Compiler / Tools

Chapel Team, Cray Inc.

Chapel version 1.18

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Outline

- Mason Improvements
- LLVM Back-end Improvements
- Tab Completion Improvements
- Error Message Improvements

Mason Improvements

Mason Improvements: Background

- **Mason originally added in Chapel 1.16.0**
  - Command line tool for package management and building
  - Considered under development
    - No breaking changes made to date, but reserving that right until version 1.0
- **Package metadata centralized in registries**
  - Official registry located on Github: chapel-lang/mason-registry
  - Users can create their own internal or public registries
- **Package source code decentralized across git repositories**
  - Supports any valid git address
    - Github, Gitlab, local git repositories, etc.
- **Has supported Chapel packages only**
  - This prevented many user packages from being mason packages

Mason: This Effort

- **Improved general usability of mason**
  - Added “--no-update” flag for better offline support
  - Added “mason {add, rm} <package>” for managing dependencies
  - Added support for package tests and examples
  - Improved documentation
- **Added build-on-last-modified behavior**
  - Eliminates unnecessary rebuilds
- **Added support for non-Chapel packages in mason**
  - Supports Spack packages (mason external)
  - Supports system packages (mason system)

Mason: This Effort – Improved Usability

- **Added 'mason {add, rm}' for dependency management**
  - Allows managing dependencies without editing manifest file

```
mason add MatrixMarket@0.1.0
mason add --external hdf5@1.10.1 # Spack package
mason rm MatrixMarket
```

- **Improved offline support**
  - --no-update flag added to skip registry update, which requires internet
  - Many mason commands invoke a registry update by default
    - this would cause connection warnings for offline users
  - For example:

```
mason build --no-update
```

- **Improved documentation**
  - Created a "Basic Usage" section
    - walks through how to use mason
    - includes copy/paste-friendly examples

Mason: This Effort – Improved Usability

- **Added 'mason test'**
  - Tests can be added to '<package>/test/'
  - 'mason test' will compile and run all tests, reporting pass/fail results
    - any top-level Chapel program in 'test/' assumed to be a test program
    - pass/fail is determined by an exit code (non-zero means fail)
    - test output can be piped to stdout with flag: 'mason test --show'
  - For example:

```
$ mason test
--- Results ---
Test: myPackageTest Passed

--- Summary: 1 tests run ---
-----> 1 Passed
-----> 0 Failed
```

Mason: This Effort – Improved Usability

- **Added support for package examples**
  - Examples can be added to '<package>/example/'
  - 'mason build --example <filename>' will compile an example
    - Omitting the filename will build all examples
  - 'mason run –example <filename>' will run an example
    - Omitting the filename will list all available examples to run
  - Examples can be specified in the manifest file
    - compiler and execution options can also be specified
    - if omitted from manifest, examples will be found automatically in 'example/'

```
[examples]
examples = ["myPackageExample.chpl"]

[examples.myPackageExample]
execopts = ["--count=20"]
compopts = ["--savec tmp"]
```

Mason: This Effort – Build on Last Modified

- **Mason skips compilation when project "not modified"**
  - Similar to 'make' behavior when build dependencies are unchanged
- **Project considered "not modified" when:**
  - Target binary already exists
  - Lock file already exists
  - Source files have not been modified since binary last built
    - this includes dependency code as well
  - Manifest file has not been modified since binary last built
    - this accounts for modified dependencies, versions, compilation flags, etc.
  - Force flag is not thrown, '--force'
    - this flag was added to override this feature
- **User notified when skipping build:**

```
$ mason build
Updating mason-registry
Skipping Build... No changes to project
```

Mason: This Effort – Spack Integration

- **Spack is a system package manager**
  - Developed with HPC users in mind
  - Developed by LLNL
  - Spack has ~3000 packages in its registry
  - Supports multiple configurations, platforms, and compilers
- **Mason uses Spack to manage non-Chapel dependencies**
- **Relying on a single package manager has tradeoffs:**
  - Using only Spack means Mason's success is tied to Spack's success
  - Using only Spack enables version resolution for external packages
    - Mason offloads version resolution of external packages onto Spack

Mason: This Effort – Spack Integration

- **Accessed through 'mason external' command**
  - Users are required to install Spack backend to use this feature:

```
$ mason external install openssl@1.0.2k
To use `mason external` call `mason external --setup`
$ mason external --setup
```

