Data Movement on Emerging Large-Scale Parallel Systems

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Abstract

Large-scale HPC systems are an important driver for solving computational problems in scientific communities. Next-generation HPC systems will not only grow in scale but also in heterogeneity. This increased system complexity entails more challenges to data movement in HPC applications. Data movement on emerging HPC systems requires asynchronous fine-grained communication and efficient data placement in the main memory. This thesis proposes an innovative programming model and algorithm to prepare HPC applications for the next computing era: (1) a data streaming model that supports emerging data-intensive applications on supercomputers, (2) a decoupling model that improves parallelism and mitigates the impact of imbalance in applications, (3) a new framework and methodology for predicting the impact of largescale heterogeneous memory systems on HPC applications, and (4) a data placement algorithm that uses a set of rules and a decision tree to determine the data-to-memory mapping in heterogeneous main memory.

The proposed approaches in this thesis are evaluated on multiple supercomputers with different processors and interconnect networks. The evaluation uses a diverse set of applications that represent conventional scientific applications and emerging data-analytic workloads on HPC systems. The experimental results on the petascale testbed show that the approaches obtain increasing performance improvements as system scale increases and this trend supports the approaches as a valuable contribution towards future HPC systems.