Compiler and Tool Changes

Chapel version 1.19

March 21, 2019


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@ChapelLanguage

Outline

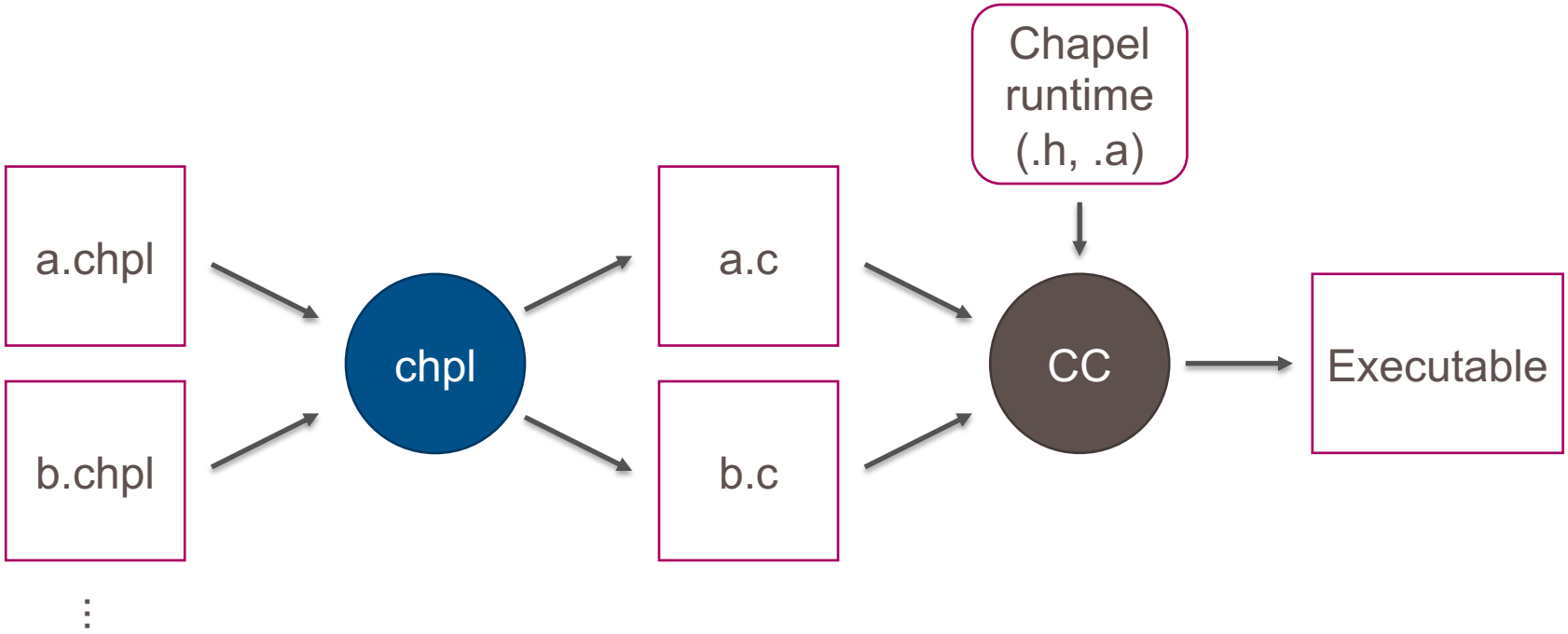
- LLVM Improvements
- Specifying Target Architecture
- Disambiguating Param Configs
- Retiring chpl-ipe

