基于 GPU 的混合式全源对最短路径算法研究

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摘　要：全源对最短路径问题在生物信息学、地理信息系统、社交网络、复杂网络分析、集成电路计算机辅助设计和交通规划等领域都有重要应用. 为了克服具体应用中因图结构差异对计算性能产生的影响，提出一种基于 GPU 架构的采样混合式全源对最短路径并行算法. 在 GPU 上通过点处理顺序预设，粗细粒度任务分解等手段优化点并行算法，并引入采样方式预估图直径，有针对性地对每个遍历层选择高效的并行策略. 与目前性能最好的 GPU 边并行算法相比，处理交通网络图等大直径图的加速比可达 7.2 倍，处理亚马逊产品联合采购网络图等小直径图的加速比可达 1.9 倍，同时采样混合式算法具备较好的伸缩性能，消除了因图结构不同而对算法性能产生的影响.

关键词：全源对最短路径；GPU；广度优先搜索；混合式算法；采样混合式算法

GPU-Based Hybrid Algorithm of All-pairs Shortest Paths

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Abstract：As an essential graph algorithmic pattern, the All-Pairs Shortest Paths Problem (APSP) plays an important role in many crucial applications such as bioinformatics, geographic information systems, social networks, complex network analysis, computer-aided design of integrated circuits and transportation planning. Due to the significant divergence of graphs, this work investigates GPU-based APSP parallel algorithms that adapt to varying graph structures. First, we propose an improved vertex-parallel algorithm, so-called optimized vertex-parallel algorithm, which performs best on graphs with a large diameter. Second, we proposed a hybrid algorithm integrating the optimized vertex-parallel algorithm vertex- and an edge-parallel algorithm that can efficiently handle graphs with arbitrary structure. Finally, we proposed a sampling heuristic to further improve the performance of the hybrid algorithm. Experimental results prove that the sampling hybrid algorithm achieves a speedup of up to 7.2× on high-diameter graphs and 1.9× on other graphs. The sampling hybrid algorithm also has a better scalability on large graphs.

Key words：all-pairs shortest paths；GPU；breath first search；hybrid algorithm；sampling hybrid algorithm

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