tables and two graphs in the output.

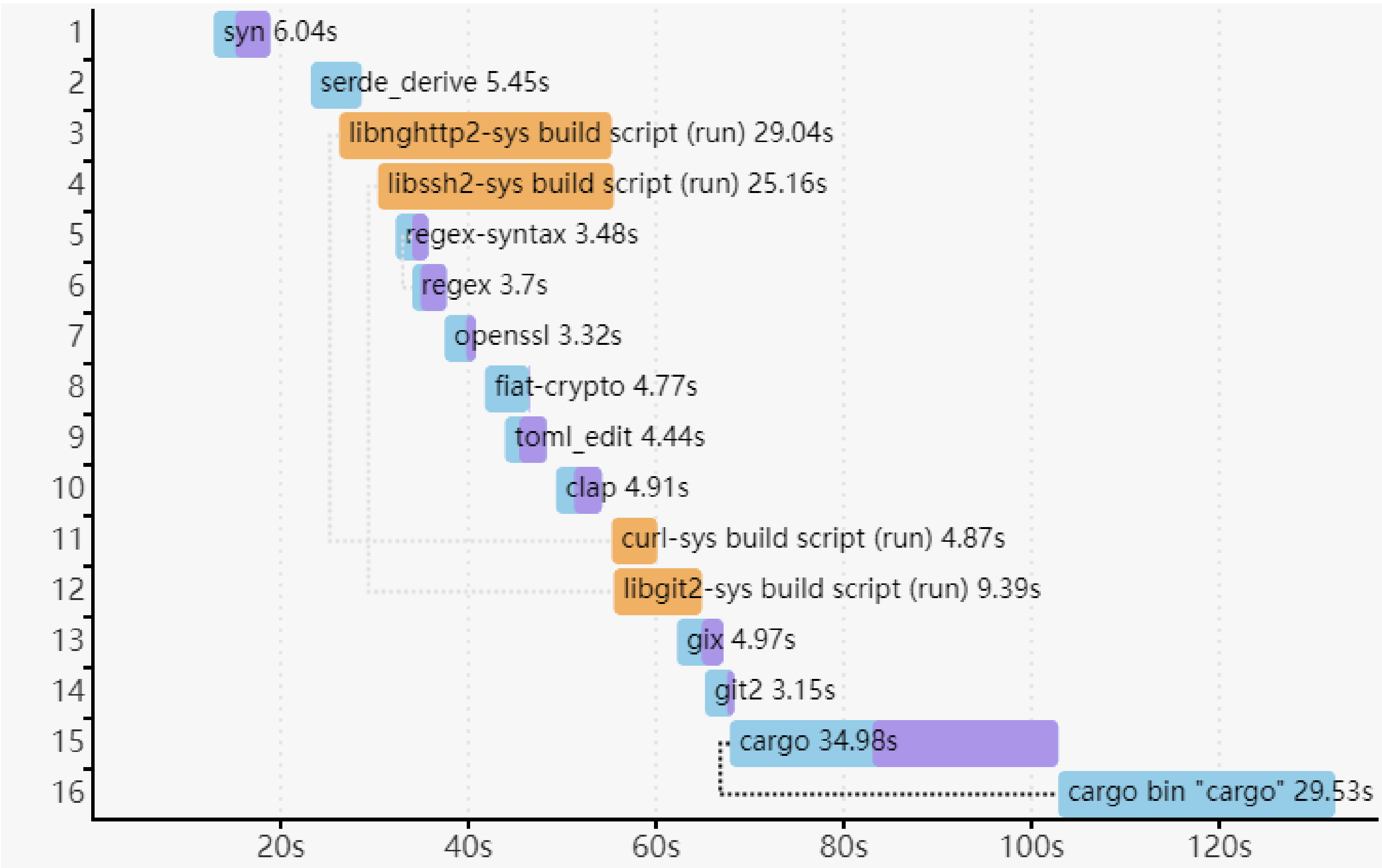
The first table displays the build information of the project, including the number of units built, the maximum number of concurrency, build time, and the version information of the currently used compiler.

Targets:	cargo 0.70.0 (lib, bin "cargo")
Profile:	dev
Fresh units:	0
Dirty units:	302
Total units:	302
Max concurrency:	6 (jobs=4 ncpu=4)
Build start:	2023-03-03T10:48:37Z
Total time:	132.5s (2m 12.5s)
rustc:	rustc 1.69.0-nightly (ef982929c 2023-01-27) Host: x86_64-unknown-linux-gnu Target: x86_64-unknown-linux-gnu

The “unit” graph shows the duration of each unit over time. A “unit” is a single compiler invocation. There are lines that show which additional units are “unlocked” when a unit finishes. That is, it shows the new units that are now allowed to run because their dependencies are all finished. Hover the mouse over a unit to highlight the lines. This can help visualize the critical path of dependencies. This may change between runs because the units may finish in different orders.

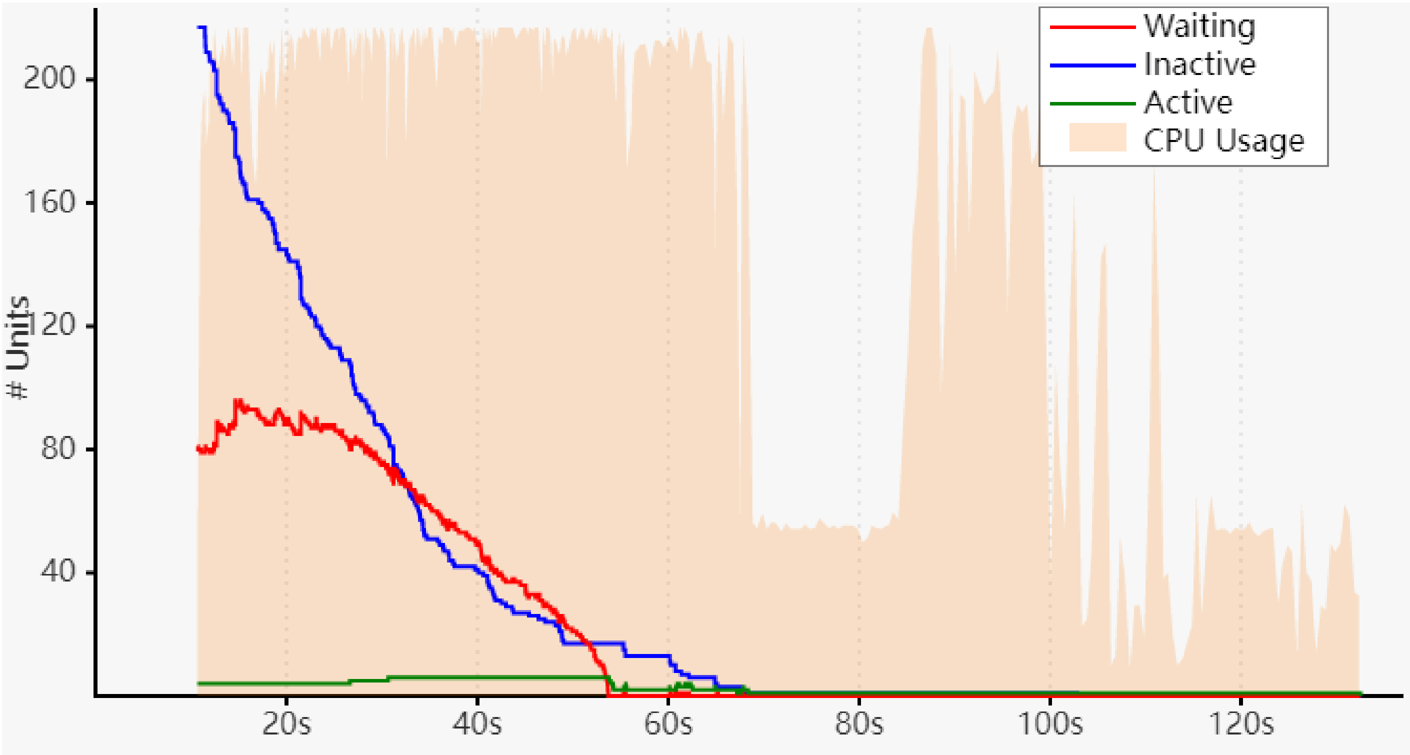
The "codegen" times are highlighted in a lavender color. In some cases, build pipelining allows units to start when their dependencies are performing code generation. This information is not always displayed (for example, binary units do not show when code generation starts).

The "custom build" units are `build.rs` scripts, which when run are highlighted in orange.



The second graph shows Cargo's concurrency over time. The background indicates CPU usage. The three lines are:

- "Waiting" (red) — This is the number of units waiting for a CPU slot to open.
- "Inactive" (blue) — This is the number of units that are waiting for their dependencies to finish.
- "Active" (green) — This is the number of units currently running.



Note: This does not show the concurrency in the compiler itself. `rustc` coordinates with Cargo via the "job server" to stay within the concurrency limit. This currently mostly applies to the code generation phase.

Tips for addressing compile times:

- Look for slow dependencies.
  - Check if they have features that you may wish to consider disabling.
  - Consider trying to remove the dependency completely.
- Look for a crate being built multiple times with different versions. Try to remove the older versions from the dependency graph.
- Split large crates into smaller pieces.
- If there are a large number of crates bottlenecked on a single crate, focus your attention on improving that one crate to improve parallelism.

The last table lists the total time and "codegen" time spent on each unit, as well as the features that were enabled during each unit's compilation.

Unstable Features

Experimental Cargo features are only available on the nightly channel. You are encouraged to experiment with these features to see if they meet your needs, and if there are any issues or problems. Check the linked tracking issues listed below for more information on the feature, and click the GitHub subscribe button if you want future updates.

After some period of time, if the feature does not have any major concerns, it can be stabilized, which will make it available on stable once the current nightly release reaches the stable channel (anywhere from 6 to 12 weeks).

There are three different ways that unstable features can be enabled based on how the feature works:

- New syntax in `Cargo.toml` requires a `cargo-features` key at the top of `Cargo.toml`, before any tables. For example:

  ```toml
  # This specifies which new Cargo.toml features are enabled.
  cargo-features = ["test-dummy-unstable"]

  [package]
  name = "my-package"
  version = "0.1.0"
  im-a-teapot = true  # This is a new option enabled by test-dummy-unstable.
  ```

- New command-line flags, options, and subcommands require the `-Z unstable-options` CLI option to also be included. For example, the new `--out-dir` option is only available on nightly:

  `cargo +nightly build --out-dir=out -Z unstable-options`

- `-Z` command-line flags are used to enable new functionality that may not have an interface, or the interface has not yet been designed, or for more complex features that affect multiple parts of Cargo. For example, the mtime-on-use feature can be enabled with:

  `cargo +nightly build -Z mtime-on-use`

  Run `cargo -Z help` to see a list of flags available.

  Anything which can be configured with a `-Z` flag can also be set in the cargo config file (`.cargo/config.toml`) in the `unstable` table. For example:

```
[unstable]
mtime-on-use = true
build-std = ["core", "alloc"]
```

Each new feature described below should explain how to use it.

List of unstable features

- Unstable-specific features
  - -Z allow-features — Provides a way to restrict which unstable features are used.
- Build scripts and linking
  - Metabuild — Provides declarative build scripts.
- Resolver and features
  - no-index-update — Prevents cargo from updating the index cache.
  - avoid-dev-deps — Prevents the resolver from including dev-dependencies during resolution.
  - minimal-versions — Forces the resolver to use the lowest compatible version instead of the highest.
  - direct-minimal-versions — Forces the resolver to use the lowest compatible version instead of the highest.
  - public-dependency — Allows dependencies to be classified as either public or private.
- Output behavior
  - out-dir — Adds a directory where artifacts are copied to.
  - Different binary name — Assign a name to the built binary that is separate from the crate name.
- Compile behavior
  - mtime-on-use — Updates the last-modified timestamp on every dependency every time it is used, to provide a mechanism to delete unused artifacts.
  - doctest-xcompile — Supports running doctests with the `--target` flag.
  - build-std — Builds the standard library instead of using pre-built binaries.
  - build-std-features — Sets features to use with the standard library.
  - binary-dep-depinfo — Causes the dep-info file to track binary dependencies.
  - panic-abort-tests — Allows running tests with the “abort” panic strategy.
  - keep-going — Build as much as possible rather than aborting on the first error.
  - check-cfg — Compile-time validation of `cfg` expressions.
  - host-config — Allows setting `[target]`-like configuration settings for host build targets.
  - target-applies-to-host — Alters whether certain flags will be passed to host build targets.
- rustdoc
  - `doctest-in-workspace` — Fixes workspace-relative paths when running doctests.

  - rustdoc-map — Provides mappings for documentation to link to external sites like docs.rs.
  - scrape-examples — Shows examples within documentation.
- `Cargo.toml` extensions
  - Profile `rustflags` option — Passed directly to rustc.
  - codegen-backend — Select the codegen backend used by rustc.
  - per-package-target — Sets the `--target` to use for each individual package.
  - artifact dependencies — Allow build artifacts to be included into other build artifacts and build them for different targets.
- Information and metadata
  - Build-plan — Emits JSON information on which commands will be run.
  - unit-graph — Emits JSON for Cargo's internal graph structure.
  - `cargo rustc --print` — Calls rustc with `--print` to display information from rustc.
- Configuration
  - config-include — Adds the ability for config files to include other files.
  - `cargo config` — Adds a new subcommand for viewing config files.
- Registries
  - credential-process — Adds support for fetching registry tokens from an external authentication program.
  - publish-timeout — Controls the timeout between uploading the crate and being available in the index
  - registry-auth — Adds support for authenticated registries, and generate registry authentication tokens using asymmetric cryptography.
- Other
  - gitoxide — Use `gitoxide` instead of `git2` for a set of operations.

allow-features

This permanently-unstable flag makes it so that only a listed set of unstable features can be used. Specifically, if you pass `-Zallow-features=foo,bar`, you'll continue to be able to pass `-Zfoo` and `-Zbar` to `cargo`, but you will be unable to pass `-Zbaz`. You can pass an empty string (`-Zallow-features=`) to disallow all unstable features.

`-Zallow-features` also restricts which unstable features can be passed to the `cargo-features` entry in `Cargo.toml`. If, for example, you want to allow

```
cargo-features = ["test-dummy-unstable"]
```

where `test-dummy-unstable` is unstable, that features would also be disallowed by `-Zallow-features=`, and allowed with `-Zallow-features=test-dummy-unstable`.

The list of features passed to cargo's `-Zallow-features` is also passed to any Rust tools that cargo ends up calling (like `rustc` or `rustdoc`). Thus, if you run `cargo -Zallow-features=`, no unstable Cargo *or* Rust features can be used.

no-index-update

- Original Issue: #3479
- Tracking Issue: #7404

The `-Z no-index-update` flag ensures that Cargo does not attempt to update the registry index. This is intended for tools such as Crater that issue many Cargo commands, and you want to avoid the network latency for updating the index each time.

mtime-on-use

- Original Issue: #6477
- Cache usage meta tracking issue: #7150

The `-Z mtime-on-use` flag is an experiment to have Cargo update the mtime of used files to make it easier for tools like cargo-sweep to detect which files are stale. For many workflows this needs to be set on *all* invocations of cargo. To make this more practical setting the `unstable.mtime_on_use` flag in `.cargo/config.toml` or the corresponding ENV variable will apply the `-Z mtime-on-use` to all invocations of nightly cargo. (the config flag is ignored by stable)

avoid-dev-deps

- Original Issue: #4988
- Tracking Issue: #5133

When running commands such as `cargo install` or `cargo build`, Cargo currently requires dev-dependencies to be downloaded, even if they are not used. The `-Z avoid-dev-deps` flag allows Cargo to avoid downloading dev-dependencies if they are not needed. The `Cargo.lock` file will not be generated if dev-dependencies are skipped.

minimal-versions

- Original Issue: #4100
- Tracking Issue: #5657

> Note: It is not recommended to use this feature. Because it enforces minimal versions for all transitive dependencies, its usefulness is limited since not all external dependencies declare proper lower version bounds. It is intended that it will be changed in the future to only enforce minimal versions for direct dependencies.

When a `Cargo.lock` file is generated, the `-Z minimal-versions` flag will resolve the dependencies to the minimum SemVer version that will satisfy the requirements (instead of the greatest version).

The intended use-case of this flag is to check, during continuous integration, that the versions specified in Cargo.toml are a correct reflection of the minimum versions that you are actually using. That is, if Cargo.toml says `foo = "1.0.0"` that you don't accidentally depend on features added only in `foo 1.5.0`.

direct-minimal-versions

- Original Issue: #4100
- Tracking Issue: #5657

When a `Cargo.lock` file is generated, the `-Z direct-minimal-versions` flag will resolve the dependencies to the minimum SemVer version that will satisfy the requirements (instead of the greatest version) for direct dependencies only.

The intended use-case of this flag is to check, during continuous integration, that the versions specified in Cargo.toml are a correct reflection of the minimum versions that you are actually using. That is, if Cargo.toml says `foo = "1.0.0"` that you don't accidentally depend on features added only in `foo 1.5.0`.

Indirect dependencies are resolved as normal so as not to be blocked on their minimal version validation.

out-dir

- Original Issue: #4875
- Tracking Issue: #6790

This feature allows you to specify the directory where artifacts will be copied to after they are built. Typically artifacts are only written to the `target/release` or `target/debug` directories. However, determining the exact filename can be tricky since you need to parse JSON output. The `--out-dir` flag makes it easier to predictably access the artifacts. Note that the artifacts are copied, so the originals are still in the `target` directory. Example:

```
cargo +nightly build --out-dir=out -Z unstable-options
```

This can also be specified in `.cargo/config.toml` files.

```
[build]
out-dir = "out"
```

doctest-xcompile

- Tracking Issue: #7040
- Tracking Rustc Issue: #64245

This flag changes `cargo test`'s behavior when handling doctests when a target is passed. Currently, if a target is passed that is different from the host cargo will simply skip testing doctests. If this flag is present, cargo will continue as normal, passing the tests to doctest, while also passing it a `--target` option, as well as enabling `-Zunstable-features --enable-per-target-ignores` and passing along information from `.cargo/config.toml`. See the rustc issue for more information.

```
cargo test --target foo -Zdoctest-xcompile
```

Build-plan

- Tracking Issue: #5579

The `--build-plan` argument for the `build` command will output JSON with information about which commands would be run without actually executing anything. This can be useful when integrating with another build tool. Example:

```
cargo +nightly build --build-plan -Z unstable-options
```

Metabuild

- Tracking Issue: rust-lang/rust#49803
- RFC: #2196

Metabuild is a feature to have declarative build scripts. Instead of writing a `build.rs` script, you specify a list of build dependencies in the `metabuild` key in `Cargo.toml`. A build script is automatically generated that runs each build dependency in order. Metabuild packages can then read metadata from `Cargo.toml` to specify their behavior.

Include `cargo-features` at the top of `Cargo.toml`, a `metabuild` key in the `package`, list the dependencies in `build-dependencies`, and add any metadata that the metabuild packages require under `package.metadata`. Example:

```
cargo-features = ["metabuild"]

[package]
name = "mypackage"
version = "0.0.1"
metabuild = ["foo", "bar"]

[build-dependencies]
foo = "1.0"
bar = "1.0"

[package.metadata.foo]
extra-info = "qwerty"
```

Metabuild packages should have a public function called `metabuild` that performs the same actions as a regular `build.rs` script would perform.

public-dependency

- Tracking Issue: #44663

The 'public-dependency' feature allows marking dependencies as 'public' or 'private'. When this feature is enabled, additional information is passed to rustc to allow the 'exported_private_dependencies' lint to function properly.

This requires the appropriate key to be set in `cargo-features`:

```
cargo-features = ["public-dependency"]

[dependencies]
my_dep = { version = "1.2.3", public = true }
private_dep = "2.0.0" # Will be 'private' by default
```

build-std

- Tracking Repository: https://github.com/rust-lang/wg-cargo-std-aware

The `build-std` feature enables Cargo to compile the standard library itself as part of a crate graph compilation. This feature has also historically been known as "std-aware Cargo". This feature is still in very early stages of development, and is also a possible massive feature addition to Cargo. This is a very large feature to document, even in the minimal form that it exists in today, so if you're curious to stay up to date you'll want to follow the tracking repository and its set of issues.

The functionality implemented today is behind a flag called `-Z build-std`. This flag indicates that Cargo should compile the standard library from source code using the same profile as the main build itself. Note that for this to work you need to have the source code for the standard library available, and at this time the only supported method of doing so is to add the `rust-src` rust rustup component:

```
$ rustup component add rust-src --toolchain nightly
```

It is also required today that the `-Z build-std` flag is combined with the `--target` flag. Note that you're not forced to do a cross compilation, you're just forced to pass `--target` in one form or another.

Usage looks like:

```
$ cargo new foo
$ cd foo
$ cargo +nightly run -Z build-std --target x86_64-unknown-linux-gnu
   Compiling core v0.0.0 (...)
   ...
   Compiling foo v0.1.0 (...)
    Finished dev [unoptimized + debuginfo] target(s) in 21.00s
     Running `target/x86_64-unknown-linux-gnu/debug/foo`
Hello, world!
```

Here we recompiled the standard library in debug mode with debug assertions (like `src/main.rs` is compiled) and everything was linked together at the end.

Using `-Z build-std` will implicitly compile the stable crates `core`, `std`, `alloc`, and `proc_macro`. If you're using `cargo test` it will also compile the `test` crate. If you're working with an environment which does not support some of these crates, then you can pass an argument to `-Zbuild-std` as well:

```
$ cargo +nightly build -Z build-std=core,alloc
```

The value here is a comma-separated list of standard library crates to build.

Requirements

As a summary, a list of requirements today to use `-Z build-std` are:

- You must install libstd's source code through `rustup component add rust-src`
- You must pass `--target`
- You must use both a nightly Cargo and a nightly rustc
- The `-Z build-std` flag must be passed to all `cargo` invocations.

Reporting bugs and helping out

The `-Z build-std` feature is in the very early stages of development! This feature for Cargo has an extremely long history and is very large in scope, and this is just the beginning. If you'd like to report bugs please either report them to:

- Cargo — https://github.com/rust-lang/cargo/issues/new — for implementation bugs
- The tracking repository — https://github.com/rust-lang/wg-cargo-std-aware/issues/new — for larger design questions.

Also if you'd like to see a feature that's not yet implemented and/or if something doesn't quite work the way you'd like it to, feel free to check out the issue tracker of the tracking repository, and if it's not there please file a new issue!

build-std-features

- Tracking Repository: https://github.com/rust-lang/wg-cargo-std-aware

This flag is a sibling to the `-Zbuild-std` feature flag. This will configure the features enabled for the standard library itself when building the standard library. The default enabled features, at this time, are `backtrace` and `panic_unwind`. This flag expects a comma-separated list and, if provided, will override the default list of features enabled.

binary-dep-depinfo

- Tracking rustc issue: #63012

The `-Z binary-dep-depinfo` flag causes Cargo to forward the same flag to `rustc` which will then cause `rustc` to include the paths of all binary dependencies in the "dep info" file (with the `.d` extension). Cargo then uses that information for change-detection (if any binary dependency changes, then the crate will be rebuilt). The primary use case is for building the compiler itself, which has implicit dependencies on the standard library that would otherwise be untracked for change-detection.

panic-abort-tests

- Tracking Issue: #67650
- Original Pull Request: #7460

The `-Z panic-abort-tests` flag will enable nightly support to compile test harness crates with `-Cpanic=abort`. Without this flag Cargo will compile tests, and everything they depend on, with `-Cpanic=unwind` because it's the only way `test`-the-crate knows how to operate. As of rust-lang/rust#64158, however, the `test` crate supports `-C panic=abort` with a test-per-process, and can help avoid compiling crate graphs multiple times.

It's currently unclear how this feature will be stabilized in Cargo, but we'd like to stabilize it somehow!

keep-going

- Tracking Issue: #10496

`cargo build --keep-going` (and similarly for `check`, `test` etc) will build as many crates in the dependency graph as possible, rather than aborting the build at the first one that fails to build.

For example if the current package depends on dependencies `fails` and `works`, one of which fails to build, `cargo check -j1` may or may not build the one that succeeds (depending on which one of the two builds Cargo picked to run first), whereas `cargo check -j1 --keep-going` would definitely run both builds, even if the one run first fails.

The `-Z unstable-options` command-line option must be used in order to use `--keep-going` while it is not yet stable:

```
cargo check --keep-going -Z unstable-options
```

config-include

- Tracking Issue: #7723

The `include` key in a config file can be used to load another config file. It takes a string for a path to another file relative to the config file, or a list of strings. It requires the `-Zconfig-include` command-line option.

```
# .cargo/config
include = '../../some-common-config.toml'
```

The config values are first loaded from the include path, and then the config file's own values are merged on top of it.

This can be paired with config-cli to specify a file to load from the command-line. Pass a path to a config file as the argument to `--config`:

```
cargo +nightly -Zunstable-options -Zconfig-include --config somefile.toml build
```

CLI paths are relative to the current working directory.

target-applies-to-host

- Original Pull Request: #9322
- Tracking Issue: #9453

Historically, Cargo's behavior for whether the `linker` and `rustflags` configuration options from environment variables and `[target]` are respected for build scripts, plugins, and other artifacts that are *always* built for the host platform has been somewhat inconsistent. When `--target` is *not* passed, Cargo respects the same `linker` and `rustflags` for build scripts as for all other compile artifacts. When `--target` *is* passed, however, Cargo respects `linker` from `[target.<host triple>]`, and does not pick up any `rustflags` configuration. This dual behavior is confusing, but also makes it difficult to correctly configure builds where the host triple and the target triple happen to be the same, but artifacts intended to run on the build host should still be configured differently.

`-Ztarget-applies-to-host` enables the top-level `target-applies-to-host` setting in Cargo configuration files which allows users to opt into different (and more consistent) behavior for these properties. When `target-applies-to-host` is unset, or set to `true`, in the configuration file, the existing Cargo behavior is preserved (though see `-Zhost-config`, which changes that default). When it is set to `false`, no options from `[target.<host triple>]`, `RUSTFLAGS`, or `[build]` are respected for host artifacts regardless of whether `--target` is passed to Cargo. To customize artifacts intended to be run on the host, use `[host]` (`host-config`).

