# Benchmarks and Performance Results

Chapel Team, Cray Inc.

Chapel version 1.12

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# Executive Summary

- **Generally speaking, performance has improved with 1.12**
- **Previous slide decks have shown performance changes:**
  …due to new interpretation of formal array arguments
  …due to optimizations motivated by stream
  …due to compiler locality optimizations
- **These slides contain additional v1.12 performance results**
  - Not tied to any specific effort, just comparisons across releases

# Outline

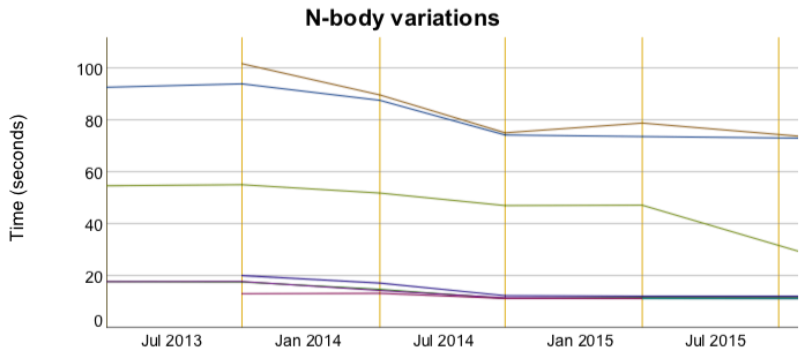
- Shootout Benchmarks Status
- Single-Locale Performance Trends
- Multi-Locale Performance Trends
- ugni+qthreads as default
- Performance Scalability Study

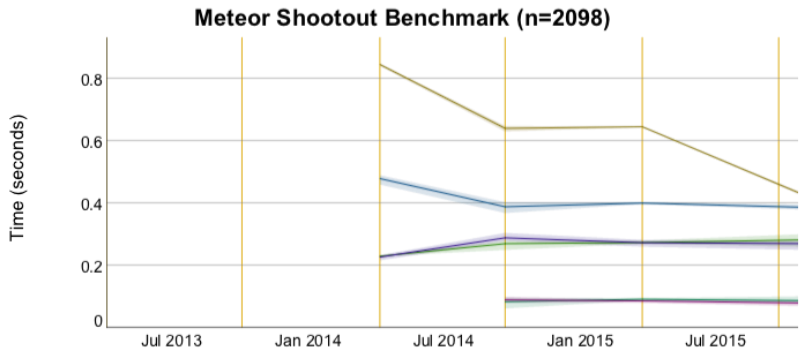
# Shootout Benchmarks Status

# Shootout Benchmark Summary

- **By design, not much effort put into shootouts for 1.12**
  - Wanted to focus primarily on multi-locale performance improvements
  - Official entry blocked by improved string support
  - A few of our fastest versions improved, but most stayed the same
  - Several of our non-fastest versions also improved

