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

Getting LLVM

- “old” git mirrors
  - only llvm repo (subprojects in separated repos, can be added later)
  - `git clone -b release_90 --single-branch git@github.com:llvm-mirror/llvm.git`

- “new” git monorepo
  - all in one repo (llvm + major subprojects)
  - `git clone -b release/9.x --single-branch git@github.com:llvm/llvm-project.git`

What LLVM is made of

- C++ libraries
  - `src/include/llvm/...`
  - `src/lib/...`
- small application (tools)
  - `src/tools/...`
  - `src/utils/...`

You can find binaries of them in the installation directory under `root/bin/...`

clang

- `clang` is a compiler based on LLVM
- It compiles all major C-like languages

- It is part of the git monorepo
- It can be added as a tool in the LLVM framework but must be manually cloned in the tool directory
    1. `cd src/tools`
    2. `git clone http://llvm.org/git/clang` (git mirror version)

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

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*

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

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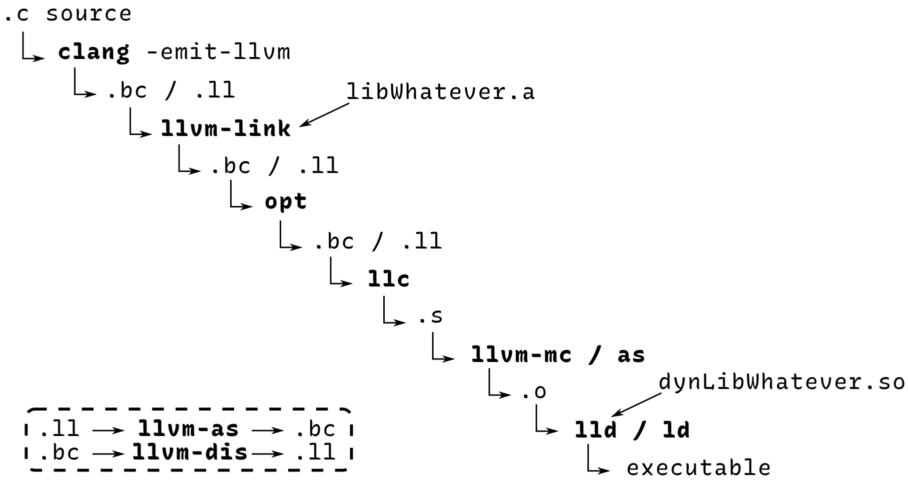
Simulating a LLVM driver manually



.c source

clang -emit-llvm

.bc / .ll

libWhatever.a

llvm-link

.bc / .ll

opt

.bc / .ll

llc

.s

llvm-mc / as

.o

dynLibWhatever.so

lld / ld

executable

.ll → **llvm-as** → .bc

.bc → **llvm-dis** → .ll

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** ($\approx$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-9.0-d
  -DLLVM_USE_LINKER=lld
  -DCMAKE_C_COMPILER=clang-9
  -DCMAKE_CXX_COMPILER=clang++-9
  ```

- Building with LLVM itself solves the RAM usage problem!
- Using **shared libraries** drops the disk usage to **10 GB**.

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

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.

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

Thank You!

Questions?