# Chapel Comes of Age: Productive Parallelism at Scale

**Brad Chamberlain, Chapel Team, Cray Inc.**

**PNW PLSE Workshop**

**May 14, 2018**


# Chapel:
# Niche or Quiche?

Brad Chamberlain, Chapel Team, Cray Inc.

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# Safe Harbor Statement

This presentation may contain forward-looking statements that are based on our current expectations. Forward looking statements may include statements about our financial guidance and expected operating results, our opportunities and future potential, our product development and new product introduction plans, our ability to expand and penetrate our addressable markets and other statements that are not historical facts. These statements are only predictions and actual results may materially vary from those projected. Please refer to Cray's documents filed with the SEC from time to time concerning factors that could affect the Company and these forward-looking statements.

# What is Chapel?



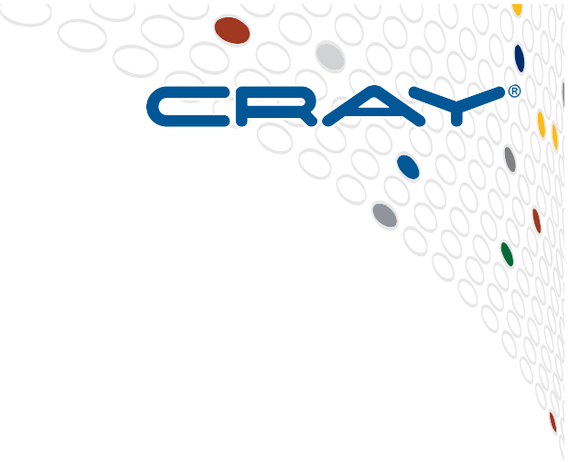
**Chapel:** A productive parallel programming language

- portable & scalable
- open-source & collaborative


**Goals:**

- Support general parallel programming
  - “any parallel algorithm on any parallel hardware”
- Make parallel programming at scale far more productive

# Chapel and Productivity



## Chapel aims to be as…

…**programmable** as Python

…**fast** as Fortran

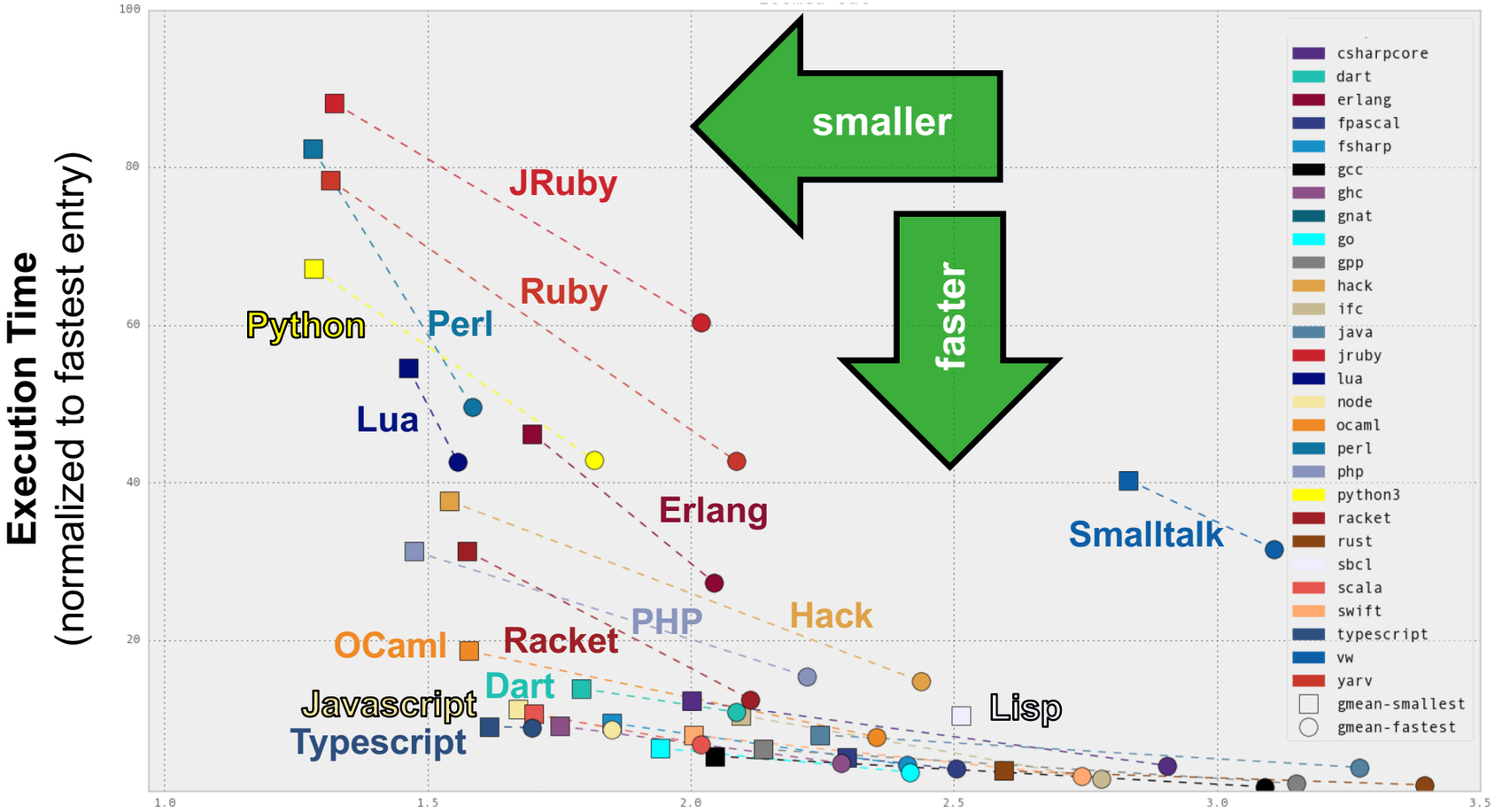
…**scalable** as MPI

…**portable** as C

…**flexible** as C++

…**fun** as [your favorite programming language]

# CLBG Cross-Language Summary
(Oct 2017 standings)



# CLBG Cross-Language Summary
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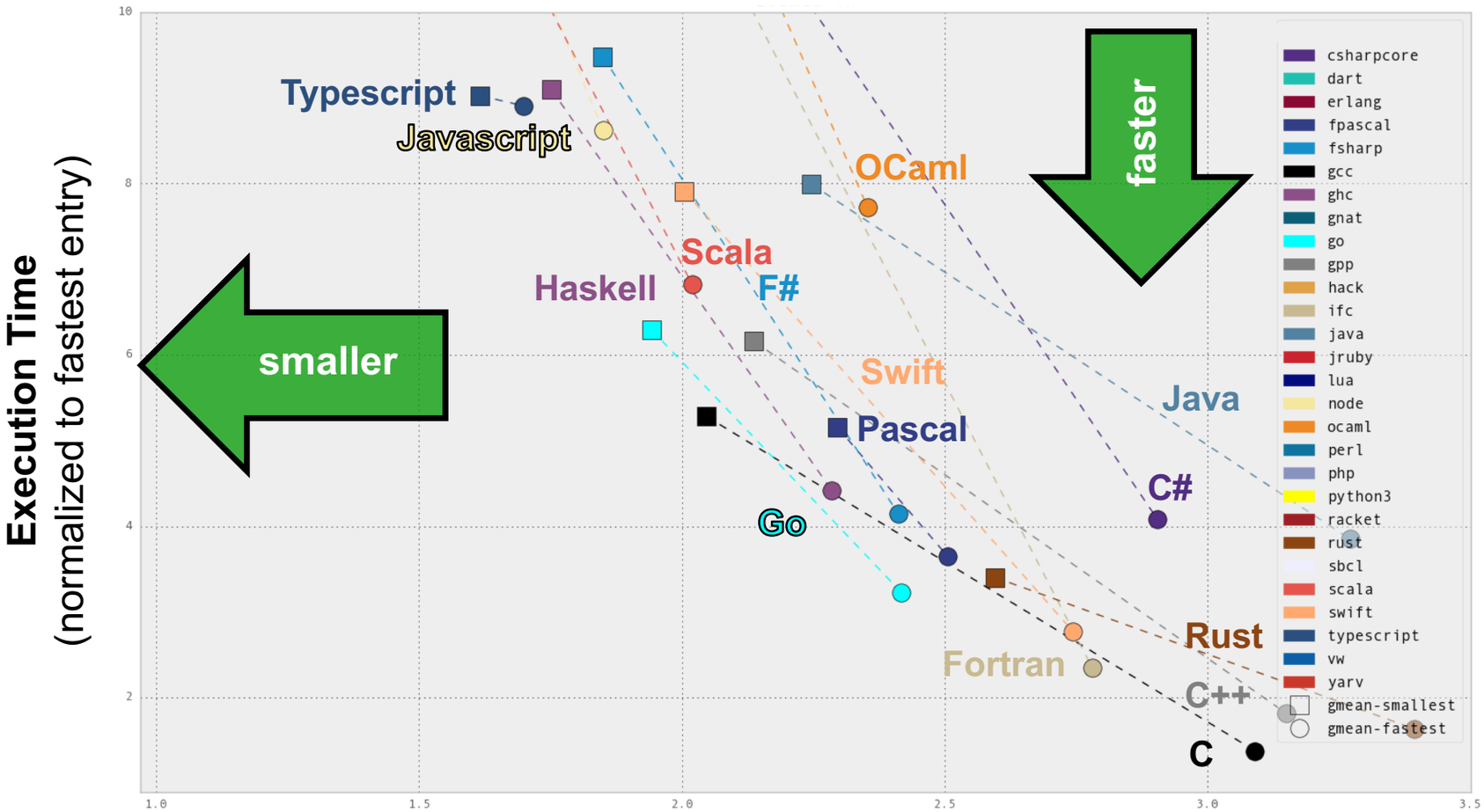

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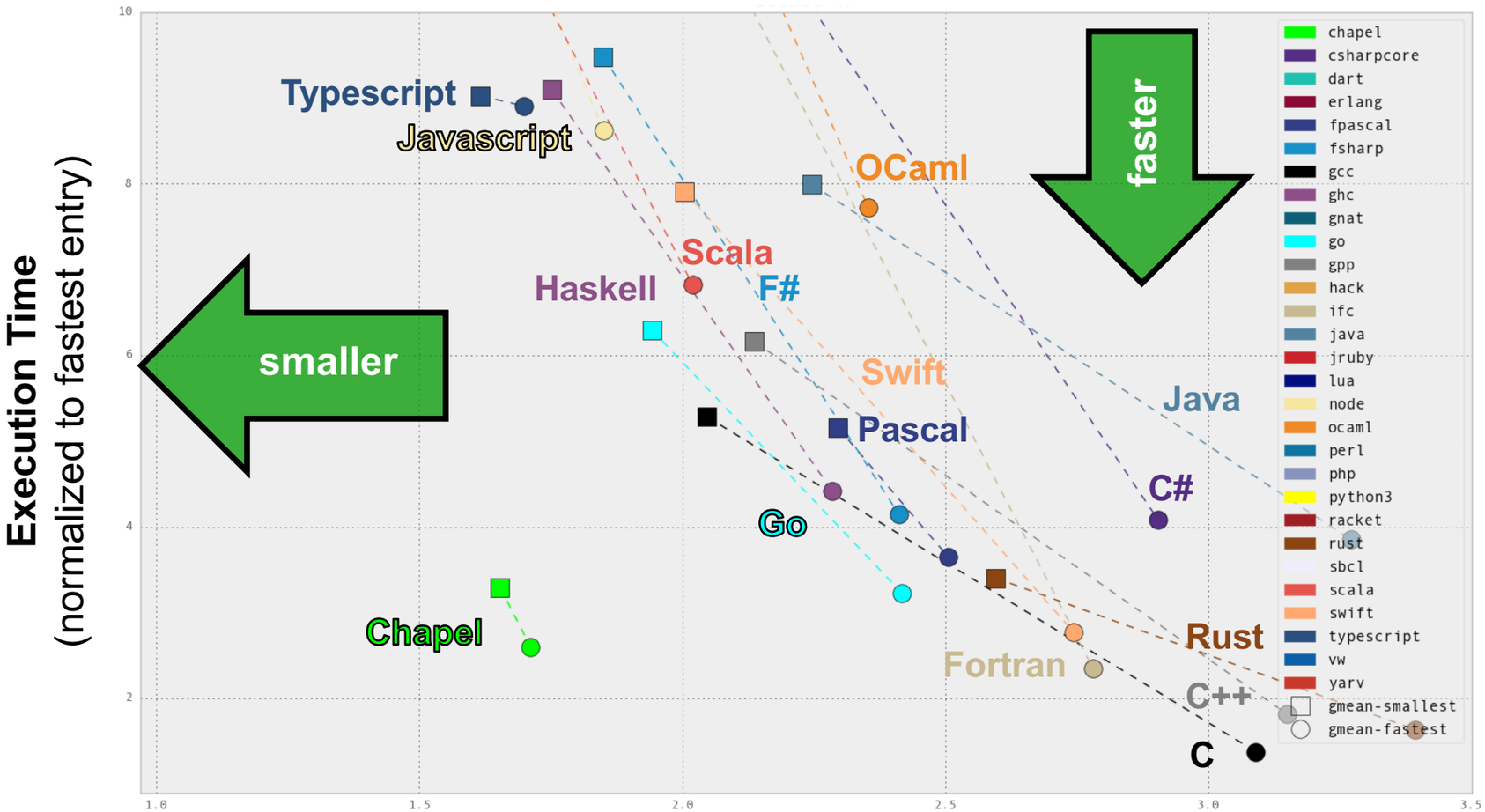