  - Spack is installed within $MASON_HOME
- **Provides subcommands, which call down to Spack:**
  - 'mason external search <search-string>'
    - searches packages on Spack registry
  - 'mason external info <package>'
    - shows information about external package
  - 'mason external compiler'
    - lists available compilers on system

Mason: This Effort – Spack Integration

- **External packages require explicit installation**
  - This behavior differs from how mason packages are installed
    - external packages tend to have a long installation time
    - we decided that this should be explicitly opted into to avoid surprise
- **Subcommands available for installing/uninstalling:**
  - 'mason external install <spack spec expression>'
  - 'mason external uninstall <package>'
- **"Spack spec expressions" allow specifying constraints**
  - For example: '<package>@<version>%<compiler>'
  - Compiler defaults to 'CHPL_TARGET_COMPILER' if unspecified
  - Spec expression documentation shown with 'mason external --spec'

Mason: This Effort – Spack Integration

- **Manifest files distinguish external packages in [external]**

```
[brick] name = "myPackage"
version = "0.1.0"
chplVersion = "1.18.0"

[external]
openSSL = "1.0.2k”
```

- **External packages can be managed with ‘mason add/rm’**

```
$ mason add --external openSSL@1.0.2k
Adding external dependency with spec openssl@1.0.2k
$ mason rm openSSL
```

Mason: This Effort – System Packages

- **Mason uses pkg-config to access packages on system**
  - Feature intended for prototyping purposes
    - only available for top-level packages
    - allows quick and easy access to the libraries available on the system
    - cannot publish packages with system dependencies
  - Pkg-config provides compiler flags for linking to the provided library
- **Accessed through "mason system" command**
- **Provides subcommands, which call down to pkg-config:**
  - 'mason system search <search-string>'
    - searches packages installed on system
  - 'mason system pc <package>'
    - prints pkg-config file of package

Mason: This Effort – System Packages

- **Manifest files distinguish system packages in [system]**
  - For example:

```
[brick] name = "myPackage"
version = "0.1.0"
chplVersion = "1.18.0"

[system]
openSSL = "0.9.8zh”
```

  - System packages can be added/removed with mason add/rm:

```
$ mason add --system openSSL@0.9.8zh
Adding system dependency openSSL version 0.9.8zh
$ mason rm openSSL
```

Mason: Impact & Status

- **Mason is becoming more mature and feature-rich**
- **Many Chapel repositories on Github can now be packaged**
  - Supporting non-Chapel dependencies was a prerequisite for many
- **Mason is still considered under development**
  - Still gathering feedback on features before locking down 1.0

