Runtime Improvements

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Outline

- Stack Tracing on Halt
- Atomic Improvements
- Memory and Comm Improvements
- Other Runtime Improvements

Stack Tracing on Halt

Stack Tracing: Background

```
1    // test.chpl
2    run();
3    proc run() {
4      writeln(logarithm(-1.0));
5    }
6    proc logarithm(x:real) {
7      if x <= 0.0 then
8        halt("invalid x");
9      return log(x);
10   }
```

```
$ ./test
test.chpl:8: error: halt reached - invalid x
```

- In this example, the error is in the caller of logarithm()
- But, the error message points to the body of logarithm()
- The location of the call is important but missing

Stack Tracing: This Effort

- **Error messages from halt can be unhelpful without context**
- **The approach is to use libunwind and optionally addr2line**
  - libunwind provides the mechanism to get a stack trace
  - Chapel compiler generates a table to help with translation
    - function addresses into names and declaration line numbers
  - … but it would be preferable to see line numbers for function calls
  - addr2line can translate the address of a call into a line number
- **Contributed by Andrea Francesco Iurio (GSoC student)**

Stack Tracing: Impact

```
1    // test.chpl
2    run();
3    proc run() {
4      writeln(logarithm(-1.0));
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6    proc logarithm(x:real) {
7      if x <= 0.0 then
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```

