Benchmarks and Performance Results

Chapel Team, Cray Inc.

Chapel version 1.11

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Executive Summary

- **Generally speaking, performance has improved with 1.11**
- **Previous slide decks have shown performance changes:**

  …due to vectorization
  …due to LICM improvements
  …due to ugni+muxed as default
  …due to parallel range iteration improvements
  …due to the local field pragma

- **These slides contain additional v1.11 performance results**
  - not tied to any specific effort, just comparisons across releases

Outline

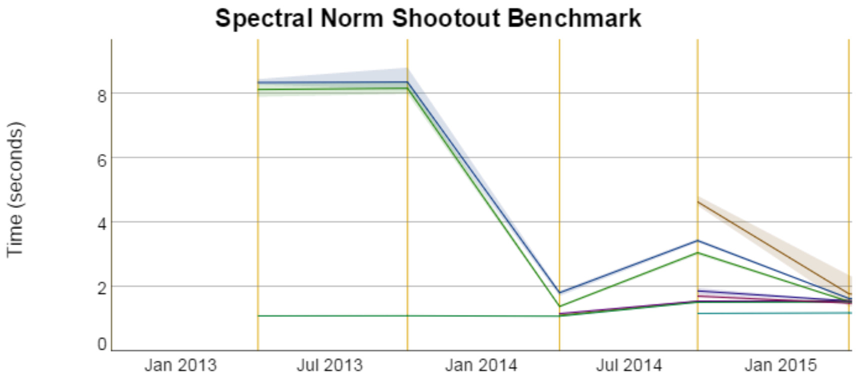
- Shootout Benchmark Status
- Single Locale Performance Trends
- Compiler Performance Trends
- Multi-locale Performance Trends
- ugni+qthreads Performance Trends
- Performance Scalability Study
- Performance Priorities and Next Steps

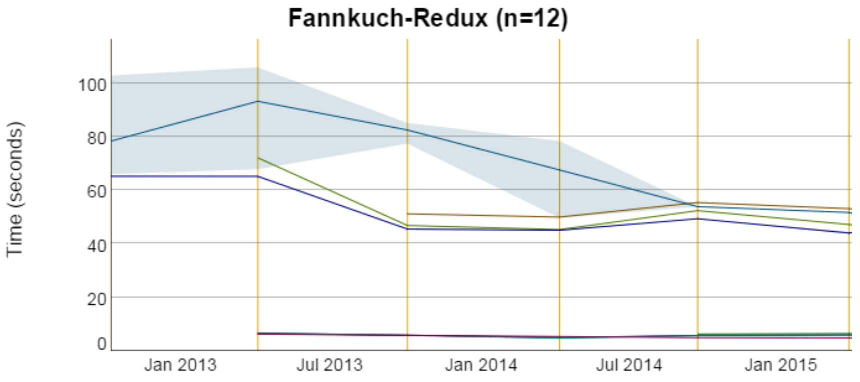
Shootout Benchmarks Status

Shootout Benchmark Summary

- **By design, not much effort put into shootouts for 1.11**
  - --no-local timings improved for some cases due to locality work
  - A few of our fastest versions improved, but most stayed the same
  - Several of our non-fastest versions also improved

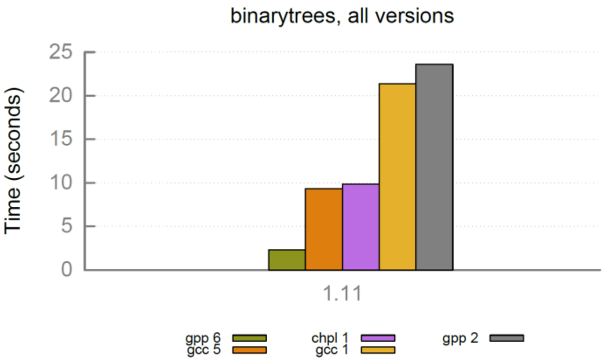
    ⇒ Chapel becoming less sensitive to writing in a specific style

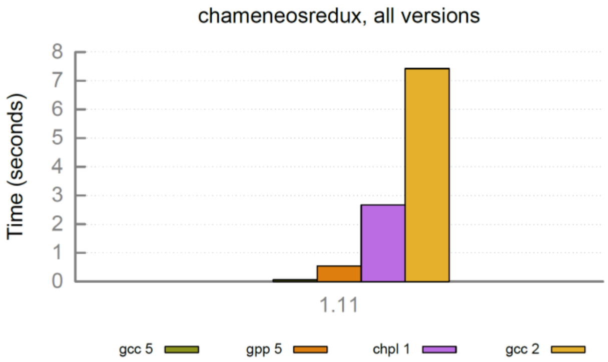


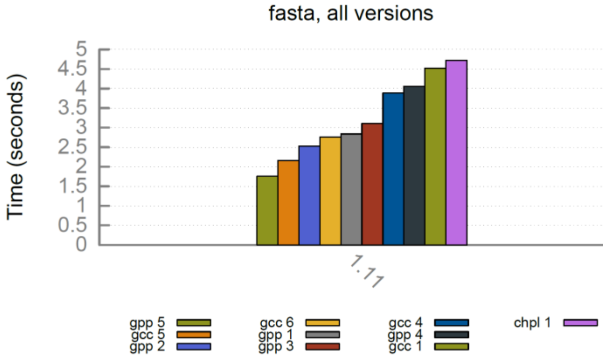


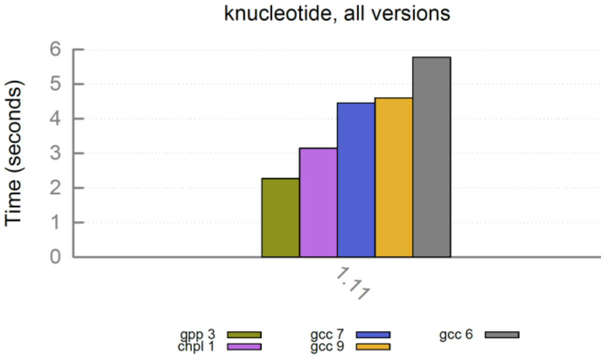
Shootout Performance Standings

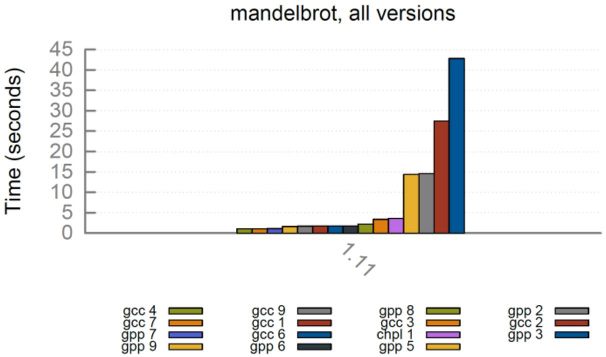
- **Chapel versions (purple) compared to C/C++ references**
  - Timings taken on 2x4-core Intel Xeon processors w/ gcc 4.7.2



