Redundancy, retiming and data flow in compiling
finite-difference applications for manycore architectures

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Background
The finite difference method is the most widely-used approach to solving partial differential
equations in computational science and engineering – with important applications from subsurface
image reconstruction to fluid dynamics to materials science and beyond. Finite difference solvers
have characteristic loop and data-access patterns that benefit from optimisations that rely on
application knowledge not available in general-purpose compilers. Devito, a software developed in
the OPESCI project, provides a high-level language for the finite difference method that opens up the
scope for such domain-specific compiler techniques.

Project aims
The goal of this project is to explore this frontier. The key idea we aim to exploit is symbolic
manipulation of algebraic expressions to expose redundant computations, and to do this in concert
with modelling of when to evaluate such expressions, where to store them, and when
pre-computing them is better than recomputing them. We think there is a way to do this in a
unified, perhaps even optimal, way.

Research methodology
A key element of our research philosophy is the rigorous development of software tools that can be
evaluated on diverse real-world problems of industrial and scientific importance. The work will be
driven (at least initially) by applications in seismic inversion, which provide a rich spectrum of
challenges. We will target the most sophisticated parallel hardware platforms available, including
manycore, multithreaded and wide-vector architectures – such as Intel’s Xeon Phi and Skylake
processors. This is an interdisciplinary project between the Earth Science and Engineering
department and the Computer Science department. As such, the candidate will work in strict contact
with world leading experts in Mathematics, Geophysics and Computer Science, from both academia
and industry (in particular, Intel Corporation).

Candidate profile
For this project, candidates should have a significant background in either computer science or
applied mathematics. Students, however, will receive extensive training in the core areas of the
project (e.g., compilers, finite differences), through lectures, workshops and direct interaction with
members of the team and external collaborators.

Contact
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Useful links
www.opesci.org - For information about Devito and the OPESCI project, with links to our publications and international collaborations.
https://github.com/opesci/devito - Devito source code repository.
https://www.slim.eos.ubc.ca - We have a strong collaboration with the SLIM group at University of British Columbia, where Devito is used to study advanced subsurface image reconstruction methods.