

## Time-parallel multiscale/multiphysics framework

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The most challenging computational problems in simulating complex stochastic systems involve modeling the coupling among processes that span several orders of magnitude in space and time. The computational difficulty arises from the fact that the representative governing equations typically apply only over a narrow range of spatiotemporal scales, thus making it necessary to represent complex systems as the interaction of multiple physics modules, termed here as multi-scale/multiphysics (MSMP) coupling. Computational simulations of such systems require algorithms that can efficiently integrate the underlying MSMP methods across the scales in order to achieve prescribed accuracy and control the computational cost. In addition, the algorithms must scale to hundreds of thousands processors or more in order to effectively harness the new computational resources and accelerate the scientific discovery.

Previously we have developed wavelet-based techniques, compound wavelet matrix (CWM) and dynamic CWM (dCWM), that are highly efficient at transferring information among multiphysics models across multiple temporal and spatial scales. This algorithmic gain is in addition to the parallel spatial scalability speed-up from traditional domain decomposition and multigrid methods. However, the CWM and dCWM algorithms are still serial in time and restricted by the smallest-system time-scales. The objective of the current research is to relax this algorithmic constraint.

In this poster, we present the results from coupling of the time parallel (TP), and the CWM algorithms that yield a new approach referred to as tpCWM. We find that the inter-scale information transfer properties of the underlying multiresolution techniques greatly improve the efficiency and scalability of MSMP simulations. Our results indicates that the tpCWM technique can accelerate time-to-solution by 2 to 3-orders of magnitude even on relatively small number of processors and this can potentially constitute a new paradigm for MSMP simulations.

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