Supercharge Your Analytics with ClickHouse

Webinar

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Analytic database landscape

Commercial solutions – fast and expensive

- Vertica
- RedShift
- Teradata
  - Etc
- The cost scales with your data

Open Source: somewhat slow, sometime buggy.
But free

- InfiniDB (now MariaDB ColumnStore)
- InfoBright
- GreenPlum (started as commerical)
- Hadoop systems
- Apache Spark

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ClickHouse – fast and free!

OpenSourced in Jun 2016

ClickHouse story

Yandex.ru - Russian search engine

Yandex Metrika - Russian “Google Analytics”

Interactive Ad Hoc reports at multiple petabytes

- *30+ billions of events daily*

No commercial solution would be cost effective and no OpenSource solution to handle this scale.

That’s how ClickHouse was born

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ClickHouse is extremely fast and scalable.

"We had no choice, but make it fast" by ClickHouse developers

Initial Requirements

- Fast. Really fast
- Data processing in real time
- Capable of storing petabytes of data
- Fault-tolerance in terms of datacenters
- Flexible query language

Technical details

Vectorized processing

Massively Parallel Processing

Shared nothing

Column store with late materialization (like C-Store and Vertica):

- Data compression
- Column locality
- No random reads

(more in details, in Russian, https://clickhouse.yandex/presentations/meetup7/internals.pdf)

Vectorized processing

Data is represented as small single-dimensional arrays (vectors), easily accessible for CPUs.

The percentage of instructions spent in interpretation logic is reduced by a factor equal to the vector-size

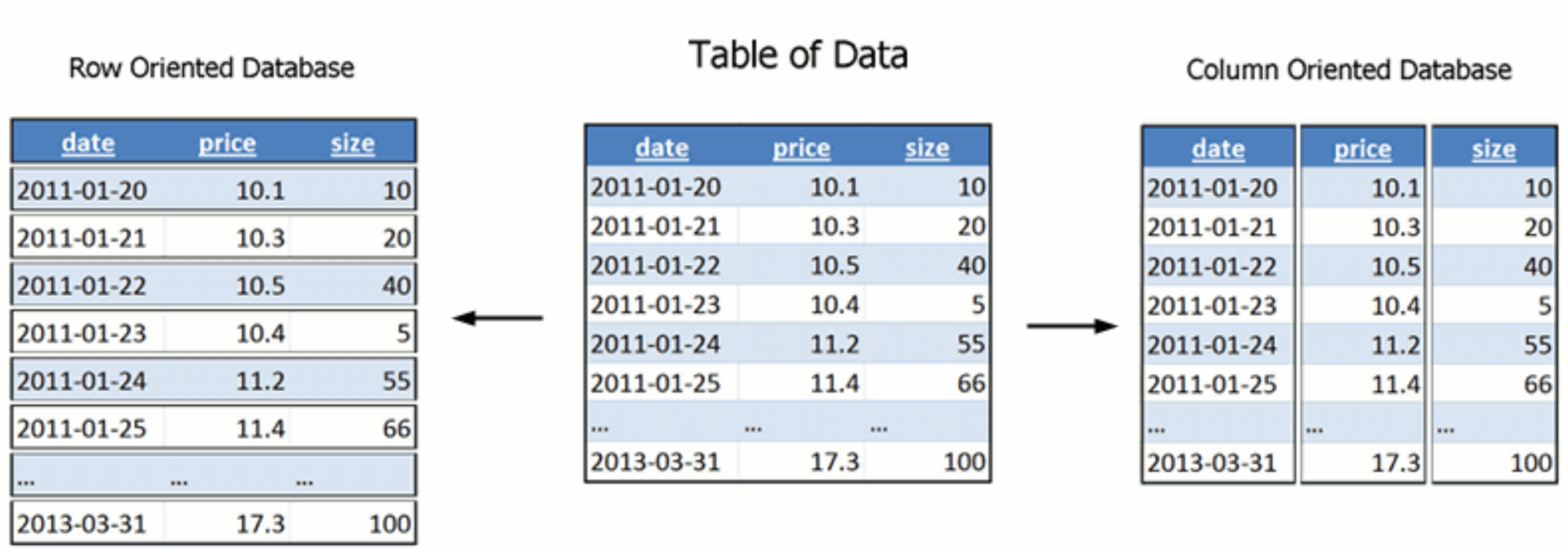
The functions that perform work now typically process an array of values in a tight loop

Tight loops can be optimized well by compilers, enable compilers to generate SIMD instructions automatically.

Modern CPUs also do well on such loops, out-of-order execution in CPUs often takes multiple loop iterations into execution concurrently, exploiting the deeply pipelined resources of modern CPUs.

It was shown that vectorized execution can improve data-intensive (OLAP) queries by a factor 50.

Column-oriented



date	price	size
2011-01-20	10.1	10
2011-01-21	10.3	20
2011-01-22	10.5	40
2011-01-23	10.4	5
2011-01-24	11.2	55
2011-01-25	11.4	66
...	...	...
2013-03-31	17.3	100

* The image taken from http://www.timestored.com/time-series-data/what-is-a-column-oriented-database

Efficient execution

```
SELECT Referer, count(*) AS count
FROM hits
WHERE CounterID = 1234 AND Date >= today() - 7
GROUP BY Referer
ORDER BY count DESC LIMIT 10
```

(* example from https://clickhouse.yandex/presentations/meetup7/internals.pdf)

- Vectorized processing
- Read only needed columns: CounterID, Referer, Date
- Compression
- With index (CounterID, Date) - fast discard of unneeded blocks

Single Server - MPP

Use multiple CPU cores on the single server

Real case: Apache log from the real web site – 1.56 billion records

Query:

```
SELECT extract(request_uri,'(w+)$') p,sum(bytes) sm,count(*) c
FROM apachelog
GROUP BY p
ORDER by c DESC limit 100
```

