Optimizing GPU-Accelerated Similarity Joins: Addressing Data-Dependent Workloads

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Introduction

Given D a dataset in n dimensions

- Distance similarity self-join → Find pairs of objects in D whose distance is within ε
- Use a grid indexing to prune the search space
- $Thread_i$ = $Query_i$
- Depending on data characteristics → Workload between threads varies a lot
- GPU's architecture (SIMT) → Idle periods for threads with less workload
  - Results in higher execution time

Solution

- Balance the workload between threads to reduce the response time
- Sort the points by workload, from most to least
  - Consecutive threads should have similar workload (Fig. 1)
- However → GPU's hardware scheduler controls the execution order of the threads
- Use a work queue to force this execution's order
  - Atomic operation to retrieve the first element of the queue, i.e., the one with most workload (Fig. 2)

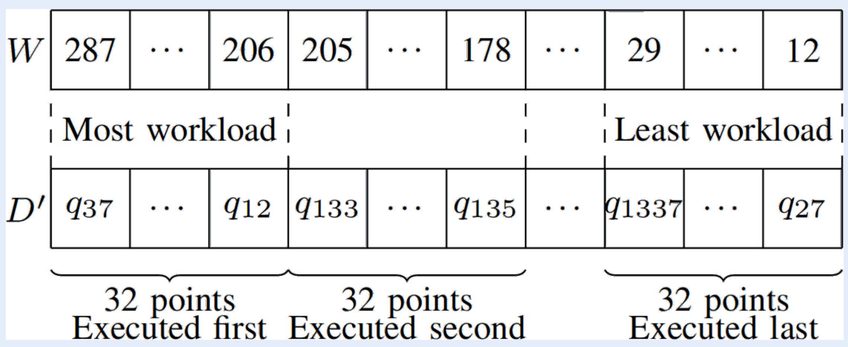


Figure 2

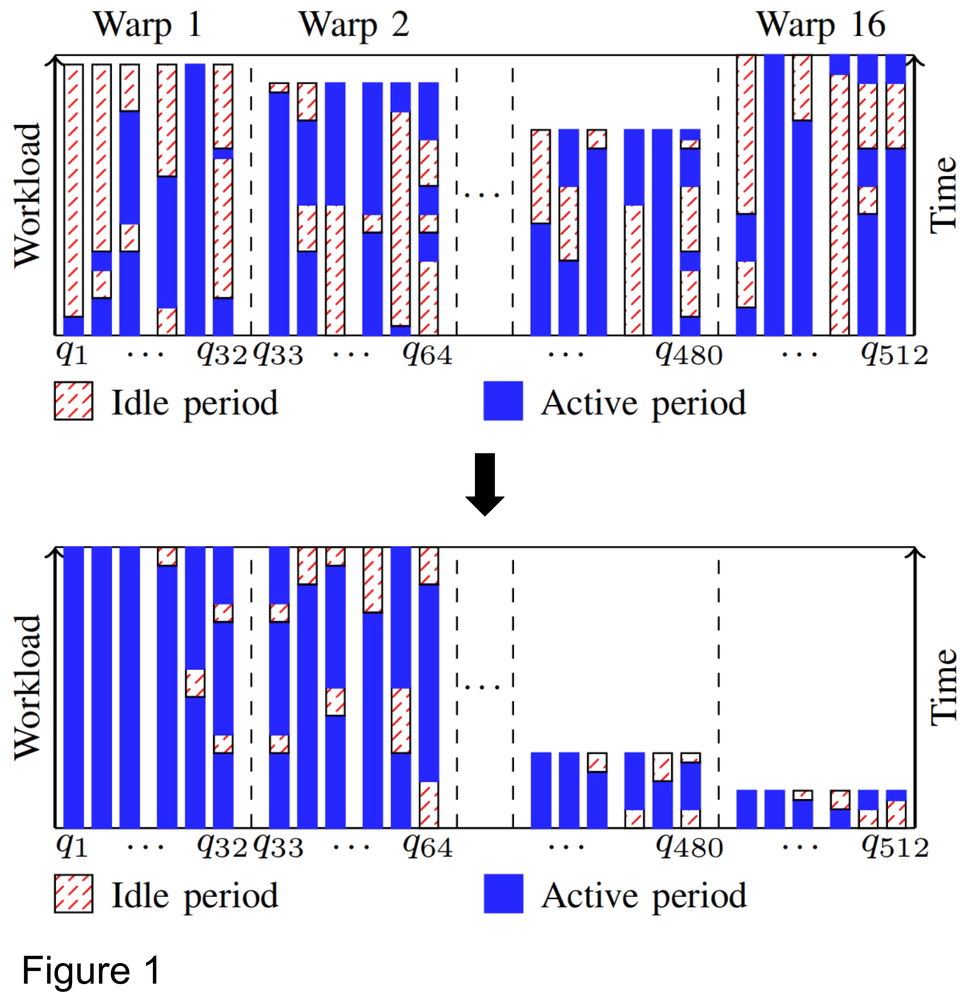


Figure 1

Results

- Compare GPUCalcGlobal [1], sorting by workload (SortByWL) and our work queue (WorkQueue) [2]
- Focus on the execution time and warp execution efficiency (WEE)
  - Percentage of active threads within a warp → higher is better
- Uniformly (Fig. 3) and exponentially (Fig. 4) distributed synthetic datasets, n = 6, 2M points