LLVM Improvements

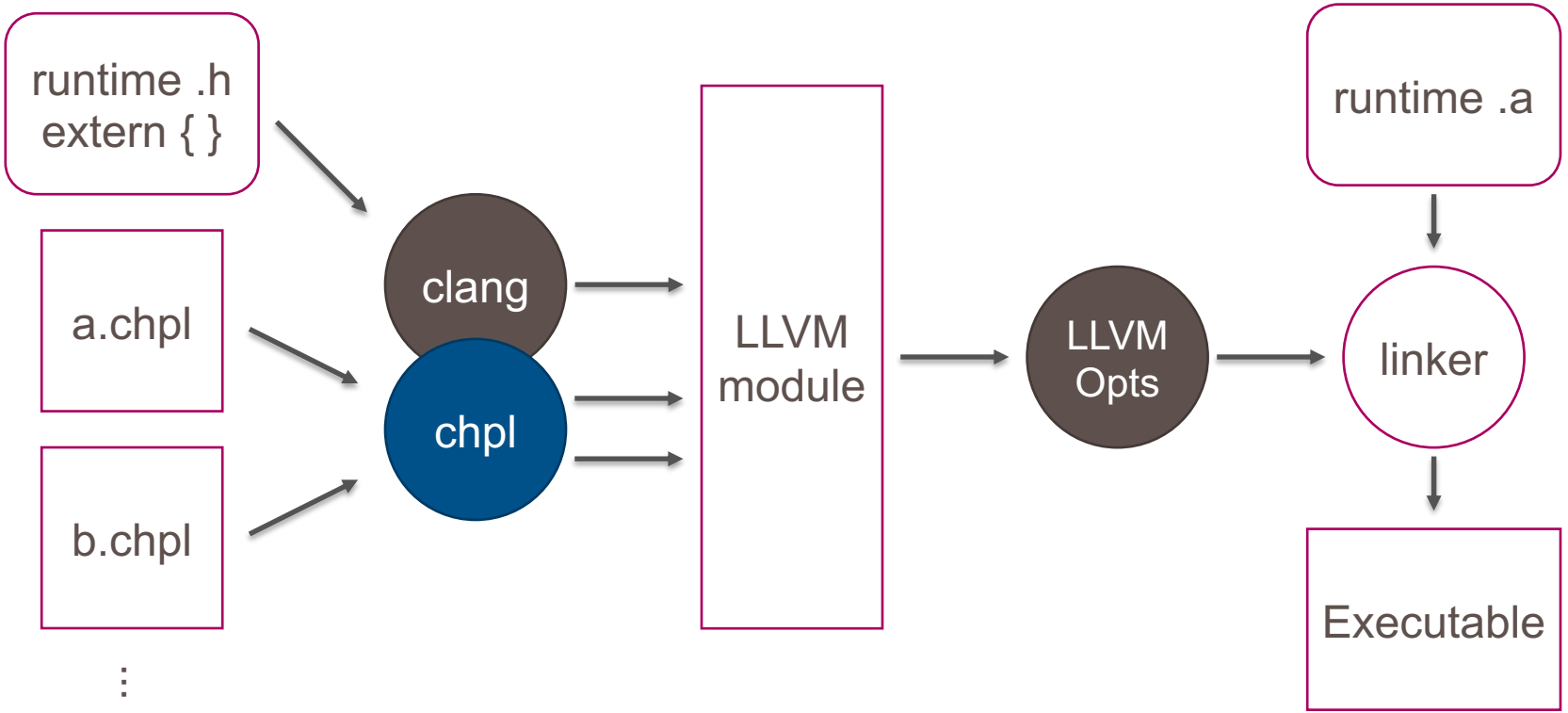
LLVM: Background

- LLVM is a compiler optimization framework
  - Actively developed and constantly improving
- The Chapel compiler generates C code by default
  - Runs a C compiler to compile the generated code
  - But can generate LLVM Intermediate Representation instead
- We want the Chapel compiler to use LLVM by default
  - To reduce maintenance vs. depending on many C compilers
  - To enable new optimization opportunities

