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# Meshfree/GFEM in hardware-efficiency prospective

Rong Tian*

*Institute of Computing Technology, Chinese Academy of Sciences, Kexueyuan Nanlu 6, Haidian, Beijing 100190, China*

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**Abstract.** A fundamental trend of processor architecture evolving towards exaflops is fast increasing floating point performance (so-called "free" flops) accompanied by much slowly increasing memory and network bandwidth. In order to fully enjoy the "free" flops, a numerical algorithm of PDEs should request more flops per byte or increase arithmetic intensity. A meshfree/GFEM approximation can be the class of the algorithm. It is shown in a GFEM without extra dof that the kind of approximation takes advantages of the high performance of manycore GPUs by a high accuracy of approximation; the "expensive" method is found to be reversely hardware-efficient on the emerging architecture of manycore.

**Keywords:** meshfree; GFEM; manycore; co-design; exascale computing

## 1. Introduction

The work is motivated by the challenge in fully utilizing high floating point performance on the emerging manycore architecture. A fundamental trend of computer architecture evolving towards exaflops ($10^{18}$ floating point operations (flops) per second) is the fast increasing compute power (the so-called "free" flops) accompanied by much slowly increasing memory and network bandwidth. Numerical simulation is seeing an unbalanced increase in the floating point performance (which increases fast) and the memory bandwidth (which increases much slowly). In other words, numerical simulation is likely to be subject to a memory constraint instead of a floating point performance constraint. As a result, a numerical method of PDEs should be designed to request more flops per unit memory access so that the "free flops" are not "wasted' (DOE Exascale Initiative Roadmap 2009, DOE Office of ASCAC 2010, Tian and Sun 2013, Tian 2012).

A meshfree method is able to increase arithmetic intensity for the same number of dofs by increasing the influence radius or by increasing the accuracy of approximation and therefore it may bear a potential in utilizing the redundant floating point capability of the emerging manycore processor. This idea is tried out on a GFEM without extra dof in this paper.

In the next section, we introduce the "performance gap" of the today's supercomputers, which is a huge performance difference between real Scientific and Engineering (S&E) applications and the LINPACK benchmark. In Section 3, by remarking on the trend of hardware change, we point out that the performance gap might be further widen if numerical algorithms do not change

*Corresponding author, Professor, E-mail: rongtian@ncic.ac.cn


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