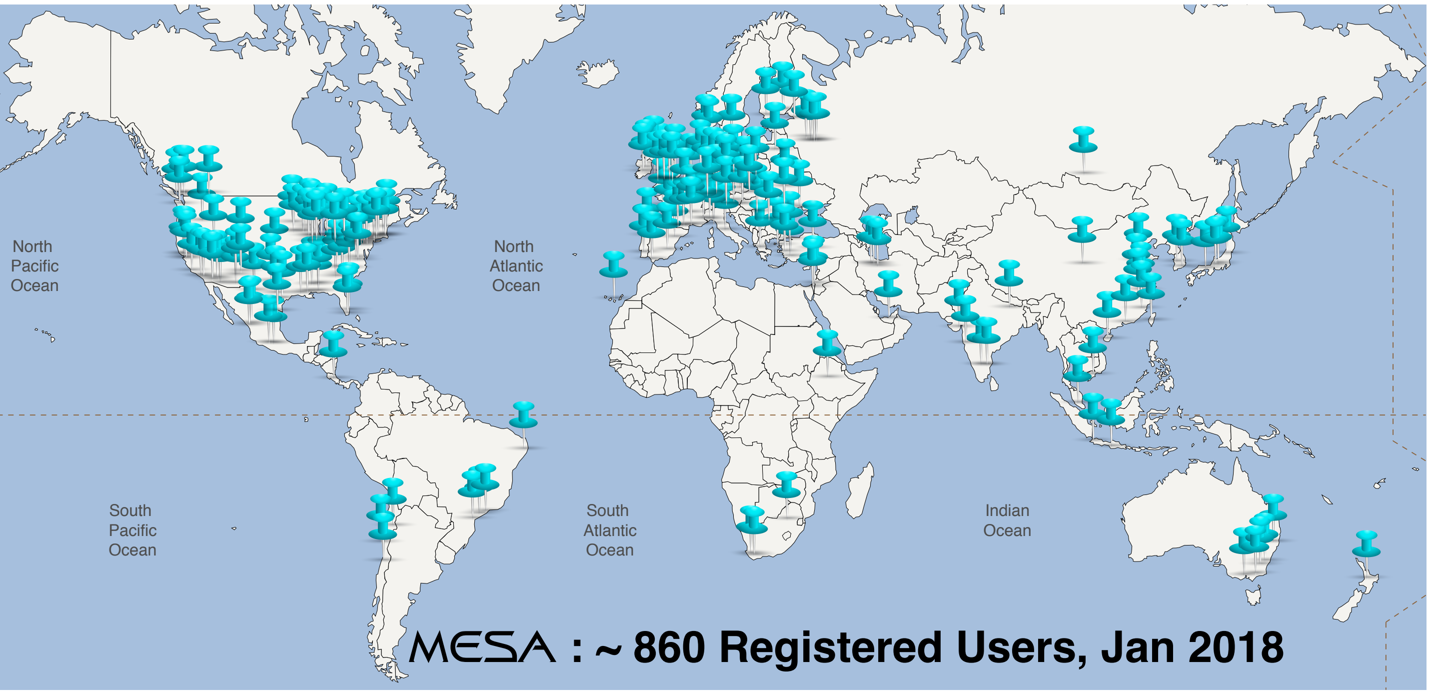
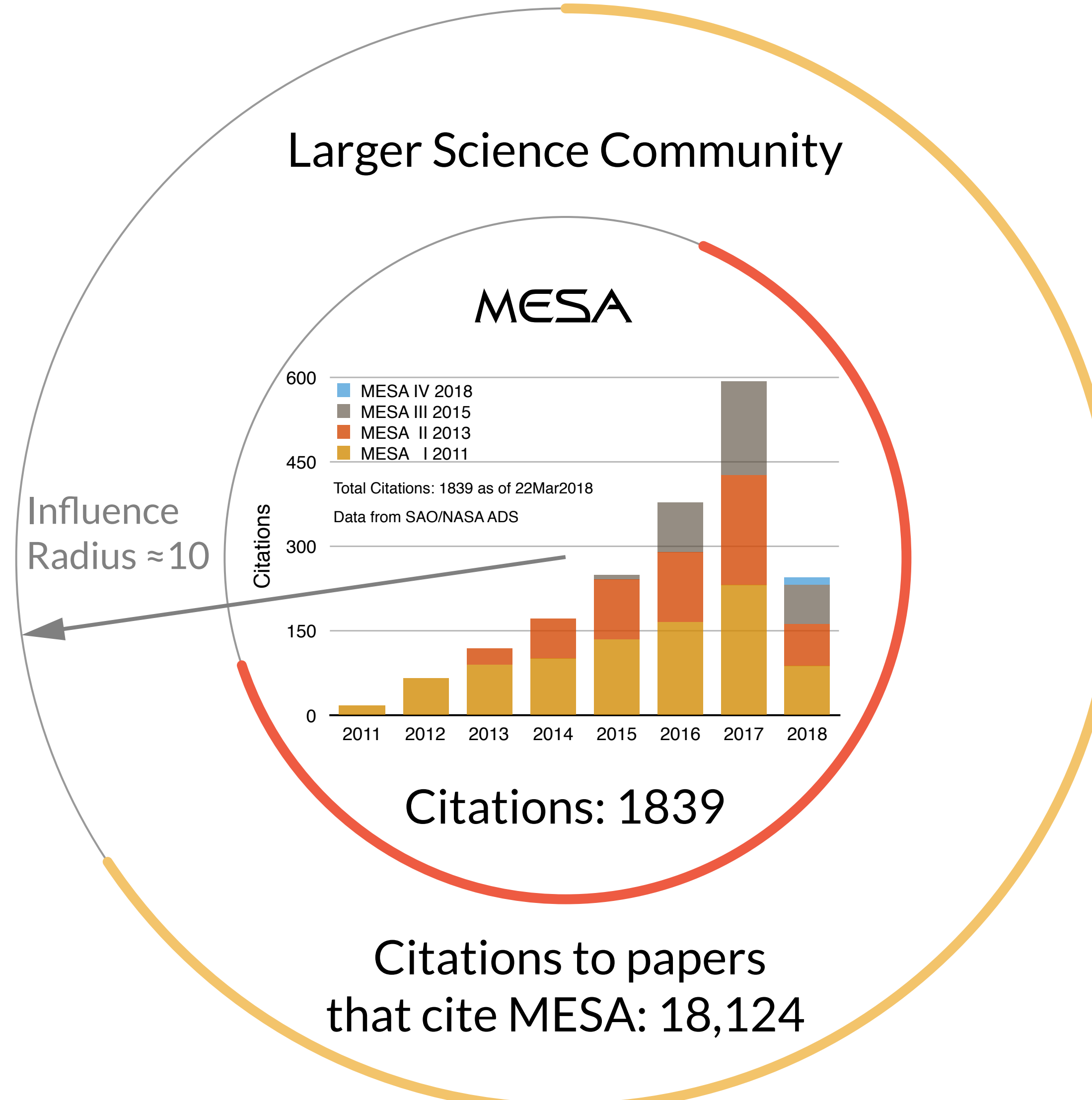
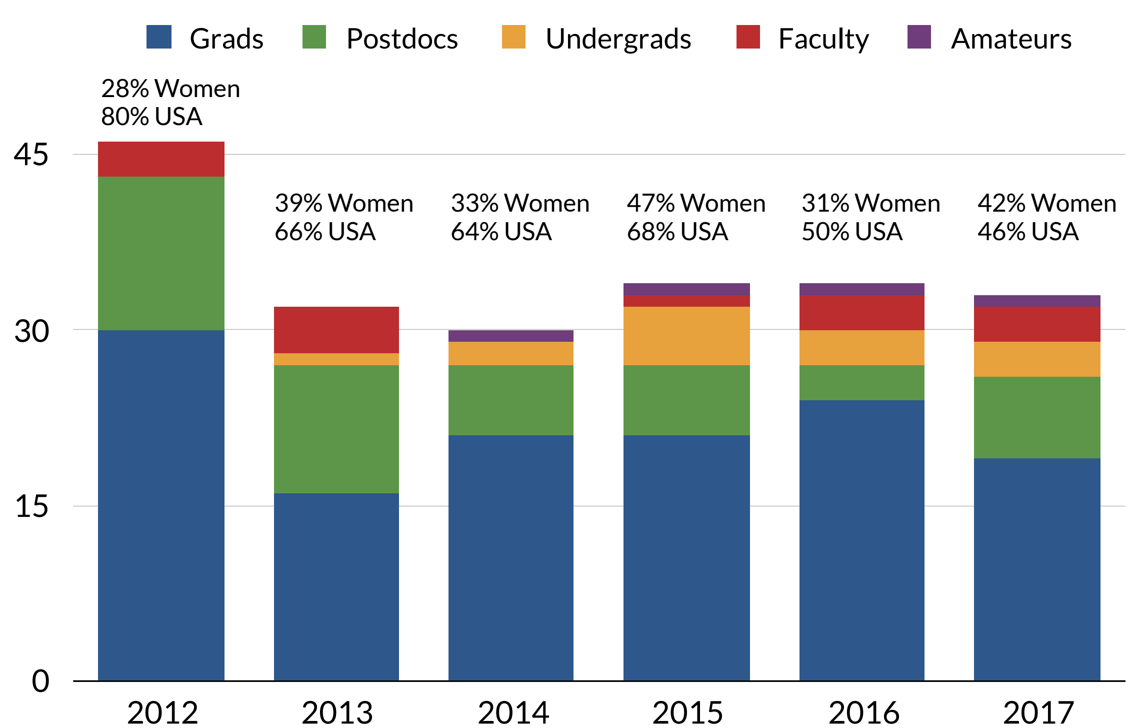
SI2-SSI : Modules for Experiments in Stellar Astrophysics (MESA)

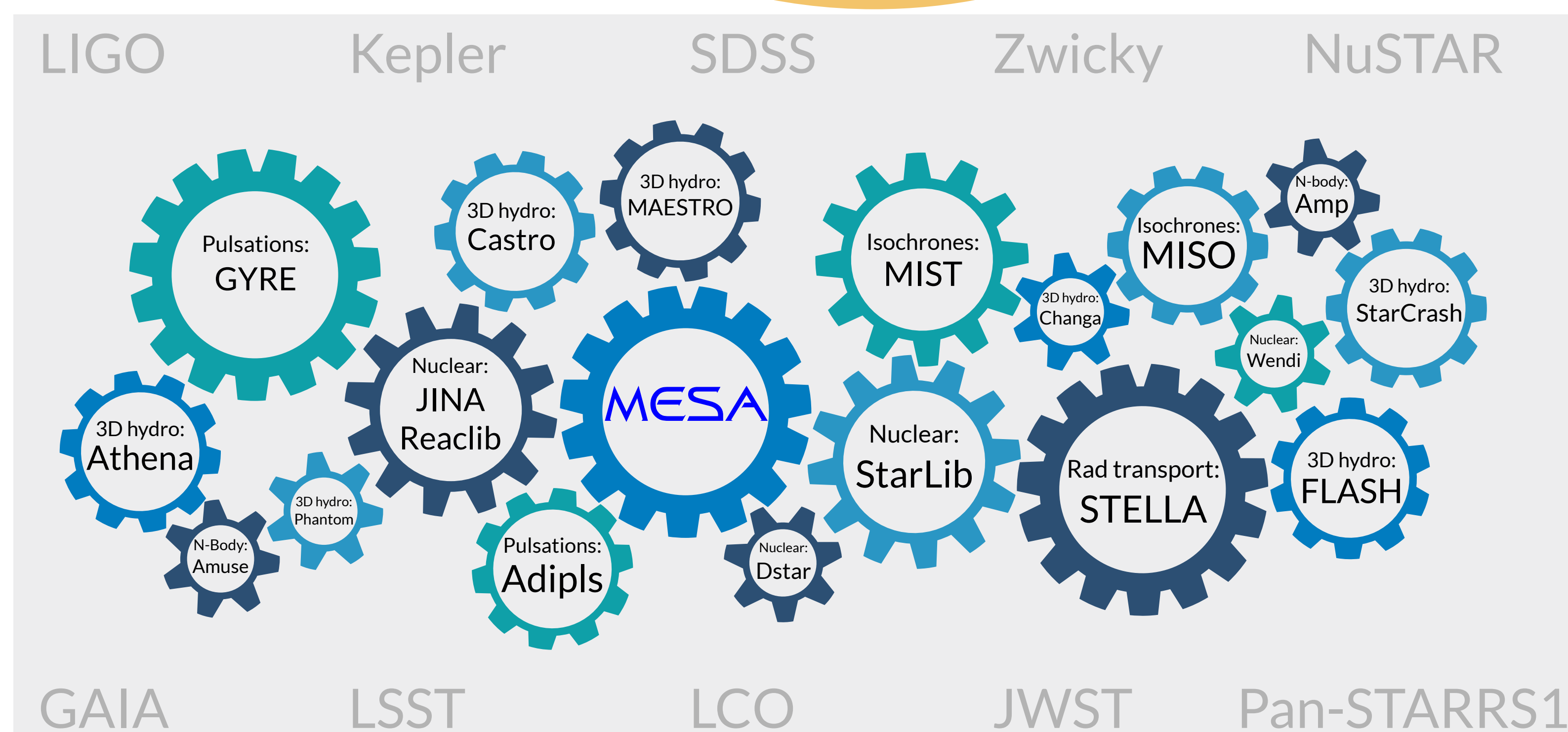
Frank Timmes (PI), Rich Townsend (Co-PI), Lars Bildsten (Co-PI), Bill Paxton (MESA's First Author), Josiah Schwab (Collaborator), Pablo Marchant (Collaborator), Rob Farmer (Collaborator)





