Empowered by Innovation NEC

PG-Strom

Query Acceleration Engine of PostgreSQL Powered by GPGPU

NEC OSS Promotion Center

The PG-Strom Project

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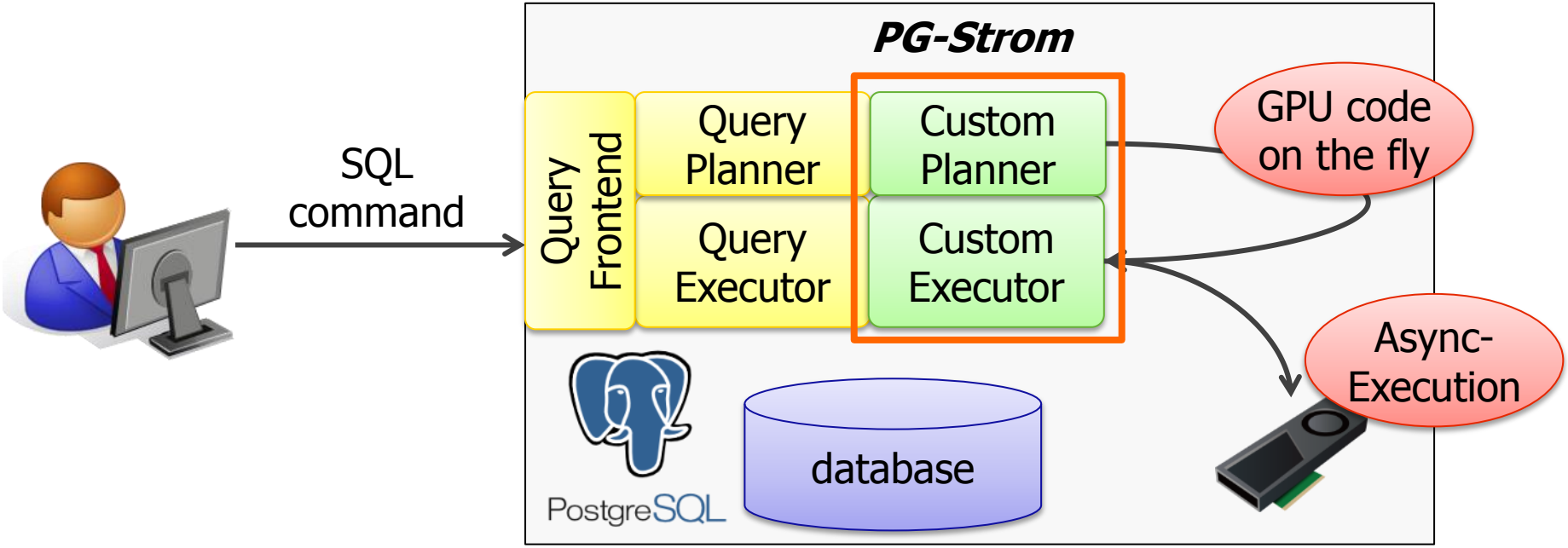
Self Introduction

- Name: KaiGai Kohei
- Company: NEC
- Mission: Software architect & Intrepreneur
- Background:
  - Linux kernel development (2003~?)
  - PostgreSQL development (2006~)
  - SAP alliance (2011~2013)
  - PG-Strom development & productization (2012~)
- PG-Strom Project:
  - In-company startup of NEC
  - Also, an open source software project

What is PG-Strom

- An Extension of PostgreSQL
- Off-loads CPU intensive SQL workloads to GPU processors
- Major Features
  - ① Automatic and just-in-time GPU code generation from SQL
  - ② Asynchronous and concurrent query executor



Concept

No Pain

- Looks like a traditional PostgreSQL database from standpoint of applications, thus, we can utilize existing tools, drivers, applications.

