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

```chapel
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
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

![Parallel Atomic fetchAdd Time (sec)](image)
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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