MESA Summer School





UCDAVIS | MUHAMMAD OSAMA

Gunrock

GPU Graph Analytics

gunrock.github.io

- **Performance**

  State-of-the-art graph processing library

- **Generality**

  Covers a **broad range** of graph algorithms

- **Programmability**

  Makes it easy to implement and extend graph algorithms from **1-GPU to multi-GPUs**

- **Scalability**

  Fits in (very) limited GPU memory space

  performance scales when using more GPUs

- **Continuous Integration**

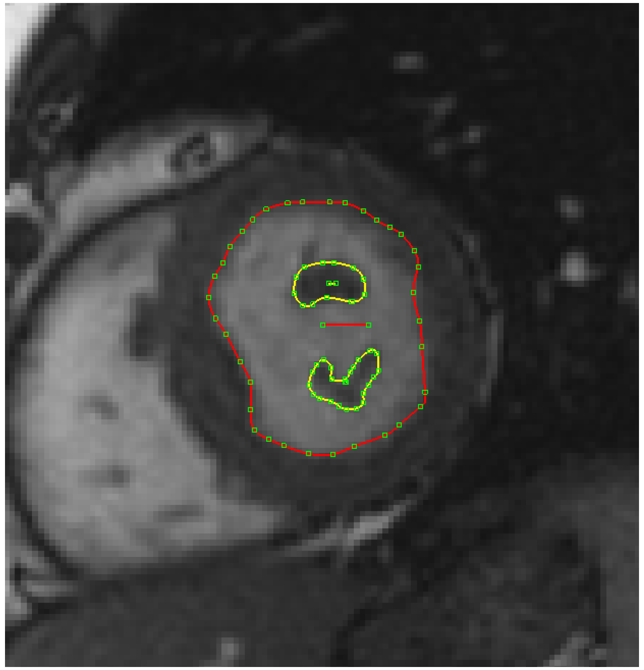
  Continuous delivery powered by **jenkins.io**

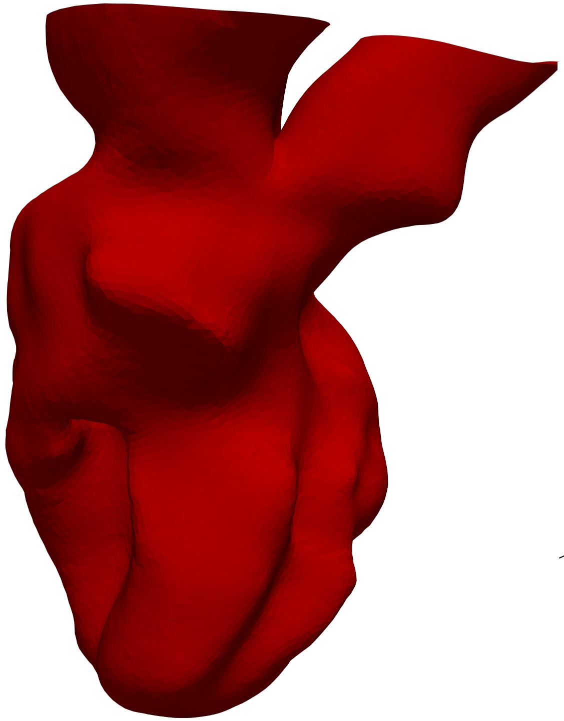
NSF DARPA NVIDIA Jenkins

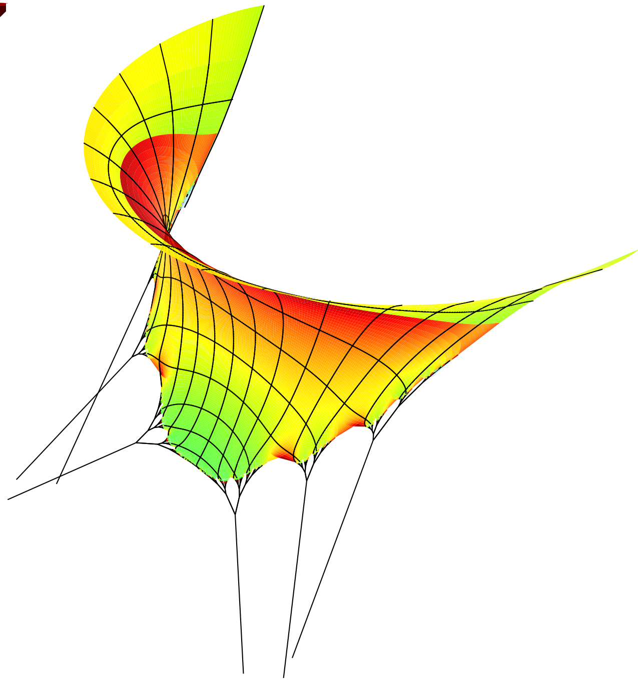
SimCardio

Open-Source, Multi-Physics, Cardiac Modeling and Simulation

Alexander D. Kaiser, PhD, Cardiothoracic Surgery, Stanford; Vijay Vedula, PhD, Cardiology, Stanford;
Nathan M. Wilson, PhD, MBA, Open-Source Medical Software Corporation; Shawn C. Shadden, PhD, Mechanical Engineering, UC Berkeley;
Ellen Kuhl, PhD, Mechanical Engineering, Stanford; Alison L. Marsden, PhD, Pediatrics and Bioengineering, Stanford







Major support for this work was provided by the NSF SI2-SSI Collaborative Research Program (Awards #1339824 and #1663671).

HydroShare: Cyberinfrastructure for Advancing Hydrologic Knowledge through Collaborative Integration of Data Science, Modeling and Analysis

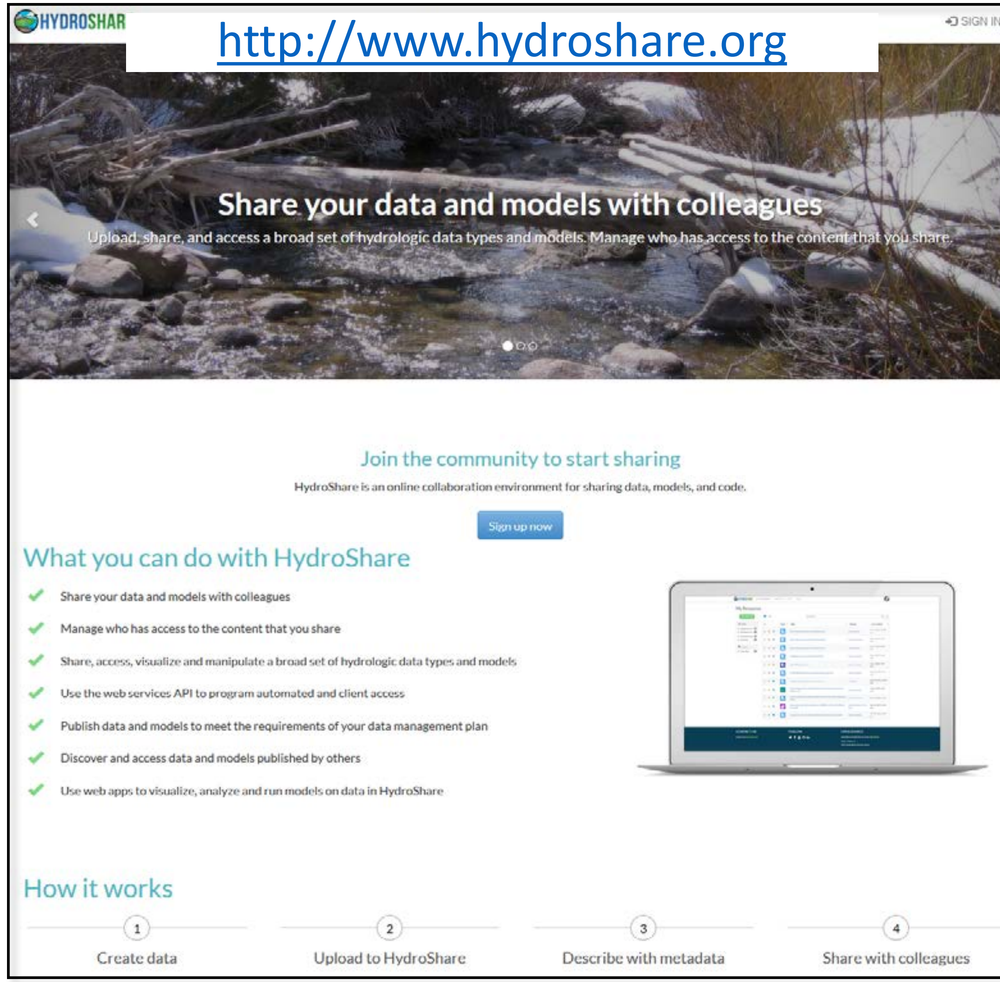
David Tarboton, Ray Idaszak, Shaowen Wang, Jeffery Horsburgh, Dan Ames, Martyn Clark, Jon Goodall, Alva Couch, Hong Yi, Tony Castronova, Christina Bandaragoda, Rick Hooper

Advancing Hydrologic Understanding

- requires integration of information from multiple sources
- is data and computationally intensive
- requires collaboration and working as a team/community

HydroShare is a system to advance hydrologic science by enabling the community to more easily and freely share products resulting from their research, not just the scientific publication summarizing a study, but also the data and models used to create the scientific publication.

- **F**indable
- **A**ccessible
- **I**nteroperable
- **R**eusable



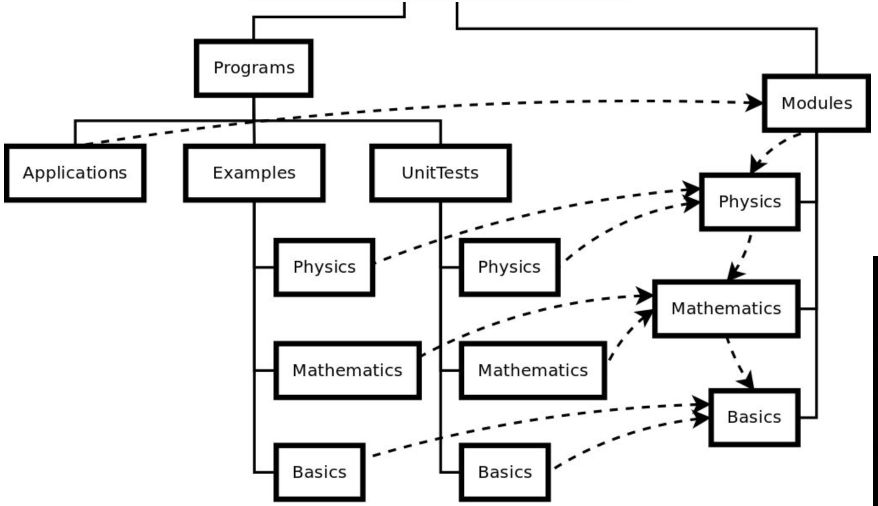
- Open data
- Transparency
- Research Reproducibility
- Enhanced trust in research

