Chapel: A Productive Parallel Programming Language

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Women Techmakers: Community Tech-Talks

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What is Chapel?

- **An emerging parallel programming language**
  - Design and development led by Cray Inc.
    - in collaboration with academia, labs, industry; domestically & internationally
- **An open-source (Apache license) project on GitHub**
- **A work-in-progress**
- **Goal: Improve productivity of parallel programming**

Chapel is Portable

- **Chapel's design is intended to be hardware-independent**

- **The current release requires:**
  - a C compiler
  - a *NIX environment
  - POSIX threads
  - (for distributed execution): support for RDMA, MPI, or UDP

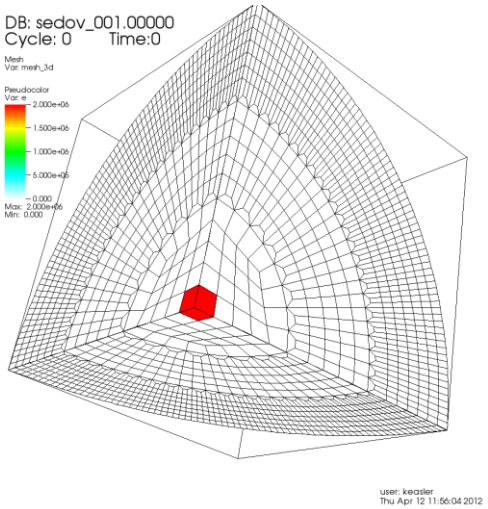
- **Chapel can run on…**

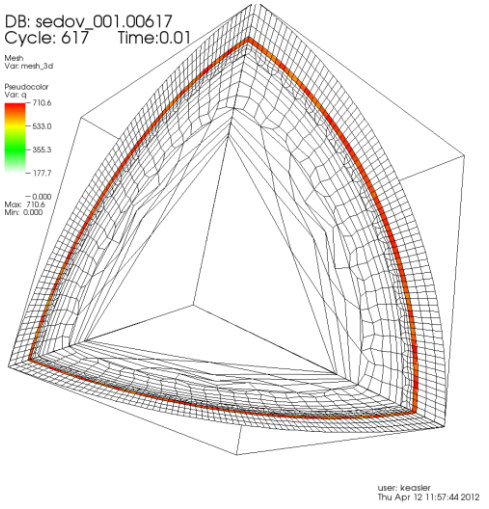
  …laptops and workstations
  …commodity clusters
  …the cloud
  …HPC systems from Cray and other vendors
  …modern processors like Intel Xeon Phi, GPUs*, etc.

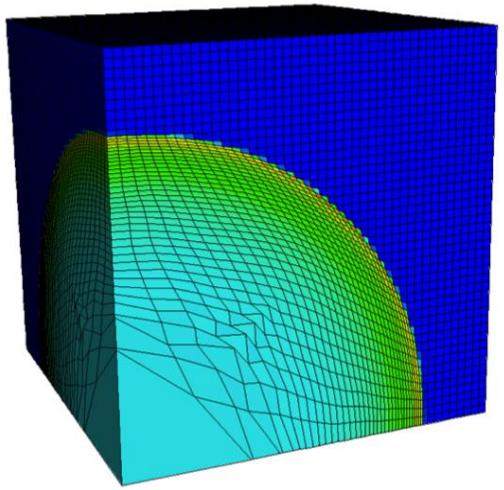
  * = academic work only; not yet supported by the official release

LULESH: a DOE Proxy Application

Goal: Solve one octant of the spherical Sedov problem (blast wave) using Lagrangian hydrodynamics for a single material