    ⇒ Chapel becoming less sensitive to writing in a specific style

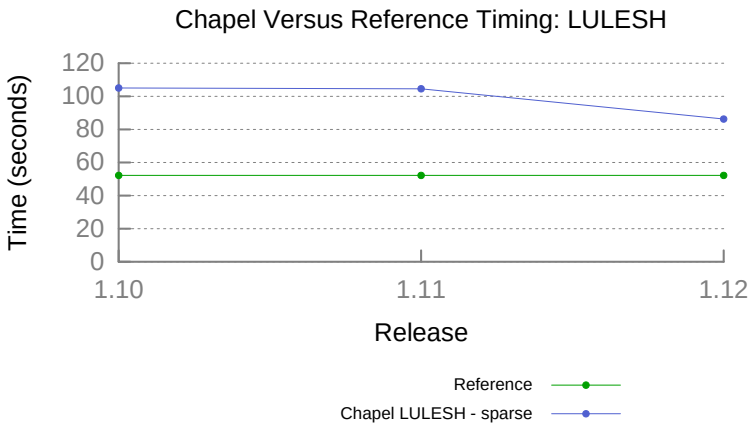


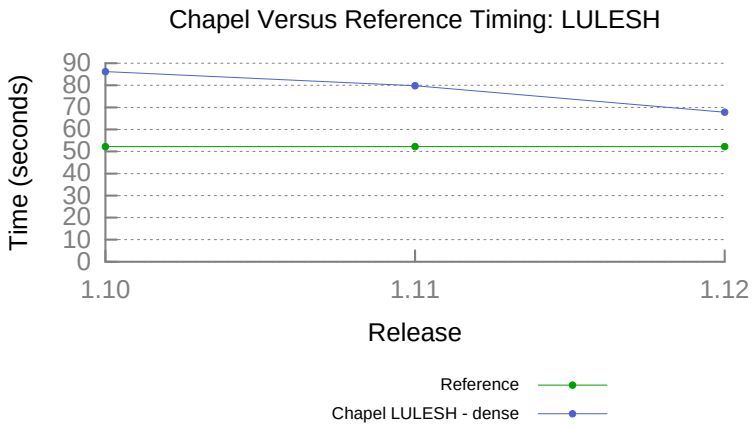



# Single-Locale Performance Trends

# Single-Locale Performance

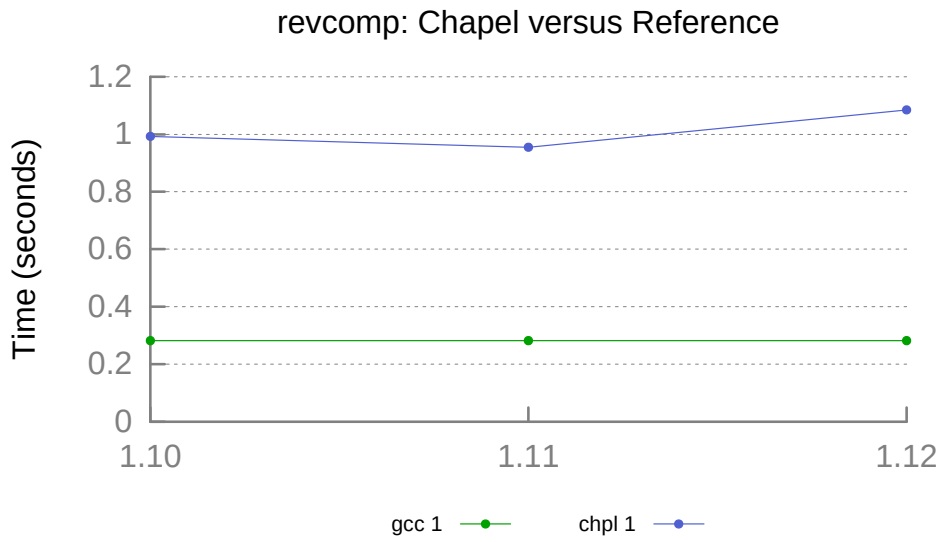
- **Overall, single-locale performance remained the same**
  - A few benchmarks such as lulesh showed improvements



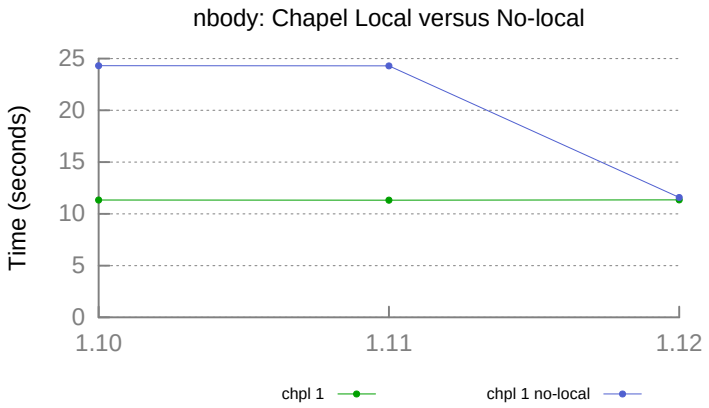
# Single-Locale Performance

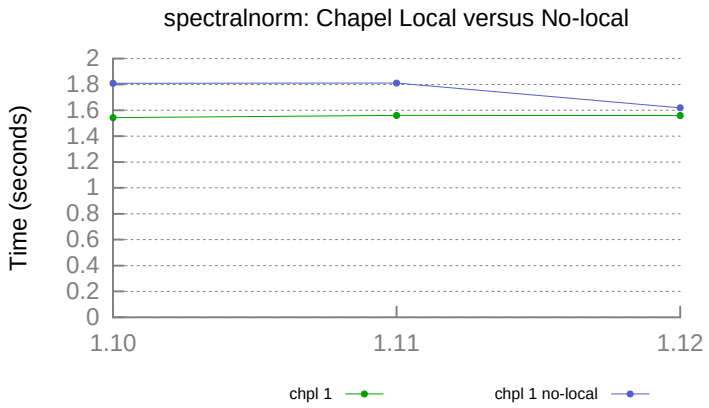
- **Overall, single-locale performance remained the same**
  - One known (and acceptable) regression for reverse-complement
    - result of a bug fix in I/O code (original code was fast, but wrong)

