

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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Jicheng Xie



Medusa A Parallel Graph Processing System On Graphics:

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Table of Contents Medusa A Parallel Graph Processing System On Graphics

1. Understanding the eBook Medusa A Parallel Graph Processing System On Graphics
 - The Rise of Digital Reading Medusa A Parallel Graph Processing System On Graphics
 - Advantages of eBooks Over Traditional Books
2. Identifying Medusa A Parallel Graph Processing System On Graphics
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Medusa A Parallel Graph Processing System On Graphics
 - User-Friendly Interface
4. Exploring eBook Recommendations from Medusa A Parallel Graph Processing System On Graphics
 - Personalized Recommendations
 - Medusa A Parallel Graph Processing System On Graphics User Reviews and Ratings
 - Medusa A Parallel Graph Processing System On Graphics and Bestseller Lists
5. Accessing Medusa A Parallel Graph Processing System On Graphics Free and Paid eBooks
 - Medusa A Parallel Graph Processing System On Graphics Public Domain eBooks
 - Medusa A Parallel Graph Processing System On Graphics eBook Subscription Services
 - Medusa A Parallel Graph Processing System On Graphics Budget-Friendly Options
6. Navigating Medusa A Parallel Graph Processing System On Graphics eBook Formats
 - ePub, PDF, MOBI, and More
 - Medusa A Parallel Graph Processing System On Graphics Compatibility with Devices
 - Medusa A Parallel Graph Processing System On Graphics Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Medusa A Parallel Graph Processing System On Graphics
 - Highlighting and Note-Taking Medusa A Parallel Graph Processing System On Graphics
 - Interactive Elements Medusa A Parallel Graph Processing System On Graphics

8. Staying Engaged with Medusa A Parallel Graph Processing System On Graphics
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Medusa A Parallel Graph Processing System On Graphics
9. Balancing eBooks and Physical Books Medusa A Parallel Graph Processing System On Graphics
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Medusa A Parallel Graph Processing System On Graphics
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Medusa A Parallel Graph Processing System On Graphics
 - Setting Reading Goals Medusa A Parallel Graph Processing System On Graphics
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Medusa A Parallel Graph Processing System On Graphics
 - Fact-Checking eBook Content of Medusa A Parallel Graph Processing System On Graphics
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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