Use of the Cactus Framework for Multi-block CFD Applications

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Abstract. Since its first design in 1997, the Cactus framework [1] has been used for various scientific simulations including astrophysics [2] and CFD [3]. Cactus' modular structure enables collaborative code development between different groups, and the central core along with computational toolkits supports automatic parallelization, seamless development and deployment on modern computer architectures and easy access to many cutting-edge software technologies such as Globus, HDF5, PETSc library, and advanced visualization tools. However, initial Cactus-based CFD codes had limitations. Since these codes were developed individually, their application thorns do not follow any programming standard or coordinated development. Moreover, current applications have been restricted to single-block geometric problems, due to the absence of multi-block data structure support in the Cactus driver. These motivated us to newly design and develop a Cactus CFD toolkit which can cover multi-block simulations on complex geometries.

A detailed schematic of designed Cactus CFD toolkit including a CFD flowchart is shown in Figure 1. Of the CFD modules described on the flowchart, some components generally used on numerical simulations are already available: Carpet driver for automatic parallelization and multi-block data structure, multipatch for multi-block mesh generation, MoL (Method of Line) for time integration of the governing equation. Thus, we focused on implementing CFD-specific modules, such as flux schemes, initial condition and boundary condition, TecPlot-compatible PLOT3D output data, and time integration method optimized for CFD simulations. A general coordinate transformation routine is also implemented, which has not been implemented on the Cactus framework. Developed toolkit is validated through the diffusion simulation on the multi-block domain. The solution shows physically accurate diffusion phenomena, as seen in Figure 2.

Keywords: Cactus, CFD (Computational Fluid Dynamics), Multiblock Driver, High Performance Computing

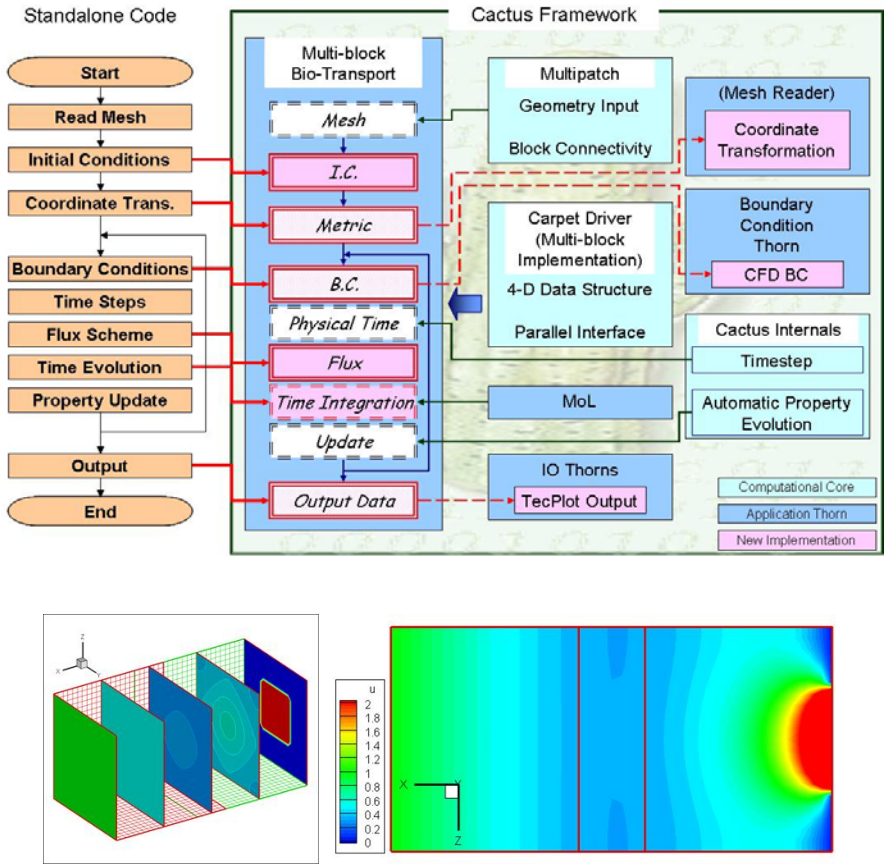

Fig. 1. Designed Schematic of a Cactus CFD Toolkit and Diffusion Simulation on a Multi-block Domain

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