

# Relational Algorithms for Multi-Bulk-Synchronous Processors

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## Application Space: Data Warehousing



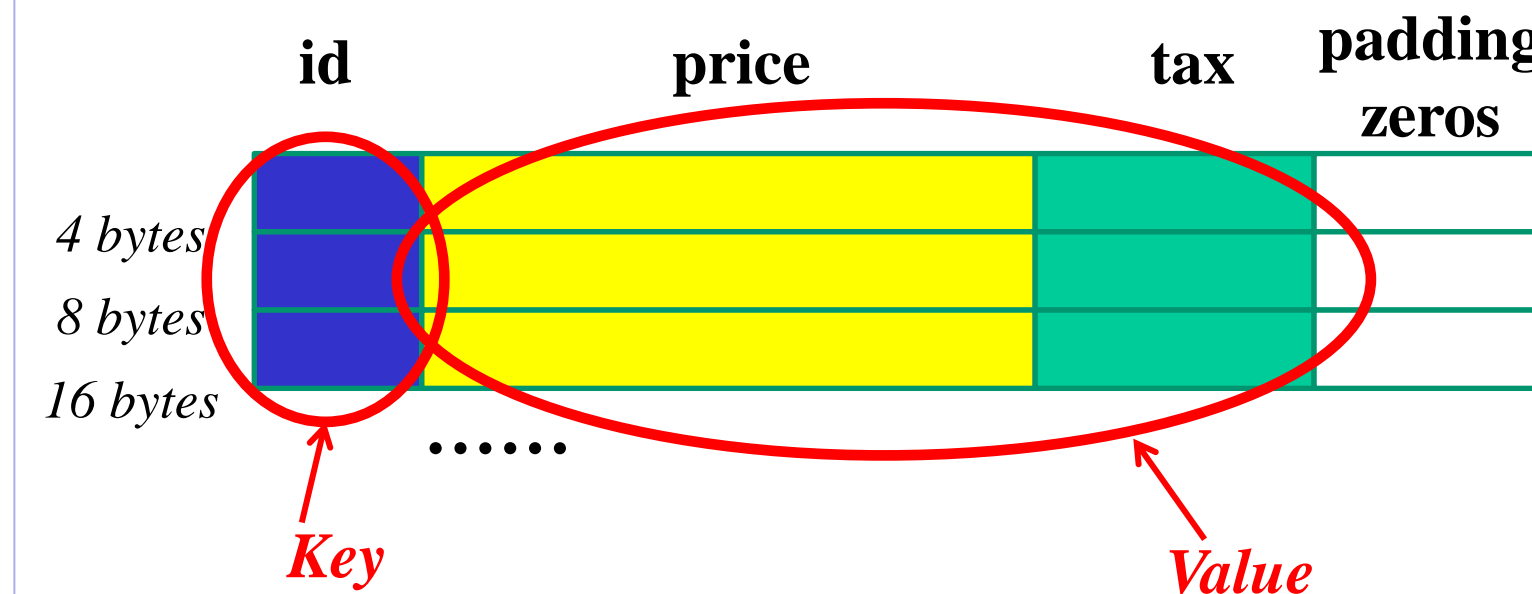
- On-line and off-line analysis
  - Retail analysis
  - Forecasting
  - Pricing
  - Etc...
- Combination of relational data queries and computational kernels
- Current applications process 1 to 50 TBs of data [1]
- Not a traditional domain for GPU acceleration, but:
  - Parallel queries experience good speedup on GPUs [2]
  - GPU-related techniques can be applied to other "Big Data" problems like irregular graphs, sorting

```
.....
LargeQty(p) <- Qty(q),
q > 1000.
.....
```

