# The LLVM compiler framework

## Writing a pass: Quick Start

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*These slides were originally written by Stefano Cherubin for the “Code Transformation and Optimization” course.*

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# Understanding LLVM

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LLVM is **not** a compiler.

LLVM is a
**collection of components**
which is **useful**
to build a compiler.

# Getting LLVM

All work on LLVM goes to the **monorepo** on GitHub

- It contains LLVM + major subprojects handled by the LLVM project
- `git clone -b release/10.x --single-branch git@github.com:llvm/llvm-project.git`

A few years ago they used a private SVN repository, the switch to GitHub is recent

# What LLVM is made of

- C++ libraries
  - `llvm/include/llvm/...`
  - `llvm/lib/...`

- small application (tools)
  - `llvm/tools/...`
  - `llvm/utils/...`

Binaries installed under `bin/...`

# Commands

| | |
|---|---|
| **llvm-as** | LLVM assembler |
| **llvm-dis** | LLVM disassembler |
| **opt** | LLVM optimizer |
| **llc** | LLVM static compiler |
| **lli** | directly execute programs from LLVM bitcode |
| **llvm-link** | LLVM bitcode linker |
| **llvm-mca** | LLVM machine code analyzer |
| **llvm-nm** | list LLVM bitcode and object file's symbol table |
| **llvm-stress** | generate random .ll files |
| **llvm-config** | prints out install configuration parameters |
| **llvm-dwarfdump** | print contents of DWARF sections |

For a complete reference, see the LLVM command guide*

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*`http://llvm.org/docs/CommandGuide/index.html`

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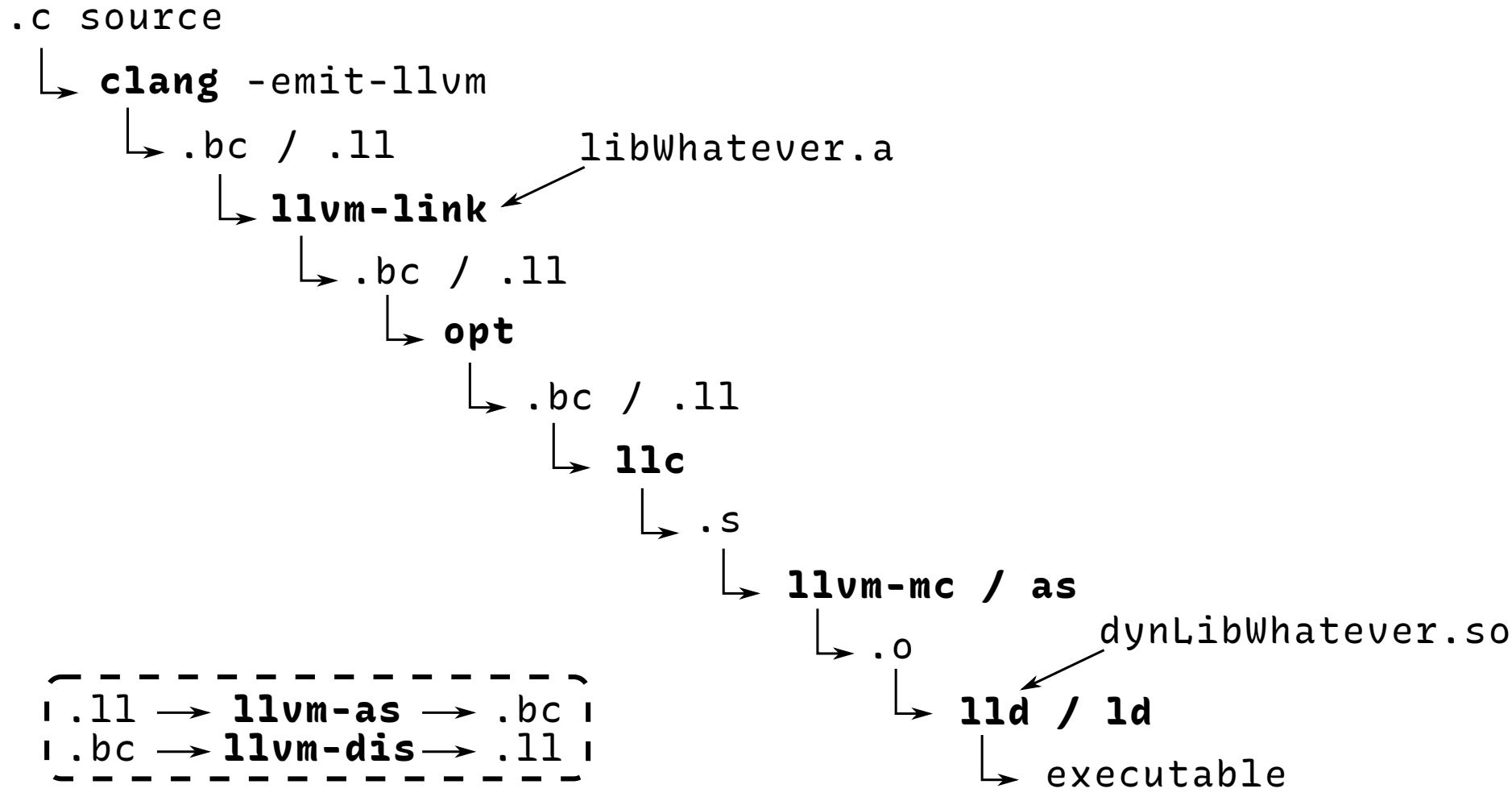
# Simulating a LLVM driver manually