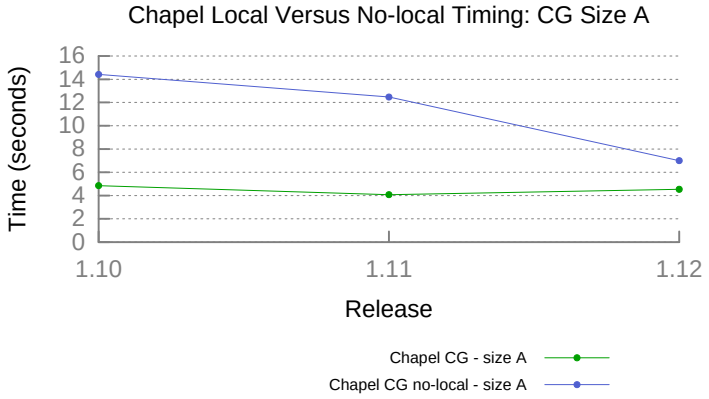


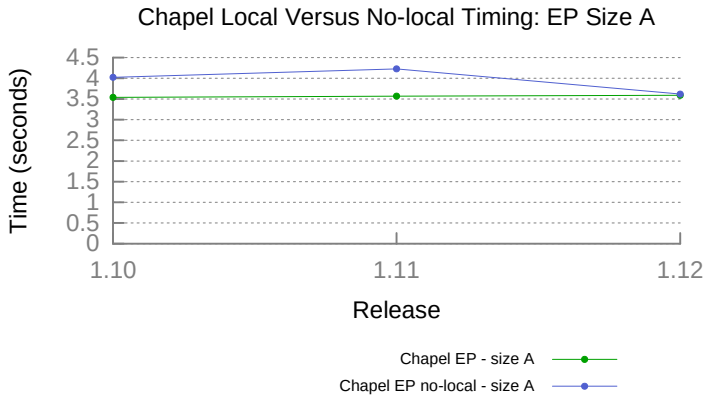
# Single-Locale Performance

- No-local execution improved due to locality optimizations



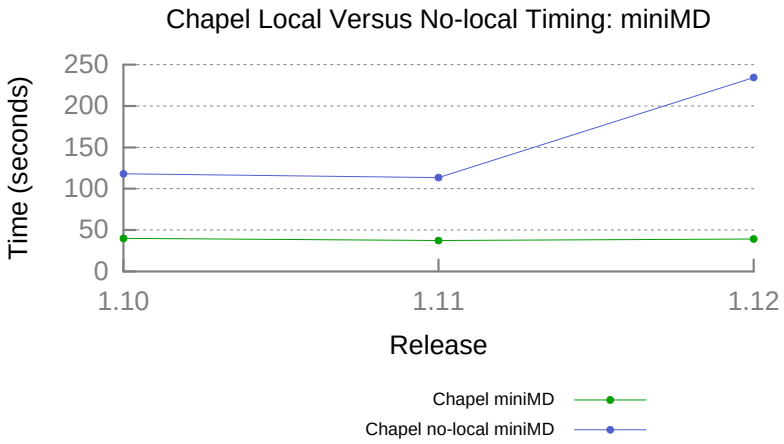



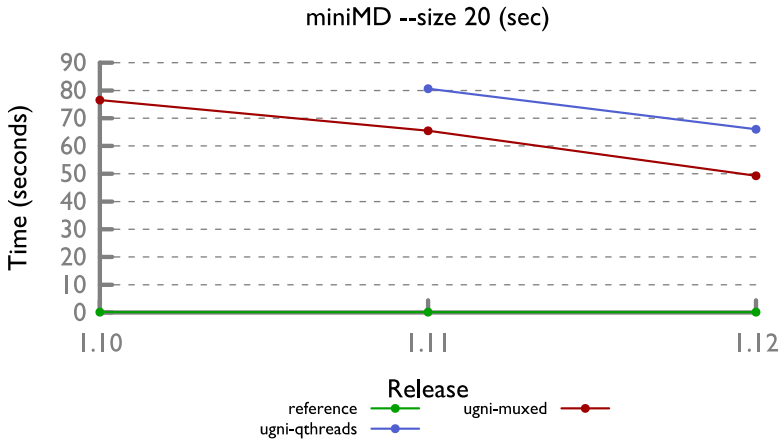



# Single-Locale Performance

- **Surprising no-local regression for miniMD**
  - Still investigating the root cause
  - Not seen in our nightly multi-locale or no-local performance testing
    - in fact multi-locale performance improved since last release