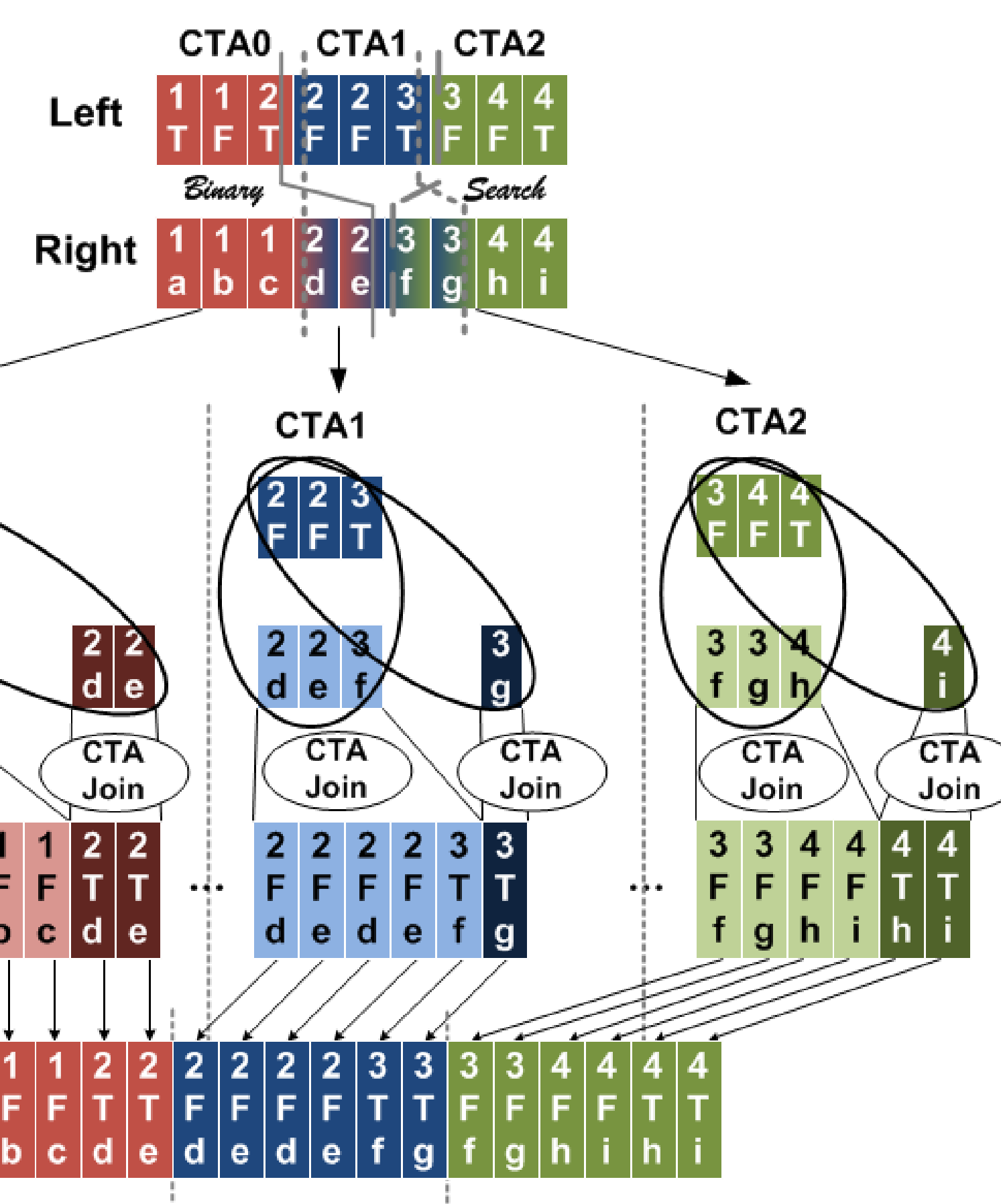
## Relational Algorithm Design

- Strategy: Increase core utilizations until the computation becomes memory bound, and then achieve near peak utilization of the memory interface
- Hybrid multi-stage algorithm (partition, compute, gather) to make trade-offs between computation complexity and memory access efficiency

