Hewlett Packard
Enterprise

CHAPEL:
FIVE HIGHLIGHTS SINCE CLSAC 2019

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WHAT IS CHAPEL?

Chapel: A modern parallel programming language

- portable & scalable
- open-source & collaborative

Goals:

- Support general parallel programming
- Make parallel programming at scale far more productive

CHAPEL TENDS TO BE COMPACT, CLEAN, AND FAST (BALE INDEX-GATHER)

Exstack version

```
i=0;
while( exstack_proceed(ex, (i==l_num_req)) ) {
  i0 = i;
  while(i < l_num_req) {
    l_indx = pckindx[i] >> 16;
    pe  = pckindx[i] & 0xffff;
    if(!exstack_push(ex, &l_indx, pe))
      break;
    i++;
  }

  exstack_exchange(ex);

  while(exstack_pop(ex, &idx , &fromth)) {
    idx  = ltable[idx];
    exstack_push(ex, &idx, fromth);
  }
  lgp_barrier();
  exstack_exchange(ex);

  for(j=i0; j<i; j++) {
    fromth = pckindx[j] & 0xffff;
    exstack_pop_thread(ex, &idx, (uint64_t)fromth);
    tgt[j] = idx;
  }
  lgp_barrier();
}
```

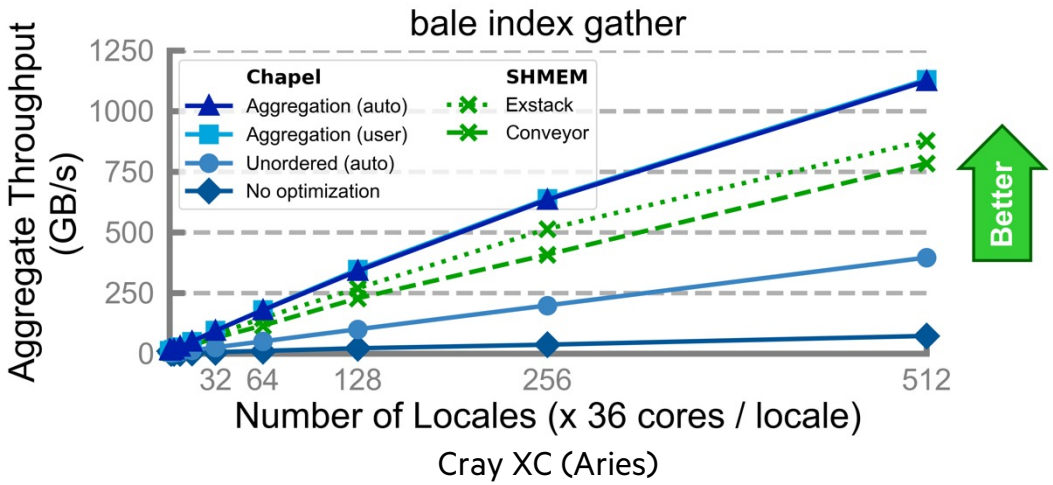
Conveyors version

```
i = 0;
while (more = convey_advance(requests, (i == l_num_req)),
       more | convey_advance(replies, !more)) {

  for (; i < l_num_req; i++) {
    pkg.idx = i;
    pkg.val = pckindx[i] >> 16;
    pe = pckindx[i] & 0xffff;
    if (! convey_push(requests, &pkg, pe))
      break;
  }

  while (convey_pull(requests, ptr, &from) == convey_OK) {
    pkg.idx = ptr->idx;
    pkg.val = ltable[ptr->val];
    if (! convey_push(replies, &pkg, from)) {
      convey_unpull(requests);
      break;
    }
  }

  while (convey_pull(replies, ptr, NULL) == convey_OK)
    tgt[ptr->idx] = ptr->val;
}
```



Manually Tuned Chapel version (using explicit aggregator type)

```
forall (d, i) in zip(Dst, Inds) with (var agg = new SrcAggregator(int)) do
  agg.copy(d, Src[i]);
```

