

# Improving build times

## Setup

Use a clang stdenv:

```
nix develop .#native-clangStdenvPackages
```

Then delete `build/` if you were using gcc before. Enable build-time profiling with:

```
just setup; meson configure build -Dprofile-build=enabled
```

Then run the build: `just compile`.

Enabling build-time profiling itself costs about 10% of compile time but has no other disadvantage.

## Build time reports

Use `maintainers/buildtime_report.sh build/` to generate a build time report. This will tell you where all our build time went by looking at the trace files and producing a badness summary.

## Sample report

### Build-time report sample

```
lix/lix2 » ClangBuildAnalyzer --analyze buildtimeold.bin
Analyzing build trace from 'buildtimeold.bin'...
**** Time summary:
Compilation (551 times):
  Parsing (frontend):      1465.3 s
  Codegen & opts (backend): 1110.9 s

**** Files that took longest to parse (compiler frontend):
10478 ms: build/src/libstore/liblixstore.so.p/build_local-derivation-goal.cc.o
10319 ms: build/src/libexpr/liblixexpr.so.p/primops.cc.o
 9947 ms: build/src/nix/nix.p/flake.cc.o
 9850 ms: build/src/libexpr/liblixexpr.so.p/eval.cc.o
```

9751 ms: build/src/nix/nix.p/profile.cc.o  
9643 ms: build/src/nix/nix.p/develop.cc.o  
9296 ms: build/src/libcmd/liblixcmd.so.p/installable-attr-path.cc.o  
9286 ms: build/src/libstore/liblixstore.so.p/build\_derivation-goal.cc.o  
9208 ms: build/src/libcmd/liblixcmd.so.p/installables.cc.o  
9007 ms: build/src/nix/nix.p/..\_nix-env\_nix-env.cc.o

\*\*\*\* Files that took longest to codegen (compiler backend):

24226 ms: build/src/libexpr/liblixexpr.so.p/primops\_fromTOML.cc.o  
24019 ms: build/src/libexpr/liblixexpr.so.p/primops.cc.o  
21102 ms: build/src/libstore/liblixstore.so.p/build\_local-derivation-goal.cc.o  
16246 ms: build/src/libstore/liblixstore.so.p/store-api.cc.o  
14586 ms: build/src/nix/nix.p/..\_nix-build\_nix-build.cc.o  
13746 ms: build/src/libexpr/liblixexpr.so.p/eval.cc.o  
13287 ms: build/src/libstore/liblixstore.so.p/binary-cache-store.cc.o  
13263 ms: build/src/nix/nix.p/profile.cc.o  
12970 ms: build/src/nix/nix.p/develop.cc.o  
12621 ms: build/src/libfetchers/liblixfetchers.so.p/github.cc.o

\*\*\*\* Templates that took longest to instantiate:

42922 ms: nlohmann::basic\_json<>::parse<const char\*> (69 times, avg 622 ms)  
32180 ms: nlohmann::detail::parser<nlohmann::basic\_json<>, nlohmann::detail::i... (69 times, avg 466 ms)  
27337 ms: nix::HintFmt::HintFmt<nix::Uncolored<std::basic\_string<char>>> (246 times, avg 111 ms)  
25338 ms: nlohmann::basic\_json<>::basic\_json (293 times, avg 86 ms)  
23641 ms: nlohmann::detail::parser<nlohmann::basic\_json<>, nlohmann::detail::i... (69 times, avg 342 ms)  
20203 ms: boost::basic\_format<char>::basic\_format (492 times, avg 41 ms)  
17174 ms: nlohmann::basic\_json<>::json\_value::json\_value (368 times, avg 46 ms)  
15603 ms: boost::basic\_format<char>::parse (246 times, avg 63 ms)  
13268 ms: std::basic\_regex<char>::\_M\_compile (28 times, avg 473 ms)  
12757 ms: std::\_\_detail::\_Compiler<std::regex\_traits<char>>::\_Compiler (28 times, avg 455 ms)  
10813 ms: std::\_\_detail::\_Compiler<std::regex\_traits<char>>::\_M\_disjunction (28 times, avg 386 ms)  
10719 ms: std::\_\_detail::\_Compiler<std::regex\_traits<char>>::\_M\_alternative (28 times, avg 382 ms)  
10508 ms: std::\_\_detail::\_Compiler<std::regex\_traits<char>>::\_M\_term (28 times, avg 375 ms)  
9516 ms: nlohmann::detail::json\_sax\_dom\_callback\_parser<nlohmann::basic\_json<... (69 times, avg 137 ms)  
9112 ms: std::\_\_detail::\_Compiler<std::regex\_traits<char>>::\_M\_atom (28 times, avg 325 ms)  
8683 ms: std::basic\_regex<char>::basic\_regex (18 times, avg 482 ms)  
8241 ms: std::operator<=> (438 times, avg 18 ms)  
7561 ms: std::vector<boost::io::detail::format\_item<char, std::char\_traits<ch... (246 times, avg 30 ms)