Query is suited for parallel execution – most time spent in extract function

Execution on single server

56 threads / 28 cores | Intel(R) Xeon(R) CPU E5-2683 v3 @ 2.00GHz

Query execution time

With 1 thread allowed: 823.646 sec ~ 1.89 mln records/sec

With 56 threads allowed: 23.587 sec ~ 66.14 mln records/sec

Speedup: 34.9x times

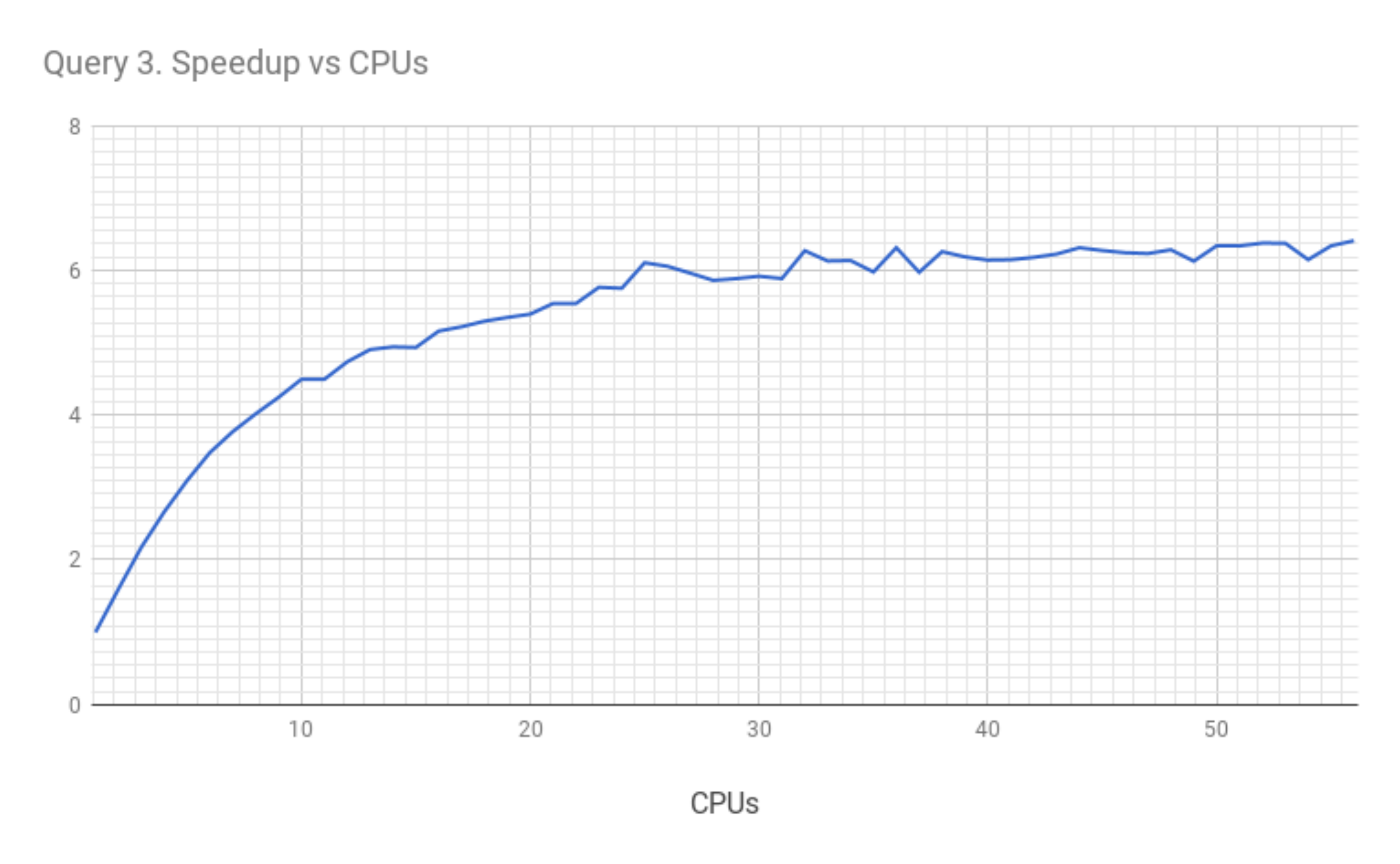

Query 1. Speedup vs CPUs
40
30
20
10
0
10
20
30
40
50
CPUs

Query 3

```
SELECT y, request_uri, cnt
FROM ( SELECT access_date y, request_uri, count(*) AS cnt
       FROM apachelog
                    GROUP BY y, request_uri
                    ORDER BY y ASC )
ORDER BY y,cnt DESC LIMIT 1 BY y
```

Less suitable for parallel execution – serialization to build a temporary table for internal subquery

Speedup: 6.4x times



Query 3. Speedup vs CPUs
8
6
4
2
0
10
20
30
40
50
CPUs

More details in the blog post:
https://www.percona.com/blog/2017/09/13/massive-parallel-log-processing-clickhouse/

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Data distribution

If a single server is not enough

Distributed query

SELECT foo FROM distributed_table

SELECT foo FROM local_table GROUP BY col1

- Server 1

SELECT foo FROM local_table GROUP BY col1

- Server 2

SELECT foo FROM local_table GROUP BY col1

- Server 3

NYC taxi benchmark

CSV 227 GB, ~1.3 bln rows

SELECT passenger_count, avg(total_amount) FROM trips GROUP BY passenger_count

N Servers	1	3	140
Time, sec	1.224	0.438	0.043
Speedup		x2.8	x28.5

* Taken from https://clickhouse.yandex/presentations/meetup7/internals.pdf

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Reliability

Any number of replicas

Any replication topology

Multi-master

Cross-DC

Asynchronous (for speed)

- ➔ *Delayed replicas, possible stale data reads*
- More on data distribution and replication https://www.altinity.com/blog/2017/6/5/clickhouse-data-distribution

