A Unified Data-Driven Approach for Programming In Situ Analysis and Visualization

Overview
Among today’s challenges of constrained power budgets and rapidly changing processor and system architecture designs, this project aims to study a unified data-driven approach for programming applications and in situ analysis and visualization. Our studies are driven by the needs of common operations as well as those of three application areas.

Themes Addressed
This project focuses on studying the impact of the following in the context of a unified data-driven approach:
- Supporting effective in situ data management, analysis, and visualization.
- Providing a foundation for building efficient and effective workflow management.
- Enabling an interactive in situ user environment on the underlying runtime software design.
- Understanding the impact on existing applications, infrastructures, and tools.

Mission Problems
- Constrained power budgets for supercomputing.
- Increased quantities of data generated by scientific computing.
- Limits on placement and movement of data due to performance and energy constraints at extreme scale.
- Programming scientific applications and data analysis and visualization amid rapidly changing processor and system architecture designs.

Collaborations
- Application areas of combustion, climate and cosmology, with scientists located at Sandia, Los Alamos and Argonne.
- ExaCT Co-Design Center.
- Industry partners from DOE FastForward and DesignForward activities (AMD and NVIDIA).
- The biennial workshop that will include the external community.

Legion Programming Model
Legion is a data-driven parallel programming model that provides tools for programming scientific applications and data analysis and visualization amid rapidly changing processor and system architecture designs.

Implementing Analysis and Visualization Algorithms Using Legion

Legion: Data-Aware Programming Model
This project is based on the Legion Programming Model and Runtime System. [http://legion.stanford.edu]

Legion has scaled to over 8,000 nodes with a new implementation of the S3D combustion code on Titan at Oak Ridge National Laboratory.

Unifying Applications and Analytics
- Standard Interface
- Legion-based Interface

Co-Design Applications And Architectures

Combustion
We are focused on several in situ analytics and visualization tools used to identify regions where a flame is extinguishing or auto-igniting. These will all utilize the Legion-based implementation of S3D.

Climate
In an effort to understand ocean heat uptake, sea level rise and the ocean’s role in global heat transport, climate scientists use Lagrangian tracers as an important diagnostic tool. We will work with climate scientists on analyzing large numbers of tracers within the Model for Prediction Across Scales (MPAS) ocean model.

Architecture Co-Design
Our primary hardware interests are in tracking features related to the memory hierarchy, including storage systems, processor-in-memory (PIM) and non-volatile memory (NVRAM) configurations and their algorithmic and programmability aspects.