# Writing a LLVM pass

There are a lot of tutorials available:

- Official developer guide
  `llvm.org/docs/WritingAnLLVMPass`

- Out-of-source pass
  `github.com/quarkslab/`
  `llvm-dev-meeting-tutorial-2015`

We will follow the first one, with a few adjustments.

# Building LLVM

To test your pass you need a **Debug+Assertions** build of LLVM.

This build needs to be **kept separated** from normal Release builds
(it's very slow!)

The best way to get such a LLVM build is to **make it yourself**!

# Building LLVM

- Detailed instructions:
  `https://llvm.org/docs/GettingStarted.html`

**Problem 1** With the **default options**, a finished build takes **25 GB of disk space**

**Problem 2** A standard build with the GNU toolchain uses **a lot of RAM** (≈16 GB or more with a modern 4 core CPU!) especially when linking

We need to customize the build process a bit...

# Building LLVM

- The build flags I like to use:

```
-GNinja
-DLLVM_ENABLE_PROJECTS='clang'
-DLLVM_INSTALL_UTILS=ON
-DLLVM_BUILD_LLVM_DYLIB=ON
-DLLVM_LINK_LLVM_DYLIB=ON
-DLLVM_OPTIMIZED_TABLEGEN=ON
-DLLVM_INCLUDE_EXAMPLES=OFF
-DCMAKE_INSTALL_PREFIX=/opt/llvm-10.0-d
-DLLVM_USE_LINKER=lld
-DCMAKE_C_COMPILER=clang-10
-DCMAKE_CXX_COMPILER=clang++-10
```

- Building with LLVM itself solves the RAM usage problem!
  - Not required on macOS or *BSD: they already ship LLVM as default
- Using **shared libraries** drops the disk usage to **10 GB**.

  The build products alone will still take 20 GB of disk space...

# Last notes on building

You can add other projects to the LLVM build by modifying the value of the `LLVM_ENABLE_PROJECTS` flag

Good practice: **always include clang**

- You can easily see on a production quality compiler the impact of changes you made on your local copy of LLVM

To install cutting-edge release LLVM if your Linux distribution does not provide it:

- `https://apt.llvm.org`

# Testing

LLVM has an internal testing infrastructure*. Please use it.

**llvm-lit** LLVM Integrated Tester

1. Forge a proper LLVM-IR input file (.ll) for your test case
2. Instrument it with `lit` script comments
3. Run `lit` on your test
   - `llvm-lit /llvm/test/myTests/singleTest.ll`
     run a single test
   - `llvm-lit /llvm/test/myTests`
     run the test suite (folder)
4. Run `lit` on the LLVM test suite (regression testing)

To submit a bug report to LLVM developers you will be asked to write a `lit` test case that highlights the bug.

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*`http://llvm.org/docs/TestingGuide.html`

# Thank You!

Questions?