Elegant Chapel version (compiler-optimized w/ '--auto-aggregation')

```
forall (d, i) in zip(Dst, Inds) do
  d = Src[i];
```

Highlight 1: Aggregators (explicit and compiler-added)

CHAPEL SUPPORT FOR GPUS

Typical 2019-era Chapel Talk:

- **Me:** "Chapel's goal is to support any parallel algorithm on any parallel architecture."
- **Audience Q:** "So… does Chapel support GPUs?"
- **Me** *(with head bowed in shame)***:** "Only through interoperability with CUDA/OpenCL/OpenACC/OpenMP/…"

STREAM TRIAD EP: SHARED MEMORY

stream-ep.chpl

```
config var n = 1_000_000,
           alpha = 0.01;



    var A, B, C: [1..n] real;
    A = B + alpha * C;
```

Declare three arrays of size ‘n’

Whole-array operations compute Stream Triad in parallel

So far, this is simply a multi-core program

Nothing refers to remote locales (nodes), explicitly or implicitly

STREAM TRIAD EP: DISTRIBUTED MEMORY

stream-ep.chpl

```
config var n = 1_000_000,
           alpha = 0.01;

coforall loc in Locales {
  on loc {
    var A, B, C: [1..n] real;
    A = B + alpha * C;
  }
}
```

'coforall' loops execute each iteration as an independent task

the array of locales (nodes) on which this program is running

have each task run 'on' its locale

then run multi-core Stream, as before

This is a CPU-only program

Nothing refers to GPUs, explicitly or implicitly

STREAM TRIAD EP: DISTRIBUTED MEMORY, GPUS ONLY

stream-ep.chpl

```
config var n = 1_000_000,
           alpha = 0.01;

coforall loc in Locales {
  on loc {

    coforall gpu in here.gpus do on gpu {
      var A, B, C: [1..n] real;
      A = B + alpha * C;
    }
  }
}
```

Use a similar ‘coforall’ + ‘on’ idiom to run a Triad concurrently on each of this locale’s GPUs

This is a GPU-only program

Nothing other than coordination code runs on the CPUs

STREAM TRIAD EP: DISTRIBUTED MEMORY, GPUS AND CPUS

stream-ep.chpl

```
config var n = 1_000_000,
           alpha = 0.01;

coforall loc in Locales {
  on loc {
    cobegin {
      coforall gpu in here.gpus do on gpu {
        var A, B, C: [1..n] real;
        A = B + alpha * C;
      }
      {
        var A, B, C: [1..n] real;
        A = B + alpha * C;
      }
    }
  }
}
```

‘cobegin { … }’ creates a task per child statement

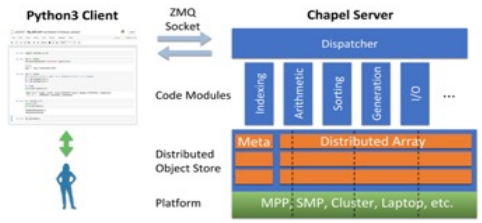
one task runs our GPU triad

the other runs the CPU triad

Highlight 2: Chapel now supports GPUs!
(via a work-in-progress prototype)

This program uses all CPUs and GPUs across all of your compute nodes

FLAGSHIP CHAPEL APPLICATIONS



Arkouda

What? Interactive Data Analytics at Supercomputing Scale

Who? Mike Merrill, Bill Reus, et al., *U.S. DoD*

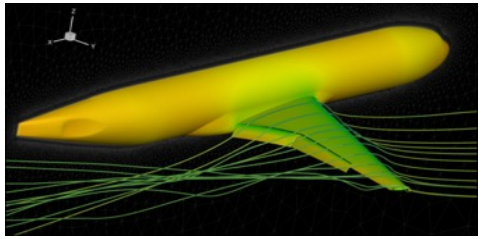
How Much? ~25k lines of Chapel written since January 2019

Why Chapel? Scalability, supported rapid development, supports Pythonic code

Highlight 3: Both apps went into production & matured significantly

Arkouda Highlights Since CLSAC 2019

- Extensible, Modular Architecture
- Many, many New Features
- Performance and Scalability Improvements…



