The Chapel Language:
Background and Status

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Customer Briefing, SC16

November 14–17, 2016

The Chapel Team's Vision

To create a programming language that is…

- …as productive as Python
- …as fast as Fortran
- …as portable as C
- …as scalable as MPI / UPC / SHMEM
- …as fun as <your favorite language here>

The Challenge

Q: Why don't we have such languages already?

A: ~~Technical challenges?~~

- while they exist, we don't think this is the primary issue…

A: Due to a lack of…

…long-term efforts

…resources

…community will

…co-design between developers and users

…patience

Chapel is our effort to reverse this trend

What is Chapel?

Chapel: A productive parallel programming language

Characteristics:

- portable
- open-source
- a collaborative effort
- a work-in-progress

Goals:

- Support general parallel programming
  - "any parallel algorithm on any parallel hardware"
- Make parallel programming far more productive

What does “Productivity” mean to you?

Recent Graduate:

“something similar to what I used in school: Python, Matlab, Java, …”

Seasoned HPC Programmer:

“that sugary stuff that I can’t use because I need full control to ensure good performance”

Computational Scientist:

“something that lets me express my parallel computations without requiring me to wrestle with architecture-specific details”

Chapel Team:

“something that lets the computational scientist express what they want,
without taking away the control the HPC programmer needs,
implemented in a language as attractive as recent graduates would like.”

Chapel is Portable

- **Chapel is designed to be hardware-independent**
- **The current implementation requires:**
  - a C/C++ compiler
  - a *NIX environment (Linux, OS X, BSD, Cygwin, …)
  - POSIX threads
  - UDP, MPI, or RDMA (for distributed memory execution)
- **As a result, Chapel can run on…**

  …laptops and workstations
  …commodity clusters
  …the cloud
  …HPC systems from Cray and other vendors

Chapel is Open-Source

- Chapel's development is hosted at GitHub
  - https://github.com/chapel-lang
- Chapel is licensed as Apache v2.0 software
- Instructions for download + install are online
  - see http://chapel.cray.com/download.html to get started

Chapel History and Characterization

Chapel's Origins: HPCS

DARPA HPCS: High Productivity Computing Systems

- **Goal:** improve productivity by a factor of 10x
- **Timeframe:** Summer 2002 – Fall 2012
- Cray developed a new system architecture, network, software stack…
  - this became the very successful Cray XC30™ Supercomputer Series

…and a new programming language: Chapel

Chapel's 5-year push

- **Based on positive user response to Chapel under HPCS, Cray undertook a five-year effort to improve it**
  - we're currently ~3.5 years in
- **Focus Areas:**
  1. Improving **performance** and scaling
  2. **Fixing** immature aspects of the language and implementation
     - e.g., strings, memory management, error handling, …
  3. **Porting** to emerging architectures
     - Intel Xeon Phi, accelerators, heterogeneous processors and memories, …
  4. Improving **interoperability**
  5. Growing the Chapel user and developer **community**
     - including non-scientific computing communities
  6. Exploring transition of Chapel **governance** to a neutral, external body

The Chapel Team at Cray (Summer 2016)

14 full-time employees + 2 summer interns + 1 visiting professor
(one of each started after this photo was taken)