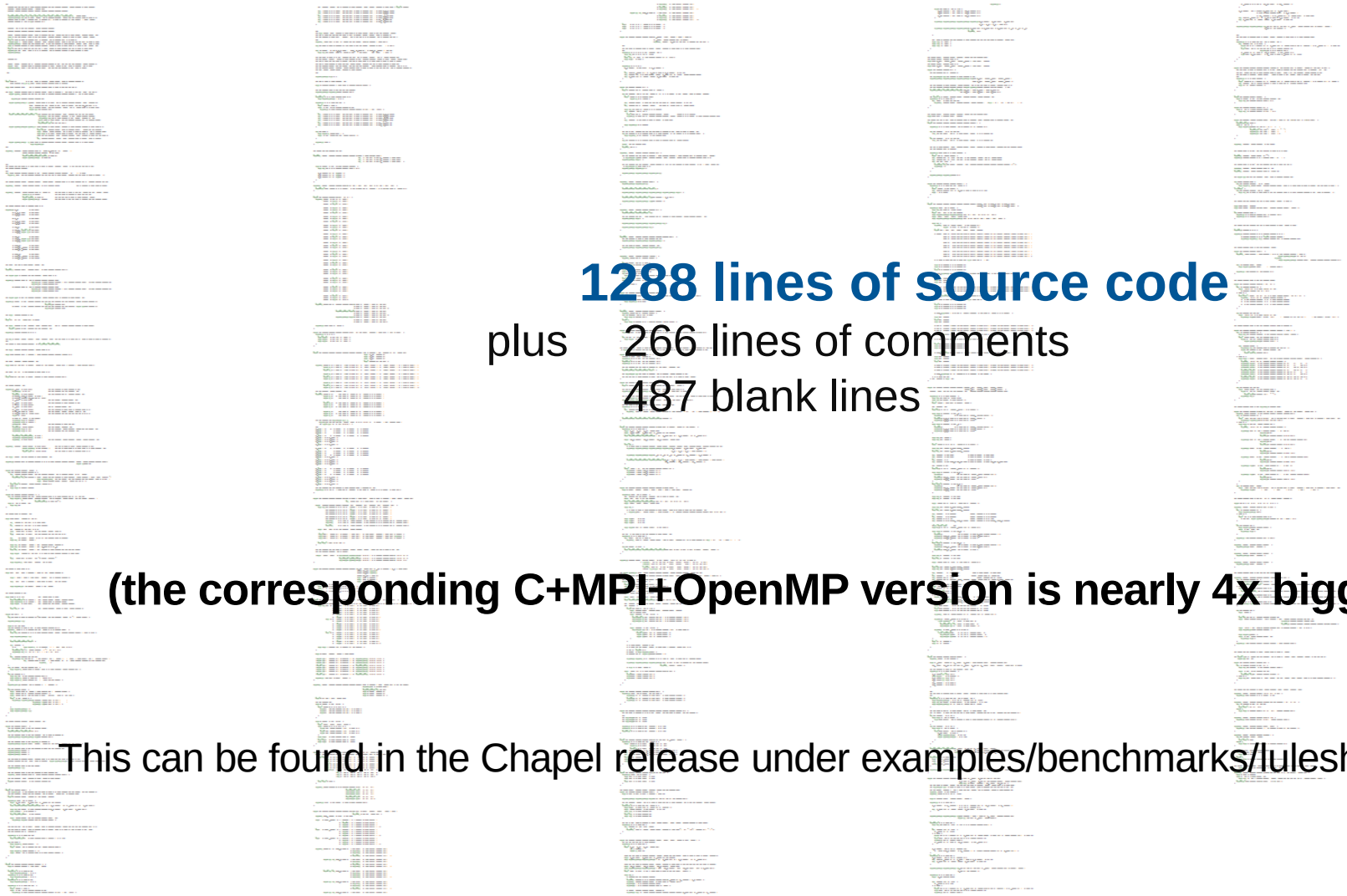




pictures courtesy of Rob Neely, Bert Still, Jeff Keasler, LLNL

LULESH in Chapel

LULESH in Chapel



1288 lines of source code