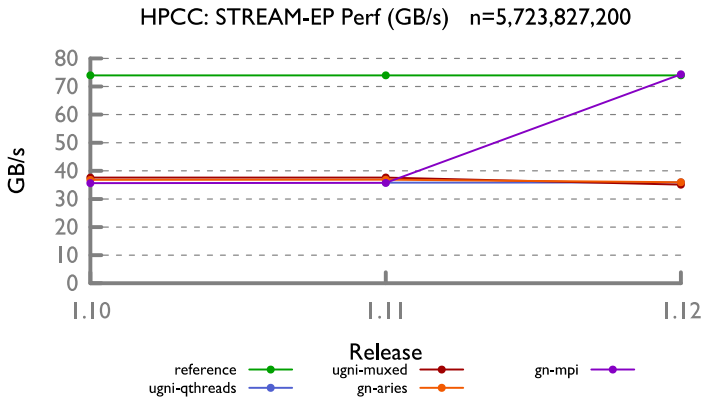


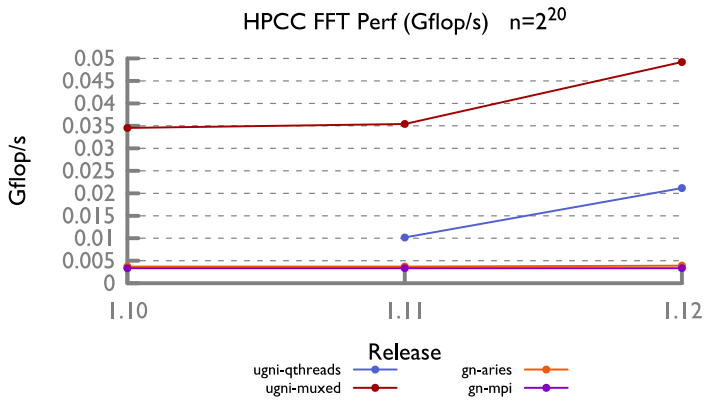



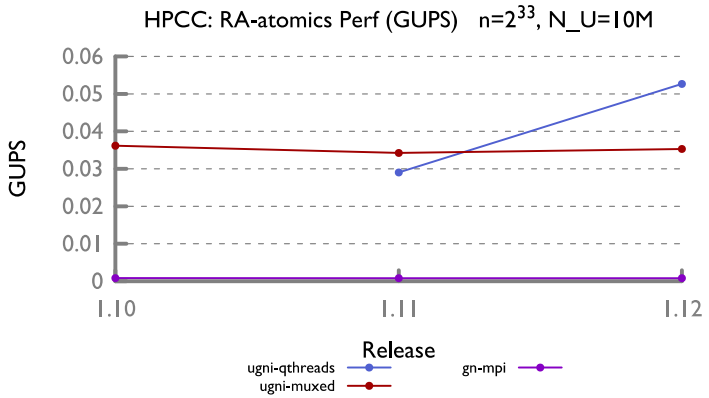
# Multi-Locale Performance Trends

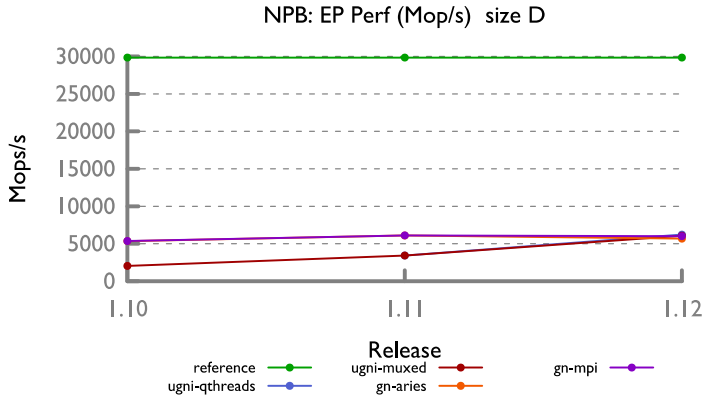
# Multi-locale Performance

- **Multi-locale improvements for many benchmarks**
  - Result of optimizations motivated by stream case study



# ugni+qthreads as default

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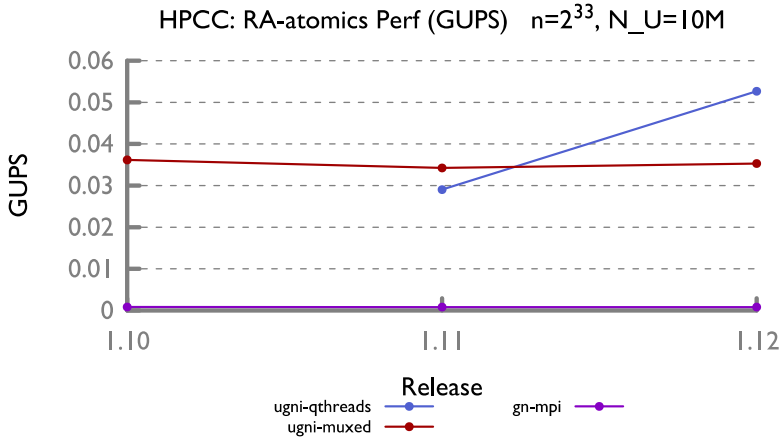
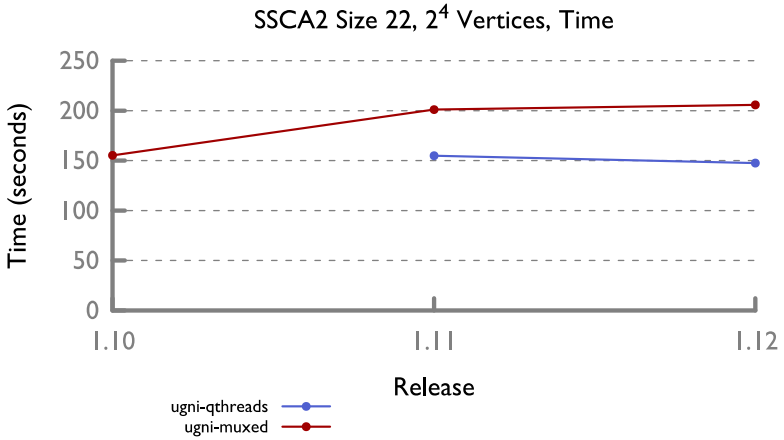
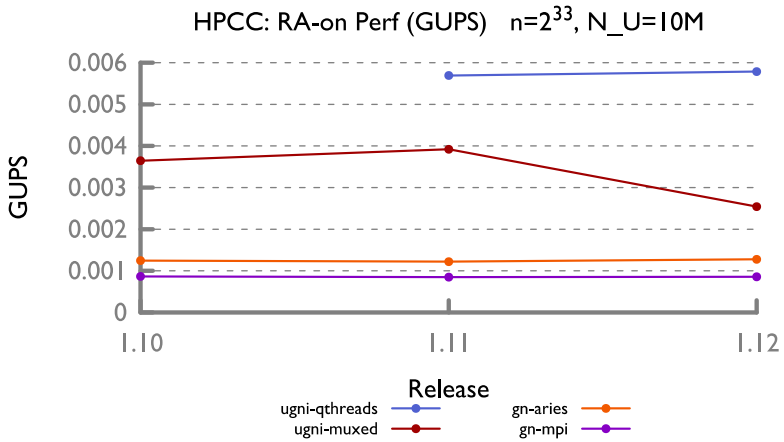
- **Saw ugni+qthreads becoming more competitive**
  - Decided to make it our default instead of ugni+muxed
    - puts us one step closer to retiring muxed