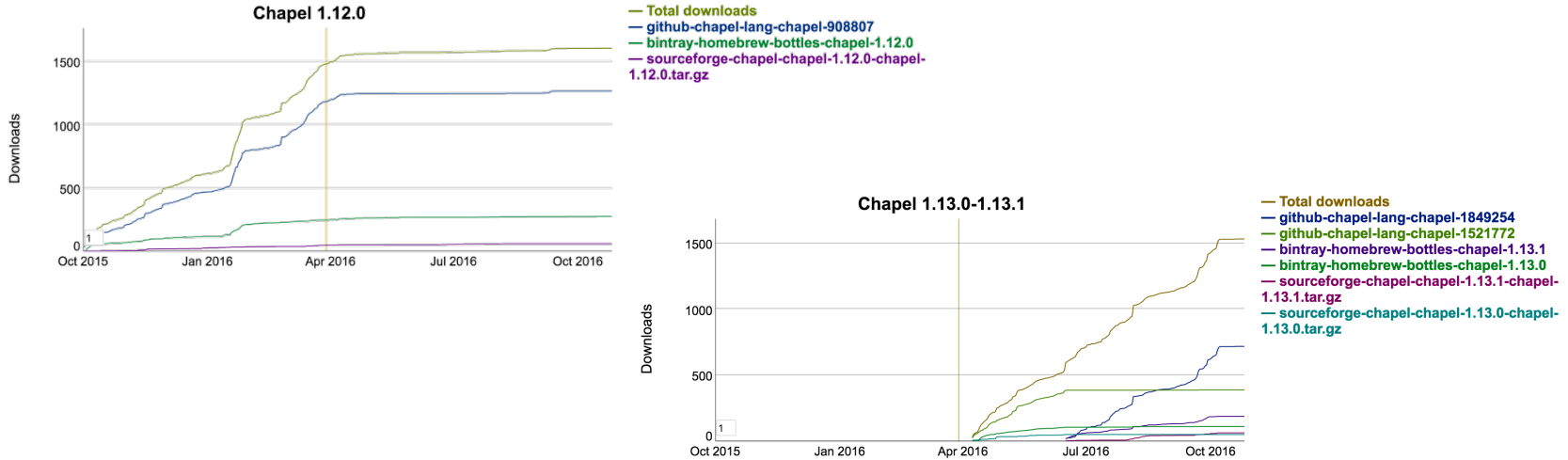
Chapel is a Collaborative Effort

(and several others…)

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

Chapel is a Work-in-Progress

- **Currently being picked up by early adopters**
  - 3000+ downloads per year across two releases



  - Users who try it generally like what they see

A notable early adopter

Chapel in the (Cosmological) Wild 1:00 – 2:00

Nikhil Padmanabhan, *Yale University Professor, Physics & Astronomy*

Abstract: This talk aims to present my personal experiences using Chapel in my research. My research interests are in observational cosmology; more specifically, I use large surveys of galaxies to constrain the evolution of the Universe
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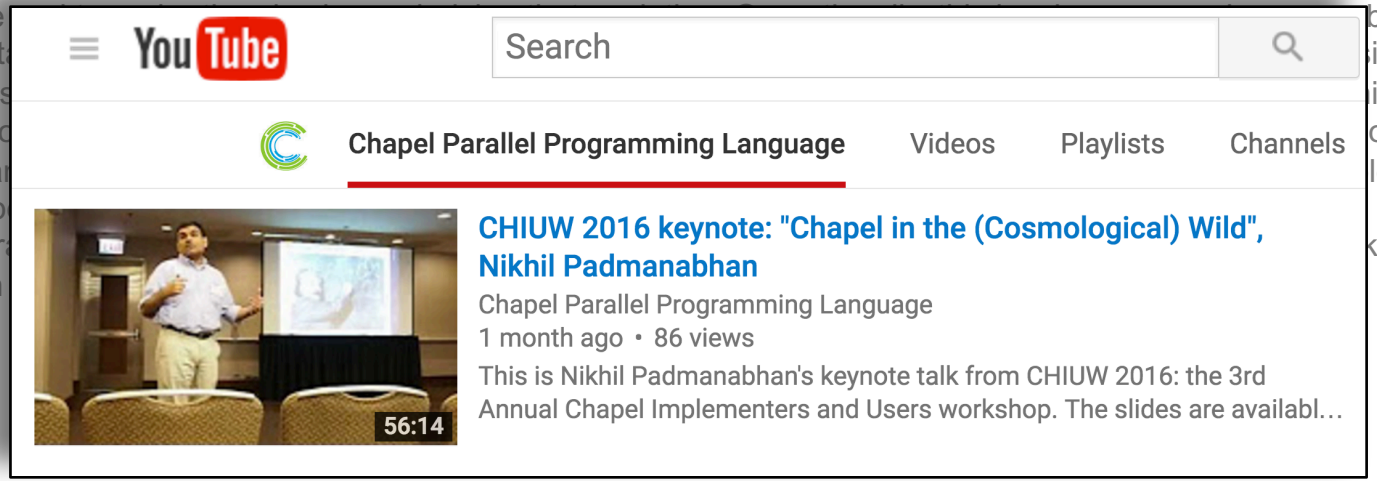