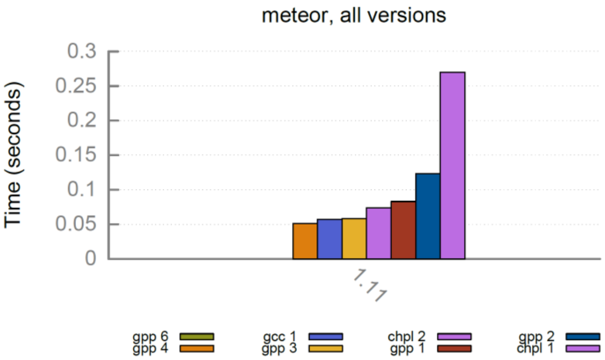




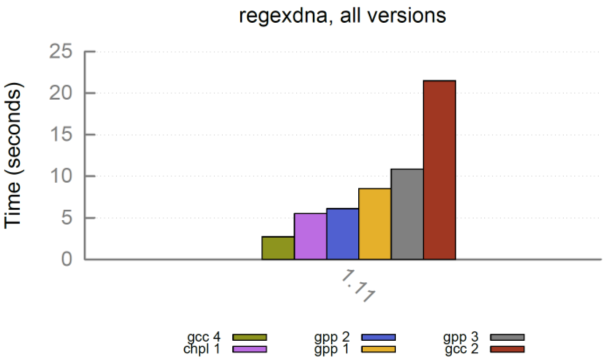


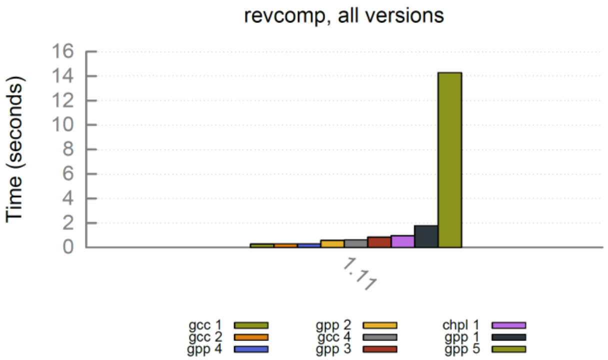


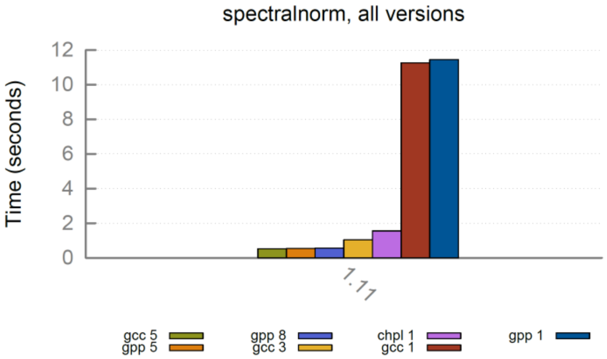
Shootout Performance Standings (continued)

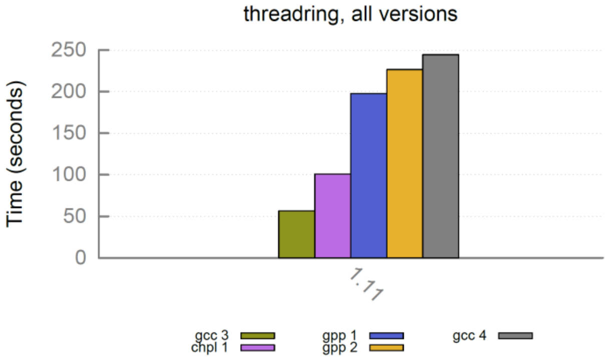


Note: two Chapel versions above, one faster, one more elegant









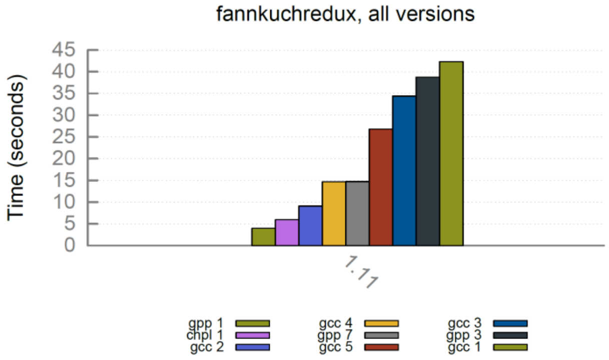
Shootout Performance Standings (continued)

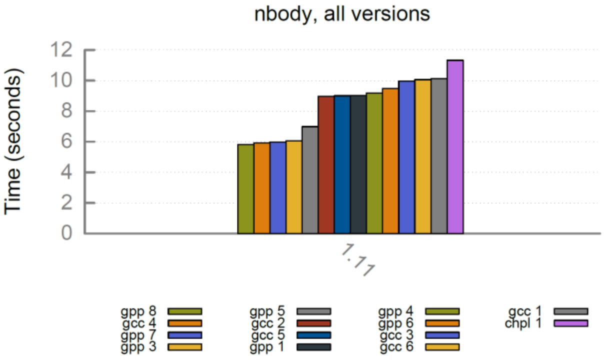
- **The following cases deserve additional notes:**

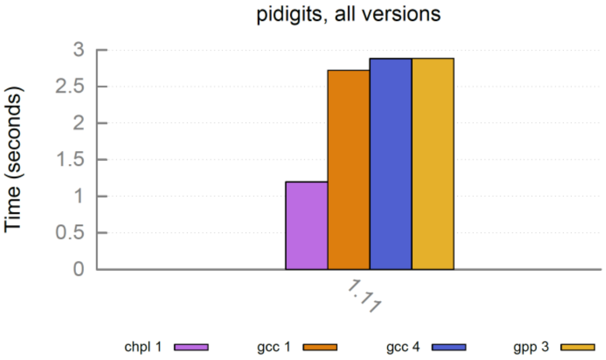
  fannkuch-redux:
  - reference versions hard-code #threads for the 4-core shootout system
  - Chapel doesn't, to its benefit on this 8-core system

  nbody:
  - the five fastest reference versions use vector intrinsics
  - the Chapel version vectorizes, yet not with gcc 4.7.2, so no benefit there

  pidigits:
  - the reference versions use an older system installation of GMP
  - Chapel uses a newer, bundled version that results in the difference