In the future, `target-applies-to-host` may end up defaulting to `false` to provide more sane and consistent default behavior.

```
# config.toml
target-applies-to-host = false
```

```
cargo +nightly -Ztarget-applies-to-host build --target x86_64-unknown-linux-gnu
```

host-config

- Original Pull Request: #9322
- Tracking Issue: #9452

The `host` key in a config file can be used pass flags to host build targets such as build scripts that must run on the host system instead of the target system when cross compiling. It supports both generic and host arch specific tables. Matching host arch tables take precedence over generic host tables.

It requires the `-Zhost-config` and `-Ztarget-applies-to-host` command-line options to be set, and that `target-applies-to-host = false` is set in the Cargo configuration file.

```
# config.toml
[host]
linker = "/path/to/host/linker"
[host.x86_64-unknown-linux-gnu]
linker = "/path/to/host/arch/linker"
rustflags = ["-Clink-arg=--verbose"]
[target.x86_64-unknown-linux-gnu]
linker = "/path/to/target/linker"
```

The generic `host` table above will be entirely ignored when building on a `x86_64-unknown-linux-gnu` host as the `host.x86_64-unknown-linux-gnu` table takes precedence.

Setting `-Zhost-config` changes the default for `target-applies-to-host` to `false` from `true`.

```
cargo +nightly -Ztarget-applies-to-host -Zhost-config build --target x86_64-unknown-linux-gnu
```

unit-graph

- Tracking Issue: #8002

The `--unit-graph` flag can be passed to any build command (`build`, `check`, `run`, `test`, `bench`, `doc`, etc.) to emit a JSON object to stdout which represents Cargo's internal unit graph. Nothing is actually built, and the command returns immediately after printing. Each "unit" corresponds to an execution of the compiler. These objects also include which unit each unit depends on.

```
cargo +nightly build --unit-graph -Z unstable-options
```

This structure provides a more complete view of the dependency relationship as Cargo sees it. In particular, the "features" field supports the new feature resolver where a dependency can be built multiple times with different features. `cargo metadata` fundamentally cannot represent the relationship of features between different dependency kinds, and features now depend on which command is run and which packages and targets are selected. Additionally it can provide details about intra-package dependencies like build scripts or tests.

The following is a description of the JSON structure:

```
{
  /* Version of the JSON output structure. If any backwards incompatible
     changes are made, this value will be increased.
  */
  "version": 1,
  /* Array of all build units. */
  "units": [
    {
      /* An opaque string which indicates the package.
         Information about the package can be obtained from `cargo metadata`.
      */
      "pkg_id": "my-package 0.1.0 (path+file:///path/to/my-package)",
      /* The Cargo target. See the `cargo metadata` documentation for more
         information about these fields.
         https://doc.rust-lang.org/cargo/commands/cargo-metadata.html
      */
      "target": {
        "kind": ["lib"],
        "crate_types": ["lib"],
        "name": "my-package",
        "src_path": "/path/to/my-package/src/lib.rs",
        "edition": "2018",
        "test": true,
        "doctest": true
      },
      /* The profile settings for this unit.
         These values may not match the profile defined in the manifest.
         Units can use modified profile settings. For example, the "panic"
         setting can be overridden for tests to force it to "unwind".
      */
      "profile": {
        /* The profile name these settings are derived from. */
        "name": "dev",
        /* The optimization level as a string. */
        "opt_level": "0",
        /* The LTO setting as a string. */
        "lto": "false",
        /* The codegen units as an integer.
           `null` if it should use the compiler's default.
        */
        "codegen_units": null,
        /* The debug information level as an integer.
           `null` if it should use the compiler's default (0).
        */
        "debuginfo": 2,
        /* Whether or not debug-assertions are enabled. */
        "debug_assertions": true,
        /* Whether or not overflow-checks are enabled. */
        "overflow_checks": true,
        /* Whether or not rpath is enabled. */
        "rpath": false,
        /* Whether or not incremental is enabled. */
        "incremental": true,
        /* The panic strategy, "unwind" or "abort". */
        "panic": "unwind"
      },
      /* Which platform this target is being built for.
         A value of `null` indicates it is for the host.
         Otherwise it is a string of the target triple (such as
         "x86_64-unknown-linux-gnu").
```

```
      */
      "platform": null,
      /* The "mode" for this unit. Valid values:

         * "test" --- Build using `rustc` as a test.
         * "build" --- Build using `rustc`.
         * "check" --- Build using `rustc` in "check" mode.
         * "doc" --- Build using `rustdoc`.
         * "doctest" --- Test using `rustdoc`.
         * "run-custom-build" --- Represents the execution of a build script.
      */
      "mode": "build",
      /* Array of features enabled on this unit as strings. */
      "features": ["somefeat"],
      /* Whether or not this is a standard-library unit,
         part of the unstable build-std feature.
         If not set, treat as `false`.
      */
      "is_std": false,
      /* Array of dependencies of this unit. */
      "dependencies": [
        {
          /* Index in the "units" array for the dependency. */
          "index": 1,
          /* The name that this dependency will be referred as. */
          "extern_crate_name": "unicode_xid",
          /* Whether or not this dependency is "public",
             part of the unstable public-dependency feature.
             If not set, the public-dependency feature is not enabled.
          */
          "public": false,
          /* Whether or not this dependency is injected into the prelude,
             currently used by the build-std feature.
             If not set, treat as `false`.
          */
          "noprelude": false
        }
      ]
    },
    // ...
  ],
  /* Array of indices in the "units" array that are the "roots" of the
     dependency graph.
  */
  "roots": [0],
}
```

Profile `rustflags` option

- Original Issue: rust-lang/cargo#7878
- Tracking Issue: rust-lang/cargo#10271

This feature provides a new option in the `[profile]` section to specify flags that are passed directly to rustc. This can be enabled like so:

```
cargo-features = ["profile-rustflags"]

[package]
# ...

[profile.release]
rustflags = [ "-C", "..." ]
```

To set this in a profile in Cargo configuration, you need to use either `-Z profile-rustflags` or `[unstable]` table to enable it. For example,

```
# .cargo/config.toml
[unstable]
profile-rustflags = true

[profile.release]
rustflags = [ "-C", "..." ]
```

rustdoc-map

- Tracking Issue: #8296

This feature adds configuration settings that are passed to `rustdoc` so that it can generate links to dependencies whose documentation is hosted elsewhere when the dependency is not documented. First, add this to `.cargo/config`:

```
[doc.extern-map.registries]
crates-io = "https://docs.rs/"
```

Then, when building documentation, use the following flags to cause links to dependencies to link to docs.rs:

```
cargo +nightly doc --no-deps -Zrustdoc-map
```

The `registries` table contains a mapping of registry name to the URL to link to. The URL may have the markers `{pkg_name}` and `{version}` which will get replaced with the corresponding values. If neither are specified, then Cargo defaults to appending `{pkg_name}/{version}/` to the end of the URL.

Another config setting is available to redirect standard library links. By default, rustdoc creates links to https://doc.rust-lang.org/nightly/. To change this behavior, use the `doc.extern-map.std` setting:

```
[doc.extern-map]
std = "local"
```

A value of `"local"` means to link to the documentation found in the `rustc` sysroot. If you are using rustup, this documentation can be installed with `rustup component add rust-docs`.

The default value is `"remote"`.

The value may also take a URL for a custom location.

per-package-target

- Tracking Issue: #9406
- Original Pull Request: #9030
- Original Issue: #7004

The `per-package-target` feature adds two keys to the manifest: `package.default-target` and `package.forced-target`. The first makes the package be compiled by default (ie. when no `--target` argument is passed) for some target. The second one makes the package always be compiled for the target.

Example:

```
[package]
forced-target = "wasm32-unknown-unknown"
```

In this example, the crate is always built for `wasm32-unknown-unknown`, for instance because it is going to be used as a plugin for a main program that runs on the host (or provided on the command line) target.

artifact-dependencies

- Tracking Issue: #9096
- Original Pull Request: #9992

Allow Cargo packages to depend on `bin`, `cdylib`, and `staticlib` crates, and use the artifacts built by those crates at compile time.

Run `cargo` with `-Z bindeps` to enable this functionality.

Example: use *cdylib* artifact in build script

The `Cargo.toml` in the consuming package, building the `bar` library as `cdylib` for a specific build target…

```
[build-dependencies]
bar = { artifact = "cdylib", version = "1.0", target = "wasm32-unknown-unknown" }
```

…along with the build script in `build.rs`.

```
fn main() {
  wasm::run_file(std::env::var("CARGO_CDYLIB_FILE_BAR").unwrap());
}
```

Example: use *binary* artifact and its library in a binary

The `Cargo.toml` in the consuming package, building the `bar` binary for inclusion as artifact while making it available as library as well…

```
[dependencies]
bar = { artifact = "bin", version = "1.0", lib = true }
```

…along with the executable using `main.rs`.

```
fn main() {
  bar::init();
  command::run(env!("CARGO_BIN_FILE_BAR"));
}
```

publish-timeout

- Tracking Issue: 11222

The `publish.timeout` key in a config file can be used to control how long `cargo publish` waits between posting a package to the registry and it being available in the local index.

A timeout of `0` prevents any checks from occurring. The current default is `60` seconds.

It requires the `-Zpublish-timeout` command-line options to be set.

```
# config.toml
[publish]
timeout = 300  # in seconds
```

registry-auth

- Tracking Issue: 10474
- RFC: #3139

Enables Cargo to include the authorization token for API requests, crate downloads and sparse index updates by adding a configuration option to config.json in the registry index.

To use this feature, the registry server must include `"auth-required": true` in `config.json`, and you must pass the `-Z registry-auth` flag on the Cargo command line.

When using the sparse protocol, Cargo will attempt to fetch the `config.json` file before fetching any other files. If the server responds with an HTTP 401, then Cargo will assume that the registry requires authentication and re-attempt the request for `config.json` with the authentication token included.

On authentication failure (or missing authentication token) the server MAY include a `WWW-Authenticate` header with a `Cargo login_url` challenge to indicate where the user can go to get a token.

```
WWW-Authenticate: Cargo login_url="https://test-registry-login/me
```

This same flag is also used to enable asymmetric authentication tokens.

- Tracking Issue: 10519
- RFC: #3231

Add support for Cargo to authenticate the user to registries without sending secrets over the network.

In `config.toml` and `credentials.toml` files there is a field called `private-key`, which is a private key formatted in the secret subset of `PASERK` and is used to sign asymmetric tokens

A keypair can be generated with `cargo login --generate-keypair` which will:

- generate a public/private keypair in the currently recommended fashion.
- save the private key in `credentials.toml`.
- print the public key in PASERK public format.

It is recommended that the `private-key` be saved in `credentials.toml`. It is also supported in `config.toml`, primarily so that it can be set using the associated environment variable, which is the recommended way to provide it in CI contexts. This setup is what we have for the `token` field for setting a secret token.

There is also an optional field called `private-key-subject` which is a string chosen by the registry. This string will be included as part of an asymmetric token and should not be secret. It is intended for the rare use cases like “cryptographic proof that the central CA server authorized this action”. Cargo requires it to be non-whitespace printable ASCII. Registries that need non-ASCII data should base64 encode it.

Both fields can be set with `cargo login --registry=name --private-key --private-key-subject="subject"` which will prompt you to put in the key value.

A registry can have at most one of `private-key`, `token`, or `credential-process` set.

All PASETOs will include `iat`, the current time in ISO 8601 format. Cargo will include the following where appropriate:

- `sub` an optional, non-secret string chosen by the registry that is expected to be claimed with every request. The value will be the `private-key-subject` from the `config.toml` file.
- `mutation` if present, indicates that this request is a mutating operation (or a read-only operation if not present), must be one of the strings `publish`, `yank`, or `unyank`.

  - `name` name of the crate related to this request.
  - `vers` version string of the crate related to this request.
  - `cksum` the SHA256 hash of the crate contents, as a string of 64 lowercase hexadecimal digits, must be present only when `mutation` is equal to `publish`
- `challenge` the challenge string received from a 401/403 from this server this session. Registries that issue challenges must track which challenges have been issued/used and never accept a given challenge more than once within the same validity period (avoiding the need to track every challenge ever issued).

The "footer" (which is part of the signature) will be a JSON string in UTF-8 and include:

- `url` the RFC 3986 compliant URL where cargo got the config.json file,
  - If this is a registry with an HTTP index, then this is the base URL that all index queries are relative to.
  - If this is a registry with a GIT index, it is the URL Cargo used to clone the index.
- `kid` the identifier of the private key used to sign the request, using the PASERK IDs standard.

PASETO includes the message that was signed, so the server does not have to reconstruct the exact string from the request in order to check the signature. The server does need to check that the signature is valid for the string in the PASETO and that the contents of that string matches the request. If a claim should be expected for the request but is missing in the PASETO then the request must be rejected.

credential-process

- Tracking Issue: #8933
- RFC: #2730

The `credential-process` feature adds a config setting to fetch registry authentication tokens by calling an external process.

Token authentication is used by the `cargo login`, `cargo publish`, `cargo owner`, `cargo yank`, and `cargo logout` commands.

To use this feature, you must pass the `-Z credential-process` flag on the command-line. Additionally, you must remove any current tokens currently saved in the `credentials.toml` file (which can be done with the `cargo logout` command).

`credential-process` Configuration

To configure which process to run to fetch the token, specify the process in the `registry` table in a config file:

```
[registry]
credential-process = "/usr/bin/cargo-creds"
```

If you want to use a different process for a specific registry, it can be specified in the `registries` table:

```
[registries.my-registry]
credential-process = "/usr/bin/cargo-creds"
```

The value can be a string with spaces separating arguments or it can be a TOML array of strings.

Command-line arguments allow special placeholders which will be replaced with the corresponding value:

- `{name}` — The name of the registry.
- `{api_url}` — The base URL of the registry API endpoints.
- `{action}` — The authentication action (described below).

Process names with the prefix `cargo:` are loaded from the `libexec` directory next to cargo. Several experimental credential wrappers are included with Cargo, and this provides convenient access to them:

```
[registry]
credential-process = "cargo:macos-keychain"
```

The current wrappers are:

- `cargo:macos-keychain`: Uses the macOS Keychain to store the token.
- `cargo:wincred`: Uses the Windows Credential Manager to store the token.
- `cargo:1password`: Uses the 1password `op` CLI to store the token. You must install the `op` CLI from the 1password website. You must run `op signin` at least once with the appropriate arguments (such as `op signin my.1password.com user@example.com`), unless you provide the sign-in-address and email arguments. The master password will be required on each request unless the appropriate `OP_SESSION` environment variable is set. It supports the following command-line arguments:
  - `--account`: The account shorthand name to use.
  - `--vault`: The vault name to use.
  - `--sign-in-address`: The sign-in-address, which is a web address such as `my.1password.com`.
  - `--email`: The email address to sign in with.

A wrapper is available for GNOME libsecret to store tokens on Linux systems. Due to build limitations, this wrapper is not available as a pre-compiled binary. This can be built and installed manually. First, install libsecret using your system package manager (for example, `sudo apt install libsecret-1-dev`). Then build and install the wrapper with `cargo install cargo-credential-gnome-secret`. In the config, use a path to the binary like this:

```
[registry]
credential-process = "cargo-credential-gnome-secret {action}"
```

`credential-process` Interface

There are two different kinds of token processes that Cargo supports. The simple "basic" kind will only be called by Cargo when it needs a token. This is intended for simple and easy integration with password managers, that can often use pre-existing tooling. The more advanced "Cargo" kind supports different actions passed as a command-line argument. This is intended for more pleasant integration experience, at the expense of requiring a Cargo-specific process to glue to the password manager. Cargo will determine which kind is supported by the `credential-process` definition. If it contains the `{action}` argument, then it uses the advanced style, otherwise it assumes it only supports the "basic" kind.

Basic authenticator

A basic authenticator is a process that returns a token on stdout. Newlines will be trimmed. The process inherits the user's stdin and stderr. It should exit 0 on success, and nonzero on error.

With this form, `cargo login` and `cargo logout` are not supported and return an error if used.

Cargo authenticator

The protocol between the Cargo and the process is very basic, intended to ensure the credential process is kept as simple as possible. Cargo will execute the process with the `{action}` argument indicating which action to perform:

- `store` — Store the given token in secure storage.
- `get` — Get a token from storage.
- `erase` — Remove a token from storage.

The `cargo login` command uses `store` to save a token. Commands that require authentication, like `cargo publish`, uses `get` to retrieve a token. `cargo logout` uses the `erase` command to remove a token.

The process inherits the user's stderr, so the process can display messages. Some values are passed in via environment variables (see below). The expected interactions are:

- `store` — The token is sent to the process's stdin, terminated by a newline. The process should store the token keyed off the registry name. If the process fails, it should exit with a nonzero exit status.

- `get` — The process should send the token to its stdout (trailing newline will be trimmed). The process inherits the user's stdin, should it need to receive input.

If the process is unable to fulfill the request, it should exit with a nonzero exit code.

- `erase` — The process should remove the token associated with the registry name. If the token is not found, the process should exit with a 0 exit status.

Environment

The following environment variables will be provided to the executed command:

- `CARGO` — Path to the `cargo` binary executing the command.
- `CARGO_REGISTRY_INDEX_URL` — The URL of the registry index.
- `CARGO_REGISTRY_NAME_OPT` — Optional name of the registry. Should not be used as a storage key. Not always available.

cargo config

- Original Issue: #2362
- Tracking Issue: #9301

The `cargo config` subcommand provides a way to display the configuration files that cargo loads. It currently includes the `get` subcommand which can take an optional config value to display.

```
cargo +nightly -Zunstable-options config get build.rustflags
```

If no config value is included, it will display all config values. See the `--help` output for more options available.

doctest-in-workspace

- Tracking Issue: #9427

The `-Z doctest-in-workspace` flag changes the behavior of the current working directory used when running doctests. Historically, Cargo has run `rustdoc --test` relative to the root of the package, with paths relative from that root. However, this is inconsistent with how `rustc` and `rustdoc` are normally run in a workspace, where they are run relative to the workspace root. This inconsistency causes problems in various ways, such as when passing RUSTDOCFLAGS with relative paths, or dealing with diagnostic output.

The `-Z doctest-in-workspace` flag causes cargo to switch to running `rustdoc` from the root of the workspace. It also passes the `--test-run-directory` to `rustdoc` so that when *running* the tests, they are run from the root of the package. This preserves backwards compatibility and is consistent with how normal unittests are run.

rustc `--print`

- Tracking Issue: #9357

`cargo rustc --print=VAL` forwards the `--print` flag to `rustc` in order to extract information from `rustc`. This runs `rustc` with the corresponding `--print` flag, and then immediately exits without compiling. Exposing this as a cargo flag allows cargo to inject the correct target and RUSTFLAGS based on the current configuration.

The primary use case is to run `cargo rustc --print=cfg` to get config values for the appropriate target and influenced by any other RUSTFLAGS.

Different binary name

- Tracking Issue: #9778
- PR: #9627

The `different-binary-name` feature allows setting the filename of the binary without having to obey the restrictions placed on crate names. For example, the crate name must use only `alphanumeric` characters or `-` or `_`, and cannot be empty.

The `filename` parameter should **not** include the binary extension, `cargo` will figure out the appropriate extension and use that for the binary on its own.

The `filename` parameter is only available in the `[[bin]]` section of the manifest.

```
cargo-features = ["different-binary-name"]

[package]
name =  "foo"
version = "0.0.1"

[[bin]]
name = "foo"
filename = "007bar"
path = "src/main.rs"
```

scrape-examples

- RFC: #3123
- Tracking Issue: #9910

The `-Z rustdoc-scrape-examples` flag tells Rustdoc to search crates in the current workspace for calls to functions. Those call-sites are then included as documentation. You can use the flag like this:

```
cargo doc -Z unstable-options -Z rustdoc-scrape-examples
```

By default, Cargo will scrape examples from the example targets of packages being documented. You can individually enable or disable targets from being scraped with the `doc-scrape-examples` flag, such as:

```
# Enable scraping examples from a library
[lib]
doc-scrape-examples = true

# Disable scraping examples from an example target
[[example]]
name = "my-example"
doc-scrape-examples = false
```

Note on tests: enabling `doc-scrape-examples` on test targets will not currently have any effect. Scraping examples from tests is a work-in-progress.

Note on dev-dependencies: documenting a library does not normally require the crate's dev-dependencies. However, example targets require dev-deps. For backwards compatibility, `-Z rustdoc-scrape-examples` will *not* introduce a dev-deps requirement for `cargo doc`. Therefore examples will *not* be scraped from example targets under the following conditions:

1. No target being documented requires dev-deps, AND
2. At least one crate with targets being documented has dev-deps, AND
3. The `doc-scrape-examples` parameter is unset or false for all `[[example]]` targets.

If you want examples to be scraped from example targets, then you must not satisfy one of the above conditions. For example, you can set `doc-scrape-examples` to true for one example target, and that signals to Cargo that you are ok with dev-deps being build for `cargo doc`.

check-cfg

- RFC: #3013
- Tracking Issue: #10554

`-Z check-cfg` command line enables compile time checking of name and values in `#[cfg]`, `cfg!`, `#[link]` and `#[cfg_attr]` with the `rustc` and `rustdoc` unstable `--check-cfg` command line.

It's values are:

- `features`: enables features checking via `--check-cfg=values(feature, ...)`. Note than this command line options will probably become the default when stabilizing.
- `names`: enables well known names checking via `--check-cfg=names()`.
- `values`: enables well known values checking via `--check-cfg=values()`.
- `output`: enable the use of `rustc-check-cfg` in build script.

For instance:

```
cargo check -Z unstable-options -Z check-cfg=features
cargo check -Z unstable-options -Z check-cfg=names
cargo check -Z unstable-options -Z check-cfg=values
cargo check -Z unstable-options -Z check-cfg=features,names,values
```

Or for `output`:

```
// build.rs
println!("cargo:rustc-check-cfg=names(foo, bar)");
```

```
cargo check -Z unstable-options -Z check-cfg=output
```

`cargo:rustc-check-cfg=CHECK_CFG`

The `rustc-check-cfg` instruction tells Cargo to pass the given value to the `--check-cfg` flag to the compiler. This may be used for compile-time detection of unexpected conditional compilation name and/or values.

This can only be used in combination with `-Zcheck-cfg=output` otherwise it is ignored with a warning.

If you want to integrate with Cargo features, use `-Zcheck-cfg=features` instead of trying to do it manually with this option.

codegen-backend

The `codegen-backend` feature makes it possible to select the codegen backend used by rustc using a profile.

Example:

```
[package]
name = "foo"

[dependencies]
serde = "1.0.117"

[profile.dev.package.foo]
codegen-backend = "cranelift"
```

To set this in a profile in Cargo configuration, you need to use either `-Z codegen-backend` or `[unstable]` table to enable it. For example,

```
# .cargo/config.toml
[unstable]
codegen-backend = true

[profile.dev.package.foo]
codegen-backend = "cranelift"
```

gitoxide

- Tracking Issue: #11813

With the 'gitoxide' unstable feature, all or the the specified git operations will be performed by the `gitoxide` crate instead of `git2`.

While `-Zgitoxide` enables all currently implemented features, one can individually select git operations to run with `gitoxide` with the `-Zgitoxide=operation[,operationN]` syntax.

Valid operations are the following:

- `fetch` - All fetches are done with `gitoxide`, which includes git dependencies as well as the crates index.
- `shallow-index` *(planned)* - perform a shallow clone of the index.
- `shallow-deps` *(planned)* - perform a shallow clone of git dependencies.
- `checkout` *(planned)* - checkout the worktree, with support for filters and submodules.

Stabilized and removed features

Compile progress

The compile-progress feature has been stabilized in the 1.30 release. Progress bars are now enabled by default. See `term.progress` for more information about controlling this feature.

Edition

Specifying the `edition` in `Cargo.toml` has been stabilized in the 1.31 release. See the edition field for more information about specifying this field.

rename-dependency

Specifying renamed dependencies in `Cargo.toml` has been stabilized in the 1.31 release. See renaming dependencies for more information about renaming dependencies.

Alternate Registries

Support for alternate registries has been stabilized in the 1.34 release. See the Registries chapter for more information about alternate registries.

Offline Mode

The offline feature has been stabilized in the 1.36 release. See the `--offline` flag for more information on using the offline mode.

publish-lockfile

The `publish-lockfile` feature has been removed in the 1.37 release. The `Cargo.lock` file is always included when a package is published if the package contains a binary target. `cargo install` requires the `--locked` flag to use the `Cargo.lock` file. See `cargo package` and `cargo install` for more information.

default-run

The `default-run` feature has been stabilized in the 1.37 release. See the `default-run` field for more information about specifying the default target to run.

cache-messages

Compiler message caching has been stabilized in the 1.40 release. Compiler warnings are now cached by default and will be replayed automatically when re-running Cargo.

install-upgrade

The `install-upgrade` feature has been stabilized in the 1.41 release. `cargo install` will now automatically upgrade packages if they appear to be out-of-date. See the `cargo install` documentation for more information.

Profile Overrides

Profile overrides have been stabilized in the 1.41 release. See Profile Overrides for more information on using overrides.

Config Profiles

Specifying profiles in Cargo config files and environment variables has been stabilized in the 1.43 release. See the config `[profile]` table for more information about specifying profiles in config files.

crate-versions

The `-Z crate-versions` flag has been stabilized in the 1.47 release. The crate version is now automatically included in the `cargo doc` documentation sidebar.

Features

The `-Z features` flag has been stabilized in the 1.51 release. See feature resolver version 2 for more information on using the new feature resolver.

package-features

The `-Z package-features` flag has been stabilized in the 1.51 release. See the resolver version 2 command-line flags for more information on using the features CLI options.

