XDF XILINX DEVELOPER FORUM

Deepgreen MPP with FPGA: A supercharged Greenplum Data Warehouse solution

Presented By

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It’s Time for a complete rewrite

The End of an Architectural Era
(It’s time for a complete rewrite)

by

Michael Stonebraker

- **New Application**
- **Rich Data**
  - Text
  - IoT, Geospatial
  - Media
- **Intelligent Data**
  - Query getting more complex
  - Geospatial
  - Machine learning/Data mining
  - AI/Deep learning

Complete Rewrite

Hardware Trend

CPU has peaked,
FPGA has more room

Storage Hierarchy

- Big memory
- SSD
- Lots of bandwidth

Network
10, 100 GigE

Deepgreen MPP Database

- MPP (Massively Parallel Processing) shared nothing data warehouse
- Based on the open source Greenplum Database, 100% compatible
- Complete new query execution engine (LLVM JIT, SIMD)
- On premise and in clouse (AWS)
- *Adding FPGA*

A New Golden Age for Computer Architecture

AWARDS & RECOGNITION

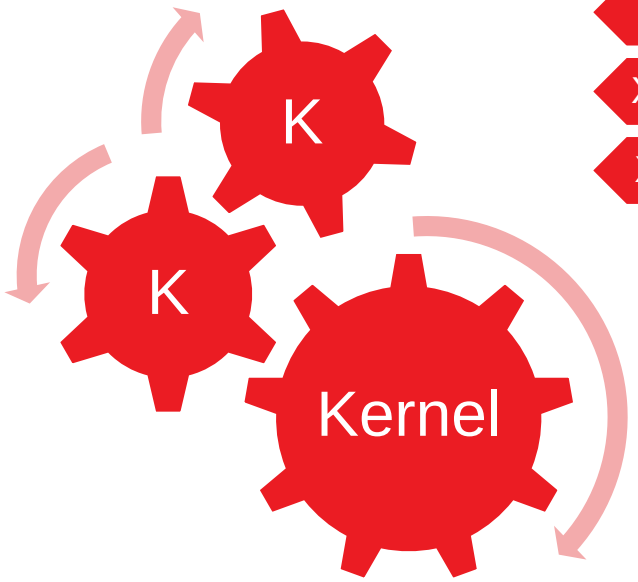
John Hennessy and David Patterson Receive 2017 ACM A.M. Turing Award

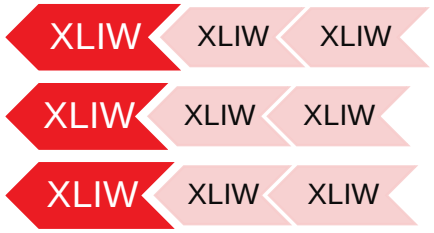
- **Domain Specific Hardware/Software Co-Design**
- **Enhanced Security**
- **Open Instruction Set**
- **Agile Chip Development**

Putting FPGA In Deepgreen

Challenges	Our Approach
Memory is big, but not big enough	Identify the bottleneck
Throughput vs Latency	New algorithm tuned for FPGA
Multi-CPU/Core	Offload to FPGA, none preemptive
Multiuser environment	XLIW: eXtra Long Instruction Word

XLIW: eXtra Long Instruction Word





XLIW: Hasher
Data, Data, Data …

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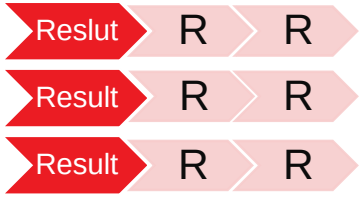
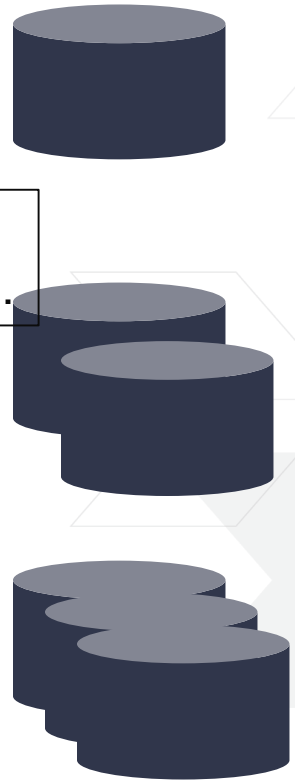




