Fuchsia

Fuchsia Clang Toolchain

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What is Fuchsia?

Fuchsia is an open source operating system that prioritizes security, updatability, and performance.

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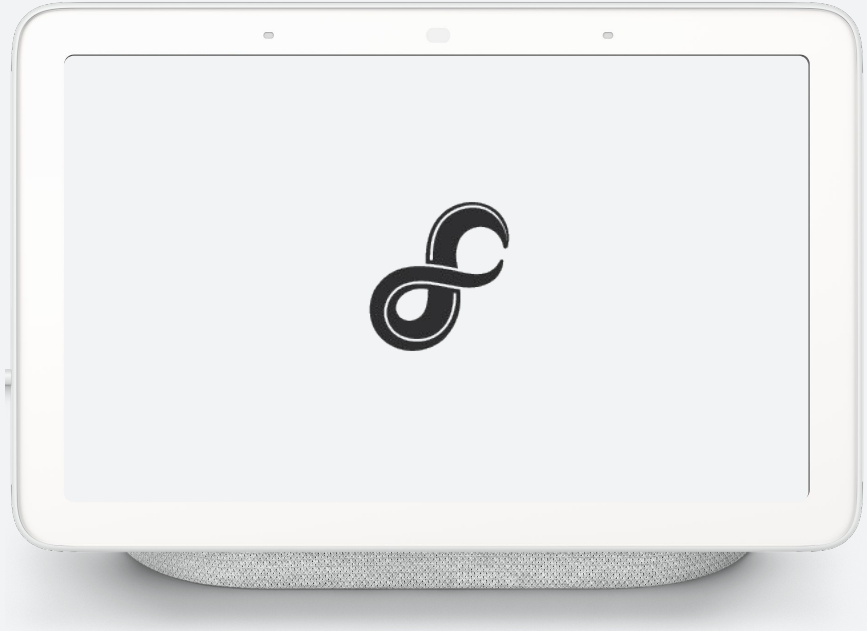
Fuchsia was built from ground up and after 5 years of development, we started shipping to the public for the first time on Google Nest Hub devices earlier this year.



Fuchsia Clang Toolchain

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A complete C/C++ toolchain distribution that includes a number of LLVM tools and runtime libraries.

We use it to build all of Fuchsia—everything from bootloader to kernel, system libraries, user applications and even host tools—as well as other related projects such as Pigweed, Dart and Flutter.

It is used by hundreds of developers—both inside and outside of Google—and thousands of automated builders.

Goals

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Our goal is to deliver a modern cross-compiling LLVM-based toolchain without any legacy components.

We want to provide the same exact experience on every supported host platform.

Everything we use is open-source and anyone should be able to reproduce our toolchain build.

Philosophy

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We follow the "live at HEAD" model and release new toolchains on a ~weekly cadence.

We don't carry any downstream patches, rather we prefer developing new features in upstream and adopting them in our toolchain as soon as they are available.

Our toolchain is self-contained both in terms of its host and target runtime requirements, and supports a range of platforms and versions.

Supported platforms

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Host platforms

Linux	x86-64	ARM64
macOS	x86-64	WIP
Windows	x86-64	

Target platforms

Linux	x86, x86-64	ARM, ARM64
macOS	x86-64	ARM64
Windows	x86-64	
Fuchsia	x86-64	ARM64

Toolchain components

Tools

Compiler	Clang
Assembler	LLVM (integrated)
Linker	LLD

Runtimes

Compiler runtimes	compiler-rt
Unwind library	libunwind
C++ ABI library	libc++abi
C++ standard library	libc++

Building

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We use the LLVM runtimes build, building runtimes for all supported targets within a single CMake invocation.

We include a number of multilibs for `-fno-exceptions`, `-fsanitize=address`, etc.

For the production toolchain, we use two-stage build where the second stage is optimized with LTO (and PGO in the near future).

Example

Note that some details were omitted for brevity.

```
cmake -G Ninja -S llvm-project/llvm -B build \
  -DCMAKE_TOOLCHAIN_FILE="${SRC}/ToolChain.cmake" \
  -DFUCHSIA_SDK="${FUCHSIA_SDK}" \
  -C llvm-project/clang/cmake/caches/Fuchsia.cmake
ninja stage2-distribution
ninja stage2-install-distribution
```

Testing

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We run all LLVM, LLD and Clang tests on each build.

We also run compiler-rt, libunwind, libc++abi, libc++ tests on the host, but not on Fuchsia (yet).