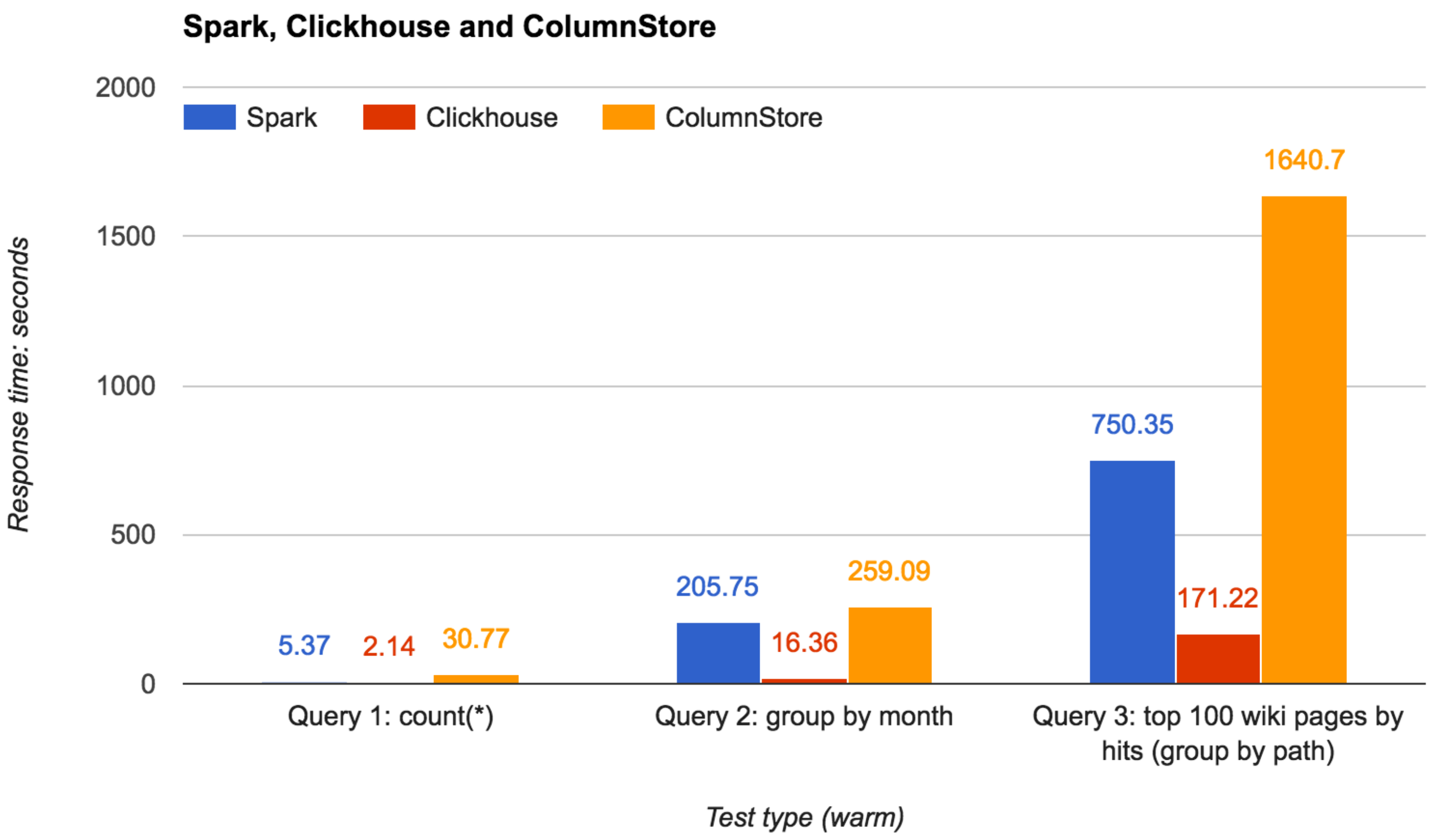
Benchmarks!

ClickHouse vs Spark vs MariaDB ColumnStore

Wikipedia page Counts, loaded full with the year 2008, ~26 billion rows

https://www.percona.com/blog/2017/03/17/column-store-database-benchmarks-mariadb-columnstore-vs-clickhouse-vs-apache-spark/

ClickHouse vs Spark vs MariaDB ColumnStore



Cloud: ClickHouse vs RedShift

https://www.altinity.com/blog/2017/6/20/clickhouse-vs-redshift

5 queries based on NYC taxi dataset

Query 1:
```
SELECT dictGetString('taxi_zones', 'zone', toUInt64(pickup_location_id)) AS zone, count() AS c
    FROM yellow_tripdata_staging
    GROUP BY pickup_location_id
    ORDER BY c DESC LIMIT 10
```

RedShift 1 instance / 3 instances of ds2.xlarge (4 vCPU / 31 GiB memory)

ClickHouse 1 instance r4.xlarge (4 vCPU / 30.5 GiB memory)


RedShift x1, RedShift x3 and CH on AWS x1
150
100
sec
50
0
query
15
7
3.3
1
0.5
8
47
20
31
140
48
36
70
20
32
1
2
3
4
5
RedShift x1
RedShift x3
CH on AWS x1

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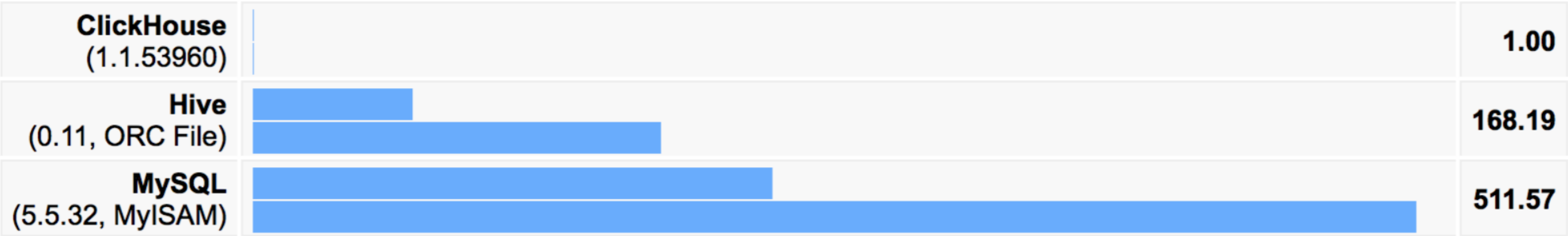
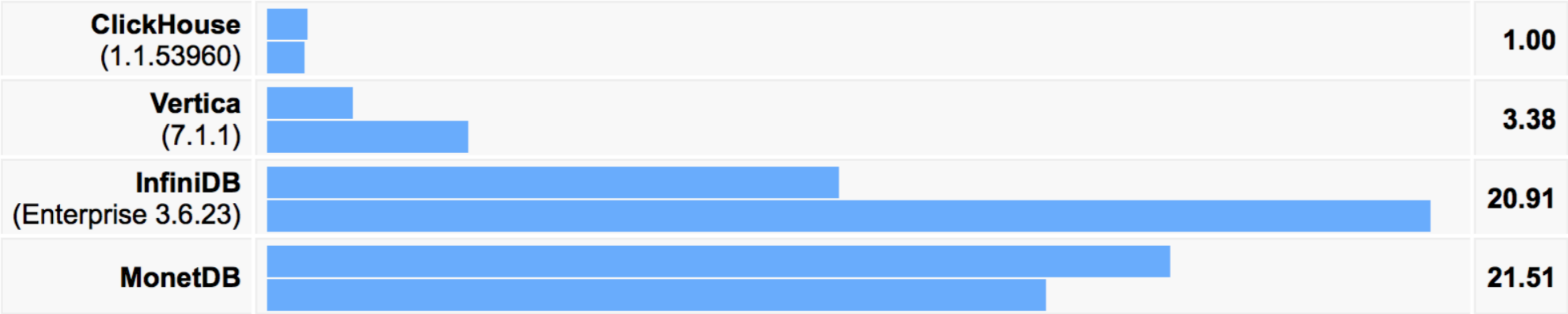
By Yandex, see [2]