Resolver

The `resolver` feature in `Cargo.toml` has been stabilized in the 1.51 release. See the resolver versions for more information about specifying resolvers.

extra-link-arg

The `extra-link-arg` feature to specify additional linker arguments in build scripts has been stabilized in the 1.56 release. See the build script documentation for more information on specifying extra linker arguments.

configurable-env

The `configurable-env` feature to specify environment variables in Cargo configuration has been stabilized in the 1.56 release. See the config documentation for more information about configuring environment variables.

rust-version

The `rust-version` field in `Cargo.toml` has been stabilized in the 1.56 release. See the rust-version field for more information on using the `rust-version` field and the `--ignore-rust-version` option.

patch-in-config

The `-Z patch-in-config` flag, and the corresponding support for `[patch]` section in Cargo configuration files has been stabilized in the 1.56 release. See the patch field for more information.

edition 2021

The 2021 edition has been stabilized in the 1.56 release. See the `edition` field for more information on setting the edition. See `cargo fix --edition` and The Edition Guide for more information on migrating existing projects.

Custom named profiles

Custom named profiles have been stabilized in the 1.57 release. See the profiles chapter for more information.

Profile `strip` option

The profile `strip` option has been stabilized in the 1.59 release. See the profiles chapter for more information.

Future incompat report

Support for generating a future-incompat report has been stabilized in the 1.59 release. See the future incompat report chapter for more information.

Namespaced features

Namespaced features has been stabilized in the 1.60 release. See the Features chapter for more information.

Weak dependency features

Weak dependency features has been stabilized in the 1.60 release. See the Features chapter for more information.

timings

The `-Ztimings` option has been stabilized as `--timings` in the 1.60 release. (`--timings=html` and the machine-readable `--timings=json` output remain unstable and require `-Zunstable-options`.)

config-cli

The `--config` CLI option has been stabilized in the 1.63 release. See the config documentation for more information.

multitarget

The `-Z multitarget` option has been stabilized in the 1.64 release. See `build.target` for more information about setting the default target platform triples.

crate-type

The `--crate-type` flag for `cargo rustc` has been stabilized in the 1.64 release. See the `cargo rustc` documentation for more information.

Workspace Inheritance

Workspace Inheritance has been stabilized in the 1.64 release. See workspace.package, workspace.dependencies, and inheriting-a-dependency-from-a-workspace for more information.

terminal-width

The `-Z terminal-width` option has been stabilized in the 1.68 release. The terminal width is always passed to the compiler when running from a terminal where Cargo can automatically detect the width.

sparse-registry

Sparse registry support has been stabilized in the 1.68 release. See Registry Protocols for more information.

`cargo logout`

The `cargo logout` command has been stabilized in the 1.70 release.

Cargo Commands

- General Commands
- Build Commands
- Manifest Commands
- Package Commands
- Publishing Commands

General Commands

- cargo
- cargo help
- cargo version

cargo(1)

NAME

cargo — The Rust package manager

SYNOPSIS

`cargo` [*options*] *command* [*args*]
`cargo` [*options*] `--version`
`cargo` [*options*] `--list`
`cargo` [*options*] `--help`
`cargo` [*options*] `--explain` *code*

DESCRIPTION

This program is a package manager and build tool for the Rust language, available at https://rust-lang.org.

COMMANDS

Build Commands

cargo-bench(1)
    Execute benchmarks of a package.

cargo-build(1)
    Compile a package.

cargo-check(1)
    Check a local package and all of its dependencies for errors.

cargo-clean(1)
    Remove artifacts that Cargo has generated in the past.

cargo-doc(1)
    Build a package's documentation.

[cargo-fetch(1)]
Fetch dependencies of a package from the network.

[cargo-fix(1)]
Automatically fix lint warnings reported by rustc.

[cargo-run(1)]
Run a binary or example of the local package.

[cargo-rustc(1)]
Compile a package, and pass extra options to the compiler.

[cargo-rustdoc(1)]
Build a package's documentation, using specified custom flags.

[cargo-test(1)]
Execute unit and integration tests of a package.

Manifest Commands

[cargo-generate-lockfile(1)]
Generate `Cargo.lock` for a project.

[cargo-locate-project(1)]
Print a JSON representation of a `Cargo.toml` file's location.

[cargo-metadata(1)]
Output the resolved dependencies of a package in machine-readable format.

[cargo-pkgid(1)]
Print a fully qualified package specification.

[cargo-tree(1)]
Display a tree visualization of a dependency graph.

[cargo-update(1)]
Update dependencies as recorded in the local lock file.

[cargo-vendor(1)]
Vendor all dependencies locally.

[cargo-verify-project(1)]
Check correctness of crate manifest.

Package Commands

[cargo-init(1)]
Create a new Cargo package in an existing directory.

`cargo-install(1)`
: Build and install a Rust binary.

`cargo-new(1)`
: Create a new Cargo package.

`cargo-search(1)`
: Search packages in crates.io.

`cargo-uninstall(1)`
: Remove a Rust binary.

Publishing Commands

`cargo-login(1)`
: Save an API token from the registry locally.

`cargo-logout(1)`
: Remove an API token from the registry locally.

`cargo-owner(1)`
: Manage the owners of a crate on the registry.

`cargo-package(1)`
: Assemble the local package into a distributable tarball.

`cargo-publish(1)`
: Upload a package to the registry.

`cargo-yank(1)`
: Remove a pushed crate from the index.

General Commands

`cargo-help(1)`
: Display help information about Cargo.

`cargo-version(1)`
: Show version information.

OPTIONS

Special Options

`-V`
`--version`

Print version info and exit. If used with `--verbose`, prints extra information.

`--list`
: List all installed Cargo subcommands. If used with `--verbose`, prints extra information.

`--explain` *code*
: Run `rustc --explain CODE` which will print out a detailed explanation of an error message (for example, `E0004`).

Display Options

`-v`
`--verbose`
: Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
: Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
: Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Manifest Options

`--frozen`
`--locked`
: Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
: Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*
: If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
: Prints help information.

`-Z` *flag*
: Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

FILES

`~/.cargo/`
Default location for Cargo's "home" directory where it stores various files. The location can be changed with the `CARGO_HOME` environment variable.

`$CARGO_HOME/bin/`
Binaries installed by cargo-install(1) will be located here. If using rustup, executables distributed with Rust are also located here.

`$CARGO_HOME/config.toml`
The global configuration file. See the reference for more information about configuration files.

`.cargo/config.toml`
Cargo automatically searches for a file named `.cargo/config.toml` in the current directory, and all parent directories. These configuration files will be merged with the global configuration file.

`$CARGO_HOME/credentials.toml`
Private authentication information for logging in to a registry.

`$CARGO_HOME/registry/`
This directory contains cached downloads of the registry index and any downloaded dependencies.

`$CARGO_HOME/git/`
This directory contains cached downloads of git dependencies.

Please note that the internal structure of the `$CARGO_HOME` directory is not stable yet and may be subject to change.

EXAMPLES

1. Build a local package and all of its dependencies:

```
cargo build
```

2. Build a package with optimizations:

```
cargo build --release
```

3. Run tests for a cross-compiled target:

```
cargo test --target i686-unknown-linux-gnu
```

4. Create a new package that builds an executable:

```
cargo new foobar
```

5. Create a package in the current directory:

```
mkdir foo && cd foo
cargo init .
```

6. Learn about a command's options and usage:

```
cargo help clean
```

BUGS

See https://github.com/rust-lang/cargo/issues for issues.

SEE ALSO

rustc(1), rustdoc(1)

cargo-help(1)

NAME

cargo-help — Get help for a Cargo command

SYNOPSIS

`cargo help` [*subcommand*]

DESCRIPTION

Prints a help message for the given command.

EXAMPLES

1. Get help for a command:

   ```
   cargo help build
   ```

2. Help is also available with the `--help` flag:

   ```
   cargo build --help
   ```

SEE ALSO

cargo(1)

cargo-version(1)

NAME

cargo-version — Show version information

SYNOPSIS

`cargo version` [*options*]

DESCRIPTION

Displays the version of Cargo.

OPTIONS

`-v`
`--verbose`
    Display additional version information.

EXAMPLES

1. Display the version:

   ```
   cargo version
   ```

2. The version is also available via flags:

   ```
   cargo --version
   cargo -V
   ```

3. Display extra version information:

   ```
   cargo -Vv
   ```

SEE ALSO

cargo(1)

Build Commands

- `cargo bench`
- `cargo build`
- `cargo check`
- `cargo clean`
- `cargo doc`
- `cargo fetch`
- `cargo fix`
- `cargo run`
- `cargo rustc`
- `cargo rustdoc`
- `cargo test`
- `cargo report`

cargo-bench(1)

NAME

cargo-bench — Execute benchmarks of a package

SYNOPSIS

`cargo bench` [*options*] [*benchname*] [`--` *bench-options*]

DESCRIPTION

Compile and execute benchmarks.

The benchmark filtering argument *benchname* and all the arguments following the two dashes (`--`) are passed to the benchmark binaries and thus to *libtest* (rustc's built in unit-test and micro-benchmarking framework). If you are passing arguments to both Cargo and the binary, the ones after `--` go to the binary, the ones before go to Cargo. For details about libtest's arguments see the output of `cargo bench -- --help` and check out the rustc book's chapter on how tests work at https://doc.rust-lang.org/rustc/tests/index.html.

As an example, this will run only the benchmark named `foo` (and skip other similarly named benchmarks like `foobar`):

```
cargo bench -- foo --exact
```

Benchmarks are built with the `--test` option to `rustc` which creates a special executable by linking your code with libtest. The executable automatically runs all functions annotated with the `#[bench]` attribute. Cargo passes the `--bench` flag to the test harness to tell it to run only benchmarks.

The libtest harness may be disabled by setting `harness = false` in the target manifest settings, in which case your code will need to provide its own `main` function to handle running benchmarks.

> **Note**: The `#[bench]` attribute is currently unstable and only available on the nightly channel. There are some packages available on crates.io that may help with running benchmarks on the stable channel, such as Criterion.

By default, `cargo bench` uses the `bench` profile, which enables optimizations and disables debugging information. If you need to debug a benchmark, you can use the `--profile=dev` command-line option to switch to the dev profile. You can then run the debug-enabled benchmark within a debugger.

Working directory of benchmarks

The working directory of every benchmark is set to the root directory of the package the benchmark belongs to. Setting the working directory of benchmarks to the package's root directory makes it possible for benchmarks to reliably access the package's files using relative paths, regardless from where `cargo bench` was executed from.

OPTIONS

Benchmark Options

`--no-run`
: Compile, but don't run benchmarks.

`--no-fail-fast`
: Run all benchmarks regardless of failure. Without this flag, Cargo will exit after the first executable fails. The Rust test harness will run all benchmarks within the executable to completion, this flag only applies to the executable as a whole.

Package Selection

By default, when no package selection options are given, the packages selected depend on the selected manifest file (based on the current working directory if `--manifest-path` is not given). If the manifest is the root of a workspace then the workspaces default members are selected, otherwise only the package defined by the manifest will be selected.

The default members of a workspace can be set explicitly with the `workspace.default-members` key in the root manifest. If this is not set, a virtual workspace will include all workspace members (equivalent to passing `--workspace`), and a non-virtual workspace will include only the root crate itself.

`-p` *spec*…
`--package` *spec*…
: Benchmark only the specified packages. See cargo-pkgid(1) for the SPEC format. This flag may be specified multiple times and supports common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally

expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each pattern.

`--workspace`
Benchmark all members in the workspace.

`--all`
Deprecated alias for `--workspace`.

`--exclude` *SPEC…*
Exclude the specified packages. Must be used in conjunction with the `--workspace` flag. This flag may be specified multiple times and supports common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each pattern.

Target Selection

When no target selection options are given, `cargo bench` will build the following targets of the selected packages:

- lib — used to link with binaries and benchmarks
- bins (only if benchmark targets are built and required features are available)
- lib as a benchmark
- bins as benchmarks
- benchmark targets

The default behavior can be changed by setting the `bench` flag for the target in the manifest settings. Setting examples to `bench = true` will build and run the example as a benchmark. Setting targets to `bench = false` will stop them from being benchmarked by default. Target selection options that take a target by name ignore the `bench` flag and will always benchmark the given target.

Binary targets are automatically built if there is an integration test or benchmark being selected to benchmark. This allows an integration test to execute the binary to exercise and test its behavior. The `CARGO_BIN_EXE_<name>` environment variable is set when the integration test is built so that it can use the `env` macro to locate the executable.

Passing target selection flags will benchmark only the specified targets.

Note that `--bin`, `--example`, `--test` and `--bench` flags also support common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each glob pattern.

`--lib`
Benchmark the package's library.

`--bin` *name…*

Benchmark the specified binary. This flag may be specified multiple times and supports common Unix glob patterns.

`--bins`
Benchmark all binary targets.

`--example` *name*…
Benchmark the specified example. This flag may be specified multiple times and supports common Unix glob patterns.

`--examples`
Benchmark all example targets.

`--test` *name*…
Benchmark the specified integration test. This flag may be specified multiple times and supports common Unix glob patterns.

`--tests`
Benchmark all targets in test mode that have the `test = true` manifest flag set. By default this includes the library and binaries built as unittests, and integration tests. Be aware that this will also build any required dependencies, so the lib target may be built twice (once as a unittest, and once as a dependency for binaries, integration tests, etc.). Targets may be enabled or disabled by setting the `test` flag in the manifest settings for the target.

`--bench` *name*…
Benchmark the specified benchmark. This flag may be specified multiple times and supports common Unix glob patterns.

`--benches`
Benchmark all targets in benchmark mode that have the `bench = true` manifest flag set. By default this includes the library and binaries built as benchmarks, and bench targets. Be aware that this will also build any required dependencies, so the lib target may be built twice (once as a benchmark, and once as a dependency for binaries, benchmarks, etc.). Targets may be enabled or disabled by setting the `bench` flag in the manifest settings for the target.

`--all-targets`
Benchmark all targets. This is equivalent to specifying `--lib --bins --tests --benches --examples`.

Feature Selection

The feature flags allow you to control which features are enabled. When no feature options are given, the `default` feature is activated for every selected package.

See the features documentation for more details.

`-F` *features*
`--features` *features*
Space or comma separated list of features to activate. Features of workspace members may be enabled with `package-name/feature-name` syntax. This flag may be specified multiple times, which enables all specified features.

`--all-features`
Activate all available features of all selected packages.

`--no-default-features`
Do not activate the `default` feature of the selected packages.

Compilation Options

`--target` *triple*
Benchmark for the given architecture. The default is the host architecture. The general format of the triple is `<arch><sub>-<vendor>-<sys>-<abi>`. Run `rustc --print target-list` for a list of supported targets. This flag may be specified multiple times.

This may also be specified with the `build.target` config value.

Note that specifying this flag makes Cargo run in a different mode where the target artifacts are placed in a separate directory. See the build cache documentation for more details.

`--profile` *name*
Benchmark with the given profile. See the the reference for more details on profiles.

`--ignore-rust-version`
Benchmark the target even if the selected Rust compiler is older than the required Rust version as configured in the project's `rust-version` field.

`--timings=`*fmts*
Output information how long each compilation takes, and track concurrency information over time. Accepts an optional comma-separated list of output formats; `--timings` without an argument will default to `--timings=html`. Specifying an output format (rather than the default) is unstable and requires `-Zunstable-options`. Valid output formats:

- `html` (unstable, requires `-Zunstable-options`): Write a human-readable file `cargo-timing.html` to the `target/cargo-timings` directory with a report of the compilation. Also write a report to the same directory with a timestamp in the filename if you want to look at older runs. HTML output is suitable for human consumption only, and does not provide machine-readable timing data.
- `json` (unstable, requires `-Zunstable-options`): Emit machine-readable JSON information about timing information.

Output Options

`--target-dir` *directory*
Directory for all generated artifacts and intermediate files. May also be specified with the `CARGO_TARGET_DIR` environment variable, or the `build.target-dir` config value. Defaults to `target` in the root of the workspace.

Display Options

By default the Rust test harness hides output from benchmark execution to keep results readable. Benchmark output can be recovered (e.g., for debugging) by passing `--nocapture` to the benchmark binaries:

```
cargo bench -- --nocapture
```

`-v`
`--verbose`
Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

`--message-format` *fmt*
The output format for diagnostic messages. Can be specified multiple times and consists of comma-separated values. Valid values:

- `human` (default): Display in a human-readable text format. Conflicts with `short` and `json`.
- `short`: Emit shorter, human-readable text messages. Conflicts with `human` and `json`.
- `json`: Emit JSON messages to stdout. See the reference for more details. Conflicts with `human` and `short`.
- `json-diagnostic-short`: Ensure the `rendered` field of JSON messages contains the "short" rendering from rustc. Cannot be used with `human` or `short`.
- `json-diagnostic-rendered-ansi`: Ensure the `rendered` field of JSON messages contains embedded ANSI color codes for respecting rustc's default color scheme. Cannot be used with `human` or `short`.
- `json-render-diagnostics`: Instruct Cargo to not include rustc diagnostics in JSON messages printed, but instead Cargo itself should render the JSON diagnostics coming from rustc. Cargo's own JSON diagnostics and others coming from rustc are still emitted. Cannot be used with `human` or `short`.

Manifest Options

`--manifest-path` *path*
: Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
: Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
: Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*
: If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

Miscellaneous Options

The `--jobs` argument affects the building of the benchmark executable but does not affect how many threads are used when running the benchmarks. The Rust test harness runs benchmarks serially in a single thread.

`-j` *N*
`--jobs` *N*
Number of parallel jobs to run. May also be specified with the `build.jobs` config value. Defaults to the number of logical CPUs. If negative, it sets the maximum number of parallel jobs to the number of logical CPUs plus provided value. Should not be 0.

`--keep-going`
Build as many crates in the dependency graph as possible, rather than aborting the build on the first one that fails to build. Unstable, requires `-Zunstable-options`.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Build and execute all the benchmarks of the current package:

```
cargo bench
```

2. Run only a specific benchmark within a specific benchmark target:

```
cargo bench --bench bench_name -- modname::some_benchmark
```

SEE ALSO

cargo(1), cargo-test(1)

cargo-build(1)

NAME

cargo-build — Compile the current package

SYNOPSIS

`cargo build` [*options*]

DESCRIPTION

Compile local packages and all of their dependencies.

OPTIONS

Package Selection

By default, when no package selection options are given, the packages selected depend on the selected manifest file (based on the current working directory if `--manifest-path` is not given). If the manifest is the root of a workspace then the workspaces default members are selected, otherwise only the package defined by the manifest will be selected.

The default members of a workspace can be set explicitly with the `workspace.default-members` key in the root manifest. If this is not set, a virtual workspace will include all workspace members (equivalent to passing `--workspace`), and a non-virtual workspace will include only the root crate itself.

`-p` *spec*…
`--package` *spec*…
Build only the specified packages. See cargo-pkgid(1) for the SPEC format. This flag may be specified multiple times and supports common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each pattern.

`--workspace`
Build all members in the workspace.

`--all`
: Deprecated alias for `--workspace`.

`--exclude` *SPEC…*
: Exclude the specified packages. Must be used in conjunction with the `--workspace` flag. This flag may be specified multiple times and supports common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each pattern.

Target Selection

When no target selection options are given, `cargo build` will build all binary and library targets of the selected packages. Binaries are skipped if they have `required-features` that are missing.

Binary targets are automatically built if there is an integration test or benchmark being selected to build. This allows an integration test to execute the binary to exercise and test its behavior. The `CARGO_BIN_EXE_<name>` environment variable is set when the integration test is built so that it can use the `env` macro to locate the executable.

Passing target selection flags will build only the specified targets.

Note that `--bin`, `--example`, `--test` and `--bench` flags also support common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each glob pattern.

`--lib`
: Build the package's library.

`--bin` *name…*
: Build the specified binary. This flag may be specified multiple times and supports common Unix glob patterns.

`--bins`
: Build all binary targets.

`--example` *name…*
: Build the specified example. This flag may be specified multiple times and supports common Unix glob patterns.

`--examples`
: Build all example targets.

`--test` *name…*
: Build the specified integration test. This flag may be specified multiple times and supports common Unix glob patterns.

`--tests`
: Build all targets in test mode that have the `test = true` manifest flag set. By default this includes the library and binaries built as unittests, and

integration tests. Be aware that this will also build any required dependencies, so the lib target may be built twice (once as a unittest, and once as a dependency for binaries, integration tests, etc.). Targets may be enabled or disabled by setting the `test` flag in the manifest settings for the target.

`--bench` *name*…
: Build the specified benchmark. This flag may be specified multiple times and supports common Unix glob patterns.

`--benches`
: Build all targets in benchmark mode that have the `bench = true` manifest flag set. By default this includes the library and binaries built as benchmarks, and bench targets. Be aware that this will also build any required dependencies, so the lib target may be built twice (once as a benchmark, and once as a dependency for binaries, benchmarks, etc.). Targets may be enabled or disabled by setting the `bench` flag in the manifest settings for the target.

`--all-targets`
: Build all targets. This is equivalent to specifying `--lib --bins --tests --benches --examples`.

Feature Selection

The feature flags allow you to control which features are enabled. When no feature options are given, the `default` feature is activated for every selected package.

See the features documentation for more details.

`-F` *features*
`--features` *features*
: Space or comma separated list of features to activate. Features of workspace members may be enabled with `package-name/feature-name` syntax. This flag may be specified multiple times, which enables all specified features.

`--all-features`
: Activate all available features of all selected packages.

`--no-default-features`
: Do not activate the `default` feature of the selected packages.

Compilation Options

`--target` *triple*
: Build for the given architecture. The default is the host architecture. The general format of the triple is `<arch><sub>-<vendor>-<sys>-<abi>`. Run `rustc --print target-list` for a list of supported targets. This flag may be specified multiple times.

This may also be specified with the `build.target` config value.

Note that specifying this flag makes Cargo run in a different mode where the target artifacts are placed in a separate directory. See the build cache documentation for more details.

`-r`
`--release`
Build optimized artifacts with the `release` profile. See also the `--profile` option for choosing a specific profile by name.

`--profile` *name*
Build with the given profile. See the the reference for more details on profiles.

`--ignore-rust-version`
Build the target even if the selected Rust compiler is older than the required Rust version as configured in the project's `rust-version` field.

`--timings=`*fmts*
Output information how long each compilation takes, and track concurrency information over time. Accepts an optional comma-separated list of output formats; `--timings` without an argument will default to `--timings=html`. Specifying an output format (rather than the default) is unstable and requires `-Zunstable-options`. Valid output formats:

- `html` (unstable, requires `-Zunstable-options`): Write a human-readable file `cargo-timing.html` to the `target/cargo-timings` directory with a report of the compilation. Also write a report to the same directory with a timestamp in the filename if you want to look at older runs. HTML output is suitable for human consumption only, and does not provide machine-readable timing data.
- `json` (unstable, requires `-Zunstable-options`): Emit machine-readable JSON information about timing information.

Output Options

`--target-dir` *directory*
Directory for all generated artifacts and intermediate files. May also be specified with the `CARGO_TARGET_DIR` environment variable, or the `build.target-dir` config value. Defaults to `target` in the root of the workspace.

`--out-dir` *directory*
Copy final artifacts to this directory.

This option is unstable and available only on the nightly channel and requires the `-Z unstable-options` flag to enable. See https://github.com/rust-lang/cargo/issues/6790 for more information.

Display Options

`-v`
`--verbose`

Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

`--message-format` *fmt*
The output format for diagnostic messages. Can be specified multiple times and consists of comma-separated values. Valid values:

- `human` (default): Display in a human-readable text format. Conflicts with `short` and `json`.
- `short`: Emit shorter, human-readable text messages. Conflicts with `human` and `json`.
- `json`: Emit JSON messages to stdout. See the reference for more details. Conflicts with `human` and `short`.
- `json-diagnostic-short`: Ensure the `rendered` field of JSON messages contains the "short" rendering from rustc. Cannot be used with `human` or `short`.
- `json-diagnostic-rendered-ansi`: Ensure the `rendered` field of JSON messages contains embedded ANSI color codes for respecting rustc's default color scheme. Cannot be used with `human` or `short`.
- `json-render-diagnostics`: Instruct Cargo to not include rustc diagnostics in JSON messages printed, but instead Cargo itself should render the JSON diagnostics coming from rustc. Cargo's own JSON diagnostics and others coming from rustc are still emitted. Cannot be used with `human` or `short`.

`--build-plan`
Outputs a series of JSON messages to stdout that indicate the commands to run the build.

This option is unstable and available only on the nightly channel and requires the `-Z unstable-options` flag to enable. See https://github.com/rust-lang/cargo/issues/5579 for more information.

Manifest Options

`--manifest-path` *path*

Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*
If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
: Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

Miscellaneous Options

`-j` *N*
`--jobs` *N*
: Number of parallel jobs to run. May also be specified with the `build.jobs` config value. Defaults to the number of logical CPUs. If negative, it sets the maximum number of parallel jobs to the number of logical CPUs plus provided value. Should not be 0.

`--keep-going`
: Build as many crates in the dependency graph as possible, rather than aborting the build on the first one that fails to build. Unstable, requires `-Zunstable-options`.

`--future-incompat-report`
: Displays a future-incompat report for any future-incompatible warnings produced during execution of this command

See cargo-report(1)

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Build the local package and all of its dependencies:

```
cargo build
```

2. Build with optimizations:

```
cargo build --release
```

SEE ALSO

cargo(1), cargo-rustc(1)

cargo-check(1)

NAME

cargo-check — Check the current package

SYNOPSIS

`cargo check` [*options*]

DESCRIPTION

Check a local package and all of its dependencies for errors. This will essentially compile the packages without performing the final step of code generation, which is faster than running `cargo build`. The compiler will save metadata files to disk so that future runs will reuse them if the source has not been modified. Some diagnostics and errors are only emitted during code generation, so they inherently won't be reported with `cargo check`.

OPTIONS

Package Selection

By default, when no package selection options are given, the packages selected depend on the selected manifest file (based on the current working directory if `--manifest-path` is not given). If the manifest is the root of a workspace then the workspaces default members are selected, otherwise only the package defined by the manifest will be selected.

The default members of a workspace can be set explicitly with the `workspace.default-members` key in the root manifest. If this is not set, a virtual workspace will include all workspace members (equivalent to passing `--workspace`), and a non-virtual workspace will include only the root crate itself.

`-p` *spec*…
`--package` *spec*…
    Check only the specified packages. See cargo-pkgid(1) for the SPEC format. This flag may be specified multiple times and supports common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob

patterns before Cargo handles them, you must use single quotes or double quotes around each pattern.