Use Case 1: Hash Join

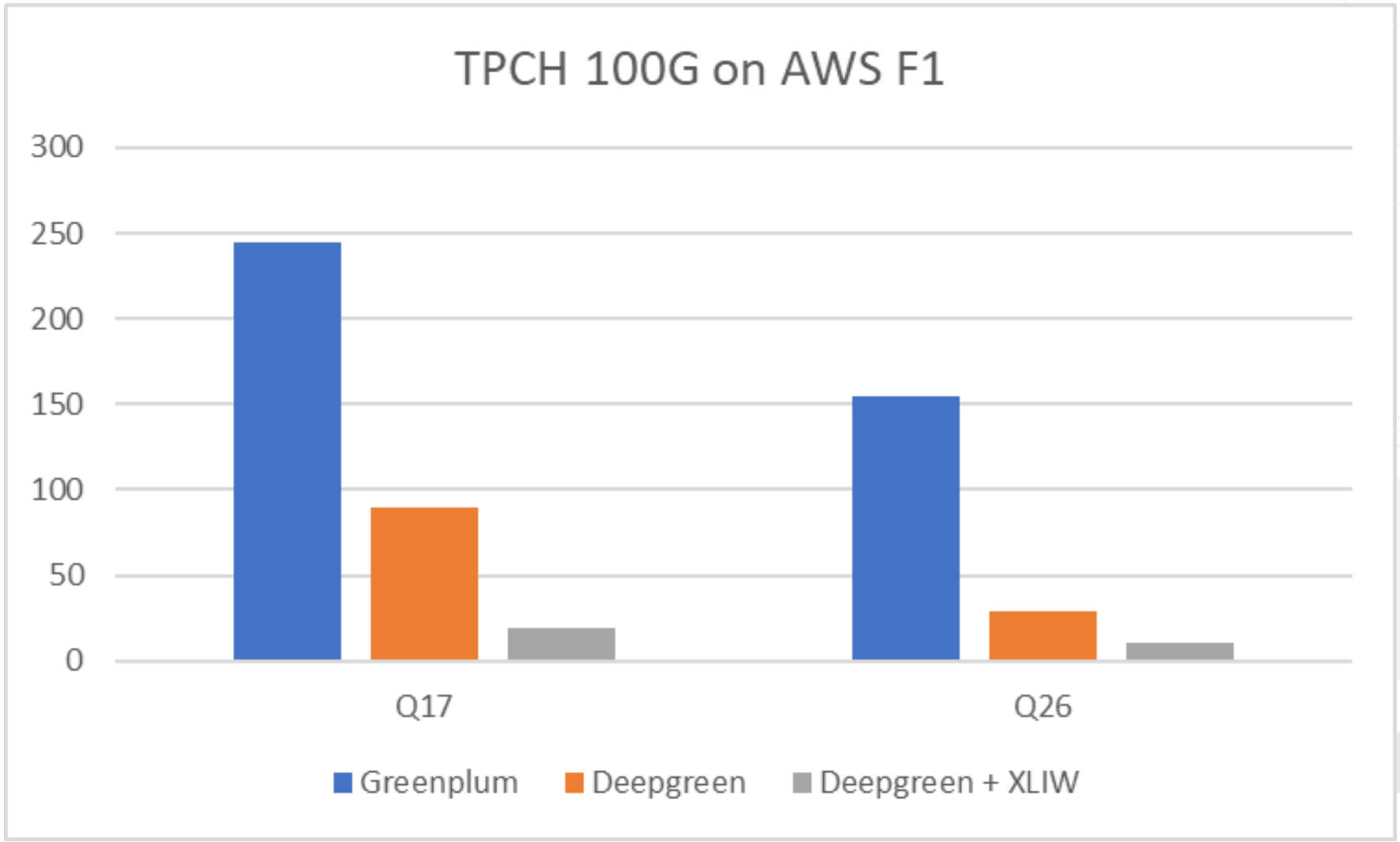
Hash Join

- Select * FROM A JOIN B ON A.x = B.x and A.y = B.y …
- One of the most important, expensive operation in OLAP
- Very simple algorithm
  - Read everything from A (or B, whichever is smaller)
  - Build a hash table
  - For each record from B
  - Probe the hash table.
  - Out all matching pairs
  - More complicated in real system, but this is the idea
- Lots of records joined
- Hash table is not cache friendly