Highlights of the first 3-1/2 years

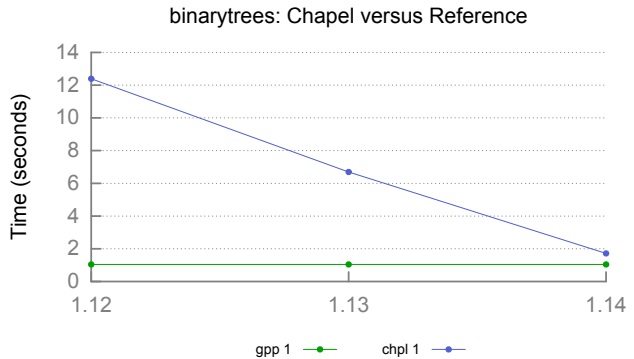
The Standard Library has Grown Significantly

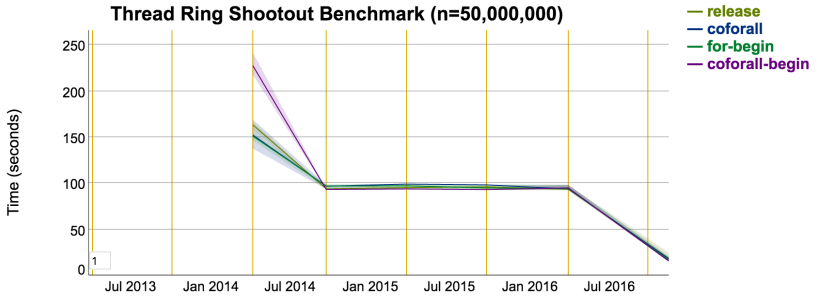
- **Many new modules:**
  - Bigints
  - Bit Operations
  - Spawn
  - PCG Random Number Generation
  - File System / Path utilities
  - HDFS / cURL
  - LAPACK
  - Reflection
  - Barrier
  - …
- **Several from users:**
  - FFTW
  - BLAS
  - MPI
  - ZeroMQ
  - Matrix Market
  - JAMA
  - …

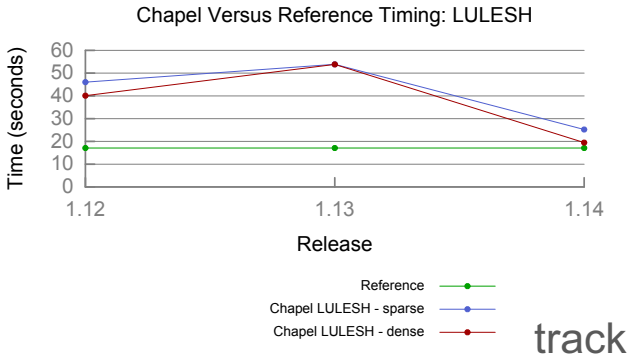
The Language and Compiler are Improving

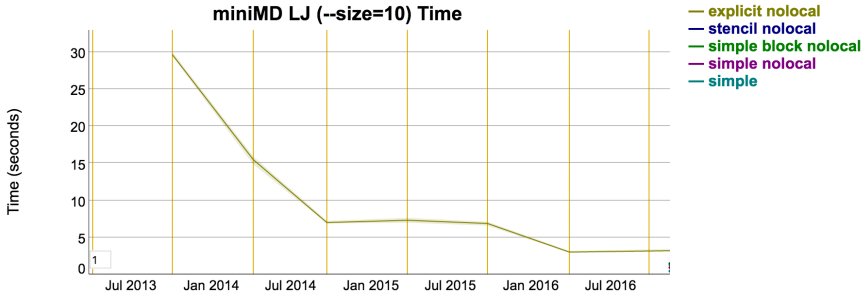
- Interoperability
- Strings
- Namespace features
- Semantic changes to reduce race conditions
- Improved set / vector operations
- Numerous bug fixes
- …