We have extended lit output format to better integrate into our infrastructure.

LUCI

phosek@google.com | Logout

Build fuchsia / toolchain.ci / clang-linux-x64 / b8836678975716717441 | Switch to the legacy build page

failed after 21 mins 5 secs

Overview | Test Results 1 | Steps & Logs | Related Builds | Timeline | Blamelist

Step('clang.test') (retcode: 1)

Failed Tests (View All Test)

- LLVM :: tools/llvm-profdata/forward-compatible.test

Showing 1 / 1 failed tests. [view all]

Steps & Logs (View in Steps Tab)

Show: ☑ Succeeded Steps ☐ Debug Logs ☐ Expand by default

- 2ms 1. setup_build running recipe: "contrib/clang_toolchain"
- 1.3s 2. ensure goma
- 2.7s 3. ensure_packages
- 230ms 4. create pkg dir
- 212ms 5. makedirs
- 12ms 6. git init
- 11ms 7. git remote
- 11ms 8. set fetch.uriprotocols
- 4.8m 9. cache
- 213ms 10. git fetch
- 9.1s 11. git checkout
- 12ms 12. git rev-parse
- 248ms 13. git clean
- 141ms 14. submodule
- 3.0s 15. setup goma
- 5.8s 16. zlib
- 10s 17. libxml2
- 213ms 18. source manifest
- 209ms 19. create llvm build dir
- 15m 20. clang
  - 15s 1. configure
  - 217ms 2. read CMakeError.log
  - 6.0m 3. build
  - 8.4m 4. test
    - execution details
    - stdout [raw]

Input

Revision: 813235947d07890ea55a6de039261d0c409c8b42

Infra

Buildbucket ID: 8836678975716717441
Swarming Task: 55dcf4a6f750d610
Bot: fuchsia-toolchain-ci-n2-32-ssd4-us-central1-a-0-8yho
Service Account: fuchsia-ci-builder@fuchsia-infra.iam.gserviceaccount.com
Recipe: contrib/clang_toolchain

Timing

Created: 23:40:40 Tue, Sep 07 2021 PDT
Started: 23:40:51 Tue, Sep 07 2021 PDT
Ended: 00:01:56 Wed, Sep 08 2021 PDT
Pending: 10 secs
Execution: 21 mins 5 secs

Build Logs

- stdout [raw]
- stderr [raw]

Actions

RETRY BUILD

Tags

buildset: commit/gitiles/llvm.googlesource.com/llvm-project/+/813235947d07890ea55a6de039261d0c409c8b42
user_agent: recipe

Enabled Experiments

- luci.use_realms

Input Properties

```
{
  "led_builder_is_bootstrapped": true,
  "recipe": "contrib/clang_toolchain",
  "recipes_host_override": "fuchsia.googlesource.com",
  "recipes_integration_ref_override": "refs/heads/main"
}
```

Output Properties

```
{}
```

LUCI

phosek@google.com | Logout

Build fuchsia / toolchain.ci / clang-linux-x64 / b8836678975716717441 | Switch to the legacy build page

failed after 21 mins 5 secs

Overview | **Test Results** 1 | Steps & Logs | Related Builds | Timeline | Blamelist

Configure Table | Press / to search test results... | EXPAND ALL | COLLAPSE ALL

S Name

1 test variant: status=*UNEXPECTED*

LLVM :: tools/llvm-profdata/forward-compatible.test

ID: LLVM :: tools/llvm-profdata/forward-com... | bucket: toolchain.ci, builder: clang-linux-x64

19ms **run #1** unexpectedly failed

Summary:

```
Script:
--
: 'RUN: at line 1';   /b/s/w/ir/x/w/staging/llvm_build/bin/llvm-profdata show -sample /b/s/w/ir/x/w/llvm-project/llvm/test/tools/llvm-profdata/Inputs/unknown.section.extbin.profdata | /b/s/w/ir/x/w/staging/llvm_build/bin/FileCheck
/b/s/w/ir/x/w/llvm-project/llvm/test/tools/llvm-profdata/forward-compatible.test
: 'RUN: at line 2';   /b/s/w/ir/x/w/staging/llvm_build/bin/llvm-profdata show -sample -show-sec-info-only /b/s/w/ir/x/w/llvm-project/llvm/test/tools/llvm-profdata/Inputs/unknown.section.extbin.profdata |
/b/s/w/ir/x/w/staging/llvm_build/bin/FileCheck /b/s/w/ir/x/w/llvm-project/llvm/test/tools/llvm-profdata/forward-compatible.test -check-prefix=HDR
--
Exit Code: 2

Command Output (stderr):
--

UNREACHABLE executed at llvm/include/llvm/ProfileData/SampleProf.h:153!
FileCheck error: '<stdin>' is empty.
FileCheck command line:  /b/s/w/ir/x/w/staging/llvm_build/bin/FileCheck /b/s/w/ir/x/w/llvm-project/llvm/test/tools/llvm-profdata/forward-compatible.test -check-prefix=HDR

--
```

