Yandex

Quick tour of ClickHouse internals

Aleksey Zatelepin

ClickHouse use cases

A stream of events

- Actions of website visitors Yandex Metrica
- Ad impressions
- DNS queries
- E-commerce transactions
- ...

> We want to save info about these events and then glean some insights from it

ClickHouse philosophy

- Interactive queries on data updated in real time
- Cleaned structured data is needed
- Try hard not to pre-aggregate anything
- Query language: a dialect of SQL + extensions

Sample query in a web analytics system

Top-10 referers for a website for the last week.

```
SELECT Referer, count(*) AS count
FROM hits
WHERE CounterID = 111 AND Date >= today() - 7
GROUP BY Referer
ORDER BY count DESC
LIMIT 10
```

How to execute a query *fast*?

Read data fast

- Only needed columns: `CounterID, Date, Referer`
- Locality of reads (an index is needed!)
- Data compression

How to execute a query *fast*?

Read data fast

- Only needed columns: `CounterID, Date, Referer`
- Locality of reads (an index is needed!)
- Data compression

Process data fast

- Vectorized execution (block-based processing)
- Parallelize to all available cores and machines
- Specialization and low-level optimizations

Index needed!

The principle is the same as with classic DBMSes

A majority of queries will contain conditions on CounterID and (possibly) Date

`(CounterID, Date)` fits the bill

Check this by mentally sorting the table by primary key

Differences

- The table will be physically sorted on disk
- Is not a unique constraint

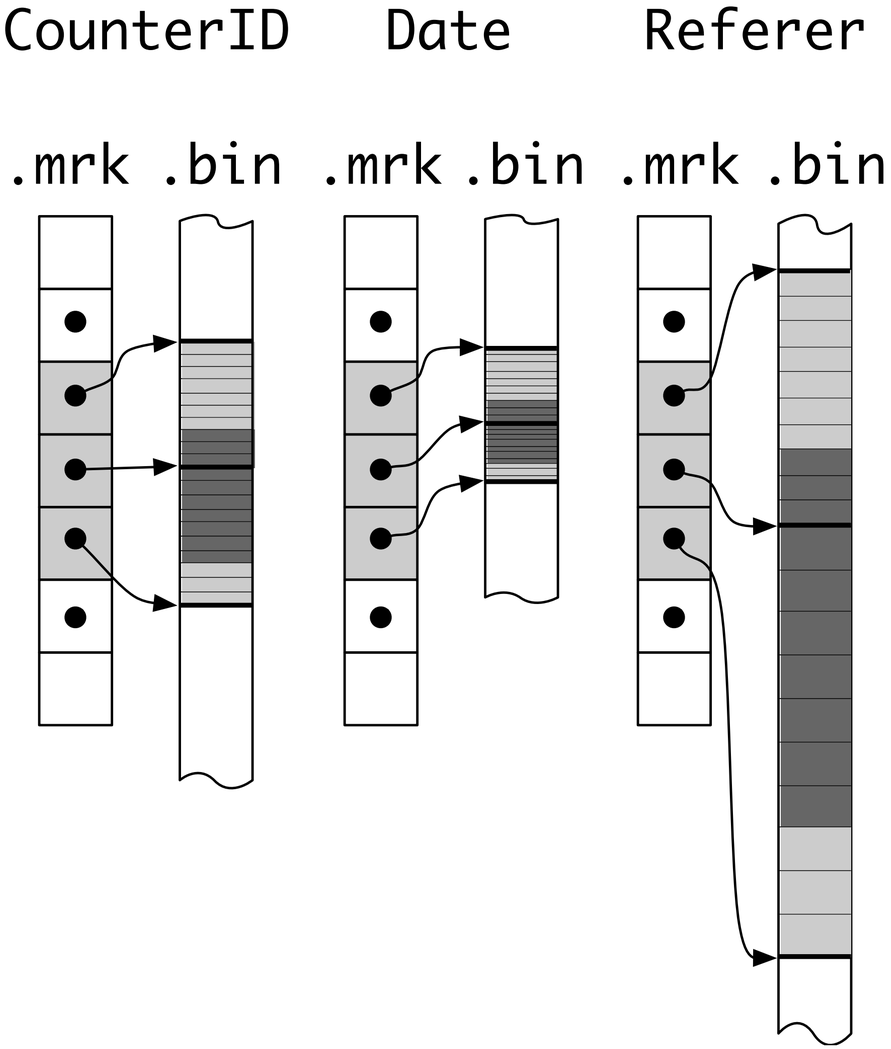
Index internals

(CounterID, Date)

primary.idx

	…	…
	111	2017-07-22
N	111	2017-10-04
N+8192	111	2018-01-25
N+16384	222	2013-02-16
	222	2013-03-12
	…	…

(One entry each 8192 rows)



