

Medusa: A Parallel Graph Processing System on Graphics Processors

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ABSTRACT

Medusa is a parallel graph processing system on graphics processors (GPUs). The core design of Medusa is to enable developers to leverage the massive parallelism and other hardware features of GPUs by writing sequential C/C++ code for a small set of APIs. This simplifies the implementation of parallel graph processing on the GPU. The runtime system of Medusa automatically executes the user-defined APIs in parallel on the GPU, with a series of optimizations based on the architecture features of GPUs and characteristics of graph applications. In this paper, we present an overview of the Medusa system and a case study of adopting Medusa to a research project on social network simulations. With Medusa, users without GPU programming experience can quickly implement their graph operations on the GPU, which accelerates the discovery and findings of domain-specific applications.

1. INTRODUCTION

GPGPU (General-Purpose Computation on Graphics Processing Units) is gaining increasing popularity in performance acceleration for many applications, including graph processing [8, 10]. A Modern GPU can have over an order of magnitude higher memory bandwidth and computation power than a multi-core CPU. With intensive and application-specific optimizations, GPU-based graph algorithms have shown significant performance improvement over CPU-based implementations. For example, the GPU accelerated breadth first search (BFS) algorithm is up to 14 times faster than multi-core implementation [10]. However, despite the recent improvements on GPGPU programmability, writing a correct and efficient GPU program is challenging in general and even more difficult for the highly irregular graph applications.

To address the above-mentioned issues and simplify programming graph processing algorithms on the GPU, we propose the Medusa parallel graph processing programming framework. Like exist-

ing programming frameworks such as Hadoop [17] and Mars [9], Medusa provides a small set of APIs for developers to implement their applications by writing sequential (C/C++) code. Different from Hadoop and Mars, which adopts the MapReduce programming model [3], Medusa adopts our novel "Edge-Message-Vertex" (EMV) graph programming model for fine-grained processing on edges, messages and vertices. Medusa embraces an efficient message passing based runtime. It automatically executes user-defined APIs in parallel within one GPU and across multiple GPUs, and hides the complexity of GPU programming from developers. Thus, developers can write the same APIs, which automatically run on one or multiple GPUs. To maximally leverage the power of GPUs, Medusa embraces a series of optimizations based on the architecture features of GPUs and characteristics of graph applications.

As a case study, we adopt Medusa to implement GPU accelerated simulation of information propagation over social networks. Simulation of information propagation is computationally intensive and fortunately highly parallelizable, which makes it viable for GPU acceleration. By the case study, we demonstrate that Medusa both improves the coding productivity and brings significant performance speedups.

This paper gives an overview of Medusa based on work reported in [20, 18, 11, 12, 13]. We first present the design of the main components of Medusa's system architecture and evaluation results. We then present the case study developed based on Medusa. Finally, we conclude this paper and present the future work.

2. RELATED WORK

Parallel graph processing. It has been observed that many common graph algorithms can be formulated using a form of the bulk synchronous parallel (BSP) model [14] (we call it *GBSP*). Under

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David Baud



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Principles of Big Graph: In-depth Insight, 2023-01-24 Principles of Big Graph In depth Insight Volume 128 in the Advances in Computer series highlights new advances in the field with this new volume presenting interesting chapters on a variety of topics including CESDAM Centered subgraph data matrix for large graph representation Bivariate cluster and suitability analysis of NoSQL Solutions for big graph applications An empirical investigation on Big Graph using deep learning Analyzing correlation between quality and accuracy of graph clustering geneBF Filtering protein coded gene graph data using bloom filter Processing large graphs with an alternative representation MapReduce based convolutional graph neural networks A comprehensive review Fast exact triangle counting in large graphs using SIMD acceleration A comprehensive investigation on attack graphs Qubit representation of a binary tree and its operations in quantum computation Modified ML KNN Role of similarity measures and nearest neighbor configuration in multi label text classification on big social network graph data Big graph based online learning through social networks Community detection in large scale real world networks Power rank An interactive web page ranking algorithm GA based energy efficient modelling of a wireless sensor network The major challenges of big graph and their solutions A review and An investigation on socio cyber crime graph Provides an update on the issues and challenges faced by current researchers Updates on future research agendas Includes advanced topics for intensive research for researchers [Web and Big Data. APWeb-WAIM 2020 International Workshops](#) Qun Chen,Jianxin Li,2021-03-31 This book constitutes revised selected papers from the workshops of the 4th Asia Pacific Web and Web Age Information Management International Joint Conference on Web and Big Data APWeb WAIM 2020 The Third International Workshop on Knowledge Graph Management and Applications KGMA 2020 The Second International Workshop on Semi structured Big Data Management and Applications SemiBDMA 2020 and The First International Workshop on Deep Learning in Large scale Unstructured Data Analytics DeepLUDA 2020 held in Tianjin China in September 2020 Due to the COVID 19 pandemic the conference was held online The 13 papers were thoroughly reviewed and selected from the numerous submissions and present recent research on the theory design and implementation of data management systems **Information and Communication Technology for Intelligent Systems** Suresh Chandra Satapathy,Amit Joshi,2018-12-30 The book gathers papers addressing state of the art research in all areas of Information and Communication Technologies and their applications in intelligent computing cloud storage data mining and software analysis It presents the outcomes of the third International Conference on Information and Communication Technology for Intelligent Systems which was held on April 6 7 2018 in Ahmedabad India Divided into two volumes the book discusses the fundamentals of various data analytics and algorithms making it a valuable resource for researchers future studies **Cloud Computing for Data-Intensive Applications** Xiaolin Li,Judy Qiu,2014-12-02 This book presents a range of cloud computing platforms for data intensive scientific applications It covers systems that deliver infrastructure as a

service including HPC as a service virtual networks as a service scalable and reliable storage algorithms that manage vast cloud resources and applications runtime and programming models that enable pragmatic programming and implementation toolkits for eScience applications Many scientific applications in clouds are also introduced such as bioinformatics biology weather forecasting and social networks Most chapters include case studies Cloud Computing for Data Intensive Applications targets advanced level students and researchers studying computer science and electrical engineering Professionals working in cloud computing networks databases and more will also find this book useful as a reference [Data Sources](#) ,2000

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