`--workspace`
Check all members in the workspace.

`--all`
Deprecated alias for `--workspace`.

`--exclude` *SPEC…*
Exclude the specified packages. Must be used in conjunction with the `--workspace` flag. This flag may be specified multiple times and supports common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each pattern.

Target Selection

When no target selection options are given, `cargo check` will check all binary and library targets of the selected packages. Binaries are skipped if they have `required-features` that are missing.

Passing target selection flags will check only the specified targets.

Note that `--bin`, `--example`, `--test` and `--bench` flags also support common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each glob pattern.

`--lib`
Check the package's library.

`--bin` *name…*
Check the specified binary. This flag may be specified multiple times and supports common Unix glob patterns.

`--bins`
Check all binary targets.

`--example` *name…*
Check the specified example. This flag may be specified multiple times and supports common Unix glob patterns.

`--examples`
Check all example targets.

`--test` *name…*
Check the specified integration test. This flag may be specified multiple times and supports common Unix glob patterns.

`--tests`
Check all targets in test mode that have the `test = true` manifest flag set. By default this includes the library and binaries built as unittests, and integration tests. Be aware that this will also build any required

dependencies, so the lib target may be built twice (once as a unittest, and once as a dependency for binaries, integration tests, etc.). Targets may be enabled or disabled by setting the `test` flag in the manifest settings for the target.

`--bench` *name*…
: Check the specified benchmark. This flag may be specified multiple times and supports common Unix glob patterns.

`--benches`
: Check all targets in benchmark mode that have the `bench = true` manifest flag set. By default this includes the library and binaries built as benchmarks, and bench targets. Be aware that this will also build any required dependencies, so the lib target may be built twice (once as a benchmark, and once as a dependency for binaries, benchmarks, etc.). Targets may be enabled or disabled by setting the `bench` flag in the manifest settings for the target.

`--all-targets`
: Check all targets. This is equivalent to specifying `--lib --bins --tests --benches --examples`.

Feature Selection

The feature flags allow you to control which features are enabled. When no feature options are given, the `default` feature is activated for every selected package.

See the features documentation for more details.

`-F` *features*
`--features` *features*
: Space or comma separated list of features to activate. Features of workspace members may be enabled with `package-name/feature-name` syntax. This flag may be specified multiple times, which enables all specified features.

`--all-features`
: Activate all available features of all selected packages.

`--no-default-features`
: Do not activate the `default` feature of the selected packages.

Compilation Options

`--target` *triple*
: Check for the given architecture. The default is the host architecture. The general format of the triple is `<arch><sub>-<vendor>-<sys>-<abi>`. Run `rustc --print target-list` for a list of supported targets. This flag may be specified multiple times.

This may also be specified with the `build.target` config value.

Note that specifying this flag makes Cargo run in a different mode where the target artifacts are placed in a separate directory. See the build cache documentation for more details.

`-r`
`--release`
Check optimized artifacts with the `release` profile. See also the `--profile` option for choosing a specific profile by name.

`--profile` *name*
Check with the given profile.

As a special case, specifying the `test` profile will also enable checking in test mode which will enable checking tests and enable the `test` cfg option. See rustc tests for more detail.

See the the reference for more details on profiles.

`--ignore-rust-version`
Check the target even if the selected Rust compiler is older than the required Rust version as configured in the project's `rust-version` field.

`--timings=`*fmts*
Output information how long each compilation takes, and track concurrency information over time. Accepts an optional comma-separated list of output formats; `--timings` without an argument will default to `--timings=html`. Specifying an output format (rather than the default) is unstable and requires `-Zunstable-options`. Valid output formats:

- `html` (unstable, requires `-Zunstable-options`): Write a human-readable file `cargo-timing.html` to the `target/cargo-timings` directory with a report of the compilation. Also write a report to the same directory with a timestamp in the filename if you want to look at older runs. HTML output is suitable for human consumption only, and does not provide machine-readable timing data.
- `json` (unstable, requires `-Zunstable-options`): Emit machine-readable JSON information about timing information.

Output Options

`--target-dir` *directory*
Directory for all generated artifacts and intermediate files. May also be specified with the `CARGO_TARGET_DIR` environment variable, or the `build.target-dir` config value. Defaults to `target` in the root of the workspace.

Display Options

`-v`
`--verbose`
Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`

`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

`--message-format` *fmt*
The output format for diagnostic messages. Can be specified multiple times and consists of comma-separated values. Valid values:

- `human` (default): Display in a human-readable text format. Conflicts with `short` and `json`.
- `short`: Emit shorter, human-readable text messages. Conflicts with `human` and `json`.
- `json`: Emit JSON messages to stdout. See the reference for more details. Conflicts with `human` and `short`.
- `json-diagnostic-short`: Ensure the `rendered` field of JSON messages contains the "short" rendering from rustc. Cannot be used with `human` or `short`.
- `json-diagnostic-rendered-ansi`: Ensure the `rendered` field of JSON messages contains embedded ANSI color codes for respecting rustc's default color scheme. Cannot be used with `human` or `short`.
- `json-render-diagnostics`: Instruct Cargo to not include rustc diagnostics in JSON messages printed, but instead Cargo itself should render the JSON diagnostics coming from rustc. Cargo's own JSON diagnostics and others coming from rustc are still emitted. Cannot be used with `human` or `short`.

Manifest Options

`--manifest-path` *path*
Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`

Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*
: If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
: Prints help information.

`-Z` *flag*
: Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

Miscellaneous Options

`-j` *N*
`--jobs` *N*
: Number of parallel jobs to run. May also be specified with the `build.jobs` config value. Defaults to the number of logical CPUs. If negative, it sets the maximum number of parallel jobs to the number of logical CPUs plus provided value. Should not be 0.

`--keep-going`
: Build as many crates in the dependency graph as possible, rather than aborting the build on the first one that fails to build. Unstable, requires `-Zunstable-options`.

`--future-incompat-report`
: Displays a future-incompat report for any future-incompatible warnings produced during execution of this command

  See cargo-report(1)

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Check the local package for errors:

```
cargo check
```

2. Check all targets, including unit tests:

```
cargo check --all-targets --profile=test
```

SEE ALSO

cargo(1), cargo-build(1)

cargo-clean(1)

NAME

cargo-clean — Remove generated artifacts

SYNOPSIS

`cargo clean` [*options*]

DESCRIPTION

Remove artifacts from the target directory that Cargo has generated in the past.

With no options, `cargo clean` will delete the entire target directory.

OPTIONS

Package Selection

When no packages are selected, all packages and all dependencies in the workspace are cleaned.

`-p` *spec*…
`--package` *spec*…
: Clean only the specified packages. This flag may be specified multiple times. See cargo-pkgid(1) for the SPEC format.

Clean Options

`--doc`
: This option will cause `cargo clean` to remove only the `doc` directory in the target directory.

`--release`
: Remove all artifacts in the `release` directory.

`--profile` *name*
: Remove all artifacts in the directory with the given profile name.

`--target-dir` *directory*
Directory for all generated artifacts and intermediate files. May also be specified with the `CARGO_TARGET_DIR` environment variable, or the `build.target-dir` config value. Defaults to `target` in the root of the workspace.

`--target` *triple*
Clean for the given architecture. The default is the host architecture. The general format of the triple is `<arch><sub>-<vendor>-<sys>-<abi>`. Run `rustc --print target-list` for a list of supported targets. This flag may be specified multiple times.

This may also be specified with the `build.target` config value.

Note that specifying this flag makes Cargo run in a different mode where the target artifacts are placed in a separate directory. See the build cache documentation for more details.

Display Options

`-v`
`--verbose`
Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Manifest Options

`--manifest-path` *path*
Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error.

The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
: Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*
: If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
: Prints help information.

`-Z` *flag*
: Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Remove the entire target directory:

```
cargo clean
```

2. Remove only the release artifacts:

```
cargo clean --release
```

SEE ALSO

cargo(1), cargo-build(1)

cargo-doc(1)

NAME

cargo-doc — Build a package's documentation

SYNOPSIS

`cargo doc` [*options*]

DESCRIPTION

Build the documentation for the local package and all dependencies. The output is placed in `target/doc` in rustdoc's usual format.

OPTIONS

Documentation Options

`--open`
: Open the docs in a browser after building them. This will use your default browser unless you define another one in the `BROWSER` environment variable or use the `doc.browser` configuration option.

`--no-deps`
: Do not build documentation for dependencies.

`--document-private-items`
: Include non-public items in the documentation. This will be enabled by default if documenting a binary target.

Package Selection

By default, when no package selection options are given, the packages selected depend on the selected manifest file (based on the current working directory if `--manifest-path` is not given). If the manifest is the root of a workspace then the workspaces default members are selected, otherwise only the package defined by the manifest will be selected.

The default members of a workspace can be set explicitly with the `workspace.default-members` key in the root manifest. If this is not set, a virtual workspace will include all workspace members (equivalent to passing `--workspace`), and a non-virtual workspace will include only the root crate itself.

`-p` *spec…*
`--package` *spec…*
: Document only the specified packages. See cargo-pkgid(1) for the SPEC format. This flag may be specified multiple times and supports common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each pattern.

`--workspace`
: Document all members in the workspace.

`--all`
: Deprecated alias for `--workspace`.

`--exclude` *SPEC…*
: Exclude the specified packages. Must be used in conjunction with the `--workspace` flag. This flag may be specified multiple times and supports common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each pattern.

Target Selection

When no target selection options are given, `cargo doc` will document all binary and library targets of the selected package. The binary will be skipped if its name is the same as the lib target. Binaries are skipped if they have `required-features` that are missing.

The default behavior can be changed by setting `doc = false` for the target in the manifest settings. Using target selection options will ignore the `doc` flag and will always document the given target.

`--lib`
: Document the package's library.

`--bin` *name…*
: Document the specified binary. This flag may be specified multiple times and supports common Unix glob patterns.

`--bins`
: Document all binary targets.

`--example` *name…*
: Document the specified example. This flag may be specified multiple times and supports common Unix glob patterns.

`--examples`
: Document all example targets.

Feature Selection

The feature flags allow you to control which features are enabled. When no feature options are given, the `default` feature is activated for every selected package.

See the features documentation for more details.

`-F` *features*
`--features` *features*
: Space or comma separated list of features to activate. Features of workspace members may be enabled with `package-name/feature-name` syntax. This flag may be specified multiple times, which enables all specified features.

`--all-features`
: Activate all available features of all selected packages.

`--no-default-features`
: Do not activate the `default` feature of the selected packages.

Compilation Options

`--target` *triple*
: Document for the given architecture. The default is the host architecture. The general format of the triple is `<arch><sub>-<vendor>-<sys>-<abi>`. Run `rustc --print target-list` for a list of supported targets. This flag may be specified multiple times.

This may also be specified with the `build.target` config value.

Note that specifying this flag makes Cargo run in a different mode where the target artifacts are placed in a separate directory. See the build cache documentation for more details.

`-r`
`--release`
: Document optimized artifacts with the `release` profile. See also the `--profile` option for choosing a specific profile by name.

`--profile` *name*
: Document with the given profile. See the the reference for more details on profiles.

`--ignore-rust-version`
: Document the target even if the selected Rust compiler is older than the required Rust version as configured in the project's `rust-version` field.

`--timings=`*fmts*
: Output information how long each compilation takes, and track concurrency information over time. Accepts an optional comma-separated list of output formats; `--timings` without an argument will default to `--timings=html`. Specifying an output format (rather than the default) is unstable and requires `-Zunstable-options`. Valid output formats:

- `html` (unstable, requires `-Zunstable-options`): Write a human-readable file `cargo-timing.html` to the `target/cargo-timings` directory with a report of the compilation. Also write a report to the same directory with a timestamp in the filename if you want to look at older runs. HTML output is suitable for human consumption only, and does not provide machine-readable timing data.
- `json` (unstable, requires `-Zunstable-options`): Emit machine-readable JSON information about timing information.

Output Options

`--target-dir` *directory*
Directory for all generated artifacts and intermediate files. May also be specified with the `CARGO_TARGET_DIR` environment variable, or the `build.target-dir` config value. Defaults to `target` in the root of the workspace.

Display Options

`-v`
`--verbose`
Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

`--message-format` *fmt*
The output format for diagnostic messages. Can be specified multiple times and consists of comma-separated values. Valid values:

- `human` (default): Display in a human-readable text format. Conflicts with `short` and `json`.
- `short`: Emit shorter, human-readable text messages. Conflicts with `human` and `json`.
- `json`: Emit JSON messages to stdout. See the reference for more details. Conflicts with `human` and `short`.

- `json-diagnostic-short`: Ensure the `rendered` field of JSON messages contains the "short" rendering from rustc. Cannot be used with `human` or `short`.
- `json-diagnostic-rendered-ansi`: Ensure the `rendered` field of JSON messages contains embedded ANSI color codes for respecting rustc's default color scheme. Cannot be used with `human` or `short`.
- `json-render-diagnostics`: Instruct Cargo to not include rustc diagnostics in JSON messages printed, but instead Cargo itself should render the JSON diagnostics coming from rustc. Cargo's own JSON diagnostics and others coming from rustc are still emitted. Cannot be used with `human` or `short`.

Manifest Options

`--manifest-path` *path*
: Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
: Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

  These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
: Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

  Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

  May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*
: If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may

be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
: Prints help information.

`-Z` *flag*
: Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

Miscellaneous Options

`-j` *N*
`--jobs` *N*
: Number of parallel jobs to run. May also be specified with the `build.jobs` config value. Defaults to the number of logical CPUs. If negative, it sets the maximum number of parallel jobs to the number of logical CPUs plus provided value. Should not be 0.

`--keep-going`
: Build as many crates in the dependency graph as possible, rather than aborting the build on the first one that fails to build. Unstable, requires `-Zunstable-options`.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Build the local package documentation and its dependencies and output to `target/doc`.

   ```
   cargo doc
   ```

SEE ALSO

cargo(1), cargo-rustdoc(1), rustdoc(1)

cargo-fetch(1)

NAME

cargo-fetch — Fetch dependencies of a package from the network

SYNOPSIS

`cargo fetch` [*options*]

DESCRIPTION

If a `Cargo.lock` file is available, this command will ensure that all of the git dependencies and/or registry dependencies are downloaded and locally available. Subsequent Cargo commands will be able to run offline after a `cargo fetch` unless the lock file changes.

If the lock file is not available, then this command will generate the lock file before fetching the dependencies.

If `--target` is not specified, then all target dependencies are fetched.

See also the cargo-prefetch plugin which adds a command to download popular crates. This may be useful if you plan to use Cargo without a network with the `--offline` flag.

OPTIONS

Fetch options

`--target` *triple*

Fetch for the given architecture. The default is all architectures. The general format of the triple is `<arch><sub>-<vendor>-<sys>-<abi>`. Run `rustc --print target-list` for a list of supported targets. This flag may be specified multiple times.

This may also be specified with the `build.target` config value.

Note that specifying this flag makes Cargo run in a different mode where the target artifacts are placed in a separate directory. See the build cache documentation for more details.

Display Options

`-v`
`--verbose`
Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Manifest Options

`--manifest-path` *path*
Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*
: If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
: Prints help information.

`-Z` *flag*
: Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Fetch all dependencies:

```
cargo fetch
```

SEE ALSO

cargo(1), cargo-update(1), cargo-generate-lockfile(1)

cargo-fix(1)

NAME

cargo-fix — Automatically fix lint warnings reported by rustc

SYNOPSIS

`cargo fix` [*options*]

DESCRIPTION

This Cargo subcommand will automatically take rustc's suggestions from diagnostics like warnings and apply them to your source code. This is intended to help automate tasks that rustc itself already knows how to tell you to fix!

Executing `cargo fix` will under the hood execute cargo-check(1). Any warnings applicable to your crate will be automatically fixed (if possible) and all remaining warnings will be displayed when the check process is finished. For example if you'd like to apply all fixes to the current package, you can run:

```
cargo fix
```

which behaves the same as `cargo check --all-targets`.

`cargo fix` is only capable of fixing code that is normally compiled with `cargo check`. If code is conditionally enabled with optional features, you will need to enable those features for that code to be analyzed:

```
cargo fix --features foo
```

Similarly, other `cfg` expressions like platform-specific code will need to pass `--target` to fix code for the given target.

```
cargo fix --target x86_64-pc-windows-gnu
```

If you encounter any problems with `cargo fix` or otherwise have any questions or feature requests please don't hesitate to file an issue at https://github.com/rust-lang/cargo.

Edition migration

The `cargo fix` subcommand can also be used to migrate a package from one edition to the next. The general procedure is:

1. Run `cargo fix --edition`. Consider also using the `--all-features` flag if your project has multiple features. You may also want to run `cargo fix --edition` multiple times with different `--target` flags if your project has platform-specific code gated by `cfg` attributes.
2. Modify `Cargo.toml` to set the edition field to the new edition.
3. Run your project tests to verify that everything still works. If new warnings are issued, you may want to consider running `cargo fix` again (without the `--edition` flag) to apply any suggestions given by the compiler.

And hopefully that's it! Just keep in mind of the caveats mentioned above that `cargo fix` cannot update code for inactive features or `cfg` expressions. Also, in some rare cases the compiler is unable to automatically migrate all code to the new edition, and this may require manual changes after building with the new edition.

OPTIONS

Fix options

`--broken-code`
: Fix code even if it already has compiler errors. This is useful if `cargo fix` fails to apply the changes. It will apply the changes and leave the broken code in the working directory for you to inspect and manually fix.

`--edition`
: Apply changes that will update the code to the next edition. This will not update the edition in the `Cargo.toml` manifest, which must be updated manually after `cargo fix --edition` has finished.

`--edition-idioms`
: Apply suggestions that will update code to the preferred style for the current edition.

`--allow-no-vcs`
: Fix code even if a VCS was not detected.

`--allow-dirty`
: Fix code even if the working directory has changes.

`--allow-staged`
: Fix code even if the working directory has staged changes.

Package Selection

By default, when no package selection options are given, the packages selected depend on the selected manifest file (based on the current working directory if `--manifest-path` is not given). If the manifest is the root of a workspace then the workspaces default members are selected, otherwise only the package defined by the manifest will be selected.

The default members of a workspace can be set explicitly with the `workspace.default-members` key in the root manifest. If this is not set, a virtual workspace will include all workspace members (equivalent to passing `--workspace`), and a non-virtual workspace will include only the root crate itself.

`-p` *spec…*
`--package` *spec…*
Fix only the specified packages. See cargo-pkgid(1) for the SPEC format. This flag may be specified multiple times and supports common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each pattern.

`--workspace`
Fix all members in the workspace.

`--all`
Deprecated alias for `--workspace`.

`--exclude` *SPEC…*
Exclude the specified packages. Must be used in conjunction with the `--workspace` flag. This flag may be specified multiple times and supports common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each pattern.

Target Selection

When no target selection options are given, `cargo fix` will fix all targets (`--all-targets` implied). Binaries are skipped if they have `required-features` that are missing.

Passing target selection flags will fix only the specified targets.

Note that `--bin`, `--example`, `--test` and `--bench` flags also support common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each glob pattern.

`--lib`
Fix the package's library.

`--bin` *name…*

Fix the specified binary. This flag may be specified multiple times and supports common Unix glob patterns.

`--bins`
: Fix all binary targets.

`--example` *name*…
: Fix the specified example. This flag may be specified multiple times and supports common Unix glob patterns.

`--examples`
: Fix all example targets.

`--test` *name*…
: Fix the specified integration test. This flag may be specified multiple times and supports common Unix glob patterns.

`--tests`
: Fix all targets in test mode that have the `test = true` manifest flag set. By default this includes the library and binaries built as unittests, and integration tests. Be aware that this will also build any required dependencies, so the lib target may be built twice (once as a unittest, and once as a dependency for binaries, integration tests, etc.). Targets may be enabled or disabled by setting the `test` flag in the manifest settings for the target.

`--bench` *name*…
: Fix the specified benchmark. This flag may be specified multiple times and supports common Unix glob patterns.

`--benches`
: Fix all targets in benchmark mode that have the `bench = true` manifest flag set. By default this includes the library and binaries built as benchmarks, and bench targets. Be aware that this will also build any required dependencies, so the lib target may be built twice (once as a benchmark, and once as a dependency for binaries, benchmarks, etc.). Targets may be enabled or disabled by setting the `bench` flag in the manifest settings for the target.

`--all-targets`
: Fix all targets. This is equivalent to specifying `--lib --bins --tests --benches --examples`.

Feature Selection

The feature flags allow you to control which features are enabled. When no feature options are given, the `default` feature is activated for every selected package.

See the features documentation for more details.

`-F` *features*
`--features` *features*
: Space or comma separated list of features to activate. Features of workspace members may be enabled with `package-name/feature-name` syntax. This flag may be specified multiple times, which enables all specified features.

`--all-features`
Activate all available features of all selected packages.

`--no-default-features`
Do not activate the `default` feature of the selected packages.

Compilation Options

`--target` *triple*
Fix for the given architecture. The default is the host architecture. The general format of the triple is `<arch><sub>-<vendor>-<sys>-<abi>`. Run `rustc --print target-list` for a list of supported targets. This flag may be specified multiple times.

This may also be specified with the `build.target` config value.

Note that specifying this flag makes Cargo run in a different mode where the target artifacts are placed in a separate directory. See the build cache documentation for more details.

`-r`
`--release`
Fix optimized artifacts with the `release` profile. See also the `--profile` option for choosing a specific profile by name.

`--profile` *name*
Fix with the given profile.

As a special case, specifying the `test` profile will also enable checking in test mode which will enable checking tests and enable the `test` cfg option. See rustc tests for more detail.

See the the reference for more details on profiles.

`--ignore-rust-version`
Fix the target even if the selected Rust compiler is older than the required Rust version as configured in the project's `rust-version` field.

`--timings=`*fmts*
Output information how long each compilation takes, and track concurrency information over time. Accepts an optional comma-separated list of output formats; `--timings` without an argument will default to `--timings=html`. Specifying an output format (rather than the default) is unstable and requires `-Zunstable-options`. Valid output formats:

- `html` (unstable, requires `-Zunstable-options`): Write a human-readable file `cargo-timing.html` to the `target/cargo-timings` directory with a report of the compilation. Also write a report to the same directory with a timestamp in the filename if you want to look at older runs. HTML output is suitable for human consumption only, and does not provide machine-readable timing data.
- `json` (unstable, requires `-Zunstable-options`): Emit machine-readable JSON information about timing information.

Output Options

`--target-dir` *directory*
: Directory for all generated artifacts and intermediate files. May also be specified with the `CARGO_TARGET_DIR` environment variable, or the `build.target-dir` config value. Defaults to `target` in the root of the workspace.

Display Options

`-v`
`--verbose`
: Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
: Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
: Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

`--message-format` *fmt*
: The output format for diagnostic messages. Can be specified multiple times and consists of comma-separated values. Valid values:

- `human` (default): Display in a human-readable text format. Conflicts with `short` and `json`.
- `short`: Emit shorter, human-readable text messages. Conflicts with `human` and `json`.
- `json`: Emit JSON messages to stdout. See the reference for more details. Conflicts with `human` and `short`.
- `json-diagnostic-short`: Ensure the `rendered` field of JSON messages contains the "short" rendering from rustc. Cannot be used with `human` or `short`.
- `json-diagnostic-rendered-ansi`: Ensure the `rendered` field of JSON messages contains embedded ANSI color codes for respecting rustc's default color scheme. Cannot be used with `human` or `short`.
- `json-render-diagnostics`: Instruct Cargo to not include rustc diagnostics in JSON messages printed, but instead Cargo itself should render the JSON diagnostics coming from rustc. Cargo's own JSON diagnostics and others coming from rustc are still emitted. Cannot be used with `human` or `short`.

Manifest Options

`--manifest-path` *path*
: Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
: Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

  These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
: Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

  Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

  May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*
: If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

  This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

Miscellaneous Options

`-j` *N*
`--jobs` *N*
Number of parallel jobs to run. May also be specified with the `build.jobs` config value. Defaults to the number of logical CPUs. If negative, it sets the maximum number of parallel jobs to the number of logical CPUs plus provided value. Should not be 0.

`--keep-going`
Build as many crates in the dependency graph as possible, rather than aborting the build on the first one that fails to build. Unstable, requires `-Zunstable-options`.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Apply compiler suggestions to the local package:

```
cargo fix
```

2. Update a package to prepare it for the next edition:

```
cargo fix --edition
```

3. Apply suggested idioms for the current edition:

```
cargo fix --edition-idioms
```

SEE ALSO

cargo(1), cargo-check(1)

cargo-run(1)

NAME

cargo-run — Run the current package

SYNOPSIS

`cargo run` [*options*] [`--` *args*]

DESCRIPTION

Run a binary or example of the local package.

All the arguments following the two dashes (`--`) are passed to the binary to run. If you're passing arguments to both Cargo and the binary, the ones after `--` go to the binary, the ones before go to Cargo.

Unlike cargo-test(1) and cargo-bench(1), `cargo run` sets the working directory of the binary executed to the current working directory, same as if it was executed in the shell directly.

OPTIONS

Package Selection

By default, the package in the current working directory is selected. The `-p` flag can be used to choose a different package in a workspace.

`-p` *spec*
`--package` *spec*
The package to run. See cargo-pkgid(1) for the SPEC format.

Target Selection

When no target selection options are given, `cargo run` will run the binary target. If there are multiple binary targets, you must pass a target flag to choose one. Or, the `default-run` field may be specified in the `[package]` section of `Cargo.toml` to choose the name of the binary to run by default.

`--bin` *name*
: Run the specified binary.

`--example` *name*
: Run the specified example.

Feature Selection

The feature flags allow you to control which features are enabled. When no feature options are given, the `default` feature is activated for every selected package.

See the features documentation for more details.

`-F` *features*
`--features` *features*
: Space or comma separated list of features to activate. Features of workspace members may be enabled with `package-name/feature-name` syntax. This flag may be specified multiple times, which enables all specified features.

`--all-features`
: Activate all available features of all selected packages.

`--no-default-features`
: Do not activate the `default` feature of the selected packages.

Compilation Options

`--target` *triple*
: Run for the given architecture. The default is the host architecture. The general format of the triple is `<arch><sub>-<vendor>-<sys>-<abi>`. Run `rustc --print target-list` for a list of supported targets.

