Optimizing Relational Computing Performance on Heterogeneous Processors

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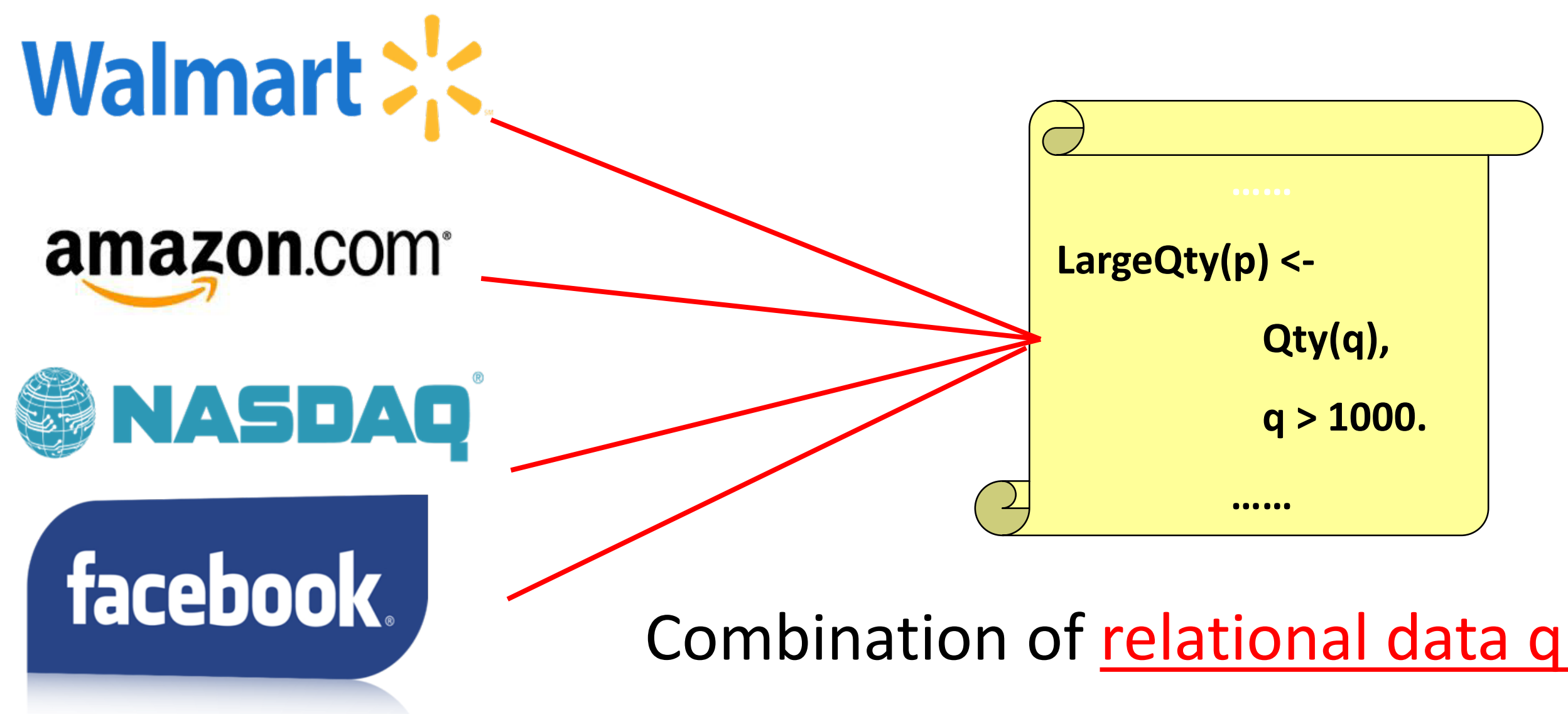
High Performance Relational Computing



Applications: Retail analysis, forecasting, pricing, etc…

Combination of relational data queries and compute kernels

- Current applications process 1 to 50 TBs of data [1]
- Not a traditional domain for GPU acceleration
- Goal: **10X-100X** application speedup over multicore processors