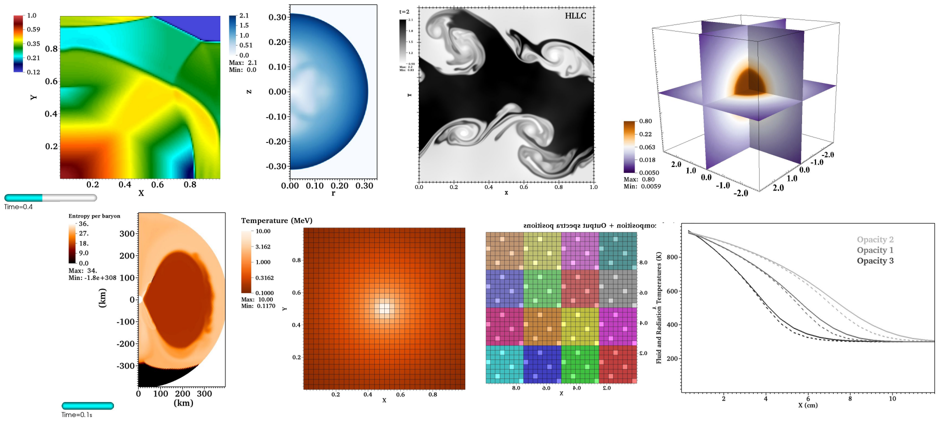
- Includes a repository for users to share and publish data and models in a variety of formats
- Includes tools (web apps) that can act on content in HydroShare

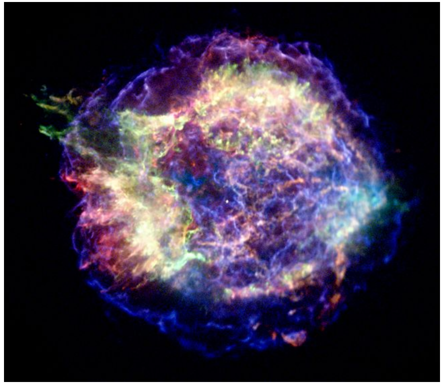
Neutrino Radiation Hydrodynamics in GenASiS

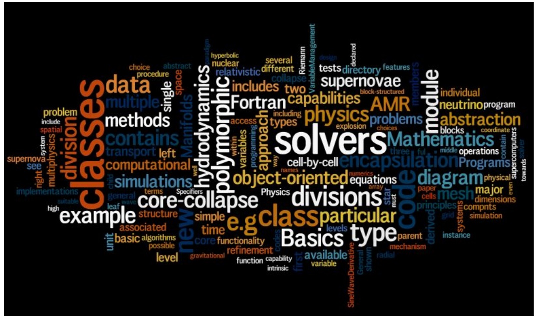
Reuben D. Budiardja, Eirik Endeve, Christian Y. Cardall, R. Daniel Murphy
The University of Tennessee -- Oak Ridge National Laboratory

GenASiS





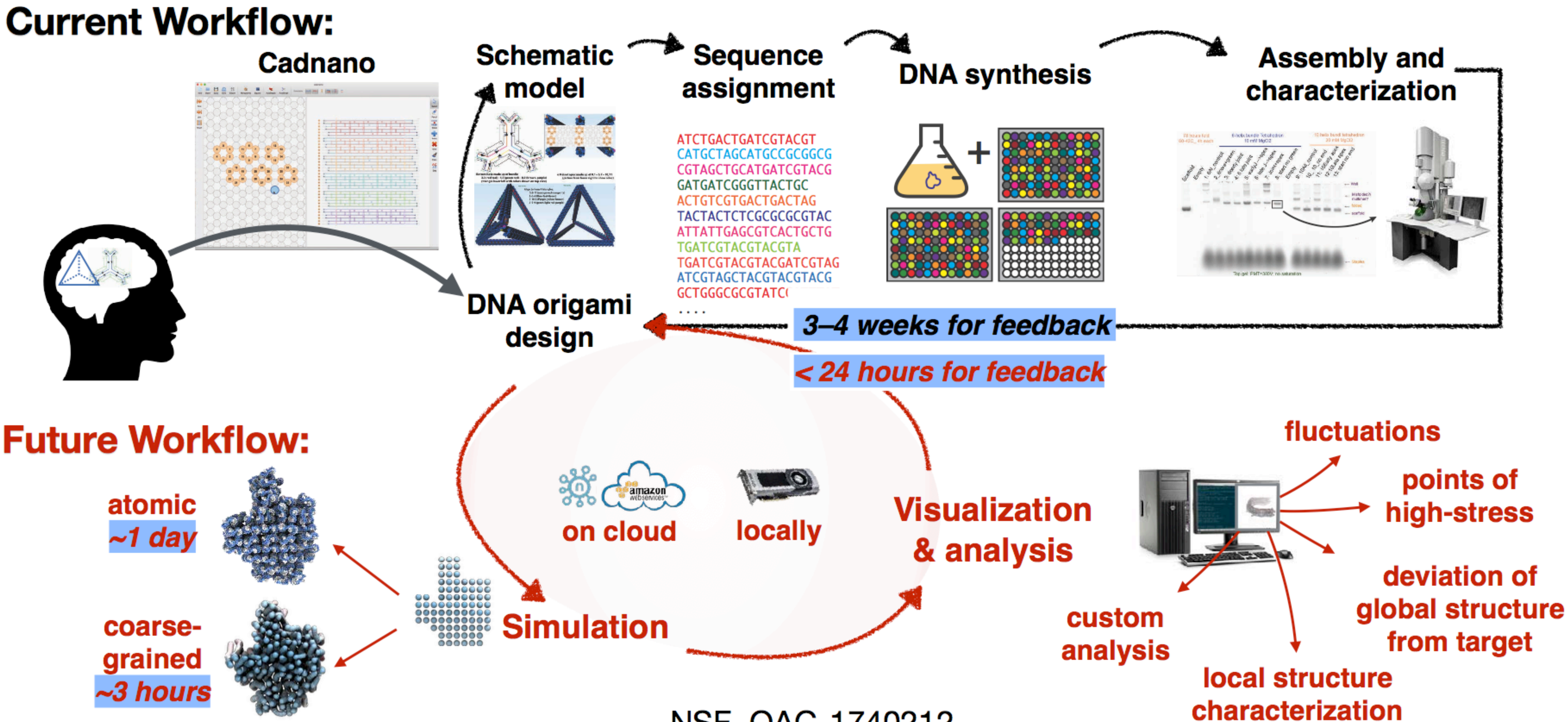




https://github.com/GenASiS
http://genasis.xyz

SI2-SSE: Collaborative Research: Integrated Tools for DNA Nanostructure Design and Simulation

PIs: Shawn Douglas (UCSF) and Aleksei Aksimentiev (UIUC)



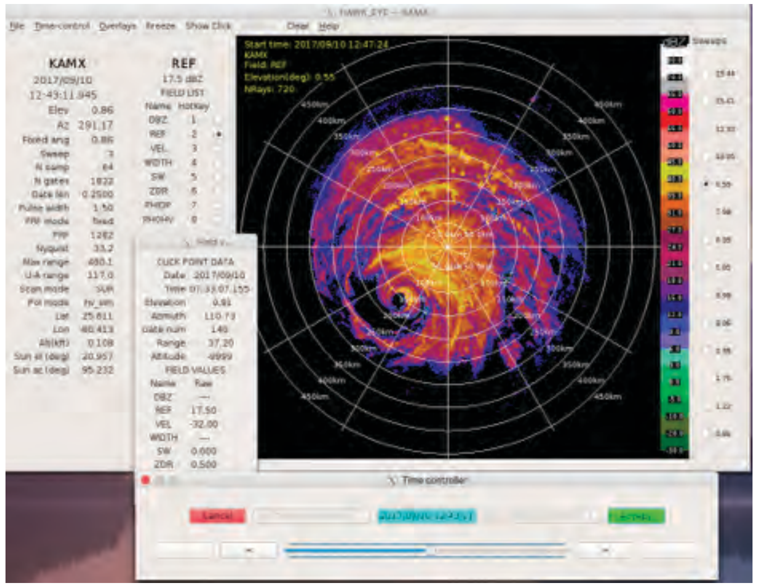
NSF OAC-1740212

LROSE:
Lidar-Radar Open Software Environment

- LROSE is a joint 4-year project between Colorado State University and the National Center for Atmospheric Research funded by NSF SI2-SSI to develop common software for the LIDAR, RADAR and Profiler community

- The 1st LROSE community workshop was held in April 2017. Focus on key applications as ‘building blocks’, allowing users to assemble trusted, reproducible workflows to accomplish more complex scientific tasks

- LROSE ***“Blaze”*** released in 2018 in a ***“Virtual Toolbox”*** Docker container or as C++ compiled native apps focused on data Conversion, Display, and Gridding. Additional tools for QC, Echo, and Wind analysis are in development

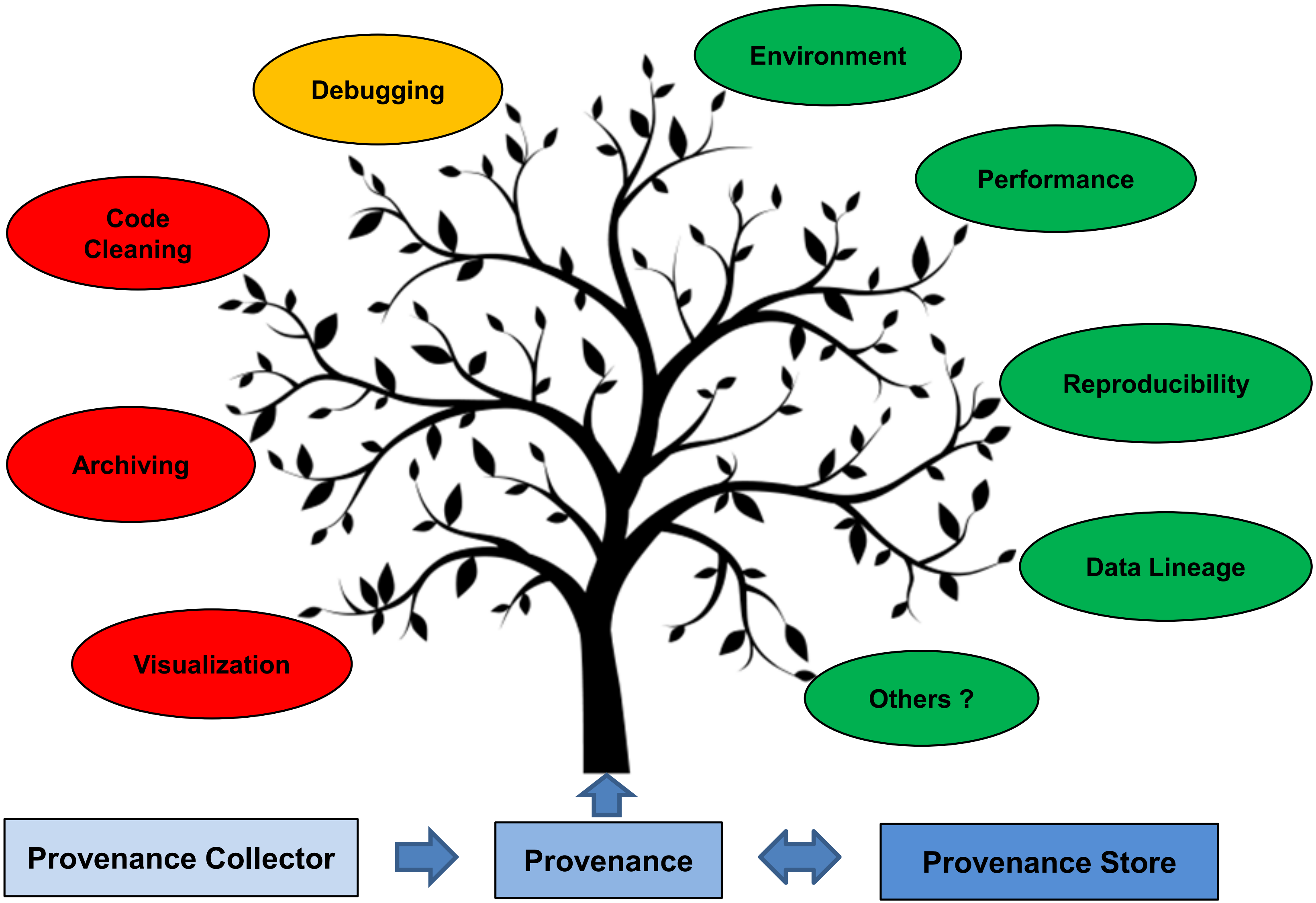


HawkEye Display of Hurricane Irma (2017)

nsf-lrose.github.io

The Fruits of Provenance

Emery R. Boose, Aaron M. Ellison, Elizabeth Fong, Matthew Lau,
Barbara S. Lerner, Jackson Okuhn, Thomas Pasquier, Margo Seltzer



