Arkouda and Chapel: Programming Models Panel

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Productive, Performant Software for Large-Scale Scientific Data Analysis, SLAC
October 21, 2025

Arkouda Overview

What is Arkouda?

Q: "What is Arkouda?"

A1: "A scalable version of NumPy / Pandas for data scientists"

A2: "An extensible framework for using supercomputers interactively from Python"

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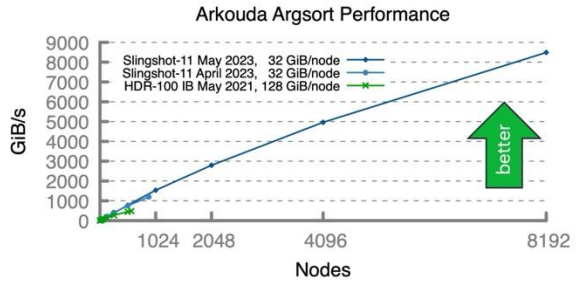
Performance and Productivity: Arkouda Argsort

HPE Cray EX
- Slingshot-11 network (200 Gb/s)
- 8192 compute nodes
- 256 TiB of 8-byte values
- ~8500 GiB/s (~31 seconds)

HPE Cray EX
- Slingshot-11 network (200 Gb/s)
- 896 compute nodes
- 28 TiB of 8-byte values
- ~1200 GiB/s (~24 seconds)

HPE Apollo
- HDR-100 InfiniBand network (100 Gb/s)
- 576 compute nodes
- 72 TiB of 8-byte values
- ~480 GiB/s (~150 seconds)



Implemented using ~100 lines of Chapel

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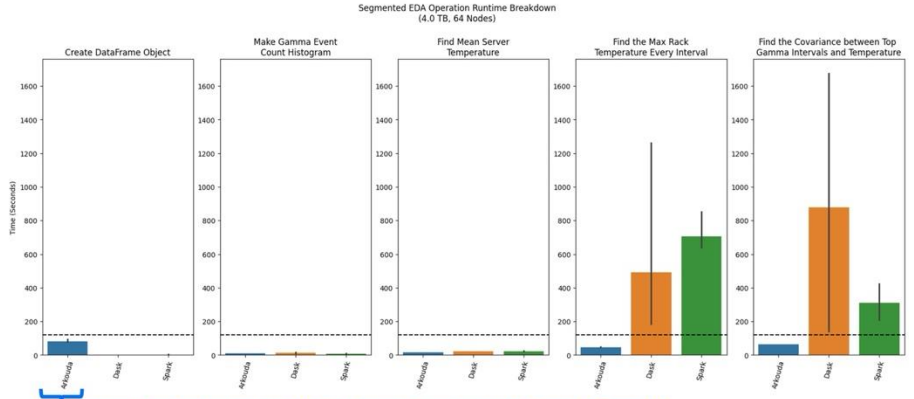
Arkouda/Dask/Spark Comparison: Zoomed out



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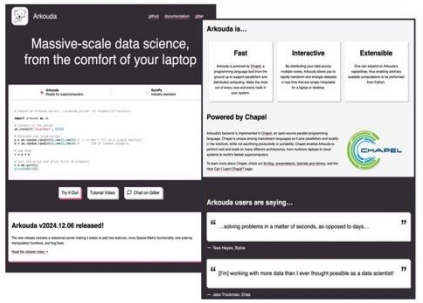
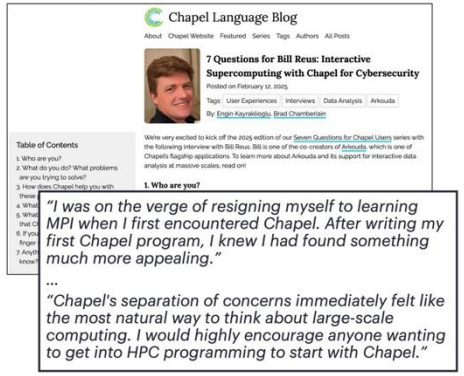
For More Information on Arkouda

Arkouda website:



Interview with founding co-developer, Bill Reus:



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Chapel Overview

What is Chapel?