Relative query processing time (lower is better):



Relative query processing time (lower is better):



More info: https://clickhouse.yandex/benchmark.html

ClickHouse – use cases

Adv networks data

Web/App analytics

Ecommerce/Telecom logs

Online games

Sensor data

Monitoring

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ClickHouse – wrong cases

Not an OLTP

Not a key-value store

Not a document store

No UPDATEs/DELETEs – does not support data modification

ClickHouse - limitations

Custom SQL dialect

As a consequence -- limited ecosystem (can not fit to standard one)

No deletes/updates:

- but there are mutable table types (engines)
- there is a way to connect to external updatable data (dictionaries)

Somewhat hard to manage for now - no variety of tools to work with

Somewhat young

Resources for users

The Documentation is available in English!

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

GUI Tool

- http://tabix.io

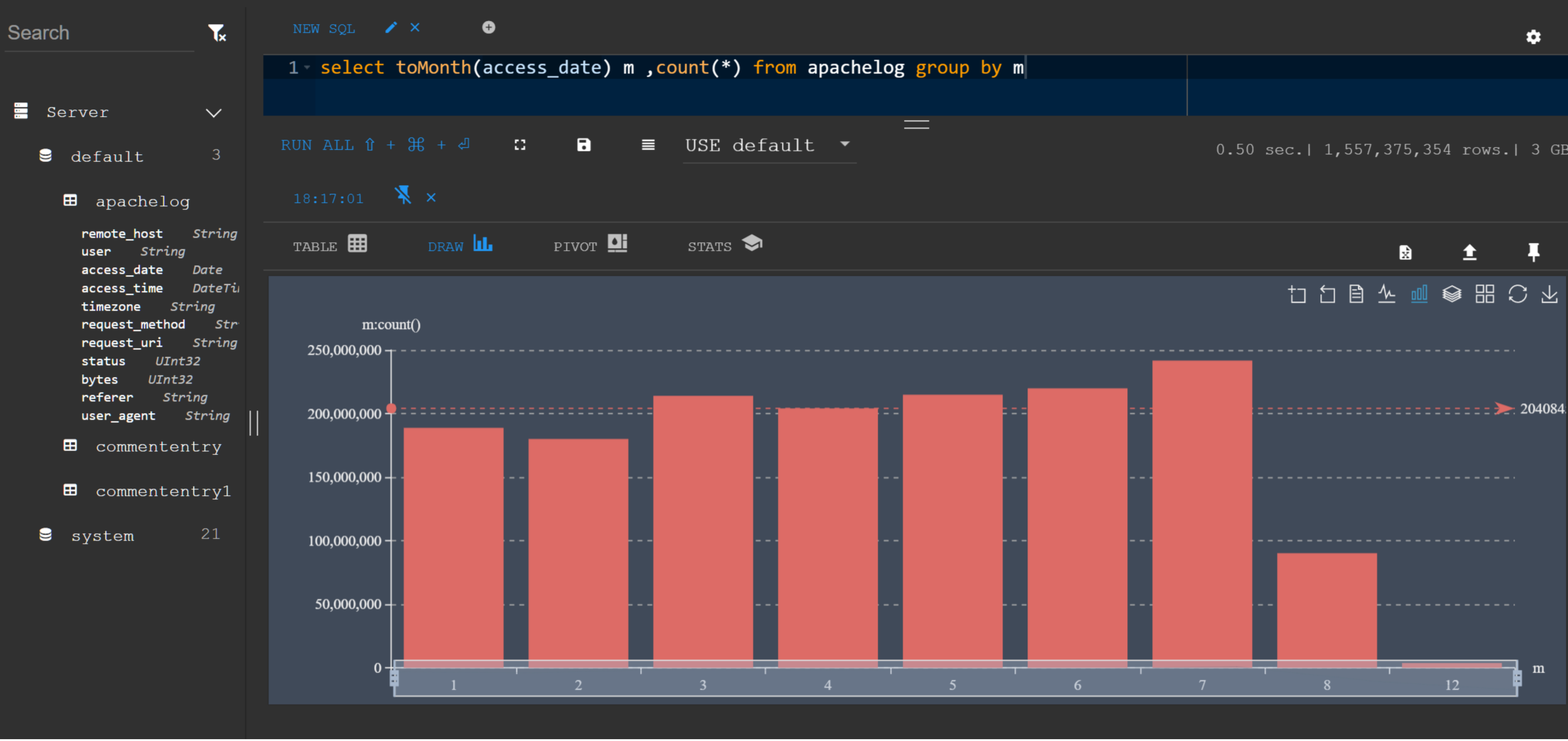
Apache Superset https://superset.incubator.apache.org supports ClickHouse

- a modern, enterprise-ready business intelligence web application

Grafana integration

- https://grafana.com/plugins/vertamedia-clickhouse-datasource

ODBC & JDBC drivers available



Search
NEW SQL
select toMonth(access_date) m ,count(*) from apachelog group by m
Server
default 3
apachelog
remote_host String
user String
access_date Date
access_time DateTi
timezone String
request_method Str
request_uri String
status UInt32
bytes UInt32
referer String
user_agent String
commententry
commententry1
system 21
RUN ALL
USE default
0.50 sec.| 1,557,375,354 rows.| 3 GB
18:17:01
TABLE
DRAW
PIVOT
STATS
m:count()
250,000,000
200,000,000
150,000,000
100,000,000
50,000,000
0
204084
1
2
3
4
5
6
7
8
12
m

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Who is using ClickHouse?