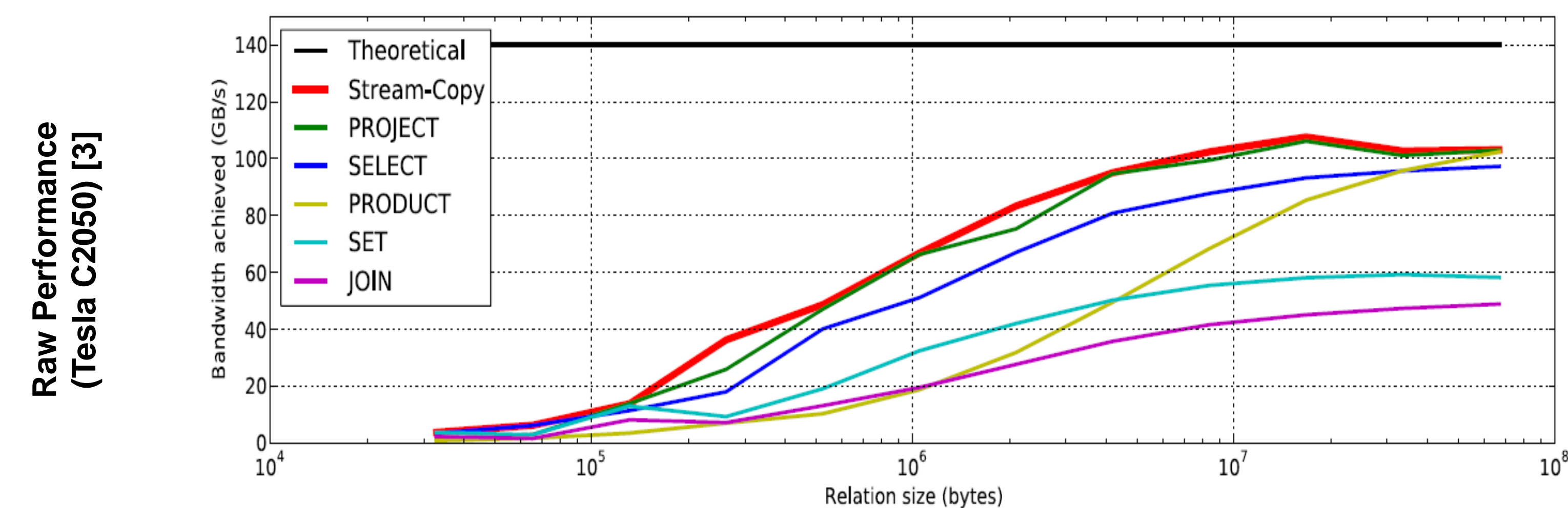
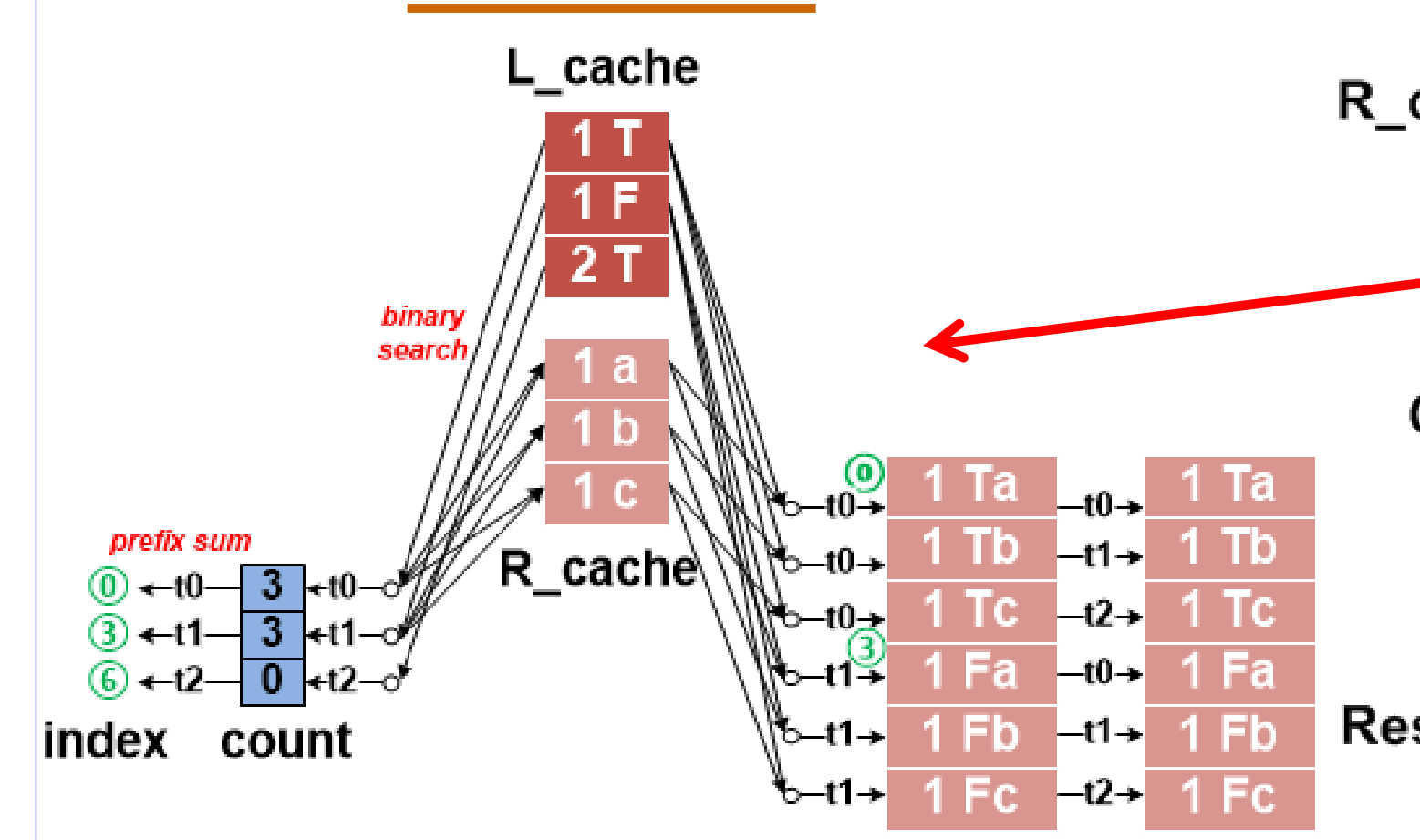
Data Structure: weakly-sorted densely packed array of tuples