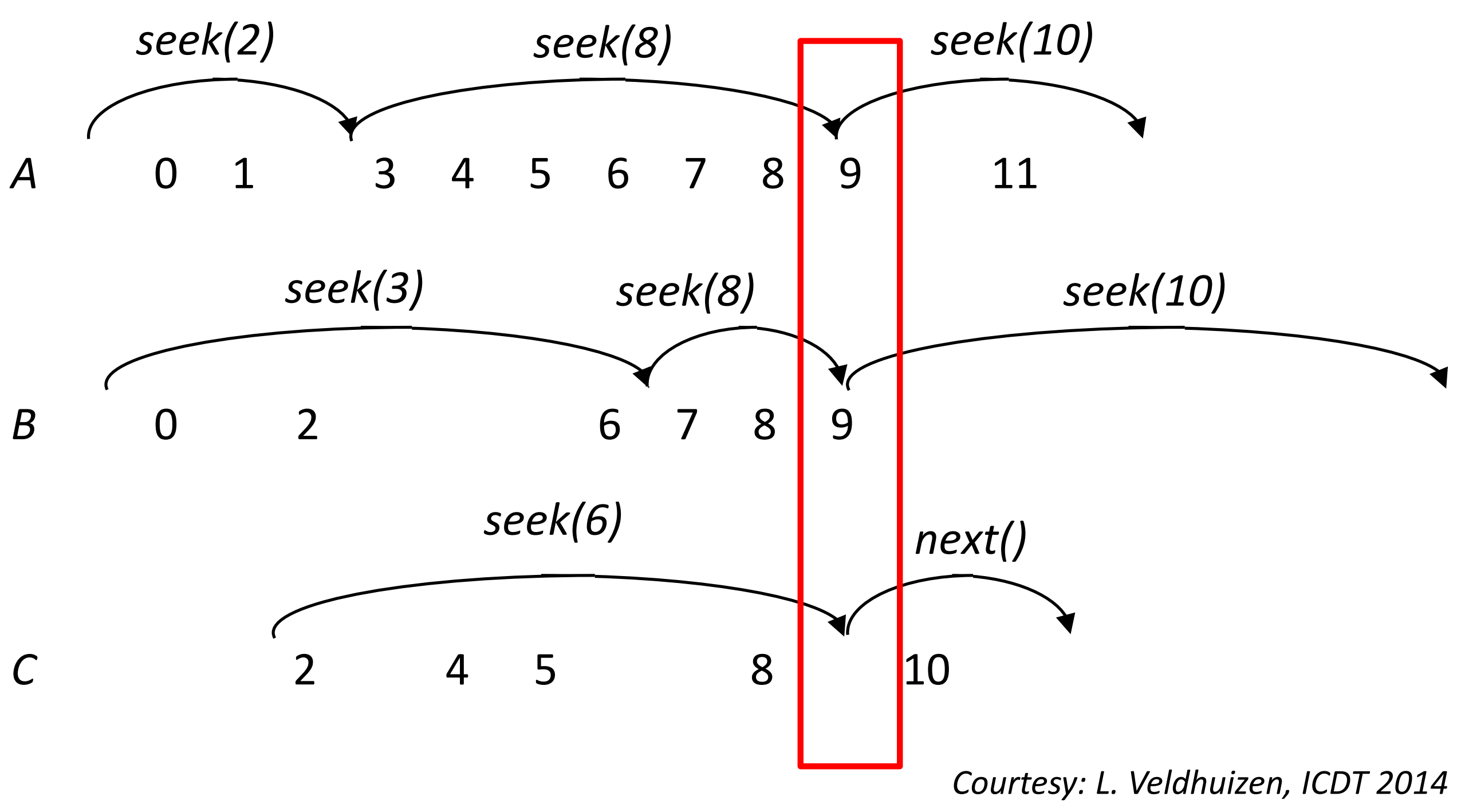
Multi-Predicate Join for SIMD Accelerators

- Implementation of Leapfrog Triejoin (LFTJ) on GPUs
- A worst-case optimal multi-predicate join algorithm
- CPU-version - T. L. Veldhuizen, *ICDT 2014*