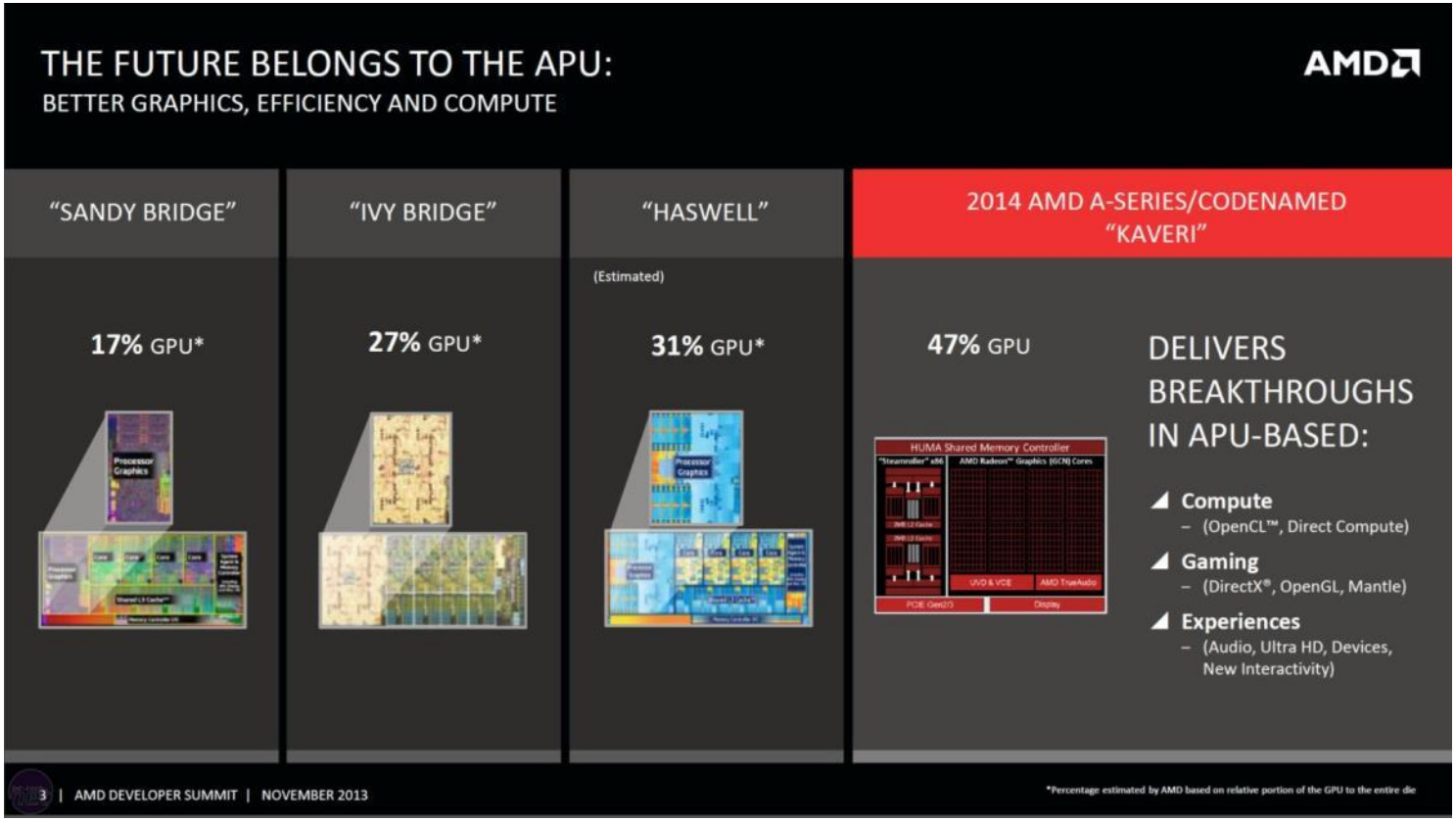
No Tuning

- Massive computing capability by GPGPU kills necessity of database tuning by human. It allows engineering folks to focus on the task only human can do.

No Complexity

- No need to export large data to external tools from RDBMS, because its computing performance is sufficient to run the workloads nearby data.

Technology Trend



SOURCE: [THE HEART OF AMD INNOVATION, Lisa Su, at AMD Developer Summit 2013]

- Movement to CPU/GPU integrated architecture rather than multicore CPU
- Free lunch for SW by HW evolution will finish soon

➔ Unless software is not designed to utilize GPU capability, unable to pull-out the full hardware capability.

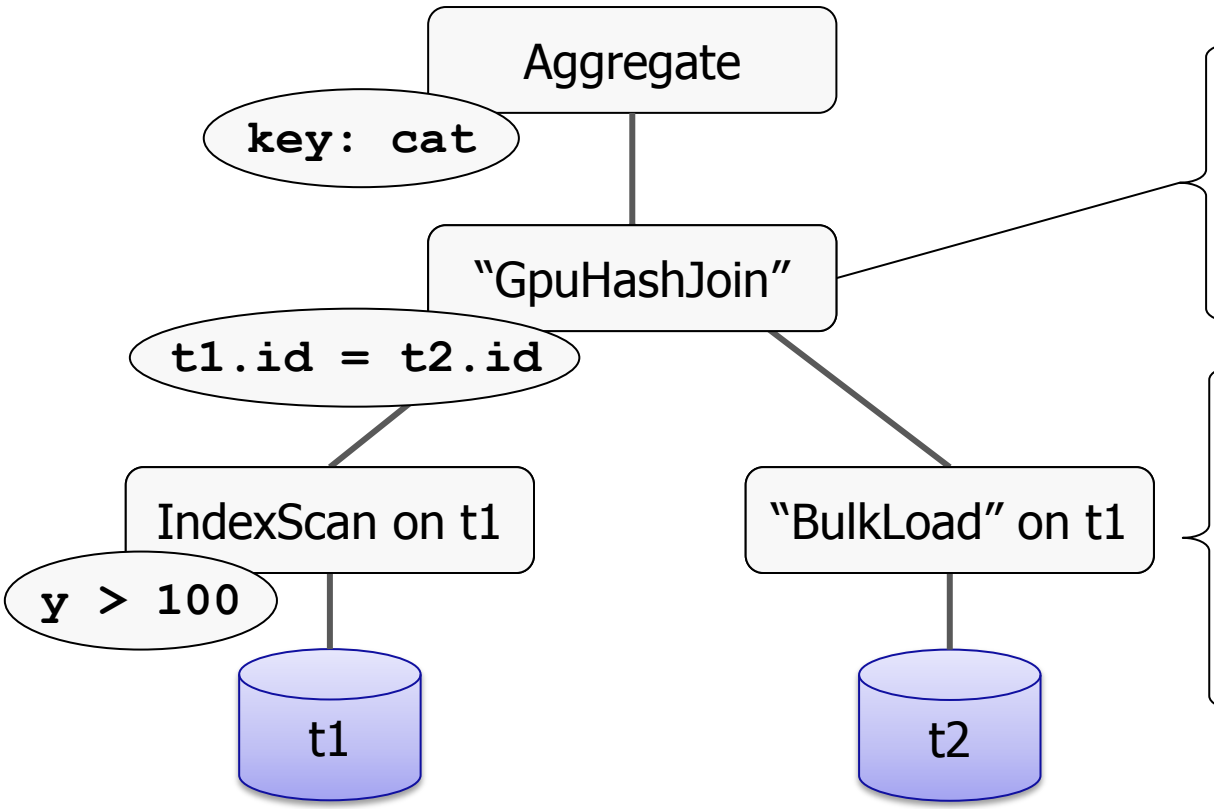
Background: How SQL is executed

```
postgres# EXPLAIN SELECT cat, avg(x) FROM t0 NATURAL JOIN t1
                  WHERE t0.z like '%abc%' GROUP BY cat;
                                  QUERY PLAN
-------------------------------------------------------------------------
HashAggregate  (cost=6629.88..6629.89 rows=1 width=12)
 Group Key: t0.cat
 ->  Hash Join  (cost=1234.00..6619.77 rows=2020 width=12)
   Hash Cond: (t0.aid = t1.aid)
   ->  Seq Scan on t0  (cost=0.00..5358.00 rows=2020 width=16)
         Filter: (z ~~ '%abc%'::text)
   ->  Hash  (cost=734.00..734.00 rows=40000 width=4)
     ->  Seq Scan on t1  (cost=0.00..734.00 rows=40000 width=4)
(8 rows)
```

