Computational Hydraulic Modeling with UPC Architecture

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Abstract. Computational hydraulic modelling based on the two-dimensional Shallow Water Equations (SWEs) is commonly performed nowadays to address various civil engineering issues including inundation flooding in rivers, tidal circulation in coastal waters, etc. The modelling effort is also becoming very intensive with increasing concerns on uncertainties due to climate changes as well as higher demands on accuracy in dense urban environment. In the last decade, the two popular parallelism architectures, namely Message Passing Interface (MPI) and OpenMP, have been utilized to accelerate the numerical simulations with High Performance Computing. However, MPI has the potential drawback of reaching the performance limitation too early with the crowded message passing among computational nodes, and therefore not able to fully capitalise the number of CPU cores available. At the same time, OpenMP is less scalable, and can only run on shared-memory machines rather than modern day computational architectures that are expandable depending on the domain size of the computation and the resources available. In this project, we developed an alternative solution for the computational hydraulic modelling using Unified Parallel C (UPC) architecture that combines the advantages of MPI scalability as well as the direct memory access of OpenMP. We implemented a second-order Godunove-type MUSCL scheme flood model with second-order accuracy with the UPC architecture, and examined the performance in the two configurations of a 64-core shared-memory machine and a 512-core distributed-memory system. The computational results showed significant time improvement over the existing sequential modelling approach.

Keyword: Computational hydraulic modelling, SWEs, high performance computing, UPC