Key idea: *Leap* over large segments to seek a specific (e.g., join) value

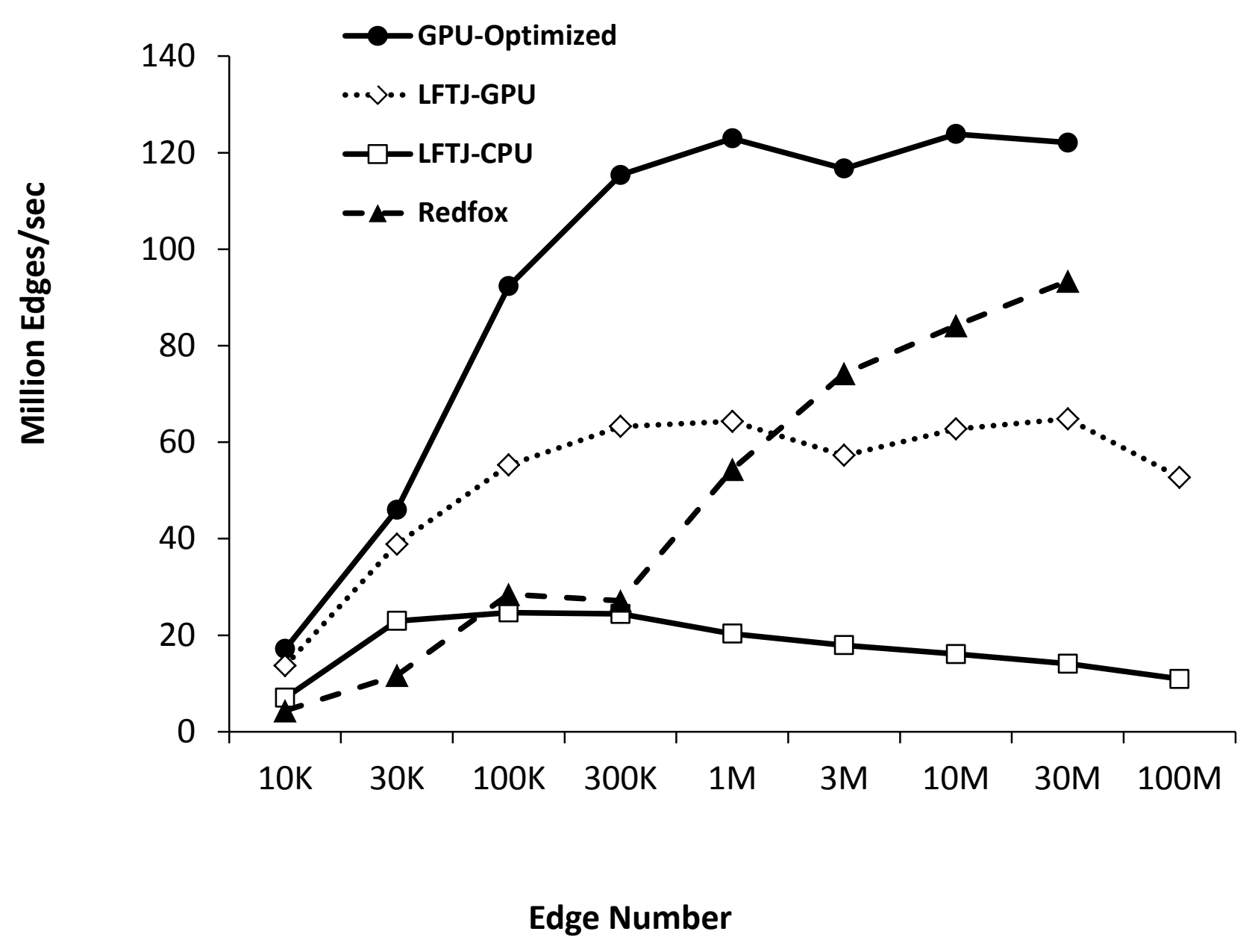
Primitives next() and seek()