Shared-Memory Performance is Improving…



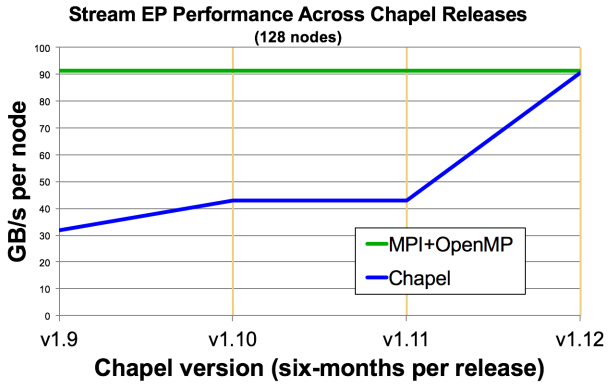


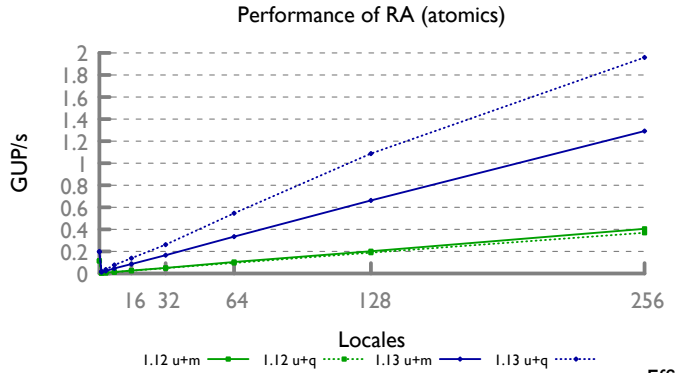


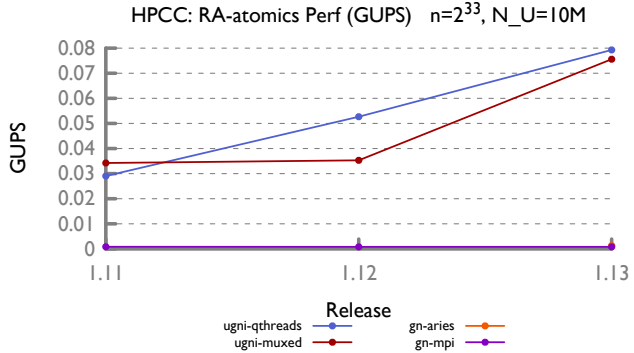


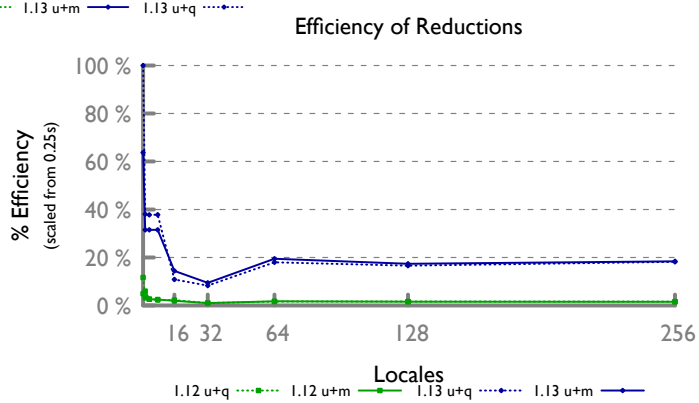
track our performance daily at: http://chapel.sourceforge.net/perf/