**Compressed Code Size** (normalized to smallest entry)

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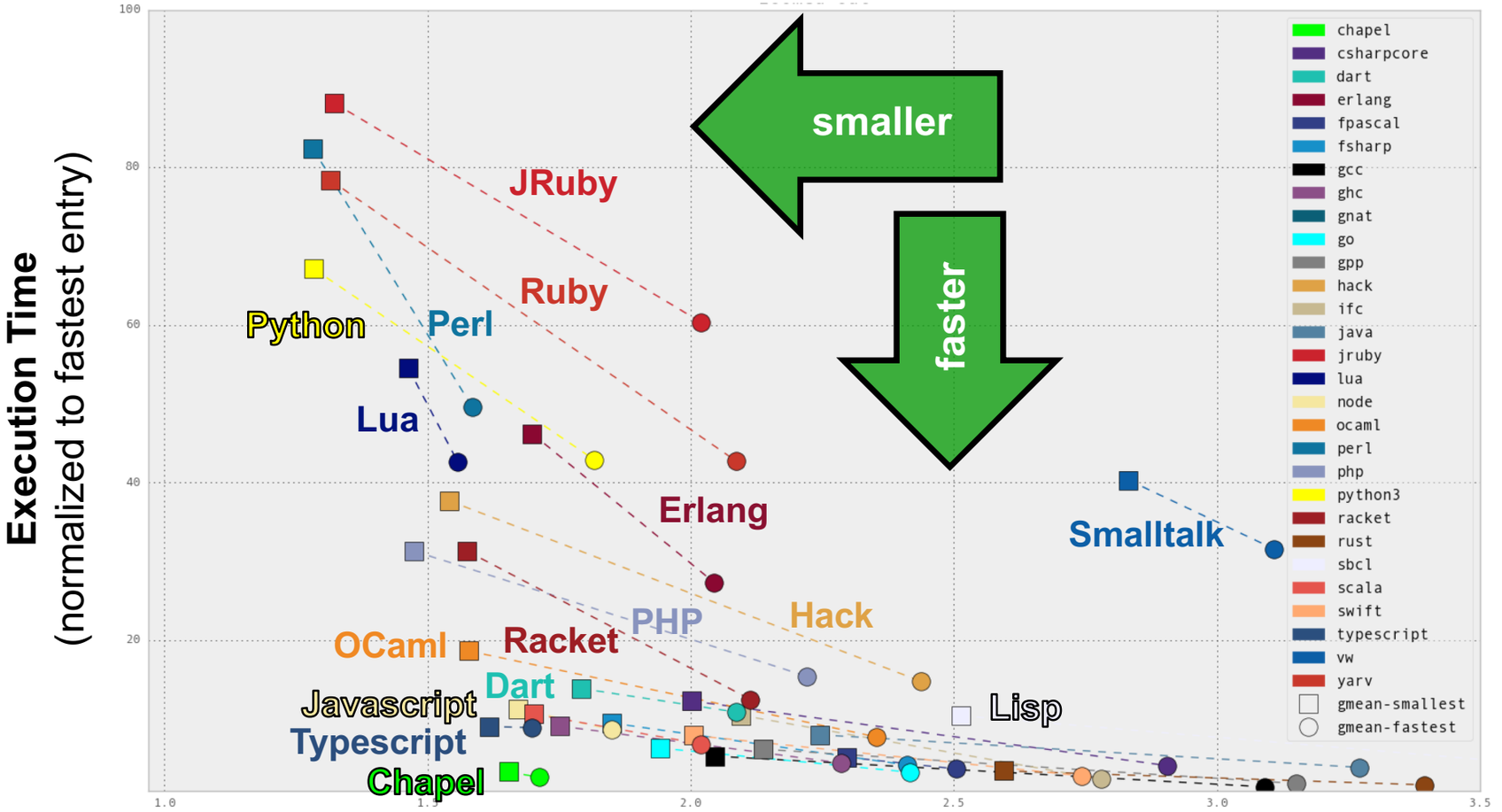
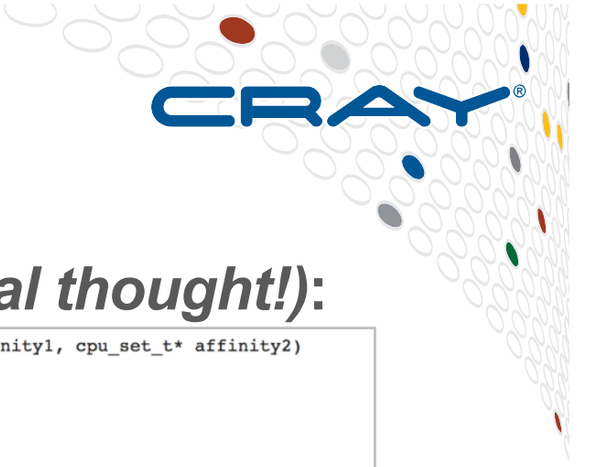
(Oct 2017 standings)



# CLBG: Qualitative Code Comparisons



## Can also browse program source code *(but this requires actual thought!)*:

```
proc main() {
  printColorEquations();

  const group1 = [i in 1..popSize1] new Chameneos(i, ((i-1)%3):Color);
  const group2 = [i in 1..popSize2] new Chameneos(i, colors10[i]);

  cobegin {
    holdMeetings(group1, n);
    holdMeetings(group2, n);
  }

  print(group1);
  print(group2);

  for c in group1 do delete c;
  for c in group2 do delete c;
}


//
// Print the results of getNewColor() for all color pairs.
//
proc printColorEquations() {
  for c1 in Color do
    for c2 in Color do
      writeln(c1, " + ", c2, " -> ", getNewColor(c1, c2));
  writeln();
}


//
// Hold meetings among the population by creating a shared meeting
// place, and then creating per-chameneos tasks to have meetings.
//
proc holdMeetings(population, numMeetings) {
  const place = new MeetingPlace(numMeetings);

  coforall c in population do           // create a task per chameneos
    c.haveMeetings(place, population);

  delete place;
}
```

*excerpt from 1210 gz Chapel entry*

```
void get_affinity(int* is_smp, cpu_set_t* affinity1, cpu_set_t* affinity2)
{
    cpu_set_t                   active_cpus;
    FILE*                       f;
    char                        buf [2048];
    char const*                 pos;
    int                         cpu_idx;
    int                         physical_id;
    int                         core_id;
    int                         cpu_cores;
    int                         apic_id;
    size_t                      cpu_count;
    size_t                      i;

    char const*                 processor_str       = "processor";
    size_t                      processor_str_len   = strlen(processor_str);
    char const*                 physical_id_str     = "physical id";
    size_t                      physical_id_str_len = strlen(physical_id_str);
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    CPU_ZERO(&active_cpus);
    sched_getaffinity(0, sizeof(active_cpus), &active_cpus);
    cpu_count = 0;
    for (i = 0; i != CPU_SETSIZE; i += 1)
    {
        if (CPU_ISSET(i, &active_cpus))
        {
            cpu_count += 1;
        }
    }

    if (cpu_count == 1)
    {
        is_smp[0] = 0;
        return;
    }

    is_smp[0] = 1;
    CPU_ZERO(affinity1);
```
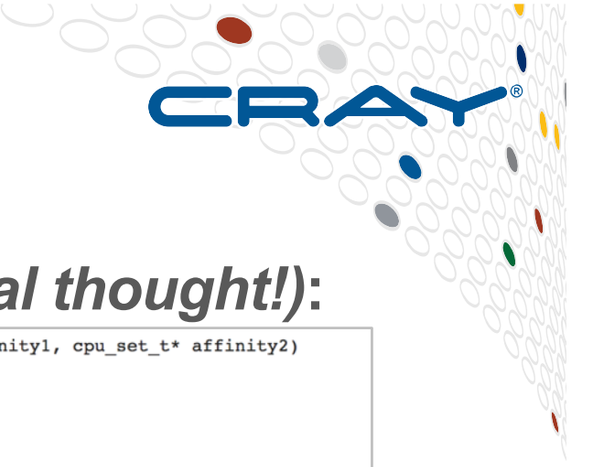

*excerpt from 2863 gz C gcc entry*

# CLBG: Qualitative Code Comparisons



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  buf [2048];
  pos;
  cpu_idx;
  physical_id;
  core_id;
  cpu_cores;
  apic_id;
  cpu_count;
  i;

  size_t                  processor_str       = "processor";
  char const*             processor_str_len   = strlen(processor_str);
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size_t                          cpu_cores_str_len    = strlen(cp

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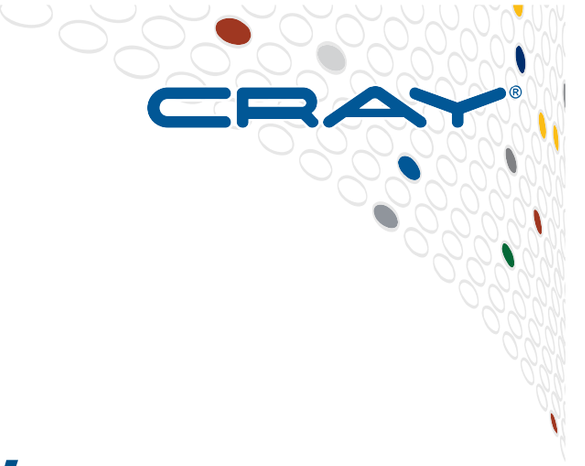
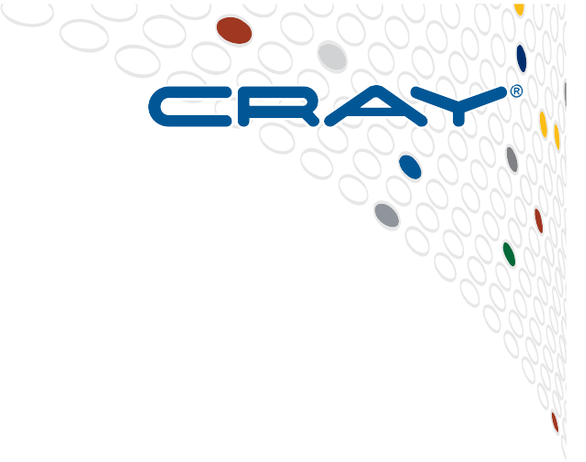


# Excerpt from PNW PLSE Review

*"Chapel has been around for quite a while, and it still seems like a niche language…"*

# Chapel: "A Niche Language"?




Chapel is arguably niche in that it…

…was originally designed for HPC

Yet, Chapel's chief concerns aren't HPC-specific:

- performance
- programmability (cf. Python)
- parallelism (cf. multicore)
- distributed memory (cf. cloud computing)

# Chapel: "A Niche Language"?

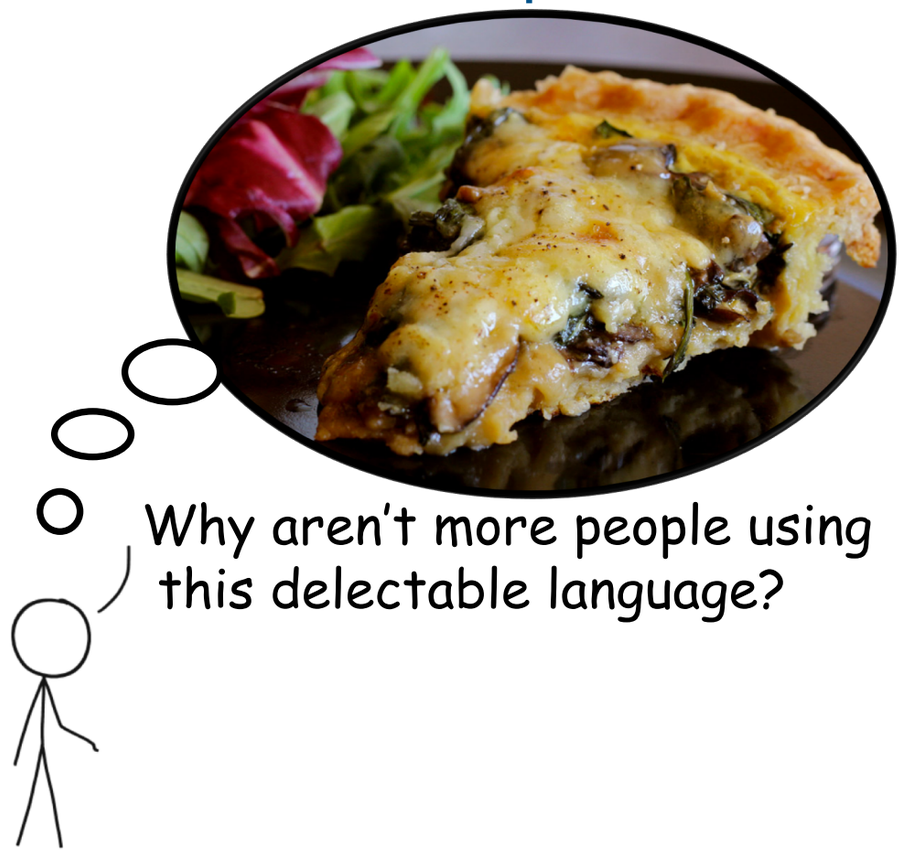
Chapel is arguably niche in that it…

- …was originally designed for HPC
- …has only a modest-sized community (so far)

**Yet, we've historically discouraged its use in production…**

# Chapel: A Quiche Language!

The outsider's impression:




The reality, for most of Chapel's history:



Image sources: https://www.themountainkitchen.com, https://xkcd.com/

# Chapel: A Quiche Language!

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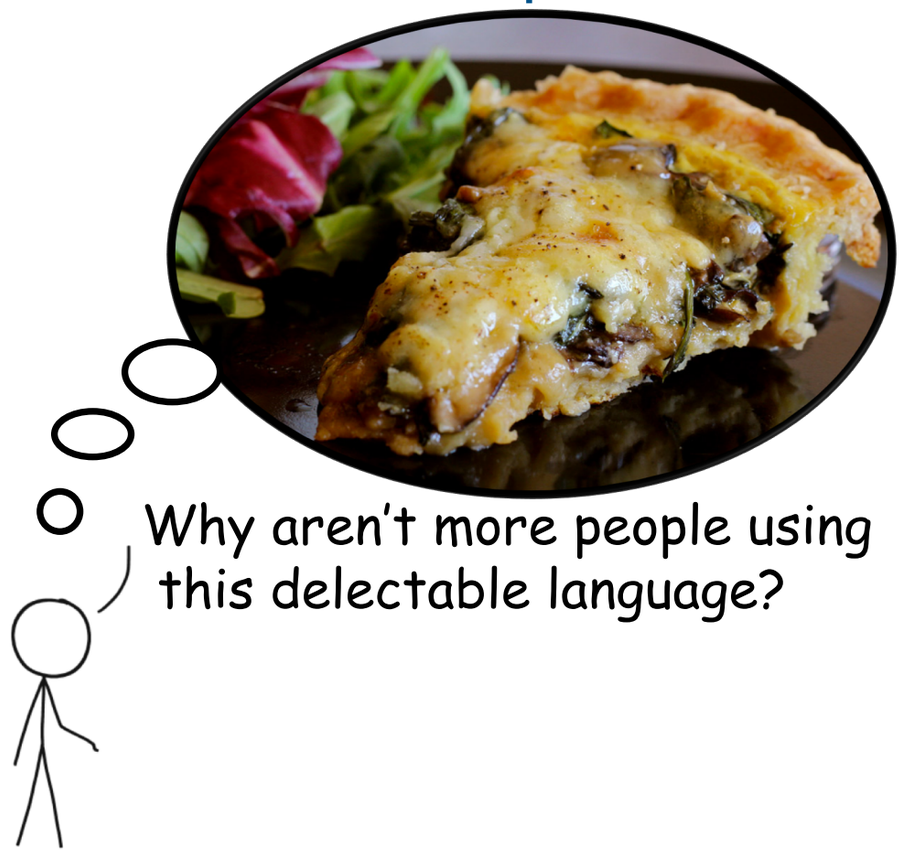


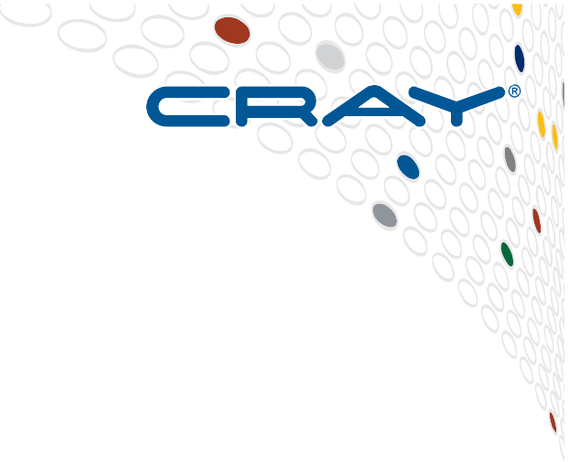

Though recently, it's more like:





Image sources: https://www.themountainkitchen.com, https://xkcd.com/

# Chapel: "Been Around for Quite Awhile"




## **Chapel's Infancy:** DARPA HPCS (2003–2012)

- Research focus: ~6-7 FTEs
  - distinguish locality from parallelism
  - seamlessly mix data- and task-parallelism
  - support user-defined distributed arrays, parallel iterators

## **Chapel's Adolescence:** "the five-year push" (2013–2018)

- Development focus: ~13-14 FTEs
  - **performance and scalability**
  - **ecosystem:** documentation, libraries, tools, …
  - **base language fixes:** OOP features, error-handling, strings, …

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## Chapel's Adolescence: "the five-year push" (2013–2018)

**Then** **Now**

- Development focus: ~13-14 FTEs
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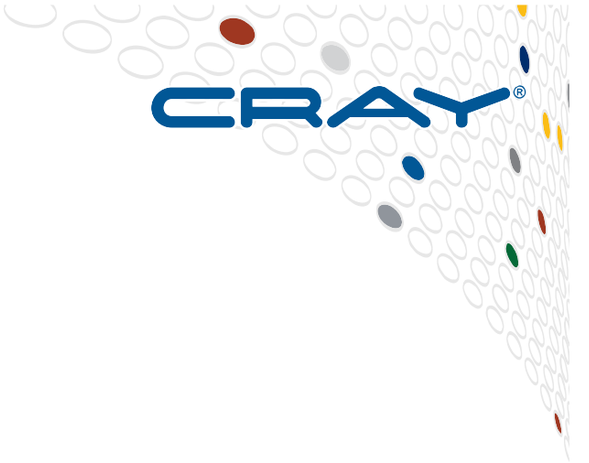
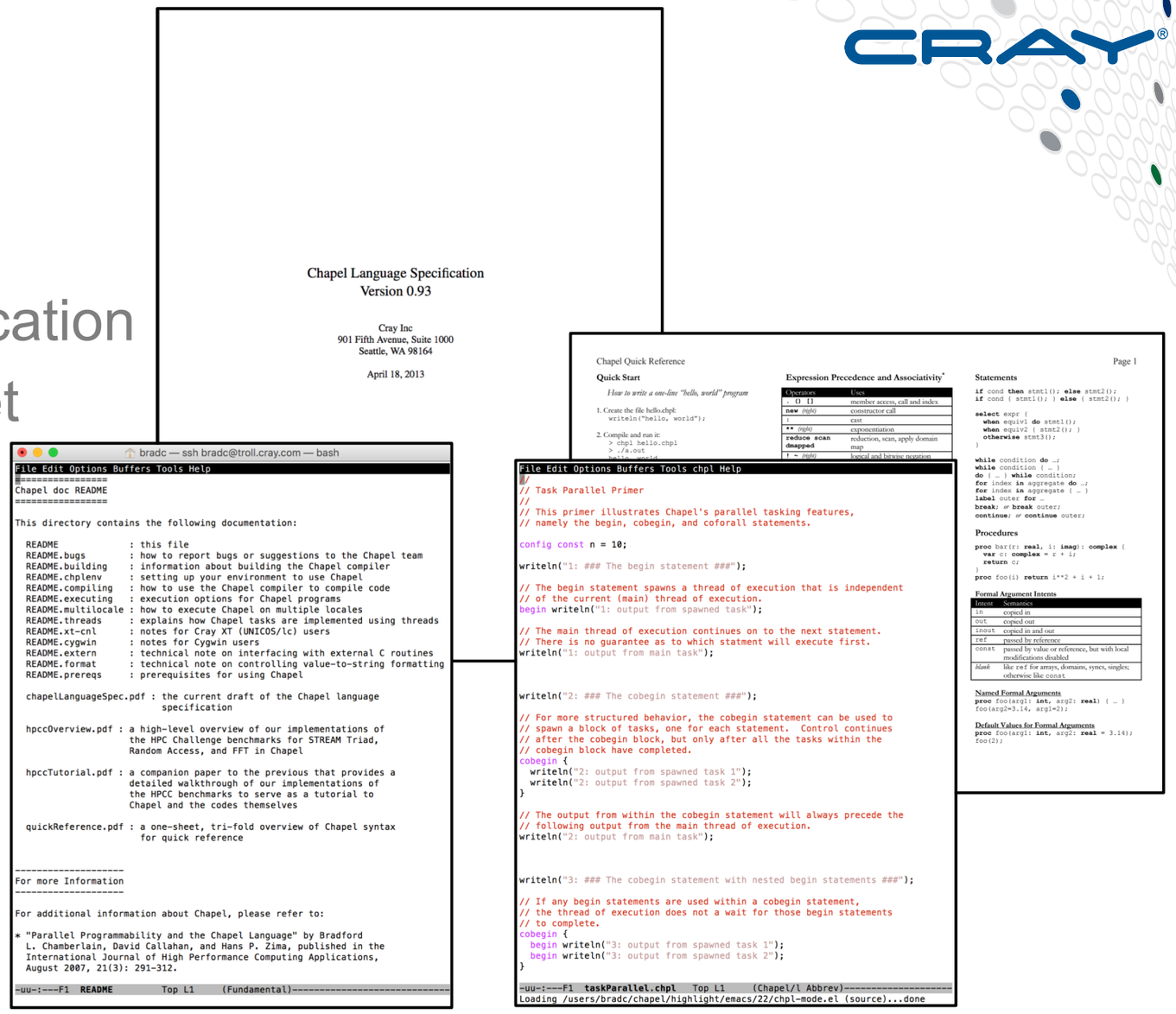


# Chapel Ecosystem: Then vs. Now

# Documentation: Then

## After HPCS:

- a PDF language specification
- a Quick Reference sheet
- a number of READMEs
- ~22 primer examples



Chapel Language Specification
Version 0.93

Cray Inc
901 Fifth Avenue, Suite 1000
Seattle, WA 98164

April 18, 2013

bradc — ssh bradc@troll.cray.com — bash

```
File Edit Options Buffers Tools Help
================
Chapel doc README
================

This directory contains the following documentation:

  README              : this file
  README.bugs         : how to report bugs or suggestions to the Chapel team
  README.building     : information about building the Chapel compiler
  README.chplenv      : setting up your environment to use Chapel
  README.compiling    : how to use the Chapel compiler to compile code
  README.executing    : execution options for Chapel programs
  README.multilocale  : how to execute Chapel on multiple locales
  README.threads      : explains how Chapel tasks are implemented using threads
  README.xt-cnl       : notes for Cray XT (UNICOS/lc) users
  README.cygwin       : notes for Cygwin users
  README.extern       : technical note on interfacing with external C routines
  README.format       : technical note on controlling value-to-string formatting
  README.prereqs      : prerequisites for using Chapel

  chapelLanguageSpec.pdf : the current draft of the Chapel language
                           specification

  hpccOverview.pdf : a high-level overview of our implementations of
                     the HPC Challenge benchmarks for STREAM Triad,
                     Random Access, and FFT in Chapel

  hpccTutorial.pdf : a companion paper to the previous that provides a
                     detailed walkthrough of our implementations of
                     the HPCC benchmarks to serve as a tutorial to
                     Chapel and the codes themselves

  quickReference.pdf : a one-sheet, tri-fold overview of Chapel syntax
                       for quick reference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For more Information
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For additional information about Chapel, please refer to:

* "Parallel Programmability and the Chapel Language" by Bradford
  L. Chamberlain, David Callahan, and Hans P. Zima, published in the
  International Journal of High Performance Computing Applications,
  August 2007, 21(3): 291-312.

-uu-:---F1  README         Top L1     (Fundamental)----------------------------
```

Chapel Quick Reference

Page 1

**Quick Start**

*How to write a one-line "hello, world" program*

1. Create the file hello.chpl:
```
writeln("hello, world");
```
2. Compile and run it:
```
> chpl hello.chpl
> ./a.out
```

**Expression Precedence and Associativity***

| Operators | Uses |
|---|---|
| . () [] | member access, call and index |
| new *(right)* | constructor call |
| : | cast |
| ** *(right)* | exponentiation |
| reduce scan | reduction, scan, apply domain |
| dmapped | map |
| ! ~ *(right)* | logical and bitwise negation |

**Statements**

```
if cond then stmt1(); else stmt2();
if cond { stmt1(); } else { stmt2(); }

select expr {
  when equiv1 do stmt1();
  when equiv2 { stmt2(); }
  otherwise stmt3();
}

while condition do …;
while condition { … }
do { … } while condition;
for index in aggregate do …;
for index in aggregate { … }
label outer for …
break; or break outer;
continue; or continue outer;
```

**Procedures**

```
proc bar(r: real, i: imag): complex {
  var c: complex = r + i;
  return c;
}
proc foo(i) return i**2 + i + 1;
```

**Formal Argument Intents**

| Intent | Semantics |
|---|---|
| in | copied in |
| out | copied out |
| inout | copied in and out |
| ref | passed by reference |
| const | passed by value or reference, but with local modifications disabled |
| *blank* | like ref for arrays, domains, syncs, singles; otherwise like const |

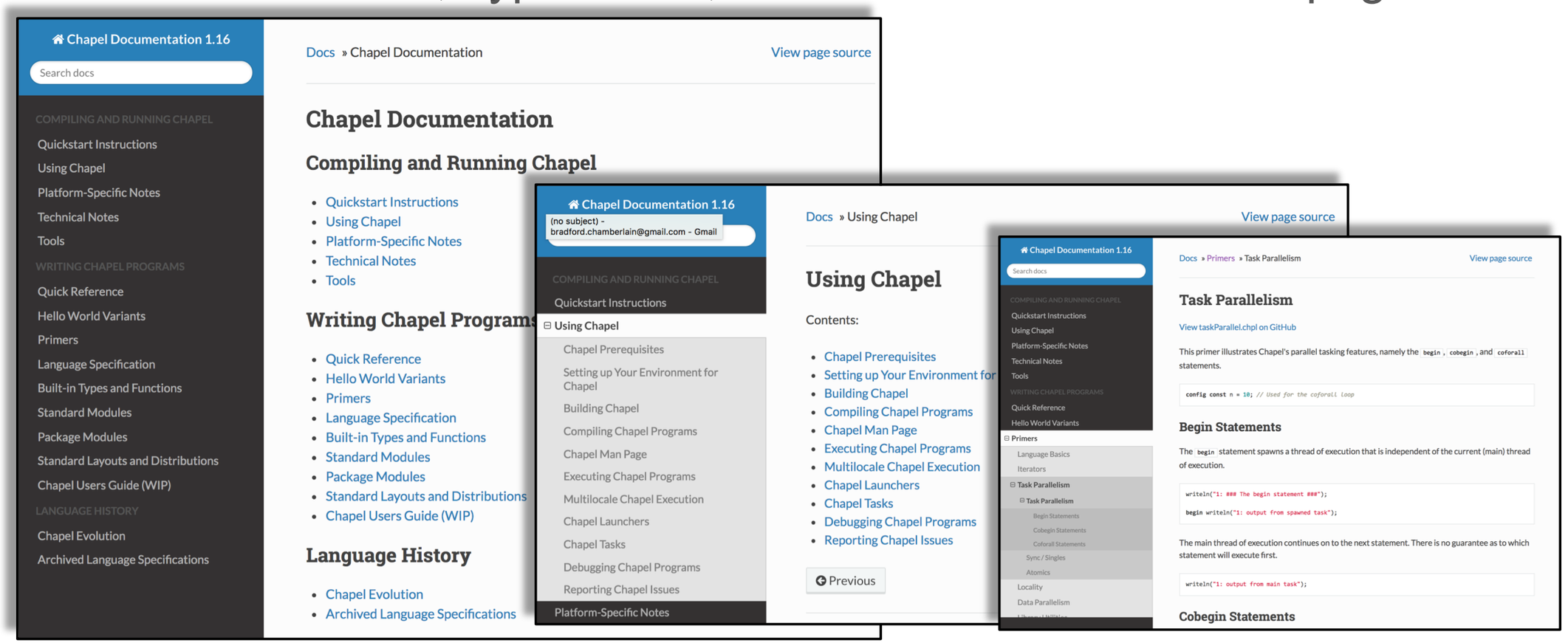
Named Formal Arguments
```
proc foo(arg1: int, arg2: real) { … }
foo(arg2=3.14, arg1=2);
```

Default Values for Formal Arguments
```
proc foo(arg1: int, arg2: real = 3.14);
foo(2);
```

```
File Edit Options Buffers Tools chpl Help
//
// Task Parallel Primer
//
// This primer illustrates Chapel's parallel tasking features,
// namely the begin, cobegin, and coforall statements.

config const n = 10;

writeln("1: ### The begin statement ###");

// The begin statement spawns a thread of execution that is independent
// of the current (main) thread of execution.
begin writeln("1: output from spawned task");

// The main thread of execution continues on to the next statement.
// There is no guarantee as to which statment will execute first.
writeln("1: output from main task");


writeln("2: ### The cobegin statement ###");

// For more structured behavior, the cobegin statement can be used to
// spawn a block of tasks, one for each statement.  Control continues
// after the cobegin block, but only after all the tasks within the
// cobegin block have completed.
cobegin {
  writeln("2: output from spawned task 1");
  writeln("2: output from spawned task 2");
}

// The output from within the cobegin statement will always precede the
// following output from the main thread of execution.
writeln("2: output from main task");


writeln("3: ### The cobegin statement with nested begin statements ###");

// If any begin statements are used within a cobegin statement,
// the thread of execution does not a wait for those begin statements
// to complete.
cobegin {
  begin writeln("3: output from spawned task 1");
  begin writeln("3: output from spawned task 2");
}

-uu-:---F1  taskParallel.chpl   Top L1     (Chapel/l Abbrev)--------------------
Loading /users/bradc/chapel/highlight/emacs/22/chpl-mode.el (source)...done
```

# Documentation: Now

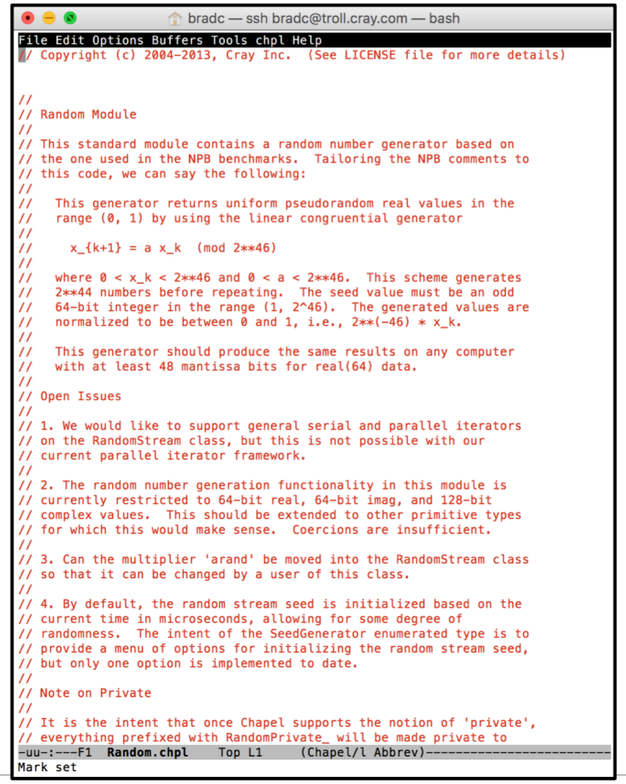
**Now:** 200+ modern, hyperlinked, web-based documentation pages

