Opensource Column Store Databases: MariaDB ColumnStore vs. ClickHouse

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About me

- Working with MySQL for 10-15 years
  - Started at MySQL AB 2006
    - *Sun Microsystems, Oracle (MySQL Consulting)*
    - *Percona since 2014*
  - Recently joined Virtual Health (medical records startup)

MariaDB ColumnStore, ClickHouse and Storage Formats

Caution:

1. This talk is **not about specifics of implementation**
   - A number of presentations about Clickhouse and MariaDB @ Percona Live 2019
2. This is all about:
   - **What? -- what is the problem**
   - **Why? -- why queries are slow**
   - **How? -- how to solve**
3. Examples are real-world example, medical insurance records
   - (but no actual PII data shown)

Into: MySQL and Slow Queries

Simple query - top 10 - clients who visited doctors most often (data from 2017-2019)

```
mysql> SELECT
    ->   client_id,
    ->   min(date) as first_visit,
    ->   max(date) as last_visit,
    ->   count(distinct date) as days_visited,
    ->   count(cv.id) as visits,
    ->   count(distinct cv.service_location_name) as locations
    -> FROM client_visit cv
    -> GROUP BY client_id
    -> ORDER by visits desc
    -> LIMIT 10;
+-----------+-------------+------------+--------------+--------+-----------+
| client_id | first_visit | last_visit | days_visited | visits | locations |
+-----------+-------------+------------+--------------+--------+-----------+
| ......... | 2017-08-07  | 2019-05-24 |          ..  |    ... |        .. |
```

10 rows in set (46.24 sec)

MySQL = { MySQL MariaDB PERCONA SERVER }

What exactly is slow?

Is 47 seconds slow?

… depends on expectations

- Data Science world it is blazing fast
- Realtime report/dashboard - extremely slow

… Web based queries - users tends to reload page if it is slow

… Leaving MySQL with tons of queries doing the same thing

What to do?

Some ideas:

1. Use index Luke!
2. Table per report
3. Pre-aggregate - table per group of reports
4. Something else

Use index

But, it is already using index:

```
           id: 1
  select_type: SIMPLE
        table: cv
   partitions: NULL
         type: index
possible_keys: FK_client_visit
          key: FK_client_visit
      key_len: 5
          ref: NULL
         rows: 10483873
     filtered: 100.00
        Extra: Using temporary; Using filesort
1 row in set, 1 warning (0.00 sec)

  PRIMARY KEY (`id`),
  KEY `FK_client_visit_author_id` (`client_id`)
```

Ok, better index: covered index

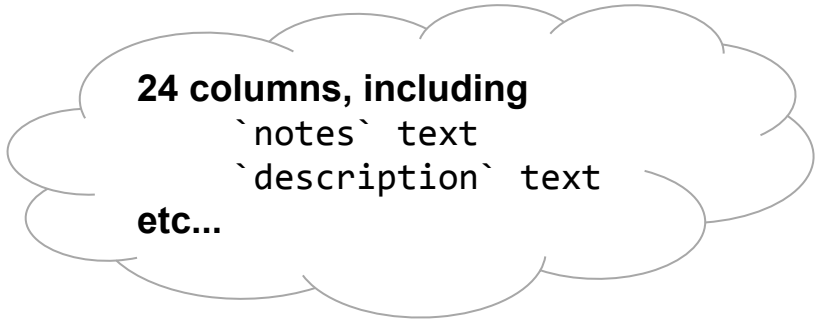
```
mysql> alter table client_visit add key comb(client_id, date, service_location_name);
Query OK, 0 rows affected (38.48 sec)
Records: 0  Duplicates: 0  Warnings: 0

         table: cv
   partitions: NULL
         type: index
possible_keys: FK_client_id,comb
          key: comb
      key_len: 776
          ref: NULL
         rows: 10483873
     filtered: 100.00
        Extra: Using index; Using temporary; Using filesort

10 rows in set (12.18 sec)
```

Ok, how large is the table?

```
mysql> show table status like 'client_visit'\G
*************************** 1. row ***************************
           Name: client_visit
         Engine: InnoDB
        Version: 10
     Row_format: Dynamic
           Rows: 10483873
 Avg_row_length: 233
    Data_length: 2 452 602 880
   Index_length: 1 644 773 376
```



~= 4G on disk, that is it!

Ok, other options in MySQL?