…as is Distributed Memory Perf. and Scaling

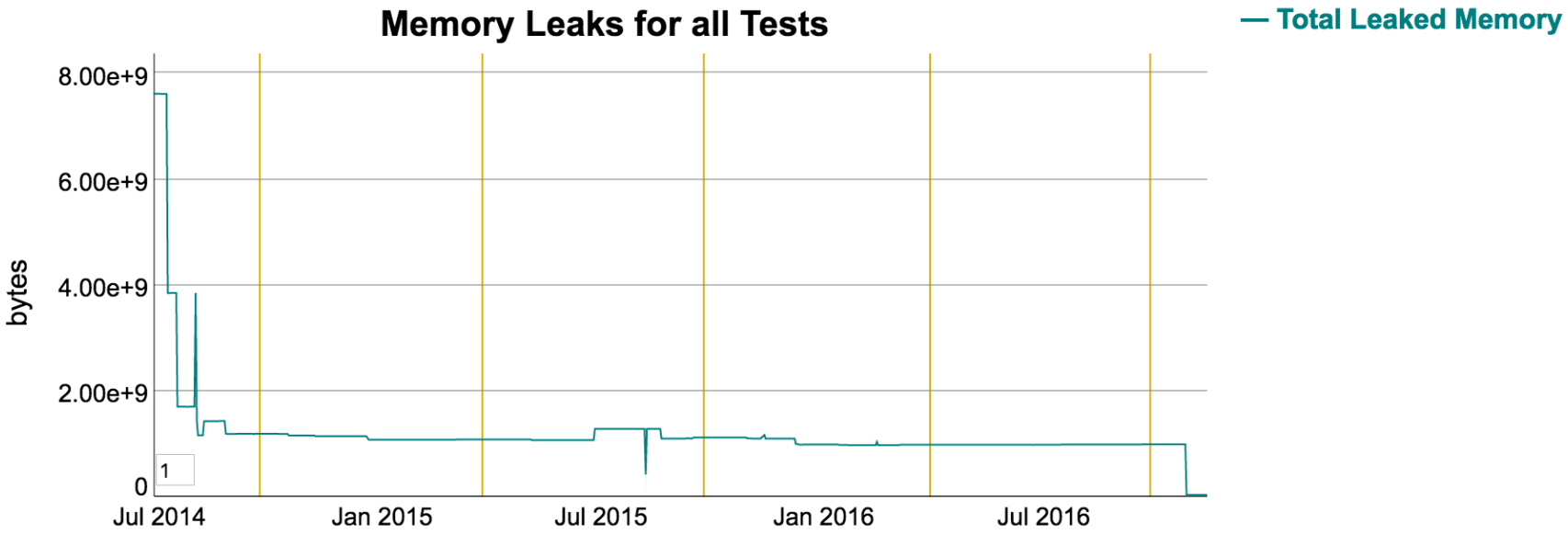




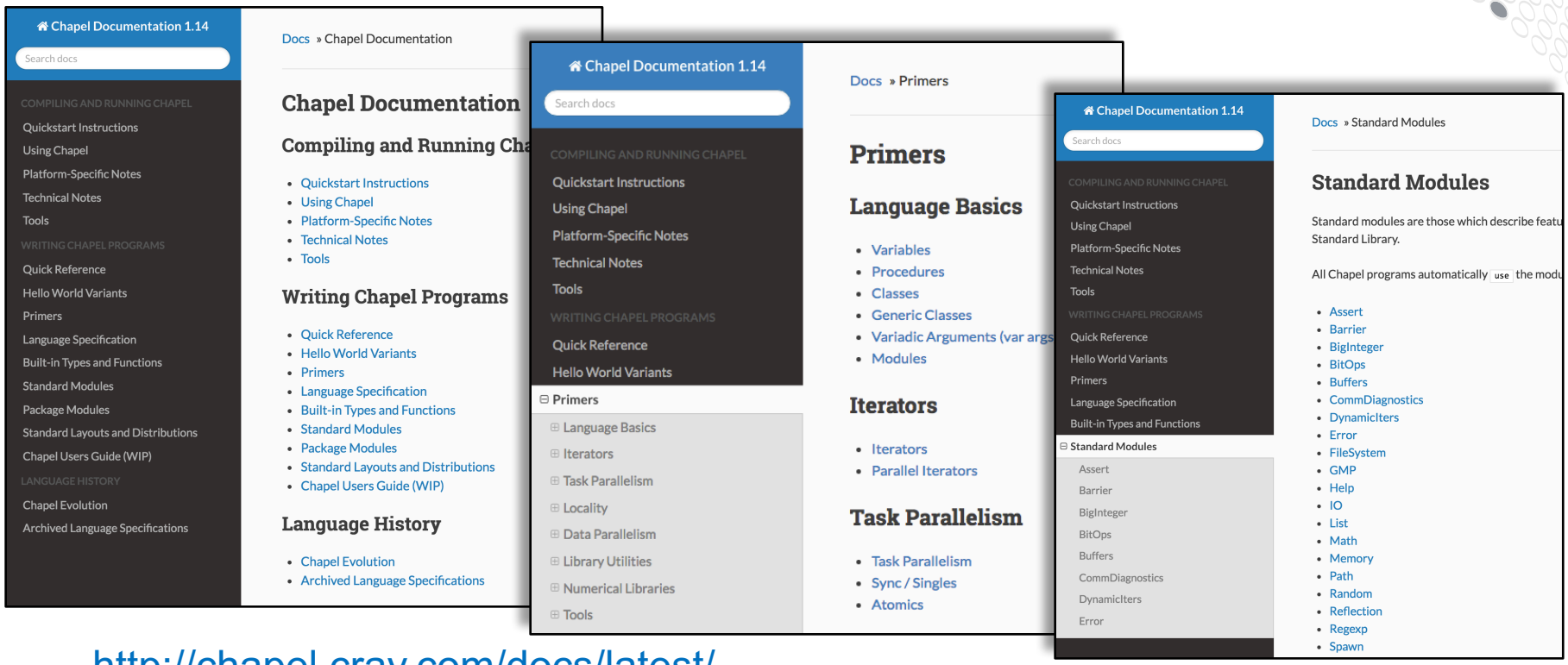




Memory Leaks Are Being Plugged

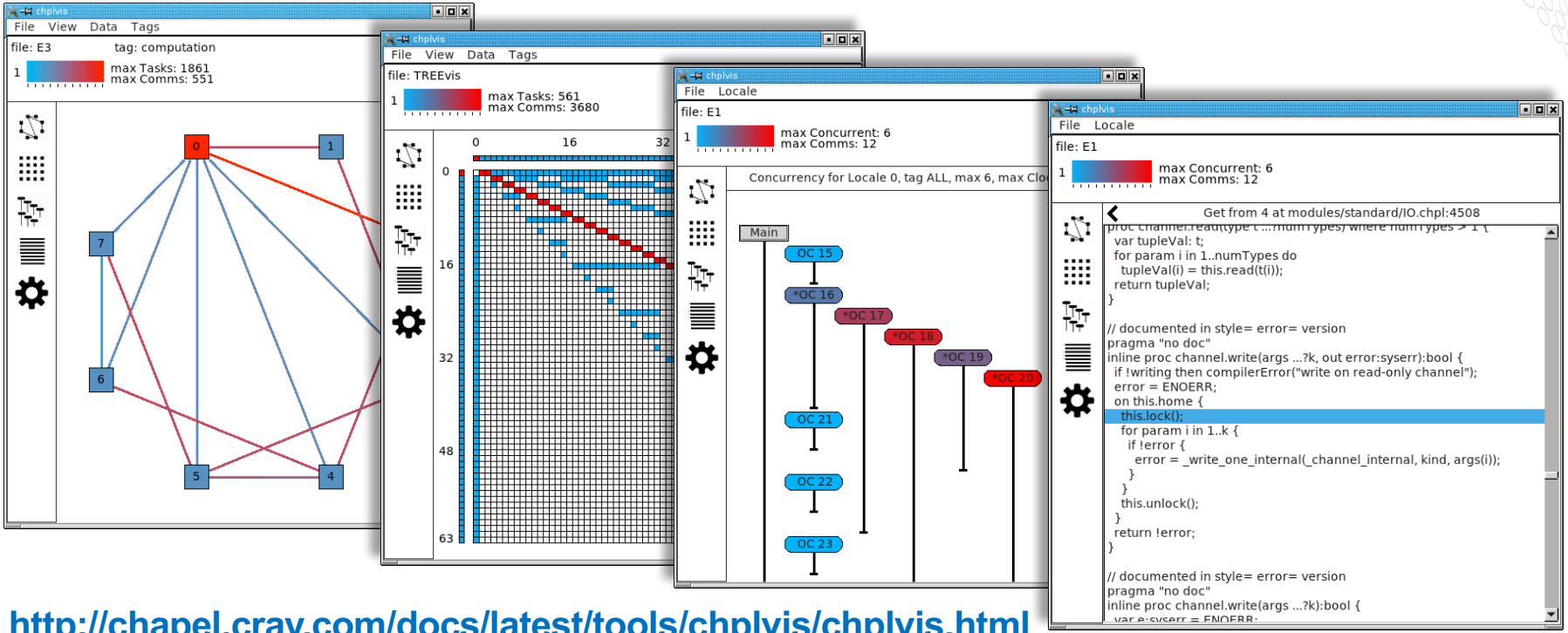


Documentation Is Now Online / Modern



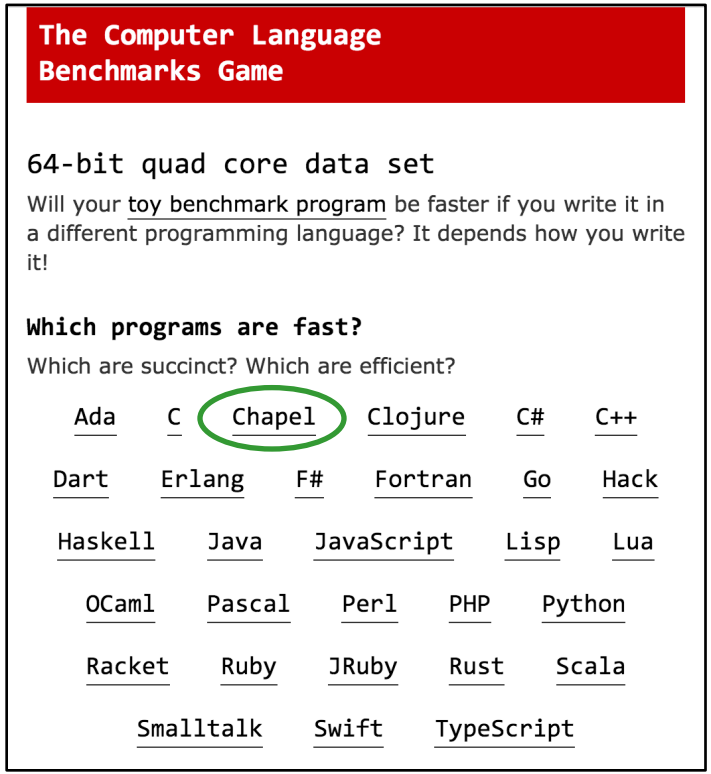
http://chapel.cray.com/docs/latest/

chplvis: Chapel Execution Visualization Tool



http://chapel.cray.com/docs/latest/tools/chplvis/chplvis.html

Computer Language Benchmarks Game



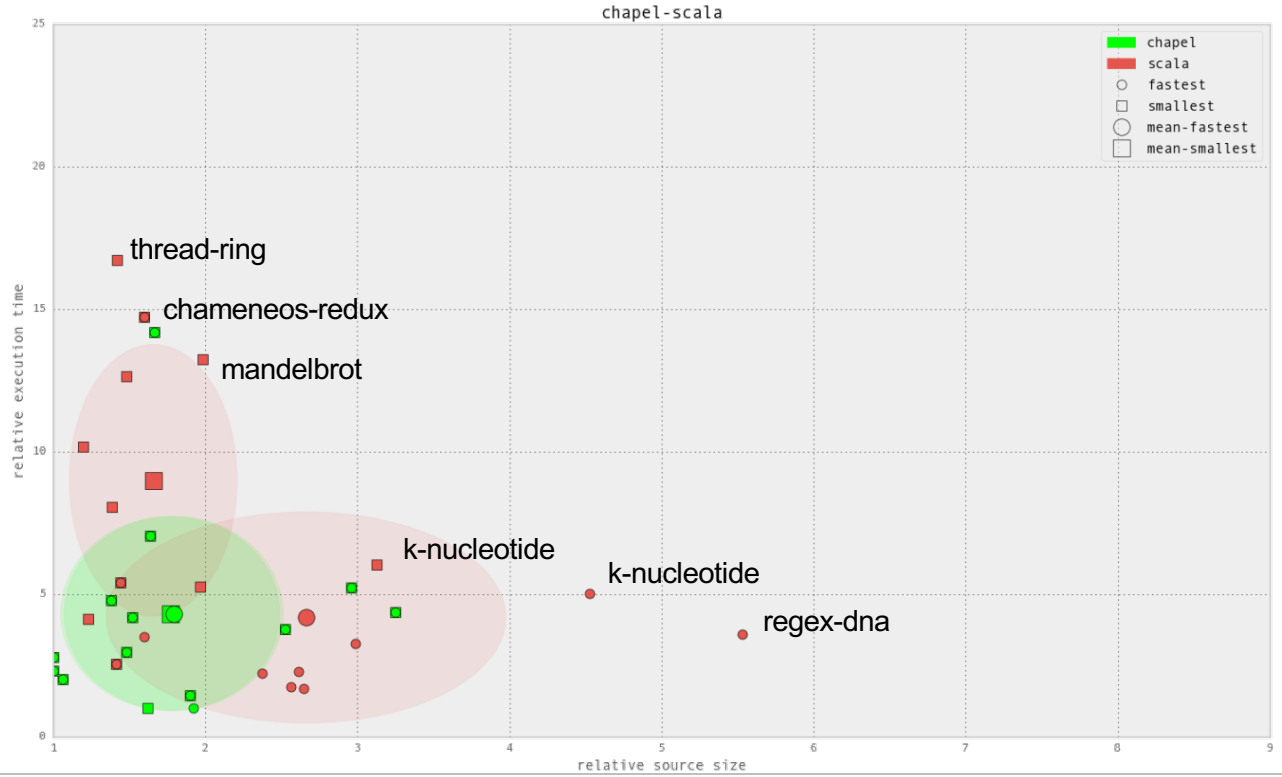
- **performance rankings:**
  - 1 top entry
  - + 2 other top-5 entries