Chapel --llvm compilation flow

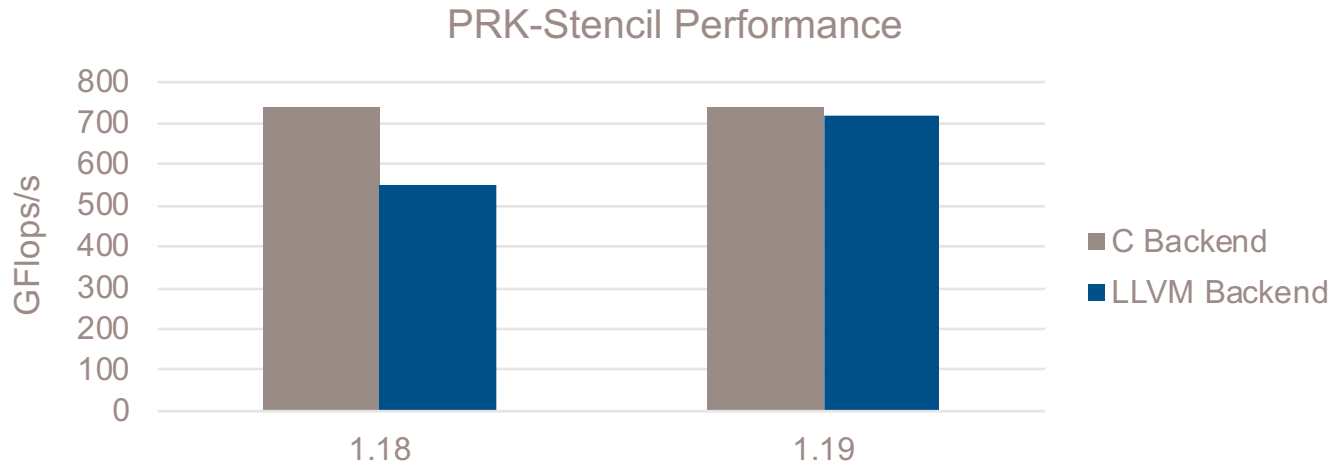


Chapel --llvm compilation flow



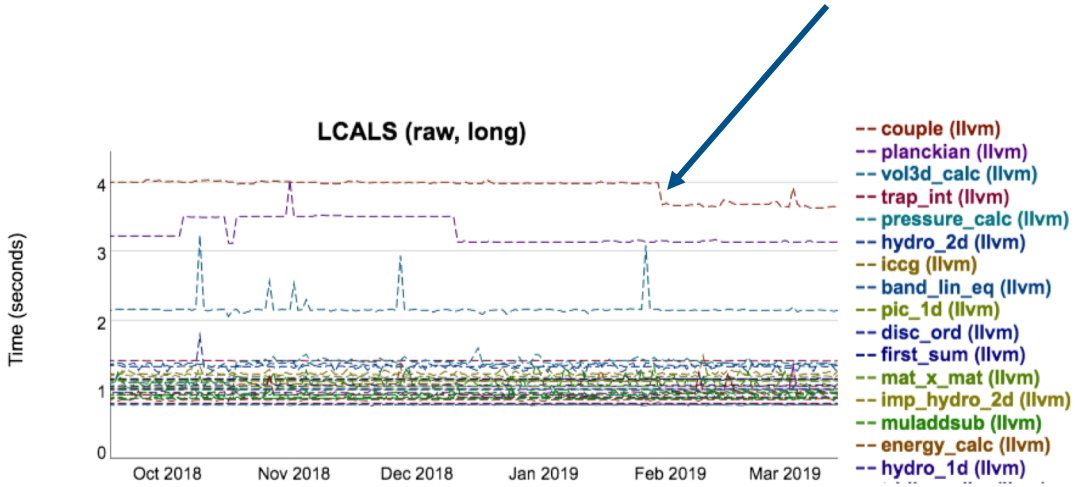
LLVM: PRK Stencil Improvement

- PRK stencil had poor multi-locale performance with --llvm
- Optimization was limited by alias analysis between C and Chapel types
- Migrated a privatization function from the C runtime to Chapel
  - Long-term, would like to improve alias analysis



LLVM: Upgrade to LLVM 7

- Upgraded the included LLVM from LLVM 6 to LLVM 7
  - Provided close to 10% improvement for LCALS 'couple' kernel