CHAMPS

What? 3D Unstructured CFD (Computational Fluid Dynamics)

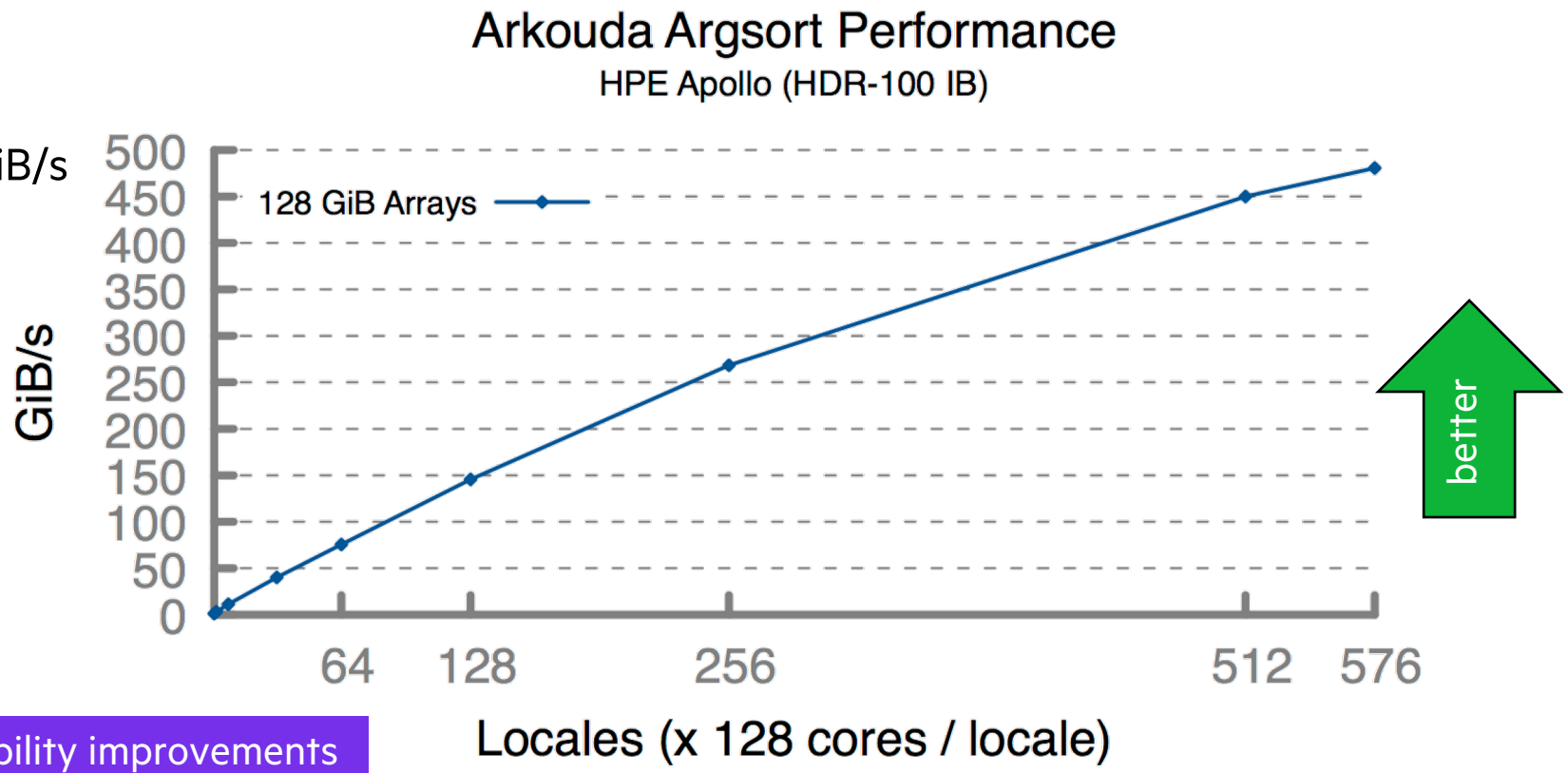
Who? Éric Laurendeau, et al., *Polytechnique Montreal*

