UNIVERSITY OF SOUTH FLORIDA

Defense of a Doctoral Dissertation

Relational Joins on GPUs for In-Memory Database Query Processing

by

Ran Rui

For the Ph.D. degree in Computer Science and Engineering

Relational join processing is one of the core functionalities in database management systems. Implementing join algorithms on parallel platforms, especially modern GPUs, has gain a lot of momentum in the past decade. This dissertation addresses the following issues on GPU join algorithms. First, we present empirical evaluations of a state-of-the-art work on GPU-based join processing. We run a comprehensive set of experiments to study how join operations can benefit from such rapid expansion of GPU capabilities. We also present improved GPU programs that take advantage of new GPU hardware/software features. Second, we report new design and implementation of join algorithms with high performance under today's GPGPU environment. We overhaul the popular radix hash join and redesign sort-merge join algorithms on GPUs by applying a series of novel techniques to utilize the hardware capacity of latest Nvidia GPU architecture and new features of the CUDA programming framework. Lastly, we explore how join processing would benefit from the adaptation of multiple GPUs. We identify the low rate and complex patterns of data transfer among the CPU and GPUs as the main challenges in designing efficient algorithms for large table joins, and we propose three distinctive designs of multi-GPU join algorithms, namely, the nested loop, global sort-merge and hybrid joins to overcome such challenges. Extensive experiments running on multiple databases and two different hardware configurations demonstrate high scalability of our algorithms over data size and significant performance boost using multiple GPUs.

Examining Committee

Kandethody Ramachandran, Ph.D., Chairperson
Yicheng Tu, Ph.D., Major Professor
Mehran Mozaffari Kermani, Ph.D.
Yu Sun, Ph.D.
Andres Tejada-Martinez, Ph.D.
Sameer Varma, Ph.D.

Tuesday, June 23, 2020
3:00 PM
Online (Collaborate Ultra)
Please email for more information
ranrui@usf.edu
THE PUBLIC IS INVITED

Publications

1) **R. Rui**, H. Li and Y. Tu, “Efficient Join Algorithms For Large Database Tables in a Multi-GPU Environment”, VLDB2021 (Under Review)

2) **R. Rui** and Y. Tu. 2017. Fast Equi-Join Algorithms on GPUs: Design and Implementation. In Proceedings of the 29th International Conference on Scientific and Statistical Database Management (SSDBM ’17). Association for Computing Machinery, New York, NY, USA, Article 17, 1–12.

3) **R. Rui**, H. Li, and Y. Tu. 2015. Join algorithms on GPUs: A revisit after seven years. In Proceedings of the 2015 IEEE International Conference on Big Data (BIG DATA ’15). IEEE Computer Society, USA, 2541–2550.

4) Y. Tu, A. Kumar, D. Yu, **R. Rui**, and R. Wheeler. 2013. Data management systems on GPUs: promises and challenges. In Proceedings of the 25th International Conference on Scientific and Statistical Database Management (SSDBM). Association for Computing Machinery, New York, NY, USA, Article 33, 1–4.

Robert Bishop, Ph.D.
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Dwayne Smith, Ph.D.
Dean, Office of Graduate Studies

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