PARALLEL ANISOTROPIC MESH ADAPTATION WITH BOUNDARY LAYERS

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ABSTRACT

This study introduces a set of procedures for anisotropic mesh adaptation accounting for mixed element types and boundary layer meshes that operates in parallel on distributed meshes. The procedures accept an anisotropic mesh metric and boundary layer size field information as inputs and apply local mesh modifications to adapt the mesh to match that size field, fully accounting for the actual geometry of curved domains while maintaining the semi-structured nature of the elements in the boundary layers.

In the distributed environment, it is crucial that during the mesh adaptation process all mesh entities communicating over part boundaries perform correct updates such that the complete mesh remains valid after its modification. This thesis presents the infrastructure to support parallel mesh modification operations using both simple point-to-point data exchange and interaction with mesh migration which is an effective means for mesh cavity localization.

To increase the scalability of large-scale simulations, this work introduces a general-purpose communication package built on top of MPI which is aimed at improving inter-processor communications independently of the supercomputer architecture being considered. The package is developed to support parallel applications that rely on computation characterized by a large number of messages of various sizes, often small, that are focused within processor neighborhoods. The current package provides a utility for dynamic applications based on two key attributes: (i) the explicit consideration of the neighborhood communication pattern to avoid many-to-many calls and to reduce the number of collective calls to a minimum, and (ii) the use of non-blocking MPI functions along with message packing to manage message flow control and reduce the number and time of communication calls.

The parallel anisotropic mesh adaptation procedures are tested on general curved 3D geometries and appropriately manage the geometrical boundary approximation. Four flow problem test cases are presented: a heat transfer manifold, a 3D shallow cavity, an M6 wing and a scramjet engine.