7475 ms: std::vector<boost::io::detail::format\_item<char, std::char\_traits<ch... (246 times, avg 30 ms)  
7309 ms: std::reverse\_iterator<std::\_Bit\_iterator> (268 times, avg 27 ms)  
7131 ms: boost::stacktrace::basic\_stacktrace<>::basic\_stacktrace (246 times, avg 28 ms)  
6868 ms: boost::stacktrace::basic\_stacktrace<>::init (246 times, avg 27 ms)  
6518 ms: std::reverse\_iterator<std::\_Bit\_const\_iterator> (268 times, avg 24 ms)  
5716 ms: std::\_\_detail::\_Synth3way::operator()<std::variant<nix::OutputsSpec:... (182 times, avg 31 ms)  
5303 ms: nix::make\_ref<nix::SingleDerivedPath, nix::DerivedPathOpaque> (178 times, avg 29 ms)  
5244 ms: std::\_uninitialized\_move\_a<boost::io::detail::format\_item<char, std... (246 times, avg 21 ms)  
4857 ms: std::make\_shared<nix::SingleDerivedPath, nix::DerivedPathOpaque> (178 times, avg 27 ms)  
4813 ms: std::\_\_detail::\_Synth3way::operator()<std::variant<nix::TextIngestio... (158 times, avg 30 ms)  
4648 ms: nlohmann::detail::json\_sax\_dom\_callback\_parser<nlohmann::basic\_json<... (69 times, avg 67 ms)  
4597 ms: std::basic\_regex<char>::basic\_regex<std::char\_traits<char>, std::all... (10 times, avg 459 ms)

\*\*\*\* Template sets that took longest to instantiate:

55715 ms: std::\_\_do\_visit<\$> (3603 times, avg 15 ms)  
47739 ms: std::\_\_detail::\_\_variant::\_\_gen\_vtable\_impl<\$>::\_\_visit\_invoke (11132 times, avg 4 ms)  
43338 ms: nlohmann::basic\_json<\$>::parse<\$> (85 times, avg 509 ms)  
43097 ms: std::\_\_detail::\_\_variant::\_\_raw\_idx\_visit<\$> (2435 times, avg 17 ms)  
32390 ms: nlohmann::detail::parser<\$>::parse (83 times, avg 390 ms)  
30986 ms: nix::HintFmt::HintFmt<\$> (1261 times, avg 24 ms)  
30255 ms: std::\_\_and<\$> (25661 times, avg 1 ms)  
29762 ms: std::unique\_ptr<\$> (2116 times, avg 14 ms)  
28609 ms: std::\_\_tuple\_compare<\$>::\_\_eq (2978 times, avg 9 ms)  
27560 ms: nlohmann::detail::parser<\$>::sax\_parse\_internal<\$> (167 times, avg 165 ms)  
27239 ms: std::variant<\$> (1959 times, avg 13 ms)  
26837 ms: std::\_\_invoke\_result<\$> (10782 times, avg 2 ms)  
25972 ms: std::tuple<\$> (5714 times, avg 4 ms)  
24247 ms: std::\_\_uniq\_ptr\_data<\$> (2116 times, avg 11 ms)  
24061 ms: std::\_\_result\_of\_impl<\$> (9029 times, avg 2 ms)  
23949 ms: std::\_\_uniq\_ptr\_impl<\$> (2116 times, avg 11 ms)  
21185 ms: std::optional<\$> (2502 times, avg 8 ms)  
21044 ms: std::pair<\$> (4989 times, avg 4 ms)  
20852 ms: std::\_\_or<\$> (24005 times, avg 0 ms)  
20203 ms: boost::basic\_format<\$>::basic\_format (492 times, avg 41 ms)  
20184 ms: std::tie<\$> (2895 times, avg 6 ms)  
19938 ms: nlohmann::basic\_json<\$>::create<\$> (668 times, avg 29 ms)  
19798 ms: std::allocator\_traits<\$>::construct<\$> (5720 times, avg 3 ms)  
19182 ms: std::\_\_detail::\_\_variant::\_Variant\_base<\$> (1959 times, avg 9 ms)

19151 ms: std::\_Rb\_tree<\$>::\_M\_erase (2320 times, avg 8 ms)  
19094 ms: std::\_Rb\_tree<\$>::~~Rb\_tree (2022 times, avg 9 ms)  
18735 ms: nlohmann::basic\_json<\$>::basic\_json (243 times, avg 77 ms)  
18546 ms: std::\_detail::\_Synth3way::\_S\_noexcept<\$> (2542 times, avg 7 ms)  
17174 ms: nlohmann::basic\_json<\$>::json\_value::json\_value (368 times, avg 46 ms)  
17111 ms: nlohmann::detail::conjunction<\$> (907 times, avg 18 ms)

\*\*\*\* Functions that took longest to compile:

2091 ms: \_GLOBAL\_\_sub\_I\_primops.cc (../src/libexpr/primops.cc)  
1799 ms: nix::fetchers::GitInputScheme::fetch(nix::ref<nix::Store>, nix::fetc... (../src/libfetchers/git.cc)  
1388 ms: nix::Settings::Settings() (../src/libstore/globals.cc)  
1244 ms: main\_nix\_build(int, char\*\*) (../src/nix-build/nix-build.cc)  
1021 ms: nix::LocalDerivationGoal::startBuilder() (../src/libstore/build/local-derivation-goal.cc)  
918 ms: nix::LocalStore::LocalStore(std::map<std::\_\_cxx11::basic\_string<char... (../src/libstore/local-store.cc)  
835 ms: opQuery(Globals&, std::\_\_cxx11::list<std::\_\_cxx11::basic\_string<char... (../src/nix-env/nix-env.cc)  
733 ms: nix::daemon::performOp(nix::daemon::TunnelLogger\*, nix::ref<nix::Sto... (../src/libstore/daemon.cc)  
589 ms: \_GLOBAL\_\_sub\_I\_tests.cc (../tests/unit/libutil/tests.cc)  
578 ms: main\_build\_remote(int, char\*\*) (../src/build-remote/build-remote.cc)  
522 ms: nix::fetchers::MercurialInputScheme::fetch(nix::ref<nix::Store>, nix... (../src/libfetchers/mercurial.cc)  
521 ms: nix::LocalDerivationGoal::registerOutputs[abi:cxx11]() (../src/libstore/build/local-derivation-goal.cc)  
461 ms: nix::getNameFromURL\_getNameFromURL\_Test::TestBody() (../tests/unit/libutil/url-name.cc)  
440 ms: nix::Installable::build2(nix::ref<nix::Store>, nix::ref<nix::Store>, ... (../src/libcmd/installables.cc)  
392 ms: nix::prim\_fetchClosure(nix::EvalState&, nix::PosIdx, nix::Value\*\*, n... (../src/libexpr/primops/fetchClosure.cc)  
390 ms: nix::NixArgs::NixArgs() (../src/nix/main.cc)  
388 ms: update(std::set<std::\_\_cxx11::basic\_string<char, std::char\_traits<ch... (../src/nix-channel/nix-channel.cc)  
340 ms: \_GLOBAL\_\_sub\_I\_primops.cc (../tests/unit/libexpr/primops.cc)  
332 ms: nix::flake::lockFlake(nix::EvalState&, nix::FlakeRef const&, nix::fl... (../src/libexpr/flake/flake.cc)  
305 ms: \_GLOBAL\_\_sub\_I\_lockfile.cc (../src/libexpr/flake/lockfile.cc)  
300 ms: nix\_store::opQuery(std::\_\_cxx11::list<std::\_\_cxx11::basic\_string<cha... (../src/nix-store/nix-store.cc)  
296 ms: nix::parseFlakeRefWithFragment(std::\_\_cxx11::basic\_string<char, std:... (../src/libexpr/flake/flakeref.cc)  
289 ms: \_GLOBAL\_\_sub\_I\_error\_traces.cc (../tests/unit/libexpr/error\_traces.cc)