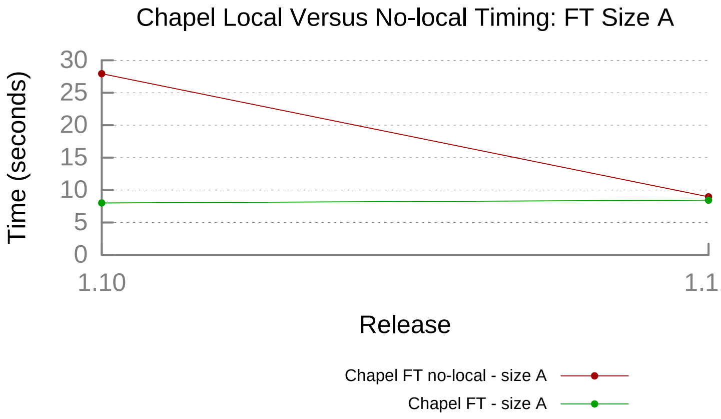


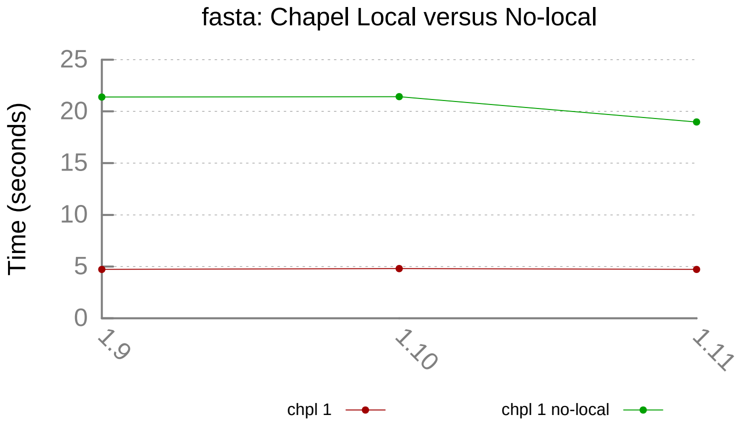


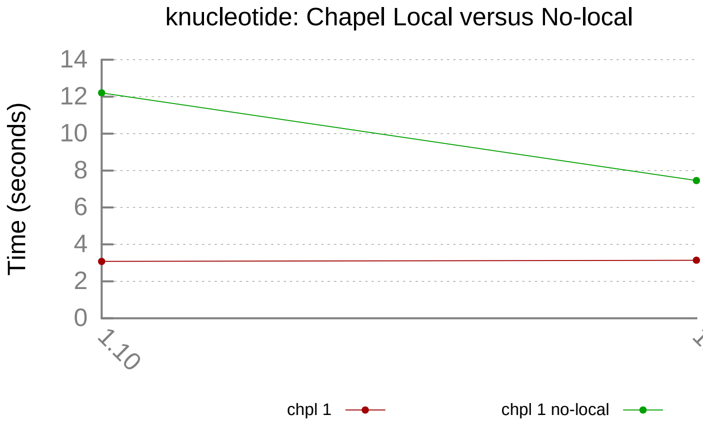
Single Locale Performance Trends

Single Locale Performance

- **No-local execution improved due to better local analysis**
  - More no-local executions complete without timing out in test system
    - e.g., FT size B, IS size A

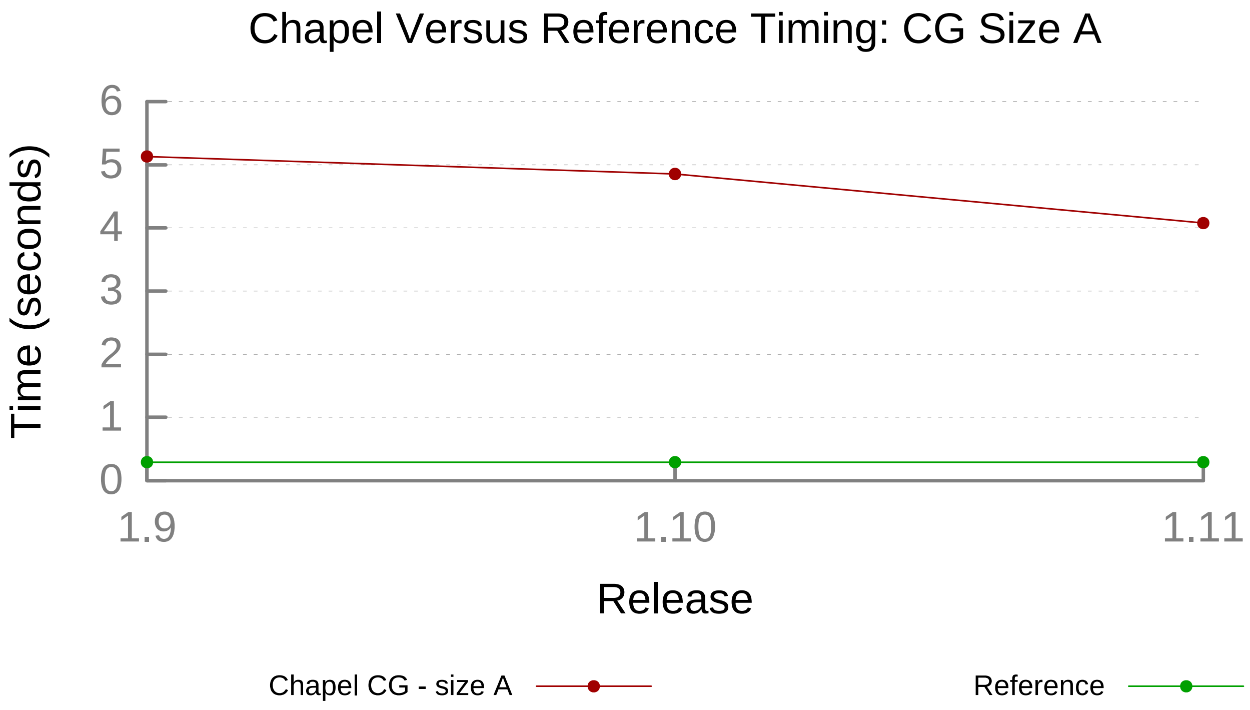






Single Locale Performance

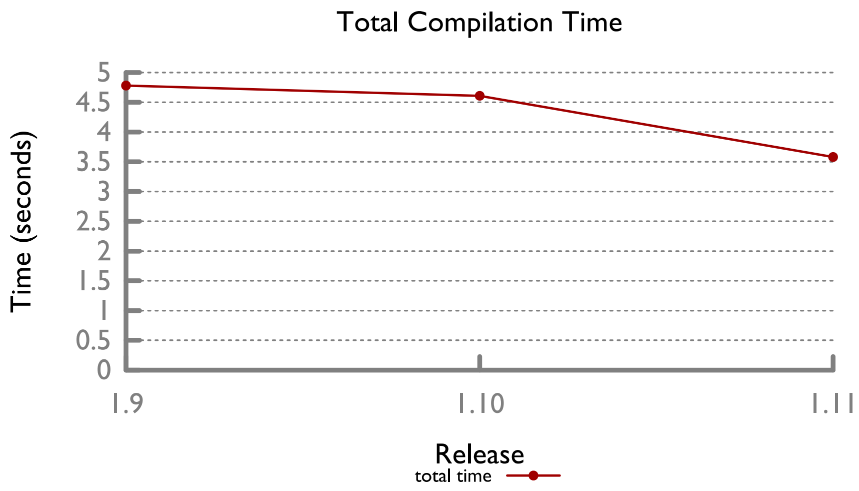
- Improvements to sparse iterators helped CG performance