Tree silhouette from: http://www.vinylsilhouettes.com

Harmonically Mapped Averaging for Everyone

Ensemble Averages

- Core of statistical mechanics
- Relate molecule coordinate averages to material properties
- Example: Pressure tensor

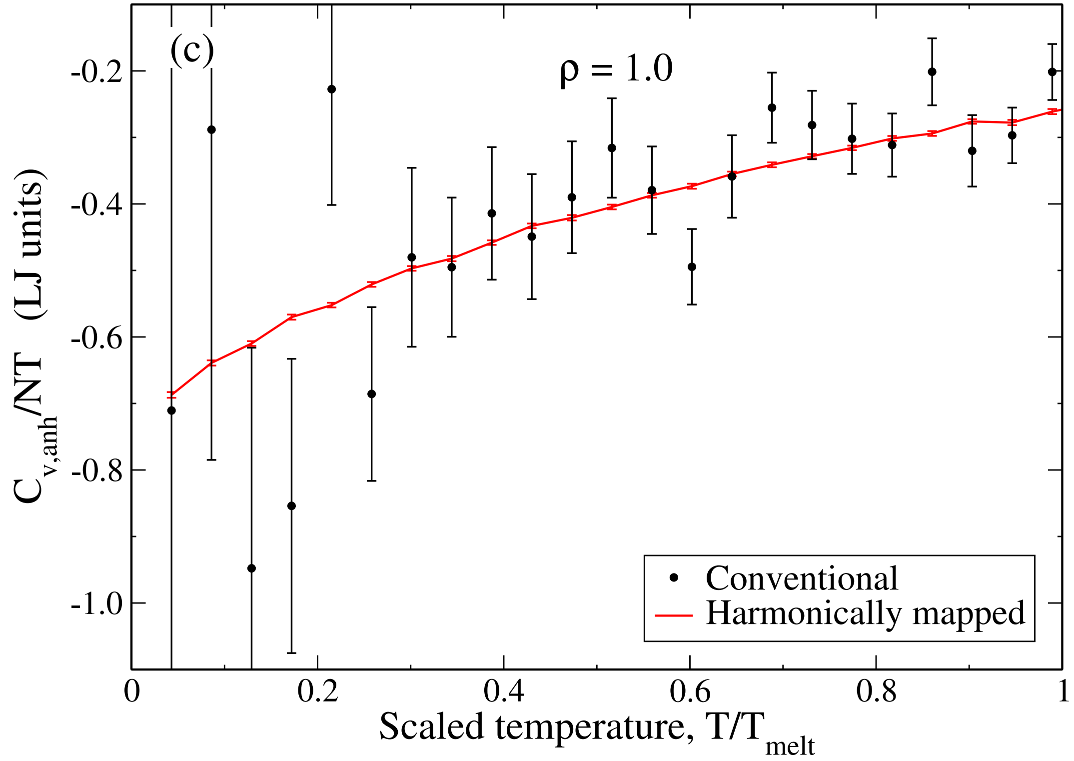
$$\mathbf{P} = \rho kT\,\mathbf{I} + \frac{1}{3V}\left\langle \sum_{i<j} \mathbf{f}_{ij}\mathbf{r}_{ij} \right\rangle$$

Mapped Averages

- Writes averages rigorously as deviation from an approximate starting point
- For crystals, a good starting point is a harmonic lattice
- Example: internal energy

$$U = \frac{3}{2}NkT + \left\langle U_{\text{config}} + \frac{1}{2}\mathbf{F}\cdot\Delta\mathbf{r} \right\rangle$$

Performance: Heat capacity



SSE project: Implement in these codes

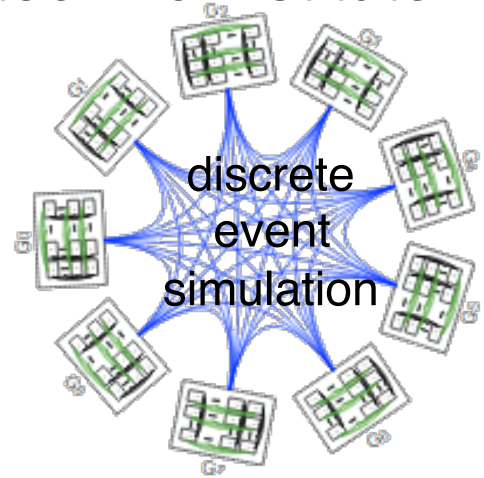
LAMMPS etomica VASP HOOMD-blue Cassandra

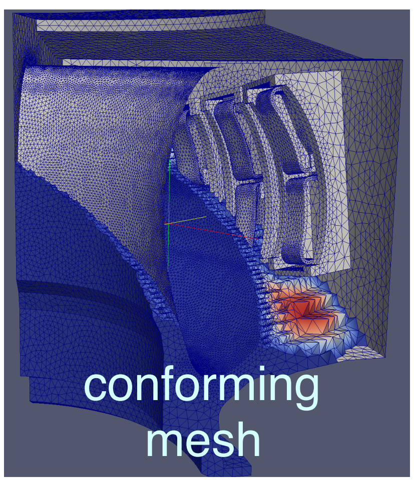
Fast Dynamic Load Balancing for Extreme Scale Systems

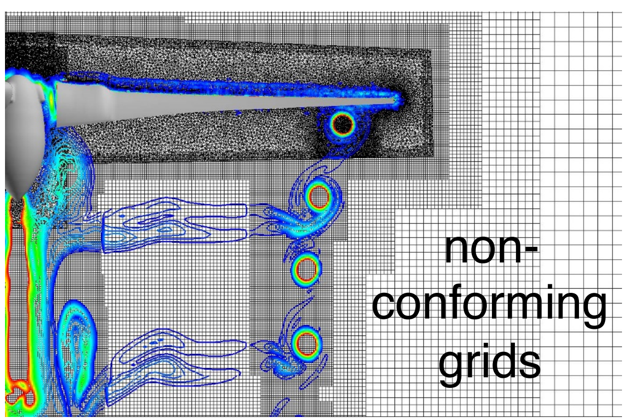
Cameron W. Smith, Gerrett Diamond, M.S. Shephard

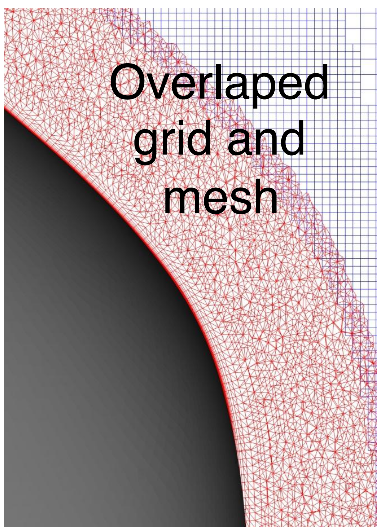
Computation Research Center, Rensselaer Polytechnic Institute

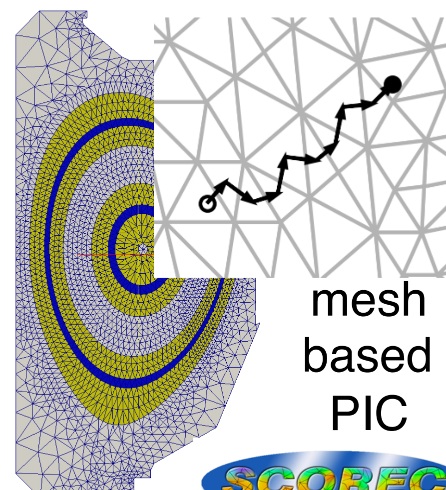
- Dynamic load balancing is a core tool needed to support automated simulations
- Goal: Generalize a multicriteria procedure to:
  - Applications past conforming unstructured meshes
  - Execute on accelerator supported systems
- Developing the EnGPar multicriteria partition improvement procedures based on a distributed N-graph











bigweatherweb.org

BIG WEATHER WEB

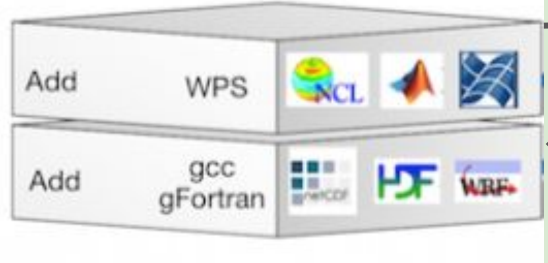
Carlos Maltzahn, Ivo Jimenez (UC Santa Cruz), Mohan Ramamurty (Unidata), Gretchen Mullendor (UND), Brian Ancell (Texas Tech), William Capehart (SD Mines), Clark Evans (UW Milwaukee), Robert Fovell, Kevin Tyle (UAlbany), Steven Greybush (PennState), Russ Schumacher (Colorado State), Kate Fossell (NCAR), Joshua Hacker, John Exby (Jupiter Intelligence)

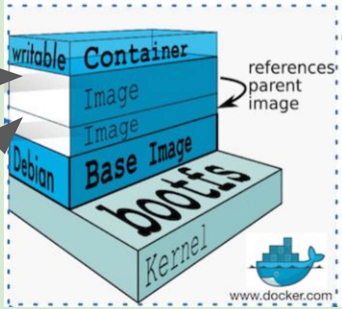
CROSS CENTER FOR RESEARCH IN OPEN SOURCE SOFTWARE cross.ucsc.edu

Crystallization Points: easily shared artifacts, community-improved over time

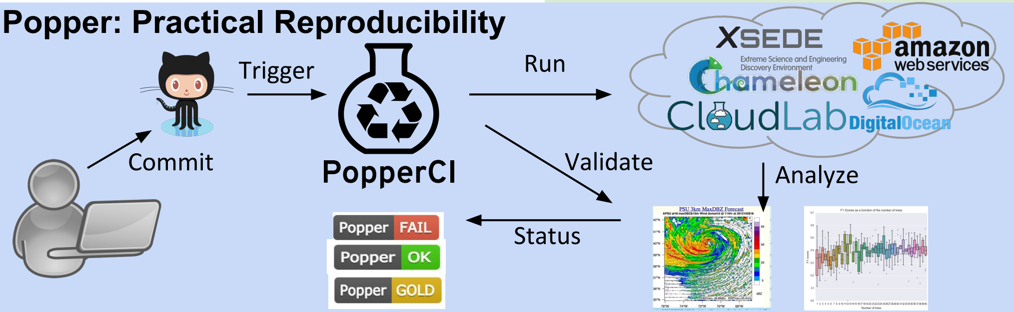
Large ensemble shared among 7 universities:
Gretchen Mullendore (UND), Brian Ancell (Texas Tech), William Capehart (SDSM), Clark Evans (UW Milwaukee), Robert Fowell (U Albany), Steven Greybush (Penn State), Russ Schumacher (CSU).

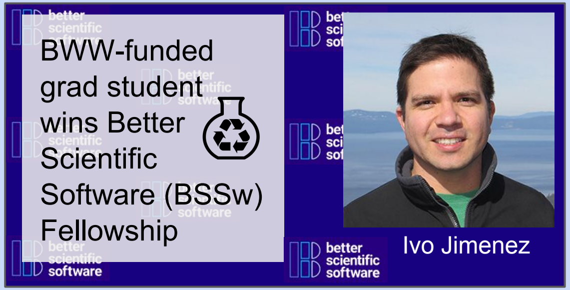
WRF in a Box: Build, Deploy, Run:





Popper: Practical Reproducibility





SI2-SSE: Analyze Visual Data from Worldwide Network Cameras (Continuous Analysis of Many CAMeras, CAM^2), NSFACI-1535108

PI: Yung-Hsiang Lu, yunglu@purdue.edu https://cam2.ecn.purdue.edu

PURDUE UNIVERSITY

SUMMARY OF 2017-2018

- New Collaborators: Google, Loyola University Chicago, Intel, Argonne National Laboratory, FIU Florida International University, safetypin, facebook
- Open-Source in github
- REST interface

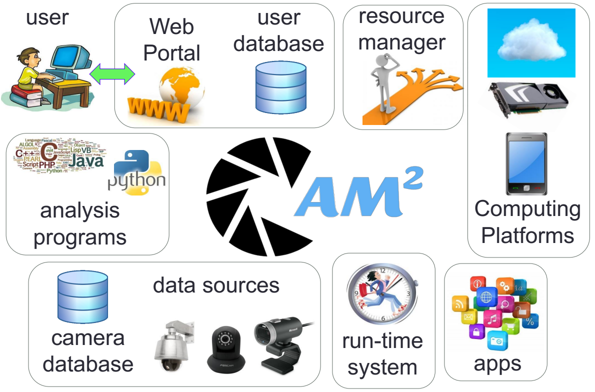
NEW PUBLICATIONS

- IEEE Transactions on Cloud Computing
- IEEE International Conference on Multimedia Information Processing and Retrieval 2018.
- ACM Multimedia 2017
- IEEE International Conference on Information Reuse 2017
- "Parallel Video Processing using Embedded Computers", IEEE Global Conference on Signal and Information Processing 2017
- "Creating the World's Largest Real-Time Camera Network", Imaging and Multimedia Analytics in a Web and Mobile World 2017
- "Internet of Video Things in 2030: a World with Many Cameras", IEEE International Symposium of Circuits and Systems 2017.

