CHAPEL 1.25 RELEASE NOTES: COMPILER AND TOOL IMPROVEMENTS

Chapel Team
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OUTLINE

• LLVM Back-end by Default
• Specifying Compilers
• c2chapel Improvements
LLVM BACK-END BY DEFAULT
LLVM BY DEFAULT

Background

**Background:**

- The compiler has traditionally generated C code to produce its executables
  - Requires a C compiler to build the final binary

- Has also had the ability to generate LLVM IR for many releases
  - Skips the step of generating and compiling C source files
  - Generates and compiles LLVM IR in memory

“The LLVM Core libraries provide a modern source- and target-independent optimizer, along with code generation support for many popular CPUs (as well as some less common ones!) These libraries are built around a well specified code representation known as the LLVM intermediate representation (‘LLVM IR’).”

- llvm.org
This Effort: Overview

This Effort:

- Made LLVM the default back-end for Chapel
  - More opportunities for optimization vs. the C back-end
  - Promotes community involvement in developing the back-end by leveraging a common infrastructure
  - Decreases longer-term testing burden

- Fixed bugs in the compiler's LLVM back-end
  - Generating incorrect instructions
  - Mishandling signedness
LLVM BY DEFAULT

This Effort: Choosing between LLVM options and C

- Changed the default value of the CHPL_LLVM setting, as follows:
  
  CHPL_LLVM=bundled  # if the bundled LLVM has already been built
  CHPL_LLVM=system   # if a system LLVM installation is detected
  CHPL_LLVM=none     # on systems where LLVM doesn’t currently work for us, like linux32
  CHPL_LLVM=unset    # otherwise

- Issue an error when building the compiler if CHPL_LLVM is detected to be 'unset'

  Error: Please set the environment variable CHPL_LLVM to a supported value.
  Supported values are:
  1) 'none' to build without LLVM support
  2) 'bundled' to build with the LLVM packaged in the third-party directory
  3) 'system' to use a pre-installed system-wide LLVM
This Effort: Opting out of LLVM

- In cases where LLVM is the default, request the C back-end via CHPL_TARGET_COMPILER
  
  ```
  export CHPL_TARGET_COMPILER=gnu
  export CHPL_TARGET_COMPILER=<supported compiler>
  ```

- Supported C compilers are listed in the Environment section of the online documentation

- To disable LLVM entirely
  
  ```
  export CHPL_LLVM=none
  ```
LLVM BY DEFAULT

Status, Next Steps

Status:
- LLVM is now the default back-end in nearly all configurations

Next Steps:
- Address performance regressions
  - Some tests lost performance with LLVM vs. the C back-end
  - 'chpl --fast' occasionally takes longer to compile with LLVM vs. the C back-end
- Upgrade from LLVM-11 to LLVM-12
- Investigate opportunities to further improve optimization with the LLVM back-end
SPECIFYING COMPILERS
SPECIFYING COMPILERS
Background, This Effort

Background:
- Generating and compiling C code was the default, but one could request LLVM code generation with ‘--llvm’
- There was no way to indicate the C or C++ compilation command / path
  - e.g., when ‘CHPL_TARGET_COMPILER=gnu’ the compilation would always use ‘gcc’
- There was confusion about how ‘CHPL_TARGET_COMPILER’ interacts with the choice of C or LLVM strategies

This Effort:
- Deprecated ‘--llvm’ and ‘--no-llvm’ flags
- Now, LLVM code generation is the default, but it can be toggled by changing the target compiler
  - ‘CHPL_TARGET_COMPILER=llvm’ or ‘--target-compiler=llvm’ requests LLVM code generation
  - ‘CHPL_TARGET_COMPILER=gnu’ or ‘--target-compiler=gnu’ requests generating C code & compiling it with ‘gcc’
- Additionally, ‘CC’ and ‘CXX’ environment variables are now available to control the C compiler command
  - ‘CHPL_HOST_CC’ / ‘CHPL_HOST_CXX’ and ‘CHPL_TARGET_CC’ / CHPL_TARGET_CXX’ are also available when needed
**SPECIFYING COMPILERS**

Impact, Next Steps

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**Impact:**

- Now ‘make’ only needs to build one runtime in LLVM-enabled configurations
- Resolved confusion about ‘CHPL_TARGET_COMPILER’ with the LLVM code generation
- Enabled a common strategy for setting the compiler command with ‘CC’ and ‘CXX’
  - including specifying the complete path to the compiler:
    
    ```
    CC=/usr/local/opt/llvm@11/bin/clang \
    CXX=/usr/local/opt/llvm@11/bin/clang++ \
    chpl myprogram.chpl
    ```
  - or requesting a particular version:
    
    ```
    CC=/gcc-10 CXX=g++-10 chpl myprogram.chpl
    ```

**Next Steps:**

- Should setting ‘CC’ / ‘CXX’ request C code generation? (issue [#18450](#18450))
  - Currently, it does
  - Probably surprising if these are broadly set on a system to request a preferred C compiler
- Run down some other challenges/ambiguities that are emerging in the new approach (e.g., issue [#18530](#18530))
**C2CHAPEL IMPROVEMENTS**

**Background:** ‘c2chapel’ is a tool that takes C header files and generates Chapel C-bindings

- Attempting to use c2chapel with Apache Arrow/Parquet led to the discovery of many issues

```
typedef struct {
    int memberVar;
} intStruct;
```

```
extern record intStruct {
    var memberVar : c_int;
}
```

**This Effort:** Extended c2chapel to work with GNU extensions and fix bugs

- Added a new `--gnu-extensions` flag to use a parser capable of handling GNU expressions
  - As a result of this, c2chapel now requires Python 3.7 instead of 3.6 (affects Chapel's whole virtual environment)
- Included Chapel C-interop modules by default to support additional C types
- Fixed support for C structs that don’t have an explicit `typedef`

**Impact:** Enabled c2chapel to fully parse Apache Arrow library

- Saves significant development time when enabling C library support
- Many c2chapel-generated programs now compile out of the box
OTHER COMPILER AND TOOL IMPROVEMENTS
For a more complete list of compiler and tool changes and improvements in the 1.25 release, refer to the following sections in the CHANGES.md file:

- ‘Tool Improvements’
- ‘Compilation-Time / Generated Code Improvements’
- ‘Portability’
- ‘GPU Computing’
- ‘Compiler Improvements’
- ‘Compiler Flags’
- ‘Bug Fixes’
- ‘Bug Fixes for Tools’