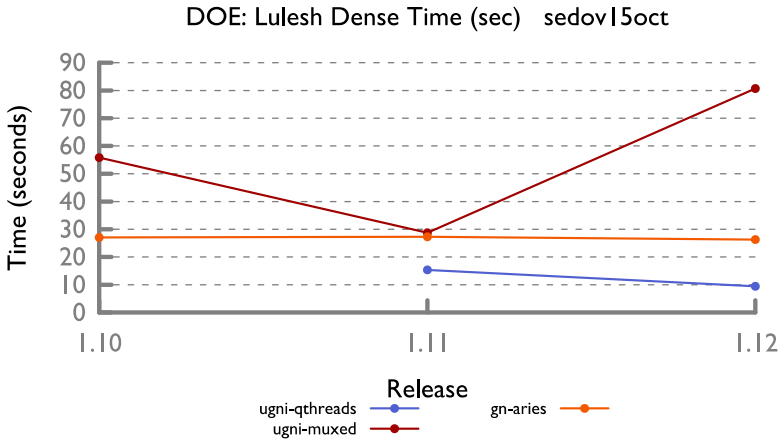


# ugni+qthreads as default

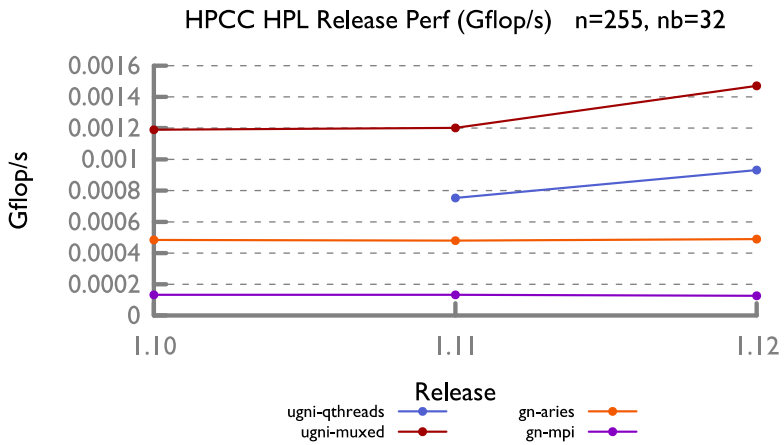
- **As a result, we left some muxed regressions unresolved**
  - For cases where qthreads was already outperforming muxed

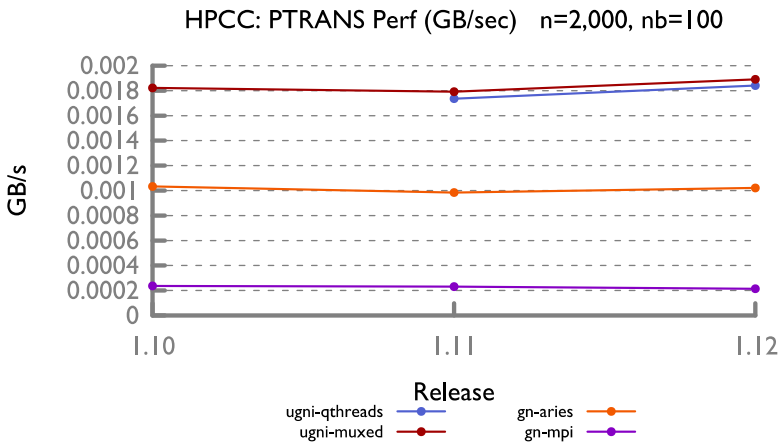


# ugni+qthreads as default

- **Still some cases where ugni+muxed outperforms**
  - Mostly for benchmarks we have not examined very closely yet
  - Will work on these remaining cases before retiring muxed