- Planner constructs query execution plan based on cost estimation
- SQL never defines how to execute the query, but what shall be returned

Background: Custom-Plan Interface

```
SELECT cat, avg(x) FROM t1, t2
WHERE t1.id = t2.id AND y > 100
        GROUP BY cat;
```



- Hash Join
- Merge Join
- Nested Loop
- **Custom Join**

- Seq Scan
- Index Scan
- Index-Only Scan
- Tid Scan
- **Custom Scan**

PG-Strom Features

Logics

- GpuScan ... Parallel evaluation of scan qualifiers
- GpuHashJoin ... Parallel multi-relational join
- GpuPreAgg ... Two phase aggregation
- GpuSort ... GPU + CPU Hybrid Sorting
- GpuNestedLoop (in develop)

Data Types

- Integer, Float, Date/Time, Numeric, Text

Function and Operators

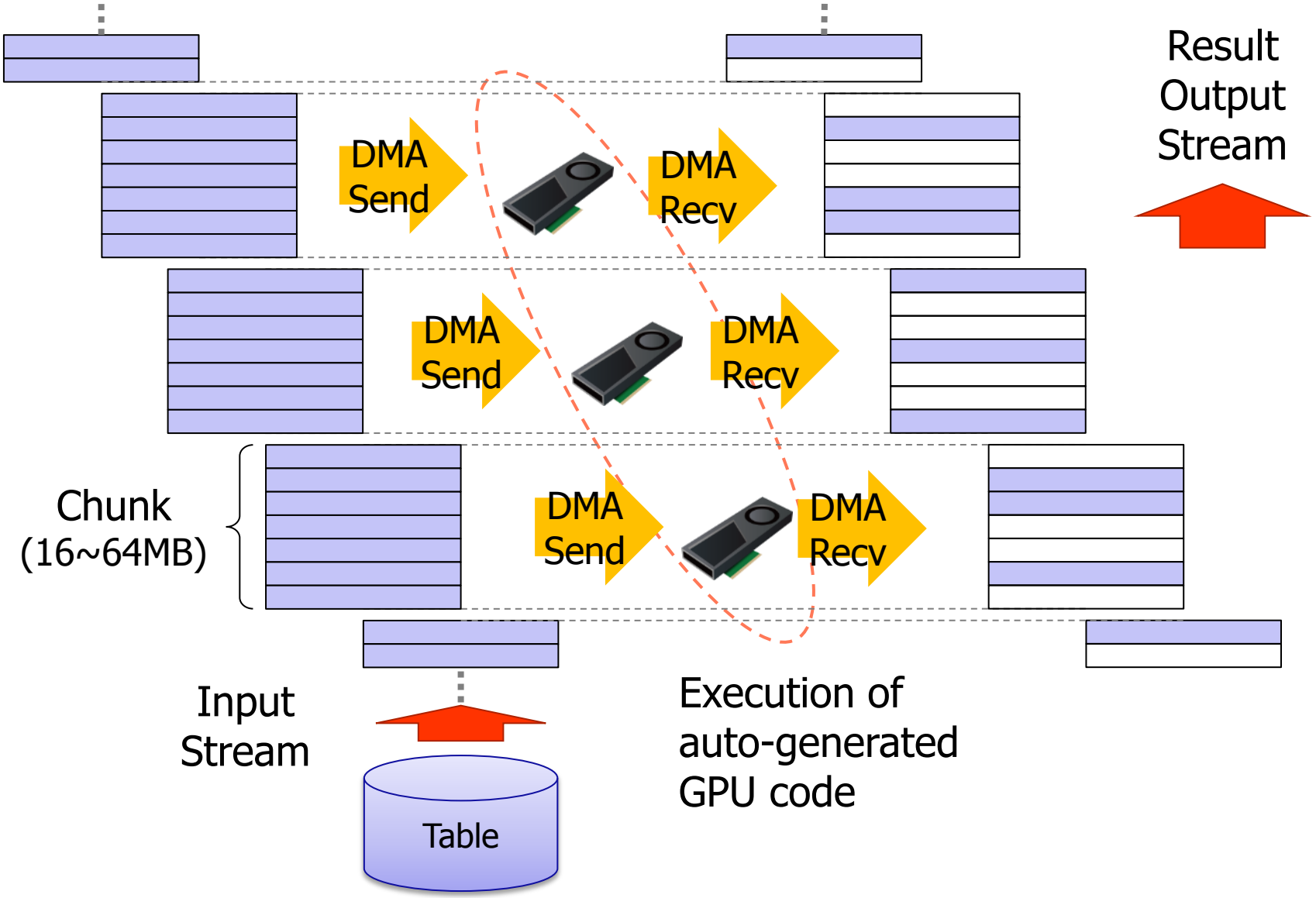
- Equality and comparison operators
- Arithmetic operators and mathematical functions
- Aggregates: count, min/max, sum, avg, std, var, corr, regr