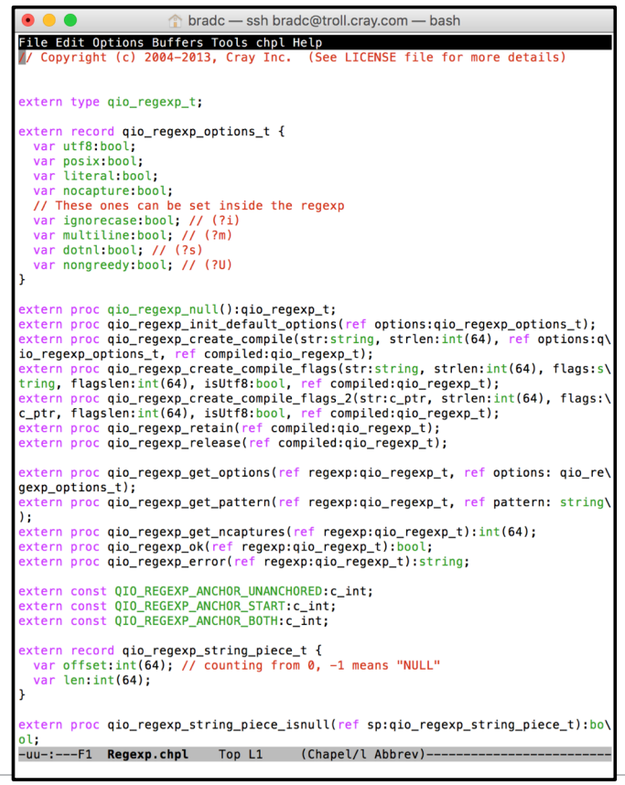


# Libraries: Then

## After HPCS: ~25 library modules

- documented via source comments, if at all:

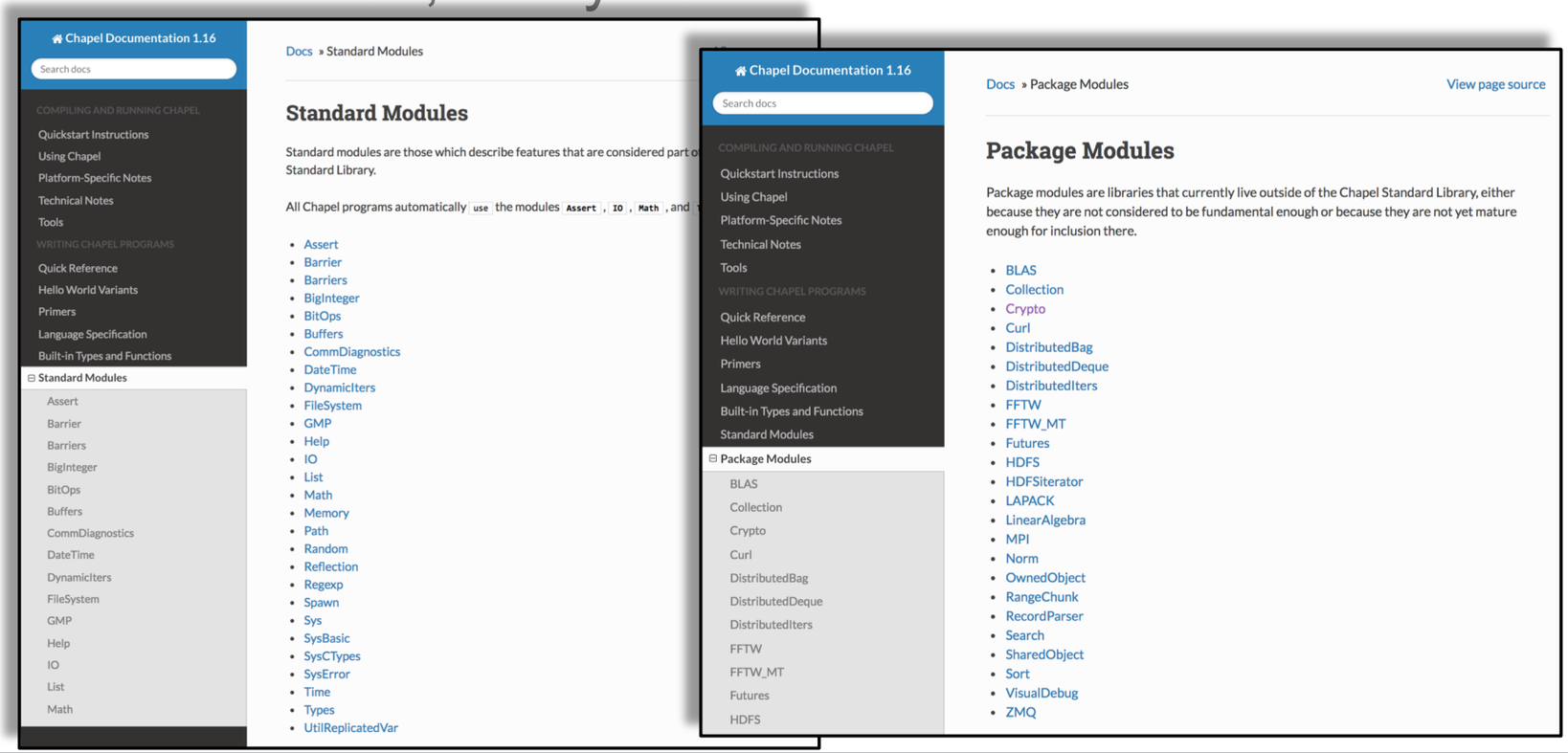


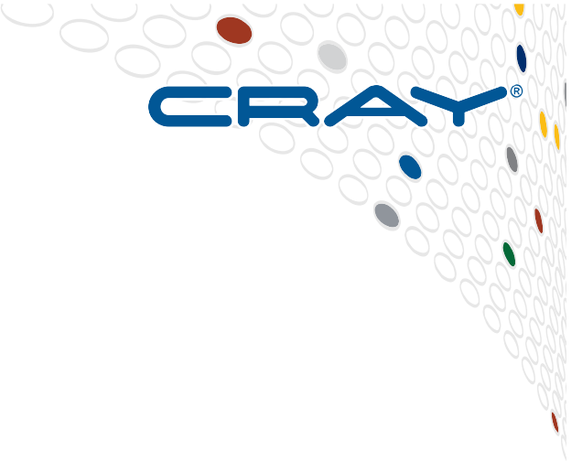
# Libraries: Now

## Now: ~60 library modules

- web-documented, many user-contributed




# Tools: Then



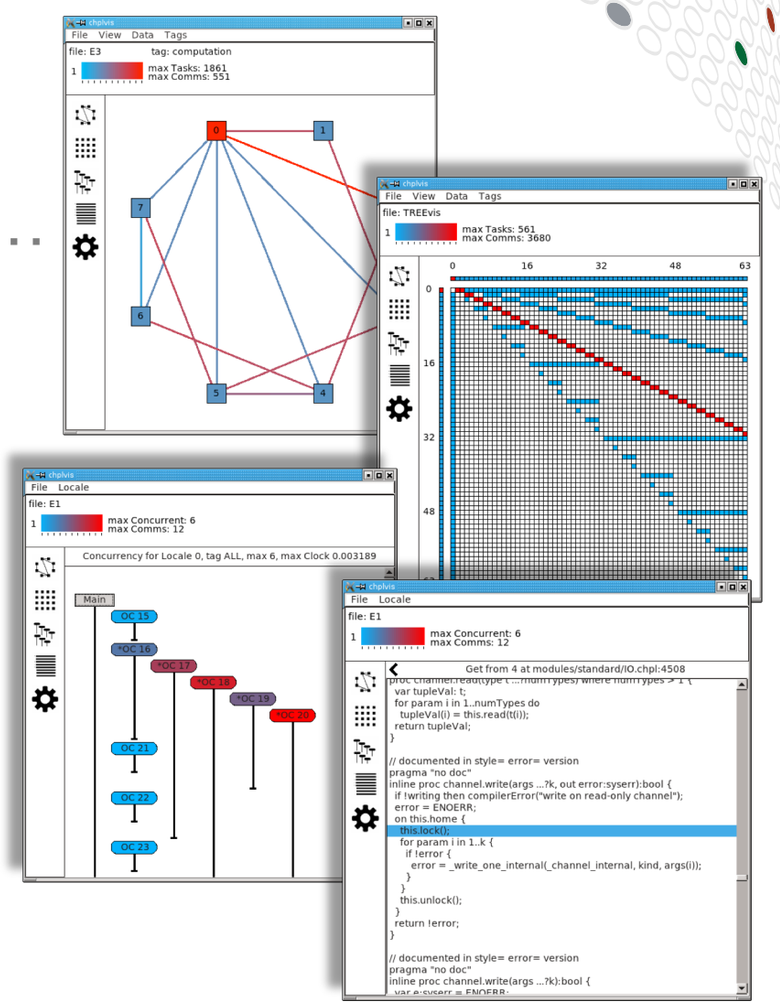
## After HPCS:

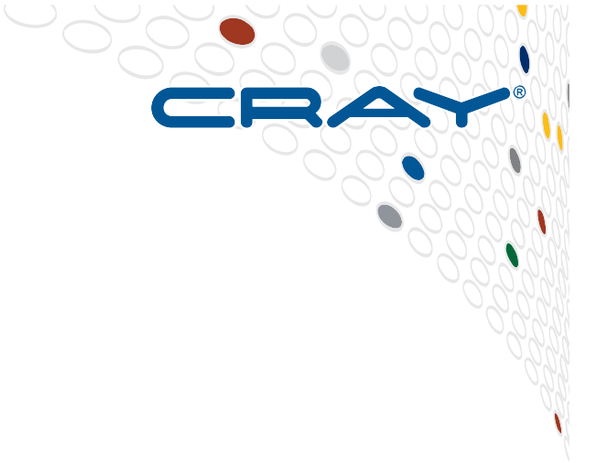
- **highlighting modes** for emacs and vim
- **chpldoc:** documentation tool (rough draft)

# Tools: Now

## Now:

- **highlighting modes** for emacs, vim, atom, …
- **chpldoc:** documentation tool
- **mason:** package manager
- **c2chapel:** interoperability aid
- **chpltags:** helps search Chapel code
- **bash tab completion:** command-line help
- **chplvis:** performance visualizer / debugger