Artifacts: 1

0 test variants: status=*EXPECTED*

Showing 1 / 1+ tests. [load more]

Distribution

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We use the LLVM build distribution support to control what tools and runtimes go into our toolchain.

CMake cache files we use are in the LLVM source tree.

Our toolchain is completely self-contained and statically links all dependencies except for the system C runtime.

See Fuchsia-stage2.cmake

Automation

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We rely extensively on automation which is what makes it feasible to "live at HEAD" and roll so frequently.

We continuously build toolchains and use every newly produced toolchain to build and test the entire system.

Every toolchain is uploaded to our package distribution system (CIPD) and is packaged into a Docker container for use in our distributed compilation service (Goma).

See CIPD package

Infrastructure

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We use LUCI, open-source continuous integration build service created by Chrome, and a combination of physical and virtual machines for building and testing.

We try to minimize the unnecessary work by using staged builds, triggering subsequent stages as needed.

We are trying to simplify the triage by automatically collecting Clang crash reproducers (and LLD eventually).

Legend: Passed | Failed | Failed Again | Running | Exception

(Show: default 25 50 100 200) [expand]

		clang								fuchsia										rbe
		ci				prod				ci					prod					
		linux		mac	windows	linux		mac	windows	core					core					goma
										arm64		host	x64		arm64		host	x64		
		a64	x64	x64	x64	a64	x64	x64	x64	dbg	rls	mac	dbg	rls	dbg	rls	mac	dbg	rls	goma
a5b72abc	AlokKumar.Sharma@amd.con																			
a01f772d	lhames@gmail.com																			
03c8b24a	l@maskray.me																			
b1d44e59	ajcbik@google.com																			
24c8eaec	kazu@google.com																			
c8b3d7d6	jpaquette@apple.com																			
e159d3cb	ahmed@bougacha.org																			
94a2f9cd	ahmed@bougacha.org																			
24252474	tejohnson@google.com																			
17589538	tedwood@quicinc.com																			
37a5a3ae	tejohnson@google.com																			
699da987	richard@metafoo.co.uk																			
5d78e33c	aeubanks@google.com																			
c3ddc13d	aeubanks@google.com																			
c90cbb2d	llvmgnsyncbot@gmail.com																			
658eb9e1	llvm-project@meinersbur.de																			
68079ef0	resistor@mac.com																			
f9e4aebe	anna@azul.com																			
8025c03f	owenpiano@gmail.com																			
065bb08b	dblaikie@gmail.com																			
b6cb03e6	anna@azul.com																			
87c00878	Matthew.Arsenault@amd.com																			
cb8c30d3	jeffniu22@gmail.com																			
f438204b	dliew@apple.com																			
1ac2d195	rob.suderman@gmail.com																			
32734304	anna@azul.com																			
7d437cf7	kimanh@chromium.org																			
8b946ab0	me@supergrecko.com																			
8264846c	dblaikie@gmail.com																			
ae2a5fac	hansang.bae@intel.com																			
d249200f	compnerd@compnerd.org																			
40acc0ad	dblaikie@gmail.com																			
4ac4e521	anna@azul.com																			
248e430f	listmail@philipreames.com																			
acaca564	mascasa@google.com																			
385f380e	kazu@google.com																			
e5a32d72	spatel@rotateright.com																			
9bdb19cc	listmail@philipreames.com																			
1b79efdc	simon.camphausen@iml.fraur																			
96ec0ff2	nicolas.vasilache@gmail.com																			

```
[72773/210831] CXX obj/src/lib/storage/vfs/cpp/libcpp.fuchsia_vfs.cc.o
FAILED: obj/src/lib/storage/vfs/cpp/libcpp.fuchsia_vfs.cc.o
../../../recipe_cleanup/clang9wJK3x/bin/clang++ -MD -MF obj/src/lib/storage/vfs/cpp/libcpp.fuchsia_vfs.cc.o.d -
D_LIBCPP_DISABLE_VISIBILITY_ANNOTATIONS -D_LIBCPP_ENABLE_THREAD_SAFETY_ANNOTATIONS=1 -...
clang++: clang/lib/Sema/SemaExprCXX.cpp:1144: clang::QualType
adjustCVQualifiersForCXXThisWithinLambda(ArrayRef<clang::sema::FunctionScopeInfo *>, clang::QualType, clang::DeclContext *,
clang::ASTC...
clang++: error: clang frontend command failed with exit code 134 (use -v to see invocation)
Fuchsia clang version 14.0.0 (https://llvm.googlesource.com/a/llvm-project ee903a207b767566b4a65f5519c545cccba28d28)
Target: aarch64-unknown-fuchsia
Thread model: posix
InstalledDir: ../../../recipe_cleanup/clang9wJK3x/bin
clang++: note: diagnostic msg:
********************

PLEASE ATTACH THE FOLLOWING FILES TO THE BUG REPORT:
Preprocessed source(s) and associated run script(s) are located at:
clang++: note: diagnostic msg: clang-crashreports/fuchsia_vfs-1c2a73.cpp
clang++: note: diagnostic msg: clang-crashreports/fuchsia_vfs-1c2a73.sh
clang++: note: diagnostic msg:

********************
```

