Compiler / Tools

Chapel Team, Cray Inc.

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Outline

- Mason Improvements
- Bash Tab Completion For chpl
- Compiler Flag Suggestions
- Default Executable Name Change
- LLVM Back-end Improvements
- Communication Optimization with --llvm-wide-opt
- Other Compiler/Tool Improvements

Mason Improvements

Mason: Background

- **Mason is the Chapel package manager**
  - Supports commands for completing different tasks

```
new       Create a new mason project
update    Update/Generate Mason.lock
build     Compile the current project
run       Build and execute src/<project name>.chpl
search    Search the registry for packages
env       Print environment variables recognized by mason
clean     Remove the target directory
doc       Build this project's documentation
```

  - Uses a registry containing “Bricks” describing packages
    - Default registry is publicly hosted at github.com/chapel-lang/mason-registry
    - MASON_REGISTRY environment variable overrides the default location
    - Only one registry can be used at a time

Mason: This Effort

- **Added support for multiple mason registries**
  - MASON_REGISTRY is now a comma separated list of registries
    - Each registry has an optional “name|” prefix to name a local directory to use
    - “name” defaults to the text following the final slash in the location

```
export MASON_REGISTRY="loc|/path/to/reg1,http://reg2.com/reg"
```

- **Added two new mason commands**

```
help      Display a help message
version   Display the mason version number
```

- **Added “make install” support**
  - After building mason it can be installed next to the “chpl” binary

Mason: Impact

- **Mason can now use multiple registries**
  - Bricks are searched for in left-to-right order of MASON_REGISTRY
  - Registries can be local and include local, private packages
  - Each registry can be named locally using MASON_REGISTRY
- **Mason can easily be installed next to the chpl binary**

```
make install
```

- **Show help/version messages with mason commands**

```
mason help
mason version
```

Mason: Next Steps

Next Steps: Continue to add and harden Mason features

- Add mason commands for additional functions

```
add       add a dependency
rm        remove a dependency
init      create a project in an existing directory
test      run project tests
...
```

- Add support for C dependencies
- Simplify creation of registries and adding new Bricks
- Improve error messages
- Add continuous integration testing for the package ecosystem

Bash Tab-completion for chpl

Tab-completion for chpl

Background: There are many verbosely-named chpl options

- Finding the right option requires searching help output or man pages

```
chpl --help
man chpl
```

This Effort: Add a bash tab-completion script for chpl

- Script knows about all compiler options and can autocomplete them
- For multiple matches, prints them and completes as much as possible

Impact: Bash users can autocomplete chpl options

- Bash users can use tab-completion for chpl compiler options

```
source $CHPL_HOME/util/chpl-completion.bash
```

Next steps: Developer vs. non-developer options

- Only autocomplete developer options when in developer mode

Compiler Flag Suggestions

Flag Suggestions

Background: Compiler gave a generic error for misspelled flags

```
$ chpl -fast
Unrecognized flag: '-f' (use '-h' for help)
$ chpl --ieee
Unrecognized flag: '--ieee' (use '-h' for help)
```

This Effort: Compiler suggests a flag in simple cases

```
$ chpl -fast
Unrecognized flag: '-f' (use '-h' for help)
       Did you mean --fast ?
$ chpl --ieee
Unrecognized flag: '--ieee' (use '-h' for help)
       Did you mean --ieee-float ?
```

Impact: Compiler is more friendly

Default Executable Name Change

Executable Name: Background

Background:

- Historically, compiling `foo.chpl` resulted in the executable `a.out`
- In 1.16, executable started being named after the main module
  - Why?
    - because every program has a single main module (vs. multiple files and modules)
    - because in practice the main module typically takes its name from its file

- However, this led to confusion in certain cases:

myProgram.chpl:

```
module M1 {
  writeln("Hello!");
}
```

```
> chpl myProgram.chpl
> ./myProgram
./myProgram: No such file or directory
```

- Users are accustomed to executables taking the name of *some* file

Executable Name: This Effort and Impact

This Effort:

- 1.17 names the executable after the file containing the main module
  - Why?
    - still uses something unique about the program
    - avoids the surprising cases that 1.16 had
    - returns to normal situation of naming executables after files
    - still supports the common case of the main module taking its name from its file

Impact:

myProgram.chpl:

```
module M1 {
  writeln("Hello!");
}
```

```
> chpl myProgram.chpl
> ./myProgram
Hello!
```