Create table per each report

Problems

1. Too many tables
2. Hard to maintain

Ok, other options in MySQL?

Pre-aggregate in a table:

- group by client_id + avg, sum, …
- group by date + avg,sum

Final report will do another aggregation if needed

Problems:

1. Some aggregates can’t be re-aggregated
2. Still too many tables
3. Hard to maintain

And it was only the beginning… now this:

```
SELECT
  cv.client_id as client_id,
  min(date) as first_visit,
  max(date) as last_visit,
  count(distinct date) as days_visited,
  count(distinct cv.id) as visits,
  count(distinct cp.cpt_code) as procedures,
  count(distinct cv.service_location_name) as locations,
  sum(billed_amount) as total_billed,
  max(billed_amount) as max_price,
  avg(billed_amount) as avg_price
FROM
     client_visit cv
     join client_procedure cp on cp.encounter_id = cv.encounter_id
     join client_procedure_claim cpc on cp.id = cpc.client_procedure_id
     join client_claim cc on cc.id = cpc.client_claim_id
GROUP BY client_id
ORDER BY total_billed desc
LIMIT 10
```

4 table JOIN, all large tables

```
+-----------+-------------+------------+--------------+--------+------------+-----------+--------------+-----------+-------------+
| client_id | first_visit | last_visit | days_visited | visits | procedures | locations | total_billed | max_price | avg_price   |
+-----------+-------------+------------+--------------+--------+------------+-----------+--------------+-----------+-------------+
|   ....... | 2018-02-14  | 2019-04-22 |           64 |     64 |         .. |        .. |    200K      |  11K      |  449.34     |
...
```

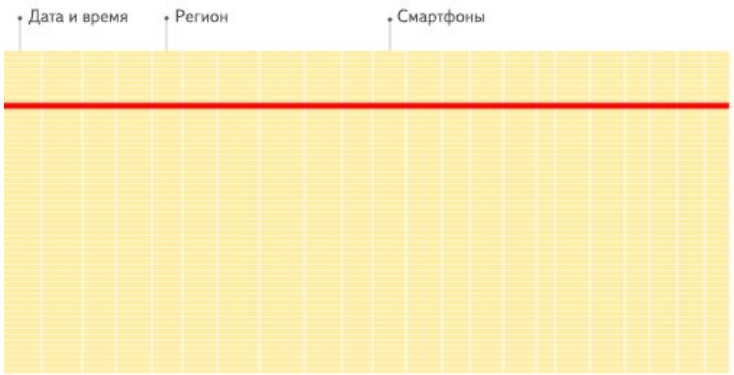
10 rows in set (5 min 18.16 sec)

Why MySQL is slow for such queries?

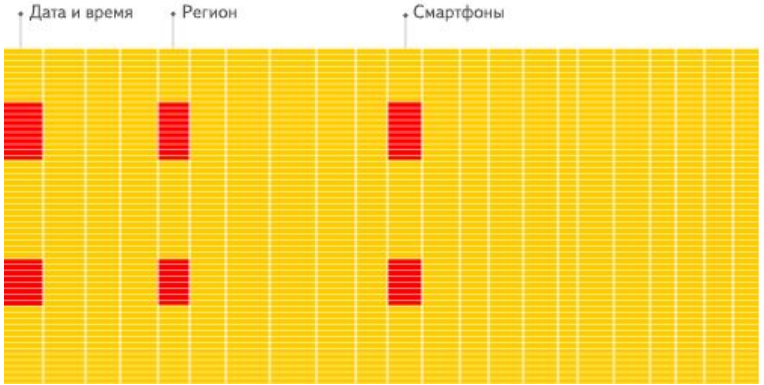
1. Row oriented - even if we retrieve 2 fields it will need to read a row
2. InnoDB organize table by pages (16k page) - will need to read more
3. MySQL will use 1 cpu core per query, not utilizing all cores

Why MySQL is slow for such queries?

Row-oriented DBMS (MySQL)



Column-oriented DBMS



https://clickhouse.yandex/docs/en/

Column Store Databases

MariaDB Columnstore

https://mariadb.com/kb/en/library/mariadb-columnstore/

Tips and Tricks with MariaDB ColumnStore

Wednesday 5:10 PM - 5:35 PM

Column Store Databases

Yandex Clickhouse

https://clickhouse.yandex/

Low Cost Transactional and Analytics With MySQL and Clickhouse, Have Your Cake and Eat It Too!