Mason: Next Steps

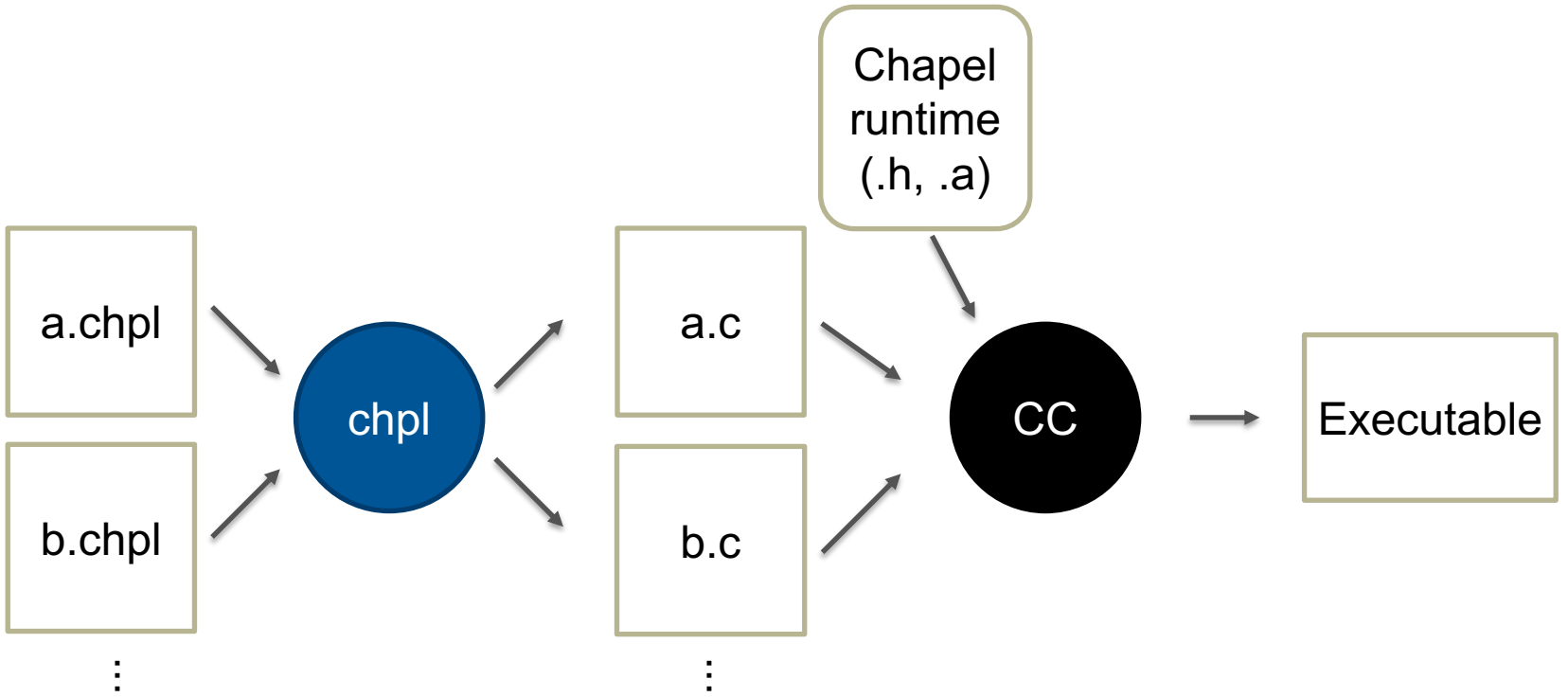
- **Implement essential package manager features**
  - Support licensing
  - Support signed packages (GPG)
  - Support a more secure way to pin package versions
  - Support packages as applications
  - Improve process for publishing packages
- **Continue to improve offline support**
  - Support environment variable for “offline mode”
- **Handle package collisions better**
  - Current namespace rules will cause many package incompatibilities
- **Cache packages on a server**
  - Ensures availability of packages in the registry
- **More next steps tracked in #7106**