This may also be specified with the `build.target` config value.

Note that specifying this flag makes Cargo run in a different mode where the target artifacts are placed in a separate directory. See the build cache documentation for more details.

`-r`
`--release`
: Run optimized artifacts with the `release` profile. See also the `--profile` option for choosing a specific profile by name.

`--profile` *name*
: Run with the given profile. See the the reference for more details on profiles.

`--ignore-rust-version`
: Run the target even if the selected Rust compiler is older than the required Rust version as configured in the project's `rust-version` field.

`--timings=`*fmts*
: Output information how long each compilation takes, and track concurrency information over time. Accepts an optional comma-separated list of output formats; `--timings` without an argument will default to `--timings=html`. Specifying an output format (rather than the default) is unstable and requires `-Zunstable-options`. Valid output formats:

- `html` (unstable, requires `-Zunstable-options`): Write a human-readable file `cargo-timing.html` to the `target/cargo-timings` directory with a report of the compilation. Also write a report to the same directory with a timestamp in the filename if you want to look at older runs. HTML output is suitable for human consumption only, and does not provide machine-readable timing data.
- `json` (unstable, requires `-Zunstable-options`): Emit machine-readable JSON information about timing information.

Output Options

`--target-dir` *directory*
: Directory for all generated artifacts and intermediate files. May also be specified with the `CARGO_TARGET_DIR` environment variable, or the `build.target-dir` config value. Defaults to `target` in the root of the workspace.

Display Options

`-v`
`--verbose`
: Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
: Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
: Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

`--message-format` *fmt*
: The output format for diagnostic messages. Can be specified multiple times and consists of comma-separated values. Valid values:

- `human` (default): Display in a human-readable text format. Conflicts with `short` and `json`.
- `short`: Emit shorter, human-readable text messages. Conflicts with `human` and `json`.
- `json`: Emit JSON messages to stdout. See the reference for more details. Conflicts with `human` and `short`.
- `json-diagnostic-short`: Ensure the `rendered` field of JSON messages contains the "short" rendering from rustc. Cannot be used with `human` or `short`.
- `json-diagnostic-rendered-ansi`: Ensure the `rendered` field of JSON messages contains embedded ANSI color codes for respecting rustc's default color scheme. Cannot be used with `human` or `short`.
- `json-render-diagnostics`: Instruct Cargo to not include rustc diagnostics in JSON messages printed, but instead Cargo itself should render the JSON diagnostics coming from rustc. Cargo's own JSON diagnostics and others coming from rustc are still emitted. Cannot be used with `human` or `short`.

Manifest Options

`--manifest-path` *path*
: Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
: Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

  These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
: Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

  Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

  May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*

If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

  This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
: Prints help information.

`-Z` *flag*
: Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

Miscellaneous Options

`-j` *N*
`--jobs` *N*
: Number of parallel jobs to run. May also be specified with the `build.jobs` config value. Defaults to the number of logical CPUs. If negative, it sets the maximum number of parallel jobs to the number of logical CPUs plus provided value. Should not be 0.

`--keep-going`
: Build as many crates in the dependency graph as possible, rather than aborting the build on the first one that fails to build. Unstable, requires `-Zunstable-options`.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Build the local package and run its main target (assuming only one binary):

   ```
   cargo run
   ```

2. Run an example with extra arguments:

   ```
   cargo run --example exname -- --exoption exarg1 exarg2
   ```

SEE ALSO

cargo(1), cargo-build(1)

cargo-rustc(1)

NAME

cargo-rustc — Compile the current package, and pass extra options to the compiler

SYNOPSIS

`cargo rustc` [*options*] [`--` *args*]

DESCRIPTION

The specified target for the current package (or package specified by `-p` if provided) will be compiled along with all of its dependencies. The specified *args* will all be passed to the final compiler invocation, not any of the dependencies. Note that the compiler will still unconditionally receive arguments such as `-L`, `--extern`, and `--crate-type`, and the specified *args* will simply be added to the compiler invocation.

See https://doc.rust-lang.org/rustc/index.html for documentation on rustc flags.

This command requires that only one target is being compiled when additional arguments are provided. If more than one target is available for the current package the filters of `--lib`, `--bin`, etc, must be used to select which target is compiled.

To pass flags to all compiler processes spawned by Cargo, use the `RUSTFLAGS` environment variable or the `build.rustflags` config value.

OPTIONS

Package Selection

By default, the package in the current working directory is selected. The `-p` flag can be used to choose a different package in a workspace.

`-p` *spec*
`--package` *spec*
    The package to build. See cargo-pkgid(1) for the SPEC format.

Target Selection

When no target selection options are given, `cargo rustc` will build all binary and library targets of the selected package.

Binary targets are automatically built if there is an integration test or benchmark being selected to build. This allows an integration test to execute the binary to exercise and test its behavior. The `CARGO_BIN_EXE_<name>` environment variable is set when the integration test is built so that it can use the `env` macro to locate the executable.

Passing target selection flags will build only the specified targets.

Note that `--bin`, `--example`, `--test` and `--bench` flags also support common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each glob pattern.

`--lib`
: Build the package's library.

`--bin` *name*…
: Build the specified binary. This flag may be specified multiple times and supports common Unix glob patterns.

`--bins`
: Build all binary targets.

`--example` *name*…
: Build the specified example. This flag may be specified multiple times and supports common Unix glob patterns.

`--examples`
: Build all example targets.

`--test` *name*…
: Build the specified integration test. This flag may be specified multiple times and supports common Unix glob patterns.

`--tests`
: Build all targets in test mode that have the `test = true` manifest flag set. By default this includes the library and binaries built as unittests, and integration tests. Be aware that this will also build any required dependencies, so the lib target may be built twice (once as a unittest, and once as a dependency for binaries, integration tests, etc.). Targets may be enabled or disabled by setting the `test` flag in the manifest settings for the target.

`--bench` *name*…
: Build the specified benchmark. This flag may be specified multiple times and supports common Unix glob patterns.

`--benches`
: Build all targets in benchmark mode that have the `bench = true` manifest flag set. By default this includes the library and binaries built as benchmarks, and

bench targets. Be aware that this will also build any required dependencies, so the lib target may be built twice (once as a benchmark, and once as a dependency for binaries, benchmarks, etc.). Targets may be enabled or disabled by setting the `bench` flag in the manifest settings for the target.

`--all-targets`
Build all targets. This is equivalent to specifying `--lib --bins --tests --benches --examples`.

Feature Selection

The feature flags allow you to control which features are enabled. When no feature options are given, the `default` feature is activated for every selected package.

See the features documentation for more details.

`-F` *features*
`--features` *features*
Space or comma separated list of features to activate. Features of workspace members may be enabled with `package-name/feature-name` syntax. This flag may be specified multiple times, which enables all specified features.

`--all-features`
Activate all available features of all selected packages.

`--no-default-features`
Do not activate the `default` feature of the selected packages.

Compilation Options

`--target` *triple*
Build for the given architecture. The default is the host architecture. The general format of the triple is `<arch><sub>-<vendor>-<sys>-<abi>`. Run `rustc --print target-list` for a list of supported targets. This flag may be specified multiple times.

This may also be specified with the `build.target` config value.

Note that specifying this flag makes Cargo run in a different mode where the target artifacts are placed in a separate directory. See the build cache documentation for more details.

`-r`
`--release`
Build optimized artifacts with the `release` profile. See also the `--profile` option for choosing a specific profile by name.

`--profile` *name*
Build with the given profile.

The `rustc` subcommand will treat the following named profiles with special behaviors:

- `check` — Builds in the same way as the cargo-check(1) command with the `dev` profile.
- `test` — Builds in the same way as the cargo-test(1) command, enabling building in test mode which will enable tests and enable the `test` cfg option. See rustc tests for more detail.
- `bench` — Builds in the same was as the cargo-bench(1) command, similar to the `test` profile.

See the the reference for more details on profiles.

`--ignore-rust-version`
Build the target even if the selected Rust compiler is older than the required Rust version as configured in the project's `rust-version` field.

`--timings=`*fmts*
Output information how long each compilation takes, and track concurrency information over time. Accepts an optional comma-separated list of output formats; `--timings` without an argument will default to `--timings=html`. Specifying an output format (rather than the default) is unstable and requires `-Zunstable-options`. Valid output formats:

- `html` (unstable, requires `-Zunstable-options`): Write a human-readable file `cargo-timing.html` to the `target/cargo-timings` directory with a report of the compilation. Also write a report to the same directory with a timestamp in the filename if you want to look at older runs. HTML output is suitable for human consumption only, and does not provide machine-readable timing data.
- `json` (unstable, requires `-Zunstable-options`): Emit machine-readable JSON information about timing information.

`--crate-type` *crate-type*
Build for the given crate type. This flag accepts a comma-separated list of 1 or more crate types, of which the allowed values are the same as `crate-type` field in the manifest for configuring a Cargo target. See `crate-type` field for possible values.

If the manifest contains a list, and `--crate-type` is provided, the command-line argument value will override what is in the manifest.

This flag only works when building a `lib` or `example` library target.

Output Options

`--target-dir` *directory*
Directory for all generated artifacts and intermediate files. May also be specified with the `CARGO_TARGET_DIR` environment variable, or the `build.target-dir` config value. Defaults to `target` in the root of the workspace.

Display Options

`-v`

`--verbose`
: Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
: Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
: Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

`--message-format` *fmt*
: The output format for diagnostic messages. Can be specified multiple times and consists of comma-separated values. Valid values:

- `human` (default): Display in a human-readable text format. Conflicts with `short` and `json`.
- `short`: Emit shorter, human-readable text messages. Conflicts with `human` and `json`.
- `json`: Emit JSON messages to stdout. See the reference for more details. Conflicts with `human` and `short`.
- `json-diagnostic-short`: Ensure the `rendered` field of JSON messages contains the "short" rendering from rustc. Cannot be used with `human` or `short`.
- `json-diagnostic-rendered-ansi`: Ensure the `rendered` field of JSON messages contains embedded ANSI color codes for respecting rustc's default color scheme. Cannot be used with `human` or `short`.
- `json-render-diagnostics`: Instruct Cargo to not include rustc diagnostics in JSON messages printed, but instead Cargo itself should render the JSON diagnostics coming from rustc. Cargo's own JSON diagnostics and others coming from rustc are still emitted. Cannot be used with `human` or `short`.

Manifest Options

`--manifest-path` *path*
: Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
: Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error.

The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
: Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*
: If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
: Prints help information.

`-Z` *flag*
: Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

Miscellaneous Options

`-j` *N*
`--jobs` *N*
Number of parallel jobs to run. May also be specified with the `build.jobs` config value. Defaults to the number of logical CPUs. If negative, it sets the maximum number of parallel jobs to the number of logical CPUs plus provided value. Should not be 0.

`--keep-going`
Build as many crates in the dependency graph as possible, rather than aborting the build on the first one that fails to build. Unstable, requires `-Zunstable-options`.

`--future-incompat-report`
Displays a future-incompat report for any future-incompatible warnings produced during execution of this command

See cargo-report(1)

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Check if your package (not including dependencies) uses unsafe code:

```
cargo rustc --lib -- -D unsafe-code
```

2. Try an experimental flag on the nightly compiler, such as this which prints the size of every type:

```
cargo rustc --lib -- -Z print-type-sizes
```

3. Override `crate-type` field in Cargo.toml with command-line option:

```
cargo rustc --lib --crate-type lib,cdylib
```

SEE ALSO

cargo(1), cargo-build(1), rustc(1)

cargo-rustdoc(1)

NAME

cargo-rustdoc — Build a package's documentation, using specified custom flags

SYNOPSIS

`cargo rustdoc` [*options*] [`--` *args*]

DESCRIPTION

The specified target for the current package (or package specified by `-p` if provided) will be documented with the specified *args* being passed to the final rustdoc invocation. Dependencies will not be documented as part of this command. Note that rustdoc will still unconditionally receive arguments such as `-L`, `--extern`, and `--crate-type`, and the specified *args* will simply be added to the rustdoc invocation.

See https://doc.rust-lang.org/rustdoc/index.html for documentation on rustdoc flags.

This command requires that only one target is being compiled when additional arguments are provided. If more than one target is available for the current package the filters of `--lib`, `--bin`, etc, must be used to select which target is compiled.

To pass flags to all rustdoc processes spawned by Cargo, use the `RUSTDOCFLAGS` environment variable or the `build.rustdocflags` config value.

OPTIONS

Documentation Options

`--open`
: Open the docs in a browser after building them. This will use your default browser unless you define another one in the `BROWSER` environment variable or use the `doc.browser` configuration option.

Package Selection

By default, the package in the current working directory is selected. The `-p` flag can be used to choose a different package in a workspace.

`-p` *spec*
`--package` *spec*
The package to document. See cargo-pkgid(1) for the SPEC format.

Target Selection

When no target selection options are given, `cargo rustdoc` will document all binary and library targets of the selected package. The binary will be skipped if its name is the same as the lib target. Binaries are skipped if they have `required-features` that are missing.

Passing target selection flags will document only the specified targets.

Note that `--bin`, `--example`, `--test` and `--bench` flags also support common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each glob pattern.

`--lib`
Document the package's library.

`--bin` *name…*
Document the specified binary. This flag may be specified multiple times and supports common Unix glob patterns.

`--bins`
Document all binary targets.

`--example` *name…*
Document the specified example. This flag may be specified multiple times and supports common Unix glob patterns.

`--examples`
Document all example targets.

`--test` *name…*
Document the specified integration test. This flag may be specified multiple times and supports common Unix glob patterns.

`--tests`
Document all targets in test mode that have the `test = true` manifest flag set. By default this includes the library and binaries built as unittests, and integration tests. Be aware that this will also build any required dependencies, so the lib target may be built twice (once as a unittest, and once as a dependency for binaries, integration tests, etc.). Targets may be enabled or disabled by setting the `test` flag in the manifest settings for the target.

`--bench` *name…*
: Document the specified benchmark. This flag may be specified multiple times and supports common Unix glob patterns.

`--benches`
: Document all targets in benchmark mode that have the `bench = true` manifest flag set. By default this includes the library and binaries built as benchmarks, and bench targets. Be aware that this will also build any required dependencies, so the lib target may be built twice (once as a benchmark, and once as a dependency for binaries, benchmarks, etc.). Targets may be enabled or disabled by setting the `bench` flag in the manifest settings for the target.

`--all-targets`
: Document all targets. This is equivalent to specifying `--lib --bins --tests --benches --examples`.

Feature Selection

The feature flags allow you to control which features are enabled. When no feature options are given, the `default` feature is activated for every selected package.

See the features documentation for more details.

`-F` *features*
`--features` *features*
: Space or comma separated list of features to activate. Features of workspace members may be enabled with `package-name/feature-name` syntax. This flag may be specified multiple times, which enables all specified features.

`--all-features`
: Activate all available features of all selected packages.

`--no-default-features`
: Do not activate the `default` feature of the selected packages.

Compilation Options

`--target` *triple*
: Document for the given architecture. The default is the host architecture. The general format of the triple is `<arch><sub>-<vendor>-<sys>-<abi>`. Run `rustc --print target-list` for a list of supported targets. This flag may be specified multiple times.

This may also be specified with the `build.target` config value.

Note that specifying this flag makes Cargo run in a different mode where the target artifacts are placed in a separate directory. See the build cache documentation for more details.

`-r`
`--release`

Document optimized artifacts with the `release` profile. See also the `--profile` option for choosing a specific profile by name.

`--profile` *name*
Document with the given profile. See the the reference for more details on profiles.

`--ignore-rust-version`
Document the target even if the selected Rust compiler is older than the required Rust version as configured in the project's `rust-version` field.

`--timings=`*fmts*
Output information how long each compilation takes, and track concurrency information over time. Accepts an optional comma-separated list of output formats; `--timings` without an argument will default to `--timings=html`. Specifying an output format (rather than the default) is unstable and requires `-Zunstable-options`. Valid output formats:

- `html` (unstable, requires `-Zunstable-options`): Write a human-readable file `cargo-timing.html` to the `target/cargo-timings` directory with a report of the compilation. Also write a report to the same directory with a timestamp in the filename if you want to look at older runs. HTML output is suitable for human consumption only, and does not provide machine-readable timing data.
- `json` (unstable, requires `-Zunstable-options`): Emit machine-readable JSON information about timing information.

Output Options

`--target-dir` *directory*
Directory for all generated artifacts and intermediate files. May also be specified with the `CARGO_TARGET_DIR` environment variable, or the `build.target-dir` config value. Defaults to `target` in the root of the workspace.

Display Options

`-v`
`--verbose`
Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.

- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

`--message-format` *fmt*
The output format for diagnostic messages. Can be specified multiple times and consists of comma-separated values. Valid values:

- `human` (default): Display in a human-readable text format. Conflicts with `short` and `json`.
- `short`: Emit shorter, human-readable text messages. Conflicts with `human` and `json`.
- `json`: Emit JSON messages to stdout. See the reference for more details. Conflicts with `human` and `short`.
- `json-diagnostic-short`: Ensure the `rendered` field of JSON messages contains the "short" rendering from rustc. Cannot be used with `human` or `short`.
- `json-diagnostic-rendered-ansi`: Ensure the `rendered` field of JSON messages contains embedded ANSI color codes for respecting rustc's default color scheme. Cannot be used with `human` or `short`.
- `json-render-diagnostics`: Instruct Cargo to not include rustc diagnostics in JSON messages printed, but instead Cargo itself should render the JSON diagnostics coming from rustc. Cargo's own JSON diagnostics and others coming from rustc are still emitted. Cannot be used with `human` or `short`.

Manifest Options

`--manifest-path` *path*
Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*
If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

Miscellaneous Options

`-j` *N*
`--jobs` *N*
Number of parallel jobs to run. May also be specified with the `build.jobs` config value. Defaults to the number of logical CPUs. If negative, it sets the maximum number of parallel jobs to the number of logical CPUs plus provided value. Should not be 0.

`--keep-going`
Build as many crates in the dependency graph as possible, rather than aborting the build on the first one that fails to build. Unstable, requires `-Zunstable-options`.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Build documentation with custom CSS included from a given file:

   ```
   cargo rustdoc --lib -- --extend-css extra.css
   ```

SEE ALSO

cargo(1), cargo-doc(1), rustdoc(1)

cargo-test(1)

NAME

cargo-test — Execute unit and integration tests of a package

SYNOPSIS

`cargo test` [*options*] [*testname*] [`--` *test-options*]

DESCRIPTION

Compile and execute unit, integration, and documentation tests.

The test filtering argument `TESTNAME` and all the arguments following the two dashes (`--`) are passed to the test binaries and thus to *libtest* (rustc's built in unit-test and micro-benchmarking framework). If you're passing arguments to both Cargo and the binary, the ones after `--` go to the binary, the ones before go to Cargo. For details about libtest's arguments see the output of `cargo test -- --help` and check out the rustc book's chapter on how tests work at https://doc.rust-lang.org/rustc/tests/index.html.

As an example, this will filter for tests with `foo` in their name and run them on 3 threads in parallel:

```
cargo test foo -- --test-threads 3
```

Tests are built with the `--test` option to `rustc` which creates a special executable by linking your code with libtest. The executable automatically runs all functions annotated with the `#[test]` attribute in multiple threads. `#[bench]` annotated functions will also be run with one iteration to verify that they are functional.

If the package contains multiple test targets, each target compiles to a special executable as aforementioned, and then is run serially.

The libtest harness may be disabled by setting `harness = false` in the target manifest settings, in which case your code will need to provide its own `main` function to handle running tests.

Documentation tests

Documentation tests are also run by default, which is handled by `rustdoc`. It extracts code samples from documentation comments of the library target, and then executes them.

Different from normal test targets, each code block compiles to a doctest executable on the fly with `rustc`. These executables run in parallel in separate processes. The compilation of a code block is in fact a part of test function controlled by libtest, so some options such as `--jobs` might not take effect. Note that this execution model of doctests is not guaranteed and may change in the future; beware of depending on it.

See the rustdoc book for more information on writing doc tests.

Working directory of tests

The working directory of every test is set to the root directory of the package the test belongs to. Setting the working directory of tests to the package's root directory makes it possible for tests to reliably access the package's files using relative paths, regardless from where `cargo test` was executed from.

OPTIONS

Test Options

`--no-run`
: Compile, but don't run tests.

`--no-fail-fast`
: Run all tests regardless of failure. Without this flag, Cargo will exit after the first executable fails. The Rust test harness will run all tests within the executable to completion, this flag only applies to the executable as a whole.

Package Selection

By default, when no package selection options are given, the packages selected depend on the selected manifest file (based on the current working directory if `--manifest-path` is not given). If the manifest is the root of a workspace then the workspaces default members are selected, otherwise only the package defined by the manifest will be selected.

The default members of a workspace can be set explicitly with the `workspace.default-members` key in the root manifest. If this is not set, a virtual workspace will include all workspace members (equivalent to passing `--workspace`), and a non-virtual workspace will include only the root crate itself.

`-p` *spec…*
`--package` *spec…*
: Test only the specified packages. See cargo-pkgid(1) for the SPEC format. This flag may be specified multiple times and supports common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each pattern.

`--workspace`
: Test all members in the workspace.

`--all`
: Deprecated alias for `--workspace`.

`--exclude` *SPEC…*
: Exclude the specified packages. Must be used in conjunction with the `--workspace` flag. This flag may be specified multiple times and supports common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each pattern.

Target Selection

When no target selection options are given, `cargo test` will build the following targets of the selected packages:

- lib — used to link with binaries, examples, integration tests, and doc tests
- bins (only if integration tests are built and required features are available)
- examples — to ensure they compile
- lib as a unit test
- bins as unit tests
- integration tests
- doc tests for the lib target

The default behavior can be changed by setting the `test` flag for the target in the manifest settings. Setting examples to `test = true` will build and run the example as a test. Setting targets to `test = false` will stop them from being tested by default. Target selection options that take a target by name ignore the `test` flag and will always test the given target.

Doc tests for libraries may be disabled by setting `doctest = false` for the library in the manifest.

Binary targets are automatically built if there is an integration test or benchmark being selected to test. This allows an integration test to execute the binary to exercise and test its behavior. The `CARGO_BIN_EXE_<name>` environment variable is set when the integration test is built so that it can use the `env` macro to locate the executable.

Passing target selection flags will test only the specified targets.

Note that `--bin`, `--example`, `--test` and `--bench` flags also support common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each glob pattern.

`--lib`
: Test the package's library.

`--bin` *name…*
: Test the specified binary. This flag may be specified multiple times and supports common Unix glob patterns.

`--bins`
: Test all binary targets.

`--example` *name…*
: Test the specified example. This flag may be specified multiple times and supports common Unix glob patterns.

`--examples`
: Test all example targets.

`--test` *name…*
: Test the specified integration test. This flag may be specified multiple times and supports common Unix glob patterns.

`--tests`
: Test all targets in test mode that have the `test = true` manifest flag set. By default this includes the library and binaries built as unittests, and integration tests. Be aware that this will also build any required dependencies, so the lib target may be built twice (once as a unittest, and once as a dependency for binaries, integration tests, etc.). Targets may be enabled or disabled by setting the `test` flag in the manifest settings for the target.

`--bench` *name…*
: Test the specified benchmark. This flag may be specified multiple times and supports common Unix glob patterns.

`--benches`
: Test all targets in benchmark mode that have the `bench = true` manifest flag set. By default this includes the library and binaries built as benchmarks, and bench targets. Be aware that this will also build any required dependencies, so the lib target may be built twice (once as a benchmark, and once as a dependency for binaries, benchmarks, etc.). Targets may be enabled or disabled by setting the `bench` flag in the manifest settings for the target.

`--all-targets`
: Test all targets. This is equivalent to specifying `--lib --bins --tests --benches --examples`.

`--doc`
: Test only the library's documentation. This cannot be mixed with other target options.

Feature Selection

The feature flags allow you to control which features are enabled. When no feature options are given, the `default` feature is activated for every selected package.

See the features documentation for more details.

`-F` *features*
`--features` *features*
: Space or comma separated list of features to activate. Features of workspace members may be enabled with `package-name/feature-name` syntax. This flag may be specified multiple times, which enables all specified features.

`--all-features`
: Activate all available features of all selected packages.

`--no-default-features`
: Do not activate the `default` feature of the selected packages.

Compilation Options

`--target` *triple*
: Test for the given architecture. The default is the host architecture. The general format of the triple is `<arch><sub>-<vendor>-<sys>-<abi>`. Run `rustc --print target-list` for a list of supported targets. This flag may be specified multiple times.

  This may also be specified with the `build.target` config value.

  Note that specifying this flag makes Cargo run in a different mode where the target artifacts are placed in a separate directory. See the build cache documentation for more details.

`-r`
`--release`
: Test optimized artifacts with the `release` profile. See also the `--profile` option for choosing a specific profile by name.

`--profile` *name*
: Test with the given profile. See the the reference for more details on profiles.

`--ignore-rust-version`
: Test the target even if the selected Rust compiler is older than the required Rust version as configured in the project's `rust-version` field.

`--timings=`*fmts*
: Output information how long each compilation takes, and track concurrency information over time. Accepts an optional comma-separated list of output formats; `--timings` without an argument will default to `--timings=html`. Specifying an output format (rather than the default) is unstable and requires `-Zunstable-options`. Valid output formats:

- `html` (unstable, requires `-Zunstable-options`): Write a human-readable file `cargo-timing.html` to the `target/cargo-timings` directory with a report of the compilation. Also write a report to the same directory with a timestamp in the filename if you want to look at older runs. HTML output is suitable for human consumption only, and does not provide machine-readable timing data.
- `json` (unstable, requires `-Zunstable-options`): Emit machine-readable JSON information about timing information.

Output Options

`--target-dir` *directory*
Directory for all generated artifacts and intermediate files. May also be specified with the `CARGO_TARGET_DIR` environment variable, or the `build.target-dir` config value. Defaults to `target` in the root of the workspace.