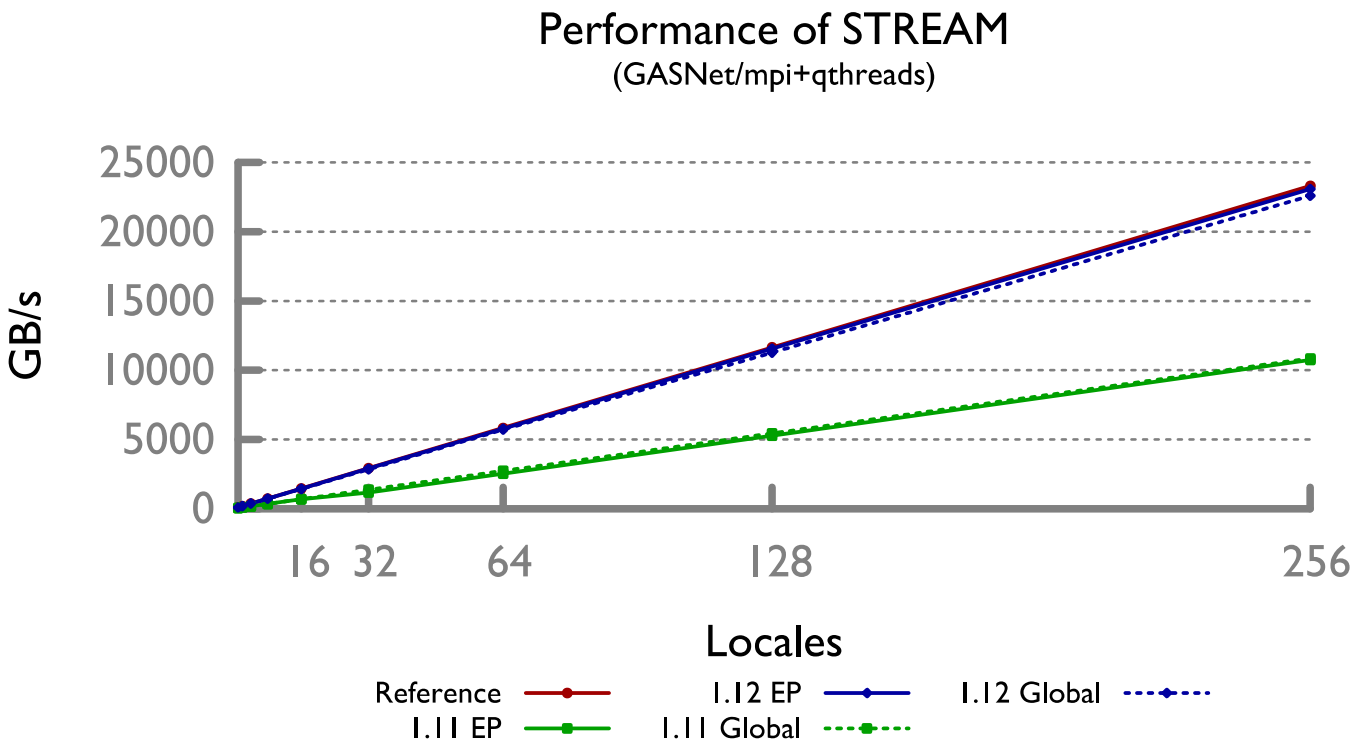
# Performance Scalability Study

# Scalability Study: Background

- **We continued the scalability study from the last releases**
  - HPCC Stream: EP and Global
  - HPCC RA: atomic, on-based, and remote memory operations (rmo)
    - these test network atomics, active messages, and puts/gets, respectively
  - Reduction of an array
- **All experiments shown here were performed on a Cray XC**
  - 1-256 locales
- **The following slides will highlight a few notable cases**
  - Stream improved dramatically as seen in previous slides decks
  - RA generally improved for qthreads, but got worse for muxed
    - 1.12 qthreads is close to 1.11 muxed performance
    - muxed declined due to using more tasks as described in optimization slides
      - not very concerned about muxed regressions now that qthreads is the default
  - Reduction performance has not changed since last release
    - (graph omitted for this reason)

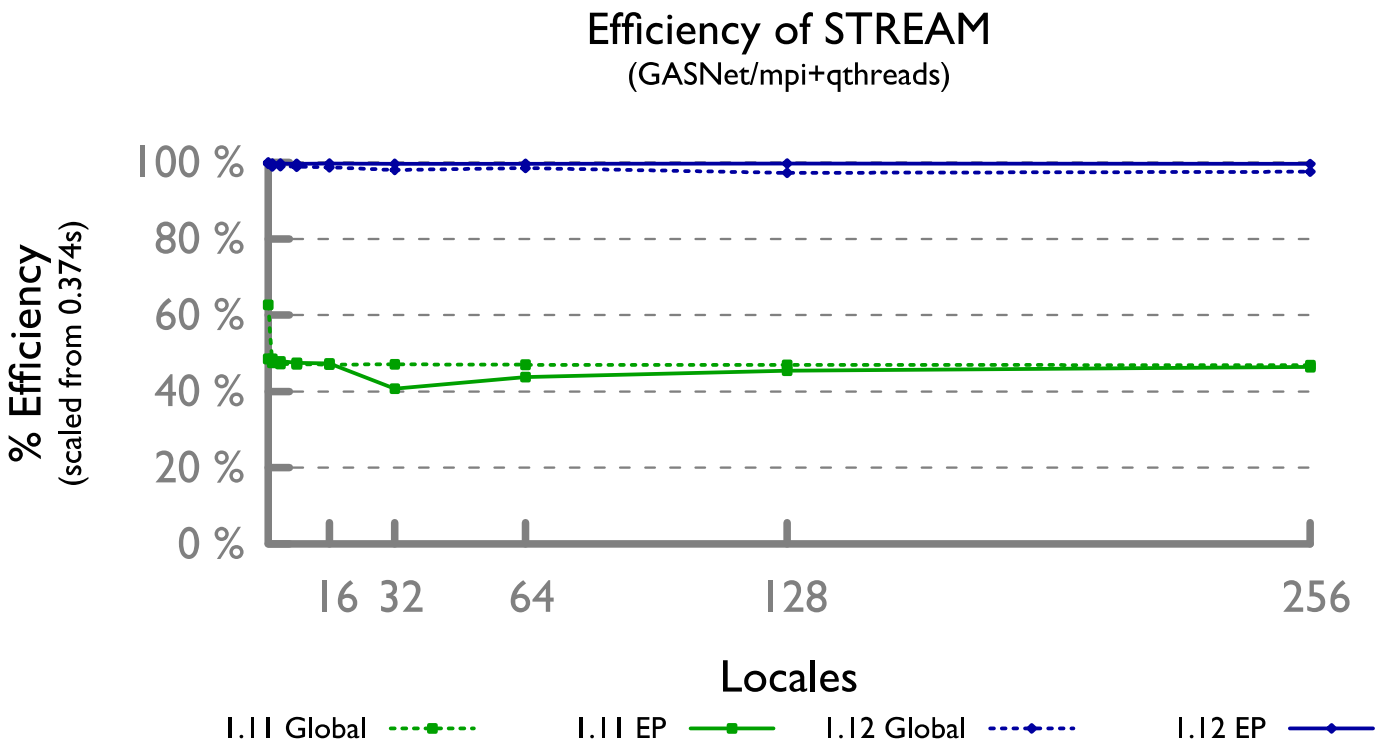
# Scalability: STREAM Performance

- **Stream performance more than doubled since last release**
  - EP is on par with the reference
  - Global is very competitive