Things to remember about indexes

Index is sparse

- Must fit into memory
- Default value of granularity (8192) is good enough
- Does not create a unique constraint
- Performance of point queries is not stellar

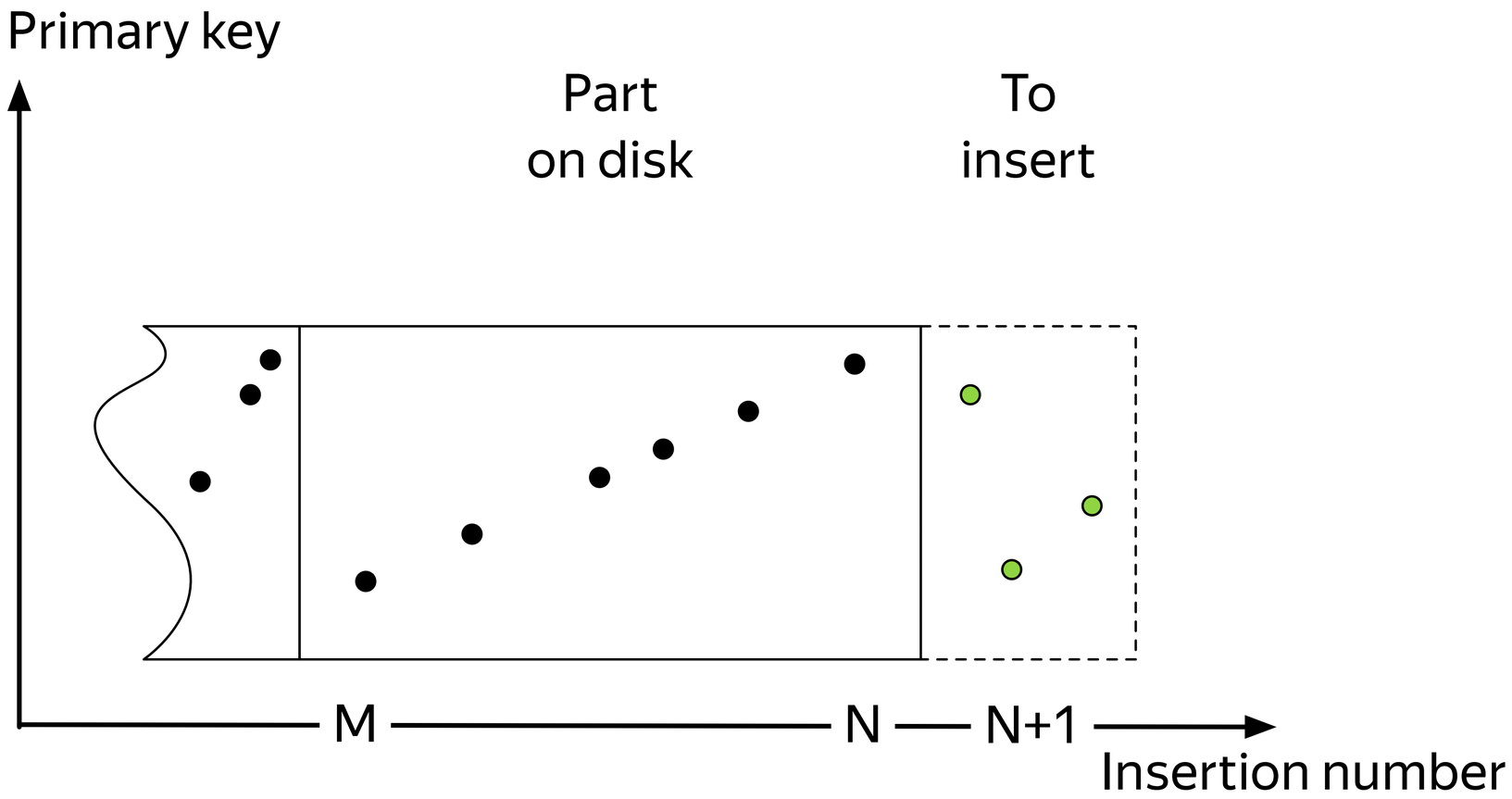
Table is sorted according to the index