Automatic GPU code generation

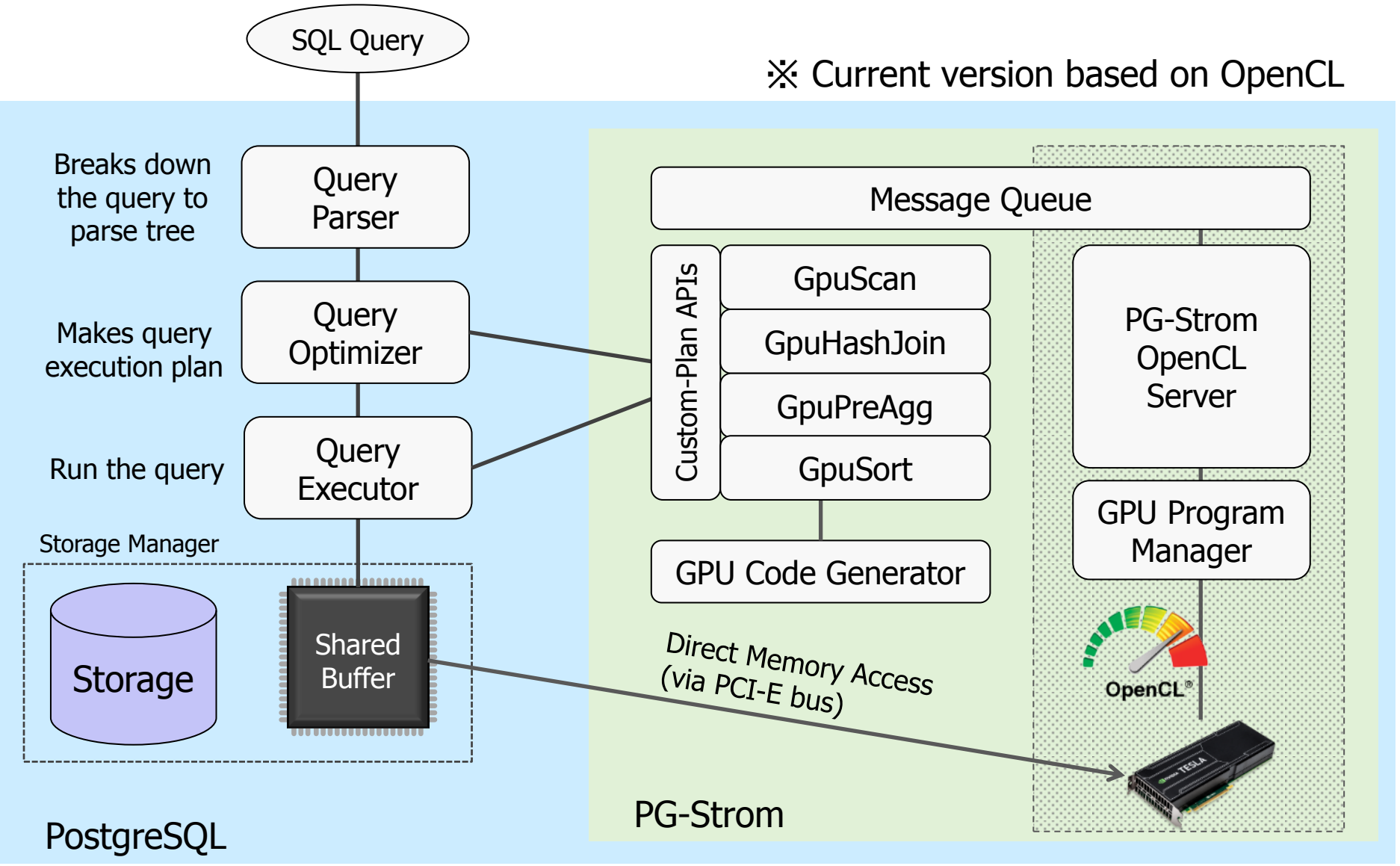
```
postgres=# SET pg_strom.show_device_kernel = on;
postgres=# EXPLAIN VERBOSE SELECT * FROM t0 WHERE sqrt(x+y) < 10;
                                                  QUERY PLAN
-------------------------------------------------------------------------------
Custom Scan (GpuScan) on public.t0  (cost=500.00..357569.35 rows=6666683 width=77)
   Output: id, cat, aid, bid, cid, did, eid, x, y, z
   Device Filter: (sqrt((t0.x + t0.y)) < 10::double precision)
   Features: likely-tuple-slot
   Kernel Source: #include "opencl_common.h"
            :
 static pg_bool_t
 gpuscan_qual_eval(__private cl_int *errcode,
                   __global kern_parambuf *kparams,
                   __global kern_data_store *kds,
                   __global kern_data_store *ktoast,
                   size_t kds_index)
 {
   pg_float8_t KPARAM_0 = pg_float8_param(kparams,errcode,0);
   pg_float8_t KVAR_8 = pg_float8_vref(kds,ktoast,errcode,7,kds_index);
   pg_float8_t KVAR_9 = pg_float8_vref(kds,ktoast,errcode,8,kds_index);

   return pgfn_float8lt(errcode,
          pgfn_dsqrt(errcode, pgfn_float8pl(errcode, KVAR_8, KVAR_9)), KPARAM_0);
 }
```

