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Flow simulations on massively parallel computers including multi-core processors

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ABSTRACT

To achieve the goal of reliable flow simulations for practical problems requires methods that are extensible to a massive level of parallelism and can attain petascale performance. In this work, the mesh is decomposed into balanced parts, where each part is assigned to a task/process under the parallel application. This leads to sharing of degrees-of-freedom between parts and requires communication of data. We present steps and structures that can be employed in parallelization of computational work to attain excellent scaling on tens of thousands of processors including multi-core architectures. The majority of work can be divided into two portions, element-level calculations to form algebraic system of equations and finding the solution.

To account for parallelization on multi-core processors, the part-level computations, over a task with shared address (memory) space on a processor/node, are performed in terms of blocks corresponding to cores. Each block is handled by a core and involves groups of elements during algebraic system formation phase and collections of rows during solution of equation system formed. Note that part-level computations over multi-cores on each node do not require any parallel communications. In this work, we study the effectiveness of the current approach and compare to alternate approaches (e.g., using communications for all cores) which already have excellent strong scaling capacity but require highly specialized communication fabric. Applications will include blood flow in patient-specific arterial system and also multi-phase flows.