Well, beside Yandex

Carto

- https://carto.com/blog/inside/geospatial-processing-with-clickhouse/

Percona

- We integrate ClickHouse as part of our Percona Monitoring and Management software

CloudFlare

- https://blog.cloudflare.com/how-cloudflare-analyzes-1m-dns-queries-per-second/

ClickHouse at CloudFlare

33 Nodes

8M+ inserts/sec

2PB+ disk size

More on CloudFlare experience

- https://www.altinity.com/sfmeetup2017

ClickHouse Demo on MemCloud

Kodiak Data and Altinity now Offer a Cloud Version of ClickHouse

ClickHouse

MEMCLOUD

Altinity

1. FASTEST MPP Open Source DBMS
2. Cutting Edge Cloud for Big Data Apps and Processing
3. World-class ClickHouse Expertise

[Try the ClickHouse on MemCloud demo here](http://clickhouse-demo.memcloud.works/)

http://clickhouse-demo.memcloud.works/

KODIAK DATA

Final words

Simply try it for your Analytics/Big Data case!

Need more info - http://clickhouse.yandex

My Contact: Vadim@percona.com

- *@VadimTk*

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- Time Series Databases, PostgreSQL, RocksDB
- Developers, Business/Case Studies, Operations
- September 25-27th, 2017
- Radisson Blu Royal Hotel, Dublin, Ireland

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  - *Reduce costs and optimize performance*
- Percona Monitoring and Management Demos
  - *Point-in-time visibility and historical trending of database performance*
  - *Detailed query analytics*
- Booth #1138

ClickHouse Webinar

Alexander Zaitsev

LifeSteet, Altinity

Who am I

- Graduated Moscow State University in 1999
- Software engineer since 1997
- Developed distributed systems since 2002
- Focused on high performance analytics since 2007
- Director of Engineering in LifeStreet
- Co-founder of Altinity

Agenda

- LifeStreet ClickHouse implementation experience
- MySQL and ClickHouse

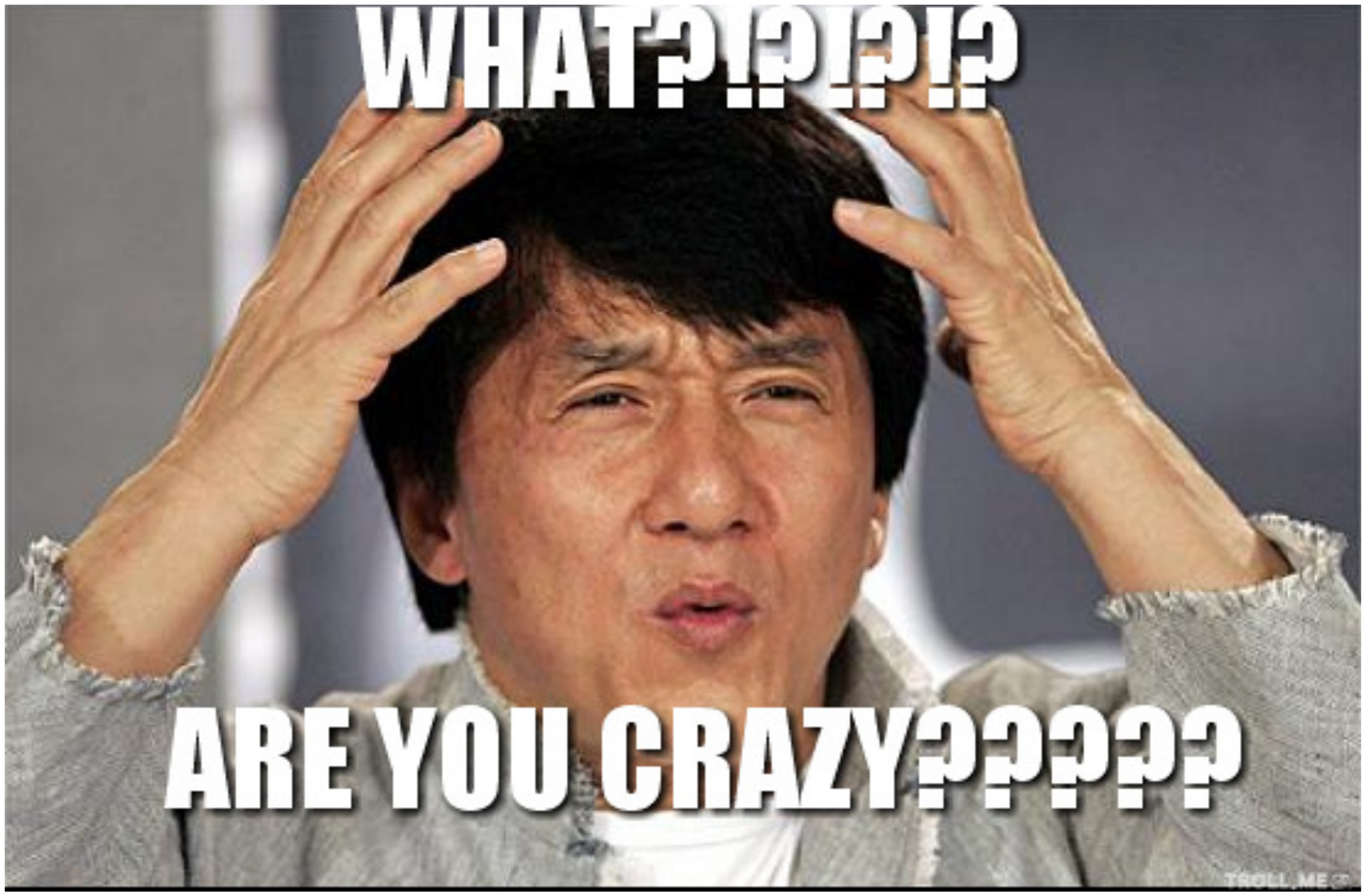
LIFESTREET

- Ad Tech company (ad exchange, ad server, RTB, DSP, DMP) since 2006
- 10,000,000,000+ events/day
- 10+ fact tables, 500+ dimensions, 100+ metrics
- Internal and external users, algos, MLs
- Different solutions tried and used in different years, including MySQL, Oracle, Vertica, many internal POCs
- Now -- ClickHouse

Flashback: ClickHouse at 08/2016

- 1-2 months in Open Source
- Internal Yandex product – no other installations
- No support, roadmap, communicated plans
- 3 official devs
- A number of visible limitations (and many invisible)
- Stories of other doomed open-sourced DBs

Develop production system with “that”?