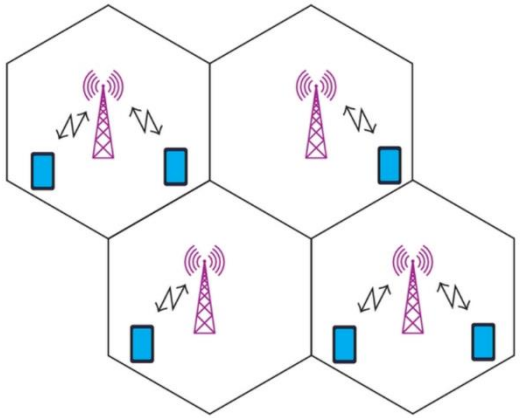
XLIW for Hash Join

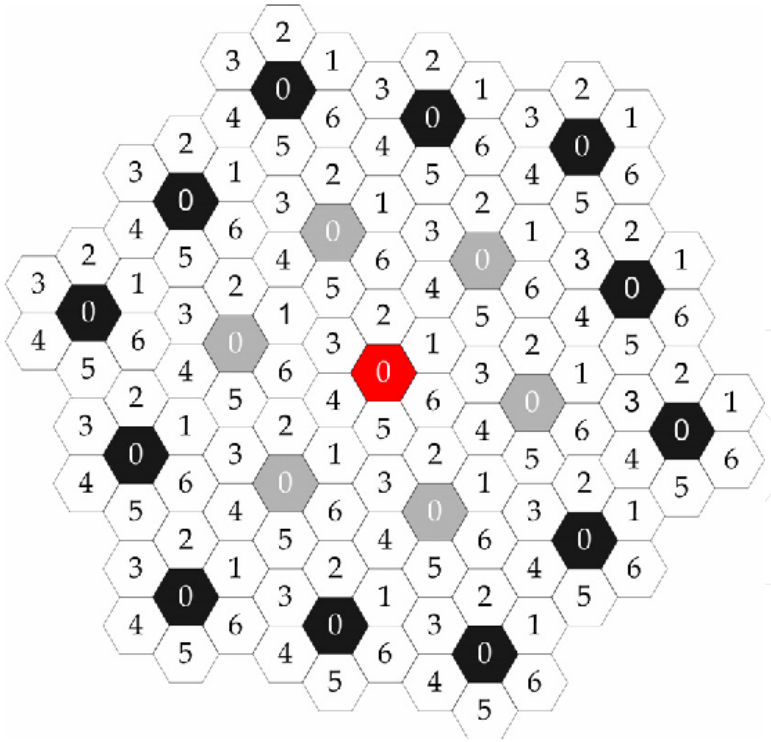
- Pack a lot of records of A, send to FPGA to compute hashes
- Instead of using hash table, we sort the hashes using a very fast radix sort. (10x faster than quicksort)
- Pack a lot of records of B, send to FPGA to compute hashes
- Sort hashes of B
- Merge
- It is a hybrid hash/sort merge join

Case 1: Hash Join Performance



Use Case 2: GeoSpatial Join





Use Case 2: GeoSpatial Join

- **SELECT area, count(*) FROM point JOIN area**

  WHERE ST_Intersects(point, area)

  group by area
- **How many user/devices (points) in each area (polygon)**
- **Intersects is an expensive operation and forces a nested loop join (slow)**
  - Naïve approach will never finish

Use Case 2: GeoSpatial Join

Greenplum + PostGIS

- Build index (R-tree)
- Index Nestloop Join
  - For each polygon, using index to lookup points nearby
  - Check the intersects condition
- Could take hours

