

# DOMAIN DECOMPOSITION OF STOCHASTIC SYSTEMS AND ITS PARALLEL IMPLEMENTATION

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Firstly, an scalable parallel algorithm is developed for the domain decomposition of uncertain dynamical systems defined by stochastic partial differential equations. The methodology is particularly amenable to parallel processing for effective exploitation of the computational and storage capability of currently available multiprocessing computational environment. Secondly, the formulation is tailored towards efficient memory usage and minimum inter-processor communication for shared memory parallelism on cluster of symmetric multiprocessor (SMP) machines. To this end, Message Passing Interface (MPI) is used in conjunction with openMP-based explicit Multi-threading as a second level parallelization to enhance performance of the stochastic domain decomposition method. MPI is used to dynamically decompose and process each subdomain among compute nodes while OpenMP directives achieves the second level parallelism involving loop-level iteration necessary for processing each substructure assigned to the given node. The MPI-OpenMP based hybrid code is designed to be compiled just serially (without requiring the use of MPI or openMP library) and with any combination of MPI and OpenMP enabled. This approach permits a systematic study on the performance improvement of the multi-level parallelism of the domain decomposition method for the stochastically uncertain dynamical systems.

## References

- [1] A. Sarkar and R. Ghanem, “Substructure Approach for the Mid-frequency Vibration of Stochastic Systems”, *Journal of the Acoustical Society of America*, **113**, 1922–193, 2003.
- [2] A. Toselli and O. Widlund, *Domain Decomposition Methods - Algorithms and Theory*, Springer Series in Computational Mathematics, Vol. 34, 2004.
- [3] B. Smith, P. Bjorstad, and W. Gropp, *Domain Decomposition, Parallel Multilevel Methods for Elliptic Partial Differential Equations*, Cambridge University Press 1996.
- [4] A. Quarteroni and A. Valli, *Domain Decomposition Methods for Partial Differential Equations*, Oxford Science Publications 1999.

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