  - + 2 other top-10 entries
  - + 3 other top-20 entries
- **code compactness rankings:**
  - 2 top entries
  - + 2 other top-5 entries
  - + 4 other top-20 entries

We want easy answers, but easy answers are often incomplete or wrong. You and I know, there's more we should understand:

stories details fast-faster-fastest

conclusions { for researchers }

CLBG Scatter Plots: Chapel vs. Scala



There's never been a better time to try Chapel

- **Lots of great progress in the past few years**
  - Like buying a laptop, waiting will always get you more…
    …but this is a great time to weigh in with your requests / concerns
- **Chapel trainings / talks / help available on request**
  - I'm available for discussions this week, as are other developers
- **Direct us to killer apps / demos that would help you**

What's Next?

Top Priorities for Spring 2017 Release

- **Language Features**
  - complete initializers, copy constructors
  - complete draft of error-handling
  - address array rewrite performance regressions
  - implement array views
- **Locality/Memory Improvements**
  - NUMA-aware domains and arrays
  - NUMA-aware memory allocation (including for ugni)
  - HBM support
- **Performance Improvements**
  - single-locale: get LCALS to parity with reference, improve shootouts
  - multi-locale: close in on ref versions of ISx, MiniMD/CoMD, LULESH
  - continue closing significant memory leaks
- **Refocus effort on IPE (REPL) and compiler v2 strategy**

Bigger Picture Chapel Challenges

- **Getting the snowball of adoption rolling**
  - including outreach to non-HPC parallel programmers
- **Amassing a large suite of library code**
- **No interpreter / REPL** (yet)
- **Separate / Incremental compilation**
- **Overhaul of current compiler source code**

Questions?