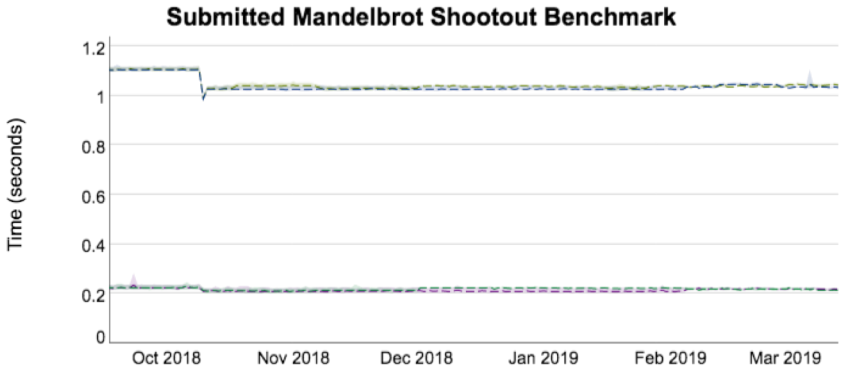


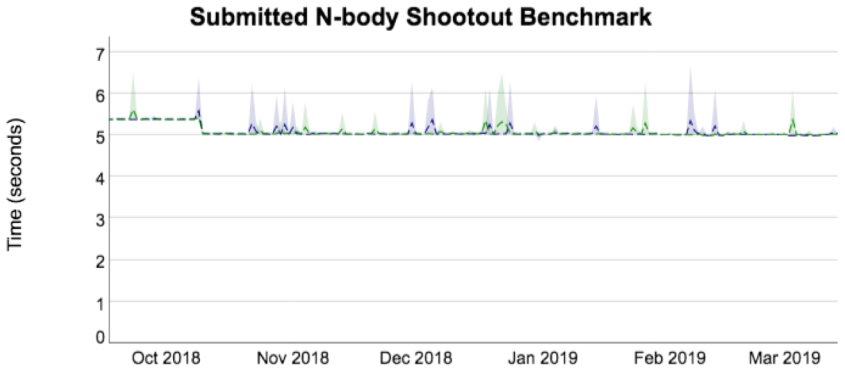
LLVM: Enhanced compatibility

- The LLVM back-end can now link statically
- Now compatible with LLVM versions 6-8
- Now compatible with MacOS Mojave
- Removed ‘register’ keyword from Qthreads (deprecated in C++)
  - Our change was merged upstream
  - Enabled '--llvm' to work on 32-bit x86
- Improved ability to find header files in more diverse installations
- Improved ability to invoke the optimizer on Cray XC systems

LLVM: Floating point optimization

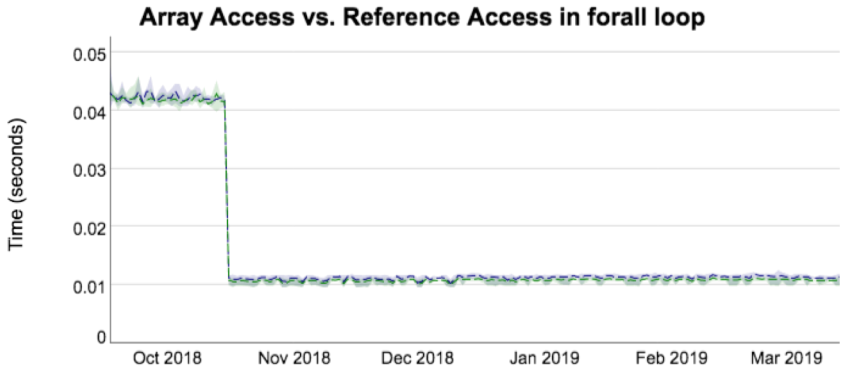
- Configured LLVM optimization to use fused floating-point multiply-add by default
- Resulted in a modest performance improvement for two benchmarks

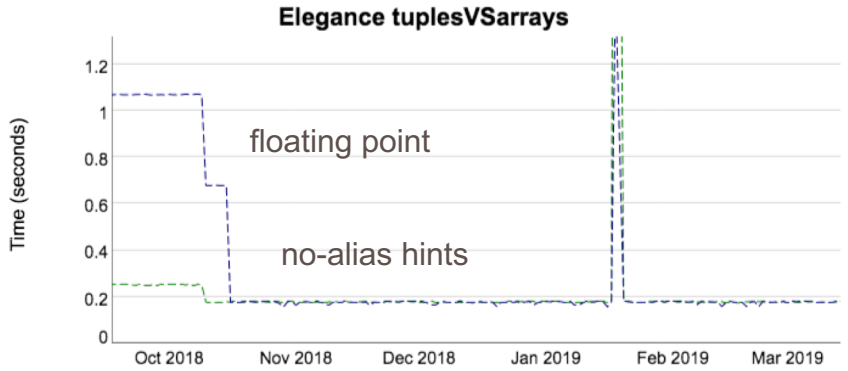




LLVM: no-alias hints

- Added new analysis pass to determine when Chapel arrays cannot alias
- Used the result to communicate to LLVM IR when array dereferences don't alias
  - via ‘noalias’ metadata
- Provided close to 2x performance improvement for some benchmarks





LLVM: Vectorization

- LLVM includes a parallel_loop_access loop metadata hint
  - Indicating to optimization no memory carried dependencies
- LLVM's LoopVectorizer is pretty good at adding runtime checks
  - To verify that aliasing doesn't introduce memory dependencies
- Now chpl emits parallel_loop_access metadata for forall and vectorizeOnly loops
  - But only when we are confident vectorization is safe
  - Can improve performance when the cost of the runtime check is significant
- Investigated prototype integration with the Region Vectorizer
  - A more general vectorizer than the LLVM Loop Vectorizer
  - Shows promising speedups for some benchmarks