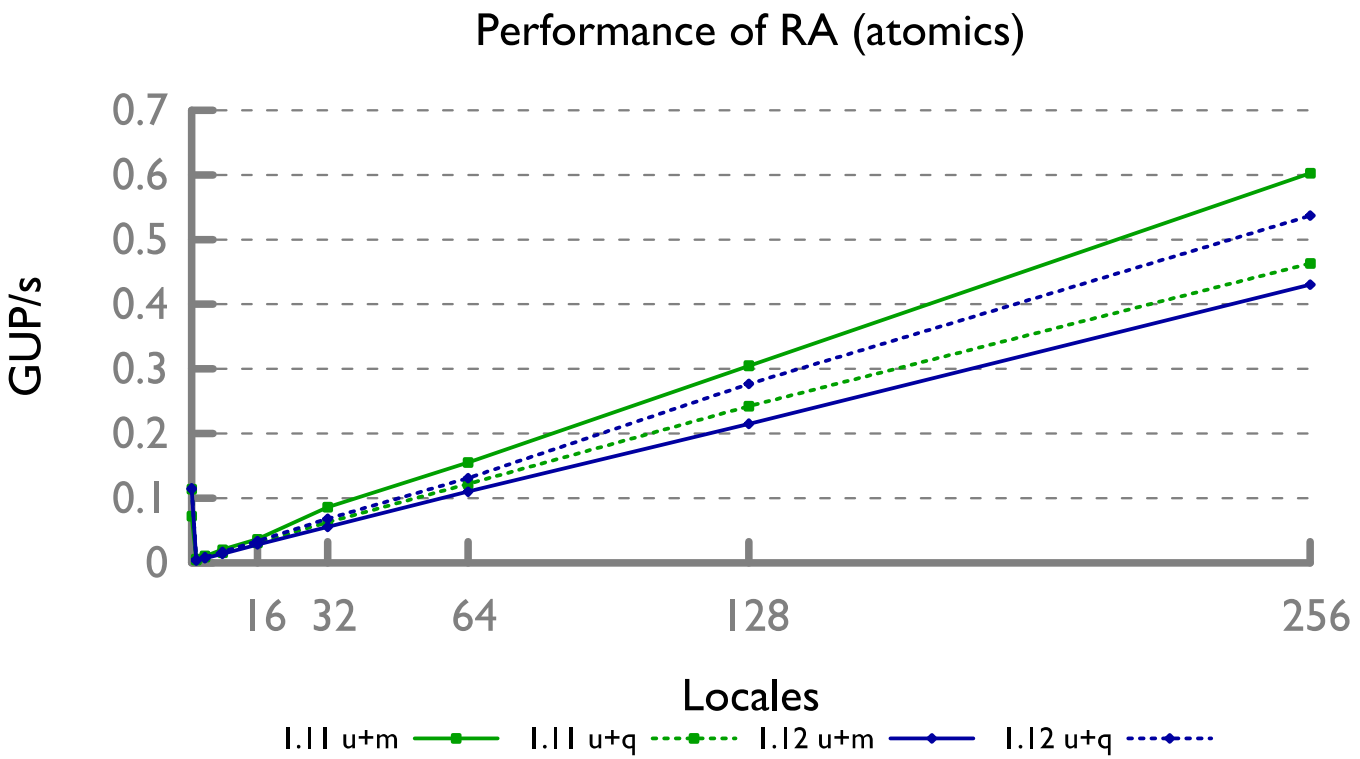
# Scalability: STREAM Efficiency

- **Stream efficiency more than doubled since last release**
  - EP efficiency is 100% at all locale counts
  - Global efficiency is 97% at 256 locales



