Oceans'17 MTS/IEEE Anchorage: Tutorial Proposal

Introduction to Parallel Distributed Memory Computing for Coastal Ocean Studies with EFDC

IBM Research – Ireland

Date: September 18th, 2017
Location: Ocean's Conference in Anchorage, Alaska
Tutorial Organizer: Dr. Fearghal O'Donncha– feardonn@ie.ibm.com
Tutorial Facilitators: Prof. Scott James – SC_James@baylor.edu
Dr. Fearghal O'Donncha

Topic Overview:

IBM Research – Ireland, in an effort to address the demands for ever-more-complex and high-resolution model simulations, has deployed the Environmental Fluid Dynamics Code (EFDC) on distributed-memory, multi-core machines and platforms. Integrating fundamentals of hydrodynamic modelling, domain decomposition, and MPI parallelisation, a serial code was surgically translated to multi-core deployment. This class will introduce participants to hydrodynamic modelling with EFDC and developing and deploying it in parallel environment. The tutorial will comprise interactive lectures, practical examples, and discussions. Details on the theory of hydrodynamic modelling and an overview of parallel computing and deployment of the EFDC model for both shared-memory and distributed-computing systems will be presented. Model simulations from case studies of a simple straight channel and a large-scale, real-world site in Galway Bay, Ireland will be presented. At the end of the tutorial, the attendees will: understand the fundamentals of parallel computing, be able to run EFDC in parallel, and be able to apply the techniques to models of their own study sites.

Target Audience:

This tutorial will benefit researchers, environmental consultants, and regulators. EFDC facilitates simulation of physical, chemical, and biological processes in bays, rivers and estuaries. By integrating with modern compute capabilities, it allows for study of various complex and real-world phenomena with high resolution and precision. Participants may ultimately apply the model to their own studies, and by gaining an understanding of the fundamental mathematical and computational theory, develop and extend their own modules. To ensure this, the tutorial follows best-practise development methodologies using the "DevOps" approach. The tool can be used to enhance decision making in industry, government, and research. For example, EFDC can be used to support Environmental Impact statements. Further, industry-specific modules such as those for simulating the impacts of aquaculture installations and hydrokinetic current-energy-converter technologies makes it particularly applicable for stakeholders from these industries. The model is complemented by an advanced data-assimilation module to integrate with observations and improve solution accuracy. The tool can be used to investigate environmentally relevant phenomena like changes to the flow field, tidal range, flushing rate, etc. to meet or help establish environmental-impact guidelines; benefiting developers and regulators alike.

Content Details:

This half-day software tutorial will introduce participants to the basics of hydrodynamic modelling and parallel computing. Both a basic and more advanced model will be demonstrated in class. Results will

be visualized with open-source tools and scripts that will be made available to attendees. Table 1 outlines the tutorial topics to be covered.

Table 1: Tutorial timeline.

Topic	Time
1. Introduction/Background/Purpose	30 minutes
2. EFDC model theory and fundamentals	30 minutes
3. MPI parallelisation theory and fundamentals	30 minutes
4. Example: Simple domain decomposition	30 minutes
Coffee break	15 minutes
5. Review of simple domain example	15 minutes
6. Example: Real-world model	30 minutes
7. Review of real-world model results	30 minutes
8. Overall summary and review	30 minutes

Format:
The tutorial materials will be presented with PowerPoint slides. In addition, the EFDC-MPI software will be demonstrated live in class. Participants will be encouraged to follow along on their own computers using the data files made available on the *Oceans'17* website prior to the meeting. All tutorial materials, including software, will be provided. Tutorial facilitators will include Dr. Fearghal O'Donncha and Prof. Scott James.

Biographical sketches:

Dr. Fearghal O'Donncha has been a Research Scientist at IBM Research – Ireland in the Cognitive IoT group for the past five years. He has extensive experience in environmental fluid dynamics modelling as well as in developing and amending codes for deployments on high-performance computing and Cloud platforms.

Prof. Scott James, PE, is an Assistant Professor at Baylor University in the Departments of Geosciences and Mechanical Engineering. He has extensive experience with marine renewable energy modeling having worked at Sandia national Laboratories for 11 years and at E^{x}ponent, Inc. for two.

References:

- O'Donncha, Fearghal, Emanuele Ragnoli, and Frank Suits. "Parallelisation study of a three-dimensional environmental flow model." *Computers & Geosciences* 64 (2014): 96-103.
- O'Donncha, Fearghal, et al. "On the Efficiency of Executing Hydro-environmental Models on Cloud." *Procedia Engineering* 154 (2016): 199-206.
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- https://www.ibm.com/blogs/research/2015/08/ibm-deepcurrent-predicts-environmental-changes-in-3-d/
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