LLVM: Next Steps

- Implement full ABI compatibility
- Make --llvm the default for the 1.20 release
- Study more benchmarks to try and improve performance
- Continue to work on Region Vectorizer integration
  - Mark more loops as vectorizeable
- Improve alias analysis between C and Chapel types

Choosing the Target Architecture and CPU for Specialization

target cpu: Background

- Before 1.19, there was no way to specify machine type
  - CHPL_TARGET_PLATFORM indicated an OS, e.g. linux64
  - CHPL_TARGET_ARCH specified a processor type, e.g. sandybridge
- In fact CHPL_TARGET_ARCH was used to determine 3 things:
  - A processor architecture, e.g. x86_64
  - A processor implementation, e.g sandybridge
  - A symbolic processor type for specialization/optimization, e.g. native
- Led to problems when one chapel directory is used for incompatible architectures
  - CHPL_TARGET_ARCH=native used same paths for both
  - Compiler build and bin directory did not differentiate at all

target cpu: This Effort

- Split CHPL_TARGET_ARCH into two flags
  - CHPL_TARGET_ARCH now means processor architecture
    - For example x86_64, arm, aarch64, ppc64
  - CHPL_TARGET_CPU now means CPU type for specialization
    - For example sandybridge, k8, native, none, sandybridge
- Added CHPL_HOST_ARCH, used it in compiler paths
  - Compiler is in bin/$CHPL_HOST_PLATFORM-$CHPL_HOST_ARCH
  - For example bin/linux64-x86_64/chpl
- Updated build and third-party install paths

target cpu: Impact

- Now possible to work with different architectures when
  - Building Chapel from source from a shared directory
  - Installing Chapel to a shared directory
  - Including when using CHPL_TARGET_CPU=native

Compile-time Config Disambiguation

Config Disambiguation: Background

Background:

- Distinct modules may happen to use the same config names

```
module M1 { config const debug = false; … }
module M2 { config const debug = true; … }
```

- Chapel has long supported execution-time disambiguation of configs:

```
$ ./myProg --M1.debug=true --M2.debug=false
```

- However, compile-time configs have not received similar support

```
$ chpl myProg.chpl -sdebug=true
myProg.chpl:2: error: Ambiguous config param or type name …
$ chpl myProg.chpl -sM1.debug=true
error: Trying to set unrecognized config param 'M1.debug' …
```

Config Disambiguation: This Effort and Impact

This Effort:

- Added disambiguation support for compile-time configs
- Improved error messages when ambiguity occurs

Impact: Compile-time disambiguation now works much better:

```
$ chpl myProg.chpl -sdebug=true
myProg.chpl:2: error: ambiguous config name (debug)
myProg.chpl:1: note: also defined here
myProg.chpl:2: note: (disambiguate using -s<modulename>.debug…)
$ chpl myProg.chpl -sM1.debug=true
$ ./myProg
```

Config Disambiguation: Next Steps

Next Steps:

- Extend disambiguation to support module paths
  - Currently only supports disambiguation of top-level module configs

```
module M1 {
  module M2 {
    config const debug = false;
  }
}
```

```
$ chpl -sM1.M2.debug=true myProg.chpl
$ ./myProg --M1.M2.debug=true
```


Retiring chpl-ipe

chpl-ipe: Background and This Effort

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Background:

- ‘chpl-ipe’ provided a prototype interactive Chapel environment
  - Added in Chapel 1.11.0
  - A proof-of-concept that supported minimal Chapel features
  - Took the approach of incrementally parsing code, interpreting the IR
  - Has received little attention or upkeep since then
- Main takeaway: interactive Chapel warrants a different compilation approach
- Meanwhile, we were carrying around the code, documentation, issues, …

This Effort: Removed chpl-ipe from the release to clear the slate

chpl-ipe: Status and Next Steps

Status:

- Still want to support Chapel in an interactive mode
- Have some proposals for how that could be achieved
  - Though they tend to require dramatic changes to the compiler
  - Such changes would likely help with other things too (e.g., compile time)

Next Steps:

- Determine the right timing and resources to pursue this
- Decide upon and prototype a new approach

For More Information

For a more complete list of compiler and tools changes in the 1.19 release, refer to 'Feature Improvements', 'Compiler Improvements', 'Performance Optimizations/Improvements', 'Portability', 'Packaging / Configuration Changes', 'Deprecated and Removed Features, and other sections in the CHANGES.md file.

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