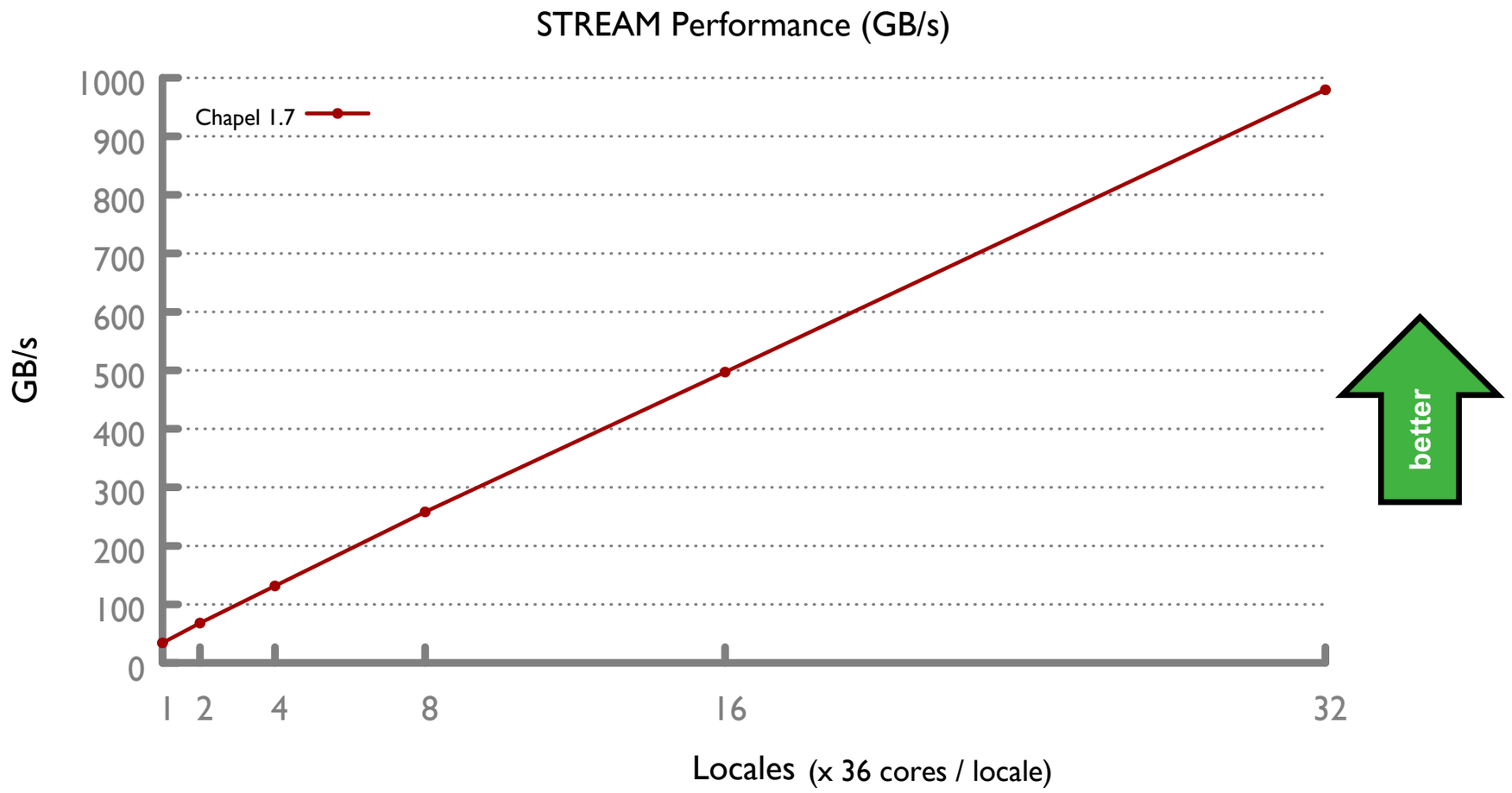


# Chapel Performance: Then vs. Now

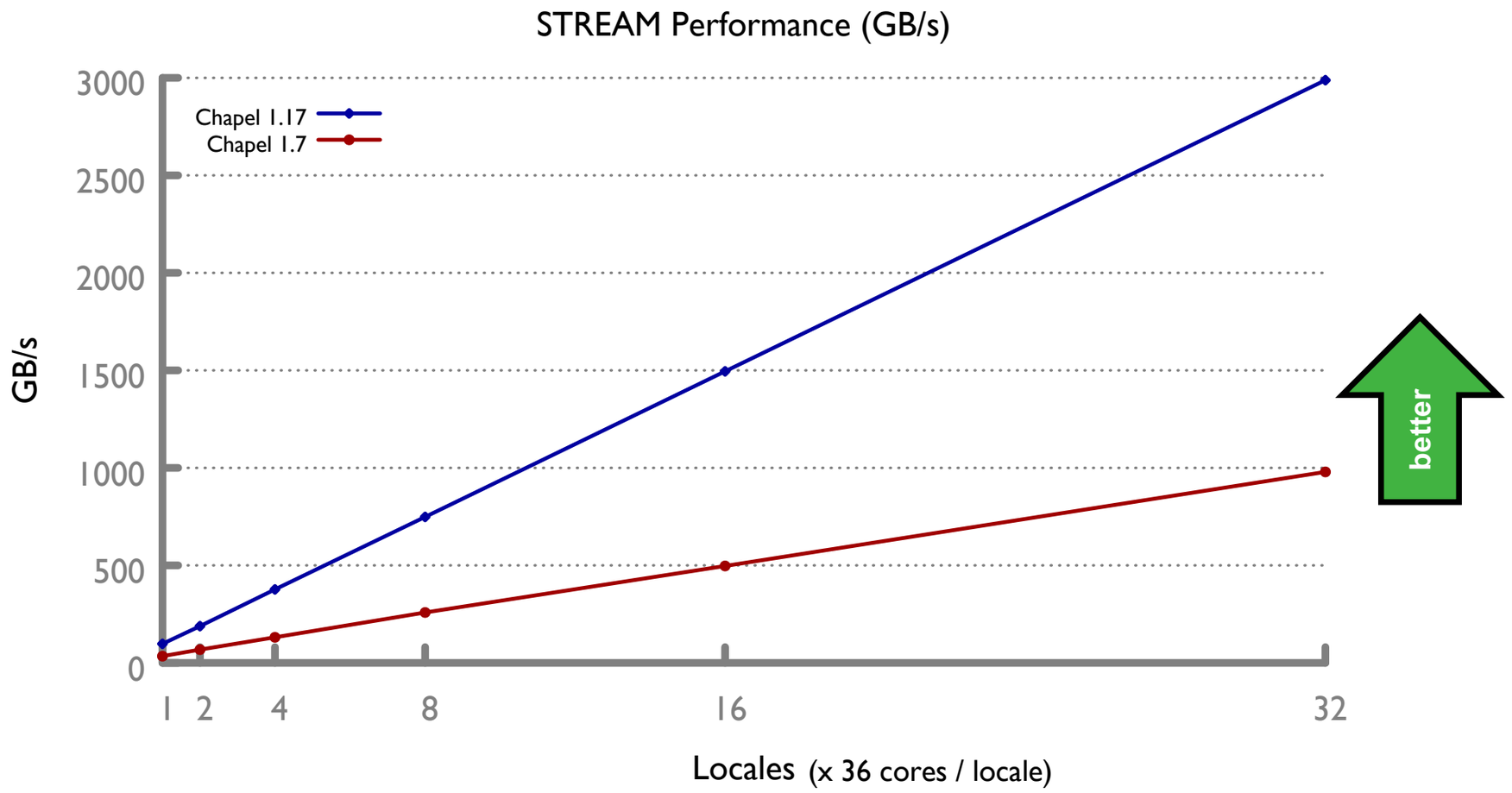
# Performance Focus Areas during 5-year push

- Cleaner, simpler generated code
- NUMA sensitivity within multi-socket nodes
- Best-use of RDMA and NIC memory registration
- Reduced overheads in tasks, memory, communication
- Bulk transfer optimizations
- …and much more…

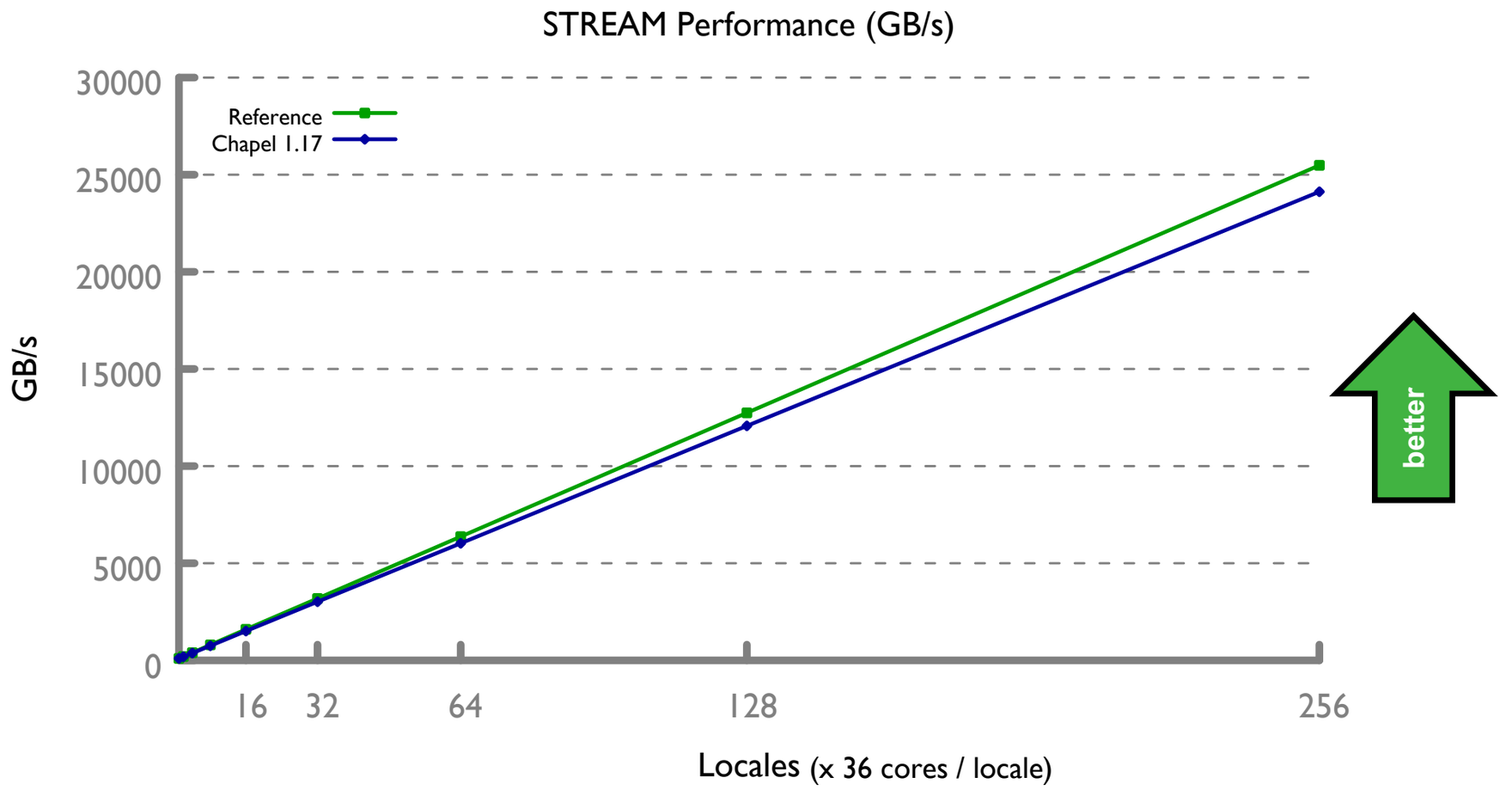
# STREAM Triad Performance: Chapel Then



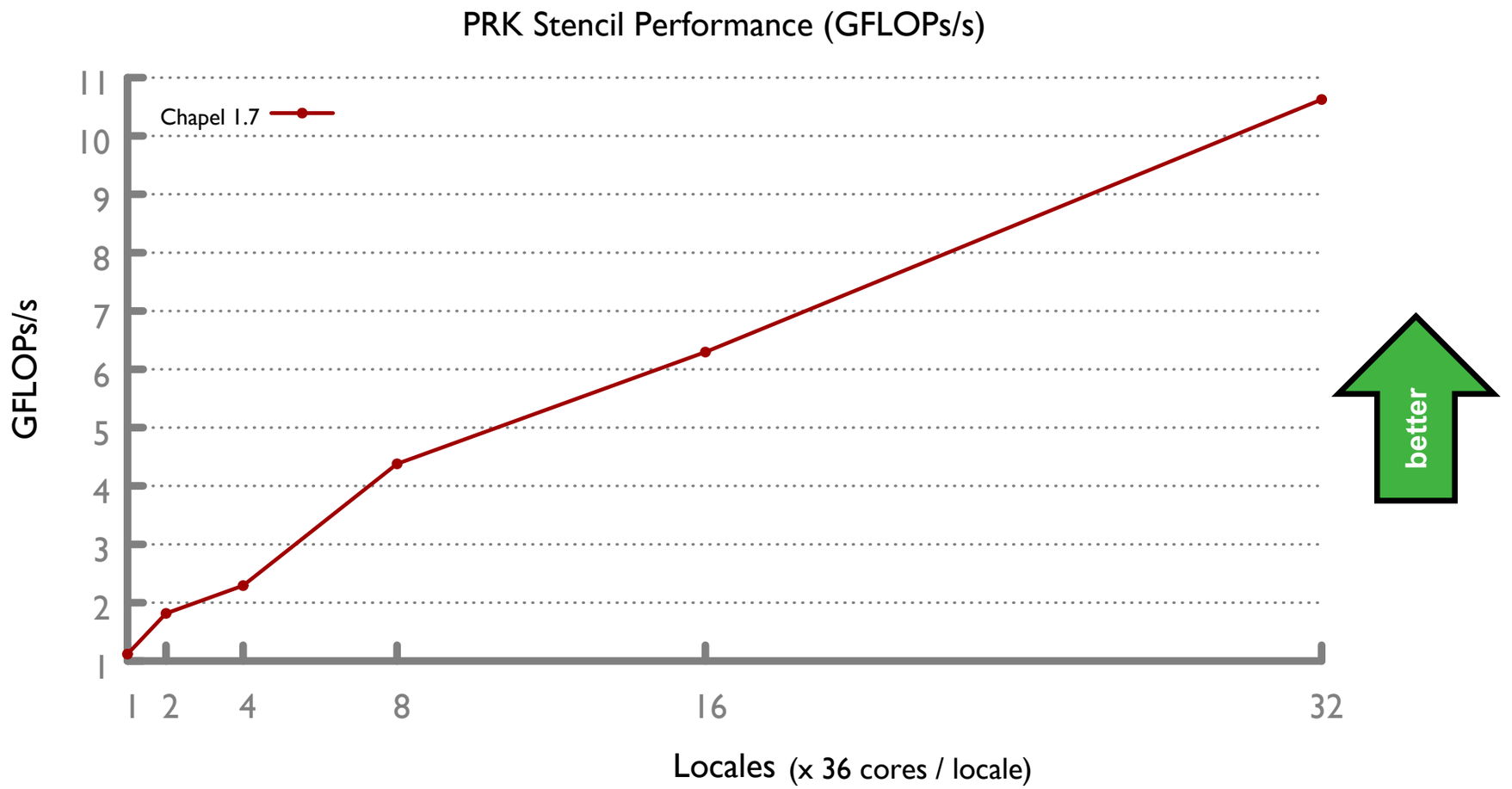
# STREAM Triad Performance: Chapel Then vs. Now



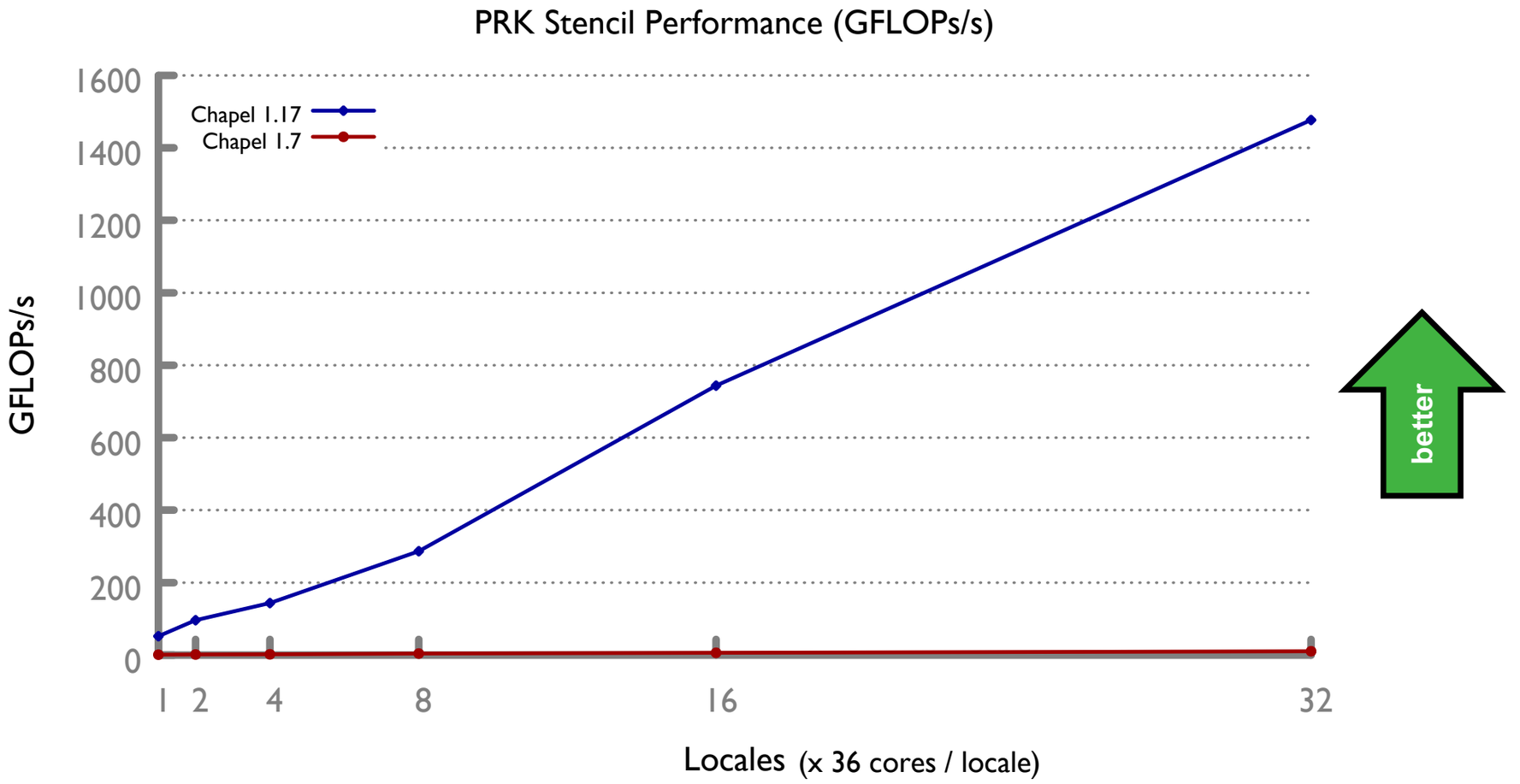
# STREAM Triad Performance: Chapel Now vs. ref