Chapel: A modern parallel programming language

- Portable & scalable
- Open-source & collaborative
- An HPSF / Linux Foundation project

HPSF
HIGH PERFORMANCE SOFTWARE FOUNDATION

CHAPEL

Goals:

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

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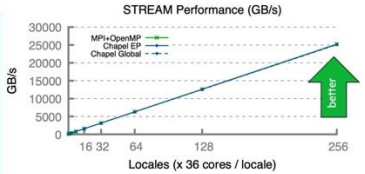
HPCC Stream Triad / RA: C+MPI+OpenMP vs. Chapel

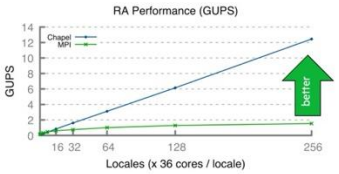
STREAM TRIAD: C + MPI + OPENMP

```
use BlockDist;

config const n = 1_000_000,
             alpha = 0.01;
const Dom = blockDist.createDomain({1..n});
var A, B, C: [Dom] real;

B = 2.0;
C = 1.0;

A = B + alpha * C;
```



HPCC RA: MPI KERNEL

```
...
forall (_, r) in zip(Updates, RandVals()) do
  T[r & indexMask].xor(r);
...
```



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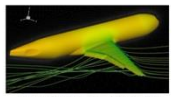
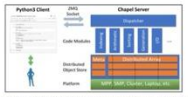
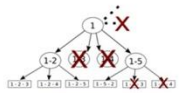
Applications of Chapel



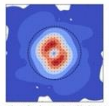
CHAMPS: 3D Unstructured CFD
Laurendeau, Bourgault-Côté, Parenteau, Plante, et al.
École Polytechnique Montréal



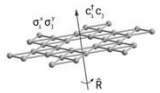
Arkouda: Interactive Data Science at Massive Scale
Mike Merrill, Bill Reus, et al.
U.S. DoD



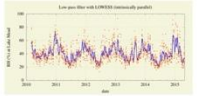
ChOp: Chapel-based Optimization
T. Carneiro, G. Helbecque, N. Melab, et al.
INRIA, IMEC, et al.



ChplUltra: Simulating Ultralight Dark Matter
Nikhil Padmanabhan, J. Luna Zagorac, et al.
Yale University et al.

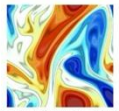


Lattice-Symmetries: a Quantum Many-Body Toolbox
Tom Westerhout
Radboud University

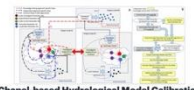


Desk dot chpl: Utilities for Environmental Eng.
Nelson Luis Dias
The Federal University of Paraná, Brazil

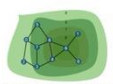
RapidQ: Mapping Coral Biodiversity
Rebecca Green, Helen Fox, Scott Bachman, et al.
The Coral Reef Alliance



ChapQG: Layered Quasigeostrophic CFD
Ian Grooms and Scott Bachman
University of Colorado, Boulder et al.



Chapel-based Hydrological Model Calibration
Marjan Asgari et al.
University of Guelph



Arachne Graph Analytics
Bader, Du, Rodriguez, et al.
New Jersey Institute of Technology

Modeling Ocean Carbon Dioxide Removal
Scott Bachman Brandon Neth, et al.
[C]Worthy

CrayAI HyperParameter Optimization (HPO)
Ben Albrecht et al.
Cray Inc. / HPE

[images provided by their respective teams and used with permission]

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Ways to engage with the Chapel Community

Synchronous Community Events

- Project Meetings, weekly
- Deep Dive / Demo Sessions, weekly timeslot
- ChapelCon (formerly CHIUW), annually

Asynchrounous Communications

- Chapel Blog, typically ~2 articles per month
- Community Newsletter, quarterly
- Announcement Emails, around big events

Social Media

FOLLOW US
- BlueSky
- Facebook
- LinkedIn
- Mastodon
- Reddit
- X (Twitter)
- YouTube

Discussion Forums

GET IN TOUCH
- Discord
- Discourse
- Email
- GitHub Issues
- Gitter
- Stack Overflow

Ways to Use Chapel

GET STARTED
- Attempt This Online
- Docker
- E4S
- GitHub Releases
- Homebrew
- Spack

(from the footer of chapel-lang.org)

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Thank You

@ChapelLanguage