LLVM Back-end Improvements

LLVM Back-end Improvements: Background

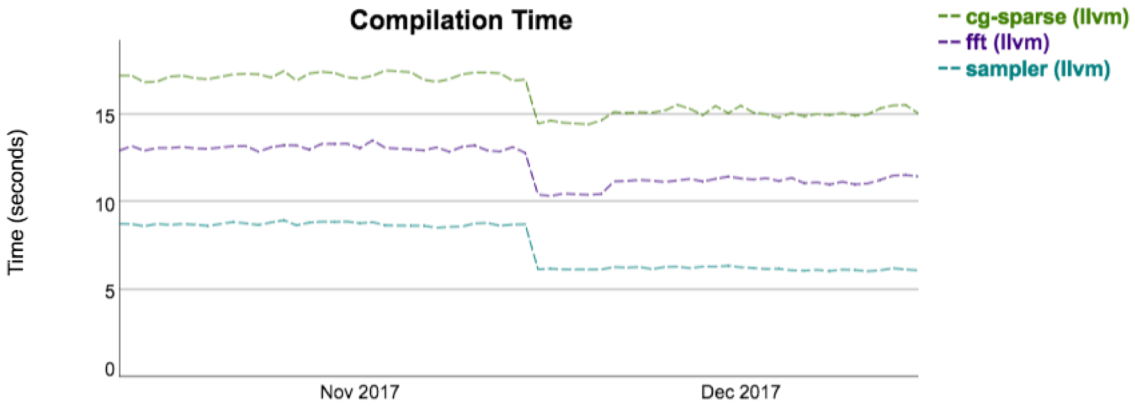
- **LLVM is a compiler optimization framework**
  - actively developed and constantly improving
- **We want LLVM to become our default back end**
  - to focus our attention instead of dividing it among C compilers
  - to improve optimization
  - to enable communication optimization

LLVM Back-end Improvements: This Effort

- Ported Chapel to LLVM 6.0
- Removed support for LLVM versions older than 4.0
- CHPL_LLVM=system now supports Mac Homebrew
- Improved precision of LLVM alias analysis metadata
- Improved --llvm compilation speed
- Addressed problems with --llvm-wide-opt
  - See: next section

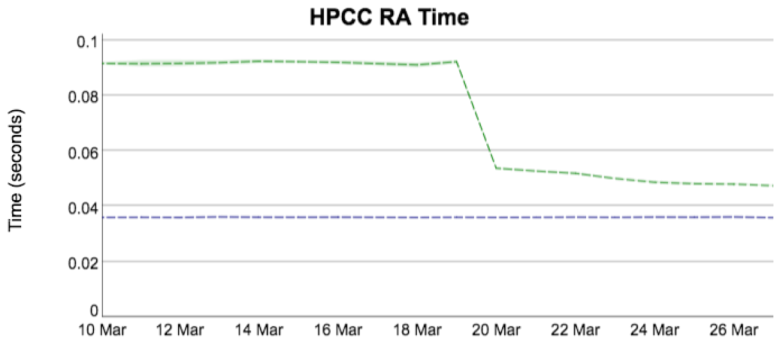
LLVM: Impact: Compilation Time

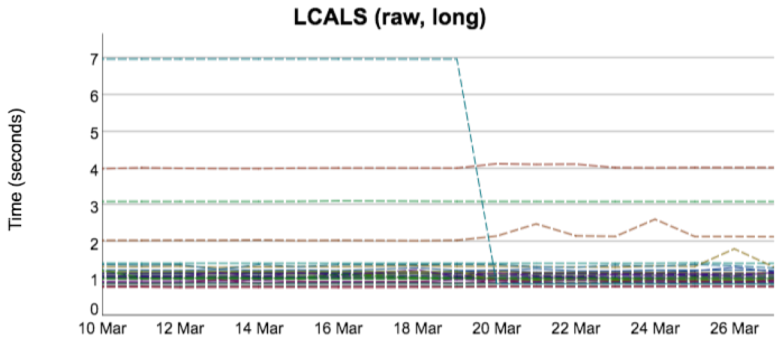
- **--llvm compilation time has improved**
  - now competitive with C backend