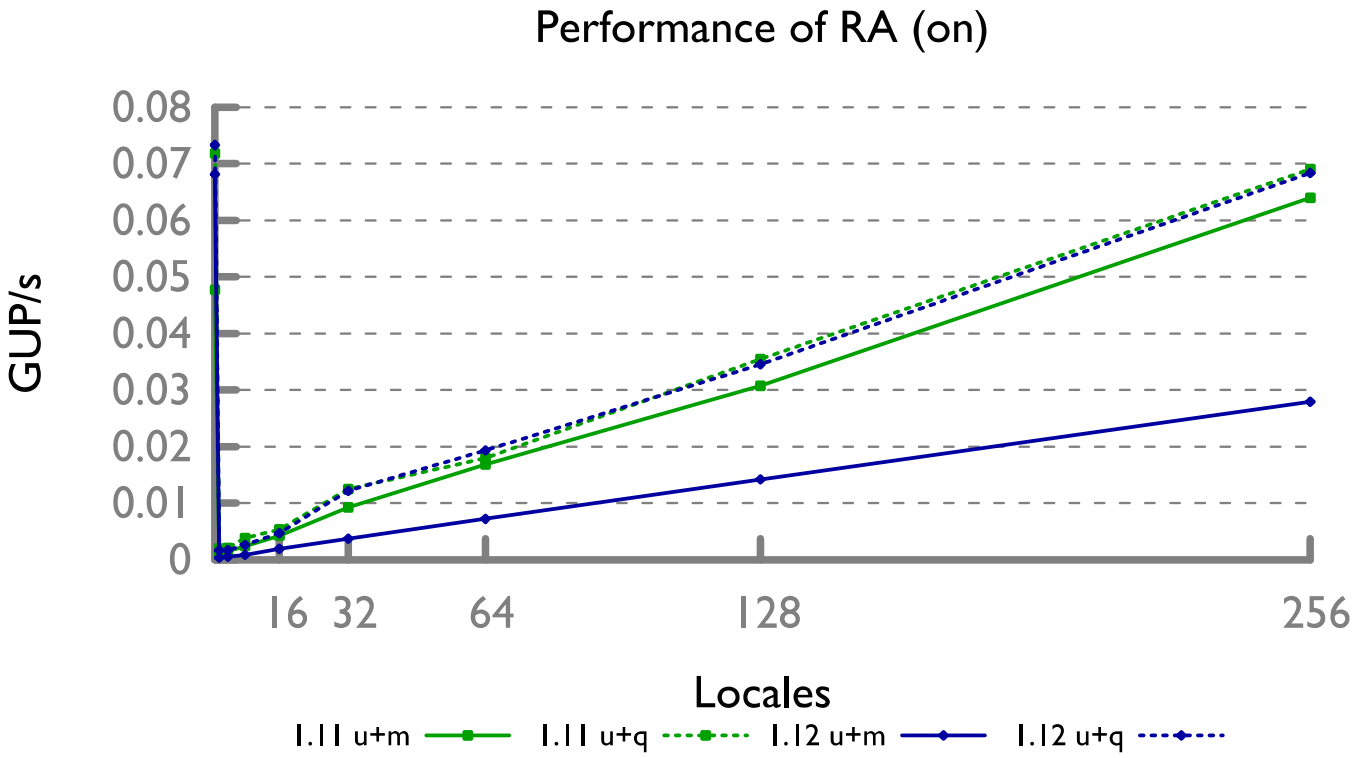
# Scalability: RA (atomics) Performance

- **RA (atomics) summary:**
  - qthreads performance improved (very close to 1.11 muxed)
  - muxed performance got worse



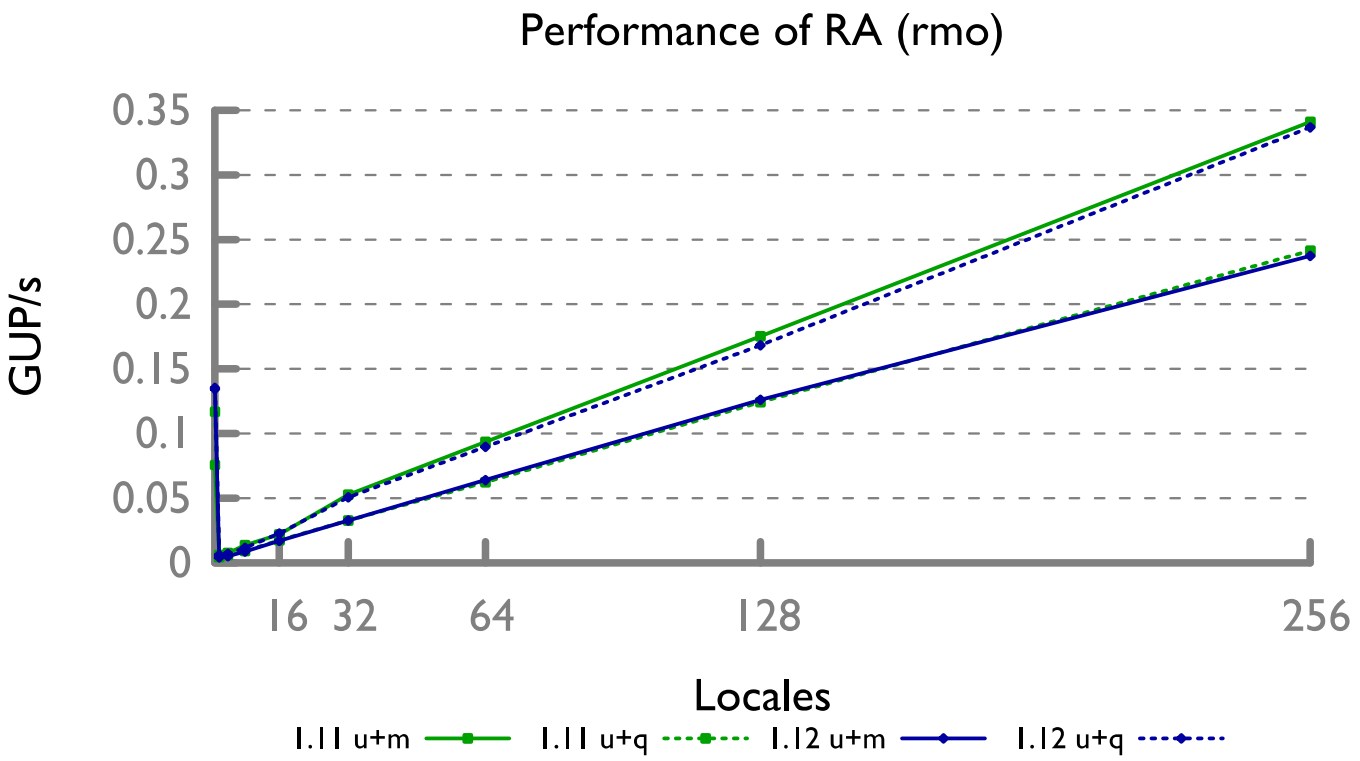
# Scalability: RA (on) Performance

- **RA (on) summary:**
  - qthreads performance remained the same (better than muxed)
  - muxed performance got worse



# Scalability: RA (rmo) Performance

- **RA (rmo) summary:**
  - qthreads performance improved (on par with 1.11 muxed)
  - muxed performance got worse



# Performance Priorities and Next Steps

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- **Continue to focus on ugni+qthreads performance**
  - understand differences compared to ugni+muxed
  - strive to close performance gaps and retire muxed tasking
- **NUMA-aware performance**
  - more focus on NUMA locale model
    - particularly address representation at execution time
  - improve array initialization (parallel, appropriate first-touch)
    - currently gated by constructor/default init/noinit capabilities
  - strive to support NUMA by default w/out performance loss
- **Continue scalability studies**
  - Reduce unnecessary communication code
  - Improve implementation of reductions

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