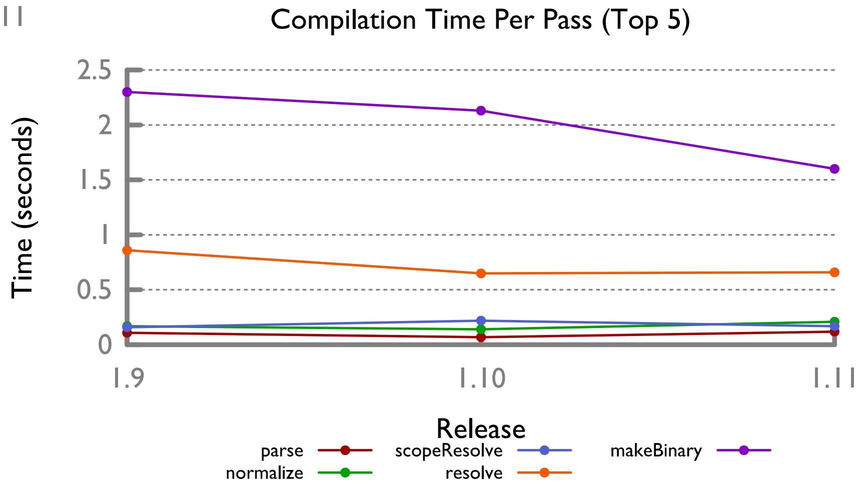


Compiler Performance Trends

Compiler Performance

- Compilation time has improved by ~1 second for all tests

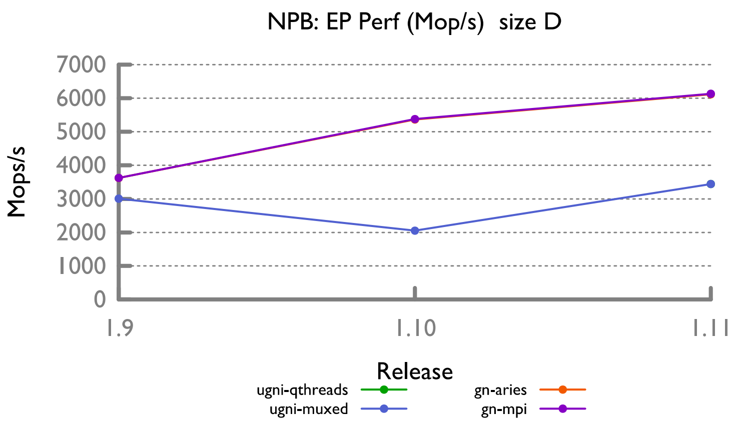


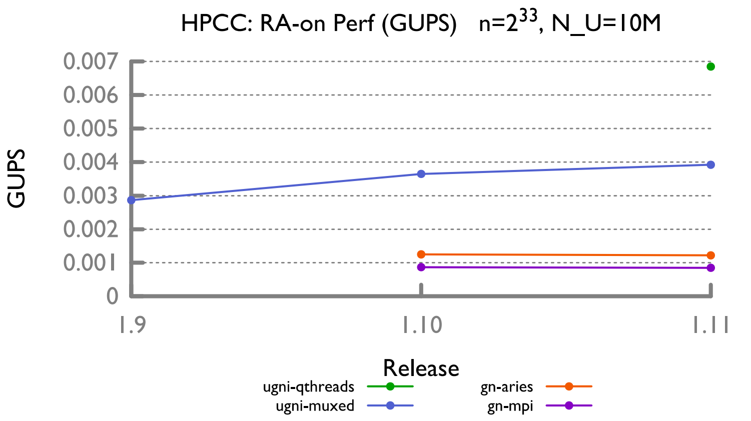


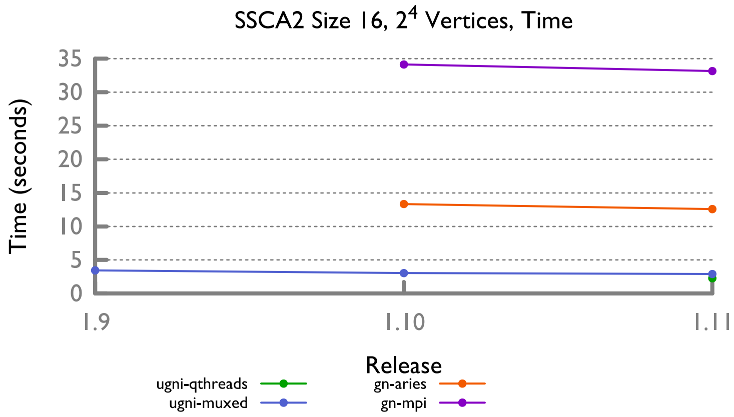
Multi-Locale Performance Trends

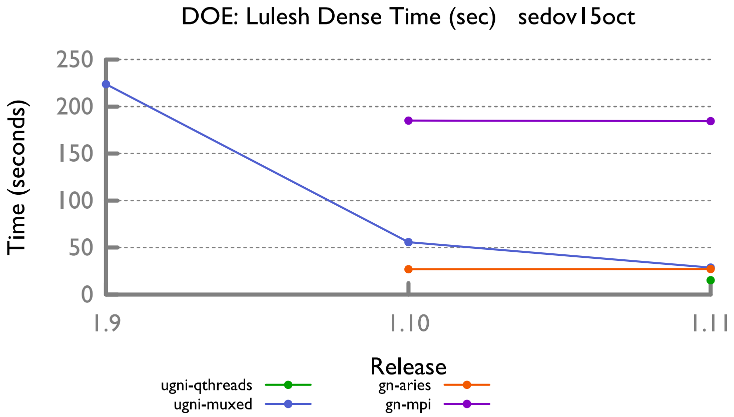
Multi-locale Performance

- Most benchmarks have remained the same or improved slightly