```
$ ./test
test.chpl:8: error: halt reached - invalid x
Stacktrace

halt() at $CHPL_HOME/modules/internal/ChapelIO.chpl:659
halt() at $CHPL_HOME/modules/internal/ChapelIO.chpl:650
logarithm() at test.chpl:9
run() at test.chpl:4
```

Stack Tracing: Status and Next Steps

Status:

- CHPL_UNWIND=libunwind and CHPL_UNWIND=system available
  - libunwind: builds libunwind from third-party
  - system: uses a pre-installed libunwind
- Support for Linux and Mac OS X
- Linux stack traces can include call sites with *-g --cpp-lines*

Next Steps:

- Nightly testing with stack trace on halt enabled
- Remove internal module paths from the error messages

Atomic Improvements

Atomic Improvements: Background

- **Chapel atomics were heavily modeled after C11 atomics**

- **Chapel runtime had two implementations of atomics**
  - locks
    - For older C compilers that do not implement atomic operations
    - Runtime maintains a lock for each atomic variable
  - intrinsics (updated in this effort)
    - Implemented with __*sync* builtins (Intel extension popularized by gcc)
    - Much faster than locks

Atomic Improvements: This Effort

- **C standard atomics (cstdlib) implementation created**
  - Runtime support implemented as thin wrappers around C routines
    - With some additional code for floating-point operations
  - Easiest to maintain
    - About 2/3 the size of the other implementations
    - Leverages C compiler vendors' testing across architectures
  - Long term, will be the most portable and performant implementation

- **Current challenges**
  - gcc performance bug inhibits optimizations around atomic operations
  - Clang uses atomic headers from operating system
    - Usually out-of-date and buggy
  - Consequently, CHPL_ATOMICS=cstdlib is not yet the default

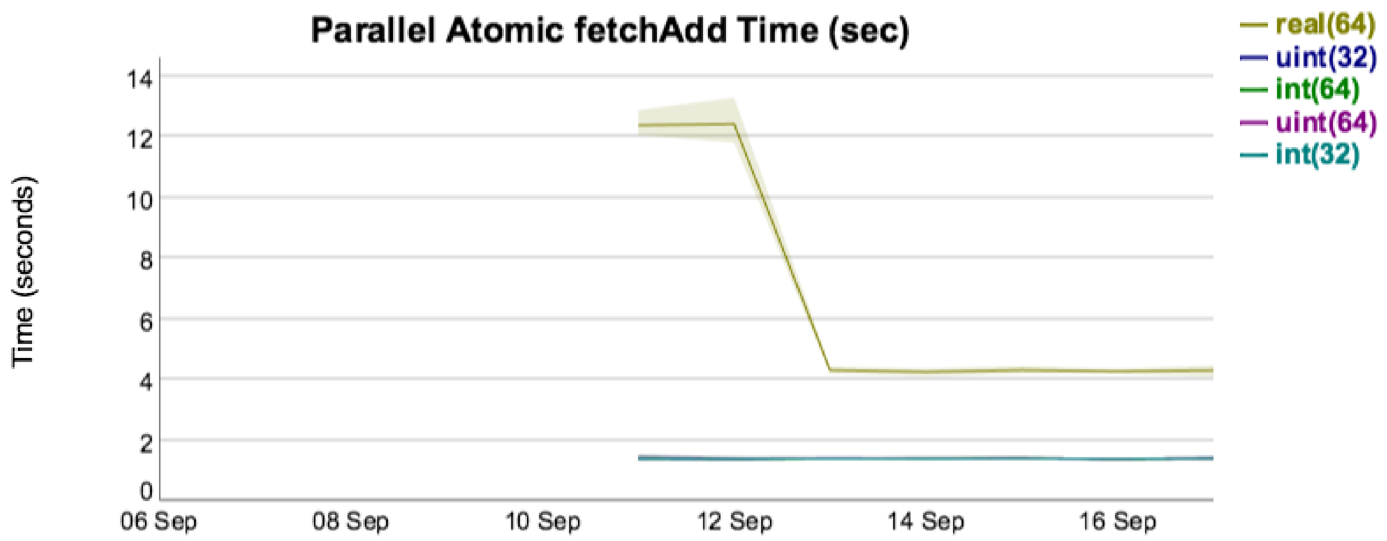
Atomic Improvements: This Effort

- **Fixed several bugs in the intrinsics implementation**
  - Made > wordsize loads/stores atomic on 32-bit platforms
  - Made < wordsize loads/stores atomic on 64-bit platforms
  - Removed type punning (undefined behavior)
  - Corrected floating-point fetch-and-add implementation

- **Improved performance of floating-point operations**
  - By eliminating use of volatile types and unnecessary memory barriers

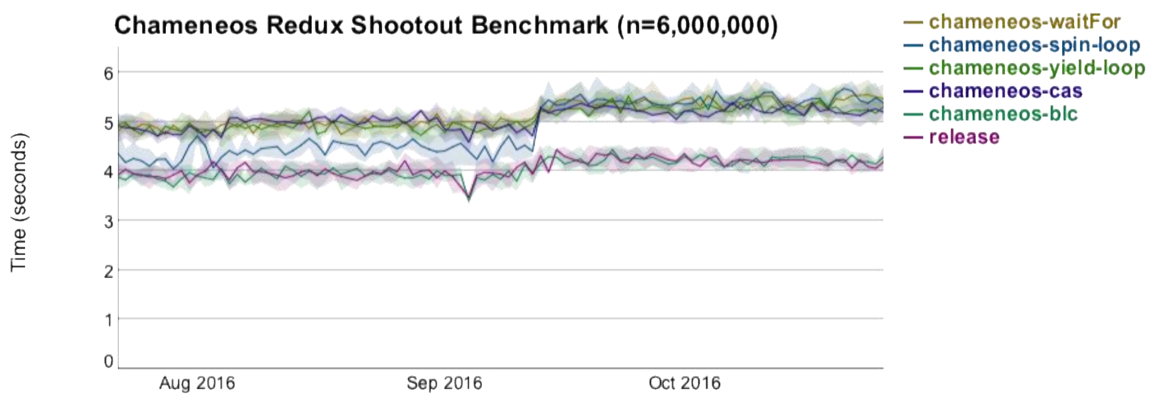
Atomic Improvements: Impact

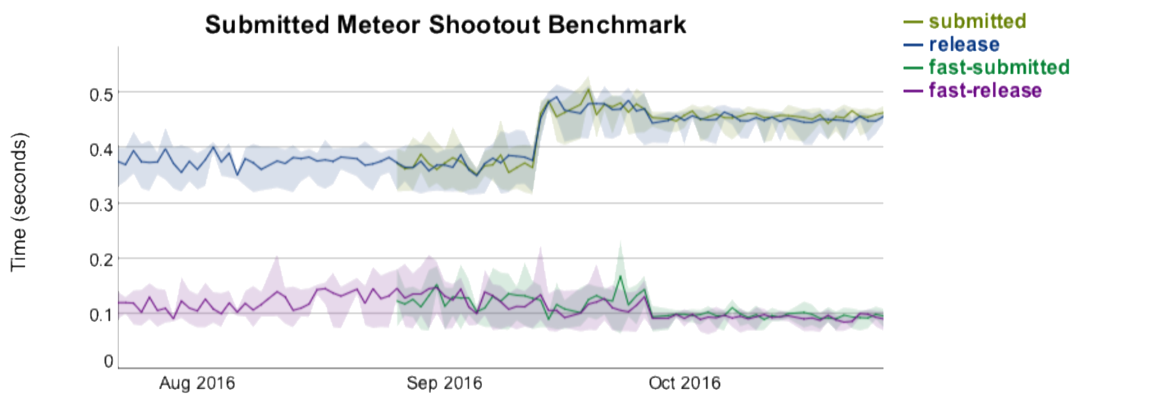
- Performance improvement for atomic real operations



Atomic Improvements: Impact

- **Minor regression for some shootout benchmarks**
  - Caused by atomic load bug fix





Atomic Improvements: Status and Next Steps

Status:

- C standard atomics available by setting CHPL_ATOMICS=cstdlib
- Intrinsics implementation has been overhauled
  - Serves as good default until C compiler cstdlib issues resolved

Next Steps:

- Work around clang atomic issues
  - Allow cstdlib atomics to become the default for clang