278 ms: nix::ErrorTraceTest\_genericClosure\_Test::TestBody() (../tests/unit/libexpr/error\_traces.cc)  
274 ms: CmdDevelop::run(nix::ref<nix::Store>, nix::ref<nix::Installable>) (../src/nix/develop.cc)  
269 ms: nix::flake::lockFlake(nix::EvalState&, nix::FlakeRef const&, nix::fl... (../src/libexpr/flake/flake.cc)  
257 ms: nix::NixRepl::processLine(std::\_\_cxx11::basic\_string<char, std::char... (../src/libcmd/repl.cc)  
251 ms: nix::derivationStrictInternal(nix::EvalState&, std::\_\_cxx11::basic\_s... (../src/libexpr/primops.cc)  
249 ms: toml::result<toml::basic\_value<toml::discard\_comments, std::unordere...  
(../src/libexpr/primops/fromTOML.cc)  
238 ms: nix::LocalDerivationGoal::runChild() (../src/libstore/build/local-derivation-goal.cc)

\*\*\*\* Function sets that took longest to compile / optimize:

10243 ms: std::vector<\$>::\_M\_fill\_insert(\_\_gnu\_cxx::\_\_normal\_iterator<\$>, unsi... (190 times, avg 53 ms)  
9752 ms: bool boost::io::detail::parse\_printf\_directive<\$>(\_\_gnu\_cxx::\_\_norma... (190 times, avg 51 ms)  
8377 ms: void boost::io::detail::put<\$>(boost::io::detail::put\_holder<\$> cons... (191 times, avg 43 ms)  
5863 ms: boost::basic\_format<\$>::parse(std::\_\_cxx11::basic\_string<\$> const&) (190 times, avg 30 ms)  
5660 ms: std::vector<\$>::\_M\_fill\_insert(std::\_Bit\_iterator, unsigned long, bo... (190 times, avg 29 ms)  
4264 ms: non-virtual thunk to boost::wrapexcept<\$>::~~wrapexcept() (549 times, avg 7 ms)  
4023 ms: std::\_Rb\_tree<\$>::\_M\_erase(std::\_Rb\_tree\_node<\$>\*) (1238 times, avg 3 ms)  
3715 ms: boost::stacktrace::detail::to\_string\_impl\_base<boost::stacktrace::de... (166 times, avg 22 ms)  
3705 ms: std::vector<\$>::\_M\_fill\_assign(unsigned long, boost::io::detail::for... (190 times, avg 19 ms)  
3326 ms: boost::basic\_format<\$>::str[abi:cxx11]() const (144 times, avg 23 ms)  
3070 ms: void boost::io::detail::mk\_str<\$>(std::\_\_cxx11::basic\_string<\$>&, ch... (191 times, avg 16 ms)  
2839 ms: boost::basic\_format<\$>::make\_or\_reuse\_data(unsigned long) (190 times, avg 14 ms)  
2321 ms: std::\_\_cxx11::basic\_string<\$>::\_M\_replace(unsigned long, unsigned lo... (239 times, avg 9 ms)  
2213 ms: std::\_Rb\_tree<\$>::\_M\_get\_insert\_hint\_unique\_pos(std::\_Rb\_tree\_const\_... (203 times, avg 10 ms)  
2200 ms: boost::wrapexcept<\$>::~~wrapexcept() (549 times, avg 4 ms)  
