GPU Databases – The New Modality of Database Analytics

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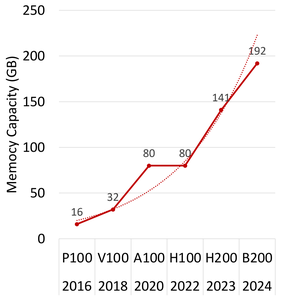
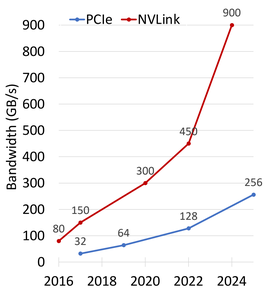
Why GPU Databases?

1. GPUs are becoming the new center of computing

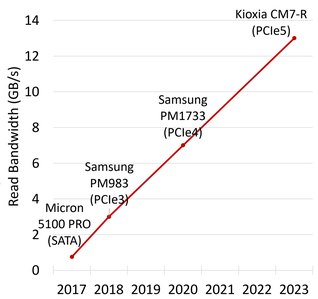
- Massive growth in computation power, memory capacity, and bandwidth in the past decade.
- With Grace superchips, **GPU memory capacity is no longer a bottleneck.**
- As storage and network performance grows, **CPU computation is the new bottleneck.**



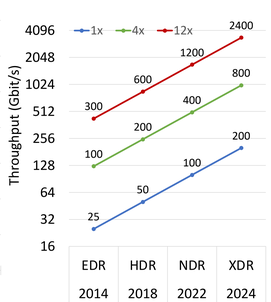
GPU Memory Capacity



Interconnect bandwidth



Storage bandwidth



Network bandwidth

2. Accessible and Affordable GPU hardware.

- GPU prices drop and availability increases over time.
- GPUs have comparable costs to CPUs in the cloud.

CPUs	On-Demand Rate (AWS)
4–192 Cores	$0.18–$11.12 / hour

GPUs	On-Demand Rate (Lambda)	
1 x H100	$2.5/hour	← $8/hour in 2023
1 x GH200	$3.2/hour	← $4.3/hour in 2024

SiriusDB Roadmap

Completed Research Works

Single-node in-memory GPU DBMS

1. Crystal Library (**SIGMOD 2020**[1])
2. Data Compression (**SIGMOD 2022**[2])
3. Hybrid CPU-GPU DBMS (**VLDB 2022**[3])
4. GPU-accelerated UDF (**DaMoN 2023**[4])
5. Multi-GPU DBMS (**VLDB 2024**[5])

Future/Ongoing Works

Terabyte-scale GPU Analytics

1. Query Exec with GPU Direct Storage.
2. Distributed GPU DBMS.
3. Supporting Complex SQL Operators.

GPU-accelerated RAG Database

1. Integrated SQL and Vector Search on GPUs.
2. Larger than GPU memory Vector Search.

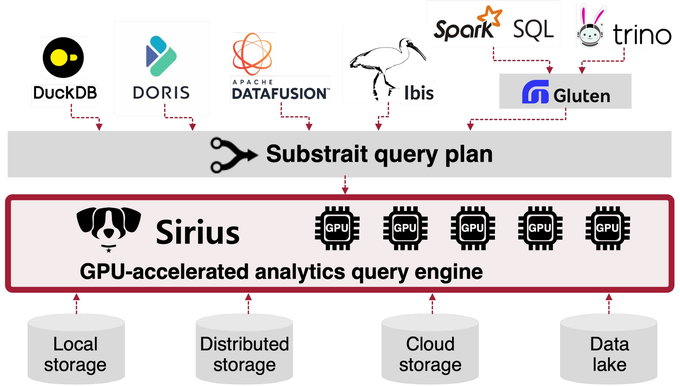
[1] Anil Shanbhag, Sam Madden, **Xiangyao Yu**. *A Study of the Fundamental Performance Characteristics of GPUs and CPUs for Database Analytics*, **SIGMOD 2020**
[2] **Bobbi Yogatama***, Anil Shanbhag*, **Xiangyao Yu**, and Samuel Madden. *Tile-based Lightweight Integer Compression in GPU*, **SIGMOD 2022**
[3] **Bobbi Yogatama**, Weiwei Gong, **Xiangyao Yu**. *Orchestrating Data placement and Query Execution in Heterogeneous CPU-GPU DBMS*, **VLDB 2022**
[4] **Bobbi Yogatama** et al. *Accelerating User-Defined Aggregate Functions with Block-wide Execution and JIT Compilation on GPUs*, **DaMoN@SIGMOD 2023**
[5] **Bobbi Yogatama**, Weiwei Gong, **Xiangyao Yu**. *Scaling your Hybrid CPU-GPU DBMS to Multiple GPUs*, **VLDB 2024**

SiriusDB: The Next-Generation GPU-Accelerated Query Engine

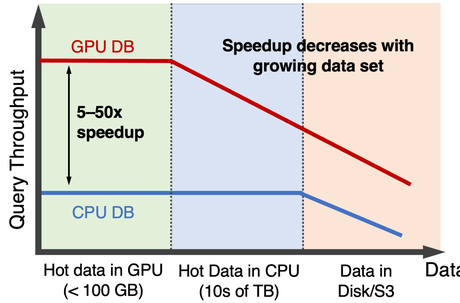
Riding the wave of GPU hardware improvement.

Unlock GPU acceleration by modifying a single line of configuration (same data, same API).

Currently supports DuckDB, more analytical processing engine will be supported in the future.



Sirius System Architecture



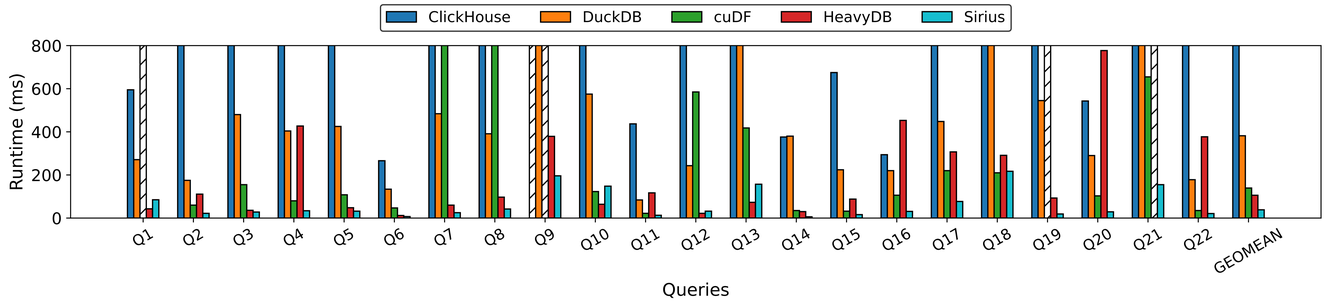
Supporting SSD/Storage in Sirius (ongoing)

Evaluation — 100 GB TPC-H Benchmark

GPU Instance: GH200 (**$3.2/hour** before discount), CPU Instance: m7i.16xlarge (**$3.2/hour**)

- ClickHouse (~10 years)
- DuckDB (~6 years)
- cuDF: A GPU-accelerated data processing library by NVIDIA (~6 years)
- HeavyDB: A Commercial GPU DB for Real-time Analytics (~10 years)
- **Sirius*: our engine (~7 months)**

***Sirius has multiple pending optimizations**



Sirius is **60x** faster than ClickHouse, **10x** faster than DuckDB, **3.6x** faster than cuDF, and **2.8x** faster than HeavyDB on a **cost-normalized hardware**