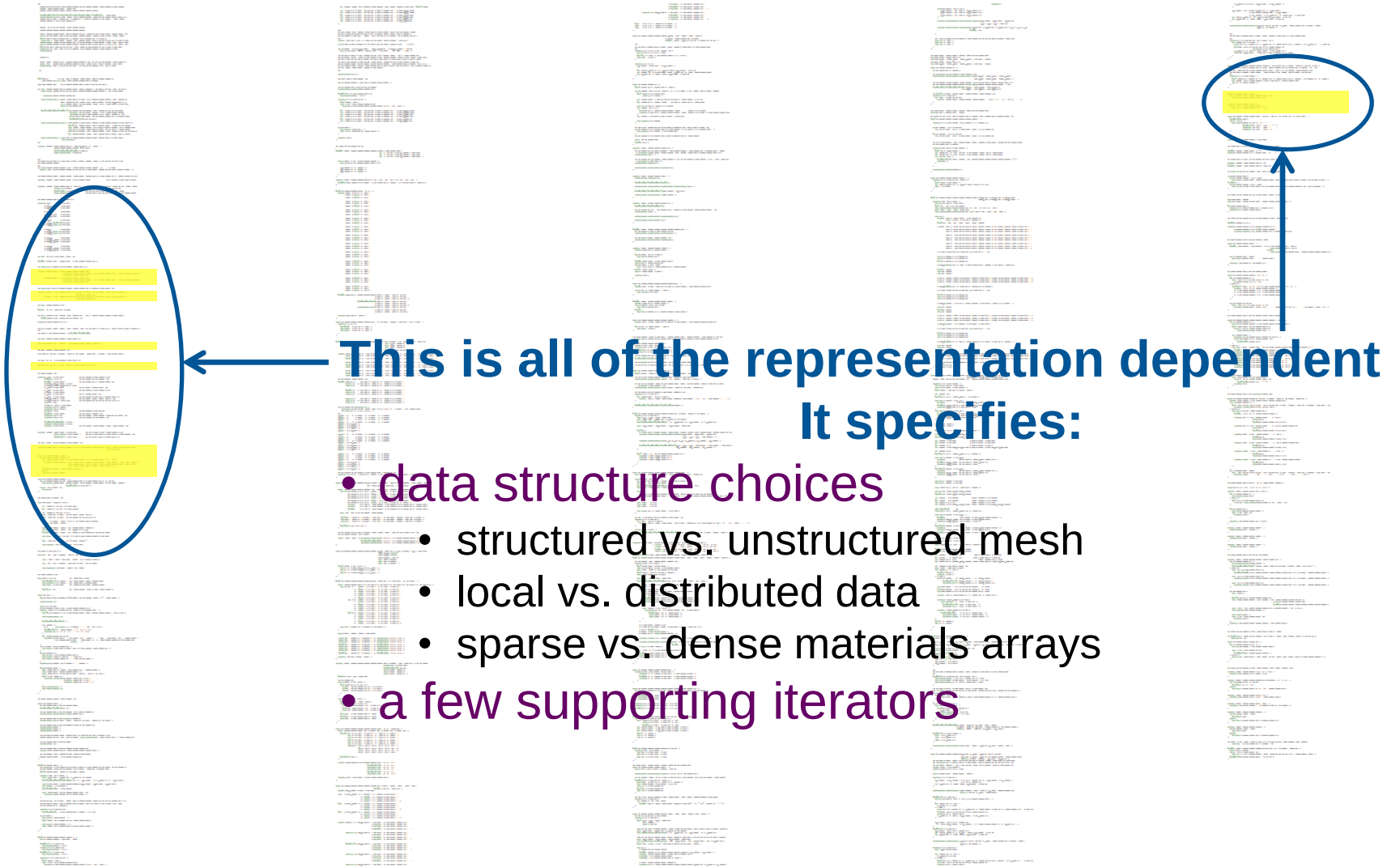
plus 266 lines of comments

487 blank lines

(the corresponding C+MPI+OpenMP version is nearly 4x bigger)