Example using a linear iterator

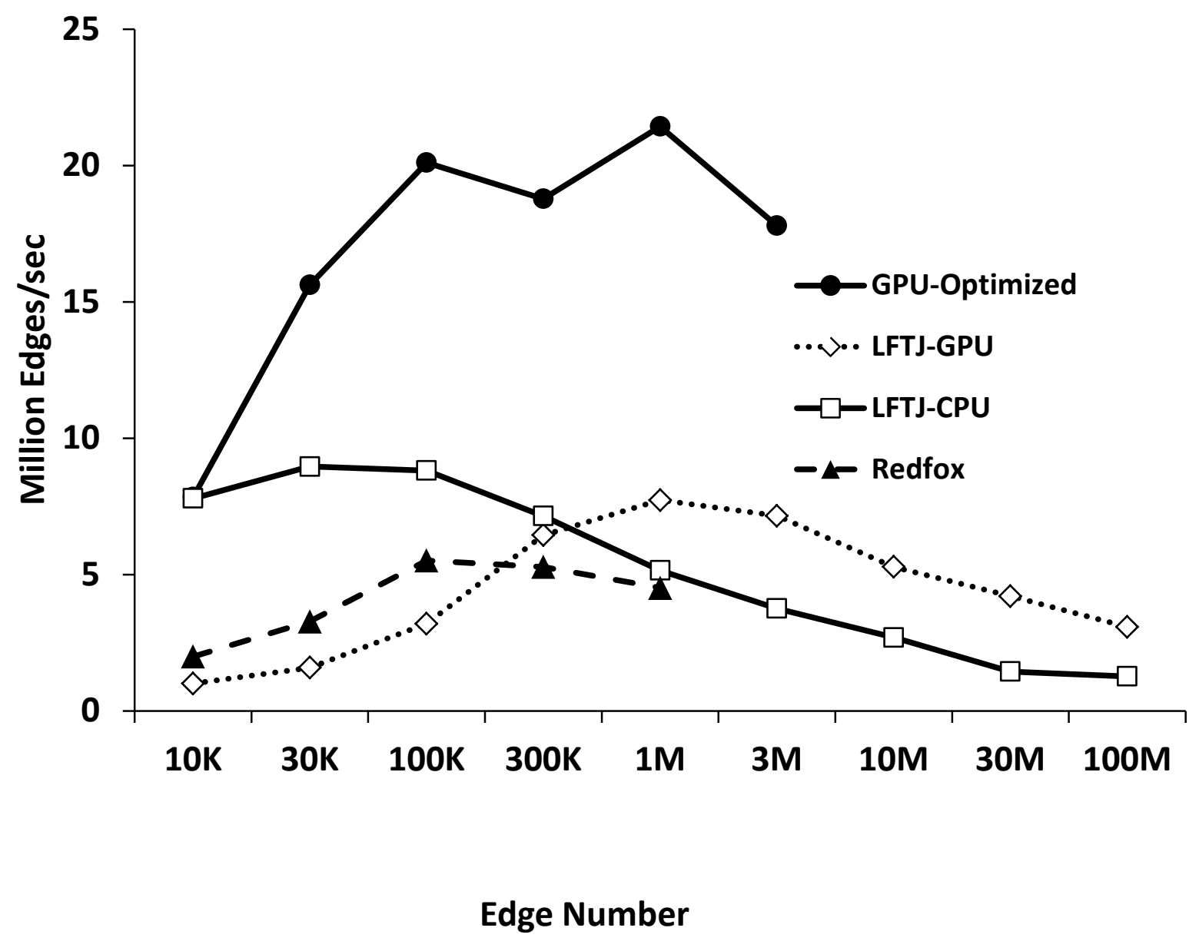


Courtesy: L. Veldhuizen, ICDT 2014

- Benefits
  - Smaller memory footprint for temporary results
  - No data reconstruction, e.g. sorting or hash table construction
- Worst-case optimal multi-predicate join in a SIMD accelerator[4]



Three-clique problem

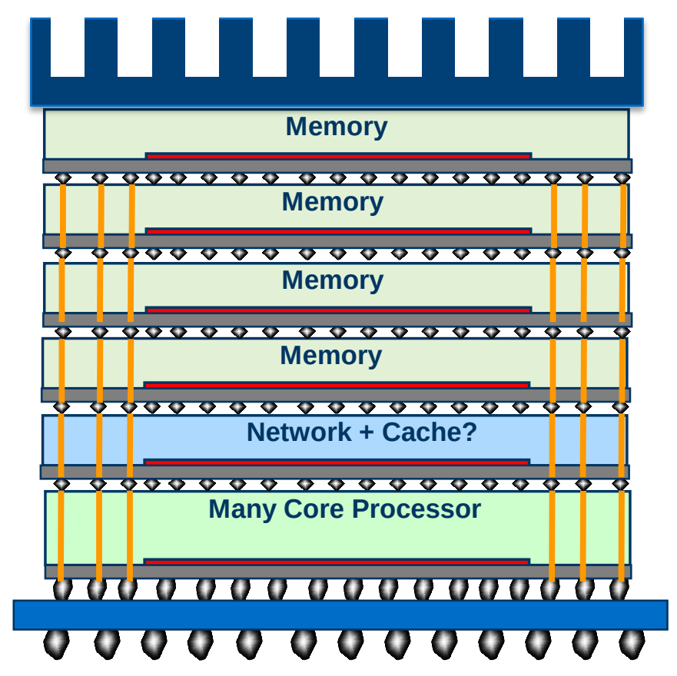


Four-clique problem

Near Memory Data Intensive Computing

Moving the compute primitives for data analytics into the memory system

- Parametric C++ processor synthesis environment
- HARP family of data parallel processors
- RISC processor core
- Assembler/emulator tools
- OpenCL compiler (in progress)