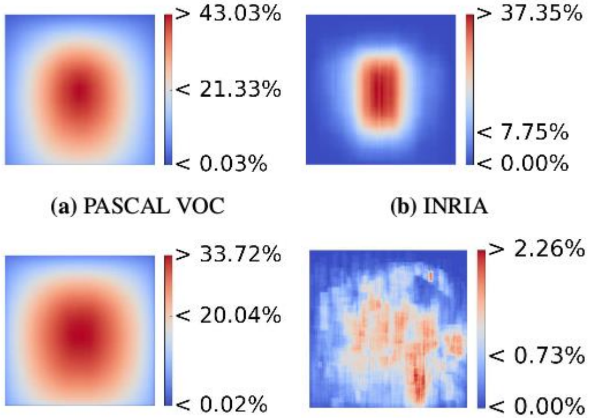
MEDIA COVERAGE

Government Technology, WIRED, MintPress News, ACM TechNews

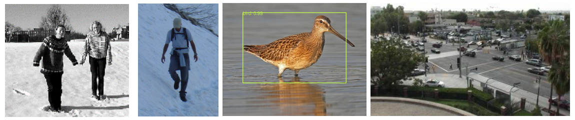
CAM2 COMPONENTS



UNDERSTAND DATA BIAS

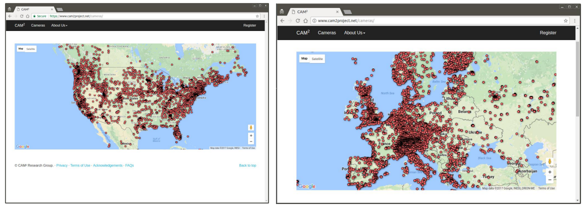


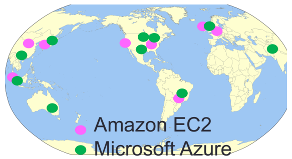
(a) PASCAL VOC (b) INRIA (c) ImageNet (g) CAM2

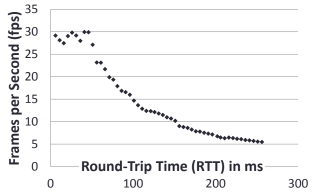


USC INRIA ImageNet CAM2

GLOBAL SCALE







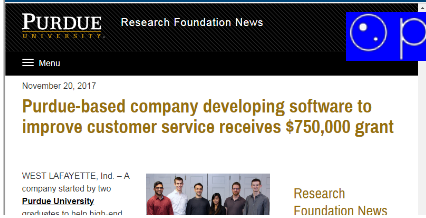
USER RECRUITMENT AND OUTREACH

Vertically Integrated Projects

Midwest Undergraduate Research Workshop

COMMERCIAL SPIN-OFF

perceive


PURDUE UNIVERSITY Research Foundation News

Menu

November 20, 2017

Purdue-based company developing software to improve customer service receives $750,000 grant

WEST LAFAYETTE, Ind. – A company started by two Purdue University graduates to help high-end

Research Foundation News

Collaborative Research: Building Sustainable Tools and Collaboration for Volcanic and Related Hazards Program: Software Infrastructure for Sustained Innovation

Abani Patra

An open source multi-physics platform to advance fundamental understanding of plasma physics and enable impactful application of plasma systems

Davide Curreli and Steve Shannon

Parsl: A Python-based Parallel Scripting Library

http://parsl-project.org

Yadu Babuji, Kyle Chard*, Ian Foster*, Daniel S. Katz°, Mike Wilde*, Anna Woodard*, Justin M. Wozniak**
**Computation Institute, University of Chicago and Argonne National Laboratory*
°National Center for Supercomputing Applications, University of Illinois at Urbana-Champaign

Goals: Easily write Python workflows that glue together external programs and Python functions; run them quickly and easily in parallel on diverse resources

Simple installation:

```
pip install parsl
```

Annotate functions to make Parsl ***apps***

- Bash apps call external applications
- Python apps call Python functions

Apps run concurrently respecting data dependencies via futures. Natural parallel programming!

Parsl scripts are independent of where they run. Write once run anywhere!

Features: Multi-site work distribution, automatic elasticity, Gobus data staging, resilience, containers.

```
from parsl import *
from parsl.configs.local import localIPP, localThreads

dfk = DataFlowKernel(config=localIPP)

@App('bash', dfk)
def generate(outputs=[]):
  return "echo $(( ( RANDOM )) &> {outputs[0]}"

@App('python', dfk)
def total(inputs=[]):
  total = 0
  for i in inputs:
      with open(i, 'r') as f:
          total += sum([int(line) for line in f])
  return total

# Create 5 files with random numbers
output_files = []
for i in range (5):
   output_files.append(generate(outputs=['random-%s.txt' % i]))

# Calculate the sum of the random numbers
t = total(inputs=[i.outputs[0] for i in output_files])
print (t.result())
```

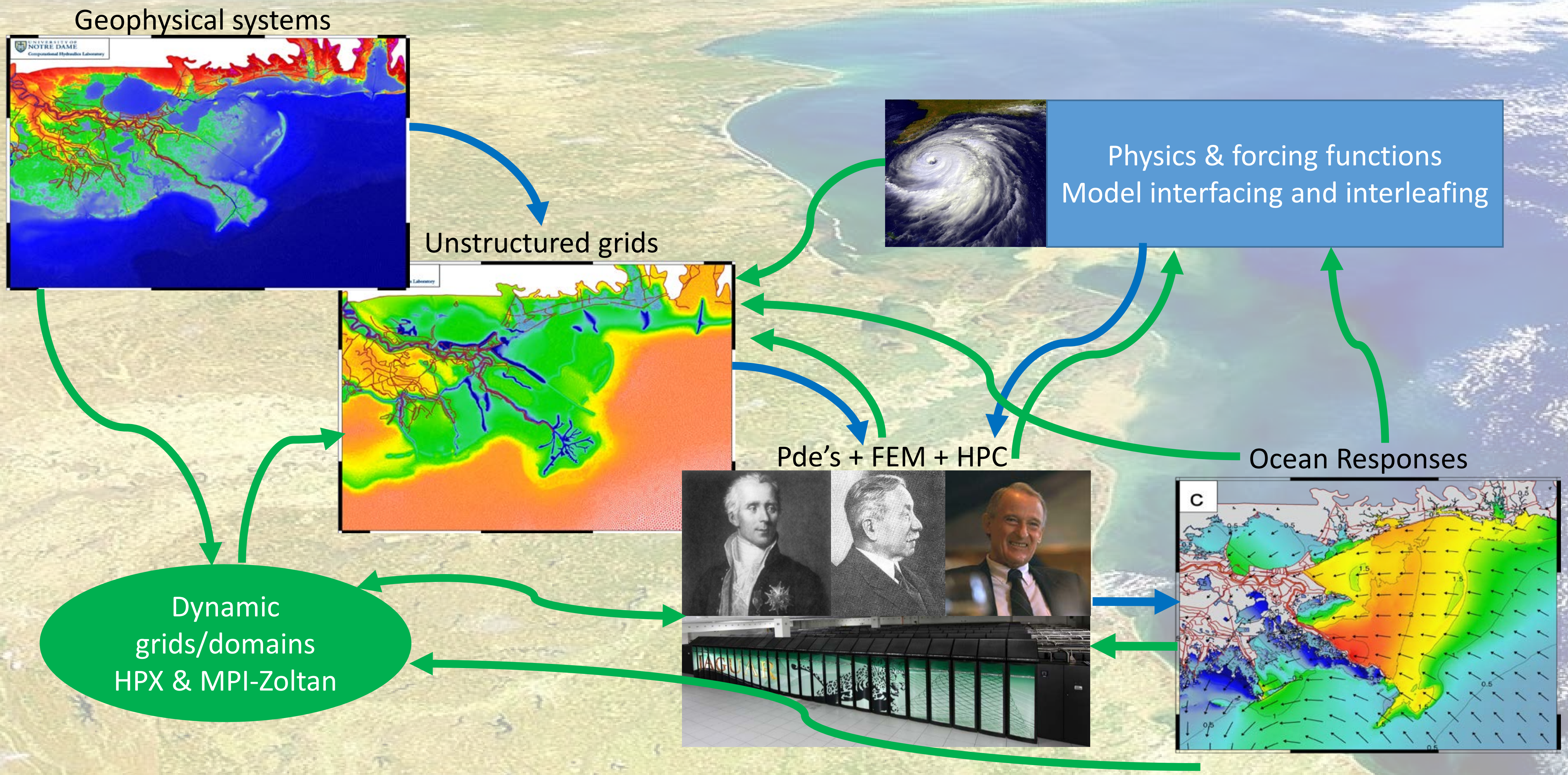
MetPy - A Python GEMPAK Replacement for Meteorological Data Analysis

Ryan May

STORM: a Scalable Toolkit for an Open Community Supporting Near Real-time High Resolution Coastal Storm Modeling

Hartmut Kaiser[1], Joannes Westerink[2], Rick Luettich[3], Clint Dawson[4]

[1]Louisiana State University, [2]University of Notre Dame, [3]University of North Carolina, [4]University of Texas at Austin



SI2-SSE: 3DSIM: A Unified Framework for 3D CPU Co-Simulation

ANKUR SRIVASTAVA

SI2-SSI: Sustainable Open-Source Quantum Dynamics and Spectroscopy Software

Xiaosong Li

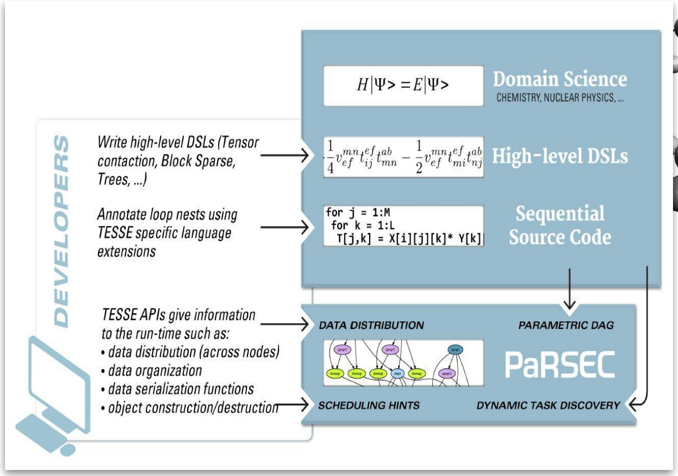
Collaborative Research: SI2-SSI: EVOLVE: Enhancing the Open MPI Software for Next Generation Architectures and Applications

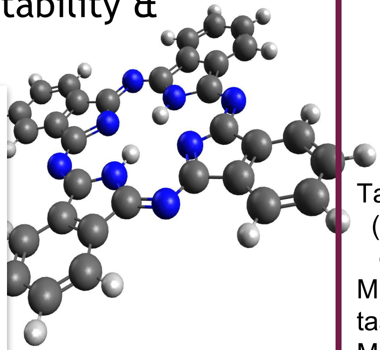
George Bosilca

SI2-SSI: TESSE
Task Based Environment for Scientific Simulation at Extreme Scale

Robert J. Harrison, Mohammad M. Javanmard, George Bosilca, Thomas Herault, Damien Genet, Edward F. Valeev

- **Challenge:**
  - Execute dynamic algorithms over irregular data on extreme scale hybrid machines using a task-based runtime
  - Guarantee performance portability & productivity





Recent Development

New Programming Model:
Templated Task Graph (TTG)

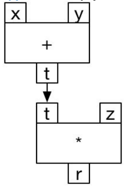
- General purpose programming model implemented in C++
- Applications composed as graphs of templated Ops encoding DAG of tasks instantiated at runtime
- Abstracts out the details of the execution runtime (PaRSEC and MADNESS already supported)

Tasks are parameterized
(loop index, label of node, couple of indices)
Minimize the known task graph
Match tasks with keys
Explicit send / implicit receive

```
void Plus::op(const keyT &key,
              baseT::input_values_tuple_type &&t,
              baseT::output_terminals_type &out) {
  auto x = baseT::get<0>(t);
  auto y = baseT::get<1>(t);
  ::send<0>((int) (key), x+y, out);
}

Plus plus;
Times times;

connect<0, 0>(&plus, &times);
```



TensorFlow for general-purpose workloads

SI2-SSE: Visualizing Astronomy Repository Data using WorldWide Telescope Software Systems

P. Bryan Heidorn (PI) and Gretchen Stahlman, University of Arizona School of Information
Julie Steffen (Co-PI) and Tom Hicks, American Astronomical Society

NSF SI2-SSE: 1642446

Project Objectives

- WorldWide Telescope visual front-end for Astrolabe repository of legacy data.
- Tools for processing raw data into Astrolabe and visualization formats needed by WWT.
- Integration of the Unified Astronomy Thesaurus (UAT) into both Astrolabe and WWT.
- Data manipulation tools necessary to use WWT as a first look in archive browsing and retrieval.
- Workshops to identify community need for years 2 and 3.