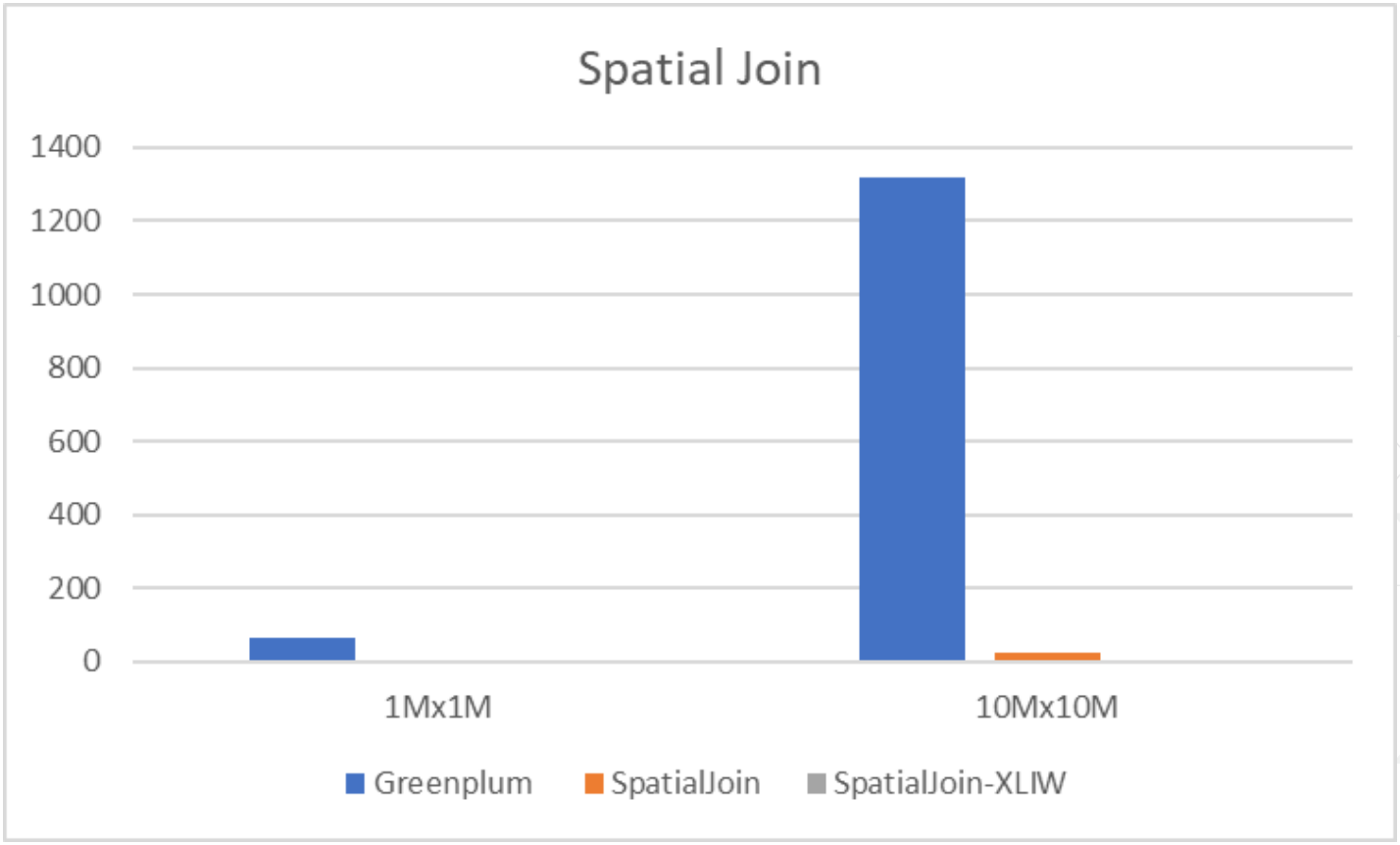
GeoSpatial Join + XLIW

- Do not use index
- Scan outer loop, build an in-memory data structure
  - Still expensive operation, but cheaper than compute intersection (like building an R-tree)
- Scan inner loop, probing the in memory data structure (like probing R-tree)
- Check intersection
  - This step is dominating execution time

XLIW: GeoSpatial Operations

- **For Intersects**
- **Packing many (point, area) pairs, send to FPGA, compute result**
  - We are not so worried about serialization cost this time
- **We could have let FPGA build the in memory data structure for us**
  - Currently not the bottleneck

Use Case II: Performance



Use Case 3: Adding Intelligence

- **An XLIW for data mining/machine learning**
- **Deepgreen Transducer Framework**
  - Allow user to embed C/Java/Go/Python code in SQL
  - Interleaved with SQL Engine code
  - First class citizen, optimized by query optimizer, executed in parallel, streaming data to/from SQL query operators like Sort/Join/Aggregate
- **ML libraries, Tensor Flow**
  - For example, Deep Neural Network in FPGA

Current Status and Future Directions

- **Deepgreen DB Appliance on AWS F1**
  - See our demo
  - On AWS Market Place soon
- **On premise**
- **We are just scratching the surface**
  - More use cases, endless opportunities
  - More to squeeze

Conclusion and Thank you

- Deepgreen MPP with FPGA on AWS F1 or On Premise
- Built for petabyte-size data warehouse applications
- Taking full advantage of modern hardware and FPGA, many crucial queries can be executed swiftly, increasing productivity of data scientists.

- Thank Xilinx team!
- Thank you all!

Adaptable.
Intelligent.

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