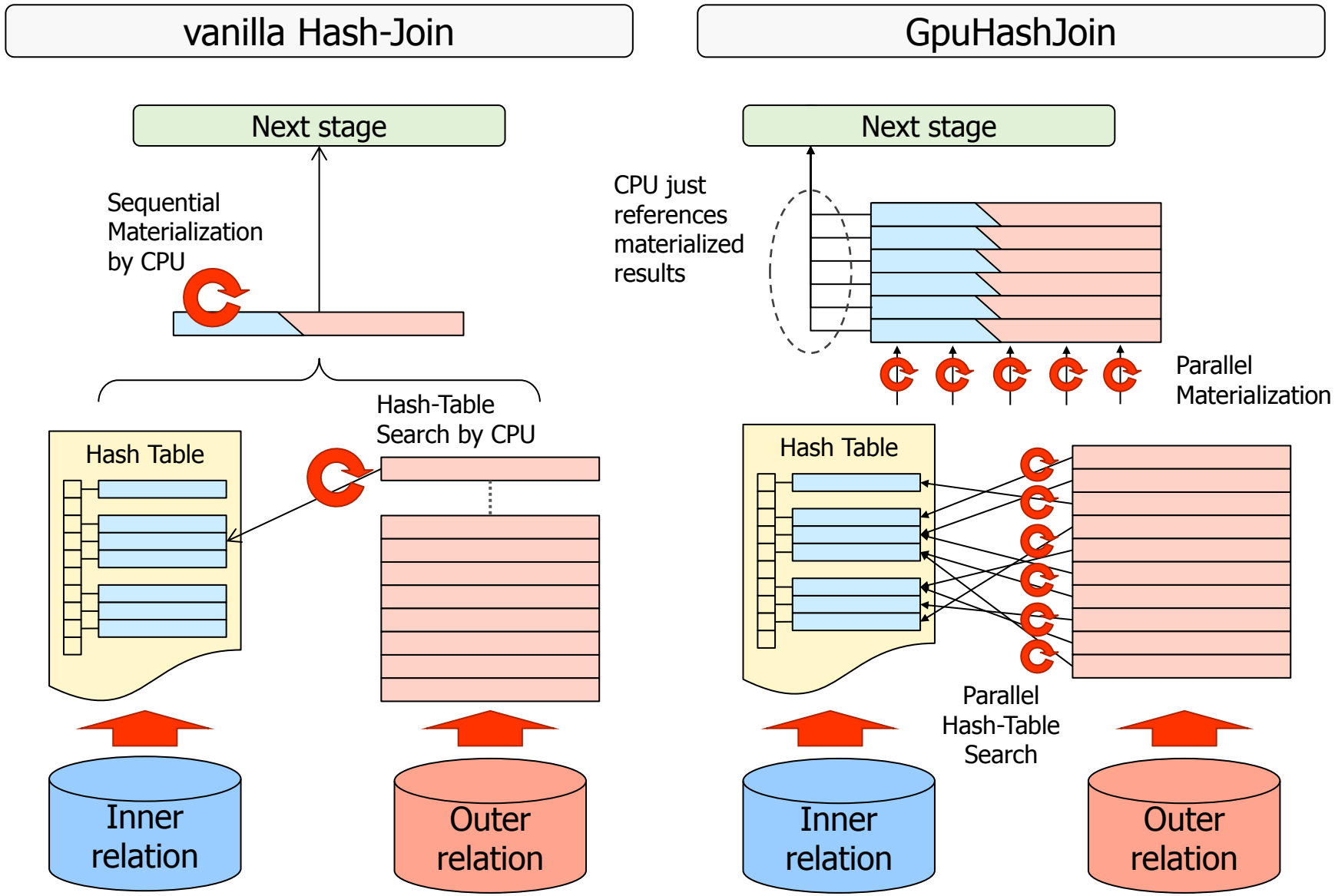
Implementation (1/3) – GpuScan



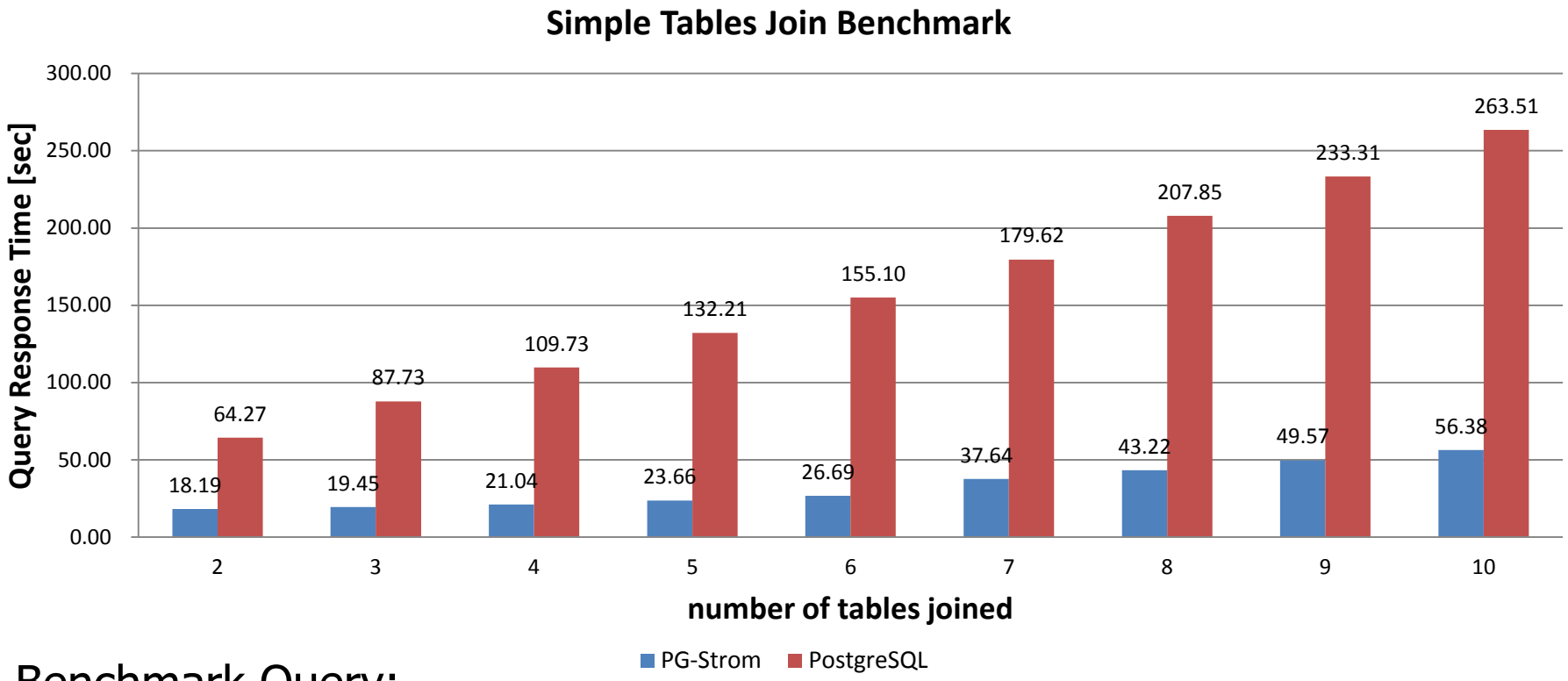
Software Architecture



Implementation (2/3) – GpuHashJoin