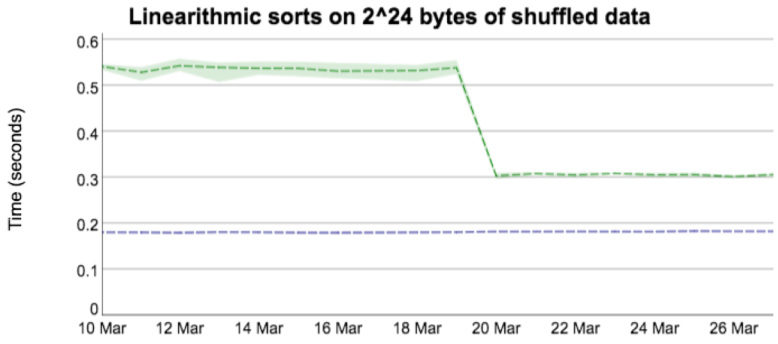


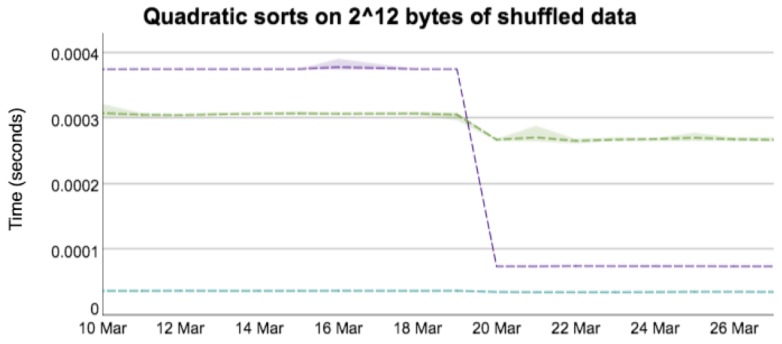
LLVM: Impact: Performance

- --llvm performance has improved with LLVM 6









LLVM Back-end Improvements

Impact:

- LLVM 6.0 vectorizes more cases when llvm-wide-opt is used
- code kept maintainable by removing obsolete version support
- users and developers can start quickly with CHPL_LLVM=system

Status:

- --llvm and --llvm-wide-opt are tested nightly
- performance is improving and generally competitive with C backend
  - occasionally beating C compilers

Next Steps:

- continue to push towards using --llvm by default
- port Chapel's LLVM interface to ARM
  - match ABI characteristics that differ from x86-64

Communication Optimization with --llvm-wide-opt

Comm Opt: Background

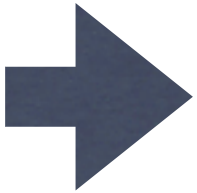
- Idea is to use LLVM passes to optimize GET and PUT
- Enabled with --llvm-wide-opt compiler flag
- First appeared in Chapel 1.8
- Unfortunately was not working in 1.15 and 1.16 releases

Comm Opt: in a Picture

```
// x is possibly remote
var sum = 0;
for i in 1..100 {
  %1 = get(x);
  sum += %1;
}
```

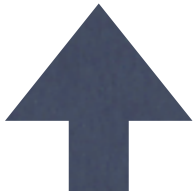
TO GLOBAL MEMORY

```
var sum = 0;
for i in 1..100 {
  %1 = load <100> %x
  sum += %1;
}
```



EXISTING LLVM OPTIMIZATION LICM

```
var sum = 0;
%1 = load <100> %x
for i in 1..100 {
  sum += %1;
}
```



TO DISTRIBUTED MEMORY

```
var sum = 0;
%1 = get(x);
for i in 1..100 {
  sum += %1;
}
```

load <100> %x = load i64 addrspace(100)* %x

Comm Opt: Details

- **Uses existing LLVM passes to optimize GET and PUT**
  - GET/PUT represented as load/store with special pointer type
  - normal LLVM optimizations run and optimize load/store as usual
  - an LLVM pass lowers them back to calls to the Chapel runtime
- **Optimization gains from this strategy can be significant**
  - See "LLVM-based Communication Optimizations for PGAS Programs"
- **Historically, needed packed wide pointers as workaround**
  - wide pointer normally stored as a 128-bit struct: {node id, address}
  - bugs in LLVM prevented using 128-bit pointers
  - packed wide pointers store node id in high bits of a 64-bit address
  - led to scalability constraints — maximum of 65536 nodes
  - sometimes made --llvm-wide-opt code slower than C backend

