Abstract

In the course of less than a decade, Graphics Processing Units (GPUs) have evolved from narrowly scoped application specific accelerators to general-purpose parallel machines capable of accommodating an ever-growing set of algorithms. At the same time, programming GPUs appears to have become trapped around an attractor characterised by ad-hoc practices, non-portable implementations and inexact, uninformative performance reporting. The purpose of this paper is two-fold, on one hand pursuing an in-depth look at GPU hardware and its characteristics, and on the other demonstrating that portable, generic, mathematically grounded programming of these machines is possible and desirable. An agent-based meta-heuristic, the Max-Min Ant System (MMAS), provides the context. The major contributions brought about by this article are the following: (1) an optimal, portable, generic-algorithm based MMAS implementation is derived; (2) an in-depth analysis of AMD's Graphics Core Next (GCN) GPU and the C++ AMP programming model is supplied; (3) a more robust approach to performance reporting is presented; (4) novel techniques for raising the abstraction level without sacrificing performance are employed. This represents the first implementation of an algorithm from the Ant Colony Optimisation (ACO) family using C++ AMP, whilst at the same time being one of the first uses of the latter programming environment.

References
- O. Nitica, "A Parallel Ant Colony Optimization Algorithm for the Travelling
Salesman Problem: Improving Performance Using CUDA,\textquote{Ant Colony Optimization Parallel Algorithm for GPU},\textquote{Carleton University, Honours Project COMP 4905, Apr. 2011.}
- K. Tantawy, \textquote{Ant Colony Optimization Parallel Algorithm for GPU}, Carleton University, Honours Project COMP 4905, Apr. 2011.
- M. Dorigo, \textquote{Ant colony optimization.}\textquote{Cambridge, Mass: MIT Press, 2004.}
- A. Munshi, \textquote{Ed.}, \textquote{OpenCL programming guide.}\textquote{Upper Saddle River, NJ: Addison-Wesley, 2012.}
- D. Vandevoorde, \textquote{C++ templates: the complete guide.}\textquote{Boston, MA: Addison-Wesley, 2003.}
- A. A. Stepanov, \textquote{Elements of programming.}\textquote{Upper Saddle River, NJ: Addison-Wesley, 2009.}
- A. Blazinskas and A. Misevicius, \textquote{Combining 2-opt, 3-opt and 4-opt with K-swap-kick Perturbations for the Traveling Salesman Problem,}\textquote{in Proceedings of the 17th International Conference on Information and Software Technologies, IT 2011, Kaunas, Lithuania, 2011.}
- G. Reinelt, \textquote{The traveling salesman: computational solutions for TSP applications.}


**Index Terms**

Computer Science  
Languages

**Keywords**

C++ AMP  
Generic Programming  
GPU Programming  
MAX-MIN Ant System  
Parallel Meta-Heuristics