Wednesday 5:40 PM - 6:05 PM

Clickhouse Features to Blow your Mind

Thursday 11:55 AM - 12:45 PM

Column-store tests

Testing box 1:

- AWS ec2 instance, c5d.4xlarge
- RAM: 32.0 GiB
- vCPU: 16
- Disk: NVMe SSD + EBS

Testing box 2:

- AWS ec2 instance, c5d.18xlarge
- RAM: 144.0 GiB
- vCPU: 72
- Disk: NVMe SSD + EBS

Is it worth using column store: Q1

	MySQL	Clickhouse	MariaDB
Response time (sec)	46.24	0.754	11.43
Speed increase compared to MySQL (times, %)		62x 6248%	4x 404%

AWS ec2 instance,
c5d.4xlarge

Is it worth using column store: Q2

	MySQL	Clickhouse	MariaDB
Response time (sec)	5 min 18.16 sec	33.83 sec	1 min 2.16 sec
Speed increase compared to MySQL (times, %)		9x 940%	5x 511%

AWS ec2 instance,
c5d.4xlarge

Table sizes on disk

	MySQL	Clickhouse	ColumnStore
client_visit	5,876,219,904	793,976,832	3,606,462,464
client_procedure	13,841,203,200	2,253,180,928	9,562,865,664
client_procedure_claim	2,466,250,752	292,007,936	335,683,584
client_claim	11,710,496,768	2,400,182,272	6,720,749,568
Total	33,894,170,624	5,739,347,968	20,225,761,280
Smaller compared to MySQL size (x)		**5.91**	**1.68**

Compression

Exporting from MySQL

Usually 3 options

1. ETL to Star Schema
2. ETL to flat de-normalized tables
3. Copy / replicate realtime (as is)

I will talk about option 3.

Yandex Clickhouse

```
sudo apt-get install clickhouse-client
clickhouse-server
```

Clickhouse: export from mysql (schema)

https://github.com/Altinity/clickhouse-mysql-data-reader

1. Schema import

```
$ clickhouse-mysql --create-table-sql \
        --src-host=mysql-replica-host \
        --src-user=export \
        --src-password=xxxxxx \
        --src-schemas=main \
        --src-tables=client_condition,client_procedure,client_visit
```

It will choose partition key and sort key, i.e.

```
ENGINE = MergeTree() PARTITION BY toYYYYMM(created_date) ORDER BY client_id
```

Beware: enum is not supported (bug)

Clickhouse: export from MySQL (data)

1. Use clickhouse-mysql-data-reader (slower)
2. Use native Clickhouse MySQL connection:

```
INSERT INTO client_procedure_claim SELECT *
FROM
mysql('host', 'db', 'client_procedure_claim', 'export', 'xxxxx')
Ok.


0 rows in set. Elapsed: 17.821 sec. Processed 37.40 million rows, 299.18
MB (2.10 million rows/s., 16.79 MB/s.)
```

Clickhouse: connect using MySQL client

https://github.com/sysown/proxysql/wiki/ClickHouse-Support

```
$ wget
https://github.com/sysown/proxysql/releases/download/v2.0.4/p
roxysql_2.0.4-ubuntu18_amd64.deb
```

```
$ dpkg -i proxysql_2.0.4-clickhouse-ubuntu18_amd64.deb
```

```
$ proxysql --clickhouse-server
```

Clickhouse: connect using MySQL client

```
$ mysql -h 127.0.0.1 -P 6032 ...
Admin> SELECT * FROM clickhouse_users;
Empty set (0.00 sec)

Admin> INSERT INTO clickhouse_users VALUES ('clicku','clickp',1,100);
Query OK, 1 row affected (0.00 sec)

Admin> LOAD CLICKHOUSE USERS TO RUNTIME;
Query OK, 0 rows affected (0.00 sec)

Admin> SAVE CLICKHOUSE USERS TO DISK;
Query OK, 0 rows affected (0.01 sec)
```

https://github.com/sysown/proxysql/wiki/ClickHouse-Support

Clickhouse: connect using MySQL client

```
mysql -h 127.0.0.1 -P 6090 -uclicku -pclickp
...
Server version: 5.5.30 (ProxySQL ClickHouse Module)

mysql> select  client_id,    count(cv.id) as visits,
count(distinct cv.service_location_name) as locations
from  client_visit cv
group by  client_id order by visits desc  limit 10;
+-----------+--------+-----------+
| client_id | visits | locations |
+-----------+--------+-----------+
...
10 rows in set (0.53 sec)
```