Comm Opt: This Effort, Impact

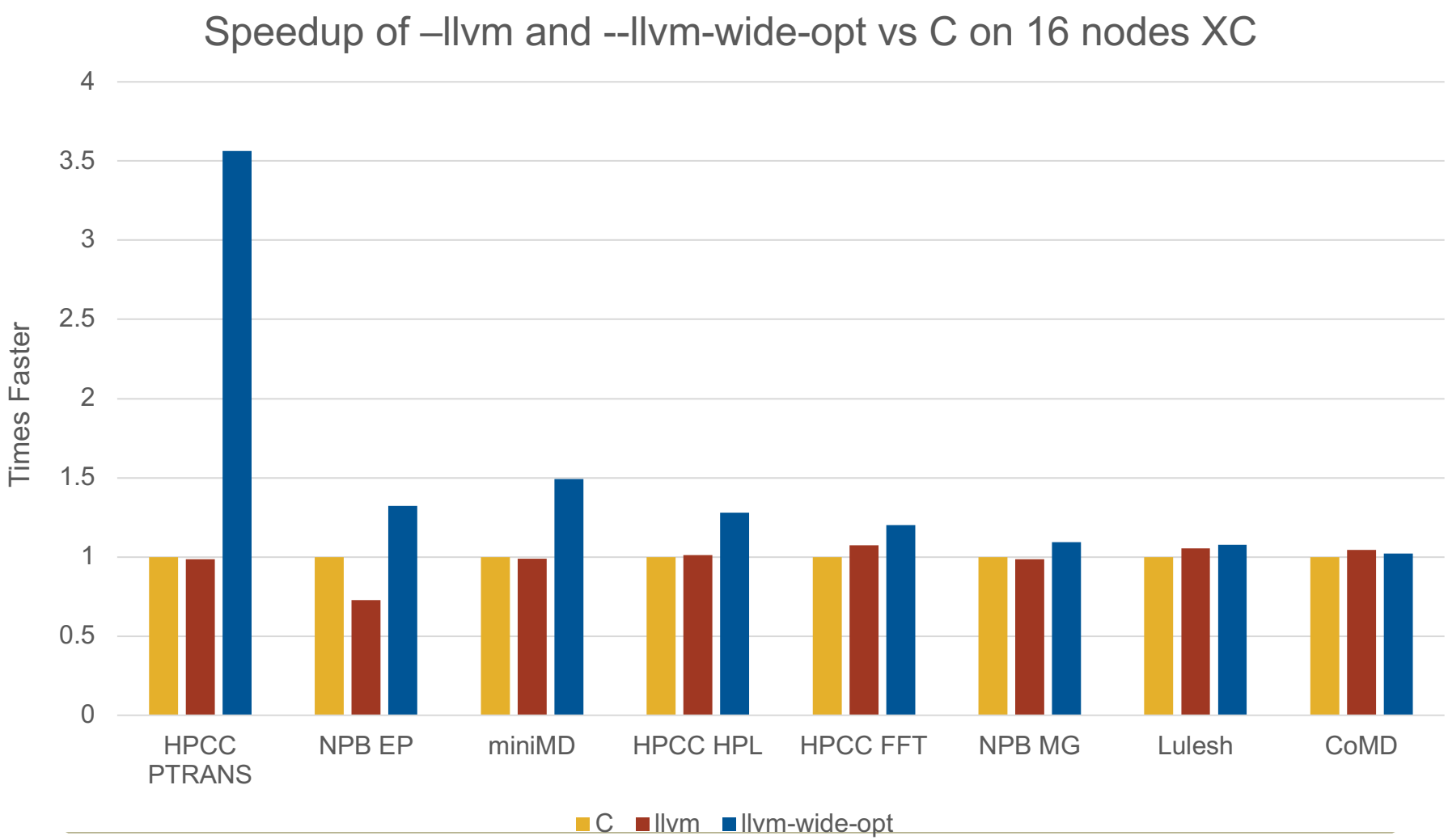
This Effort: Fix --llvm-wide-opt for 1.17

- remove packed wide pointer workaround
- remove CHPL_WIDE_POINTERS configuration variable
- resolve other bugs, including 2 bugs in LLVM itself
- perform initial performance study

Impact: --llvm-wide-opt is much closer to production quality

- Design now supports more than 100,000 nodes
- Overhead is reduced
- No longer reduces performance relative to the C backend
- Significant performance improvement for some benchmarks

Comm Opt: Impact



Comm Opt: Next Steps

- Perform more testing
- Contribute bug fixes for 128-bit pointers upstream
- Enable --llvm-wide-opt by default with --fast
- Reduce compile time spent in this optimization

Other Compiler/Tool Improvements

Other Compiler/Tool Improvements

- Extern blocks now support #defines with casted literals
- Rewrote and improved the `printchplenv` tool
- Rewrote and improved the `compileline` tool
- Added error handling constructs to syntax highlighters
- Added `prototype` modules to syntax highlighters

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