This can be found in the Chapel release under examples/benchmarks/lulesh/*.chpl

LULESH in Chapel

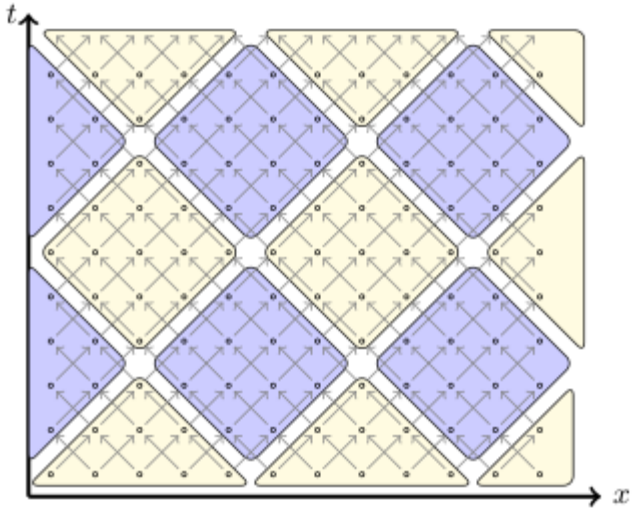


This is all of the representation dependent code. It specifies:

- data structure choices
  - structured vs. unstructured mesh
  - local vs. distributed data
  - sparse vs. dense materials arrays
- a few supporting iterators

Other Uses of Chapel: Diamond Tiling

- **Tiling – strategy to reduce mem. bandwidth pressure**
  - Improves performance and scalability of benchmark
  - Usually must be done by hand
  - Traditionally:
    - Difficult to write
    - Difficult to maintain
    - Not especially portable



Source: Bertolacci et. al. "Parameterized Diamond Tiling for Stencil Computations with Chapel parallel iterators." ACM International Conference on Supercomputing, Newport Beach, CA. June 8-11, 2015. Conference Presentation/Paper.

Other Uses of Chapel: Diamond Tiling

```
// Loop over tile wavefronts.
for (kt=ceild(3,tau)-3; kt<=floord(3*T,tau); kt++) {
  // The next two loops iterate within a tile wavefront.
  int k1_lb = ceild(3*Lj+2+(kt-2)*tau,tau*3);
  int k1_ub = floord(3*Uj+(kt+2)*tau,tau*3);
  int k2_lb = floord((2*kt-2)*tau-3*Ui+2,tau*3);
  int k2_ub = floord((2+2*kt)*tau-3*Li-2,tau*3);
  // Loops over tile coordinates within a parallel wavefront of tiles.
  #pragma omp parallel for ...
  for (k1 = k1_lb; k1 <= k1_ub; k1++) {
    for (x = k2_lb; x <= k2_ub; x++) {
      k2 = x - k1;
      // Removing k1 term from k2 upper and lower bounds enables collapse(2).
      // Loop over time within a tile.
      for (t = max(1, floord(kt*tau-1, 3)); t < min(T+1, tau + floord(kt*tau, 3)); t++) {
        write = t & 1;
        // equivalent to t mod 2
        read = 1 - write;
        // Loops over the spatial dimensions within each tile.
        for (i =  max(Li,max((kt-k1-k2)*tau-t, 2*t-(2+k1+k2)*tau+2)); i <= min(Ui,min((1+kt-k1-k2)*tau-t-1,
        2*t-(k1+k2)*tau)); i++) {
          for (j =  max(Lj,max(tau*k1-t, t-i-(1+k2)*tau+1)); j <= min(Uj,min((1+k1)*tau-t-1, t-i-k2*tau));
          j++) {
            A[write][x][y] = (A[read][x-1][y] + A[read][x][y-1] + ... ; } } } } } }
```