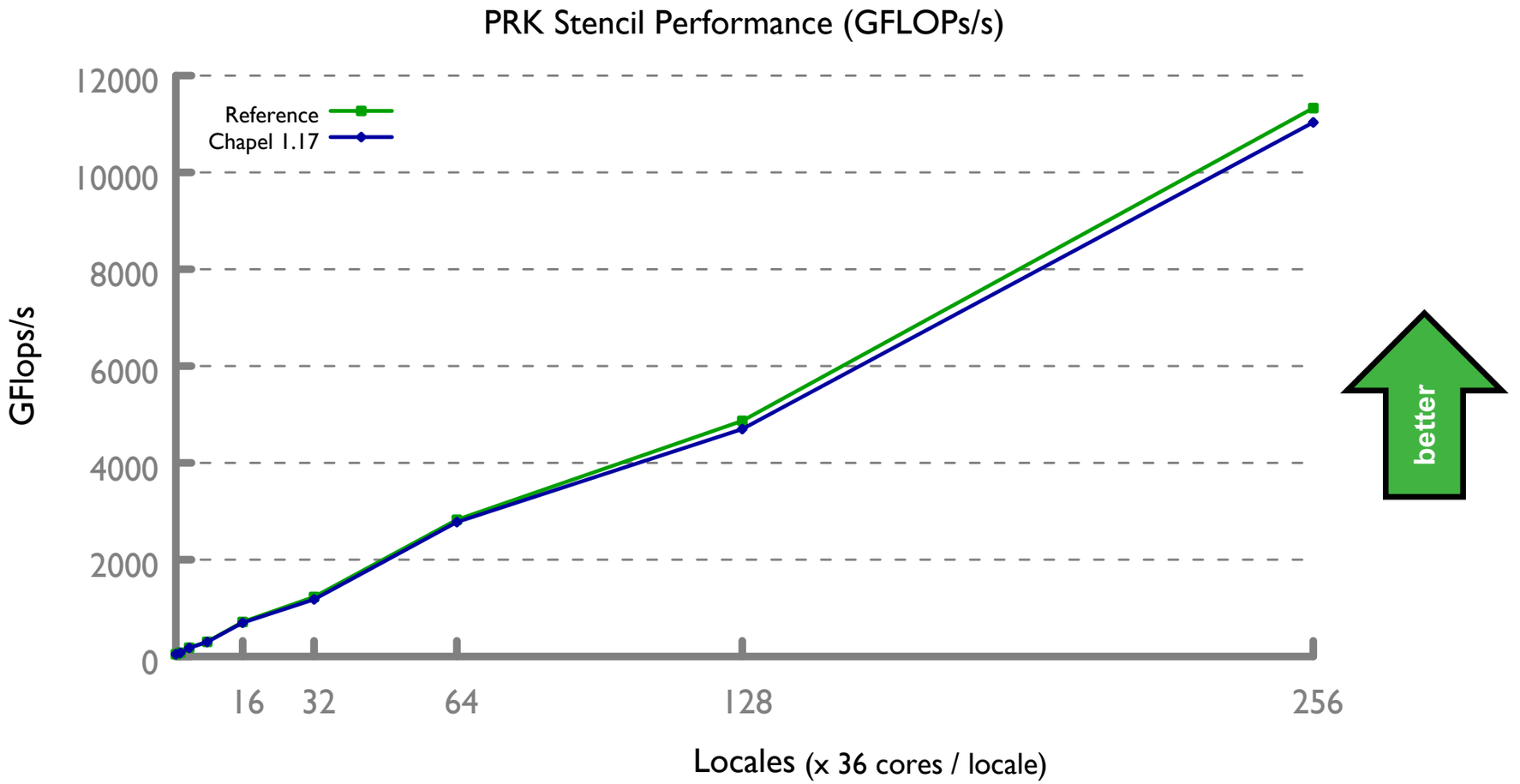
# PRK Stencil Performance: Chapel Then



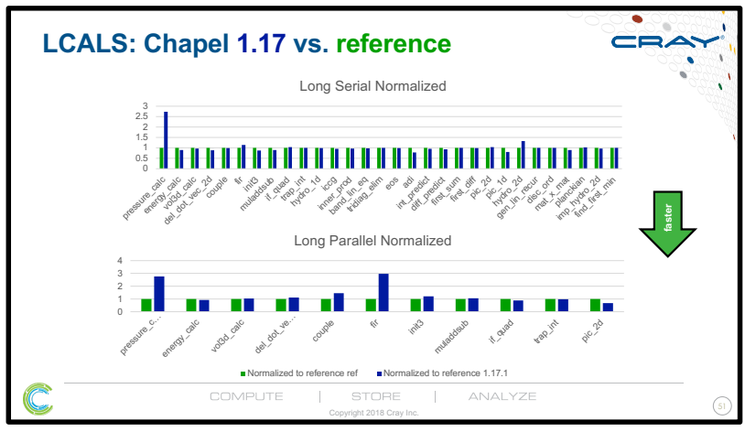

# PRK Stencil Performance: Chapel Then vs. Now



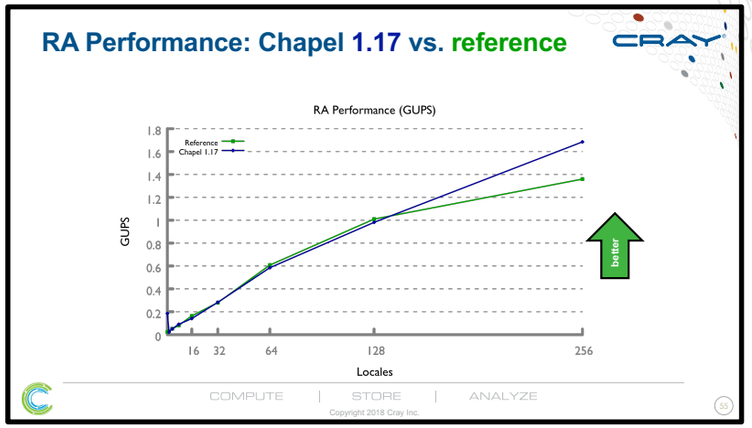
# PRK Stencil Performance: Chapel Now vs. ref



# HPC Patterns: Chapel Now vs. reference

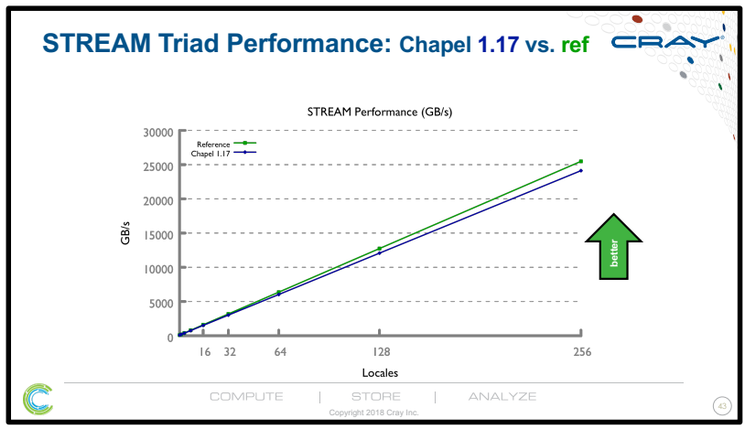



LCALS

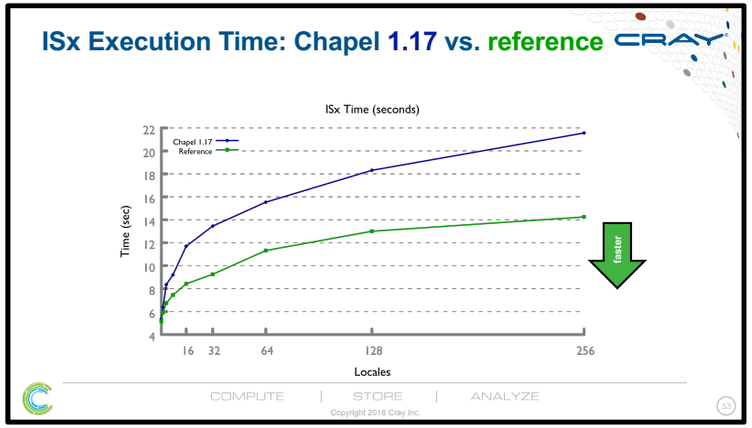



HPCC RA

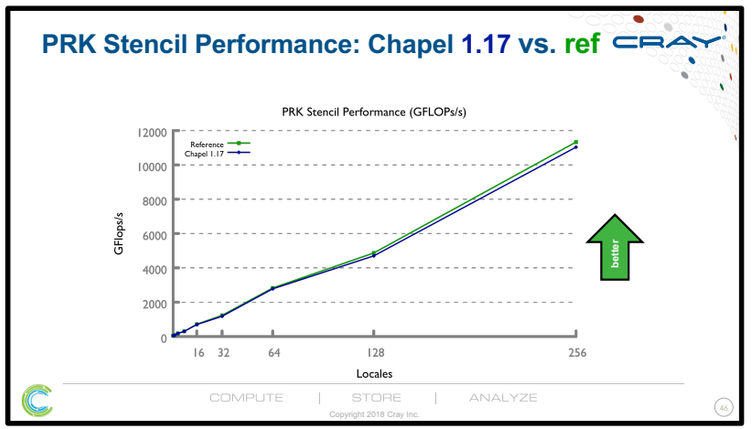
STREAM Triad




ISx

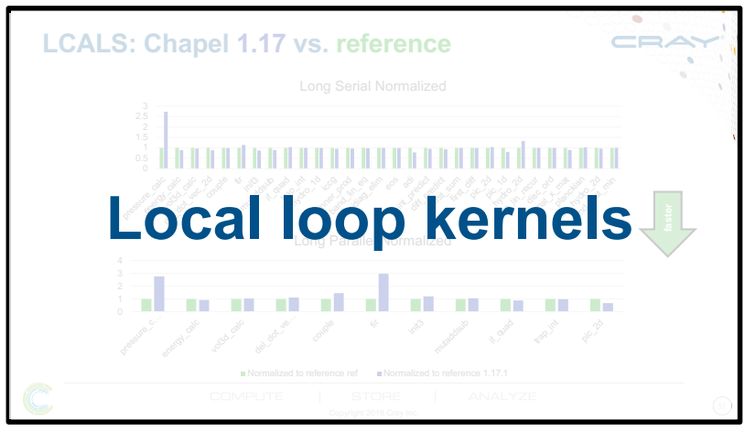



PRK Stencil




Nightly performance tickers online at:
https://chapel-lang.org/perf-nightly.html

# HPC Patterns: Chapel Now vs. reference

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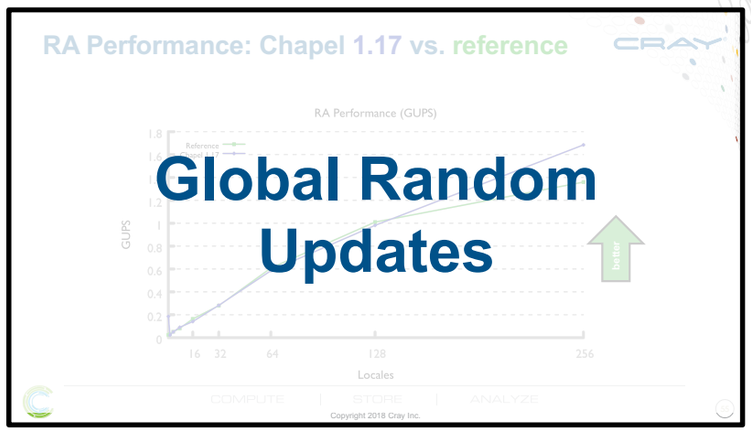
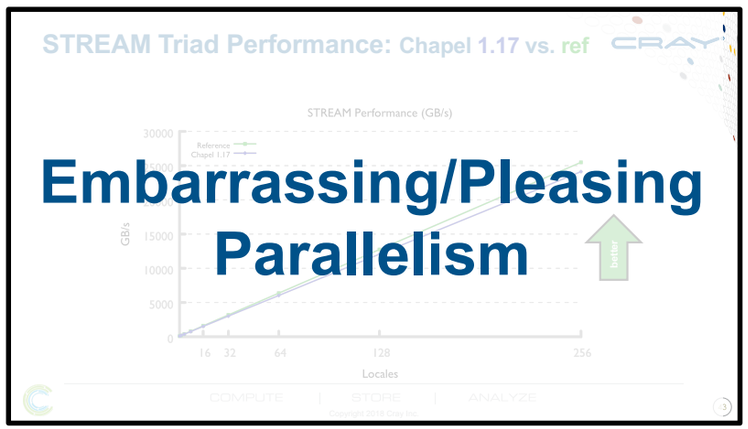
HPCC RA

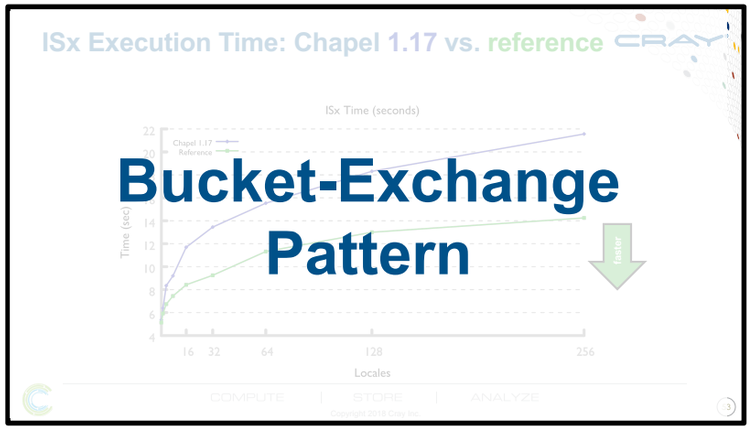


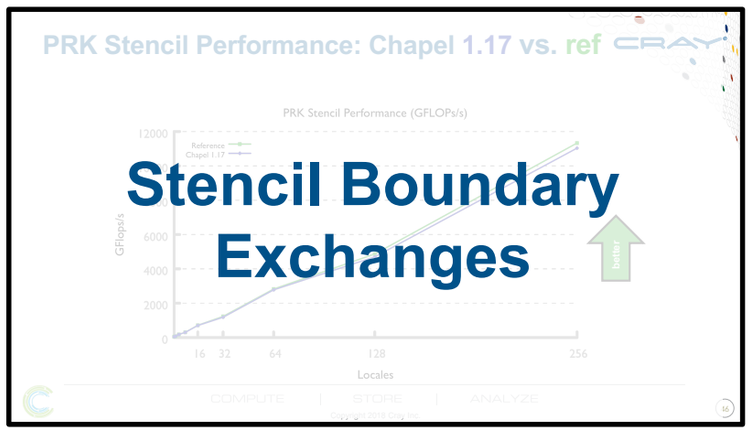

STREAM Triad

ISx

PRK Stencil





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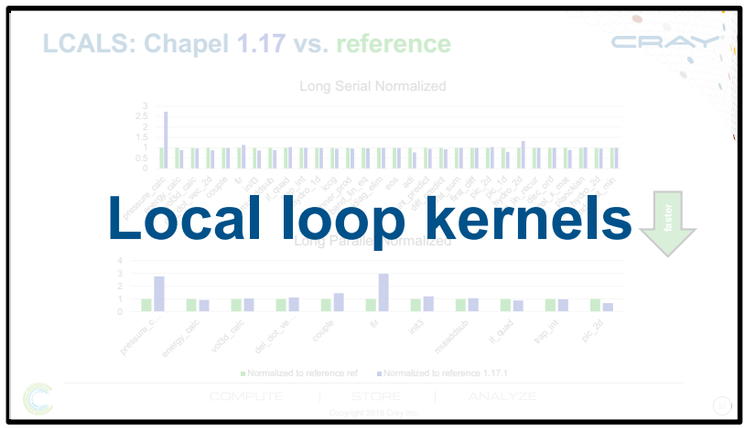
# HPC Patterns: Chapel Now vs. reference