ProxySQL to Clickhouse - experimental

Some bugs exists:

```
select  min(date) as first_visit,  max(date) as last_visit from
client_visit;
ERROR 2013 (HY000): Lost connection to MySQL server during query
```

Clickhouse - joining MySQL source

```
CREATE VIEW clients_mysql as select * from
mysql('mysql_host', 'db', 'client', 'export', 'xxxx');

select count(*) from clients_mysql;

SELECT count(*)
FROM clients_mysql

┌─count()─┐
│ 1035284 │
└─────────┘
```

Clickhouse - joining MySQL source

```
SELECT cv.client_id as client_id ...
FROM
...
INNER JOIN
(
    SELECT
        user_id,
        is_active
    FROM clients_mysql
) AS c ON cv.client_id = c.user_id
WHERE c.is_active = 1
...
```

```
CREATE VIEW clients_mysql as
select * from

mysql('mysql_host', 'db',
'client', 'export', 'xxxx');
```

```
10 rows in set. Elapsed: 36.653 sec. Processed 122.58 million
rows, 2.30 GB (3.34 million rows/s., 62.72 MB/s.)
```

MariaDB Column Store Architecture

Application

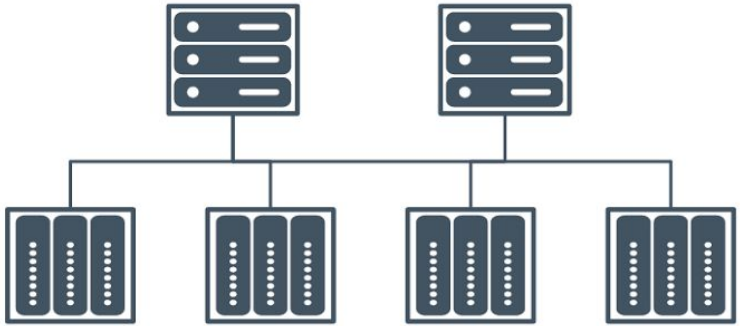
BI Tool

SQL Client

Custom
Big Data App

MariaDB SQL Front End (User Module)

Distributed Query Engine (Performance Module)



Data Storage

Columnar Distributed Data Storage

Local Storage | SAN/NAS | EBS | GlusterFS | CEPH

MariaDB ColumnStore: export from mysql

Schema import - need to create custom schema

mysqldump --no-data

… change engine=InnoDB to engine=Columnstore

MariaDB ColumnStore: export from mysql

Schema import - need to create custom schema

mysqldump --no-data does not work out of the box

```
$ mcsmysql test < client_visit.sql
ERROR 1069 (42000) at line 25: Too many keys specified; max 0
keys allowed

$ mcsmysql test < client_visit.sql
ERROR 1075 (42000) at line 25: Incorrect table definition; there
can be only one auto column and it must be defined as a key
```

MariaDB ColumnStore: export from mysql (data)

Fastest way -

1. mysql > select into outfile …
2. $ cpimport ...

Easiest way:

1. Import into InnoDB locally (columnstore includes MySQL server)
2. Run “insert into columstore_table select * from innodb_table”

MariaDB ColumnStore: Joining MySQL source

1. Export using InnoDB storage engine
2. JOIN across engines

```
SELECT ...
FROM
     client_visit cv
     join client_procedure cp on cp.encounter_id = cv.encounter_id
     join client_procedure_claim cpc on cp.id = cpc.client_procedure_id
     join client_claim cc on cc.id = cpc.client_claim_id
     join client_innodb c on cv.client_id = c.user_id
WHERE c.is_active = 1
GROUP BY client_id
ORDER BY total_billed desc
limit 10;
```

Clickhouse: replication from MySQL

```
clickhouse-mysql --src-server-id=1 --src-resume --src-wait
--nice-pause=1 --src-host=10.0.0.142 --src-user=chreader
--src-password=pass --src-tables=wiki.pageviews
--dst-host=127.0.0.1 --pump-data --csvpool
```

ColumnStore: replication from MySQL

Coming soon

https://jira.mariadb.org/browse/MCOL-498

https://jira.mariadb.org/browse/MCOL-593

Update / delete - MariaDB ColumnStore

DMLs are usually the slowest in Columnar Stores

Single row:

```
MariaDB [vh]> update client set is_active = 0 where user_id = 3216031;
Query OK, 1 row affected (0.156 sec)
Rows matched: 0  Changed: 0  Warnings: 0
```

