Compiler / Implementation

Chapel Team, Cray Inc.
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Outline

- Const-checking Improvements
- New Execution Time Checks
- Denormalize Pass On By Default
- Printing the Static Call Graph
- Error Message Improvements
- Bug Fixes
Const-checking Improvements
Const-checking: Background

- Chapel’s const-checking has been incomplete

- Problematic areas:
  - blank-intent array arguments
  - methods that set 'this' or a field

- These examples should report an error but compile in 1.14

```chapel
proc setOne(A) {
    A[1] = 1;
}
const A: [1..4] int;
setOne(A); // 1.14: missing error

record R {
    var x: int;
    proc reset() {
        this.x = 0;
    }
}
const r = new R(1);
r.reset(); // 1.14: missing error
```
Const-checking: This Effort

- Adds new const-checking implementation
- Better handling of many difficult cases
  - return intent overloads
  - array blank intent and record 'this' blank intent
  - field access
- The examples now report a compilation error

```plaintext
proc setOne(A) {
    A[1] = 1;
}
const A: [1..4] int;
setOne(A);  // 1.15: compilation error

record R {
    var x: int;
    proc reset() {
        this.x = 0;
    }
}
const r = new R(1);
r.reset();  // 1.15: compilation error
```
Const-checking: Impact and Next Steps

Impact:
- New checking revealed a significant number of errors
  - in both standard modules and in tests
- Fixing these improved the quality of module and test code

Next Steps:
- Address problem areas in the improved implementation
  - if expressions
  - tuples, especially nested tuples
New Execution Time Checks
Exec-time checks: Divide by Zero

Background:
- Chapel supports many execution-time checks to avoid exceptions
  - goal: users should not typically see segfaults, floating point exceptions, etc.
- checks are on by default to support productivity
  - can be disabled for performance runs (e.g., --no-bounds-checks, --fast)
- Recently, a few users have run into faults due to integer divide-by-zero

This Effort:
- add execution time checks to guard against integral divide-by-zero
  - floating point types behave as always
- add new flag to enable/disable these checks:  
  --[no-]div-by-zero-checks
- also controlled by ‘--[no-]checks’ and ‘--fast’

Impact: users now get better error messages in such cases
Exec-time checks: empty ‘Block’ bounding box

**Background:**
- Chapel’s ‘Block’ distribution takes a domain bounding box argument
  - indicates which indices define the block distribution
- If domain was empty / uninitialized, caused a divide-by-zero error
- Check on previous slide now catches divide-by-zero
  - but root cause would be unclear to a typical user (“I wasn’t dividing…”)

**This Effort:**
- add execution time checks to guard against such cases:
  - error: halt reached - Block() requires a non-empty boundingBox
- always enabled: ‘Block’ distributions are already expensive to set up
  - overhead of new check unlikely to be noticeable

**Impact:** users will now get better error messages for such cases
Exec-time checks: Next Steps

- Continue to improve messages for confusing error cases
- As error-handling feature matures, use it for such cases
Denormalize Pass On By Default
**Denormalize: Background**

- **Introduced ‘denormalize’ compiler pass in 1.14**
  - Goal: make generated C code easier to read
  - Disabled by default due to insufficient time for testing prior to release
    - Controlled with “--[no-]denormalize”

- **Consider this Chapel code:**
  ```chapel
  config var x = 123;
  writeln(x*x + x);
  ```

- **Generated C without denormalize:**
  ```c
  int tempA = x * x;
  int tempB = tempA + x;
  writeln_chpl(tempB);
  ```

- **With denormalize:**
  ```c
  writeln_chpl(x*x + x);
  ```
Denormalize: This Effort and Next Steps

This Effort:
- Enabled denormalize pass by default
- Fixed minor bugs revealed by further testing

Impact:
- Cleaner code for developers to read

Next Steps:
- Clean up more cases in generated code
  - e.g. unnecessary casts, parentheses
Printing the Static Call Graph
Printing the Static Call Graph

**Background:** It can be useful to see the call graph of a program
- to understand which functions call other functions
- including both direct calls and indirect calls through other functions

**This Effort:** Add --print-callgraph compiler option
- prints full static call graph starting from program entry point

**Impact:** Helps to understand the flow of a program at a glance

```plaintext
--print-callgraph output for ptrans.chpl example benchmark

main
    printConfiguration
    printProblemSize
    initArrays
    verifyResults
    CPlusATranspose
    chpl__reduce7_eltype
    printResults
```
Error Message Improvements
Error Message Improvements

- Re-assigning a ‘param’ after it is initialized
- Indicate illegal ‘param’ types more clearly
- Print multiple ‘param’ errors before halting compilation
- Applying ‘inline’ to a recursive function
- Trying to cast to a value rather than a type
- Trying to capture a generic function
- An initializer that attempts to return a value
- Provide a clear message if a copy initializer is needed but is not defined
- Using domain queries in field declarations
- Querying the ‘IRV’ of a non-sparse array
- Applying vector ops to non-1D rectangular arrays
- Removed warning for some cases of serialized assignments
- Improvements to messages for $CHPL_HOME/util/chplenv/ scripts
Bug Fixes
Bug Fixes

- Multiple bugs relating to array-of-array and sparse-array semantics
- Reading null bytes into strings when lengths are specified
- Resetting size when clearing sparse block-distributed domains
- Failure to resolve ‘uint **= uint’
- Support for ‘extern’ blocks
- Wrong LD was selected by our Makefiles
- Buffer overflow problem in the parser for long function signatures
- Broken link to Quickstart.rst
- LLVM back-end couldn’t support multiple --ccflags
- Off-by-one bug in string.split()
- Extern procedures returning ‘void’
- Arrays of c_strings in --no-local compilation mode
More Bug Fixes

- Order of module-scope variable deinitializations
- Generalized the find() routine on arrays to non-1D arrays
- Type methods did not support default arguments well
- Pop_front() could cause the array to grow
- The --cpp-lines flag was sometimes ignored
- fixed a bug in ‘Spawn’ when one sub-process consumes another's output
- An error in BlockCyclic indexing
- User-defined initializers wouldn’t accept array fields
- Error creating virtual dispatch tables for generic class inheritance
- Recursive iterator inlining
- An error supporting ‘stridable’ queries on Replicated arrays
- A copy propagation bug related to array allocation
Even More Bug Fixes

- A ‘chplvis’ bug that caused segmentation faults
- Type methods could be overly generic w.r.t. their receiver
- An error casting reference expressions
- Fixed a race condition in initializing locale models
- Fixed bugs in the standalone parallel iterator for CSR domains
- Fixed a bug related to module-scoped ‘ref’ declarations
- Fixed a bug in which the number of CPUs was sometimes reported to be 0
- Fixed bugs in the ‘localSubdomain*’ calls for local arrays/domains
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