2093 ms: std::vector<\$>::~~vector() (574 times, avg 3 ms)  
1894 ms: bool std::\_\_detail::\_Compiler<\$>::\_M\_expression\_term<\$>(std::\_\_detai... (112 times, avg 16 ms)  
1871 ms: int boost::io::detail::upper\_bound\_from\_fstring<\$>(std::\_\_cxx11::bas... (190 times, avg 9 ms)  
1867 ms: boost::wrapexcept<\$>::clone() const (549 times, avg 3 ms)  
1824 ms: std::\_Rb\_tree\_iterator<\$> std::\_Rb\_tree<\$>::\_M\_emplace\_hint\_unique<\$... (244 times, avg 7 ms)  
ms)  
1821 ms: toml::result<\$> toml::detail::sequence<\$>::invoke<\$>(toml::detail::l... (93 times, avg 19 ms)  
1814 ms: nlohmann::json\_abi\_v3\_11\_2::detail::serializer<\$>::dump(nlohmann::js... (39 times, avg 46 ms)  
1799 ms: nix::fetchers::GitInputScheme::fetch(nix::ref<\$>, nix::fetchers::Inp... (1 times, avg 1799 ms)  
1771 ms: boost::io::detail::format\_item<char, std::char\_traits<char>, std::al... (190 times, avg 9 ms)  
1762 ms: std::\_\_detail::\_BracketMatcher<\$>::\_BracketMatcher(std::\_\_detail::\_B... (112 times, avg 15 ms)  
1760 ms: std::\_Function\_handler<\$>::\_M\_manager(std::\_Any\_data&, std::\_Any\_dat... (981 times, avg 1 ms)  
1733 ms: std::\_\_detail::\_Compiler<\$>::\_M\_quantifier() (28 times, avg 61 ms)  
1694 ms: std::\_\_cxx11::basic\_string<\$>::\_M\_mutate(unsigned long, unsigned lon... (251 times, avg 6 ms)

1650 ms: std::vector<\$>::vector(std::vector<\$> const&) (210 times, avg 7 ms)

1650 ms: boost::io::basic\_altstringbuf<\$>::overflow(int) (190 times, avg 8 ms)

\*\*\*\* Expensive headers:

178153 ms: ../src/libcmd/installable-value.hh (included 52 times, avg 3426 ms), included via:

40x: command.hh

5x: command-installable-value.hh

3x: installable-flake.hh

2x: <direct include>

2x: installable-attr-path.hh

176217 ms: ../src/libutil/error.hh (included 246 times, avg 716 ms), included via:

36x: command.hh installable-value.hh installables.hh derived-path.hh config.hh experimental-features.hh

12x: globals.hh config.hh experimental-features.hh

11x: file-system.hh file-descriptor.hh

6x: serialise.hh strings.hh

6x: <direct include>

6x: archive.hh serialise.hh strings.hh

...

173243 ms: ../src/libstore/store-api.hh (included 152 times, avg 1139 ms), included via:

55x: <direct include>

39x: command.hh installable-value.hh installables.hh

7x: libexpr.hh

4x: local-store.hh

4x: command-installable-value.hh installable-value.hh installables.hh

3x: binary-cache-store.hh

...