Update / delete - Clickhouse

Implemented as “Alter table update” (mutations)

Asynchronous

https://clickhouse.yandex/docs/en/query_language/alter/#alter-mutations

Single row:

```
:) ALTER TABLE client
    UPDATE is_active = 0 WHERE user_id = 3216031
Ok.

0 rows in set. Elapsed: 0.006 sec.
```

When NOT to use Column Store db (1)

Single row (full row) by id: `select * from client_claim where id = <num>;`

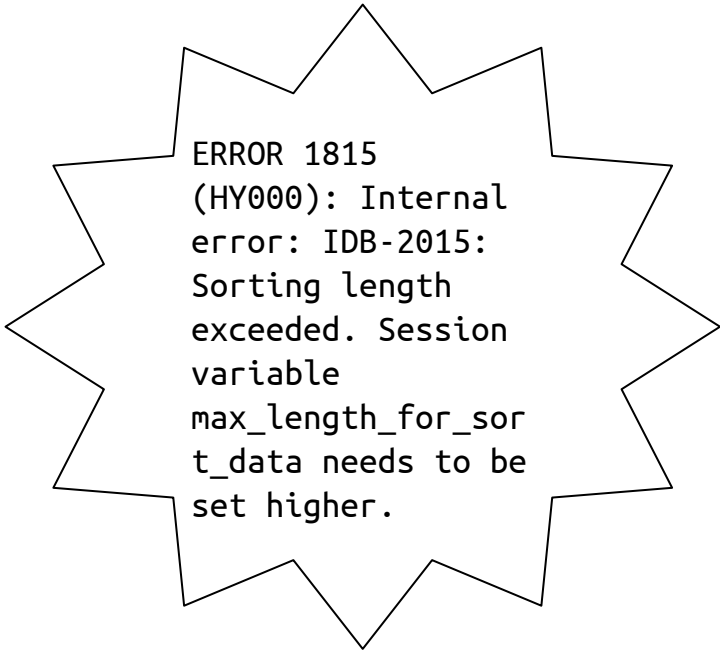
```
MySQL:          1 row in set (0.00 sec)
Columnstore:    1 row in set (0.039 sec)
Clickhouse:     1 rows in set. Elapsed: 0.023 sec.
```

When NOT to use Column Store db (2)

When we will be using index in MySQL + limit

```
SELECT *
FROM client_claim
WHERE place_of_service = 'OFFICE'
ORDER BY received_date DESC
LIMIT 10
```

Index scan




```
MySQL:          10 rows in set (0.00 sec)
Columnstore:    10 rows in set (20.838 sec)
Clickhouse:     10 rows in set. Elapsed: 1.148 sec
```

When NOT to use Column Store db (2)

```
mysql> explain SELECT * FROM client_claim  WHERE place_of_service = 'OFFICE'
ORDER BY received_date DESC LIMIT 10\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: client_claim
   partitions: NULL
         type: ref
possible_keys: place_of_service_received_date
          key: place_of_service_received_date
      key_len: 768
          ref: const
         rows: 13072594
     filtered: 100.00
        Extra: Using where
```

Other idea: daily online snapshots

- Size is columnar store DB is significantly smaller
- We can load daily snapshots
  - I.e. store 30 days of data that can be queried (without restore from backup)

Summary: Clickhouse

Advantages

- Fastest queries
- Very efficient storage

Disadvantages

- For JOINs needs RAM to store all JOINed tables
- No native MySQL protocol (only via ProxySQL)
- No standard sql support (data types, etc)

Summary: MariaDB ColumnStore

Advantages

- Native MySQL protocol - easier to integrate
- Native shared nothing cluster

Disadvantages

- Slower queries

Conclusion (1)

Clickhouse and MariaDB ColumnStore can help optimizing slow reporting queries

a. Those queries can be slow by design in MySQL
b. MySQL is good for lots of small queries rather than some smaller ones
c. MySQL will not be able to utilize all hardware resources

Conclusion (2)

We can see 5x-10x to 60x performance increase for some queries

- From 5 minutes for 30 seconds in Clickhouse

Conclusion (3)

Both systems can be used together with MySQL

a. Sync data quickly
b. Replicate realtime

Thank you!

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