Display Options

By default the Rust test harness hides output from test execution to keep results readable. Test output can be recovered (e.g., for debugging) by passing `--nocapture` to the test binaries:

```
cargo test -- --nocapture
```

`-v`
`--verbose`
Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

`--message-format` *fmt*
The output format for diagnostic messages. Can be specified multiple times and consists of comma-separated values. Valid values:

- `human` (default): Display in a human-readable text format. Conflicts with `short` and `json`.
- `short`: Emit shorter, human-readable text messages. Conflicts with `human` and `json`.
- `json`: Emit JSON messages to stdout. See the reference for more details. Conflicts with `human` and `short`.
- `json-diagnostic-short`: Ensure the `rendered` field of JSON messages contains the “short” rendering from rustc. Cannot be used with `human` or `short`.
- `json-diagnostic-rendered-ansi`: Ensure the `rendered` field of JSON messages contains embedded ANSI color codes for respecting rustc’s default color scheme. Cannot be used with `human` or `short`.
- `json-render-diagnostics`: Instruct Cargo to not include rustc diagnostics in JSON messages printed, but instead Cargo itself should render the JSON diagnostics coming from rustc. Cargo’s own JSON diagnostics and others coming from rustc are still emitted. Cannot be used with `human` or `short`.

Manifest Options

`--manifest-path` *path*

Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`

Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`

Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*

If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

  This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
: Prints help information.

`-Z` *flag*
: Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

Miscellaneous Options

The `--jobs` argument affects the building of the test executable but does not affect how many threads are used when running the tests. The Rust test harness includes an option to control the number of threads used:

```
cargo test -j 2 -- --test-threads=2
```

`-j` *N*
`--jobs` *N*
: Number of parallel jobs to run. May also be specified with the `build.jobs` config value. Defaults to the number of logical CPUs. If negative, it sets the maximum number of parallel jobs to the number of logical CPUs plus provided value. Should not be 0.

`--keep-going`
: Build as many crates in the dependency graph as possible, rather than aborting the build on the first one that fails to build. Unstable, requires `-Zunstable-options`.

`--future-incompat-report`
: Displays a future-incompat report for any future-incompatible warnings produced during execution of this command

  See cargo-report(1)

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Execute all the unit and integration tests of the current package:

   ```
   cargo test
   ```

2. Run only tests whose names match against a filter string:

   ```
   cargo test name_filter
   ```

3. Run only a specific test within a specific integration test:

   ```
   cargo test --test int_test_name -- modname::test_name
   ```

SEE ALSO

cargo(1), cargo-bench(1), types of tests, how to write tests

cargo-report(1)

NAME

cargo-report — Generate and display various kinds of reports

SYNOPSIS

`cargo report` *type* [*options*]

DESCRIPTION

Displays a report of the given *type* — currently, only `future-incompat` is supported

OPTIONS

`--id` *id*
Show the report with the specified Cargo-generated id

`-p` *spec*…
`--package` *spec*…
Only display a report for the specified package

EXAMPLES

1. Display the latest future-incompat report:

```
cargo report future-incompat
```

2. Display the latest future-incompat report for a specific package:

```
cargo report future-incompat --package my-dep:0.0.1
```

SEE ALSO

Future incompat report

- `cargo(1)`

Manifest Commands

- cargo add
- cargo generate-lockfile
- cargo locate-project
- cargo metadata
- cargo pkgid
- cargo remove
- cargo tree
- cargo update
- cargo vendor
- cargo verify-project

cargo-add(1)

NAME

cargo-add — Add dependencies to a Cargo.toml manifest file

SYNOPSIS

`cargo add` [*options*] *crate…*
`cargo add` [*options*] `--path` *path*
`cargo add` [*options*] `--git` *url* [*crate…*]

DESCRIPTION

This command can add or modify dependencies.

The source for the dependency can be specified with:

- *crate*`@`*version*: Fetch from a registry with a version constraint of "*version*"
- `--path` *path*: Fetch from the specified *path*
- `--git` *url*: Pull from a git repo at *url*

If no source is specified, then a best effort will be made to select one, including:

- Existing dependencies in other tables (like `dev-dependencies`)
- Workspace members
- Latest release in the registry

When you add a package that is already present, the existing entry will be updated with the flags specified.

Upon successful invocation, the enabled (`+`) and disabled (`-`) features of the specified dependency will be listed in the command's output.

OPTIONS

Source options

`--git` *url*
    Git URL to add the specified crate from.

`--branch` *branch*
Branch to use when adding from git.

`--tag` *tag*
Tag to use when adding from git.

`--rev` *sha*
Specific commit to use when adding from git.

`--path` *path*
Filesystem path to local crate to add.

`--registry` *registry*
Name of the registry to use. Registry names are defined in Cargo config files. If not specified, the default registry is used, which is defined by the `registry.default` config key which defaults to `crates-io`.

Section options

`--dev`
Add as a development dependency.

`--build`
Add as a build dependency.

`--target` *target*
Add as a dependency to the given target platform.

To avoid unexpected shell expansions, you may use quotes around each target, e.g., `--target 'cfg(unix)'`.

Dependency options

`--dry-run`
Don't actually write the manifest

`--rename` *name*
Rename the dependency.

`--optional`
Mark the dependency as optional.

`--no-optional`
Mark the dependency as required.

`--no-default-features`
Disable the default features.

`--default-features`
Re-enable the default features.

`-F` *features*
`--features` *features*

Space or comma separated list of features to activate. When adding multiple crates, the features for a specific crate may be enabled with `package-name/feature-name` syntax. This flag may be specified multiple times, which enables all specified features.

Display Options

`-v`
`--verbose`
Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Manifest Options

`--manifest-path` *path*
Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`-p` *spec*
`--package` *spec*
Add dependencies to only the specified package.

`--frozen`
`--locked`
Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network

is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*
If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.

- `101`: Cargo failed to complete.

EXAMPLES

1. Add `regex` as a dependency

   ```
   cargo add regex
   ```

2. Add `trybuild` as a dev-dependency

   ```
   cargo add --dev trybuild
   ```

3. Add an older version of `nom` as a dependency

   ```
   cargo add nom@5
   ```

4. Add support for serializing data structures to json with `derive`s

   ```
   cargo add serde serde_json -F serde/derive
   ```

5. Add `windows` as a platform specific dependency on `cfg(windows)`

   ```
   cargo add windows --target 'cfg(windows)'
   ```

SEE ALSO

cargo(1), cargo-remove(1)

cargo-generate-lockfile(1)

NAME

cargo-generate-lockfile — Generate the lockfile for a package

SYNOPSIS

`cargo generate-lockfile` [*options*]

DESCRIPTION

This command will create the `Cargo.lock` lockfile for the current package or workspace. If the lockfile already exists, it will be rebuilt with the latest available version of every package.

See also cargo-update(1) which is also capable of creating a `Cargo.lock` lockfile and has more options for controlling update behavior.

OPTIONS

Display Options

`-v`
`--verbose`
: Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
: Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
: Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.

- `never`: Never display colors.

May also be specified with the `term.color` config value.

Manifest Options

`--manifest-path` *path*
: Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
: Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
: Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*
: If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for

discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Create or update the lockfile for the current package or workspace:

```
cargo generate-lockfile
```

SEE ALSO

cargo(1), cargo-update(1)

cargo-locate-project(1)

NAME

cargo-locate-project — Print a JSON representation of a Cargo.toml file's location

SYNOPSIS

`cargo locate-project` [*options*]

DESCRIPTION

This command will print a JSON object to stdout with the full path to the manifest. The manifest is found by searching upward for a file named `Cargo.toml` starting from the current working directory.

If the project happens to be a part of a workspace, the manifest of the project, rather than the workspace root, is output. This can be overridden by the `--workspace` flag. The root workspace is found by traversing further upward or by using the field `package.workspace` after locating the manifest of a workspace member.

OPTIONS

`--workspace`
Locate the `Cargo.toml` at the root of the workspace, as opposed to the current workspace member.

Display Options

`--message-format` *fmt*
The representation in which to print the project location. Valid values:

- `json` (default): JSON object with the path under the key "root".
- `plain`: Just the path.

`-v`
`--verbose`
Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Manifest Options

`--manifest-path` *path*
Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

Common Options

`+`*toolchain*
If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Display the path to the manifest based on the current directory:

   ```
   cargo locate-project
   ```

SEE ALSO

cargo(1), cargo-metadata(1)

cargo-metadata(1)

NAME

cargo-metadata — Machine-readable metadata about the current package

SYNOPSIS

`cargo metadata` [*options*]

DESCRIPTION

Output JSON to stdout containing information about the workspace members and resolved dependencies of the current package.

It is recommended to include the `--format-version` flag to future-proof your code to ensure the output is in the format you are expecting.

See the cargo_metadata crate for a Rust API for reading the metadata.

OUTPUT FORMAT

The output has the following format:

```
{
    /* Array of all packages in the workspace.
       It also includes all feature-enabled dependencies unless --no-deps is used.
    */
    "packages": [
        {
            /* The name of the package. */
            "name": "my-package",
            /* The version of the package. */
            "version": "0.1.0",
            /* The Package ID, a unique identifier for referring to the package. */
            "id": "my-package 0.1.0 (path+file:///path/to/my-package)",
            /* The license value from the manifest, or null. */
            "license": "MIT/Apache-2.0",
            /* The license-file value from the manifest, or null. */
            "license_file": "LICENSE",
            /* The description value from the manifest, or null. */
            "description": "Package description.",
            /* The source ID of the package. This represents where
               a package is retrieved from.
               This is null for path dependencies and workspace members.
               For other dependencies, it is a string with the format:
               - "registry+URL" for registry-based dependencies.
                 Example: "registry+https://github.com/rust-lang/crates.io-index"
               - "git+URL" for git-based dependencies.
                 Example: "git+https://github.com/rust-lang/cargo?
rev=5e85ba14aaa20f8133863373404cb0af69eeef2c#5e85ba14aaa20f8133863373404cb0af69eeef2c"
            */
            "source": null,
            /* Array of dependencies declared in the package's manifest. */
            "dependencies": [
                {
                    /* The name of the dependency. */
                    "name": "bitflags",
                    /* The source ID of the dependency. May be null, see
                       description for the package source.
                    */
                    "source": "registry+https://github.com/rust-lang/crates.io-index",
                    /* The version requirement for the dependency.
                       Dependencies without a version requirement have a value of "*".
                    */
                    "req": "^1.0",
                    /* The dependency kind.
                       "dev", "build", or null for a normal dependency.
                    */
                    "kind": null,
                    /* If the dependency is renamed, this is the new name for
                       the dependency as a string.  null if it is not renamed.
                    */
                    "rename": null,
                    /* Boolean of whether or not this is an optional dependency. */
                    "optional": false,
                    /* Boolean of whether or not default features are enabled. */
                    "uses_default_features": true,
                    /* Array of features enabled. */
                    "features": [],
                    /* The target platform for the dependency.
                       null if not a target dependency.
                    */
                    "target": "cfg(windows)",
```

```
                /* The file system path for a local path dependency.
                   not present if not a path dependency.
                */
                "path": "/path/to/dep",
                /* A string of the URL of the registry this dependency is from.
                   If not specified or null, the dependency is from the default
                   registry (crates.io).
                */
                "registry": null
            }
        ],
        /* Array of Cargo targets. */
        "targets": [
            {
                /* Array of target kinds.
                   - lib targets list the `crate-type` values from the
                     manifest such as "lib", "rlib", "dylib",
                     "proc-macro", etc. (default ["lib"])
                   - binary is ["bin"]
                   - example is ["example"]
                   - integration test is ["test"]
                   - benchmark is ["bench"]
                   - build script is ["custom-build"]
                */
                "kind": [
                    "bin"
                ],
                /* Array of crate types.
                   - lib and example libraries list the `crate-type` values
                     from the manifest such as "lib", "rlib", "dylib",
                     "proc-macro", etc. (default ["lib"])
                   - all other target kinds are ["bin"]
                */
                "crate_types": [
                    "bin"
                ],
                /* The name of the target. */
                "name": "my-package",
                /* Absolute path to the root source file of the target. */
                "src_path": "/path/to/my-package/src/main.rs",
                /* The Rust edition of the target.
                   Defaults to the package edition.
                */
                "edition": "2018",
                /* Array of required features.
                   This property is not included if no required features are set.
                */
                "required-features": ["feat1"],
                /* Whether the target should be documented by `cargo doc`. */
                "doc": true,
                /* Whether or not this target has doc tests enabled, and
                   the target is compatible with doc testing.
                */
                "doctest": false,
                /* Whether or not this target should be built and run with `--test`
                */
                "test": true
            }
        ],
        /* Set of features defined for the package.
           Each feature maps to an array of features or dependencies it
```

```
          enables.
       */
       "features": {
           "default": [
               "feat1"
           ],
           "feat1": [],
           "feat2": []
       },
       /* Absolute path to this package's manifest. */
       "manifest_path": "/path/to/my-package/Cargo.toml",
       /* Package metadata.
          This is null if no metadata is specified.
       */
       "metadata": {
           "docs": {
               "rs": {
                   "all-features": true
               }
           }
       },
       /* List of registries to which this package may be published.
          Publishing is unrestricted if null, and forbidden if an empty array. */
       "publish": [
           "crates-io"
       ],
       /* Array of authors from the manifest.
          Empty array if no authors specified.
       */
       "authors": [
           "Jane Doe <user@example.com>"
       ],
       /* Array of categories from the manifest. */
       "categories": [
           "command-line-utilities"
       ],
       /* Optional string that is the default binary picked by cargo run. */
       "default_run": null,
       /* Optional string that is the minimum supported rust version */
       "rust_version": "1.56",
       /* Array of keywords from the manifest. */
       "keywords": [
           "cli"
       ],
       /* The readme value from the manifest or null if not specified. */
       "readme": "README.md",
       /* The repository value from the manifest or null if not specified. */
       "repository": "https://github.com/rust-lang/cargo",
       /* The homepage value from the manifest or null if not specified. */
       "homepage": "https://rust-lang.org",
       /* The documentation value from the manifest or null if not specified. */
       "documentation": "https://doc.rust-lang.org/stable/std",
       /* The default edition of the package.
          Note that individual targets may have different editions.
       */
       "edition": "2018",
       /* Optional string that is the name of a native library the package
          is linking to.
       */
       "links": null,
   }
```

```
    ],
    /* Array of members of the workspace.
       Each entry is the Package ID for the package.
    */
    "workspace_members": [
        "my-package 0.1.0 (path+file:///path/to/my-package)",
    ],
    // The resolved dependency graph for the entire workspace. The enabled
    // features are based on the enabled features for the "current" package.
    // Inactivated optional dependencies are not listed.
    //
    // This is null if --no-deps is specified.
    //
    // By default, this includes all dependencies for all target platforms.
    // The `--filter-platform` flag may be used to narrow to a specific
    // target triple.
    "resolve": {
        /* Array of nodes within the dependency graph.
           Each node is a package.
        */
        "nodes": [
            {
                /* The Package ID of this node. */
                "id": "my-package 0.1.0 (path+file:///path/to/my-package)",
                /* The dependencies of this package, an array of Package IDs. */
                "dependencies": [
                    "bitflags 1.0.4 (registry+https://github.com/rust-lang/crates.io-index)"
                ],
                /* The dependencies of this package. This is an alternative to
                   "dependencies" which contains additional information. In
                   particular, this handles renamed dependencies.
                */
                "deps": [
                    {
                        /* The name of the dependency's library target.
                           If this is a renamed dependency, this is the new
                           name.
                        */
                        "name": "bitflags",
                        /* The Package ID of the dependency. */
                        "pkg": "bitflags 1.0.4 (registry+https://github.com/rust-
lang/crates.io-index)",
                        /* Array of dependency kinds. Added in Cargo 1.40. */
                        "dep_kinds": [
                            {
                                /* The dependency kind.
                                   "dev", "build", or null for a normal dependency.
                                */
                                "kind": null,
                                /* The target platform for the dependency.
                                   null if not a target dependency.
                                */
                                "target": "cfg(windows)"
                            }
                        ]
                    }
                ],
                /* Array of features enabled on this package. */
                "features": [
                    "default"
                ]
            }
```

```
        ],
        /* The root package of the workspace.
           This is null if this is a virtual workspace. Otherwise it is
           the Package ID of the root package.
        */
        "root": "my-package 0.1.0 (path+file:///path/to/my-package)"
    },
    /* The absolute path to the build directory where Cargo places its output. */
    "target_directory": "/path/to/my-package/target",
    /* The version of the schema for this metadata structure.
       This will be changed if incompatible changes are ever made.
    */
    "version": 1,
    /* The absolute path to the root of the workspace. */
    "workspace_root": "/path/to/my-package"
    /* Workspace metadata.
       This is null if no metadata is specified. */
    "metadata": {
        "docs": {
            "rs": {
                "all-features": true
            }
        }
    }
}
```

OPTIONS

Output Options

`--no-deps`
: Output information only about the workspace members and don't fetch dependencies.

`--format-version` *version*
: Specify the version of the output format to use. Currently `1` is the only possible value.

`--filter-platform` *triple*
: This filters the `resolve` output to only include dependencies for the given target triple. Without this flag, the resolve includes all targets.

  Note that the dependencies listed in the "packages" array still includes all dependencies. Each package definition is intended to be an unaltered reproduction of the information within `Cargo.toml`.

Feature Selection

The feature flags allow you to control which features are enabled. When no feature options are given, the `default` feature is activated for every selected package.

See the features documentation for more details.

`-F` *features*
`--features` *features*
Space or comma separated list of features to activate. Features of workspace members may be enabled with `package-name/feature-name` syntax. This flag may be specified multiple times, which enables all specified features.

`--all-features`
Activate all available features of all selected packages.

`--no-default-features`
Do not activate the `default` feature of the selected packages.

Display Options

`-v`
`--verbose`
Use verbose output. May be specified twice for “very verbose” output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Manifest Options

`--manifest-path` *path*
Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
: Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

  Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

  May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*
: If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

  This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
: Prints help information.

`-Z` *flag*
: Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Output JSON about the current package:

   ```
   cargo metadata --format-version=1
   ```

SEE ALSO

cargo(1)

cargo-pkgid(1)

NAME

cargo-pkgid — Print a fully qualified package specification

SYNOPSIS

`cargo pkgid` [*options*] [*spec*]

DESCRIPTION

Given a *spec* argument, print out the fully qualified package ID specifier for a package or dependency in the current workspace. This command will generate an error if *spec* is ambiguous as to which package it refers to in the dependency graph. If no *spec* is given, then the specifier for the local package is printed.

This command requires that a lockfile is available and dependencies have been fetched.

A package specifier consists of a name, version, and source URL. You are allowed to use partial specifiers to succinctly match a specific package as long as it matches only one package. The format of a *spec* can be one of the following:

SPEC Structure	Example SPEC
name	`bitflags`
name`@`*version*	`bitflags@1.0.4`
url	`https://github.com/rust-lang/cargo`
url`#`*version*	`https://github.com/rust-lang/cargo#0.33.0`
url`#`*name*	`https://github.com/rust-lang/crates.io-index#bitflags`
url`#`*name*`@`*version*	`https://github.com/rust-lang/cargo#crates-io@0.21.0`

OPTIONS

Package Selection

`-p` *spec*

`--package` *spec*
: Get the package ID for the given package instead of the current package.

Display Options

`-v`
`--verbose`
: Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
: Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
: Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Manifest Options

`--manifest-path` *path*
: Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
: Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
: Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*
: If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
: Prints help information.

`-Z` *flag*
: Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Retrieve package specification for `foo` package:

```
cargo pkgid foo
```

2. Retrieve package specification for version 1.0.0 of `foo`:

```
cargo pkgid foo@1.0.0
```

3. Retrieve package specification for `foo` from crates.io:

```
cargo pkgid https://github.com/rust-lang/crates.io-index#foo
```

4. Retrieve package specification for `foo` from a local package:

```
cargo pkgid file:///path/to/local/package#foo
```

SEE ALSO

cargo(1), cargo-generate-lockfile(1), cargo-metadata(1)

cargo-remove(1)

NAME

cargo-remove — Remove dependencies from a Cargo.toml manifest file

SYNOPSIS

`cargo remove` [*options*] *dependency*…

DESCRIPTION

Remove one or more dependencies from a `Cargo.toml` manifest.

OPTIONS

Section options

`--dev`
Remove as a development dependency.

`--build`
Remove as a build dependency.

`--target` *target*
Remove as a dependency to the given target platform.

To avoid unexpected shell expansions, you may use quotes around each target, e.g., `--target 'cfg(unix)'`.

Miscellaneous Options

`--dry-run`
Don’t actually write to the manifest.

Display Options

`-v`

`--verbose`
: Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
: Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
: Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Manifest Options

`--manifest-path` *path*
: Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
: Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
: Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Package Selection

`-p` *spec…*
`--package` *spec…*
Package to remove from.

Common Options

`+`*toolchain*
If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Remove `regex` as a dependency

   ```
   cargo remove regex
   ```

2. Remove `trybuild` as a dev-dependency

   ```
   cargo remove --dev trybuild
   ```

3. Remove `nom` from the `x86_64-pc-windows-gnu` dependencies table

   ```
   cargo remove --target x86_64-pc-windows-gnu nom
   ```

SEE ALSO

cargo(1), cargo-add(1)

cargo-tree(1)

NAME

cargo-tree — Display a tree visualization of a dependency graph

SYNOPSIS

`cargo tree` [*options*]

DESCRIPTION

This command will display a tree of dependencies to the terminal. An example of a simple project that depends on the "rand" package:

```
myproject v0.1.0 (/myproject)
└── rand v0.7.3
    ├── getrandom v0.1.14
    │   ├── cfg-if v0.1.10
    │   └── libc v0.2.68
    ├── libc v0.2.68 (*)
    ├── rand_chacha v0.2.2
    │   ├── ppv-lite86 v0.2.6
    │   └── rand_core v0.5.1
    │       └── getrandom v0.1.14 (*)
    └── rand_core v0.5.1 (*)
[build-dependencies]
└── cc v1.0.50
```

Packages marked with `(*)` have been "de-duplicated". The dependencies for the package have already been shown elsewhere in the graph, and so are not repeated. Use the `--no-dedupe` option to repeat the duplicates.

The `-e` flag can be used to select the dependency kinds to display. The "features" kind changes the output to display the features enabled by each dependency. For example, `cargo tree -e features`:

```
myproject v0.1.0 (/myproject)
└── log feature "serde"
    └── log v0.4.8
        ├── serde v1.0.106
        └── cfg-if feature "default"
            └── cfg-if v0.1.10
```

In this tree, `myproject` depends on `log` with the `serde` feature. `log` in turn depends on `cfg-if` with "default" features. When using `-e features` it can be helpful to use `-i` flag to show how the features flow into a package. See the examples below for more detail.

Feature Unification

This command shows a graph much closer to a feature-unified graph Cargo will build, rather than what you list in `Cargo.toml`. For instance, if you specify the same dependency in both `[dependencies]` and `[dev-dependencies]` but with different features on. This command may merge all features and show a `(*)` on one of the dependency to indicate the duplicate.

As a result, for a mostly equivalent overview of what `cargo build` does, `cargo tree -e normal,build` is pretty close; for a mostly equivalent overview of what `cargo test` does, `cargo tree` is pretty close. However, it doesn't guarantee the exact equivalence to what Cargo is going to build, since a compilation is complex and depends on lots of different factors.

To learn more about feature unification, check out this dedicated section.

OPTIONS

Tree Options

`-i` *spec*
`--invert` *spec*
Show the reverse dependencies for the given package. This flag will invert the tree and display the packages that depend on the given package.

Note that in a workspace, by default it will only display the package's reverse dependencies inside the tree of the workspace member in the current directory. The `--workspace` flag can be used to extend it so that it will show the package's reverse dependencies across the entire workspace. The `-p` flag can be used to display the package's reverse dependencies only with the subtree of the package given to `-p`.

`--prune` *spec*
Prune the given package from the display of the dependency tree.

`--depth` *depth*
Maximum display depth of the dependency tree. A depth of 1 displays the direct dependencies, for example.

`--no-dedupe`
Do not de-duplicate repeated dependencies. Usually, when a package has already displayed its dependencies, further occurrences will not re-display its

dependencies, and will include a `(*)` to indicate it has already been shown. This flag will cause those duplicates to be repeated.

`-d`
`--duplicates`
Show only dependencies which come in multiple versions (implies `--invert`). When used with the `-p` flag, only shows duplicates within the subtree of the given package.

It can be beneficial for build times and executable sizes to avoid building that same package multiple times. This flag can help identify the offending packages. You can then investigate if the package that depends on the duplicate with the older version can be updated to the newer version so that only one instance is built.

`-e` *kinds*
`--edges` *kinds*
The dependency kinds to display. Takes a comma separated list of values:

- `all` — Show all edge kinds.
- `normal` — Show normal dependencies.
- `build` — Show build dependencies.
- `dev` — Show development dependencies.
- `features` — Show features enabled by each dependency. If this is the only kind given, then it will automatically include the other dependency kinds.
- `no-normal` — Do not include normal dependencies.
- `no-build` — Do not include build dependencies.
- `no-dev` — Do not include development dependencies.
- `no-proc-macro` — Do not include procedural macro dependencies.

The `normal`, `build`, `dev`, and `all` dependency kinds cannot be mixed with `no-normal`, `no-build`, or `no-dev` dependency kinds.

The default is `normal,build,dev`.

`--target` *triple*
Filter dependencies matching the given target triple. The default is the host platform. Use the value `all` to include *all* targets.

Tree Formatting Options

`--charset` *charset*
Chooses the character set to use for the tree. Valid values are "utf8" or "ascii". Default is "utf8".

`-f` *format*
`--format` *format*
Set the format string for each package. The default is "{p}".

This is an arbitrary string which will be used to display each package. The following strings will be replaced with the corresponding value:

- `{p}` — The package name.
- `{l}` — The package license.
- `{r}` — The package repository URL.
- `{f}` — Comma-separated list of package features that are enabled.
- `{lib}` — The name, as used in a `use` statement, of the package's library.

`--prefix` *prefix*
Sets how each line is displayed. The *prefix* value can be one of:

- `indent` (default) — Shows each line indented as a tree.
- `depth` — Show as a list, with the numeric depth printed before each entry.
- `none` — Show as a flat list.

Package Selection

By default, when no package selection options are given, the packages selected depend on the selected manifest file (based on the current working directory if `--manifest-path` is not given). If the manifest is the root of a workspace then the workspaces default members are selected, otherwise only the package defined by the manifest will be selected.