LLVM Back-end Improvements

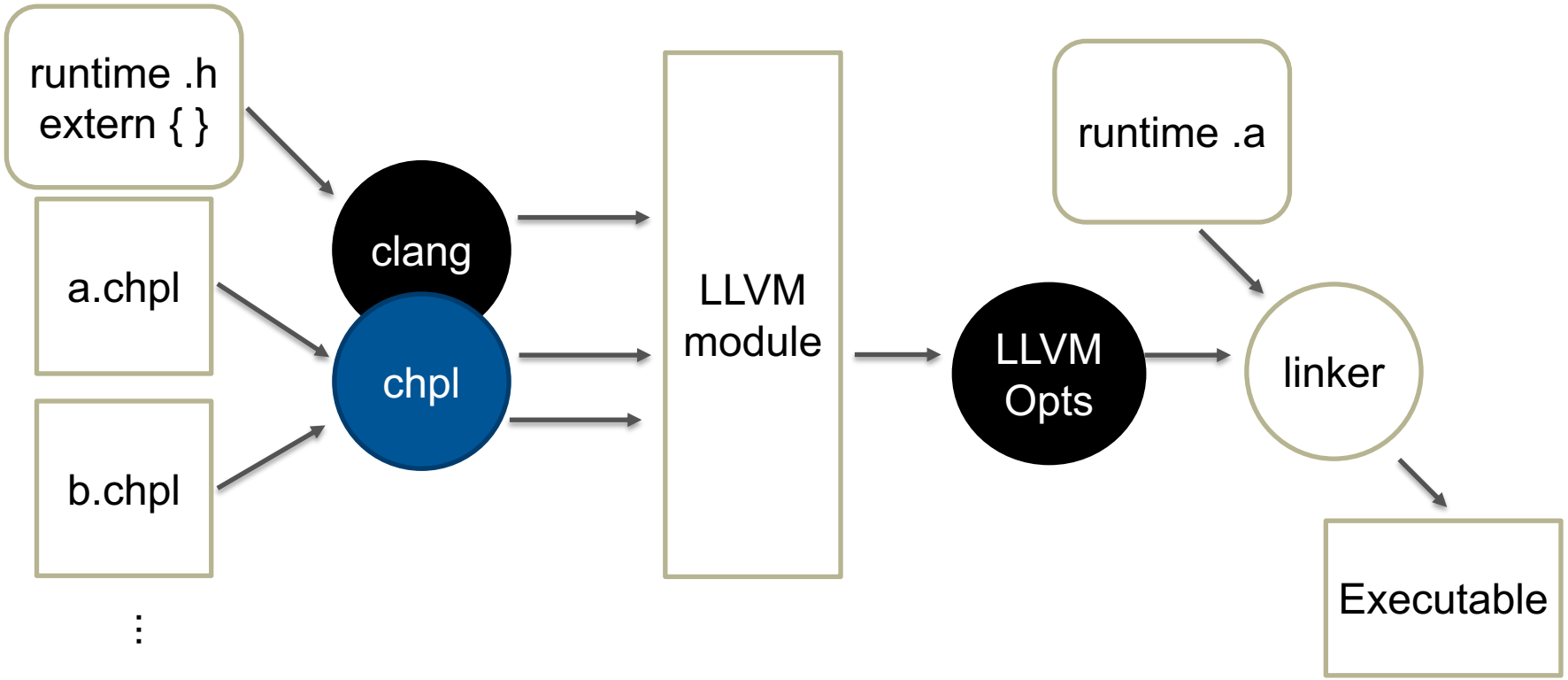
LLVM: Background

- **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 improve optimization and enable communication optimization

Chapel compilation flow



Chapel --llvm compilation flow



LLVM: This Effort

- **Broadened LLVM support for assorted use cases**
  - improved ARM support
  - made LLVM work with dynamic linking on Cray XC systems
  - updated llvm.invariant.start emission for records using initializers
  - enabled ‘chpl’ to build with LLVM 7 pre-release

LLVM: Next Steps

- **Improve ABI compatibility for non-x86 architectures**
  - particularly ARM
- **Integrate Chapel alias analysis metadata with that for C**
  - improves optimization opportunities with imported/exported functions
- **Allow --llvm to link user programs statically**
- **Improve performance for code generated with --llvm**
- **Make --llvm the default**

Tab Completion Improvements for Chapel Options

Tab Completion Improvements

Background: Tab completion of 'chpl' options was added in 1.17

- Tab completion searched against all compiler options
  …including developer options
- Tab completion completed paths looking for .chpl files
  …but mishandled paths that included the home directory marker '~'

```
% chpl ~/test.ch<tab>   ➡   % chpl \~/test.chpl
```

This Effort: Fix the issues listed above

- Only complete non-developer options unless developer mode is on

```
% chpl --g<tab>
--gasnet-segment --gmp
```

```
% chpl --devel --g<tab>
--gasnet-segment --gdb --gen-ids --gmp
```

- Paths including '~' complete successfully

```
% chpl ~/test.ch<tab>   ➡   % chpl ~/test.chpl
```

Error Message Improvements

Error Messages: Background + This Effort

Background:

- The Chapel compiler's error messages have often been lacking
  - confusing, not written with end-users in mind, internal errors, …
  - we've been focused more on supporting correct code than incorrect
  - however, as we work to attract new users, this becomes a bigger problem

This Effort:

- Striving to improve error message problems for reported cases

Error Message Improvements

- Applying '.type' to a type is consistently an error

```
writeln(uint.type: string);
```

```
uintType.chpl:1: error: can't apply '.type' to a type (uint(64))
```

- Bad accesses to type-tuples result in compile-time errors

```
type t = (int, real);

writeln(t(3): string);
writeln(t(2, 1): string);
```

```
t.chpl:3: error: type index expression '3' out of bounds
t.chpl:4: error: too many arguments to type index expression
```

Error Message Improvements (continued)

- **Recursive records result in compile-time errors**

```
record R {
  var x : R;
}
var r = new R();
```

```
r.chpl:2: error: record 'R' cannot contain a recursive field 'x' of type 'R'
```

- **And many others…**

For More Information

For a more complete list of compiler and tool changes in the 1.18 release, refer to the ‘New Tools / Tool Changes’, ‘Compiler Flags’, ‘Error Messages’, and ‘Bug Fixes’ sections in the **CHANGES.md** file.

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