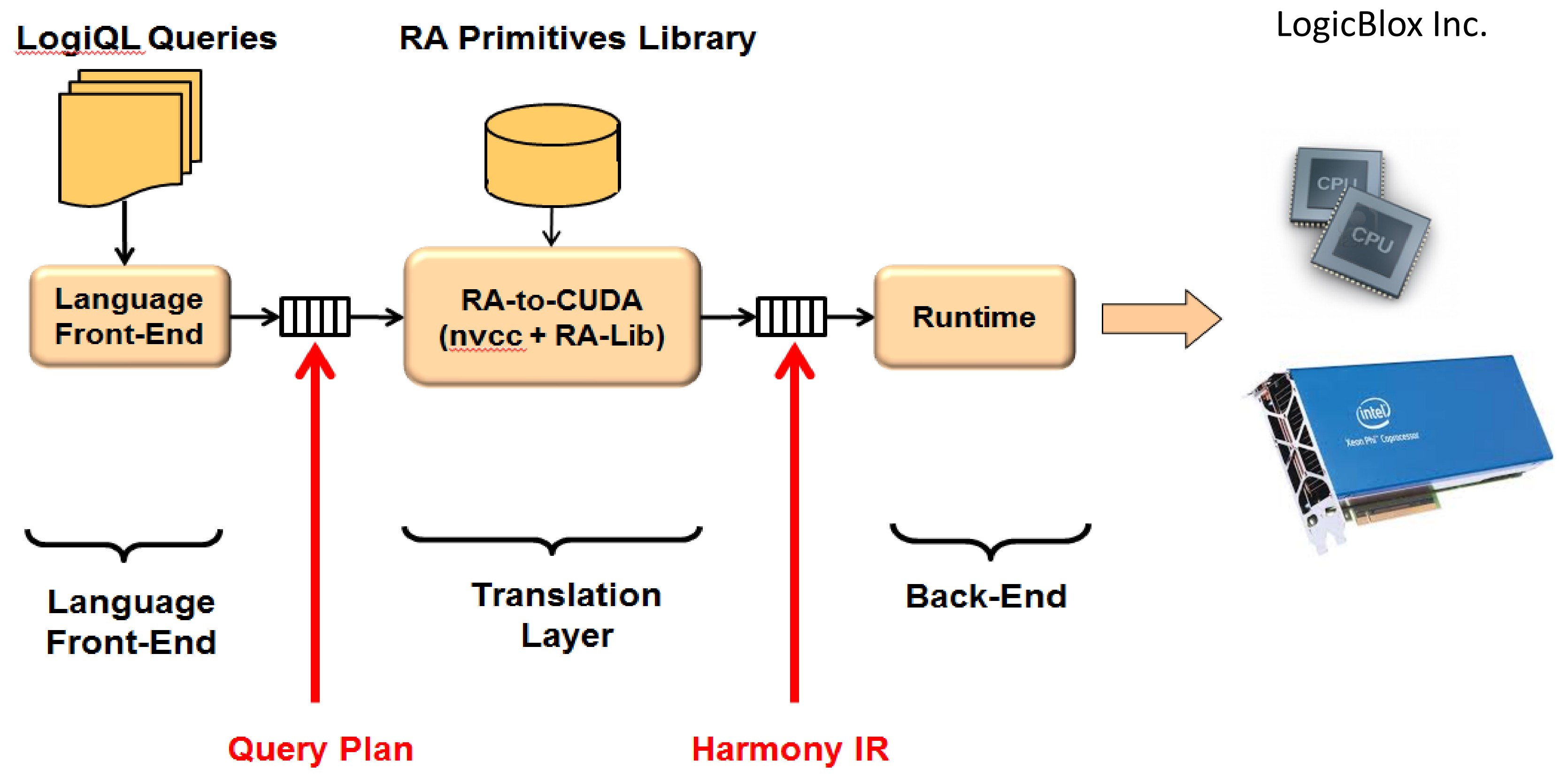


- Prototypes in execution in FPGAs
- Candidate Primitives
  - Relational Algebra, MemcacheD,
  - Sorting, search, encryption
  - Sparse matrix operations
  - Video and Text search

Intel Science & Technology
Center for Cloud Computing

Our Approach: Red Fox Tool Chain

Collaboration with LogicBlox Inc.