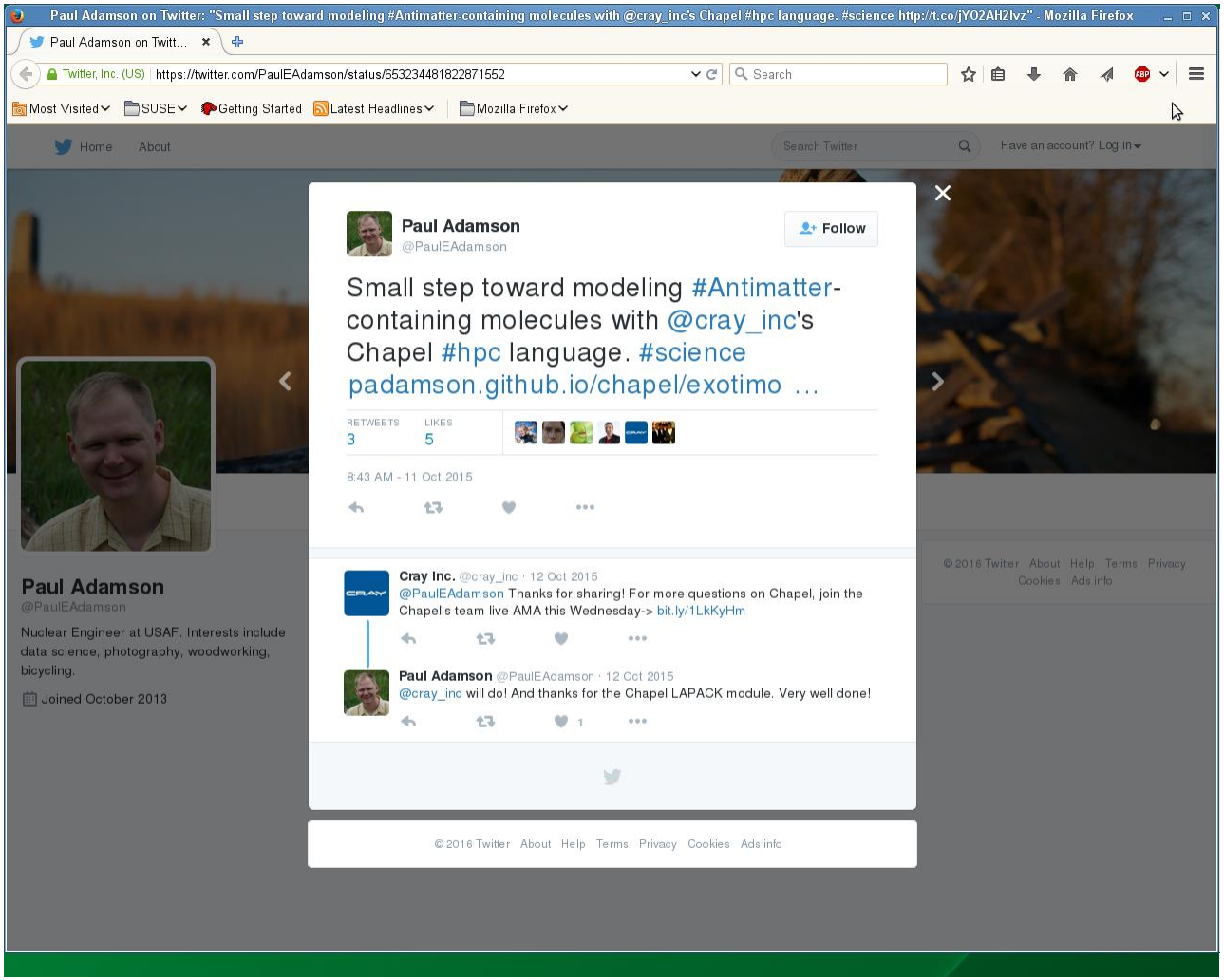
Source: Bertolacci et. al. "Parameterized Diamond Tiling for Stencil Computations with Chapel parallel iterators." ACM International Conference on Supercomputing, Newport Beach, CA. June 8-11, 2015. Conference Presentation/Paper.