ClickHouse is/was missing:

- Transactions
- Constraints
- Consistency
- UPDATE/DELETE
- NULLs (not anymore)
- Milliseconds
- Implicit type conversions
- Full SQL support
- Partitioning by any column (date only)
- Cluster management tools

But we tried and succeeded

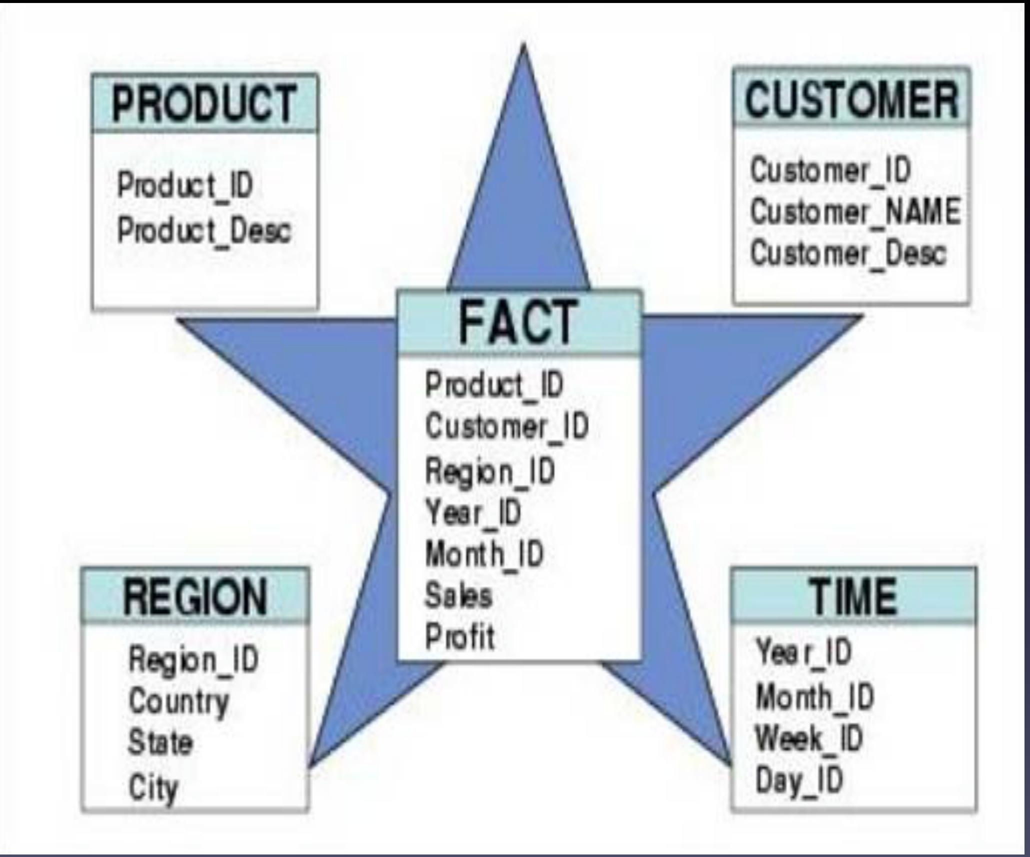
Migration problem: basic things do not fit

Main Challenges

- Design efficient schema
  - Use ClickHouse bests
  - Workaround limitations
- Design sharding and replication
- Reliable data ingestion
- Client interfaces

Typical schema: “star”

- Facts
- Dimensions
- Metrics
- Projections



De-normalized vs. normalized

De-normalized (dimensions in fact table):

- Easy
- Simple queries
- No data changes are possible
- Sub-efficient storage
- Sub-efficient queries

Normalized (dimensions in separate tables):

- More difficult to maintain
- More complex queries
- Dimensions can change
- More efficient storage
- More efficient queries

Normalized schema: traditional approach - joins

- Limited support in ClickHouse (1 level, cascade sub-selects for multiple)
- Dimension tables are not updatable

Dictionaries - ClickHouse dimensions approach

- Lookup service: key -> value
- Supports multiple external sources (files, databases etc.)
- Refreshable

Dictionaries. Example

```
SELECT country_name,
       sum(imps)
  FROM T
  ANY INNER JOIN dim_geo USING (geo_key)
 GROUP BY country_name;

vs

SELECT dictGetString(‘dim_geo’, ‘country_name’, 
geo_key) country_name,
       sum(imps)
  FROM T
 GROUP BY country_name;
```

Dictionaries. Configuration

```
<dictionary>
    <name></name>
    <source> … </source>
    <lifetime> ... </lifetime>
    <layout> … </layout>
    <structure>
        <id> ... </id>
        <attribute> ... </attribute>
        <attribute> ... </attribute>
        ...
    </structure>
</dictionary>
```

Dictionaries. Sources

- file
- mysql table
- clickhouse table
- odbc data source
- executable script
- http service

Dictionaries. Layouts

- flat
- hashed
- cache
- complex_key_hashed
- range_hashed

Dictionaries. range_hashed

- 'Effective Dated' queries

```
<layout>
    <range_hashed />
</layout>
<structure>
    <id>
        <name>id</name>
    </id>
    <range_min>
        <name>start_date</name>
    </range_min>
    <range_max>
        <name>end_date</name>
    </range_max>
```

```
dictGetFloat32('srv_ad_serving_costs',
'ad_imps_cpm', toUInt64(0), event_day)
```

Dictionaries. Update values

- By timer (default)
- Automatic for MySQL MyISAM
- Using ‘invalidate_query’
- Manually touching config file
- N dict * M nodes = N * M DB connections

Dictionaries. Restrictions

- ‘Normal’ keys are only UInt64
- No on demand update (added in 1.1.54289)
- Every cluster node has its own copy
- XML config (DDL would be better)

Tables

- Engines
- Sharding
- Distribution
- Replication

Engine = ?