NPB: EP Perf (Mop/s) size D

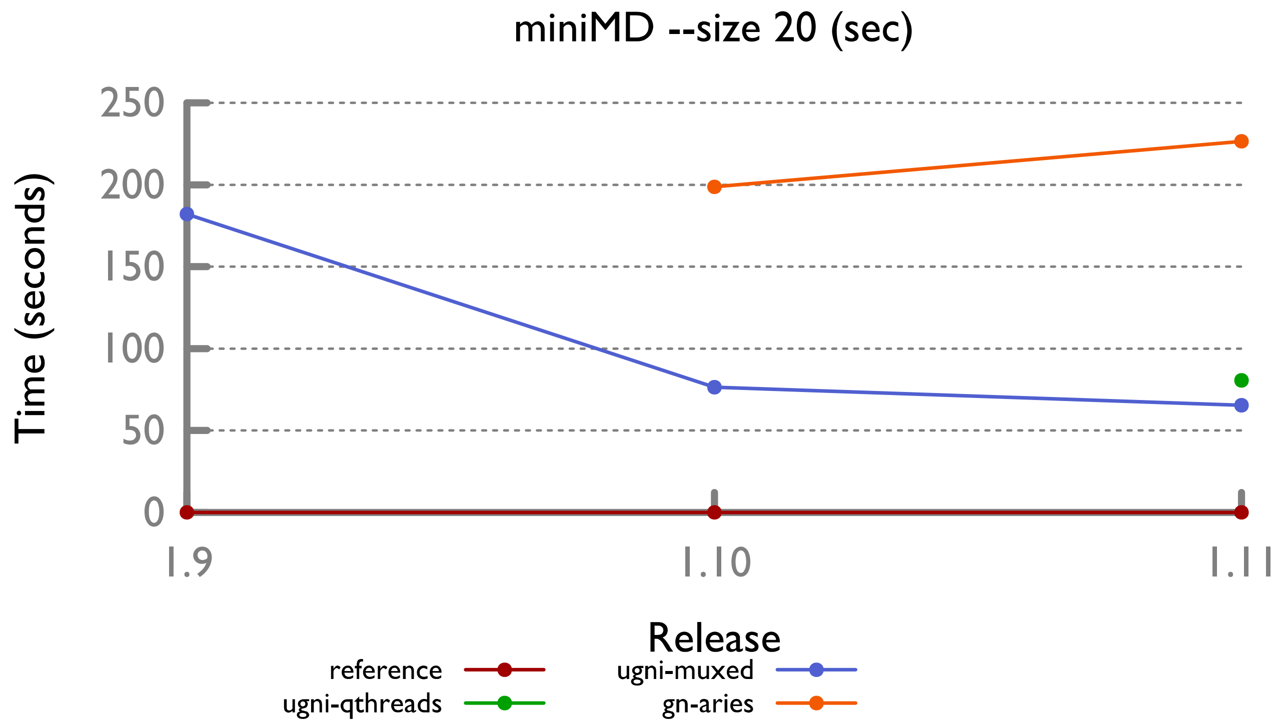

HPCC: RA-on Perf (GUPS) $n=2^{33}$, N_U=10M


SSCA2 Size 16, 2^4 Vertices, Time


DOE: Lulesh Dense Time (sec) sedov15oct

Multi-locale Performance

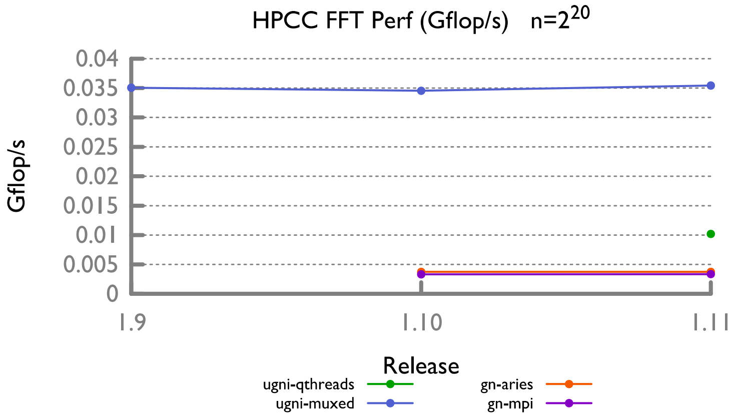
- **miniMD has gotten ~10% slower for gasnet-aries**
  - seemingly related to local class optimization
    - regression discovered while assembling this report
    - not yet sure what happened yet