How Much? ~100k lines of Chapel written since Spring 2019

Why Chapel? Reduces time-to-science for junior and senior students while scalably generating world-class results

ARKOUDA ARGSORT AT MASSIVE SCALE

- Ran on a large HPE Apollo system, summer 2021
  - 73,728 cores of AMD Rome
  - 72 TiB of 8-byte values
  - 2.5 minutes elapsed time ⇒ 480 GiB/s
  - ~100 lines of Chapel code



Highlight 4: Major performance and scalability improvements

Close to world-record performance—and very likely a record for performance/SLOC

THE CHAPEL TEAM AT HPE

Our team now consists of:

- 19 full-time employees
- 1 visiting scholar (NCAR)
- our director

We also have:

- a new hire starting early 2023
- an open summer internship

Highlight 5: Team has grown from ~12 in 2019 to ~21 today

see: https://chapel-lang.org/contributors.html
and https://chapel-lang.org/jobs.html

FUTURE WORK: CHAPEL AT THE EDGE?

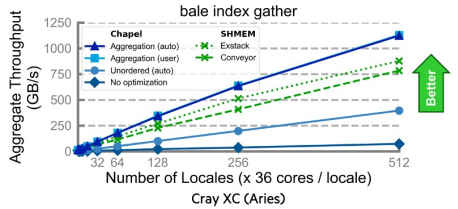
- We have admittedly focused almost exclusively on “indoor” systems, from laptops to supercomputers
  - Though at times, this has included things like Raspberry Pi or AWS

- Potential future directions (up for grabs):
  - More **diverse accelerators** than typical GPUs (several talks)
  - Coordinating **loosely-coupled Chapel programs** from edge to cloud (Pete’s talk)
    – using ZeroMQ, Sockets, or something higher-level / more abstract?
  - **Jupyter notebook support** via interactive evaluation of Chapel (Sudip’s talk)
  - Your idea here…