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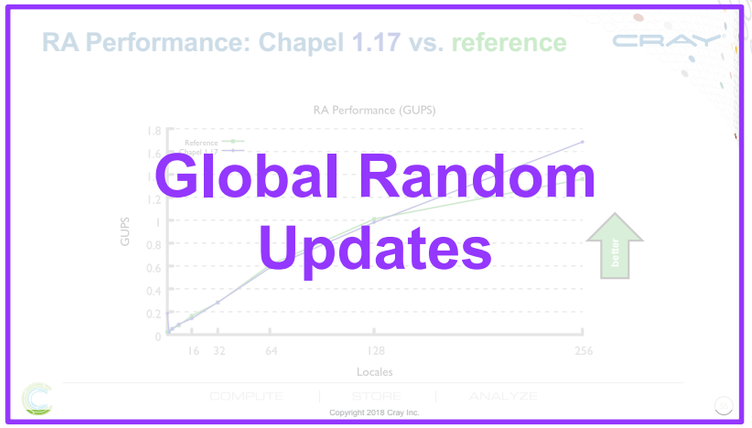
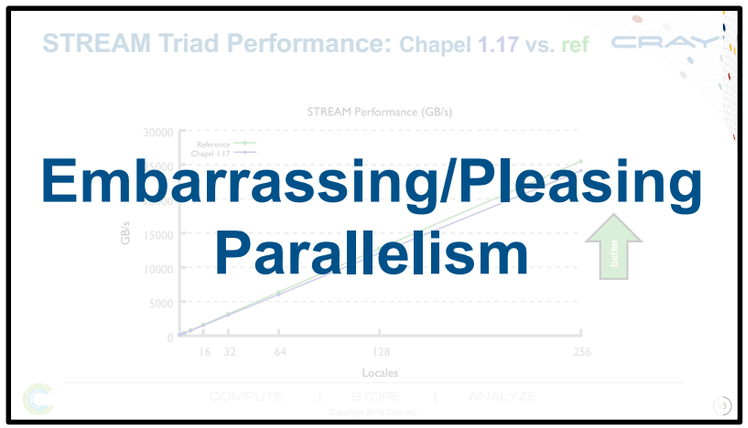
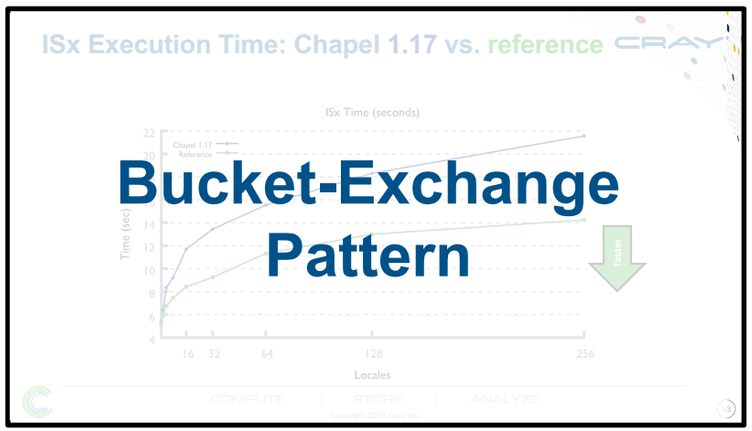


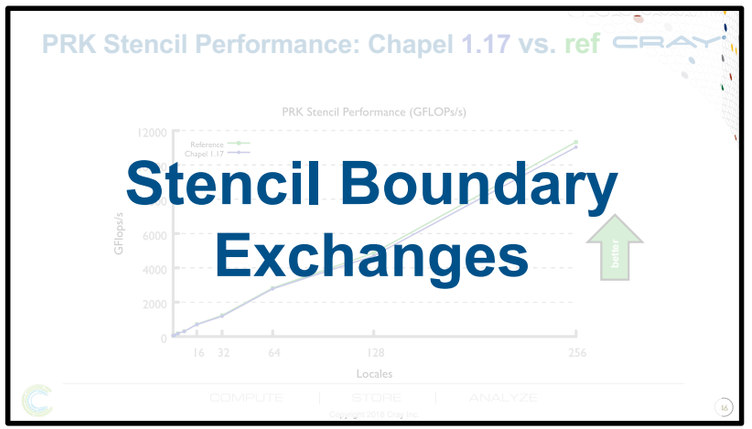

STREAM Triad

ISx

PRK Stencil








Nightly performance tickers online at:
https://chapel-lang.org/perf-nightly.html

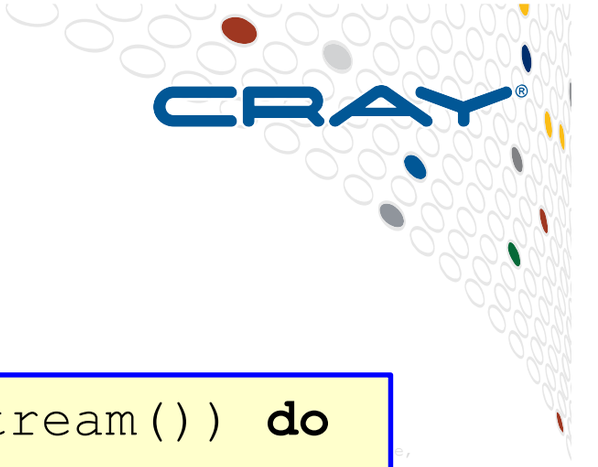
# HPCC Random Access Kernel: MPI

```
/* Perform updates to main table.  The scalar equivalent is:
 *
 *    for (i=0; i<NUPDATE; i++) {
 *      Ran = (Ran << 1) ^ (((s64Int) Ran < 0) ? POLY : 0);
 *      Table[Ran & (TABSIZE-1)] ^= Ran;
 *    }
 */

MPI_Irecv(&LocalRecvBuffer, localBufferSize, tparams.dtype64,
          MPI_ANY_SOURCE, MPI_ANY_TAG, MPI_COMM_WORLD, &inreq);
 while (i < SendCnt) {
   /* receive messages */
   do {
     MPI_Test(&inreq, &have_done, &status);
     if (have_done) {
       if (status.MPI_TAG == UPDATE_TAG) {
         MPI_Get_count(&status, tparams.dtype64, &recvUpdates);
         bufferBase = 0;
         for (j=0; j < recvUpdates; j ++) {
           inmsg = LocalRecvBuffer[bufferBase+j];
           LocalOffset = (inmsg & (tparams.TableSize - 1)) -
                         tparams.GlobalStartMyProc;
           HPCC_Table[LocalOffset] ^= inmsg;
         }
       } else if (status.MPI_TAG == FINISHED_TAG) {
         NumberReceiving--;
       } else
         MPI_Abort( MPI_COMM_WORLD, -1 );
       MPI_Irecv(&LocalRecvBuffer, localBufferSize, tparams.dtype64,
                 MPI_ANY_SOURCE, MPI_ANY_TAG, MPI_COMM_WORLD, &inreq);
     }
   } while (have_done && NumberReceiving > 0);
   if (pendingUpdates < maxPendingUpdates) {
     Ran = (Ran << 1) ^ ((s64Int) Ran < ZERO64B ? POLY : ZERO64B);
     GlobalOffset = Ran & (tparams.TableSize-1);
     if ( GlobalOffset < tparams.Top)
       WhichPe = ( GlobalOffset / (tparams.MinLocalTableSize + 1) );
     else
       WhichPe = ( (GlobalOffset - tparams.Remainder) /
                 tparams.MinLocalTableSize );
     if (WhichPe == tparams.MyProc) {
       LocalOffset = (Ran & (tparams.TableSize - 1)) -
                     tparams.GlobalStartMyProc;
       HPCC_Table[LocalOffset] ^= Ran;
   }  else {
        HPCC_InsertUpdate(Ran, WhichPe, Buckets);
        pendingUpdates++;
      }
      i++;
    }
    else {
      MPI_Test(&outreq, &have_done, MPI_STATUS_IGNORE);
      if (have_done) {
        outreq = MPI_REQUEST_NULL;
        pe = HPCC_GetUpdates(Buckets, LocalSendBuffer, localBufferSize,
                             &peUpdates);
        MPI_Isend(&LocalSendBuffer, peUpdates, tparams.dtype64, (int)pe,
                  UPDATE_TAG, MPI_COMM_WORLD, &outreq);
        pendingUpdates -= peUpdates;
      }
    }
  }
  /* send remaining updates in buckets */
  while (pendingUpdates > 0) {
    /* receive messages */
    do {
      MPI_Test(&inreq, &have_done, &status);
      if (have_done) {
        if (status.MPI_TAG == UPDATE_TAG) {
          MPI_Get_count(&status, tparams.dtype64, &recvUpdates);
          bufferBase = 0;
          for (j=0; j < recvUpdates; j ++) {
            inmsg = LocalRecvBuffer[bufferBase+j];
            LocalOffset = (inmsg & (tparams.TableSize - 1)) -
                          tparams.GlobalStartMyProc;
            HPCC_Table[LocalOffset] ^= inmsg;
          }
        } else if (status.MPI_TAG == FINISHED_TAG) {
          /* we got a done message.  Thanks for playing... */
          NumberReceiving--;
        } else {
          MPI_Abort( MPI_COMM_WORLD, -1 );
        }
        MPI_Irecv(&LocalRecvBuffer, localBufferSize, tparams.dtype64,
                  MPI_ANY_SOURCE, MPI_ANY_TAG, MPI_COMM_WORLD, &inreq);
      }
    } while (have_done && NumberReceiving > 0);
    MPI_Test(&outreq, &have_done, MPI_STATUS_IGNORE);
    if (have_done) {
      outreq = MPI_REQUEST_NULL;
      pe = HPCC_GetUpdates(Buckets, LocalSendBuffer, localBufferSize,
                           &peUpdates);
      MPI_Isend(&LocalSendBuffer, peUpdates, tparams.dtype64, (int)pe,
                UPDATE_TAG, MPI_COMM_WORLD, &outreq);
      pendingUpdates -= peUpdates;
    }
  }
  /* send our done messages */
  for (proc_count = 0 ; proc_count < tparams.NumProcs ; ++proc_count) {
    if (proc_count == tparams.MyProc) { tparams.finish_req[tparams.MyProc] =
                                        MPI_REQUEST_NULL; continue; }
    /* send garbage - who cares, no one will look at it */
    MPI_Isend(&Ran, 0, tparams.dtype64, proc_count, FINISHED_TAG,
              MPI_COMM_WORLD, tparams.finish_req + proc_count);
  }
  /* Finish everyone else up... */
  while (NumberReceiving > 0) {
    MPI_Wait(&inreq, &status);
    if (status.MPI_TAG == UPDATE_TAG) {
      MPI_Get_count(&status, tparams.dtype64, &recvUpdates);
      bufferBase = 0;
      for (j=0; j < recvUpdates; j ++) {
        inmsg = LocalRecvBuffer[bufferBase+j];
        LocalOffset = (inmsg & (tparams.TableSize - 1)) -
                      tparams.GlobalStartMyProc;
        HPCC_Table[LocalOffset] ^= inmsg;
      }
    } else if (status.MPI_TAG == FINISHED_TAG) {
      /* we got a done message.  Thanks for playing... */
      NumberReceiving--;
    } else {
      MPI_Abort( MPI_COMM_WORLD, -1 );
    }
    MPI_Irecv(&LocalRecvBuffer, localBufferSize, tparams.dtype64,
              MPI_ANY_SOURCE, MPI_ANY_TAG, MPI_COMM_WORLD, &inreq);
  }

  MPI_Waitall( tparams.NumProcs, tparams.finish_req, tparams.finish_statuses);
```

# HPCC Random Access Kernel: MPI



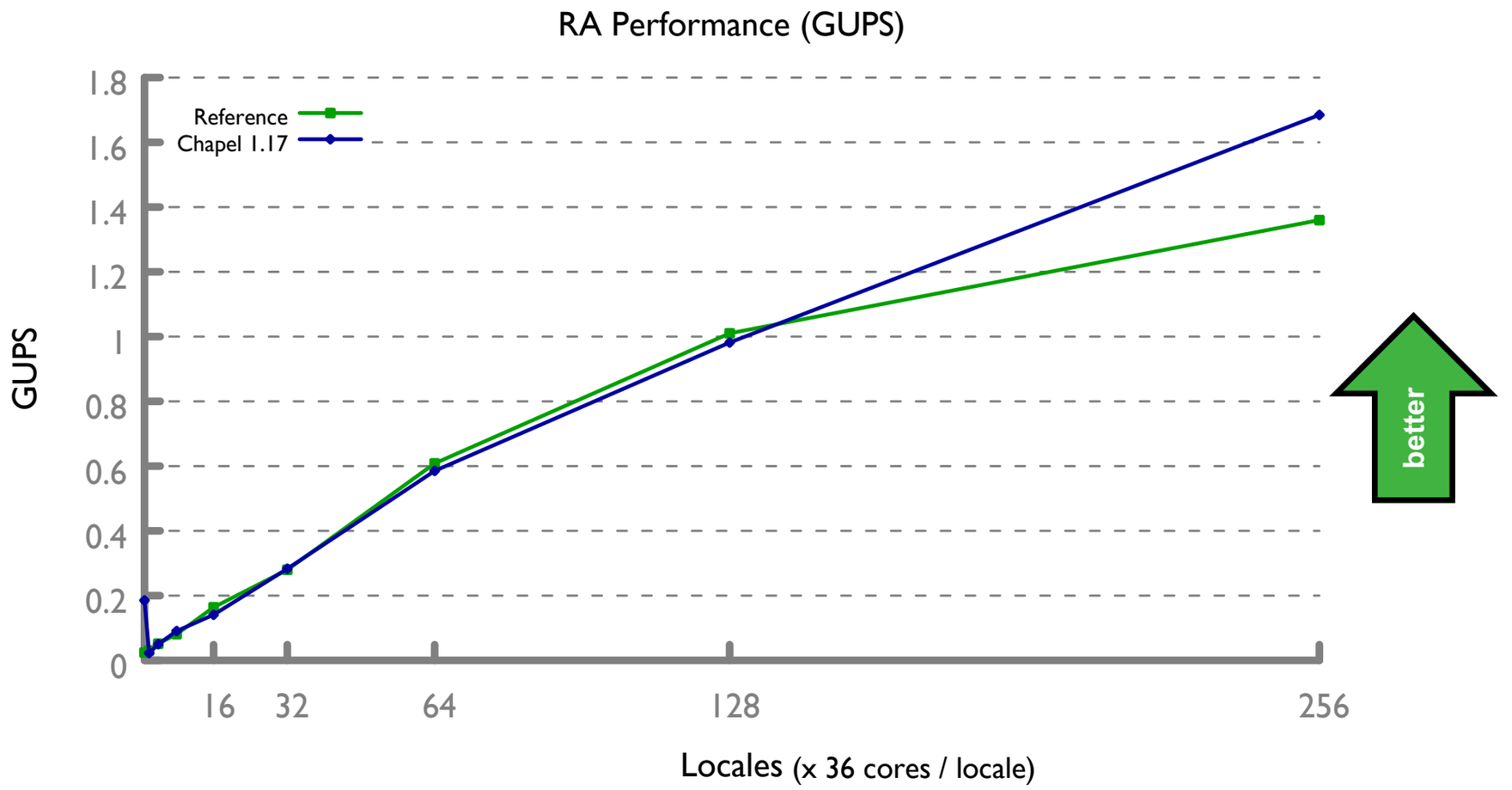
**Chapel Kernel**

```
forall (_, r) in zip(Updates, RAStream()) do
  T[r & indexMask] ^= r;
```