Benchmark result (1/2) – simple tables join



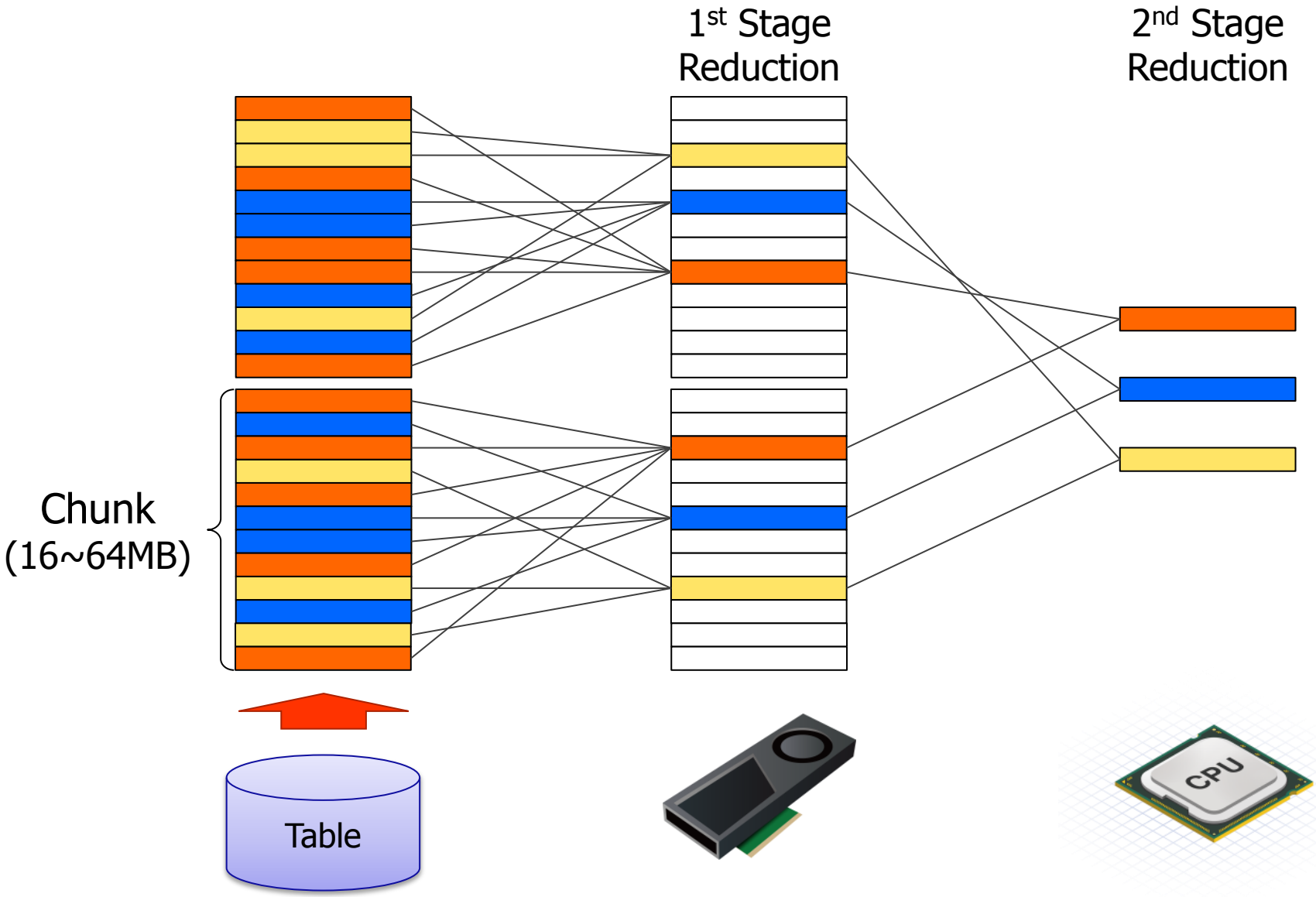
Benchmark Query:

```
SELECT * FROM t0 NATURAL JOIN t1 [NATURAL JOIN ....];
```