Other Uses of Chapel: Diamond Tiling

```
forall (read, write, x ,y) in DiamondTileIterator(L, U, T, tau) {
  A[write, x, y] = (A[read,x-1,y] + A[read,x,y-1] + A[read,x  ,y] +
        A[read,x,y+1] + A[read,x+1,y]) / 5;
}
```

Source: Bertolacci et. al. “Parameterized Diamond Tiling for Stencil Computations with Chapel parallel iterators.” ACM International Conference on Supercomputing, Newport Beach, CA. June 8-11, 2015. Conference Presentation/Paper.

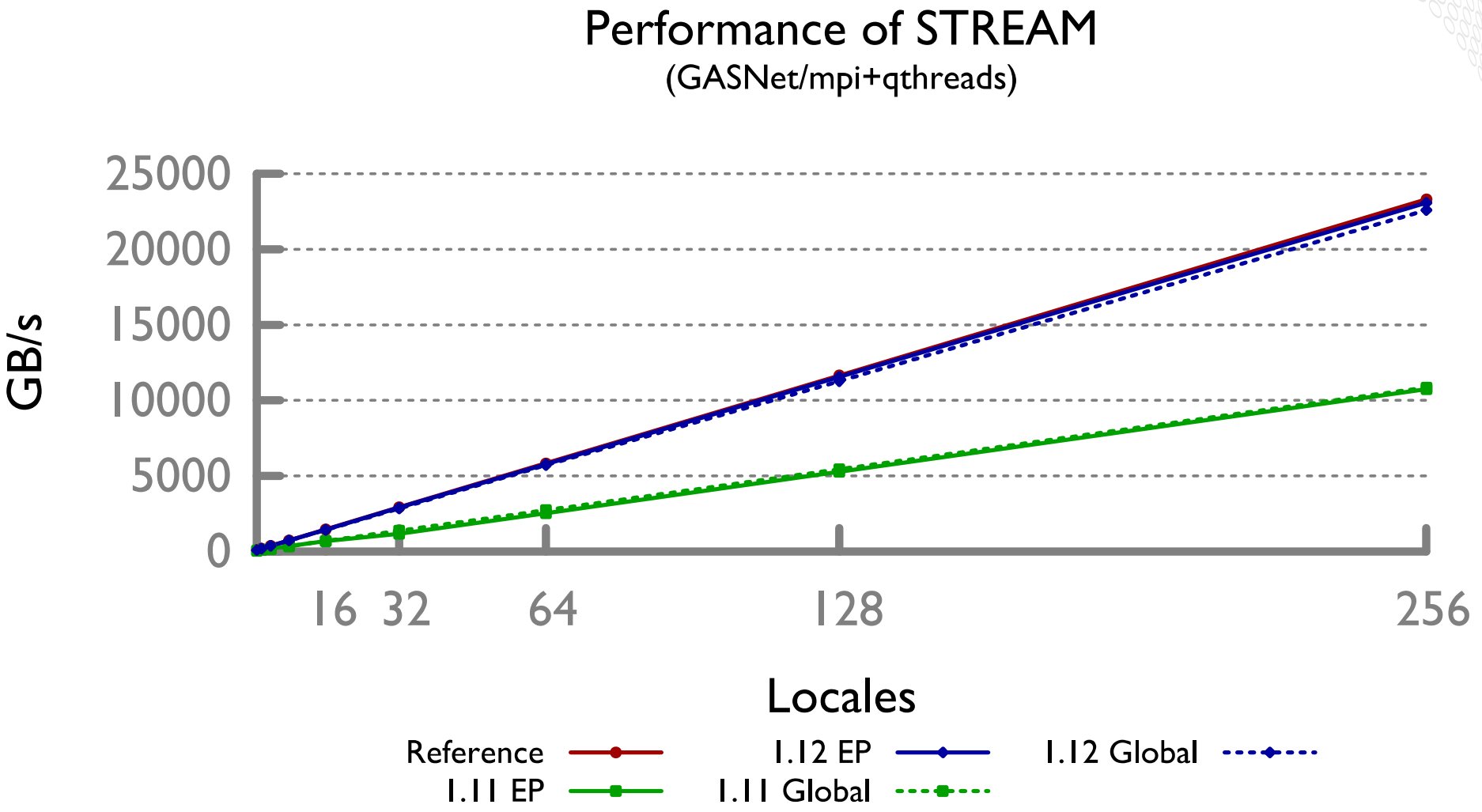
Other Uses of Chapel



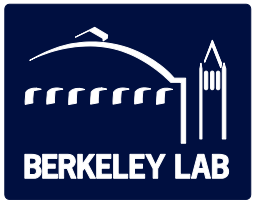
Chapel is a Work-in-Progress

- **Currently being picked up by early adopters**
  - Users who try it generally like what they see
  - Last release got 1400+ downloads over six months
- **Most features are functional and working well**
  - some areas need improvements: strings, object-oriented features
- **Performance is hit-or-miss**
  - shared memory performance is often competitive with C+OpenMP