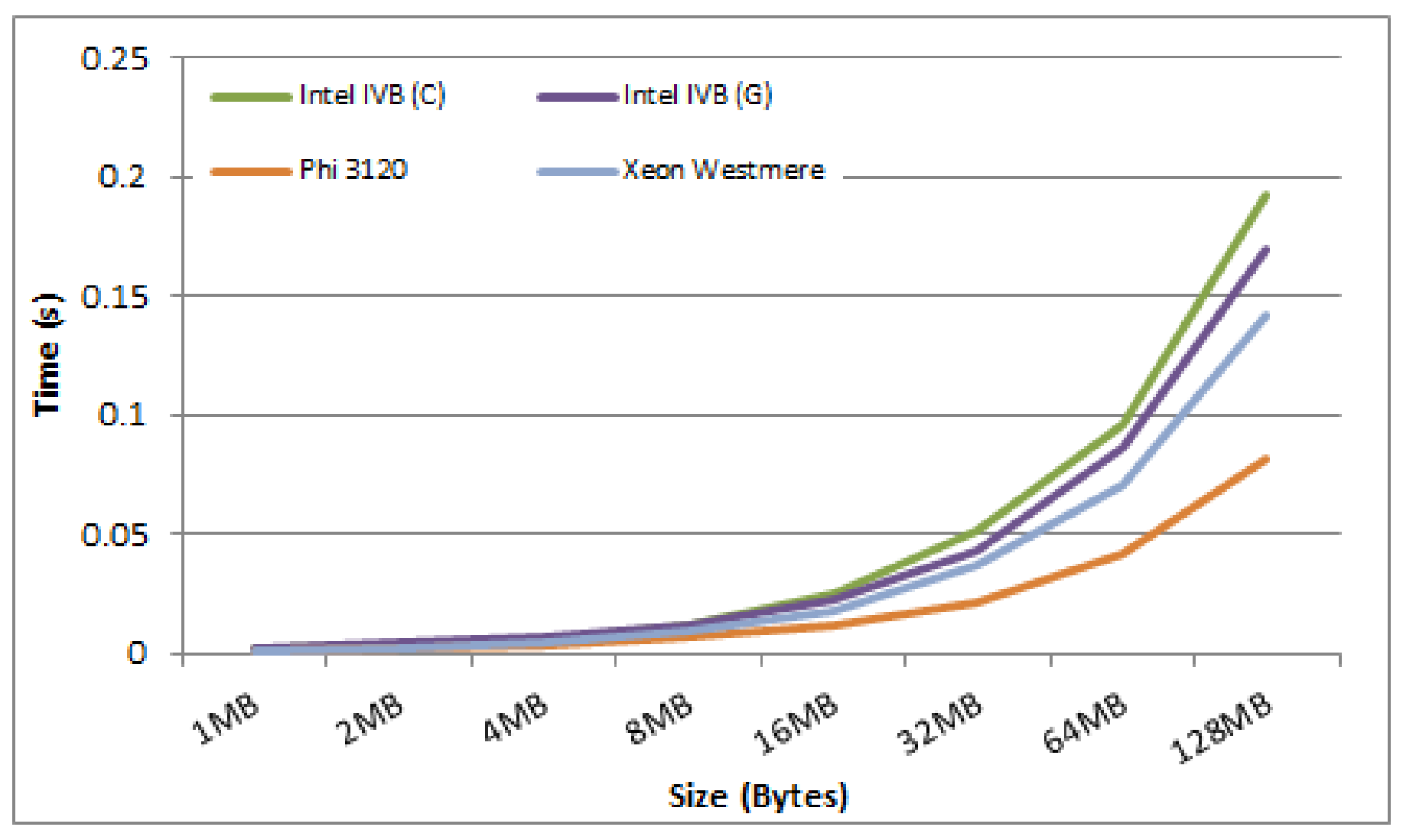
- Relational queries are translated to optimized query plans and GPU primitives via the Red Fox compilation and runtime framework [3]
- Early work used CUDA-based primitives; current work focuses on OpenCL-based primitives
- Execution on integrated and attached accelerators