170482 ms: ../src/libutil/serialise.hh (included 201 times, avg 848 ms), included via:

37x: command.hh installable-value.hh installables.hh built-path.hh realisation.hh hash.hh

14x: store-api.hh nar-info.hh hash.hh

11x: <direct include>

7x: primops.hh eval.hh attr-set.hh nixexpr.hh value.hh source-path.hh archive.hh

7x: libexpr.hh value.hh source-path.hh archive.hh

6x: fetchers.hh hash.hh

...

169397 ms: ../src/libcmd/installables.hh (included 53 times, avg 3196 ms), included via:

40x: command.hh installable-value.hh  
5x: command-installable-value.hh installable-value.hh  
3x: installable-flake.hh installable-value.hh  
2x: <direct include>  
1x: installable-derived-path.hh  
1x: installable-value.hh  
...

159740 ms: ../src/libutil/strings.hh (included 221 times, avg 722 ms), included via:

37x: command.hh installable-value.hh installables.hh built-path.hh realisation.hh hash.hh serialise.hh  
19x: <direct include>  
14x: store-api.hh nar-info.hh hash.hh serialise.hh  
11x: serialise.hh  
7x: primops.hh eval.hh attr-set.hh nixexpr.hh value.hh source-path.hh archive.hh serialise.hh  
7x: libexpr.hh value.hh source-path.hh archive.hh serialise.hh  
...

156796 ms: ../src/libcmd/command.hh (included 51 times, avg 3074 ms), included via:

42x: <direct include>  
7x: command-installable-value.hh  
2x: installable-attr-path.hh

150392 ms: ../src/libutil/types.hh (included 251 times, avg 599 ms), included via:

36x: command.hh installable-value.hh installables.hh path.hh  
11x: file-system.hh  
10x: globals.hh  
6x: fetchers.hh  
6x: serialise.hh strings.hh error.hh  
5x: archive.hh  
...

133101 ms: /nix/store/644b90j1vms44nr18yw3520pzkrq4dd1-boost-1.81.0-dev/include/boost/lexical\_cast.hpp (included 226 times, avg 588 ms), included via  
:

37x: command.hh installable-value.hh installables.hh built-path.hh realisation.hh hash.hh serialise.hh strings.hh  
19x: file-system.hh  
11x: store-api.hh nar-info.hh hash.hh serialise.hh strings.hh  
7x: primops.hh eval.hh attr-set.hh nixexpr.hh value.hh source-path.hh archive.hh serialise.hh strings.hh

```
7x: libexpr.hh value.hh source-path.hh archive.hh serialise.hh strings.hh
6x: eval.hh attr-set.hh nixexpr.hh value.hh source-path.hh archive.hh serialise.hh strings.hh
...

132887 ms: /nix/store/h2abv2l8irqj942i5rq9wbrj42kbsh5y-gcc-12.3.0/include/c++/12.3.0/memory (included
262 times, avg 507 ms), included via:
36x: command.hh installable-value.hh installables.hh path.hh types.hh ref.hh
16x: gtest.h
11x: file-system.hh types.hh ref.hh
10x: globals.hh types.hh ref.hh
10x: json.hpp
6x: serialise.hh
...

done in 0.6s.
```

## Manually looking at traces

Note that the summary in the report can miss details like *why* one particular header is bad; to find that out, use a trace viewer to inspect the JSON trace file; we suggest `rg -t json -uu error\.\hh build/ | less` to find some `.cc` trace that the bad header (in this example, `error.hh`) appears in.

You can look at individual file traces by opening some file like

`build/src/libcmd/liblxcmd.so.p/command.cc.json` in <https://ui.perfetto.dev> or another Chrome-trace-json compatible trace viewer like [Speedscope](#).

This will produce a flamegraph of the trace (screenshot shows Perfetto):