The default members of a workspace can be set explicitly with the `workspace.default-members` key in the root manifest. If this is not set, a virtual workspace will include all workspace members (equivalent to passing `--workspace`), and a non-virtual workspace will include only the root crate itself.

`-p` *spec…*
`--package` *spec…*
Display only the specified packages. See cargo-pkgid(1) for the SPEC format. This flag may be specified multiple times and supports common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each pattern.

`--workspace`
Display all members in the workspace.

`--exclude` *SPEC…*
Exclude the specified packages. Must be used in conjunction with the `--workspace` flag. This flag may be specified multiple times and supports common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each pattern.

Manifest Options

`--manifest-path` *path*
Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Feature Selection

The feature flags allow you to control which features are enabled. When no feature options are given, the `default` feature is activated for every selected package.

See the features documentation for more details.

`-F` *features*
`--features` *features*
Space or comma separated list of features to activate. Features of workspace members may be enabled with `package-name/feature-name` syntax. This flag may be specified multiple times, which enables all specified features.

`--all-features`
Activate all available features of all selected packages.

`--no-default-features`
Do not activate the `default` feature of the selected packages.

Display Options

`-v`
`--verbose`
Use verbose output. May be specified twice for “very verbose” output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`

Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Common Options

`+`*toolchain*
If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Display the tree for the package in the current directory:

   ```
   cargo tree
   ```

2. Display all the packages that depend on the `syn` package:

   ```
   cargo tree -i syn
   ```

3. Show the features enabled on each package:

   ```
   cargo tree --format "{p} {f}"
   ```

4. Show all packages that are built multiple times. This can happen if multiple semver-incompatible versions appear in the tree (like 1.0.0 and 2.0.0).

   ```
   cargo tree -d
   ```

5. Explain why features are enabled for the `syn` package:

   ```
   cargo tree -e features -i syn
   ```

   The `-e features` flag is used to show features. The `-i` flag is used to invert the graph so that it displays the packages that depend on `syn`. An example of what this would display:

```
syn v1.0.17
├── syn feature "clone-impls"
│   └── syn feature "default"
│       └── rustversion v1.0.2
│           └── rustversion feature "default"
│               └── myproject v0.1.0 (/myproject)
│                   └── myproject feature "default" (command-line)
├── syn feature "default" (*)
├── syn feature "derive"
│   └── syn feature "default" (*)
├── syn feature "full"
│   └── rustversion v1.0.2 (*)
├── syn feature "parsing"
│   └── syn feature "default" (*)
├── syn feature "printing"
│   └── syn feature "default" (*)
├── syn feature "proc-macro"
│   └── syn feature "default" (*)
└── syn feature "quote"
    ├── syn feature "printing" (*)
    └── syn feature "proc-macro" (*)
```

To read this graph, you can follow the chain for each feature from the root to see why it is included. For example, the "full" feature is added by the `rustversion` crate which is included from `myproject` (with the default features), and `myproject` is the package selected on the command-line. All of the other `syn` features are added by the "default" feature ("quote" is added by "printing" and "proc-macro", both of which are default features).

If you're having difficulty cross-referencing the de-duplicated `(*)` entries, try with the `--no-dedupe` flag to get the full output.

SEE ALSO

cargo(1), cargo-metadata(1)

cargo-update(1)

NAME

cargo-update — Update dependencies as recorded in the local lock file

SYNOPSIS

`cargo update` [*options*]

DESCRIPTION

This command will update dependencies in the `Cargo.lock` file to the latest version. If the `Cargo.lock` file does not exist, it will be created with the latest available versions.

OPTIONS

Update Options

`-p` *spec*…
`--package` *spec*…
: Update only the specified packages. This flag may be specified multiple times. See cargo-pkgid(1) for the SPEC format.

  If packages are specified with the `-p` flag, then a conservative update of the lockfile will be performed. This means that only the dependency specified by SPEC will be updated. Its transitive dependencies will be updated only if SPEC cannot be updated without updating dependencies. All other dependencies will remain locked at their currently recorded versions.

  If `-p` is not specified, all dependencies are updated.

`--aggressive`
: When used with `-p`, dependencies of *spec* are forced to update as well. Cannot be used with `--precise`.

`--precise` *precise*
: When used with `-p`, allows you to specify a specific version number to set the package to. If the package comes from a git repository, this can be a git

revision (such as a SHA hash or tag).

`-w`
`--workspace`
Attempt to update only packages defined in the workspace. Other packages are updated only if they don't already exist in the lockfile. This option is useful for updating `Cargo.lock` after you've changed version numbers in `Cargo.toml`.

`--dry-run`
Displays what would be updated, but doesn't actually write the lockfile.

Display Options

`-v`
`--verbose`
Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Manifest Options

`--manifest-path` *path*
Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`

Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*
: If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
: Prints help information.

`-Z` *flag*
: Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Update all dependencies in the lockfile:

   ```
   cargo update
   ```

2. Update only specific dependencies:

   ```
   cargo update -p foo -p bar
   ```

3. Set a specific dependency to a specific version:

   ```
   cargo update -p foo --precise 1.2.3
   ```

SEE ALSO

cargo(1), cargo-generate-lockfile(1)

cargo-vendor(1)

NAME

cargo-vendor — Vendor all dependencies locally

SYNOPSIS

`cargo vendor` [*options*] [*path*]

DESCRIPTION

This cargo subcommand will vendor all crates.io and git dependencies for a project into the specified directory at `<path>`. After this command completes the vendor directory specified by `<path>` will contain all remote sources from dependencies specified. Additional manifests beyond the default one can be specified with the `-s` option.

The `cargo vendor` command will also print out the configuration necessary to use the vendored sources, which you will need to add to `.cargo/config.toml`.

OPTIONS

Vendor Options

`-s` *manifest*
`--sync` *manifest*
: Specify an extra `Cargo.toml` manifest to workspaces which should also be vendored and synced to the output. May be specified multiple times.

`--no-delete`
: Don't delete the "vendor" directory when vendoring, but rather keep all existing contents of the vendor directory

`--respect-source-config`
: Instead of ignoring `[source]` configuration by default in `.cargo/config.toml` read it and use it when downloading crates from crates.io, for example

`--versioned-dirs`

Normally versions are only added to disambiguate multiple versions of the same package. This option causes all directories in the "vendor" directory to be versioned, which makes it easier to track the history of vendored packages over time, and can help with the performance of re-vendoring when only a subset of the packages have changed.

Manifest Options

`--manifest-path` *path*
: Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
: Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
: Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Display Options

`-v`
`--verbose`
: Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
: Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
: Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Common Options

`+`*toolchain*
If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Vendor all dependencies into a local "vendor" folder

```
cargo vendor
```

2. Vendor all dependencies into a local "third-party/vendor" folder

```
cargo vendor third-party/vendor
```

3. Vendor the current workspace as well as another to "vendor"

```
cargo vendor -s ../path/to/Cargo.toml
```

SEE ALSO

cargo(1)

cargo-verify-project(1)

NAME

cargo-verify-project — Check correctness of crate manifest

SYNOPSIS

`cargo verify-project` [*options*]

DESCRIPTION

This command will parse the local manifest and check its validity. It emits a JSON object with the result. A successful validation will display:

```
{"success":"true"}
```

An invalid workspace will display:

```
{"invalid":"human-readable error message"}
```

OPTIONS

Display Options

`-v`
`--verbose`
Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Manifest Options

`--manifest-path` *path*
: Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
: Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
: Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Common Options

`+`*toolchain*
: If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*

Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: The workspace is OK.
- `1`: The workspace is invalid.

EXAMPLES

1. Check the current workspace for errors:

```
cargo verify-project
```

SEE ALSO

cargo(1), cargo-package(1)

Package Commands

- `cargo init`
- `cargo install`
- `cargo new`
- `cargo search`
- `cargo uninstall`

cargo-init(1)

NAME

cargo-init — Create a new Cargo package in an existing directory

SYNOPSIS

`cargo init` [*options*] [*path*]

DESCRIPTION

This command will create a new Cargo manifest in the current directory. Give a path as an argument to create in the given directory.

If there are typically-named Rust source files already in the directory, those will be used. If not, then a sample `src/main.rs` file will be created, or `src/lib.rs` if `--lib` is passed.

If the directory is not already in a VCS repository, then a new repository is created (see `--vcs` below).

See cargo-new(1) for a similar command which will create a new package in a new directory.

OPTIONS

Init Options

`--bin`
: Create a package with a binary target (`src/main.rs`). This is the default behavior.

`--lib`
: Create a package with a library target (`src/lib.rs`).

`--edition` *edition*
: Specify the Rust edition to use. Default is 2021. Possible values: 2015, 2018, 2021

`--name` *name*

Set the package name. Defaults to the directory name.

`--vcs` *vcs*
: Initialize a new VCS repository for the given version control system (git, hg, pijul, or fossil) or do not initialize any version control at all (none). If not specified, defaults to `git` or the configuration value `cargo-new.vcs`, or `none` if already inside a VCS repository.

`--registry` *registry*
: This sets the `publish` field in `Cargo.toml` to the given registry name which will restrict publishing only to that registry.

Registry names are defined in Cargo config files. If not specified, the default registry defined by the `registry.default` config key is used. If the default registry is not set and `--registry` is not used, the `publish` field will not be set which means that publishing will not be restricted.

Display Options

`-v`
`--verbose`
: Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
: Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
: Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Common Options

`+`*toolchain*
: If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE or PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may

be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

  This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
: Prints help information.

`-Z` *flag*
: Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Create a binary Cargo package in the current directory:

```
cargo init
```

SEE ALSO

cargo(1), cargo-new(1)

cargo-install(1)

NAME

cargo-install — Build and install a Rust binary

SYNOPSIS

`cargo install` [*options*] *crate*[@*version*]…
`cargo install` [*options*] `--path` *path*
`cargo install` [*options*] `--git` *url* [*crate*…]
`cargo install` [*options*] `--list`

DESCRIPTION

This command manages Cargo's local set of installed binary crates. Only packages which have executable `[[bin]]` or `[[example]]` targets can be installed, and all executables are installed into the installation root's `bin` folder.

The installation root is determined, in order of precedence:

- `--root` option
- `CARGO_INSTALL_ROOT` environment variable
- `install.root` Cargo config value
- `CARGO_HOME` environment variable
- `$HOME/.cargo`

There are multiple sources from which a crate can be installed. The default location is crates.io but the `--git`, `--path`, and `--registry` flags can change this source. If the source contains more than one package (such as crates.io or a git repository with multiple crates) the *crate* argument is required to indicate which crate should be installed.

Crates from crates.io can optionally specify the version they wish to install via the `--version` flags, and similarly packages from git repositories can optionally specify the branch, tag, or revision that should be installed. If a crate has multiple binaries, the `--bin` argument can selectively install only one of them, and if you'd rather install examples the `--example` argument can be used as well.

If the package is already installed, Cargo will reinstall it if the installed version does not appear to be up-to-date. If any of the following values change, then Cargo will reinstall the package:

- The package version and source.
- The set of binary names installed.
- The chosen features.
- The profile (`--profile`).
- The target (`--target`).

Installing with `--path` will always build and install, unless there are conflicting binaries from another package. The `--force` flag may be used to force Cargo to always reinstall the package.

If the source is crates.io or `--git` then by default the crate will be built in a temporary target directory. To avoid this, the target directory can be specified by setting the `CARGO_TARGET_DIR` environment variable to a relative path. In particular, this can be useful for caching build artifacts on continuous integration systems.

Dealing with the Lockfile

By default, the `Cargo.lock` file that is included with the package will be ignored. This means that Cargo will recompute which versions of dependencies to use, possibly using newer versions that have been released since the package was published. The `--locked` flag can be used to force Cargo to use the packaged `Cargo.lock` file if it is available. This may be useful for ensuring reproducible builds, to use the exact same set of dependencies that were available when the package was published. It may also be useful if a newer version of a dependency is published that no longer builds on your system, or has other problems. The downside to using `--locked` is that you will not receive any fixes or updates to any dependency. Note that Cargo did not start publishing `Cargo.lock` files until version 1.37, which means packages published with prior versions will not have a `Cargo.lock` file available.

Configuration Discovery

This command operates on system or user level, not project level. This means that the local configuration discovery is ignored. Instead, the configuration discovery begins at `$CARGO_HOME/config.toml`. If the package is installed with `--path $PATH`, the local configuration will be used, beginning discovery at `$PATH/.cargo/config.toml`.

OPTIONS

Install Options

`--vers` *version*
`--version` *version*
Specify a version to install. This may be a version requirement, like `~1.2`, to have Cargo select the newest version from the given requirement. If the version

does not have a requirement operator (such as `^` or `~`), then it must be in the form *MAJOR.MINOR.PATCH*, and will install exactly that version; it is *not* treated as a caret requirement like Cargo dependencies are.

`--git` *url*
Git URL to install the specified crate from.

`--branch` *branch*
Branch to use when installing from git.

`--tag` *tag*
Tag to use when installing from git.

`--rev` *sha*
Specific commit to use when installing from git.

`--path` *path*
Filesystem path to local crate to install.

`--list`
List all installed packages and their versions.

`-f`
`--force`
Force overwriting existing crates or binaries. This can be used if a package has installed a binary with the same name as another package. This is also useful if something has changed on the system that you want to rebuild with, such as a newer version of `rustc`.

`--no-track`
By default, Cargo keeps track of the installed packages with a metadata file stored in the installation root directory. This flag tells Cargo not to use or create that file. With this flag, Cargo will refuse to overwrite any existing files unless the `--force` flag is used. This also disables Cargo's ability to protect against multiple concurrent invocations of Cargo installing at the same time.

`--bin` *name…*
Install only the specified binary.

`--bins`
Install all binaries.

`--example` *name…*
Install only the specified example.

`--examples`
Install all examples.

`--root` *dir*
Directory to install packages into.

`--registry` *registry*
Name of the registry to use. Registry names are defined in Cargo config files. If not specified, the default registry is used, which is defined by the `registry.default` config key which defaults to `crates-io`.

`--index` *index*
The URL of the registry index to use.

Feature Selection

The feature flags allow you to control which features are enabled. When no feature options are given, the `default` feature is activated for every selected package.

See the features documentation for more details.

`-F` *features*
`--features` *features*
Space or comma separated list of features to activate. Features of workspace members may be enabled with `package-name/feature-name` syntax. This flag may be specified multiple times, which enables all specified features.

`--all-features`
Activate all available features of all selected packages.

`--no-default-features`
Do not activate the `default` feature of the selected packages.

Compilation Options

`--target` *triple*
Install for the given architecture. The default is the host architecture. The general format of the triple is `<arch><sub>-<vendor>-<sys>-<abi>`. Run `rustc --print target-list` for a list of supported targets.

This may also be specified with the `build.target` config value.

Note that specifying this flag makes Cargo run in a different mode where the target artifacts are placed in a separate directory. See the build cache documentation for more details.

`--target-dir` *directory*
Directory for all generated artifacts and intermediate files. May also be specified with the `CARGO_TARGET_DIR` environment variable, or the `build.target-dir` config value. Defaults to a new temporary folder located in the temporary directory of the platform.

When using `--path`, by default it will use `target` directory in the workspace of the local crate unless `--target-dir` is specified.

`--debug`
Build with the `dev` profile instead the `release` profile. See also the `--profile` option for choosing a specific profile by name.

`--profile` *name*
Install with the given profile. See the the reference for more details on profiles.

`--ignore-rust-version`
Install the target even if the selected Rust compiler is older than the required Rust version as configured in the project's `rust-version` field.

`--timings=`*fmts*
Output information how long each compilation takes, and track concurrency information over time. Accepts an optional comma-separated list of output formats; `--timings` without an argument will default to `--timings=html`. Specifying an output format (rather than the default) is unstable and requires `-Zunstable-options`. Valid output formats:

- `html` (unstable, requires `-Zunstable-options`): Write a human-readable file `cargo-timing.html` to the `target/cargo-timings` directory with a report of the compilation. Also write a report to the same directory with a timestamp in the filename if you want to look at older runs. HTML output is suitable for human consumption only, and does not provide machine-readable timing data.
- `json` (unstable, requires `-Zunstable-options`): Emit machine-readable JSON information about timing information.

Manifest Options

`--frozen`
`--locked`
Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Miscellaneous Options

`-j` *N*
`--jobs` *N*
Number of parallel jobs to run. May also be specified with the `build.jobs` config value. Defaults to the number of logical CPUs. If negative, it sets the maximum

number of parallel jobs to the number of logical CPUs plus provided value. Should not be 0.

`--keep-going`
Build as many crates in the dependency graph as possible, rather than aborting the build on the first one that fails to build. Unstable, requires `-Zunstable-options`.

Display Options

`-v`
`--verbose`
Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

`--message-format` *fmt*
The output format for diagnostic messages. Can be specified multiple times and consists of comma-separated values. Valid values:

- `human` (default): Display in a human-readable text format. Conflicts with `short` and `json`.
- `short`: Emit shorter, human-readable text messages. Conflicts with `human` and `json`.
- `json`: Emit JSON messages to stdout. See the reference for more details. Conflicts with `human` and `short`.
- `json-diagnostic-short`: Ensure the `rendered` field of JSON messages contains the "short" rendering from rustc. Cannot be used with `human` or `short`.
- `json-diagnostic-rendered-ansi`: Ensure the `rendered` field of JSON messages contains embedded ANSI color codes for respecting rustc's default color scheme. Cannot be used with `human` or `short`.
- `json-render-diagnostics`: Instruct Cargo to not include rustc diagnostics in JSON messages printed, but instead Cargo itself should render the JSON diagnostics coming from rustc. Cargo's own JSON diagnostics and others coming from rustc are still emitted. Cannot be used with `human` or `short`.

Common Options

`+`*toolchain*
: If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
: Prints help information.

`-Z` *flag*
: Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Install or upgrade a package from crates.io:

```
cargo install ripgrep
```

2. Install or reinstall the package in the current directory:

   ```
   cargo install --path .
   ```

3. View the list of installed packages:

   ```
   cargo install --list
   ```

SEE ALSO

cargo(1), cargo-uninstall(1), cargo-search(1), cargo-publish(1)

cargo-new(1)

NAME

cargo-new — Create a new Cargo package

SYNOPSIS

`cargo new` [*options*] *path*

DESCRIPTION

This command will create a new Cargo package in the given directory. This includes a simple template with a `Cargo.toml` manifest, sample source file, and a VCS ignore file. If the directory is not already in a VCS repository, then a new repository is created (see `--vcs` below).

See cargo-init(1) for a similar command which will create a new manifest in an existing directory.

OPTIONS

New Options

`--bin`
Create a package with a binary target (`src/main.rs`). This is the default behavior.

`--lib`
Create a package with a library target (`src/lib.rs`).

`--edition` *edition*
Specify the Rust edition to use. Default is 2021. Possible values: 2015, 2018, 2021

`--name` *name*
Set the package name. Defaults to the directory name.

`--vcs` *vcs*
Initialize a new VCS repository for the given version control system (git, hg, pijul, or fossil) or do not initialize any version control at all (none). If

not specified, defaults to `git` or the configuration value `cargo-new.vcs`, or `none` if already inside a VCS repository.

`--registry` *registry*
: This sets the `publish` field in `Cargo.toml` to the given registry name which will restrict publishing only to that registry.

  Registry names are defined in Cargo config files. If not specified, the default registry defined by the `registry.default` config key is used. If the default registry is not set and `--registry` is not used, the `publish` field will not be set which means that publishing will not be restricted.

Display Options

`-v`
`--verbose`
: Use verbose output. May be specified twice for “very verbose” output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
: Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
: Control when colored output is used. Valid values:

  - `auto` (default): Automatically detect if color support is available on the terminal.
  - `always`: Always display colors.
  - `never`: Never display colors.

  May also be specified with the `term.color` config value.

Common Options

`+`*toolchain*
: If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE or PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*

Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Create a binary Cargo package in the given directory:

```
cargo new foo
```

SEE ALSO

cargo(1), cargo-init(1)

cargo-search(1)

NAME

cargo-search — Search packages in crates.io

SYNOPSIS

`cargo search` [*options*] [*query…*]

DESCRIPTION

This performs a textual search for crates on https://crates.io. The matching crates will be displayed along with their description in TOML format suitable for copying into a `Cargo.toml` manifest.

OPTIONS

Search Options

`--limit` *limit*
Limit the number of results (default: 10, max: 100).

`--index` *index*
The URL of the registry index to use.

`--registry` *registry*
Name of the registry to use. Registry names are defined in Cargo config files. If not specified, the default registry is used, which is defined by the `registry.default` config key which defaults to `crates-io`.

Display Options

`-v`
`--verbose`
Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Common Options

`+`*toolchain*
If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Search for a package from crates.io:

```
cargo search serde
```

SEE ALSO

cargo(1), cargo-install(1), cargo-publish(1)

cargo-uninstall(1)

NAME

cargo-uninstall — Remove a Rust binary

SYNOPSIS

`cargo uninstall` [*options*] [*spec…*]

DESCRIPTION

This command removes a package installed with cargo-install(1). The *spec* argument is a package ID specification of the package to remove (see cargo-pkgid(1)).

By default all binaries are removed for a crate but the `--bin` and `--example` flags can be used to only remove particular binaries.

The installation root is determined, in order of precedence:

- `--root` option
- `CARGO_INSTALL_ROOT` environment variable
- `install.root` Cargo config value
- `CARGO_HOME` environment variable
- `$HOME/.cargo`

OPTIONS

Install Options

`-p`
`--package` *spec…*
    Package to uninstall.

`--bin` *name…*
    Only uninstall the binary *name*.

`--root` *dir*
    Directory to uninstall packages from.

Display Options

`-v`
`--verbose`
Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Common Options

`+`*toolchain*
If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Uninstall a previously installed package.

   ```
   cargo uninstall ripgrep
   ```

SEE ALSO

cargo(1), cargo-install(1)

Publishing Commands

- `cargo login`
- `cargo logout`
- `cargo owner`
- `cargo package`
- `cargo publish`
- `cargo yank`

cargo-login(1)

NAME

cargo-login — Save an API token from the registry locally

SYNOPSIS

`cargo login` [*options*] [*token*]

DESCRIPTION

This command will save the API token to disk so that commands that require authentication, such as cargo-publish(1), will be automatically authenticated. The token is saved in `$CARGO_HOME/credentials.toml`. `CARGO_HOME` defaults to `.cargo` in your home directory.

If the *token* argument is not specified, it will be read from stdin.

The API token for crates.io may be retrieved from https://crates.io/me.

Take care to keep the token secret, it should not be shared with anyone else.

OPTIONS

Login Options

`--registry` *registry*
: Name of the registry to use. Registry names are defined in Cargo config files. If not specified, the default registry is used, which is defined by the `registry.default` config key which defaults to `crates-io`.

Display Options

`-v`
`--verbose`
: Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Common Options

`+`*toolchain*
If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Save the API token to disk:

```
cargo login
```

SEE ALSO

cargo(1), cargo-logout(1), cargo-publish(1)

cargo-logout(1)

NAME

cargo-logout — Remove an API token from the registry locally

SYNOPSIS

`cargo logout` [*options*]

DESCRIPTION

This command will remove the API token from the local credential storage. Credentials are stored in `$CARGO_HOME/credentials.toml` where `$CARGO_HOME` defaults to `.cargo` in your home directory.

If `--registry` is not specified, then the credentials for the default registry will be removed (configured by `registry.default`, which defaults to https://crates.io/).

This will not revoke the token on the server. If you need to revoke the token, visit the registry website and follow its instructions (see https://crates.io/me to revoke the token for https://crates.io/).

OPTIONS

Logout Options

`--registry` *registry*
: Name of the registry to use. Registry names are defined in Cargo config files. If not specified, the default registry is used, which is defined by the `registry.default` config key which defaults to `crates-io`.

Display Options

`-v`
`--verbose`
: Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May

also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Common Options

`+`*toolchain*
If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Remove the default registry token:

```
cargo logout
```

2. Remove the token for a specific registry:

```
cargo logout --registry my-registry
```

SEE ALSO

cargo(1), cargo-login(1)

cargo-owner(1)

NAME

cargo-owner — Manage the owners of a crate on the registry

SYNOPSIS

`cargo owner` [*options*] `--add` *login* [*crate*]
`cargo owner` [*options*] `--remove` *login* [*crate*]
`cargo owner` [*options*] `--list` [*crate*]

DESCRIPTION

This command will modify the owners for a crate on the registry. Owners of a crate can upload new versions and yank old versions. Non-team owners can also modify the set of owners, so take care!

This command requires you to be authenticated with either the `--token` option or using cargo-login(1).

If the crate name is not specified, it will use the package name from the current directory.

See the reference for more information about owners and publishing.

OPTIONS

Owner Options

`-a`
`--add` *login*…
Invite the given user or team as an owner.

`-r`
`--remove` *login*…
Remove the given user or team as an owner.

`-l`
`--list`

List owners of a crate.

`--token` *token*
API token to use when authenticating. This overrides the token stored in the credentials file (which is created by cargo-login(1)).

Cargo config environment variables can be used to override the tokens stored in the credentials file. The token for crates.io may be specified with the `CARGO_REGISTRY_TOKEN` environment variable. Tokens for other registries may be specified with environment variables of the form `CARGO_REGISTRIES_NAME_TOKEN` where `NAME` is the name of the registry in all capital letters.

`--index` *index*
The URL of the registry index to use.

`--registry` *registry*
Name of the registry to use. Registry names are defined in Cargo config files. If not specified, the default registry is used, which is defined by the `registry.default` config key which defaults to `crates-io`.

Display Options

`-v`
`--verbose`
Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Common Options

`+`*toolchain*
If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
: Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

  This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
: Prints help information.