SHOC Benchmark Implementations

http://keeneland.gatech.edu/software/keeneland/shoc

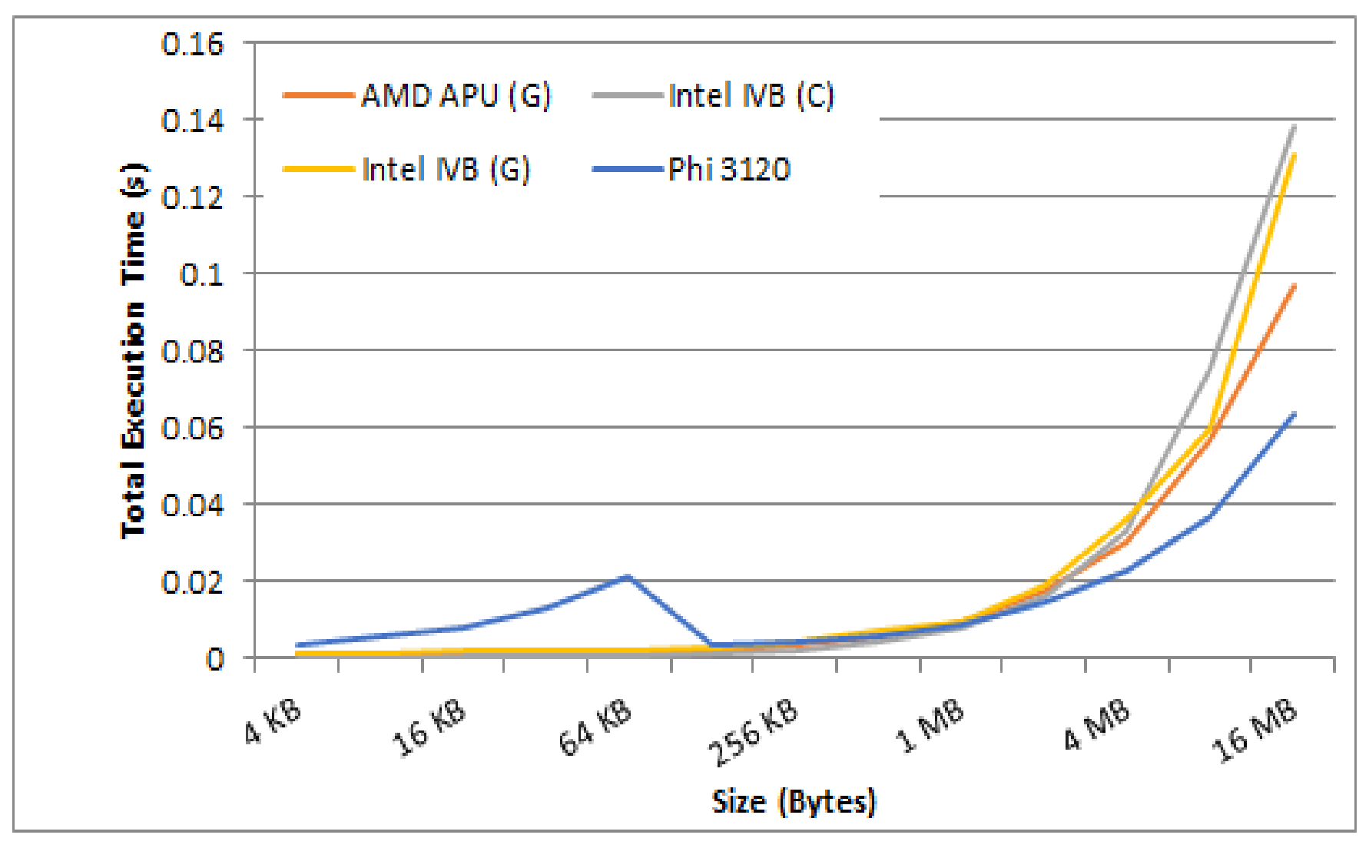
- SHOC - Scalable Heterogeneous Computing Benchmark Suite
- Standardized benchmark suite across languages and platforms
- Full support for OpenCL, CUDA. OpenACC and Phi Offload in progress.
  - Relational Algebra Primitives and TPC-H microbenchmarks
  - TPC-H queries
- Current Effort: RA implementations on Intel Phi and Gen

Select (OpenCL)



