

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)
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/644b90j1vms44nr18yw3520pzkr4dd1-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/liblixcmd.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):