Year 1 Development

- Port of key WWT functions to web interface.
  ~20k users/month since Oct

Year 2 Development Status

- Integrating software with CyVerse
- Community outreach
- Ingesting data and metadata

Year 2 Astrolabe Tools

- JS9 - WWT
- Glue
- Jupyter Notebook
- Topcat
- Customized metadata template
- UAT keywords
- DataCite DOIs

Year 2 Outreach

- Splinter session workshop held at American Astronomical Society annual meeting in January 2018
- Workshop and hackathon held at Biosphere 2 in March 2018
- Paper to be published in ApJS: *"Astrolabe: Curating, Linking and Computing Astronomy's Dark Data"*




CYVERSE™ THE UNIVERSITY OF ARIZONA

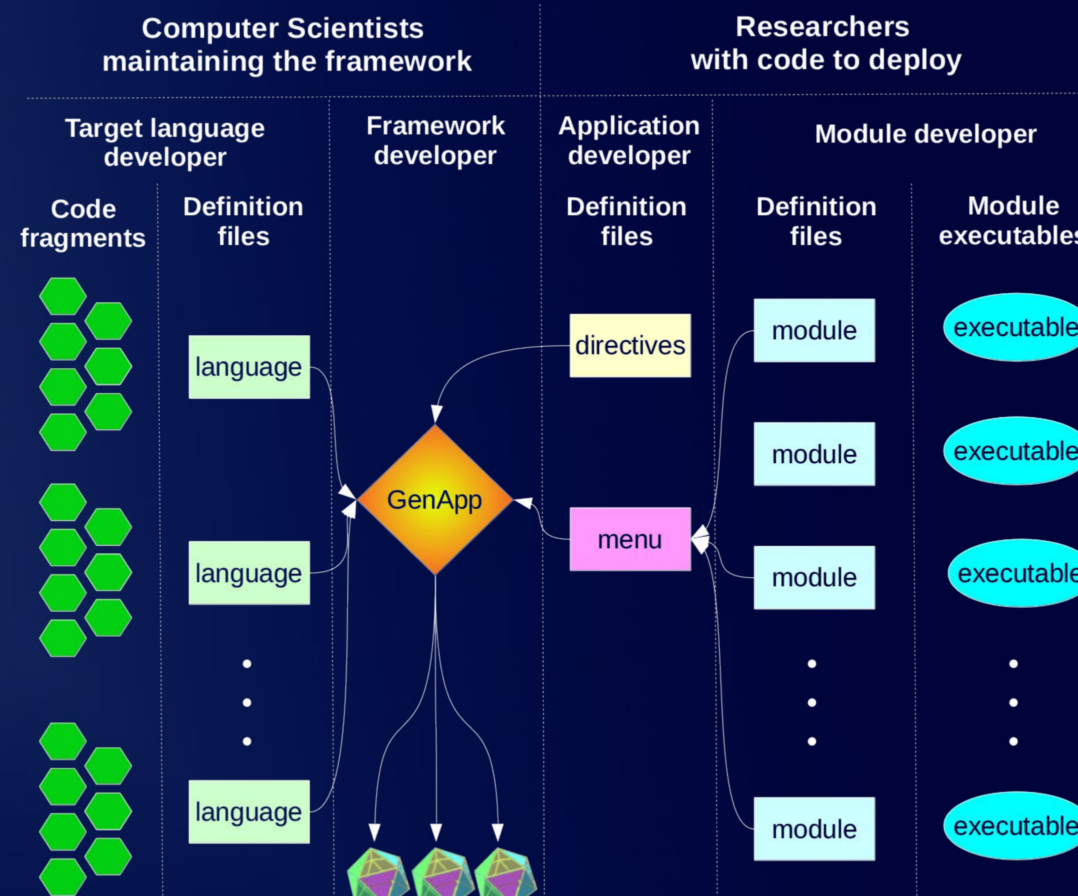
http://astrolabe.arizona.edu
https://osf.io/sp349/

AMERICAN ASTRONOMICAL SOCIETY

SI2-SSE: GenApp - A Transformative Generalized Application Cyberinfrastructure

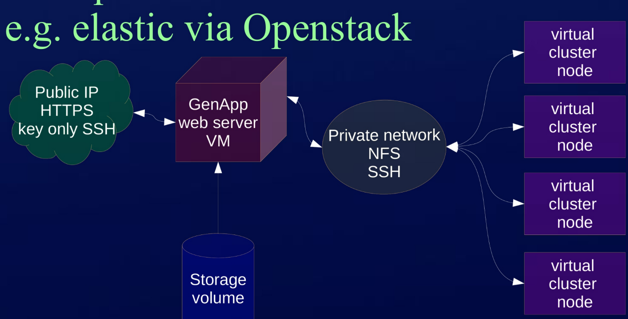
E. H. Brookes[a], J. E. Curtis[b], D. Fushman[c], S. Krueger[b] and A. Savelyev[a]

[a]Department of Biochemistry & Structural Biology, University of Texas Health Science Center at San Antonio, San Antonio, Texas
[b]NIST Center for Neutron Research, Gaithersburg, Maryland
[c]Department of Chem. & Biochem., University of Maryland, College Park, Maryland

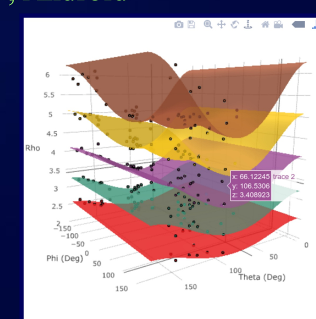


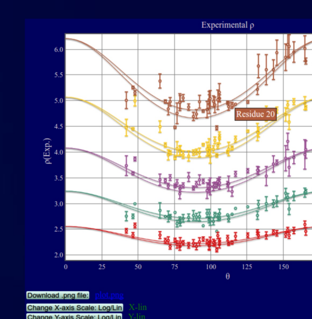
HTML5/PHP, JAVA, Qt4, Qt5, Android

Multiple Execution models
e.g. elastic via Openstack



Full featured: job management, “cloud” files, messaging, integrated feedback, context help, 2 & 3d plots, atomic structures audio, video





OAC-1740097
OAC-1739549

https://genapp.rocks

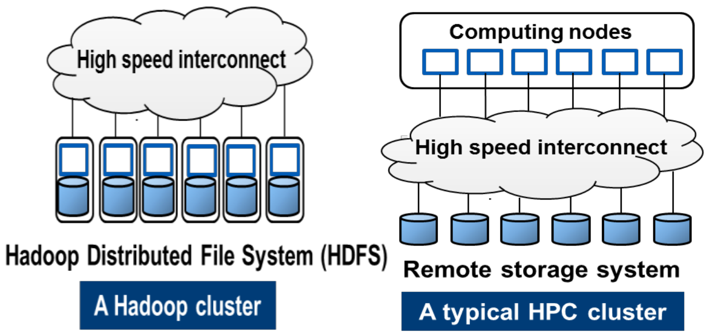
GenApp

Application Characterization for Adaptive Computing Platform Determination for Computational and Data-Enabled Science and Engineering

Haiying Shen, Associate Professor
University of Virginia, USA
hs6ms@virginia.edu

Walter B. Ligon, Associate Professor
Clemson University, USA
walt@clemson.edu

MOTIVATION



- Hadoop platforms with local storage and dedicated storage
- Different applications may benefit differently from the two platforms

PROJECT

- Application performance comparison (I/O, data, and CPU intensive)
- Best platform determination
- Adaptive hybrid Hadoop platform construction

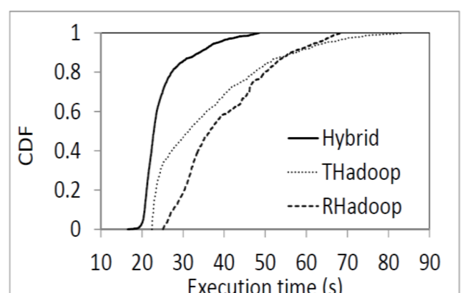
OBSERVATIONS

- Remote file system Orange File System (OFS) outperforms local file system HDFS when the data size is large due to the fast I/O.
- HDFS outperforms OFS when the data size is small due to the network latency.
- Scale-up machines are better for small jobs but not large jobs.
- Scale-out machines bring more benefits to process a larger amount of data than scale-up machines.

SOLUTIONS

- Determine thresholds to decide whether use:
  - local storage or remote storage
  - scale-up or scale-out nodes

RESULTS



Hybrid: hybrid scale-up/out cluster with OFS
THadoop: traditional scale-out Hadoop with HDFS
RHadoop: traditional scale-out Hadoop with OFS

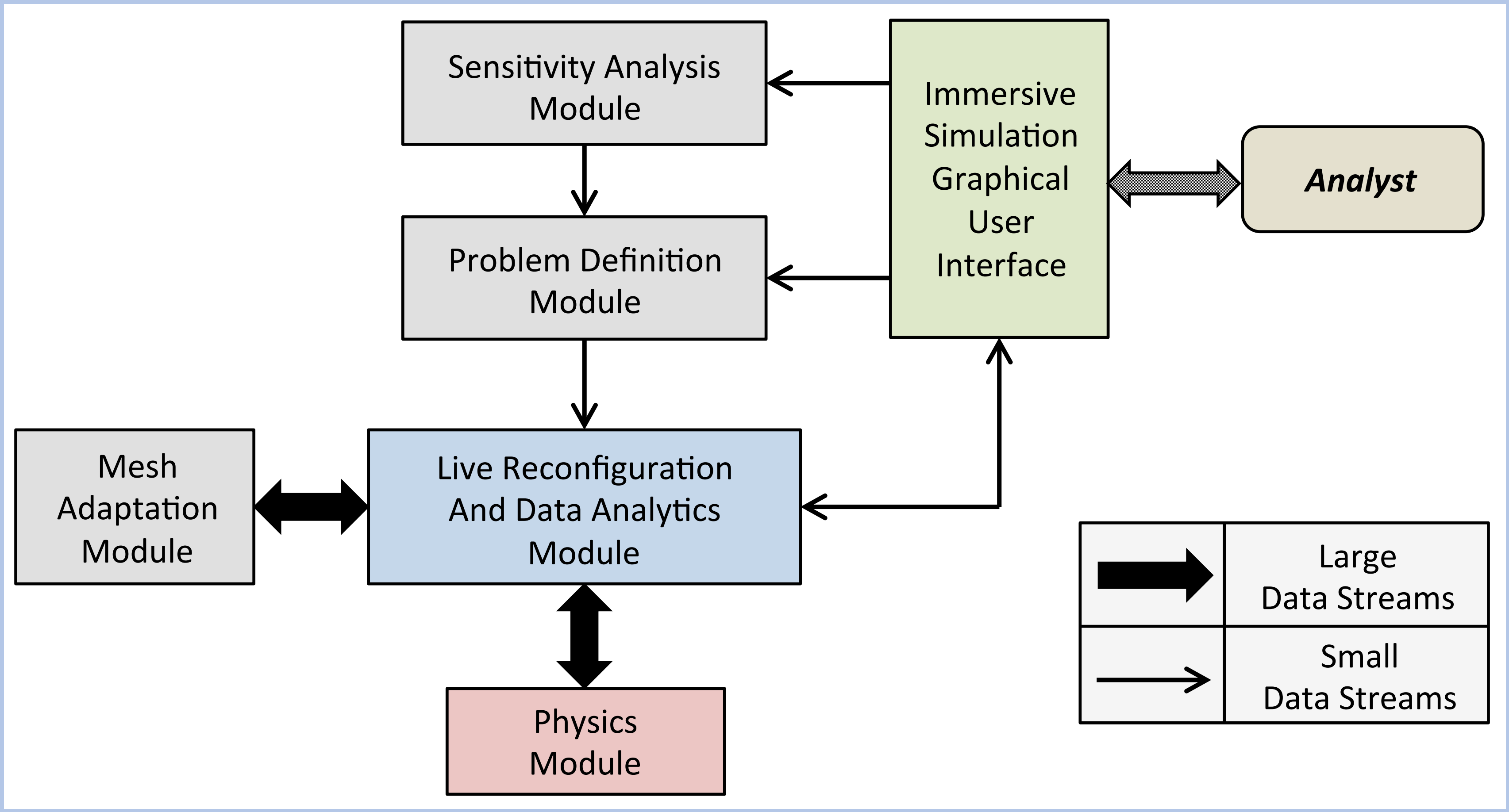
UNIVERSITY of VIRGINIA
CLEMSON UNIVERSITY
NSF

Software Elements to Enable Immersive Simulation

Corey Nelson, Felix Newberry, John A. Evans, Kurt Maute, Alireza Doostan, Kenneth E. Jansen

Ann and H.J. Smead Department of Aerospace Engineering Sciences, University of Colorado, Boulder, CO 80309

2018 NSF SI^2 PI Meeting



Acknowledgments: Funded by SI2 program of the NSF OAC-**1740330.** Collaboration of https://github.com/SCOREC/core and https://github.com/PHASTA .