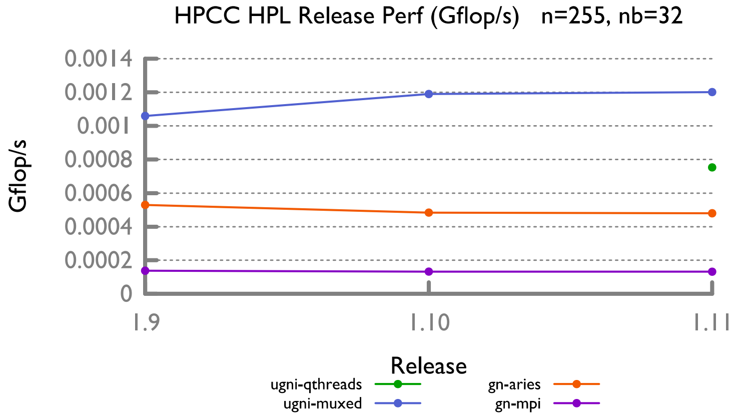


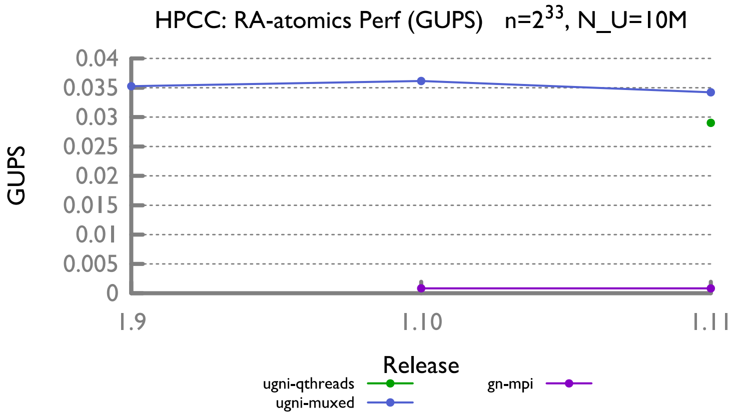
ugni+qthreads Performance Trends

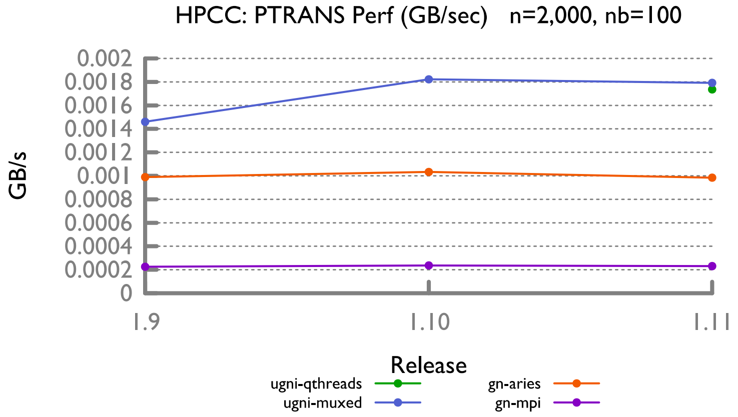
ugni+qthreads Performance

- ugni+qthreads is sometimes competitive with ugni+muxed


HPCC FFT Perf (Gflop/s) n=2^{20}

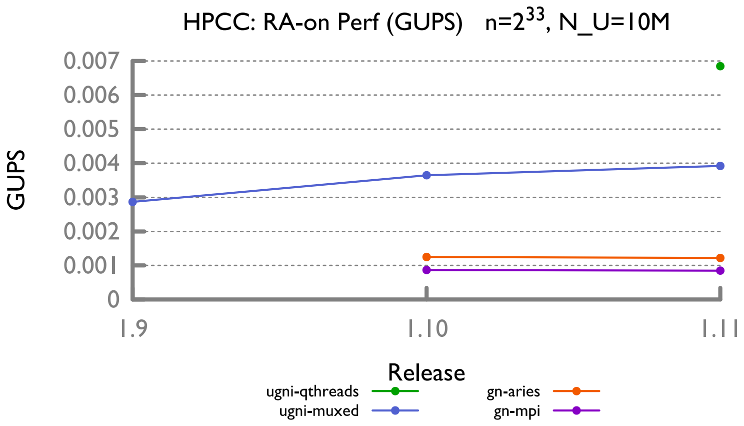

HPCC HPL Release Perf (Gflop/s) n=255, nb=32

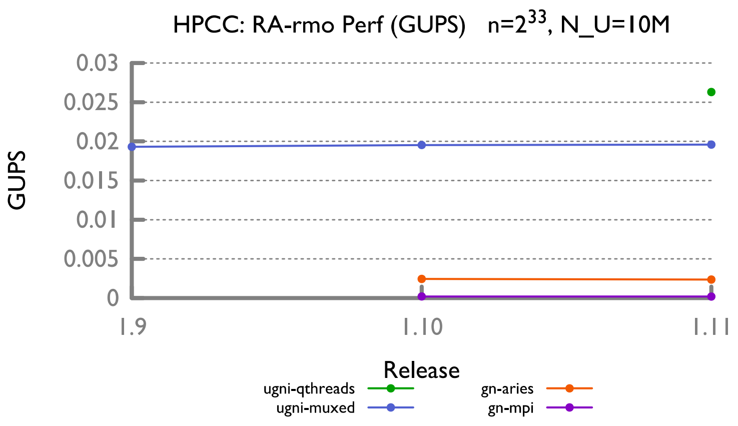

HPCC: RA-atomics Perf (GUPS) n=2^{33}, N_U=10M

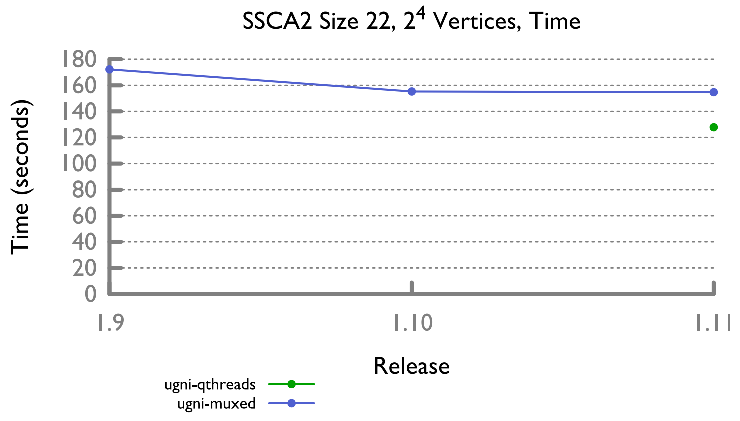

HPCC: PTRANS Perf (GB/sec) n=2,000, nb=100

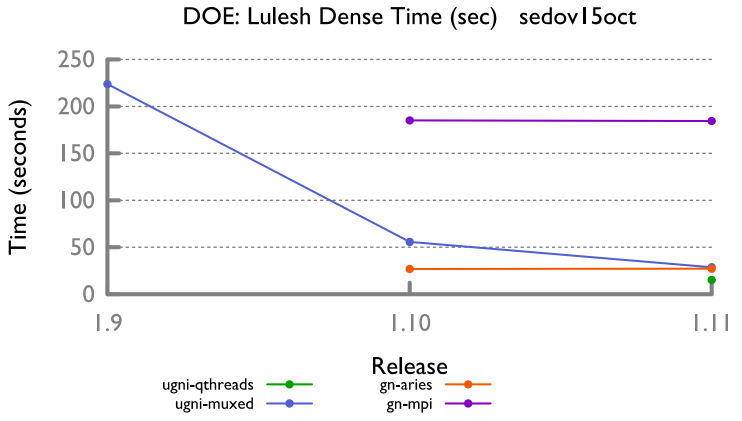
ugni+qthreads Performance