- There can be only one
- Using the index is always beneficial

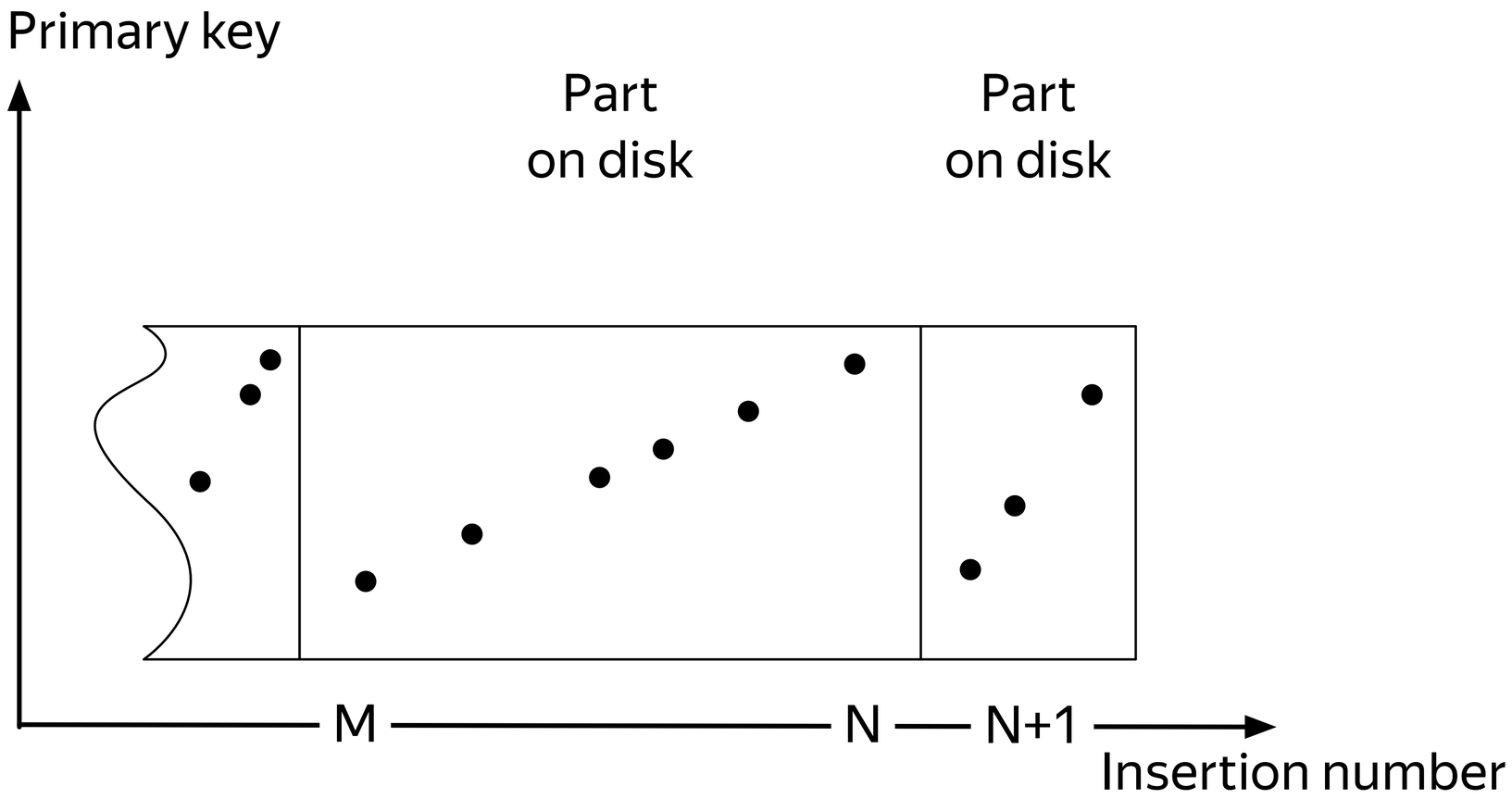
How to keep the table sorted

- Inserted events are (almost) sorted by time
  - But we need to sort by primary key!
- MergeTree: maintain a small set of sorted parts
  - Similar idea to an LSM tree