`-Z` *flag*
: Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. List owners of a package:

   ```
   cargo owner --list foo
   ```

2. Invite an owner to a package:

   ```
   cargo owner --add username foo
   ```

3. Remove an owner from a package:

```
cargo owner --remove username foo
```

SEE ALSO

cargo(1), cargo-login(1), cargo-publish(1)

cargo-package(1)

NAME

cargo-package — Assemble the local package into a distributable tarball

SYNOPSIS

`cargo package` [*options*]

DESCRIPTION

This command will create a distributable, compressed `.crate` file with the source code of the package in the current directory. The resulting file will be stored in the `target/package` directory. This performs the following steps:

1. Load and check the current workspace, performing some basic checks.
   - Path dependencies are not allowed unless they have a version key. Cargo will ignore the path key for dependencies in published packages. `dev-dependencies` do not have this restriction.
2. Create the compressed `.crate` file.
   - The original `Cargo.toml` file is rewritten and normalized.
   - `[patch]`, `[replace]`, and `[workspace]` sections are removed from the manifest.
   - `Cargo.lock` is automatically included if the package contains an executable binary or example target. cargo-install(1) will use the packaged lock file if the `--locked` flag is used.
   - A `.cargo_vcs_info.json` file is included that contains information about the current VCS checkout hash if available (not included with `--allow-dirty`).
3. Extract the `.crate` file and build it to verify it can build.
   - This will rebuild your package from scratch to ensure that it can be built from a pristine state. The `--no-verify` flag can be used to skip this step.
4. Check that build scripts did not modify any source files.

The list of files included can be controlled with the `include` and `exclude` fields in the manifest.

See the reference for more details about packaging and publishing.

.cargo_vcs_info.json format

Will generate a `.cargo_vcs_info.json` in the following format

```
{
 "git": {
   "sha1": "aac20b6e7e543e6dd4118b246c77225e3a3a1302"
 },
 "path_in_vcs": ""
}
```

`path_in_vcs` will be set to a repo-relative path for packages in subdirectories of the version control repository.

OPTIONS

Package Options

`-l`
`--list`
    Print files included in a package without making one.

`--no-verify`
    Don't verify the contents by building them.

`--no-metadata`
    Ignore warnings about a lack of human-usable metadata (such as the description or the license).

`--allow-dirty`
    Allow working directories with uncommitted VCS changes to be packaged.

Package Selection

By default, when no package selection options are given, the packages selected depend on the selected manifest file (based on the current working directory if `--manifest-path` is not given). If the manifest is the root of a workspace then the workspaces default members are selected, otherwise only the package defined by the manifest will be selected.

The default members of a workspace can be set explicitly with the `workspace.default-members` key in the root manifest. If this is not set, a virtual workspace will include all workspace members (equivalent to passing `--workspace`), and a non-virtual workspace will include only the root crate itself.

`-p` *spec*…
`--package` *spec*…

Package only the specified packages. See cargo-pkgid(1) for the SPEC format. This flag may be specified multiple times and supports common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each pattern.

`--workspace`
Package all members in the workspace.

`--exclude` *SPEC…*
Exclude the specified packages. Must be used in conjunction with the `--workspace` flag. This flag may be specified multiple times and supports common Unix glob patterns like `*`, `?` and `[]`. However, to avoid your shell accidentally expanding glob patterns before Cargo handles them, you must use single quotes or double quotes around each pattern.

Compilation Options

`--target` *triple*
Package for the given architecture. The default is the host architecture. The general format of the triple is `<arch><sub>-<vendor>-<sys>-<abi>`. Run `rustc --print target-list` for a list of supported targets. This flag may be specified multiple times.

This may also be specified with the `build.target` config value.

Note that specifying this flag makes Cargo run in a different mode where the target artifacts are placed in a separate directory. See the build cache documentation for more details.

`--target-dir` *directory*
Directory for all generated artifacts and intermediate files. May also be specified with the `CARGO_TARGET_DIR` environment variable, or the `build.target-dir` config value. Defaults to `target` in the root of the workspace.

Feature Selection

The feature flags allow you to control which features are enabled. When no feature options are given, the `default` feature is activated for every selected package.

See the features documentation for more details.

`-F` *features*
`--features` *features*
Space or comma separated list of features to activate. Features of workspace members may be enabled with `package-name/feature-name` syntax. This flag may be specified multiple times, which enables all specified features.

`--all-features`
Activate all available features of all selected packages.

`--no-default-features`

Do not activate the `default` feature of the selected packages.

Manifest Options

`--manifest-path` *path*
: Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
: Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
: Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Miscellaneous Options

`-j` *N*
`--jobs` *N*
: Number of parallel jobs to run. May also be specified with the `build.jobs` config value. Defaults to the number of logical CPUs. If negative, it sets the maximum number of parallel jobs to the number of logical CPUs plus provided value. Should not be 0.

`--keep-going`
: Build as many crates in the dependency graph as possible, rather than aborting the build on the first one that fails to build. Unstable, requires `-Zunstable-options`.

Display Options

`-v`
`--verbose`

Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Common Options

`+`*toolchain*
If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Create a compressed `.crate` file of the current package:

   ```
   cargo package
   ```

SEE ALSO

cargo(1), cargo-publish(1)

cargo-publish(1)

NAME

cargo-publish — Upload a package to the registry

SYNOPSIS

`cargo publish` [*options*]

DESCRIPTION

This command will create a distributable, compressed `.crate` file with the source code of the package in the current directory and upload it to a registry. The default registry is https://crates.io. This performs the following steps:

1. Performs a few checks, including:
    - Checks the `package.publish` key in the manifest for restrictions on which registries you are allowed to publish to.
2. Create a `.crate` file by following the steps in cargo-package(1).
3. Upload the crate to the registry. Note that the server will perform additional checks on the crate.

This command requires you to be authenticated with either the `--token` option or using cargo-login(1).

See the reference for more details about packaging and publishing.

OPTIONS

Publish Options

`--dry-run`
Perform all checks without uploading.

`--token` *token*
API token to use when authenticating. This overrides the token stored in the credentials file (which is created by cargo-login(1)).

Cargo config environment variables can be used to override the tokens stored in the credentials file. The token for crates.io may be specified with the `CARGO_REGISTRY_TOKEN` environment variable. Tokens for other registries may be specified with environment variables of the form `CARGO_REGISTRIES_NAME_TOKEN` where `NAME` is the name of the registry in all capital letters.

`--no-verify`
Don't verify the contents by building them.

`--allow-dirty`
Allow working directories with uncommitted VCS changes to be packaged.

`--index` *index*
The URL of the registry index to use.

`--registry` *registry*
Name of the registry to publish to. Registry names are defined in Cargo config files. If not specified, and there is a `package.publish` field in `Cargo.toml` with a single registry, then it will publish to that registry. Otherwise it will use the default registry, which is defined by the `registry.default` config key which defaults to `crates-io`.

Package Selection

By default, the package in the current working directory is selected. The `-p` flag can be used to choose a different package in a workspace.

`-p` *spec*
`--package` *spec*
The package to publish. See cargo-pkgid(1) for the SPEC format.

Compilation Options

`--target` *triple*
Publish for the given architecture. The default is the host architecture. The general format of the triple is `<arch><sub>-<vendor>-<sys>-<abi>`. Run `rustc --print target-list` for a list of supported targets. This flag may be specified multiple times.

This may also be specified with the `build.target` config value.

Note that specifying this flag makes Cargo run in a different mode where the target artifacts are placed in a separate directory. See the build cache documentation for more details.

`--target-dir` *directory*
Directory for all generated artifacts and intermediate files. May also be specified with the `CARGO_TARGET_DIR` environment variable, or the `build.target-dir` config value. Defaults to `target` in the root of the workspace.

Feature Selection

The feature flags allow you to control which features are enabled. When no feature options are given, the `default` feature is activated for every selected package.

See the features documentation for more details.

`-F` *features*
`--features` *features*
: Space or comma separated list of features to activate. Features of workspace members may be enabled with `package-name/feature-name` syntax. This flag may be specified multiple times, which enables all specified features.

`--all-features`
: Activate all available features of all selected packages.

`--no-default-features`
: Do not activate the `default` feature of the selected packages.

Manifest Options

`--manifest-path` *path*
: Path to the `Cargo.toml` file. By default, Cargo searches for the `Cargo.toml` file in the current directory or any parent directory.

`--frozen`
`--locked`
: Either of these flags requires that the `Cargo.lock` file is up-to-date. If the lock file is missing, or it needs to be updated, Cargo will exit with an error. The `--frozen` flag also prevents Cargo from attempting to access the network to determine if it is out-of-date.

These may be used in environments where you want to assert that the `Cargo.lock` file is up-to-date (such as a CI build) or want to avoid network access.

`--offline`
: Prevents Cargo from accessing the network for any reason. Without this flag, Cargo will stop with an error if it needs to access the network and the network is not available. With this flag, Cargo will attempt to proceed without the network if possible.

Beware that this may result in different dependency resolution than online mode. Cargo will restrict itself to crates that are downloaded locally, even if there might be a newer version as indicated in the local copy of the index. See the cargo-fetch(1) command to download dependencies before going offline.

May also be specified with the `net.offline` config value.

Miscellaneous Options

`-j` *N*
`--jobs` *N*

Number of parallel jobs to run. May also be specified with the `build.jobs` config value. Defaults to the number of logical CPUs. If negative, it sets the maximum number of parallel jobs to the number of logical CPUs plus provided value. Should not be 0.

`--keep-going`
Build as many crates in the dependency graph as possible, rather than aborting the build on the first one that fails to build. Unstable, requires `-Zunstable-options`.

Display Options

`-v`
`--verbose`
Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Common Options

`+`*toolchain*
If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for

discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
Prints help information.

`-Z` *flag*
Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Publish the current package:

```
cargo publish
```

SEE ALSO

cargo(1), cargo-package(1), cargo-login(1)

cargo-yank(1)

NAME

cargo-yank — Remove a pushed crate from the index

SYNOPSIS

`cargo yank` [*options*] *crate*@*version*
`cargo yank` [*options*] `--version` *version* [*crate*]

DESCRIPTION

The yank command removes a previously published crate's version from the server's index. This command does not delete any data, and the crate will still be available for download via the registry's download link.

Note that existing crates locked to a yanked version will still be able to download the yanked version to use it. Cargo will, however, not allow any new crates to be locked to any yanked version.

This command requires you to be authenticated with either the `--token` option or using cargo-login(1).

If the crate name is not specified, it will use the package name from the current directory.

OPTIONS

Yank Options

`--vers` *version*
`--version` *version*
The version to yank or un-yank.

`--undo`
Undo a yank, putting a version back into the index.

`--token` *token*

API token to use when authenticating. This overrides the token stored in the credentials file (which is created by cargo-login(1)).

Cargo config environment variables can be used to override the tokens stored in the credentials file. The token for crates.io may be specified with the `CARGO_REGISTRY_TOKEN` environment variable. Tokens for other registries may be specified with environment variables of the form `CARGO_REGISTRIES_NAME_TOKEN` where `NAME` is the name of the registry in all capital letters.

`--index` *index*
The URL of the registry index to use.

`--registry` *registry*
Name of the registry to use. Registry names are defined in Cargo config files. If not specified, the default registry is used, which is defined by the `registry.default` config key which defaults to `crates-io`.

Display Options

`-v`
`--verbose`
Use verbose output. May be specified twice for "very verbose" output which includes extra output such as dependency warnings and build script output. May also be specified with the `term.verbose` config value.

`-q`
`--quiet`
Do not print cargo log messages. May also be specified with the `term.quiet` config value.

`--color` *when*
Control when colored output is used. Valid values:

- `auto` (default): Automatically detect if color support is available on the terminal.
- `always`: Always display colors.
- `never`: Never display colors.

May also be specified with the `term.color` config value.

Common Options

`+`*toolchain*
If Cargo has been installed with rustup, and the first argument to `cargo` begins with `+`, it will be interpreted as a rustup toolchain name (such as `+stable` or `+nightly`). See the rustup documentation for more information about how toolchain overrides work.

`--config` *KEY=VALUE* or *PATH*
Overrides a Cargo configuration value. The argument should be in TOML syntax of `KEY=VALUE`, or provided as a path to an extra configuration file. This flag may

be specified multiple times. See the command-line overrides section for more information.

`-C` *PATH*
: Changes the current working directory before executing any specified operations. This affects things like where cargo looks by default for the project manifest (`Cargo.toml`), as well as the directories searched for discovering `.cargo/config.toml`, for example. This option must appear before the command name, for example `cargo -C path/to/my-project build`.

This option is only available on the nightly channel and requires the `-Z unstable-options` flag to enable (see #10098).

`-h`
`--help`
: Prints help information.

`-Z` *flag*
: Unstable (nightly-only) flags to Cargo. Run `cargo -Z help` for details.

ENVIRONMENT

See the reference for details on environment variables that Cargo reads.

EXIT STATUS

- `0`: Cargo succeeded.
- `101`: Cargo failed to complete.

EXAMPLES

1. Yank a crate from the index:

```
cargo yank foo@1.0.7
```

SEE ALSO

cargo(1), cargo-login(1), cargo-publish(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.com 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 package 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 packages 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 packages 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 packages 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 packages 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 you encounter an issue while running on Windows, 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` lockfile is to describe the state of the world at the time of a successful build. Cargo uses the lockfile to provide deterministic builds on different times and different systems, by ensuring that the exact same dependencies and versions are used as when the `Cargo.lock` file was originally generated.

This property is most desirable from applications and packages 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 Cargo used all of the dependencies' `Cargo.lock` files, then multiple copies of the library could 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 come 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.

The `--offline` flag was added in Rust 1.36.0. This flag tells Cargo to not access the network, and try to proceed with available cached data if possible. You can use `cargo fetch` in one project to download dependencies before going offline, and then use those same dependencies in another project with the `--offline` flag (or configuration value).

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

Why is Cargo rebuilding my code?

Cargo is responsible for incrementally compiling crates in your project. This means that if you type `cargo build` twice the second one shouldn't rebuild your crates.io dependencies, for example. Nevertheless bugs arise and Cargo can sometimes rebuild code when you're not expecting it!

We've long wanted to provide better diagnostics about this but unfortunately haven't been able to make progress on that issue in quite some time. In the meantime, however, you can debug a rebuild at least a little by setting the `CARGO_LOG` environment variable:

```
$ CARGO_LOG=cargo::core::compiler::fingerprint=info cargo build
```

This will cause Cargo to print out a lot of information about diagnostics and rebuilding. This can often contain clues as to why your project is getting rebuilt, although you'll often need to connect some dots yourself since this output isn't super easy to read just yet. Note that the `CARGO_LOG` needs to be set for the command that rebuilds when you think it should not. Unfortunately Cargo has no way right now of after-the-fact debugging "why was that rebuilt?"

Some issues we've seen historically which can cause crates to get rebuilt are:

- A build script prints `cargo:rerun-if-changed=foo` where `foo` is a file that doesn't exist and nothing generates it. In this case Cargo will keep running the build script thinking it will generate the file but nothing ever does. The fix is to avoid printing `rerun-if-changed` in this scenario.

- Two successive Cargo builds may differ in the set of features enabled for some dependencies. For example if the first build command builds the whole workspace and the second command builds only one crate, this may cause a dependency on crates.io to have a different set of features enabled, causing it and everything that depends on it to get rebuilt. There's unfortunately not really a great fix for this, although if possible it's best to have the set of features enabled on a crate constant regardless of what you're building in your workspace.

- Some filesystems exhibit unusual behavior around timestamps. Cargo primarily uses timestamps on files to govern whether rebuilding needs to happen, but if you're using a nonstandard filesystem it may be affecting the timestamps somehow (e.g. truncating them, causing them to drift, etc). In this scenario, feel free to open an issue and we can see if we can accommodate the filesystem somehow.

- A concurrent build process is either deleting artifacts or modifying files. Sometimes you might have a background process that either tries to build or check your project. These background processes might surprisingly delete some build artifacts or touch files (or maybe just by accident), which can cause rebuilds to look spurious! The best fix here would be to wrangle the background process to avoid clashing with your work.

If after trying to debug your issue, however, you're still running into problems then feel free to open an issue!

Glossary

Artifact

An *artifact* is the file or set of files created as a result of the compilation process. This includes linkable libraries, executable binaries, and generated documentation.

Cargo

Cargo is the Rust *package manager*, and the primary topic of this book.

Cargo.lock

See *lock file*.

Cargo.toml

See *manifest*.

Crate

A Rust *crate* is either a library or an executable program, referred to as either a *library crate* or a *binary crate*, respectively.

Every target defined for a Cargo package is a *crate*.

Loosely, the term *crate* may refer to either the source code of the target or to the compiled artifact that the target produces. It may also refer to a compressed package fetched from a registry.

The source code for a given crate may be subdivided into *modules*.

Edition

A *Rust edition* is a developmental landmark of the Rust language. The edition of a package is specified in the `Cargo.toml` manifest, and individual targets can specify which edition they use. See the Edition Guide for more information.

Feature

The meaning of *feature* depends on the context:

- A *feature* is a named flag which allows for conditional compilation. A feature can refer to an optional dependency, or an arbitrary name defined in a `Cargo.toml` manifest that can be checked within source code.
- Cargo has *unstable feature flags* which can be used to enable experimental behavior of Cargo itself.
- The Rust compiler and Rustdoc have their own unstable feature flags (see The Unstable Book and The Rustdoc Book).
- CPU targets have *target features* which specify capabilities of a CPU.

Index

The *index* is the searchable list of *crates* in a *registry*.

Lock file

The `Cargo.lock` *lock file* is a file that captures the exact version of every dependency used in a *workspace* or *package*. It is automatically generated by Cargo. See Cargo.toml vs Cargo.lock.

Manifest

A *manifest* is a description of a package or a workspace in a file named `Cargo.toml`.

A *virtual manifest* is a `Cargo.toml` file that only describes a workspace, and does not include a package.

Member

A *member* is a *package* that belongs to a *workspace*.

Module

Rust's module system is used to organize code into logical units called *modules*, which provide isolated namespaces within the code.

The source code for a given crate may be subdivided into one or more separate modules. This is usually done to organize the code into areas of related functionality or to control the visible scope (public/private) of symbols within the source (structs, functions, and so on).

A `Cargo.toml` file is primarily concerned with the package it defines, its crates, and the packages of the crates on which they depend. Nevertheless, you will see the term "module" often when working with Rust, so you should understand its relationship to a given crate.

Package

A *package* is a collection of source files and a `Cargo.toml` *manifest* file which describes the package. A package has a name and version which is used for specifying dependencies between packages.

A package contains multiple *targets*, each of which is a *crate*. The `Cargo.toml` file describes the type of the crates (binary or library) within the package, along with some metadata about each one — how each is to be built, what their direct dependencies are, etc., as described throughout this book.

The *package root* is the directory where the package's `Cargo.toml` manifest is located. (Compare with *workspace root*.)

The *package ID specification*, or *SPEC*, is a string used to uniquely reference a specific version of a package from a specific source.

Small to medium sized Rust projects will only need a single package, though it is common for them to have multiple crates.

Larger projects may involve multiple packages, in which case Cargo *workspaces* can be used to manage common dependencies and other related metadata between the packages.

Package manager

Broadly speaking, a *package manager* is a program (or collection of related programs) in a software ecosystem that automates the process of obtaining, installing, and upgrading artifacts. Within a programming language ecosystem, a package manager is a developer-focused tool whose primary functionality is to download library artifacts and their dependencies from some central repository; this capability is often combined with the ability to perform software builds (by invoking the language-specific compiler).

Cargo is the package manager within the Rust ecosystem. Cargo downloads your Rust package's dependencies (*artifacts* known as *crates*), compiles your packages, makes distributable packages, and (optionally) uploads them to crates.io, the Rust community's *package registry*.

Package registry

See *registry*.

Project

Another name for a package.

Registry

A *registry* is a service that contains a collection of downloadable *crates* that can be installed or used as dependencies for a *package*. The default registry in the Rust ecosystem is crates.io. The registry has an *index* which contains a list of all crates, and tells Cargo how to download the crates that are needed.

Source

A *source* is a provider that contains *crates* that may be included as dependencies for a *package*. There are several kinds of sources:

- **Registry source** — See registry.
- **Local registry source** — A set of crates stored as compressed files on the filesystem. See Local Registry Sources.
- **Directory source** — A set of crates stored as uncompressed files on the filesystem. See Directory Sources.
- **Path source** — An individual package located on the filesystem (such as a path dependency) or a set of multiple packages (such as path overrides).
- **Git source** — Packages located in a git repository (such as a git dependency or git source).

See Source Replacement for more information.

Spec

See package ID specification.

Target

The meaning of the term *target* depends on the context:

- **Cargo Target** — Cargo *packages* consist of *targets* which correspond to *artifacts* that will be produced. Packages can have library, binary, example, test, and benchmark targets. The list of targets are configured in the `Cargo.toml` *manifest*, often inferred automatically by the directory layout of the source files.

- **Target Directory** — Cargo places all built artifacts and intermediate files in the *target* directory. By default this is a directory named `target` at the *workspace* root, or the package root if not using a workspace. The directory may be changed with the `--target-dir` command-line option, the `CARGO_TARGET_DIR` environment variable, or the `build.target-dir` config option.
- **Target Architecture** — The OS and machine architecture for the built artifacts are typically referred to as a *target*.
- **Target Triple** — A triple is a specific format for specifying a target architecture. Triples may be referred to as a *target triple* which is the architecture for the artifact produced, and the *host triple* which is the architecture that the compiler is running on. The target triple can be specified with the `--target` command-line option or the `build.target` config option. The general format of the triple is `<arch><sub>-<vendor>-<sys>-<abi>` where:
    - `arch` = The base CPU architecture, for example `x86_64`, `i686`, `arm`, `thumb`, `mips`, etc.
    - `sub` = The CPU sub-architecture, for example `arm` has `v7`, `v7s`, `v5te`, etc.
    - `vendor` = The vendor, for example `unknown`, `apple`, `pc`, `nvidia`, etc.
    - `sys` = The system name, for example `linux`, `windows`, `darwin`, etc. `none` is typically used for bare-metal without an OS.
    - `abi` = The ABI, for example `gnu`, `android`, `eabi`, etc.

  Some parameters may be omitted. Run `rustc --print target-list` for a list of supported targets.

Test Targets

Cargo *test targets* generate binaries which help verify proper operation and correctness of code. There are two types of test artifacts:

- **Unit test** — A *unit test* is an executable binary compiled directly from a library or a binary target. It contains the entire contents of the library or binary code, and runs `#[test]` annotated functions, intended to verify individual units of code.
- **Integration test target** — An *integration test target* is an executable binary compiled from a *test target* which is a distinct *crate* whose source is located in the `tests` directory or specified by the `[[test]]` table in the `Cargo.toml` *manifest*. It is intended to only test the public API of a library, or execute a binary to verify its operation.

Workspace

A *workspace* is a collection of one or more *packages* that share common dependency resolution (with a shared `Cargo.lock` *lock file*), output directory, and various settings such as profiles.

A *virtual workspace* is a workspace where the root `Cargo.toml` *manifest* does not define a package, and only lists the workspace *members*.

The *workspace root* is the directory where the workspace's `Cargo.toml` manifest is located. (Compare with *package root*.)

Git Authentication

Cargo supports some forms of authentication when using git dependencies and registries. This appendix contains some information for setting up git authentication in a way that works with Cargo.

If you need other authentication methods, the `net.git-fetch-with-cli` config value can be set to cause Cargo to execute the `git` executable to handle fetching remote repositories instead of using the built-in support. This can be enabled with the `CARGO_NET_GIT_FETCH_WITH_CLI=true` environment variable.

HTTPS authentication

HTTPS authentication requires the `credential.helper` mechanism. There are multiple credential helpers, and you specify the one you want to use in your global git configuration file.

```
# ~/.gitconfig

[credential]
helper = store
```

Cargo does not ask for passwords, so for most helpers you will need to give the helper the initial username/password before running Cargo. One way to do this is to run `git clone` of the private git repo and enter the username/password.

Tip:
macOS users may want to consider using the osxkeychain helper.
Windows users may want to consider using the GCM helper.

Note: Windows users will need to make sure that the `sh` shell is available in your `PATH`. This typically is available with the Git for Windows installation.

SSH authentication

SSH authentication requires `ssh-agent` to be running to acquire the SSH key. Make sure the appropriate environment variables are set up (`SSH_AUTH_SOCK` on most Unix-like systems), and that the correct keys are added (with `ssh-add`).

Windows can use Pageant (part of PuTTY) or `ssh-agent`. To use `ssh-agent`, Cargo needs to use the OpenSSH that is distributed as part of Windows, as Cargo does not support the simulated Unix-domain sockets used by MinGW or Cygwin. More information about installing with Windows can be found at the Microsoft installation documentation and the page on key management has instructions on how to start `ssh-agent` and to add keys.

> **Note:** Cargo does not support git's shorthand SSH URLs like `git@example.com:user/repo.git`. Use a full SSH URL like `ssh://git@example.com/user/repo.git`.

> **Note:** SSH configuration files (like OpenSSH's `~/.ssh/config`) are not used by Cargo's built-in SSH library. More advanced requirements should use `net.git-fetch-with-cli`.

SSH Known Hosts

When connecting to an SSH host, Cargo must verify the identity of the host using "known hosts", which are a list of host keys. Cargo can look for these known hosts in OpenSSH-style `known_hosts` files located in their standard locations (`.ssh/known_hosts` in your home directory, or `/etc/ssh/ssh_known_hosts` on Unix-like platforms or `%PROGRAMDATA%\ssh\ssh_known_hosts` on Windows). More information about these files can be found in the sshd man page. Alternatively, keys may be configured in a Cargo configuration file with `net.ssh.known-hosts`.

When connecting to an SSH host before the known hosts has been configured, Cargo will display an error message instructing you how to add the host key. This also includes a "fingerprint", which is a smaller hash of the host key, which should be easier to visually verify. The server administrator can get the fingerprint by running `ssh-keygen` against the public key (for example, `ssh-keygen -l -f /etc/ssh/ssh_host_ecdsa_key.pub`). Well-known sites may publish their fingerprints on the web; for example GitHub posts theirs at https://docs.github.com/en/authentication/keeping-your-account-and-data-secure/githubs-ssh-key-fingerprints.

Cargo comes with the host keys for github.com built-in. If those ever change, you can add the new keys to the config or known_hosts file.

> **Note:** Cargo doesn't support the `@cert-authority` or `@revoked` markers in `known_hosts` files. To make use of this functionality, use `net.git-fetch-with-cli`. This is also a good tip if Cargo's SSH client isn't behaving the way you expect it to.