- **In other cases ugni+qthreads outperforms ugni+muxed**


HPCC: RA-on Perf (GUPS) n=2^{33}, N_U=10M


HPCC: RA-rmo Perf (GUPS) n=2^{33}, N_U=10M


SSCA2 Size 22, 2^4 Vertices, Time

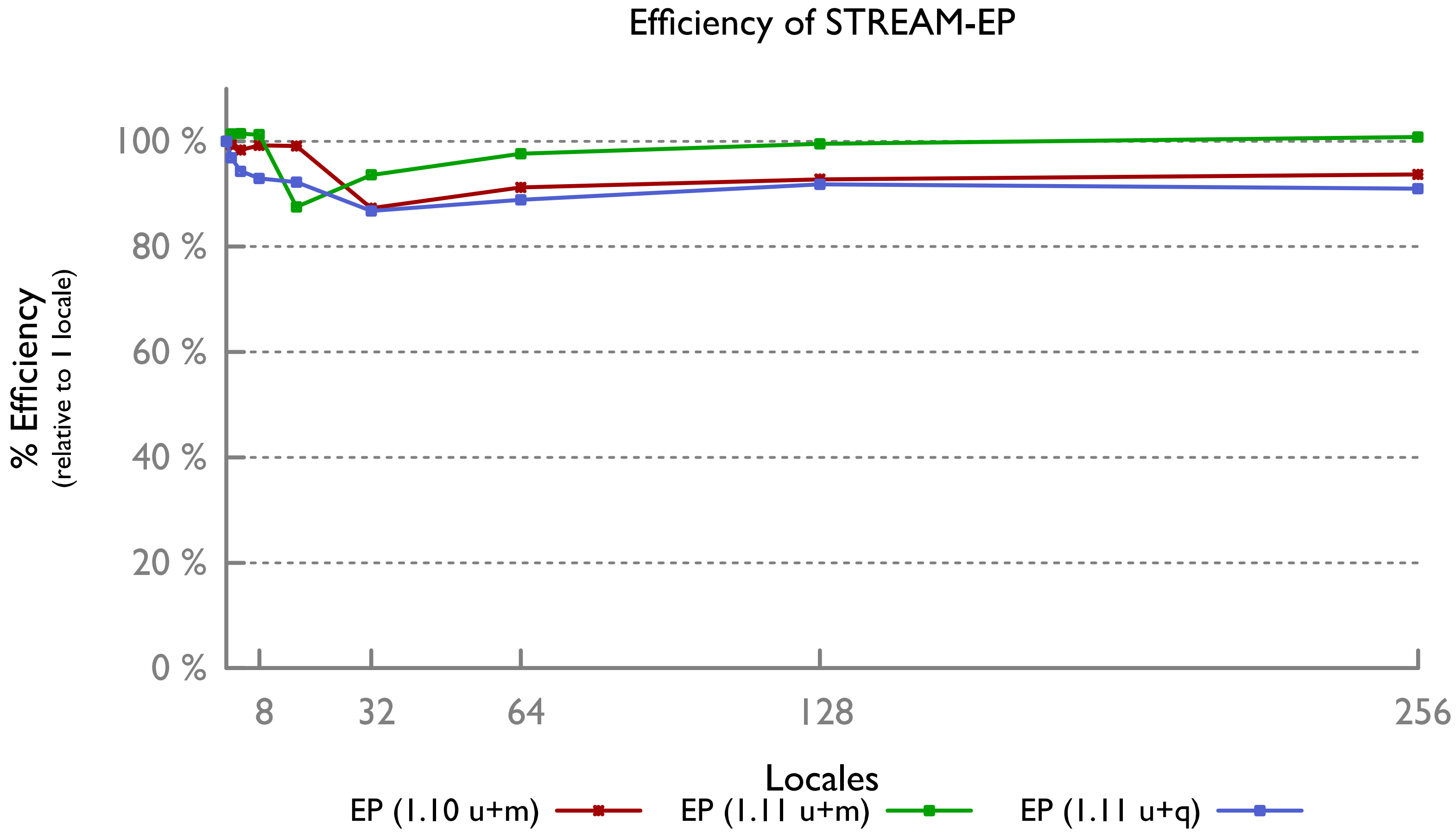

DOE: Lulesh Dense Time (sec) sedov15oct

Performance Scalability Study

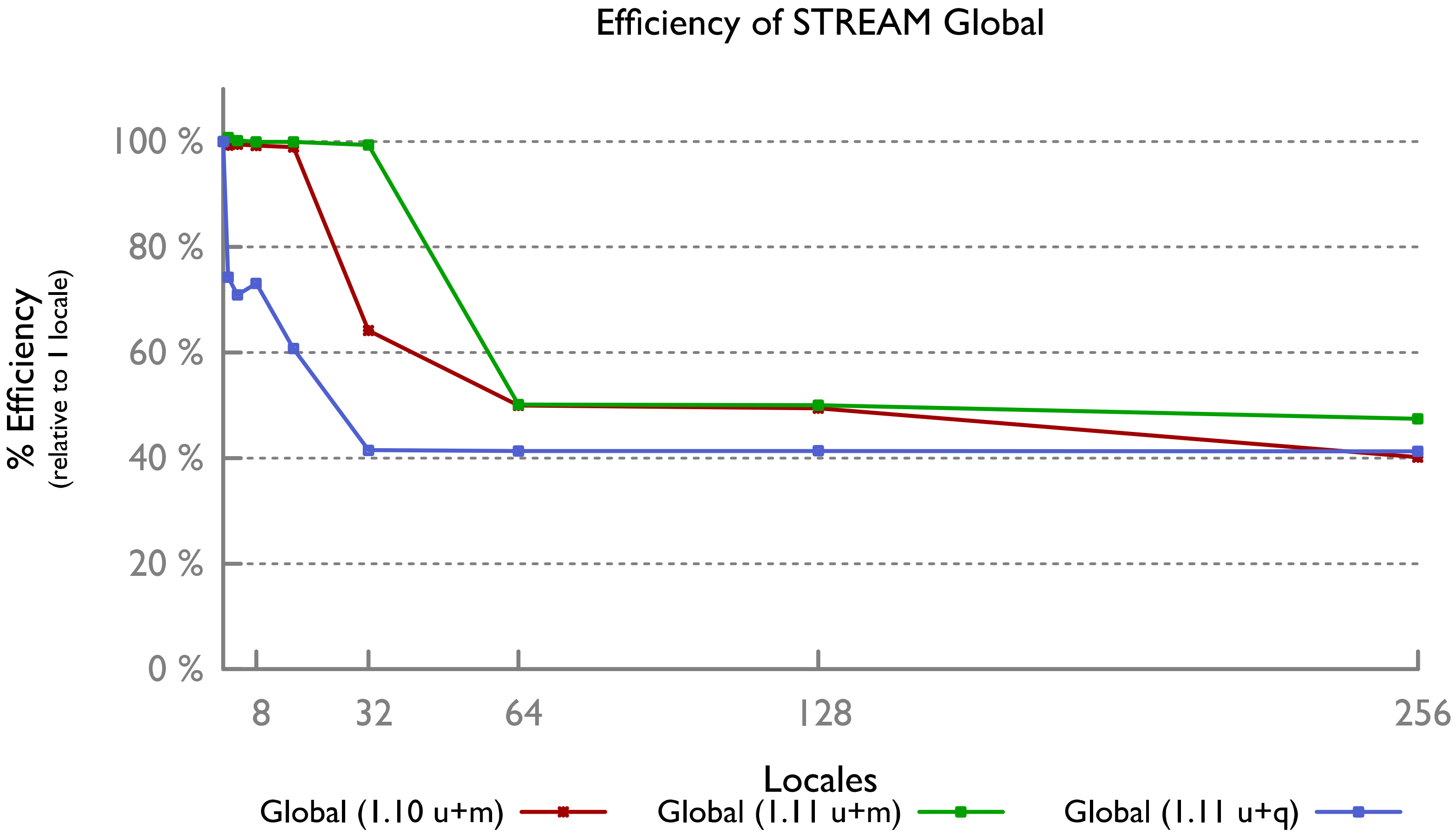
Scalability Study: Background

- **We continued the scalability study from last release**
  - 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 (up from 1-64 from last release)
  - ugni+muxed and ugni+qthreads runtimes
- **The following slides highlight a few notable cases**