- In memory:
  - Memory
  - Buffer
  - Join
  - Set
- On disk:
  - Log, TinyLog
  - MergeTree family
- Virtual:
  - Merge
  - Distributed
  - Dictionary
  - Null
- Special purpose:
  - View
  - Materialized View

Merge tree

- What is ‘merge’
- PK sorting
- Date partitioning
- Query performance

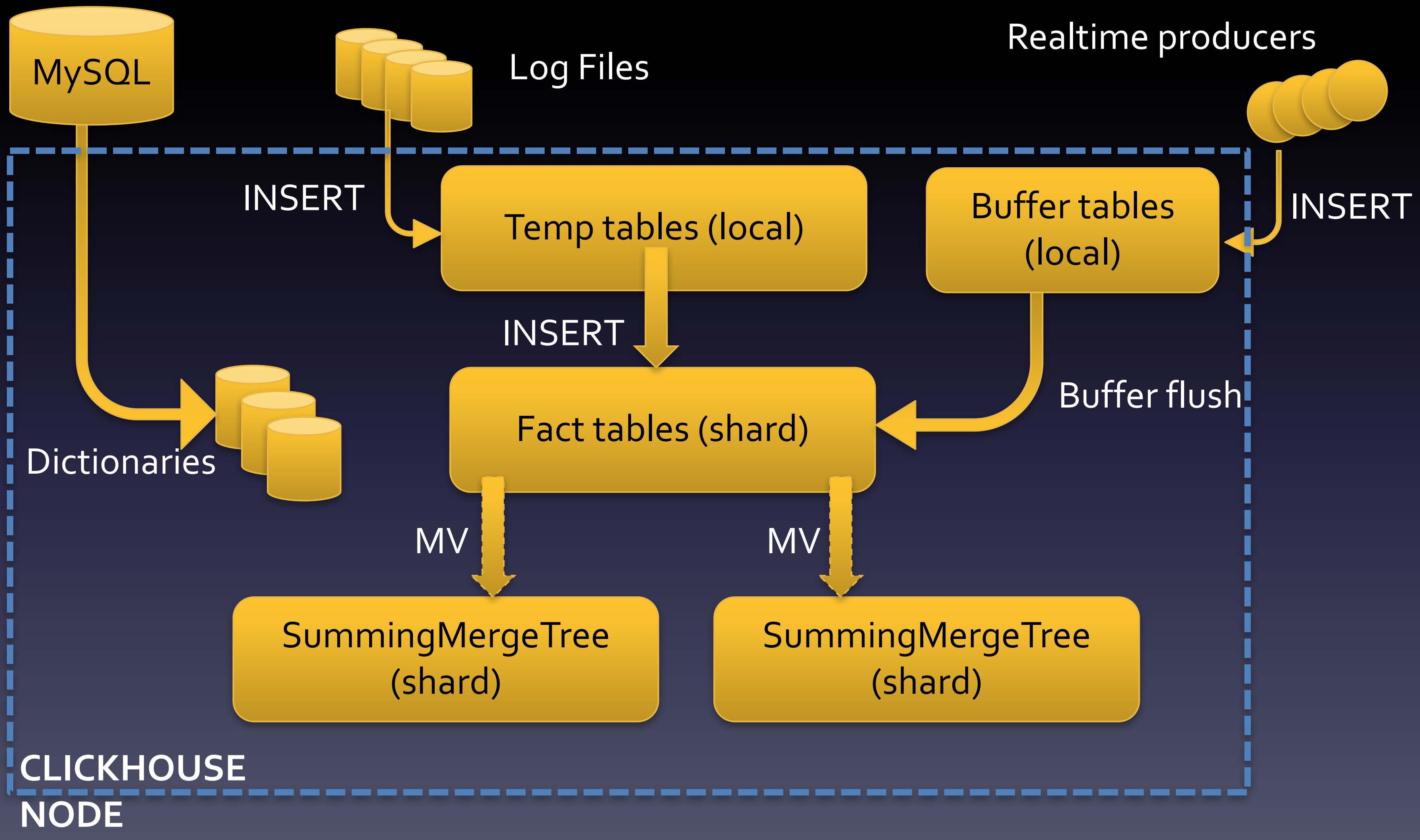
Data Load

- Multiple formats are supported, including CSV, TSV, JSONs, native binary
- Error handling
- Simple Transformations
- Load locally (better) or distributed (possible)
- Temp tables help
- Replicated tables help with de-dup

The power of Materialized Views

- MV is a table, i.e. engine, replication etc.
- Updated synchronously
- SummingMergeTree – consistent aggregation
- Alters are not straightforward, but possible

Data Load Diagram



Updates and deletes

- Dictionaries are updatable
- Replacing and Collapsing merge trees
  - eventually updates
  - SELECT … FINAL
- Partitions

Sharding and Replication

- Sharding and Distribution => Performance
  - Fact tables and MVs – distributed over multiple shards
  - Dimension tables and dicts – replicated at every node (local joins and filters)
- Replication => Reliability
  - 2-3 replicas per shard
  - Cross DC

SQL

- Supports basic SQL syntax
- Non-standard JOINs implementation:
  - 1 level only
  - ANY vs ALL
  - only USING
- Aliasing everywhere
- Array and nested data types, lambda-expressions, ARRAY JOIN
- GLOBAL IN, GLOBAL JOIN
- Approximate queries
- TopX support (LIMIT N BY)

Main Challenges Revisited

- Design efficient schema
  - Use ClickHouse bests
  - Workaround limitations
- Design sharding and replication
- Reliable data ingestion
- Client interfaces

Migration project timelines

- August 2016: POC
- October 2016: first test runs
- December 2016: production scale data load:
  - 10-50B events/ day, 20TB data/day
  - 12 x 2 servers with 12x4TB RAID10
- March 2017: Client API ready, starting migration
  - 30+ client types, 20 req/s query load
- May 2017: extension to 20 x 3 servers
- June 2017: migration completed

ClickHouse at fall 2017

- 1+ year Open Source
- 100+ prod installs worldwide
- Public changelogs, roadmap, and plans
- 10+ devs, community contributors
- Active community, blogs, case studies
- A lot of features added by community requests
- Support by Altinity