- Monitor gcc atomic performance regression issues
  - Contribute information to the bug reports where useful

Memory and Comm Improvements

CHPL_TASKS=fifo Stacks in Chapel Memory

Background: In fifo, a task runs on its host pthread's stack

- By default, pthread stacks are allocated directly from the OS
- Downside: task stacks were not in comm-layer-registered memory
  - examples: comm=gasnet and segment=fast, or comm=ugni
  - remote access to stack data was indirect (trampoline or Active Message)

This Effort: Get pthread/task stacks from Chapel heap

- Exception: want guard pages, but Chapel heap is on hugepages
  - can't change hugepage accessibility to create guard (huge)page
  - but hugepage stack alignment would be too wasteful of memory anyway

Impact: Performance improvement

- Much faster to stack-allocate Chapel variables than to heap-allocate
- Now stack allocation doesn't reduce communication performance

Stack-allocate Locals If Stack Is Communicable

Background: On-stmts may refer to function-local vars

- Historically, heaps could be remotely referenced and stacks not
- So, we heap-allocated locals ref'd in on-stmts to allow remote access
  - downside: heap allocation is much slower than stack allocation
- But now, some task stacks are remotely reachable

This Effort: Stack-allocate locals if stack is remotely reachable

- Examples:
  - comm=ugni, or comm=gasnet and segment=everything
  - tasks=fifo or muxed, without guard pages

Impact: Performance improvement

- Reduces allocation overhead

Next Steps: Do the same for tasks=qthreads

- Task stacks for tasks=qthreads are not remotely reachable
- Will need to change Qthreads itself, not just the Chapel shim

Optimize Local Non-blocking on-stmts

Background: *nonblocking* on-stmts optimize placed parallelism

- Used when source-code tasks do on-stmts and nothing else, as in:

```
begin on somewhere do …
cobegin { … ; on somewhere do … ; … }
coforall loc in Locales do on loc do …
```

- Runtime comm layer executeOnNB() initiates task on target locale
  - no runtime completion wait
- *But:* some such on-stmts turn out actually to be local
  - we used to handle this quite late, down in the runtime comm layer

This Effort: Optimize *local* nonblocking on-stmts

- Don't involve the runtime comm layer at all
- Instead, initiate on-stmt body directly, via runtime tasking layer

Impact: Reduced overhead

- Moreso for begin-on
- Not so much for cobegin-on, coforall-on which have termination sync

Other Runtime Improvements

Other Runtime Improvements

- **MassiveThreads working again for single-locale execution**
  - contributed by Kenjiro Taura

- **Bug fix: comm=gasnet out-of-segment NB GET/PUT fails**
  - out-of-segment + nonblocking is new combo, due to remote caching
  - solution: do these as blocking instead

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