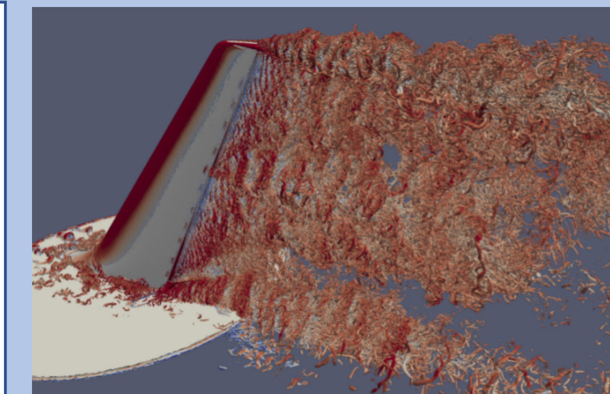
A Data-Centric Approach to Turbulence SImulation

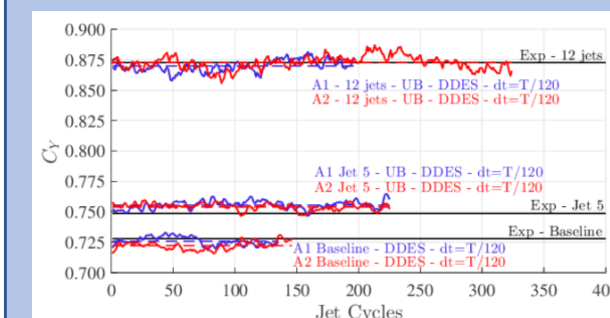
Eric Peters, Riccardo Balin, Ryan Skinner, John A. Evans, Philippe R. Spalart, Alireza Doostan, Kenneth E. Jansen

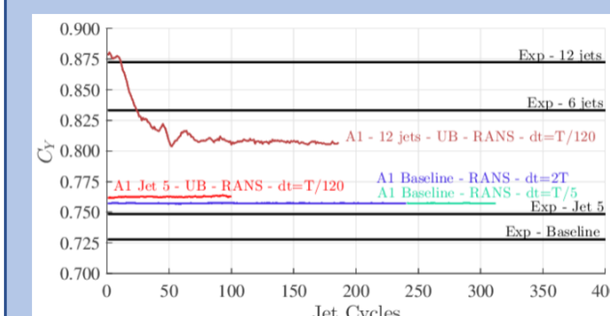
Ann and H.J. Smead Department of Aerospace Engineering Sciences, University of Colorado, Boulder, CO 80309

2018 NSF SI² PI Meeting

- Separating turbulent boundary layers are poorly predicted by Low Fidelity Models (LFM)
- High fidelity models can predict them but at a cost far too high for design or uncertainty quantification (UQ)
- Goals of this project are:
  - Leverage Multi-Fidelity Modeling (MFM) to accelerate confident design space exploration
  - Contribute to Direct Numerical Simulation (DNS) data base of separating turbulent boundary layers
  - Use Machine Learning (ML) to improve LFM turbulence modeling closures from DNS data
- https://github.com/PHASTA







Acknowledgments: Support from CDS&E program of NSF CBET-1710670. Computer resources DOE ANL INCITE program and Early Science program.

NSCI SI2-S2I2 Conceptualization of ***CFDSI***: Model, Data, and Analysis Integration for End-to-End Support of Fluid Dynamics Discovery and Innovation

University of Colorado Boulder

Kenneth E. Jansen Jed Brown, Alireza Doostan, John A. Evans, John A. Farnsworth, Peter E. Hamlington, and Kurt K. Maute

Caltech

Beverley J. McKeon

Johns Hopkins University

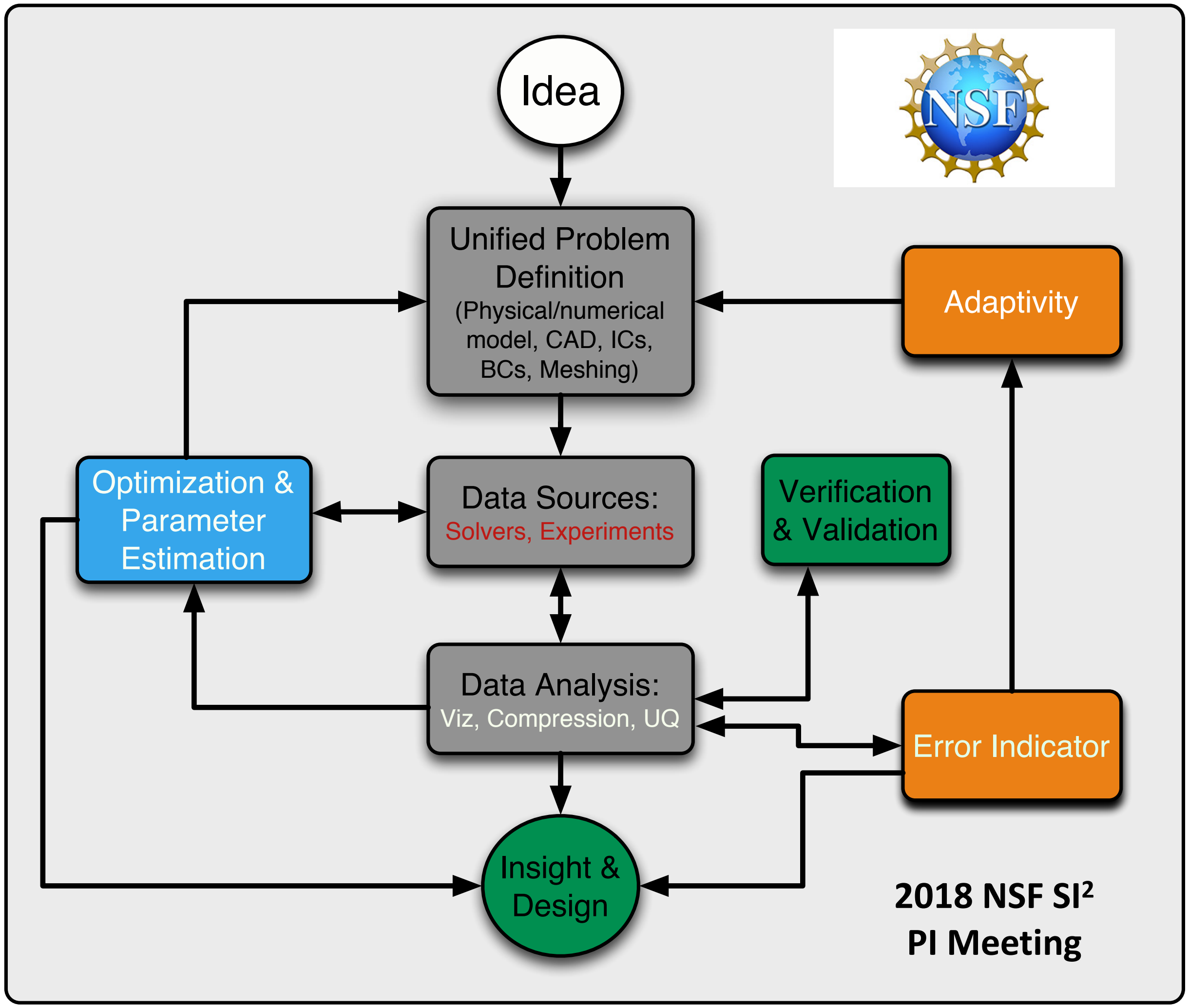
Charles V. Meneveau

TEXAS The University of Texas at Austin

Robert D. Moser

Rensselaer

Mark S. Shephard, Onkar Sahni, and Cameron Smith



2018 NSF SI² PI Meeting

Acknowledgments: Funded under the SI2 program of the National Science Foundation OAC-**1743178**. https://www.colorado.edu/events/cfdsi/

Extending the physics reach of LHCb in Run 3 using machine learning in the real-time data ingestion and reduction system

The LHCb detector is being upgraded for Run 3 (2021-2023), when the trigger system will need to **process 25 exabytes per year**.

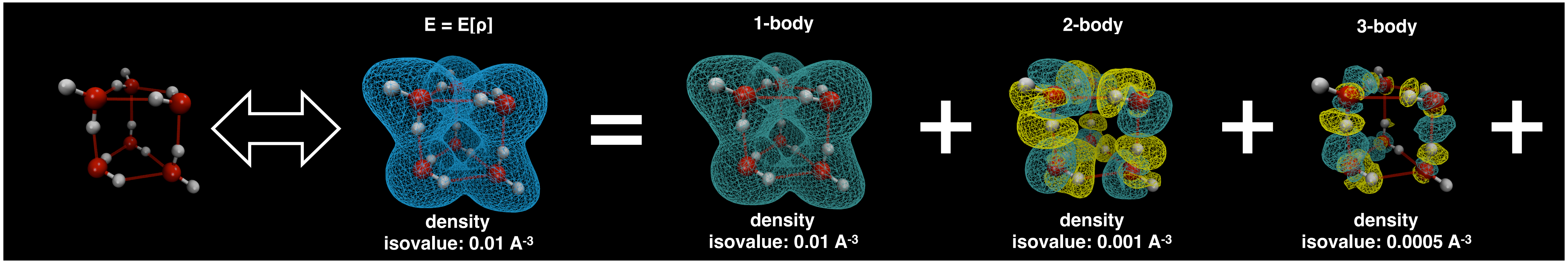
- Currently, only 0.3 of the 10 exabytes per year processed by the trigger is analyzed using high-level computing algorithms; the rest is discarded prior to this stage using simple algorithms executed on FPGAs.
- To significantly extend its physics reach in Run 3, LHCb plans to process the entire 25 exabytes each year using software triggers running on a CPU farm. On average, this will require analyzing events 100 times faster than is possible today.