  - distributed memory performance needs more work
- **We are actively working to address these lacks**

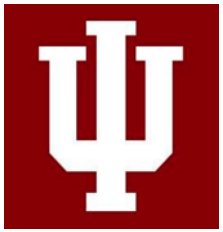
STREAM Scalability



Chapel is a Collaborative Effort



Lawrence Berkeley
National Laboratory



(and many others as well…)

http://chapel.cray.com/collaborations.html

Chapel is Open-Source

- **Chapel's development is hosted at GitHub**
  - https://github.com/chapel-lang
- **Chapel is licensed as Apache v2.0 software**
- **Download/install online**
  - see http://chapel.cray.com/download.html for instructions

Online Resources

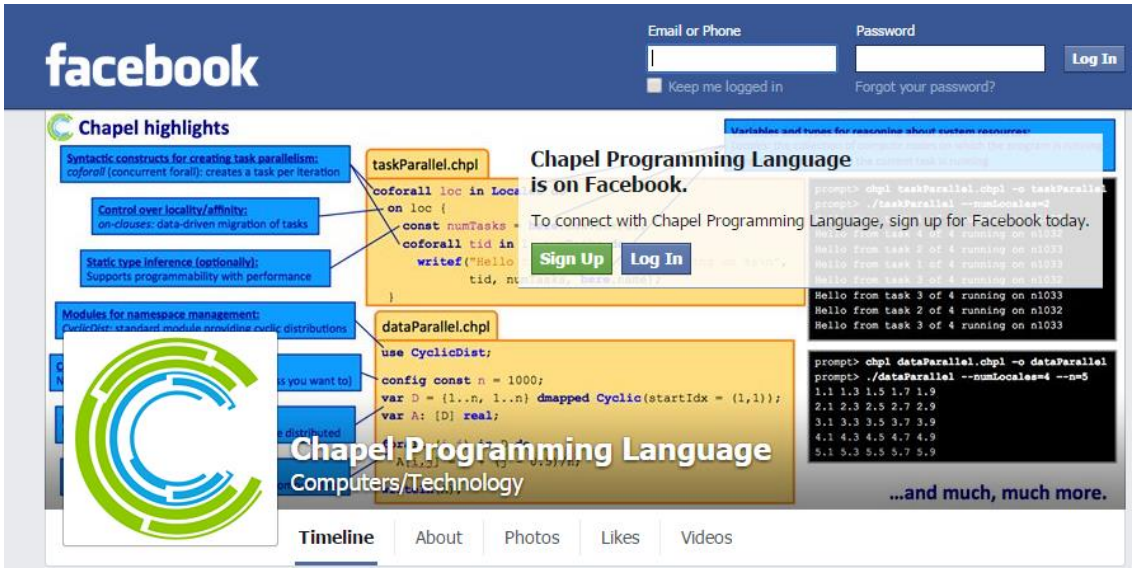
Project page: http://chapel.cray.com

- overview, papers, presentations, language spec, …

GitHub page: https://github.com/chapel-lang

- download Chapel; browse source repository; contribute code

Facebook page: https://www.facebook.com/ChapelLanguage



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http://chapel.cray.com chapel_info@cray.com http://github.com/chapel-lang/chapel/