Scalability: STREAM-EP Efficiency

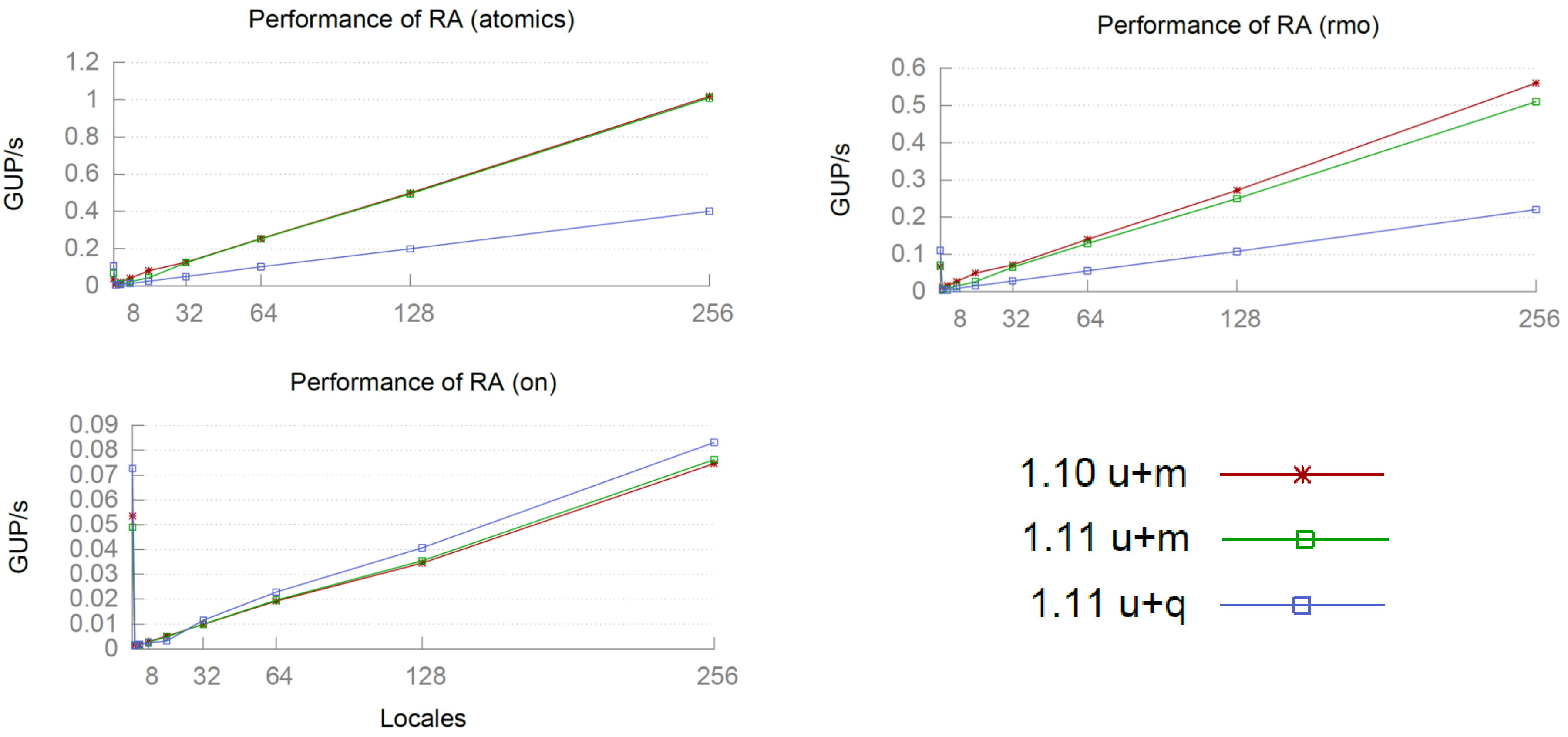


Scalability: STREAM Global Efficiency

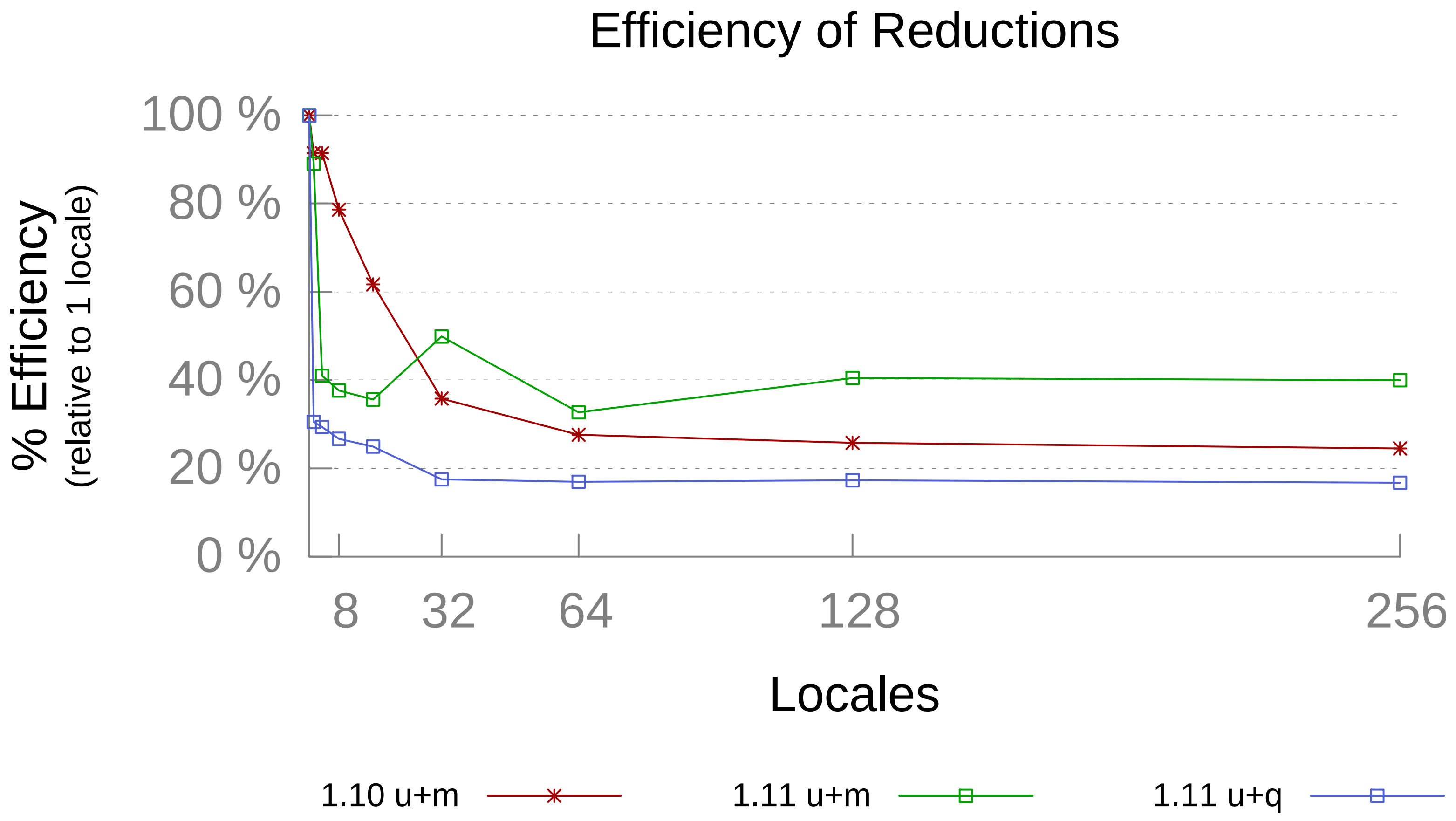


Scalability: RA Performance

- **for RA, ugni+muxed has not changed significantly**
  - More interesting is ugni+muxed vs. ugni+qthreads



Scalability: Reductions Efficiency



Performance Priorities and Next Steps

Performance Priorities and Next Steps

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

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