So now it is much easier

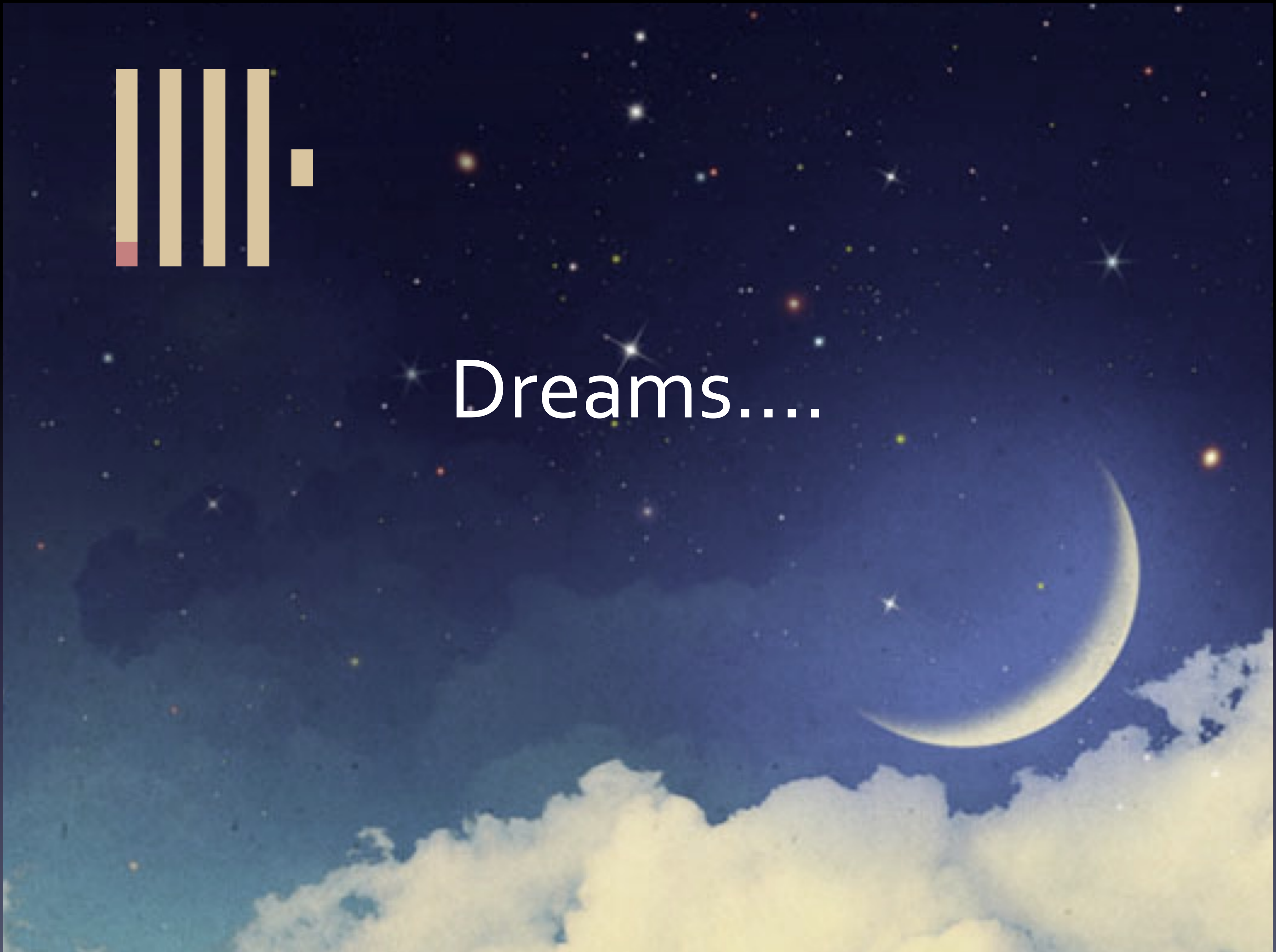
ClickHouse and MySQL

- MySQL is widespread but weak for analytics
  - TokuDB, InfiniDB somewhat help
- ClickHouse is best in analytics

How to combine?

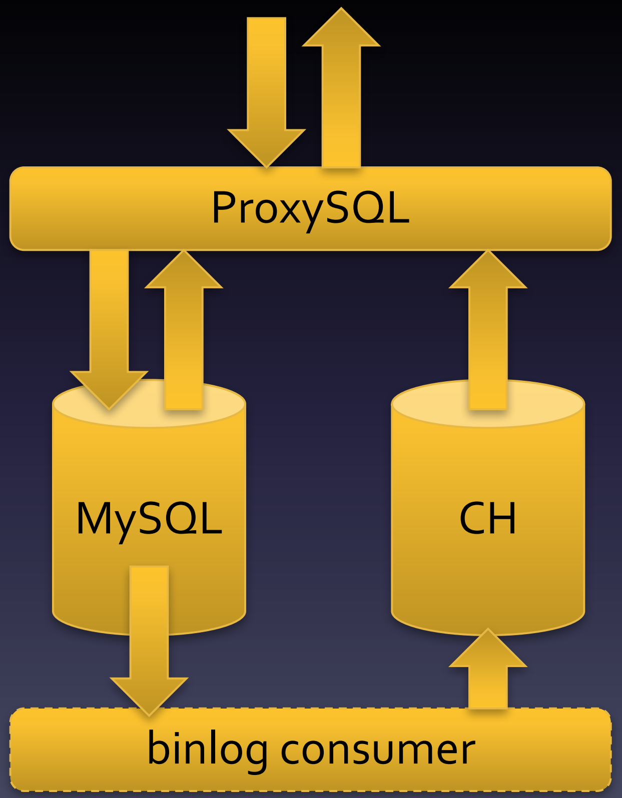
Imagine

MySQL flexibility at ClickHouse speed?


Dreams....

ClickHouse *with* MySQL

- ProxySQL to access ClickHouse data via MySQL protocol (already available)
- Binlogs integration to load MySQL data in ClickHouse in realtime (in progress)



ClickHouse *instead of* MySQL

- Web logs analytics
- Monitoring data collection and analysis
  - Percona's PMM
  - Infinidat InfiniMetrics
- Other time series apps

Questions?

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