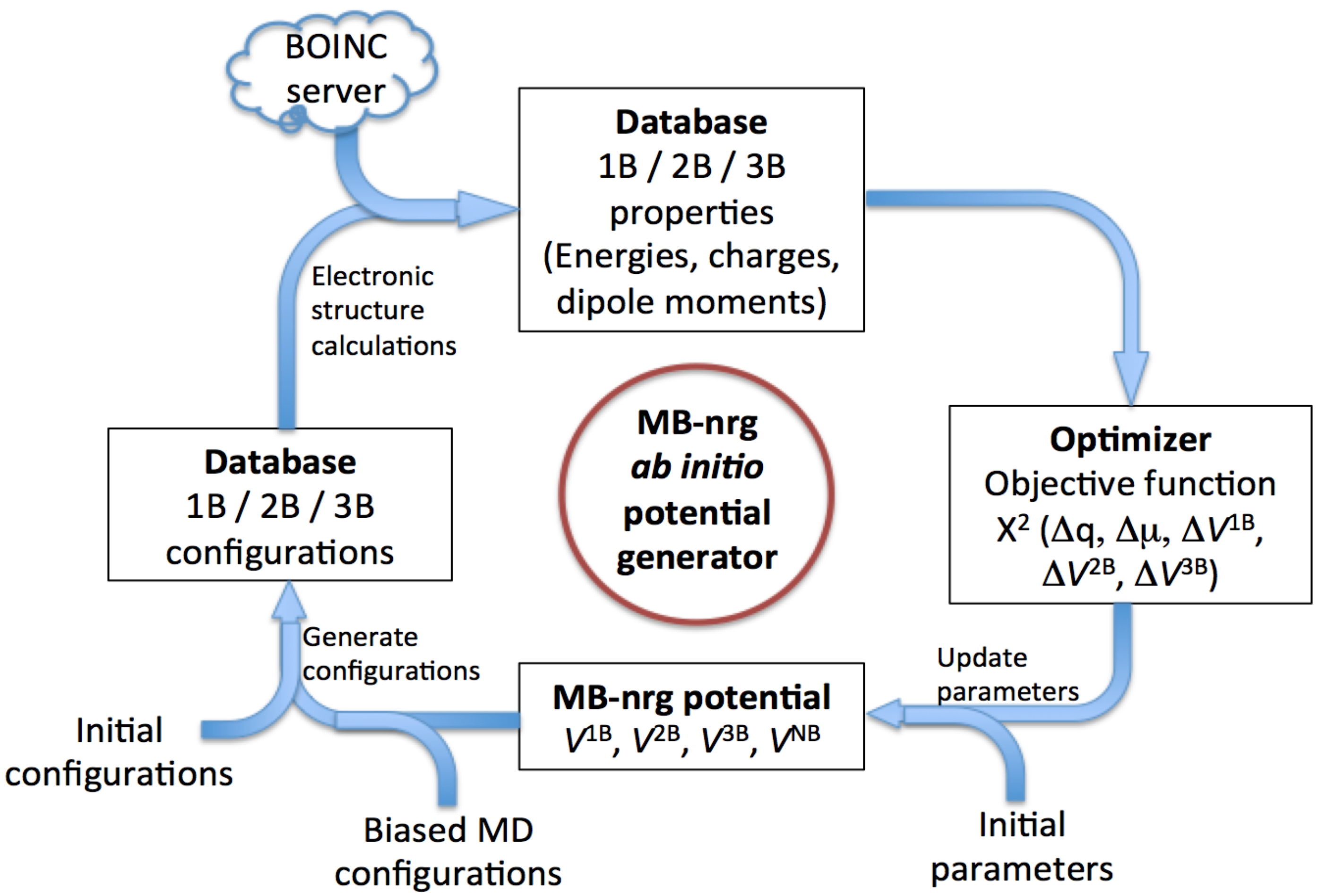
The primary objective of this project is to **expand the use of machine learning (ML) in the LHCb trigger**, to greatly improve its performance while satisfying its robustness and sustainability requirements. Specifically, ML algorithms will be developed to:

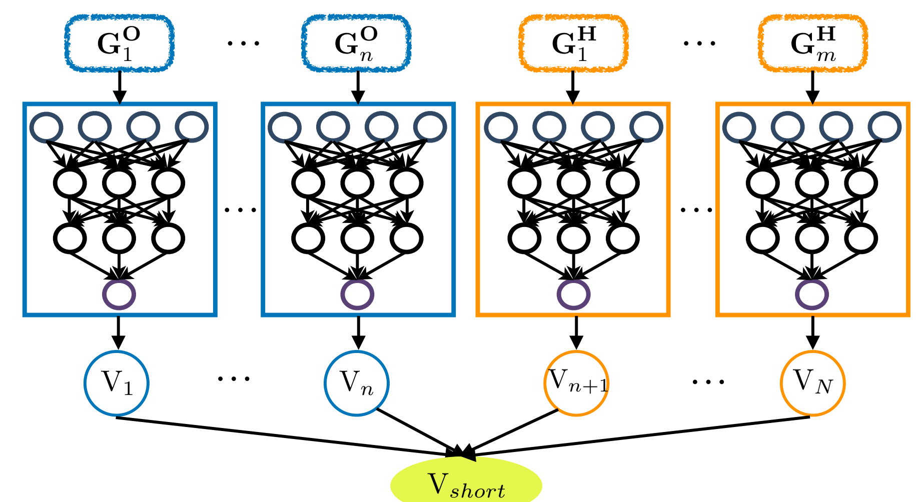
- replace the most computationally expensive parts the event pattern recognition;
- increase the performance of the event-classification algorithms; and
- reduce the # of bytes persisted per event without degrading physics performance.

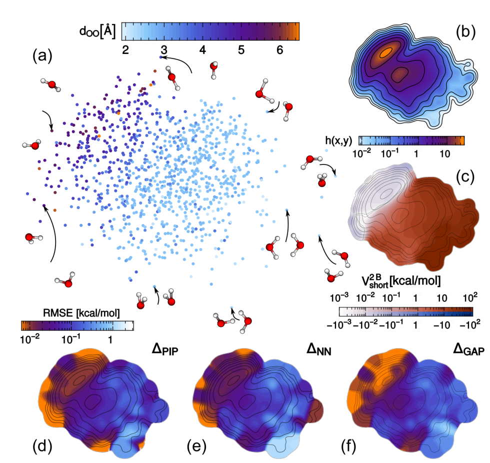
Data-Driven Models for Predictive Molecular Simulations

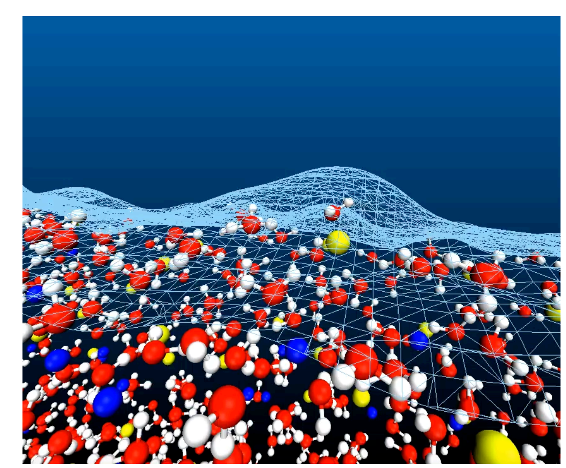
PI: Paesani; Co-PIs: Götz & Zonca











SI2SSI: Collaborative Research: A Robust High-Throughput Ab Initio Computation and Analysis Software Framework for Interface Materials Science

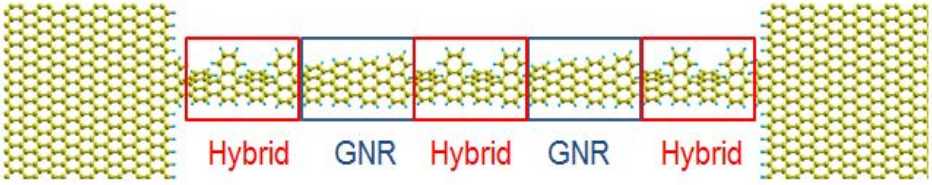
Yifei Mo

NSCI SI2-SSE: Multiscale Software for Quantum Simulations of Nanostructured Materials and Devices

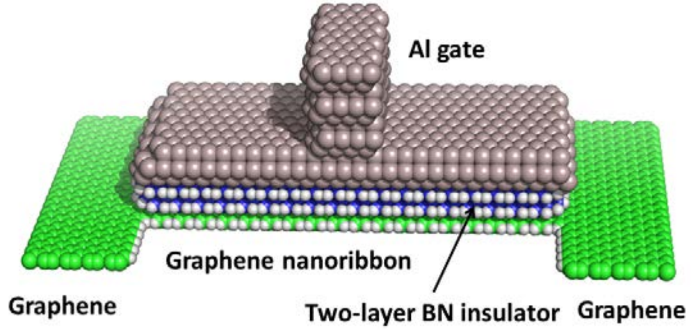
J. Bernholc, E. L. Briggs, W. Lu, C. T. Kelley, Z. Xiao, and J. Zhang
North Carolina State University, Raleigh

- **“Real” materials structures are often complex and cannot be reduced to a few hundreds of atoms**
  - **Process simulation requires large systems**
- **Materials Genome – White House initiative to “deploy advanced materials twice as fast, at a fraction of the cost”**
- **National Strategic Computing Initiative (NSCI)**
  - **Pre-exascale, 150-300 pflops ~2018; Sustained exaflop ~2021**

- **Real-space multigrid (RMG) open-source software www.rmgdft.org**
  - **High performance on supercomputers, clusters and desktops**
- **RMG-NEGF method for simulating nanoscale devices: I-V, gain, etc.**



Novel negative differential resistance device



The N-Jettiness Software Framework for Precision Perturbative QCD Calculations in Particle and Nuclear Physics

Frank Petriello

- Python Analysis Infrastructure
  - Support static/dynamic/symbolic analysis, like LLVM for C/C++ static and KLEE for C
- Use in research
  - Enable researches like software engineering, programming languages, machine learning, AI and data science
  - Improve data processing effectiveness, reliability, stability and efficiency
  - Projects
    - data provenance tracking
    - white box tuning
    - data debugging
    - instability detection in floating point data processing
    - Synthesize workarounds fro cross-project bugs in data processing ecosystems
    - Intelligent debugging assistant by probabilistic inference
    - Automated programming assignment grading and synthesis

Enhancing the PRIMME Software for Eigenvalues and SVD problems

Andreas Stathopoulos, Computer Science , College of William & Mary

Applicability: Large matrices, a number of smallest / largest / interior e-values

- Theory: state-of-the-art, optimized, preconditioned methods
- Stability and robustness: solutions close to machine precision
- Tuned: full set of defaults and auto-tuning for end-users
- Flexible: full customizability for expert users
- Performance: HPC, parallel, block (tall skinny) methods, GPUs
- Interfaces: F77, MATLAB, Python, R, Julia, Nim

https://github.com/primme/primme

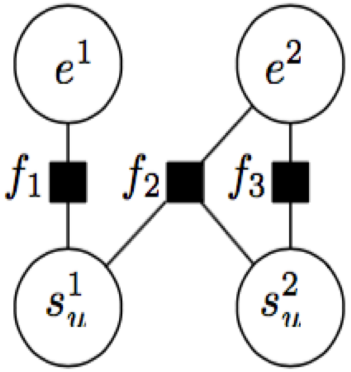
AttackTagger: Early threat Detection for Scientific Cyberinfrastructure

- Employ factor graphs, a probabilistic graphical model, to capture attacker behavior and detect malicious activities
- Learning graph structure that represents dependencies and their strength among observed events and attack stages

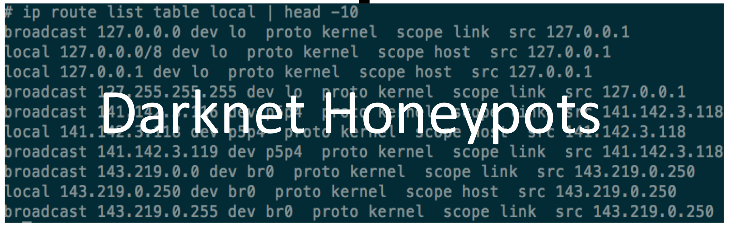
Syslog, netflow, linux auditd, bro IDS logs, etc.

Network Monitoring

Custom Data Pipeline Tools



AttackTagger



Joint project: Cyber Security and Networking Division at the NCSA and the University of Illinois DEPEND Group
http://depend.csl.illinois.edu/ http://security.ncsa.Illinois.edu

Goal: transition AttackTagger research into tool easily deployed in security monitoring ecosystems

Open Source Matrix Product States: A Simulation Platform for Quantum Computing Technologies

Daniel Jaschke, Matthew T. Jones, and Lincoln D. Carr

Quantum simulator design to support over 300 *analog* quantum computers on 10+ architectures

Beautiful visualizations, In-situ performance metrics, Fully customizable Python output

A **Model Store** maintained by a community of experts: Ising, Hubbard, Exciton, …

Methods include **strongly correlated entangled dynamics** for open and closed quantum systems

Matrix product states (MPS), exact diagonalization, Lindblad equation, Krylov time propagation, …

…

2850 downloads from SourceForge, established code in v3.0

SI2-SSE: Building Science Gateway with SGCI support on local HPC cluster *Mio*, 200+ dedicated cores

Large User Community of Experimentalists, Theorists, Educators, and Citizen Scientists

Two graduate students, PI, undergraduate researchers provide dedicated user support

https://sourceforge.net/projects/openmps/

Coastal Infrastructure Protection

The entrance the 168th Street subway station in New York City. Taken by Seidenstud - 2006

Computing Densities for Stochastic Differential Equations

Harish S. Bhat, Applied Math, UC Merced (hbhat@ucmerced.edu)

Given an SDE $dX_t = f(X_t;\theta)dt + g(X_t;\theta)dW_t$ would you like to compute its PDF? Estimate θ?

Density tracking by quadrature (DTQ) can help!