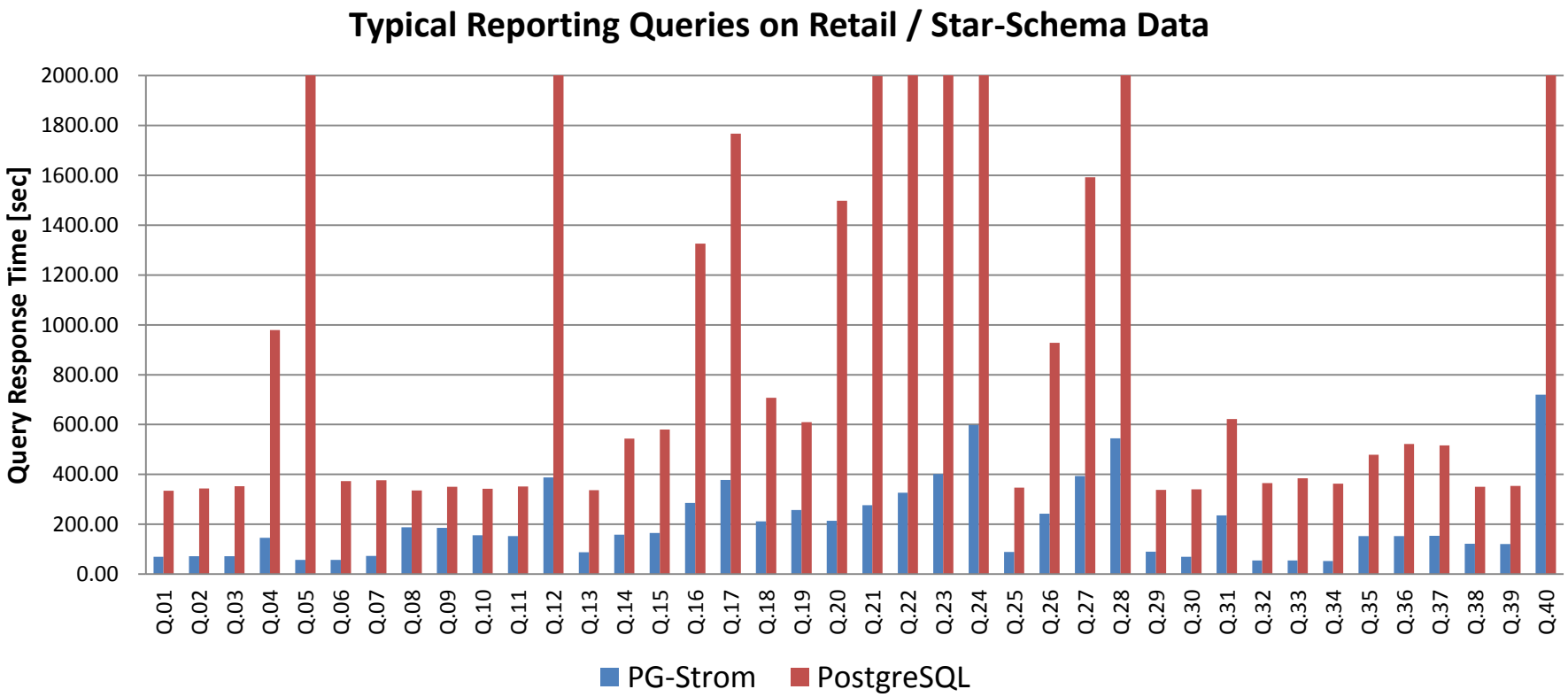
Environment:

- `t0` has 100million rows (13GB), `t1`-`t9` has 40,000 rows for each, all-data pre-loaded
- CPU: Xeon E5-2670v3 (12C, 2.3GHz) x2, RAM: 384GB, GPU: Tesla K20c x1

Implementation (3/3) – GpuPreAgg

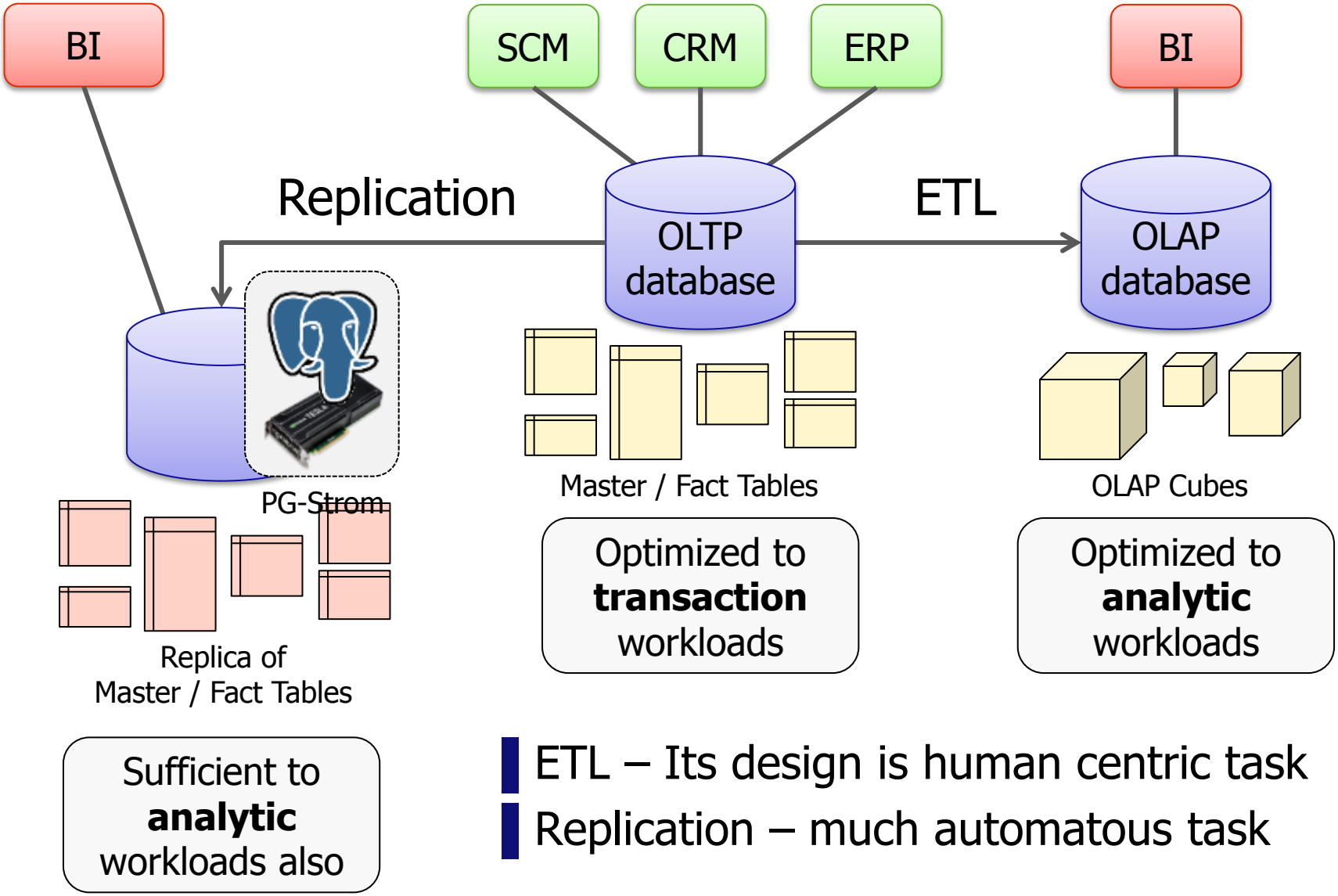


Benchmark result (2/2) – Star Schema Model



- 40 typical reporting queries
- 100GB of retail / start-schema data, all pre-loaded
- Environment
  - CPU: Xeon E5-2670v3(12C, 2.3GHz) x2, RAM: 384GB, GPU: Tesla K20c x1