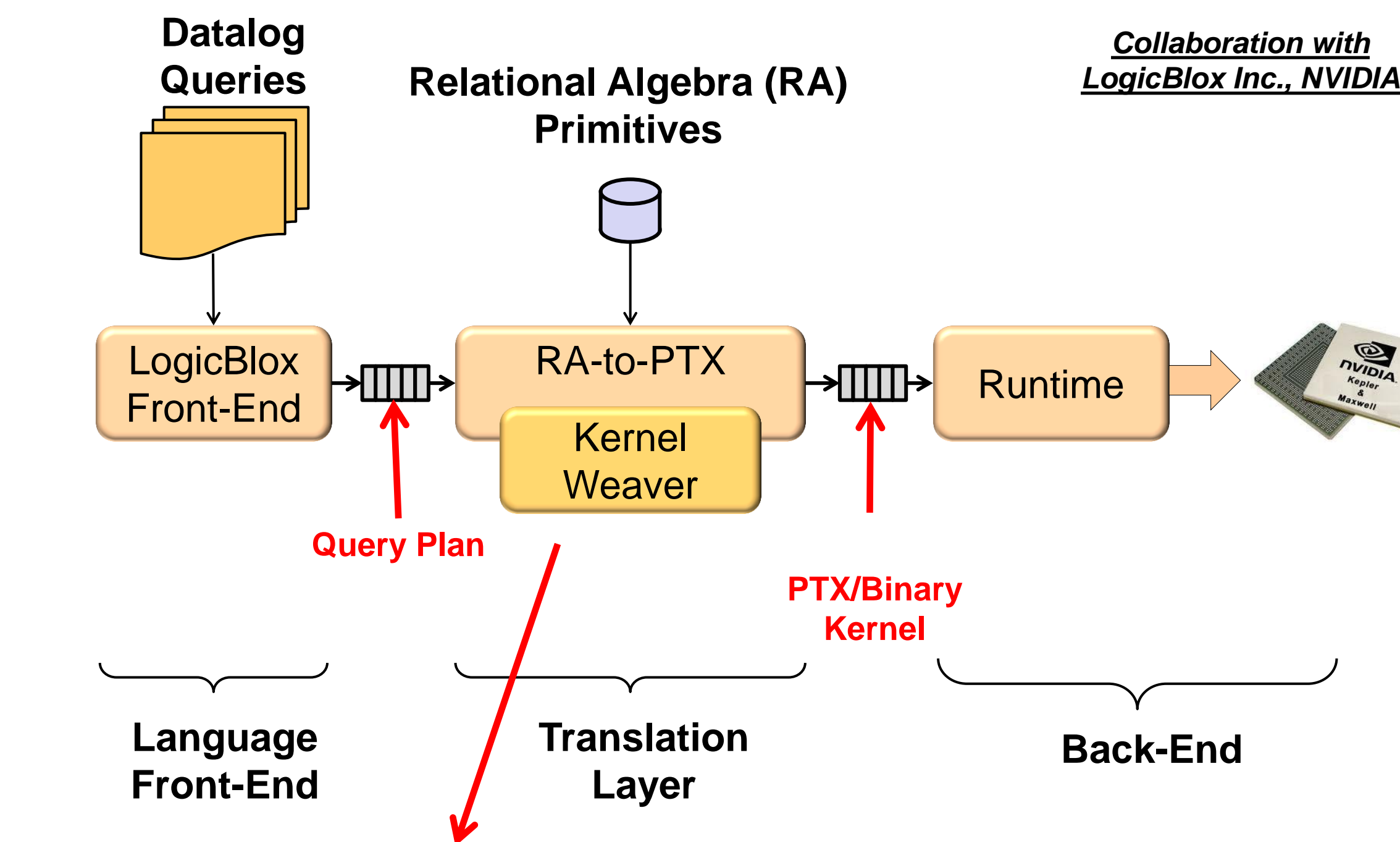
## Example of Merge Join



## CTA JOIN



## Red Fox: Execution Environment for the Enterprise

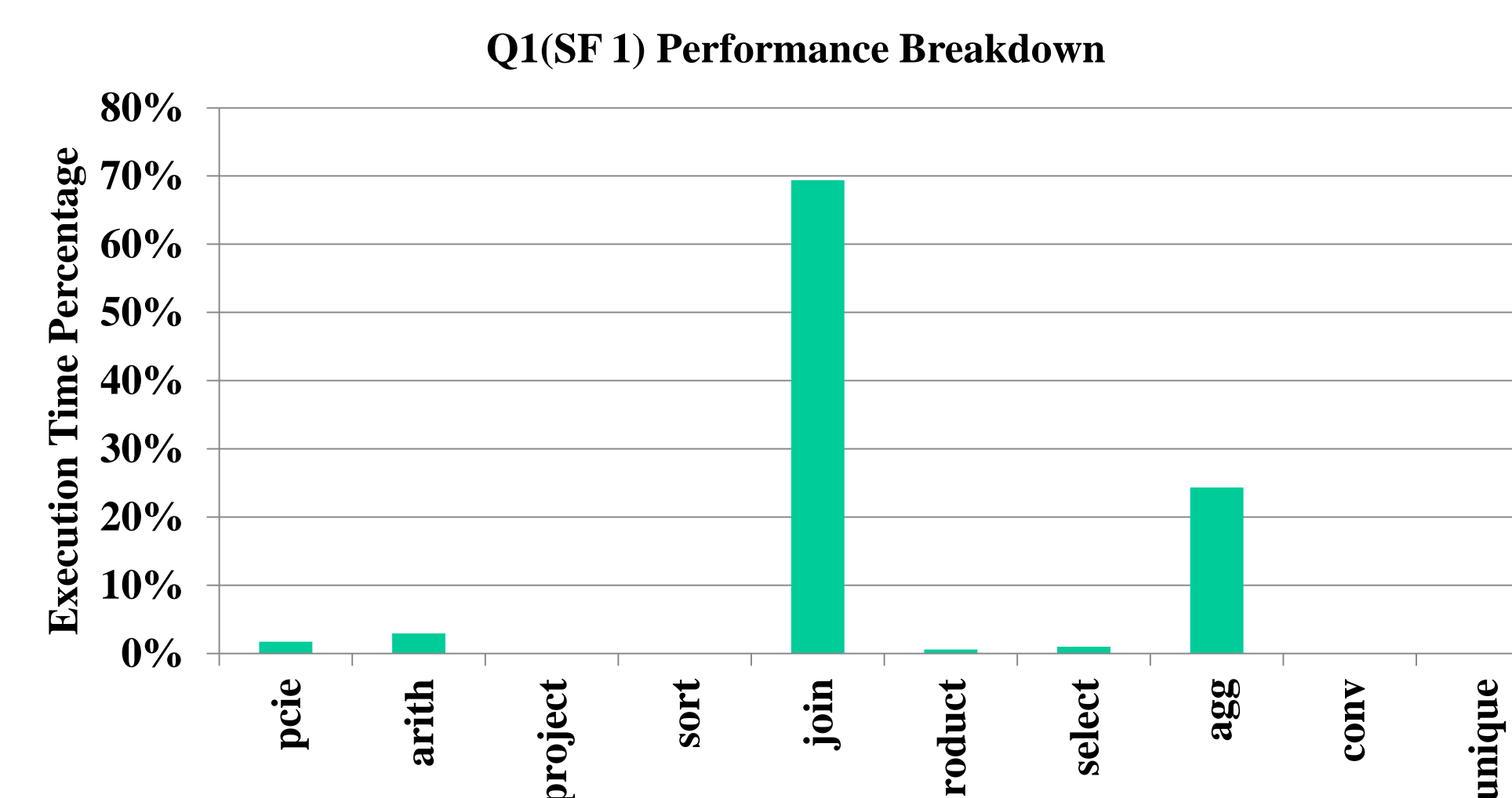
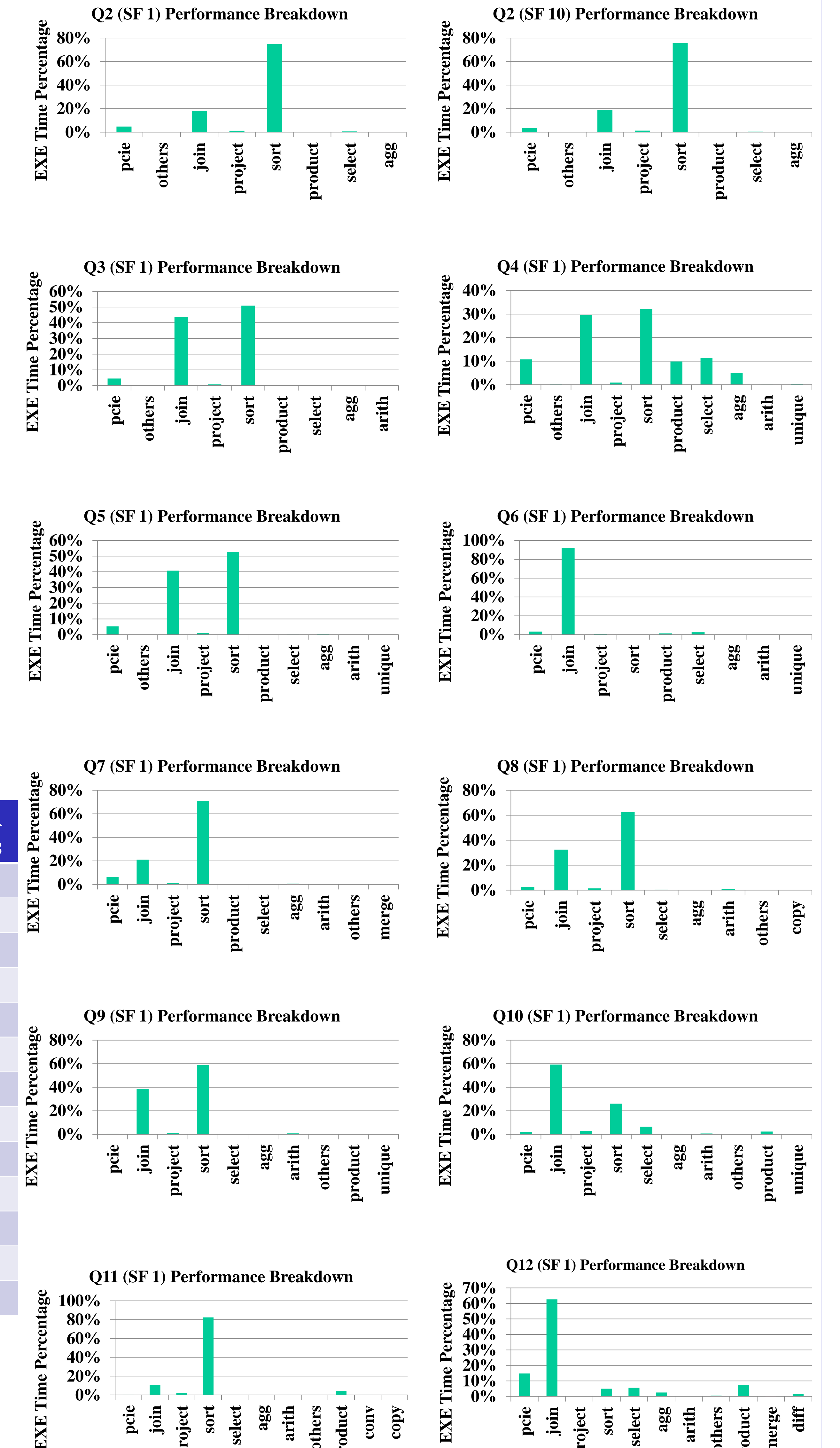


Kernel Weaver: Automatically Perform **Kernel Fusion** Optimization to reduce data movements [4,5]

## Red Fox TPC-H Benchmark Performance (Tesla C2075)

- Execution time = PCIe + GPU Computation
- Problem size is restricted by GPU memory capacity
- No data movement optimizations
- Unoptimized query plan
- RA operators are designed by us, others are from Thrust library
- Each Operators maps to several CUDA Kernels

Query	Scale Factor	Execution Time (second)	Input Size (MB)	#Operators	#CUDA Kernels
Query 1	1	7.32	528	33	146
Query 2	1	0.28	38	48	164
Query 2	10	2.56	413	48	164
Query 3	1	1.62	340	34	95
Query 4	1	0.51	264	18	56
Query 5	1	1.23	277	42	111
Query 6	1	2.52	384	28	75
Query 7	1	1.16	349	53	124
Query 8	1	3.01	334	61	162
Query 9	1	19.50	437	29	93
Query 10	1	3.54	300	46	143
Query 11	1	3.48	192	21	53
Query 12	1	0.66	438	33	107



## References

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