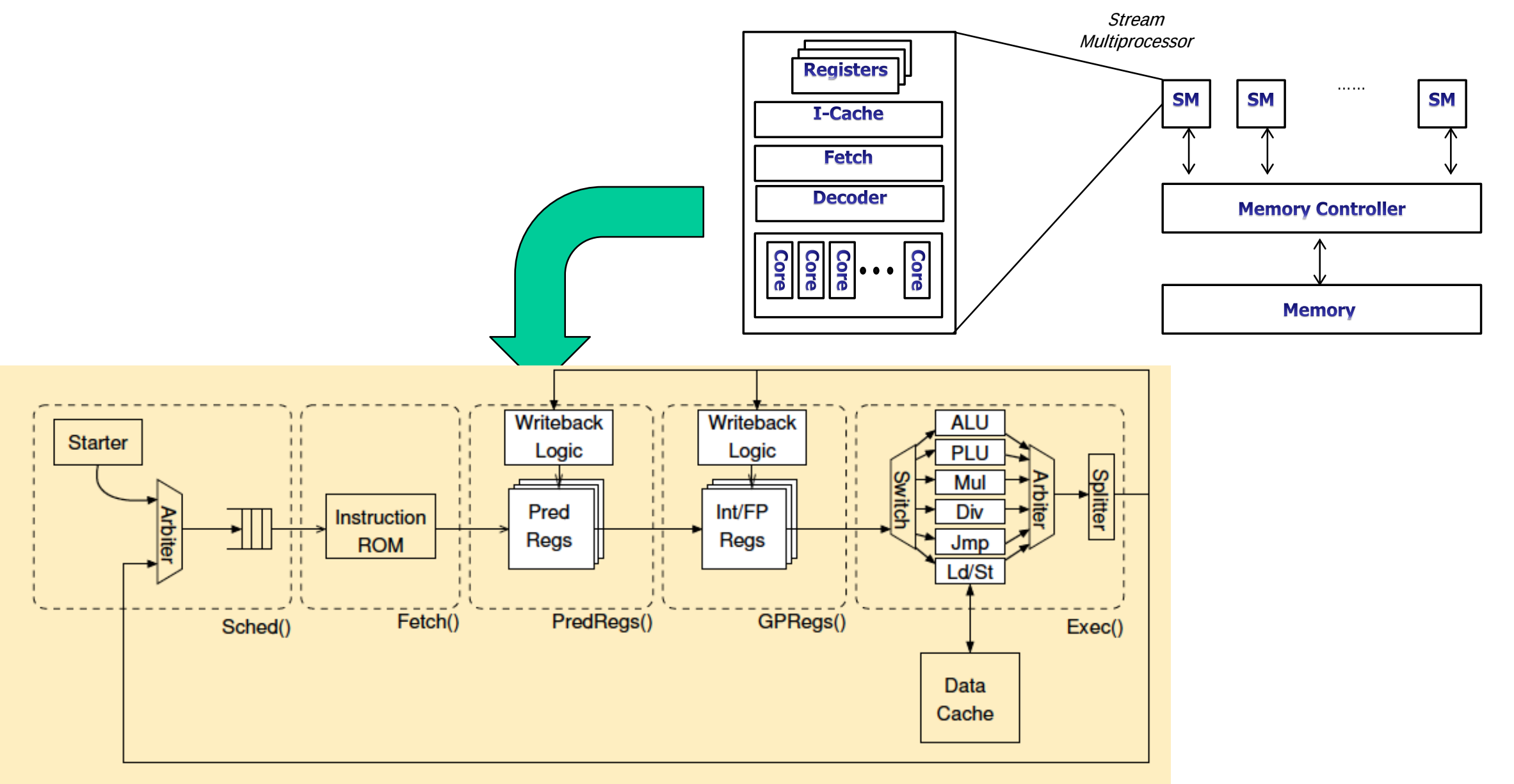
Xeon Phi excels at highly parallel primitives

Microbenchmark B (Seq. Joins)



Output size limits performance of joins

HARP Architecture V2



- Configurable
  - Registers per thread, number of lanes, data path width
  - Choice of functional units
- Small- ~1500 lines of C++

References

[1] IND. Oracle Users Group. *A New Dimension to Data Warehousing: 2011 IOUG Data Warehousing Survey.*
[2] B. He, *et al. Relational query co-processing on graphics processors.* TODS, 2009.
[3] H. Wu, *et al. Red Fox: An Execution Environment for Relational Query Processing on GPUs,* CGO 2014
[4] H. Wu, *et al. Multipredicate Join Algorithms for Accelerating Relational Graph Processing on GPUs,* ADMS 2014

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