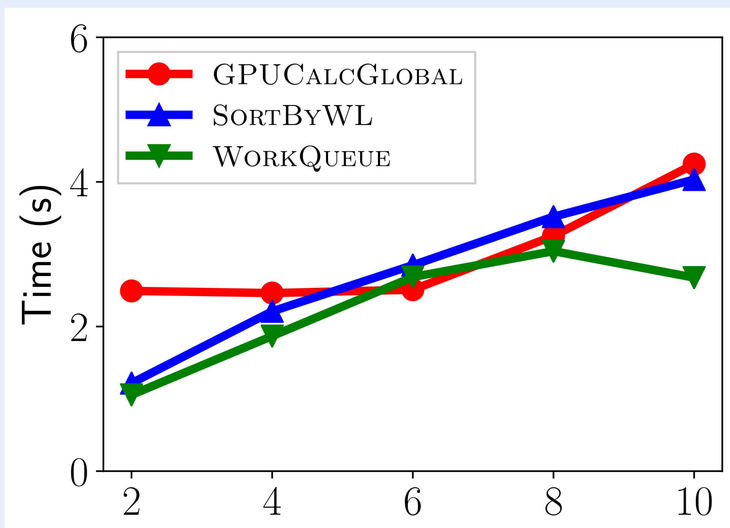


Figure 3: Uniform

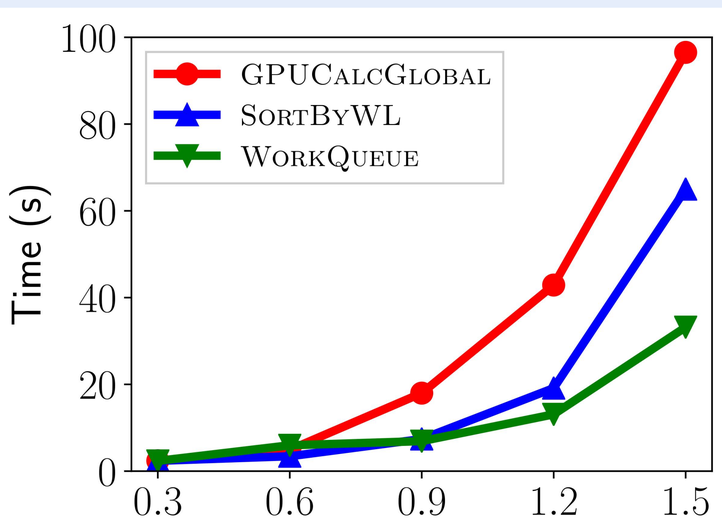
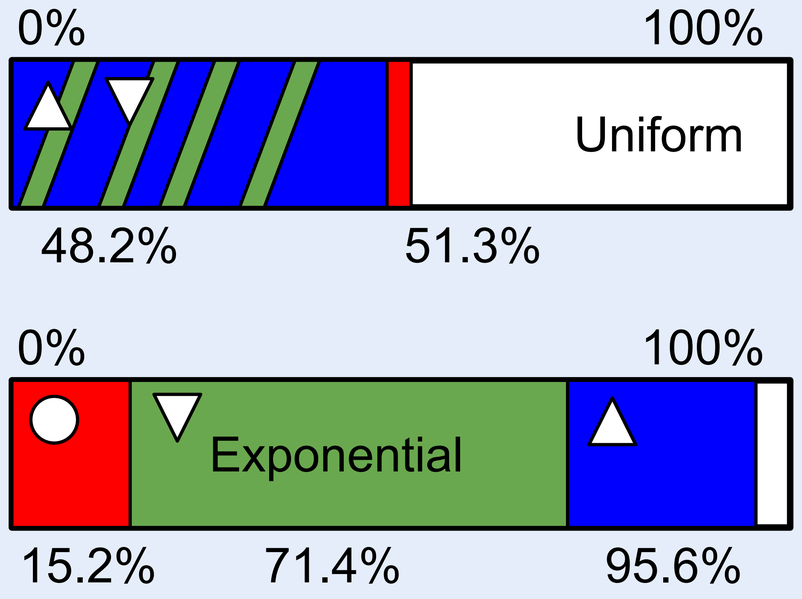


Figure 4: Exponential



- Uniformly distributed dataset → uniform workload → no need to balance, contrary to exponentially distributed

Conclusion

- Warp execution efficiency impacts response time
- 100% warp execution efficiency may indicate a computational bound
- Use the WorkQueue to improve other data dependent applications

References

[1] M. Gowanlock and B. Karsin, "GPU Accelerated Self-join for the Distance Similarity Metric," Proc. of the 2018 IEEE Intl. Parallel and Distributed Processing Symposium Workshops, pp. 477–486, 2018.

[2] B. Gallet and M. Gowanlock, "Load Imbalance Mitigation Optimizations for GPU-Accelerated Similarity Joins", Proc. of the 2018 IEEE Intl. Parallel and Distributed Processing Symposium Workshops, 2019