**MPI Comment**

```
/* Perform updates to main table. The scalar equivalent is:
 *
 *     for (i=0; i<NUPDATE; i++) {
 *       Ran = (Ran << 1) ^ (((s64Int) Ran < 0) ? POLY : 0);
 *       Table[Ran & (TABSIZE-1)] ^= Ran;
 *     }
 */
```

# RA Performance: Chapel Now vs. reference



# What's Next?

**CHIUW 2018:** The 5th annual Chapel Implementers and Users Workshop

- Vancouver BC, Friday May 25th
- Details: https://chapel-lang.org/CHIUW2018.html


**Chapel's college years:** plans for 2018-2021

- Further Performance and Scalability Improvements
- Libfabric/OFI Support
- GPU Support
- Cloud Support
- Chapel AI

# The Chapel Team at Cray (May 2018)

# Chapel Community Partners










Lawrence Berkeley
National Laboratory



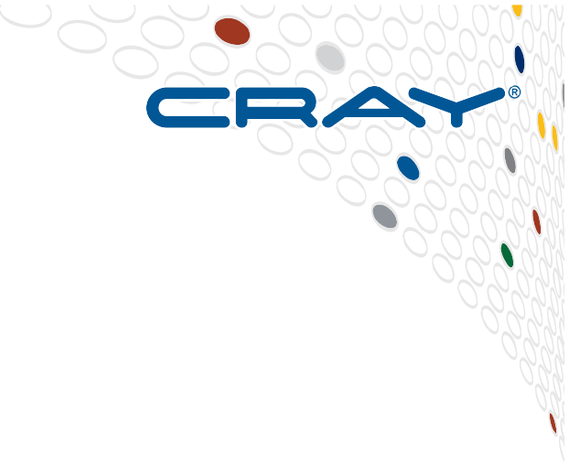


(and several others…)

https://chapel-lang.org/collaborations.html

# Summary

- **Chapel's made huge progress over the past five years**
- **Ready for use in production***
- **Open to collaborations**
  - Plenty of research questions remain

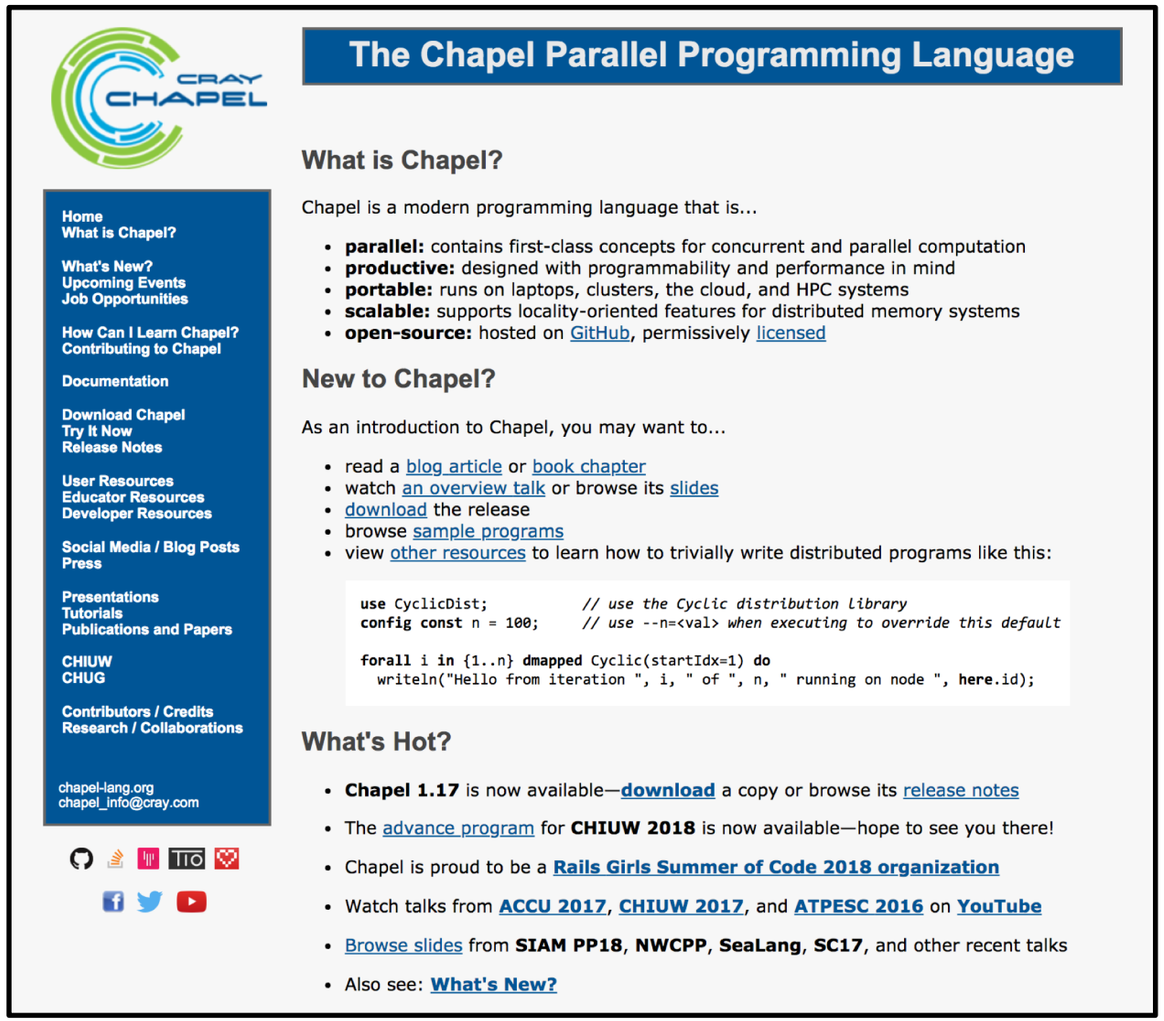


# Chapel Resources

# Chapel Central

## https://chapel-lang.org

- downloads
- documentation
- resources
- presentations
- papers



The Chapel Parallel Programming Language

Home
What is Chapel?

What's New?
Upcoming Events
Job Opportunities

How Can I Learn Chapel?
Contributing to Chapel

Documentation

Download Chapel
Try It Now
Release Notes

User Resources
Educator Resources
Developer Resources

Social Media / Blog Posts
Press

Presentations
Tutorials
Publications and Papers

CHIUW
CHUG

Contributors / Credits
Research / Collaborations

chapel-lang.org
chapel_info@cray.com

### What is Chapel?

Chapel is a modern programming language that is...

- **parallel:** contains first-class concepts for concurrent and parallel computation
- **productive:** designed with programmability and performance in mind
- **portable:** runs on laptops, clusters, the cloud, and HPC systems
- **scalable:** supports locality-oriented features for distributed memory systems
- **open-source:** hosted on GitHub, permissively licensed

### New to Chapel?

As an introduction to Chapel, you may want to...

- read a blog article or book chapter
- watch an overview talk or browse its slides
- download the release
- browse sample programs
- view other resources to learn how to trivially write distributed programs like this:

```
use CyclicDist;           // use the Cyclic distribution library
config const n = 100;     // use --n=<val> when executing to override this default

forall i in {1..n} dmapped Cyclic(startIdx=1) do
  writeln("Hello from iteration ", i, " of ", n, " running on node ", here.id);
```

### What's Hot?

- **Chapel 1.17** is now available—**download** a copy or browse its release notes
- The advance program for **CHIUW 2018** is now available—hope to see you there!
- Chapel is proud to be a **Rails Girls Summer of Code 2018 organization**
- Watch talks from **ACCU 2017**, **CHIUW 2017**, and **ATPESC 2016** on **YouTube**
- Browse slides from **SIAM PP18**, **NWCPP**, **SeaLang**, **SC17**, and other recent talks
- Also see: **What's New?**

# Chapel Social Media (no account required)

http://twitter.com/ChapelLanguage

http://facebook.com/ChapelLanguage

https://www.youtube.com/channel/UCHmm27bYjhknK5mU7ZzPGsQ/

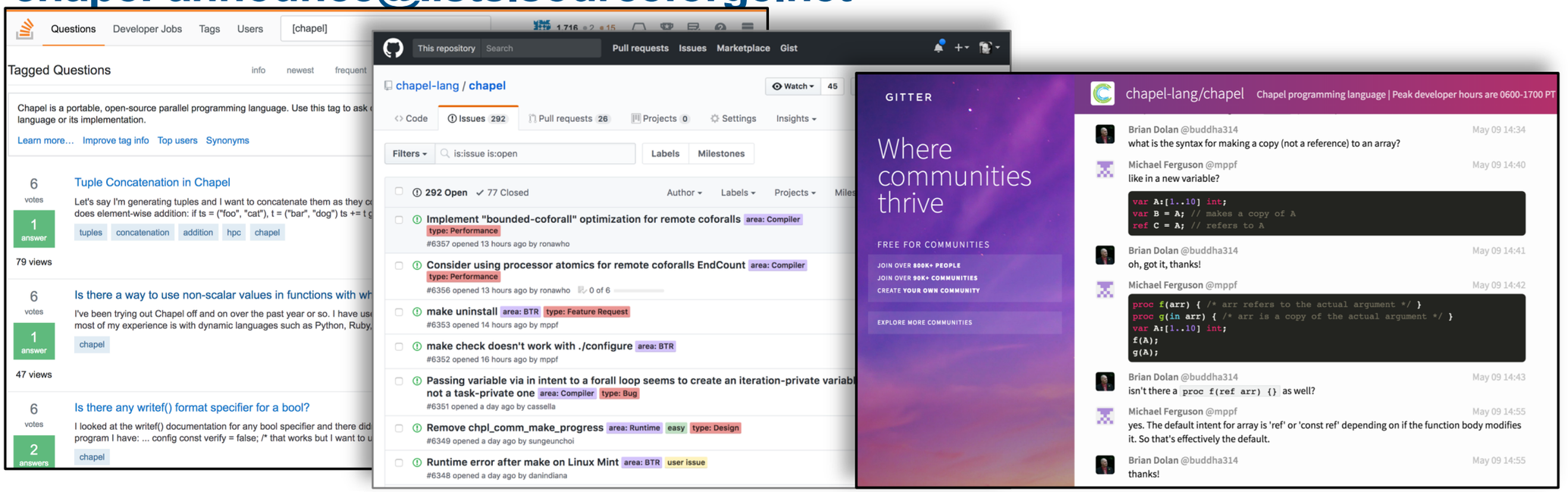
# Chapel Community

https://stackoverflow.com/questions/tagged/chapel

https://github.com/chapel-lang/chapel/issues

https://gitter.im/chapel-lang/chapel

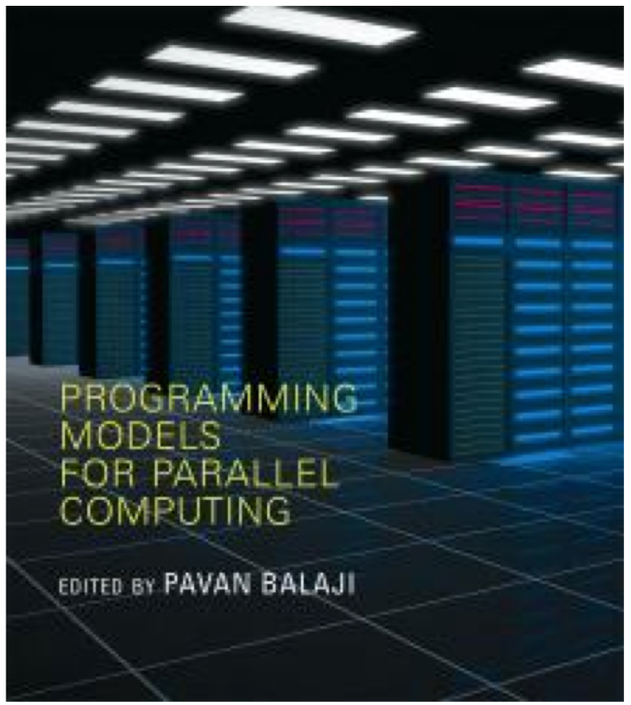
chapel-announce@lists.sourceforge.net



# Suggested Reading (healthy attention spans)

Chapel chapter from ***Programming Models for Parallel Computing***

- a detailed overview of Chapel's history, motivating themes, features
- published by MIT Press, November 2015
- edited by Pavan Balaji (Argonne)
- chapter is also available online




Other Chapel papers/publications available at **https://chapel-lang.org/papers.html**

# Suggested Reading (short attention spans)

***CHIUW 2017: Surveying the Chapel Landscape***, Cray Blog, July 2017.

- *a run-down of recent events (as of 2017)*

***Chapel: Productive Parallel Programming***, Cray Blog, May 2013.

- *a short-and-sweet introduction to Chapel*

***Six Ways to Say "Hello" in Chapel*** **(parts 1, 2, 3)**, Cray Blog, Sep-Oct 2015.

- *a series of articles illustrating the basics of parallelism and locality in Chapel*

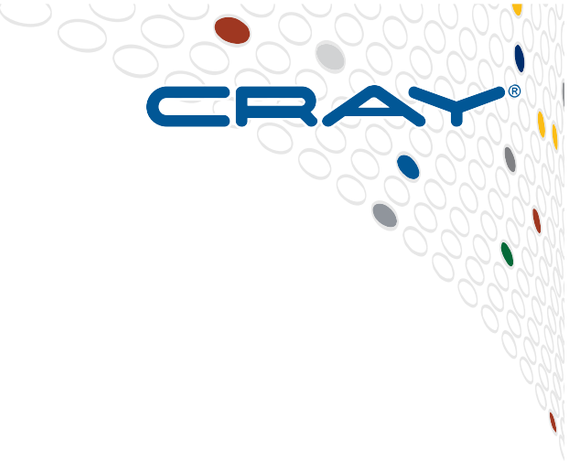
***Why Chapel?*** **(parts 1, 2, 3)**, Cray Blog, Jun-Oct 2014.

- *a series of articles answering common questions about why we are pursuing Chapel in spite of the inherent challenges*

***[Ten] Myths About Scalable Programming Languages***, IEEE TCSC Blog (index available on chapel-lang.org "blog posts" page), Apr-Nov 2012.

- *a series of technical opinion pieces designed to argue against standard reasons given for not developing high-level parallel languages*

# Where to..



**Submit bug reports:**

- GitHub issues for chapel-lang/chapel: public bug forum
- chapel_bugs@cray.com: for reporting non-public bugs

**Ask User-Oriented Questions:**

- StackOverflow: when appropriate / other users might care
- Gitter (chapel-lang/chapel): community chat with archives
- chapel-users@lists.sourceforge.net: user discussions

**Discuss Chapel development**

- chapel-developers@lists.sourceforge.net: developer discussions
- GitHub issues for chapel-lang/chapel: for feature requests, design discussions

**Discuss Chapel's use in education**

- chapel-education@lists.sourceforge.net: educator discussions

**Directly contact Chapel team at Cray:** chapel_info@cray.com

# Questions?

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