SUMMARY

Chapel is unique among programming languages

- built-in features for scalable parallel computing
- supports clean, concise code relative to conventional approaches
- ports and scales from laptops to supercomputers




```
forall (d, i) in zip(Dst, Inds) do
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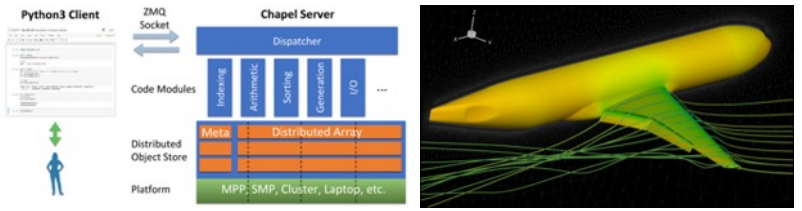
Chapel is being used in production and at scale

- users are reaping its benefits in applied, cutting-edge applications
- applicable to domains as diverse as data science and physical simulations



Progress over the past three years has been significant

- adding GPU support
- improving performance and scalability
- growing the team

CHAPEL RESOURCES

Chapel homepage: https://chapel-lang.org

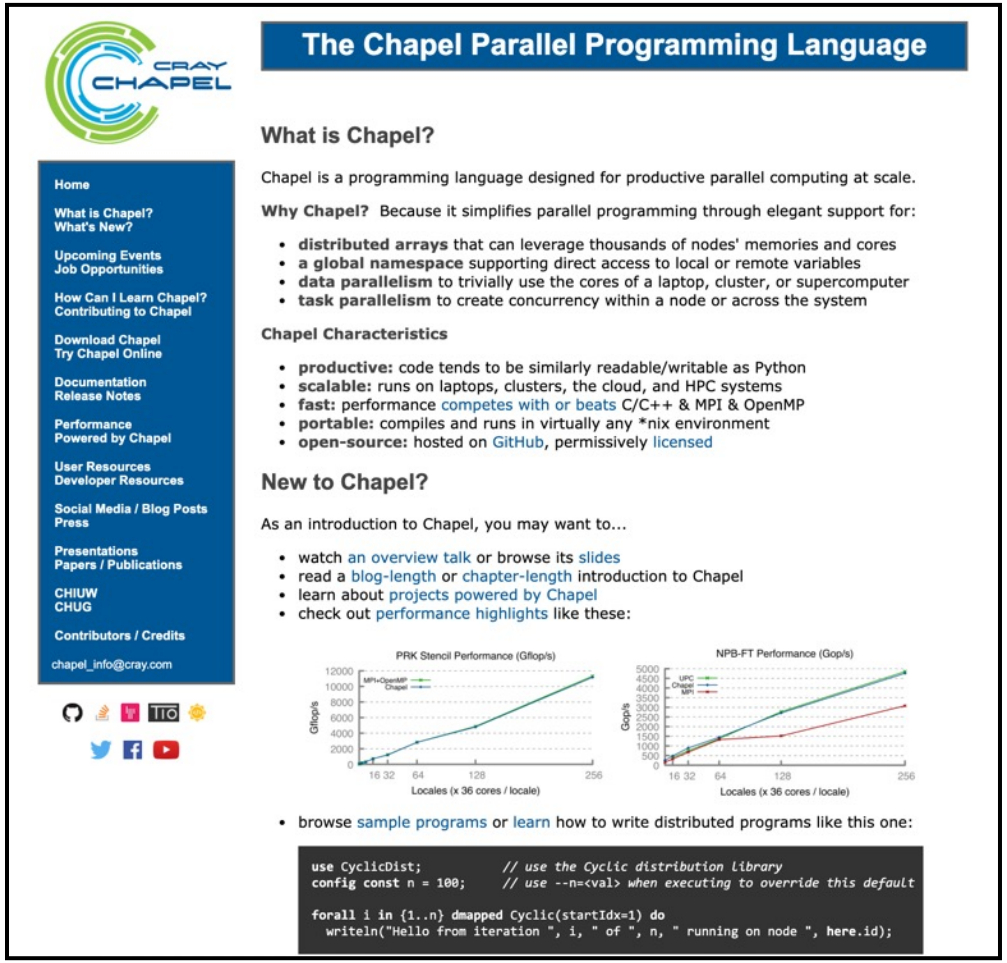
- (points to all other resources)

Social Media:

- Twitter: @ChapelLanguage
- Facebook: @ChapelLanguage
- YouTube: http://www.youtube.com/c/ChapelParallelProgrammingLanguage

Community Discussion / Support:

- Discourse: https://chapel.discourse.group/
- Gitter: https://gitter.im/chapel-lang/chapel
- Stack Overflow: https://stackoverflow.com/questions/tagged/chapel
- GitHub Issues: https://github.com/chapel-lang/chapel/issues



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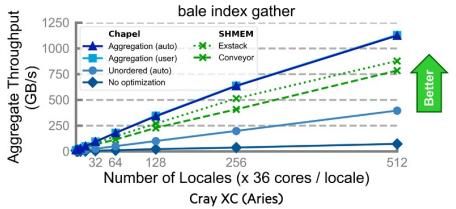


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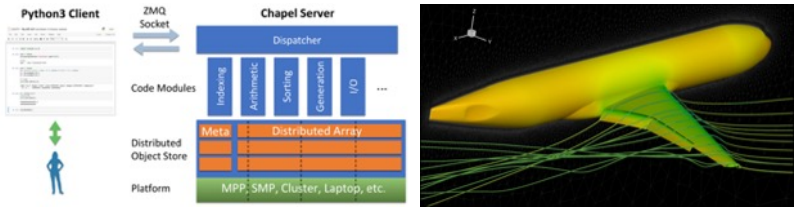

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THANK YOU

https://chapel-lang.org
@ChapelLanguage