Proposal

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DOE/Office of Science Program Office Technical Contact: Dr. Lucy Nowell, ASCR
Phone 301-903-3191, Email Lucy.Nowell@science.doe.gov
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High-Performance Decoupling of Tightly Coupled Data Flows

Investigators

Tom Peterka, Lead PI, Argonne National Laboratory
Phone 630-252-7198, Email tpeterka@mcs.anl.gov
Dries Kimpe, Co-PI, Argonne National Laboratory
Franck Cappello, Co-PI, Argonne National Laboratory
Jay Lofstead, Co-PI, Sandia National Laboratories

Abstract

Exponential increases in data size and the need to distill enormous amounts of information into usable knowledge are pushing the limits of data processing in science applications. Connecting simulations with various data analyses either through storage (loose coupling) or directly using local or remote memory (tight coupling) is the way that scientists process data, but neither of these two approaches is actually optimal for extreme-scale science. We propose loosening the grip of tight coupling, in essence *decoupling* tightly coupled data flows while keeping their favorable high performance and low power characteristics. Our utilization of optional short- and long-term storage in the dataflow gives us the best of both worlds: tight coupling whenever possible but loose coupling when usage patterns require persistent data. Our proposed research, called *Decaf,* addresses themes 2, 3, and 5 of the FOA: it targets in situ methods and workflows, and we will evaluate our research in full and proxy applications in order to **improve performance, reduce power, add fault tolerance, and enhance usability**. Our proposal will result in (1) a library of dataflow primitives, (2) a method for automatically constructing broadly applicable dataflows from the same set of primitives, designed as (3) a generic and reusable solution that other workflow and coupling tools can use. We will augment our dataflow with essential data operators—pipelining, selection, and aggregation—in order to achieve space-time data permutations within the dataflow, and we will execute the dataflow over various transport layers in current and future HPC architectures. We will integrate three levels of abstraction and software: a *high-level data description* will capture both the intrinsic and extrinsic properties of the data model; the *dataflow model* will synthesize data flows from four basic primitives, and the *transport layer* will move data and control flow with short and long-term buffering. A set of *resilience strategies* will cross-cut all three layers by combining appropriate detection and recovery techniques for fault tolerance. We will tie into existing OS/R research, the other cross-cutting element, to leverage capabilities such as global control backplanes and couple applications across enclaves or partitions. Three use cases found in science codes—Navier-Stokes CFD computations, Ginzburg-Landau superconductivity simulations, and Vlasov-Poisson N-body cosmology codes—will both motivate and validate our research.