(failure summary truncated, see the 'failure summary' log for full failure details)

Failed Tests (View All Test)

No failed tests.

Steps & Logs (View in Steps Tab)

Show: ☑ Succeeded Steps ☐ Debug Logs ☐ Expand by default

- 18m **1. build**
  - fint_params
  - failure summary
  - 3.2s **1. clang_toolchain**
  - 18s **2. gn gen** run by `fint set`
  - 17m **3. ninja** run by `fint build`
    - execution details
    - stdout [raw]
    - context.textproto
  - 2.0s **4. clang-crashreports**
    - 232ms **1. find reproducers**
    - 232ms **2. find fuchsia_vfs-1c2a73 files**
    - 343ms **3. install fuchsia/tools/bsdtar**
    - 202ms **4. create fuchsia_vfs-1c2a73.tar.gz**
    - 965ms **5. upload fuchsia_vfs-1c2a73.tar.gz to fuchsia-build**

Input

Revision: ee903a207b767566b4a65f5519c545cccba28d28

Infra

Buildbucket ID:	8836714544541408465
Swarming Task:	55daef10cef3c010
Bot:	fuchsia-ci-n2-32-ssd4-us-central1-a-3-jhbs
Service Account:	fuchsia-ci-builder@fuchsia-infra.iam.gserviceaccount.com
Recipe:	fuchsia/build

Timing

Created:	14:15:19 Tue, Sep 07 2021 PDT
Started:	14:15:24 Tue, Sep 07 2021 PDT
Ended:	14:35:15 Tue, Sep 07 2021 PDT
Pending:	4 secs
Execution:	19 mins 51 secs

Build Logs

- stdout [raw]
- stderr [raw]

Actions

RETRY BUILD

Tags

buildset:	commit/gitiles/llvm.googlesource.com/llvm-project/+/ee903a207b767566b4a65f5519c545cccba28d28
hide-in-gerrit:	subbuild
skip-retry-in-gerrit:	subbuild
user_agent:	recipe

Enabled Experiments

- luci.use_realms

Input Properties


```
1 {
2   "$fuchsia/build": {
3     "clang_toolchain": {
4       "source": "isolated",
5       "version": "687559f42c43ba4916f52b795a2747b1bac4b0adeba92e60125db849505eec20/577"
6     }
7   },
8   "$fuchsia/checkout": {
```

Areas for improvement

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Support for building LLVM runtimes as universal libraries.

Support for building dependencies (e.g. zlib, libxml2) as part of LLVM build to avoid external build logic.

Support for combining multiple LLVM tools into a single binary in the "busybox" style to reduce toolchain size.

Feature requests

Efficient support for cross-platform testing in lit which will be necessary to start running tests on Fuchsia.

Automated way to report downstream test results, it is infeasible for us to cover every configuration in upstream.

Questions?

Please post them to git.io/JudMt

Fuchsia toolchain team is looking for a software engineer to help us with runtime testing.
Please reach out if you interested in solving problems similar to the ones covered in this talk.