Expected Scenario – Reduction of ETL



- ETL – Its design is human centric task
- Replication – much automatous task

Direction of PG-Strom

Development Plan

Current version: PG-Strom β + PostgreSQL v9.5devel

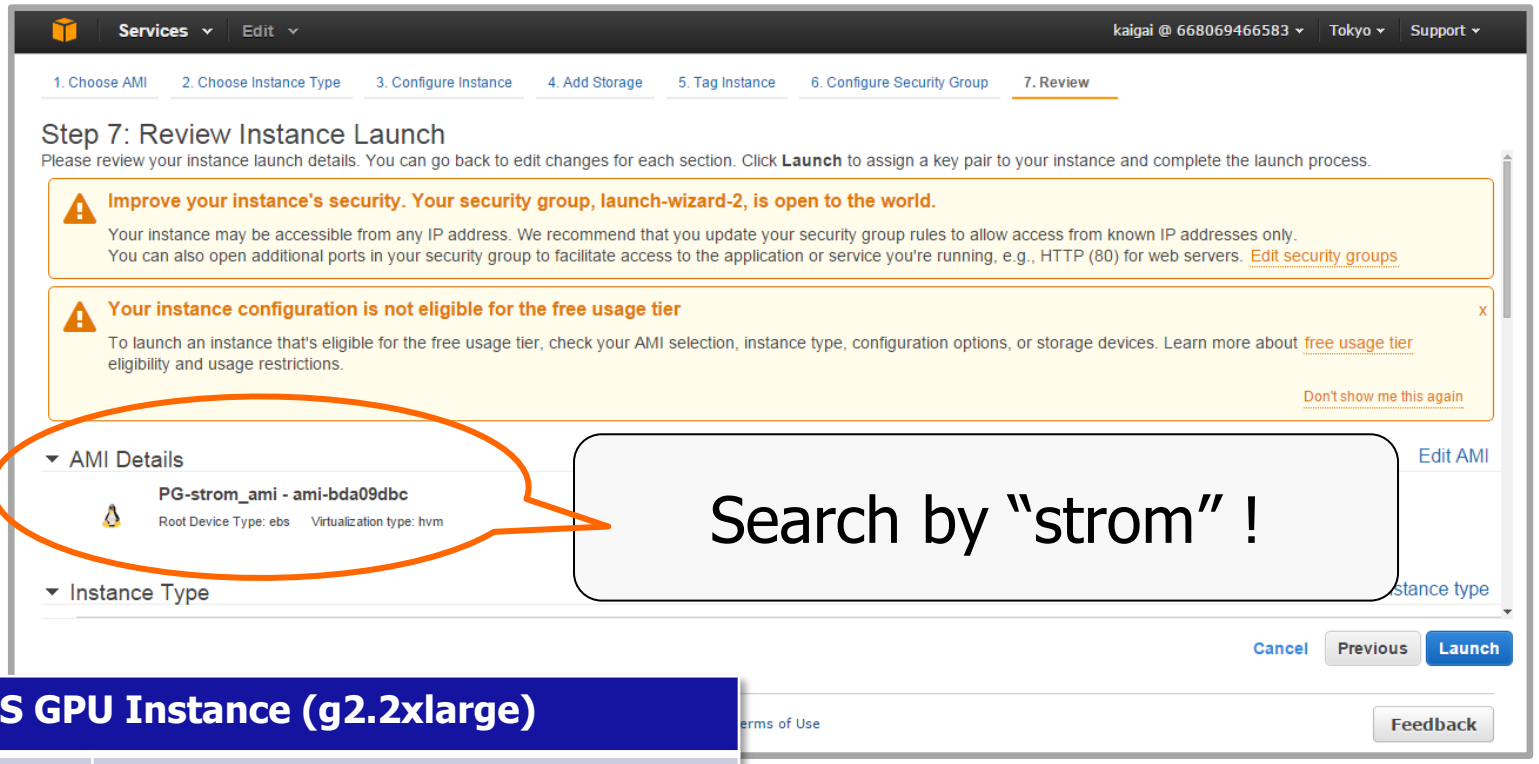
- Migration of OpenCL to CUDA
- Add support of GpuNestedLoop
- Add support multi-functional kernel
- Standardization of custom-join interface
- ...and more...?

Short term target: PostgreSQL v9.5 timeline (2015)

- Integration with funnel executor
- Investigation to SSD/NvRAM utilization
- Custom-sort/aggregate interface
- Add support for spatial data types (?)

Middle term target: PostgreSQL v9.6 timeline (2016)

Let's try – Deployment on AWS



AWS GPU Instance (g2.2xlarge)	
CPU	Xeon E5-2670 (8 xCPU)
RAM	15GB
GPU	NVIDIA GRID K2 (1536core)
Storage	60GB of SSD
Price	$0.898/hour, $646.56/mon (*) Price for on-demand instance on Tokyo region at Nov-2014

Welcome your involvement!

How to be involved?

- as a user
- as a developer
- as a business partner

check it out!

Source code

- https://github.com/pg-strom/devel

Contact US

- e-mail: kaigai@ak.jp.nec.com
- twitter: @kkaigai

...or, catch me in the Convention Center

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