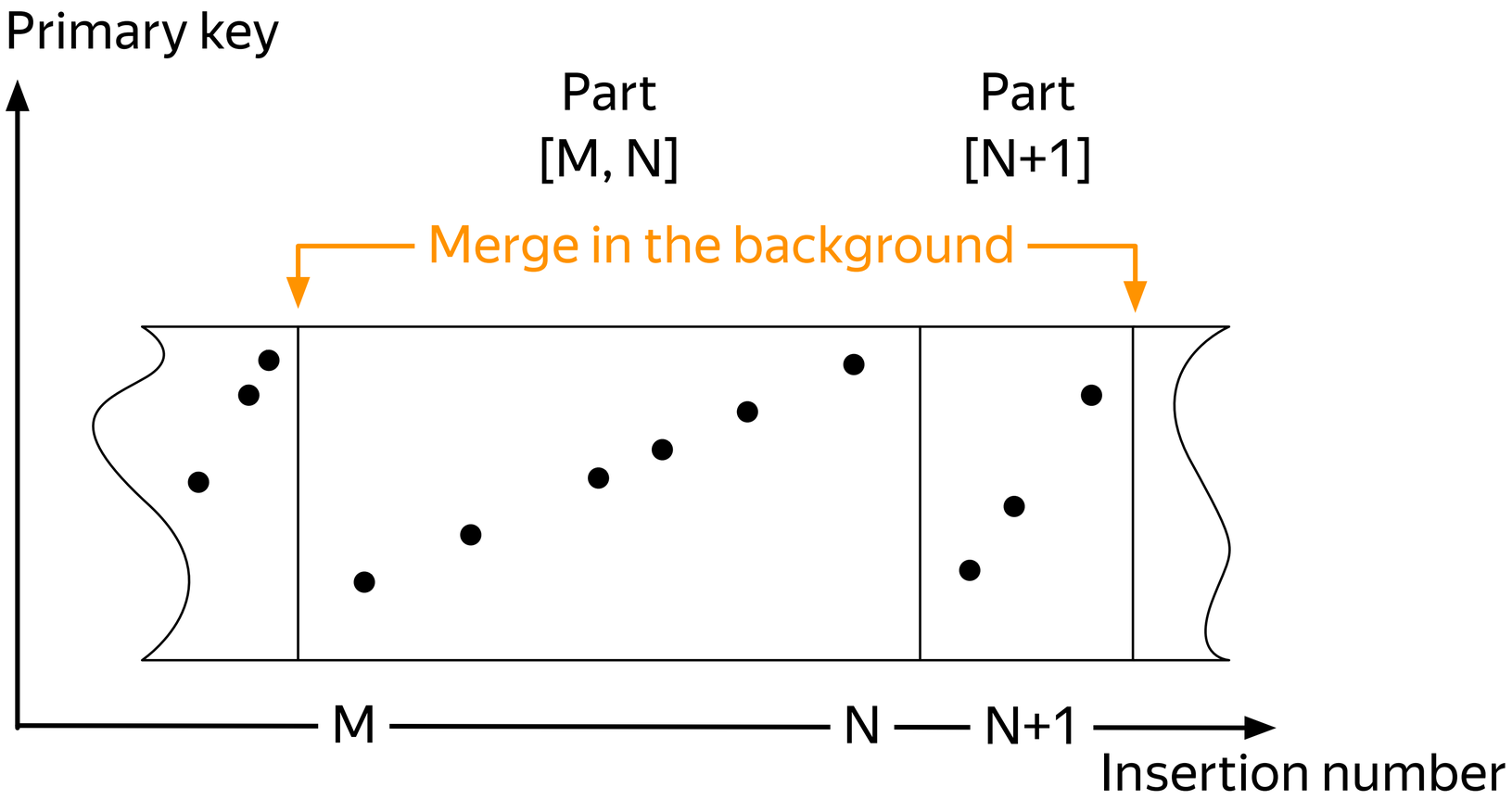
How to keep the table sorted



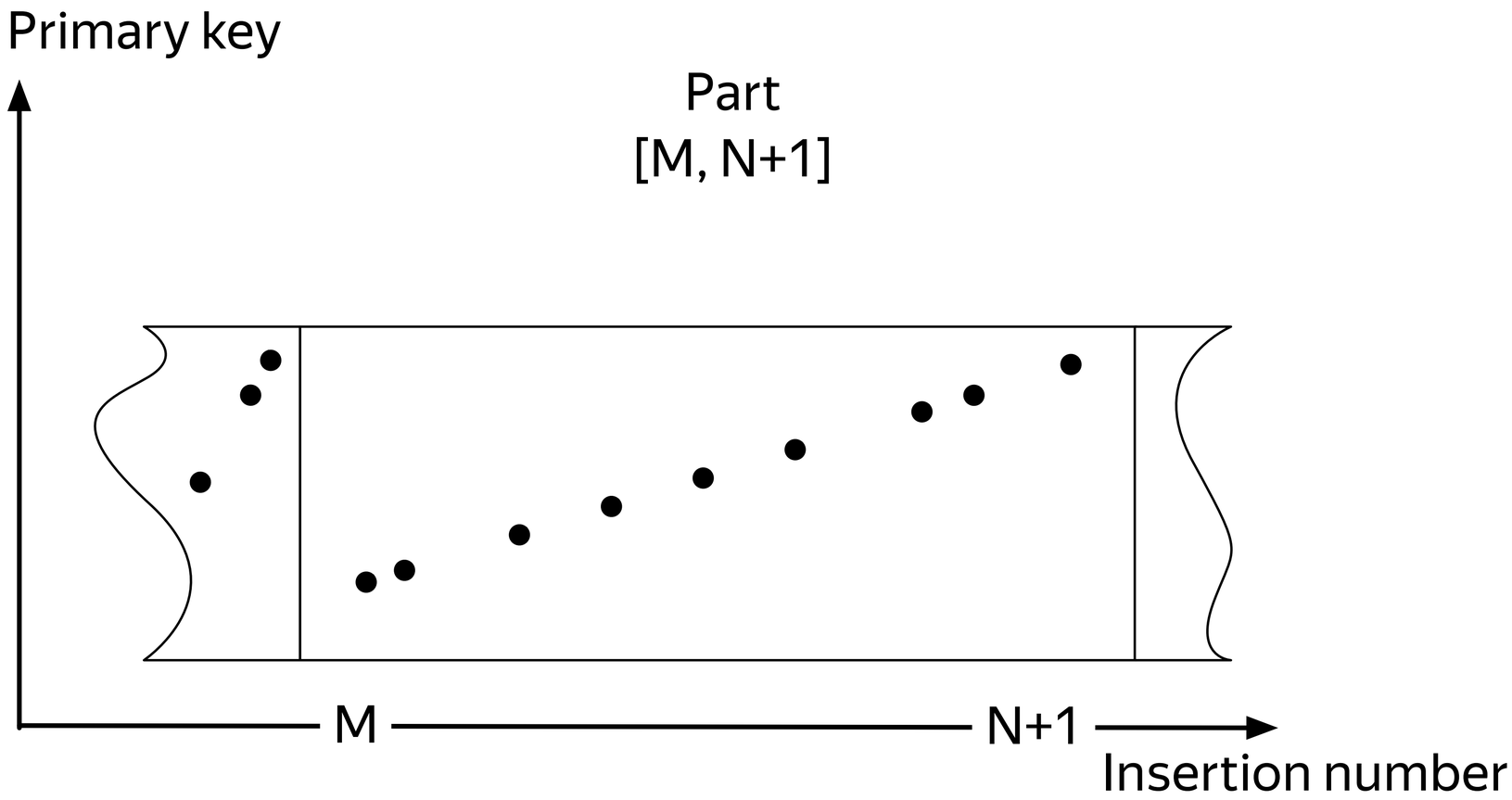
How to keep the table sorted



How to keep the table sorted



How to keep the table sorted



Things to do while merging

- **Replace/update records**
  - ReplacingMergeTree
  - CollapsingMergeTree
- **Pre-aggregate data**
  - AggregatingMergeTree
- **Metrics rollup**
  - GraphiteMergeTree

MergeTree partitioning

```
ENGINE = MergeTree … PARTITION BY toYYYYMM(Date)
```

- Table can be partitioned by any expression (default: by month)
- Parts from different partitions are not merged
- Easy manipulation of partitions

```
ALTER TABLE DROP PARTITION
ALTER TABLE DETACH/ATTACH PARTITION
```

- MinMax index by partition columns

Things to remember about MergeTree

Merging runs in the background

- Even when there are no queries!

Control total number of parts

- Rate of INSERTs
- `MaxPartsCountForPartition` and `DelayedInserts` metrics are your friends

When one server is not enough

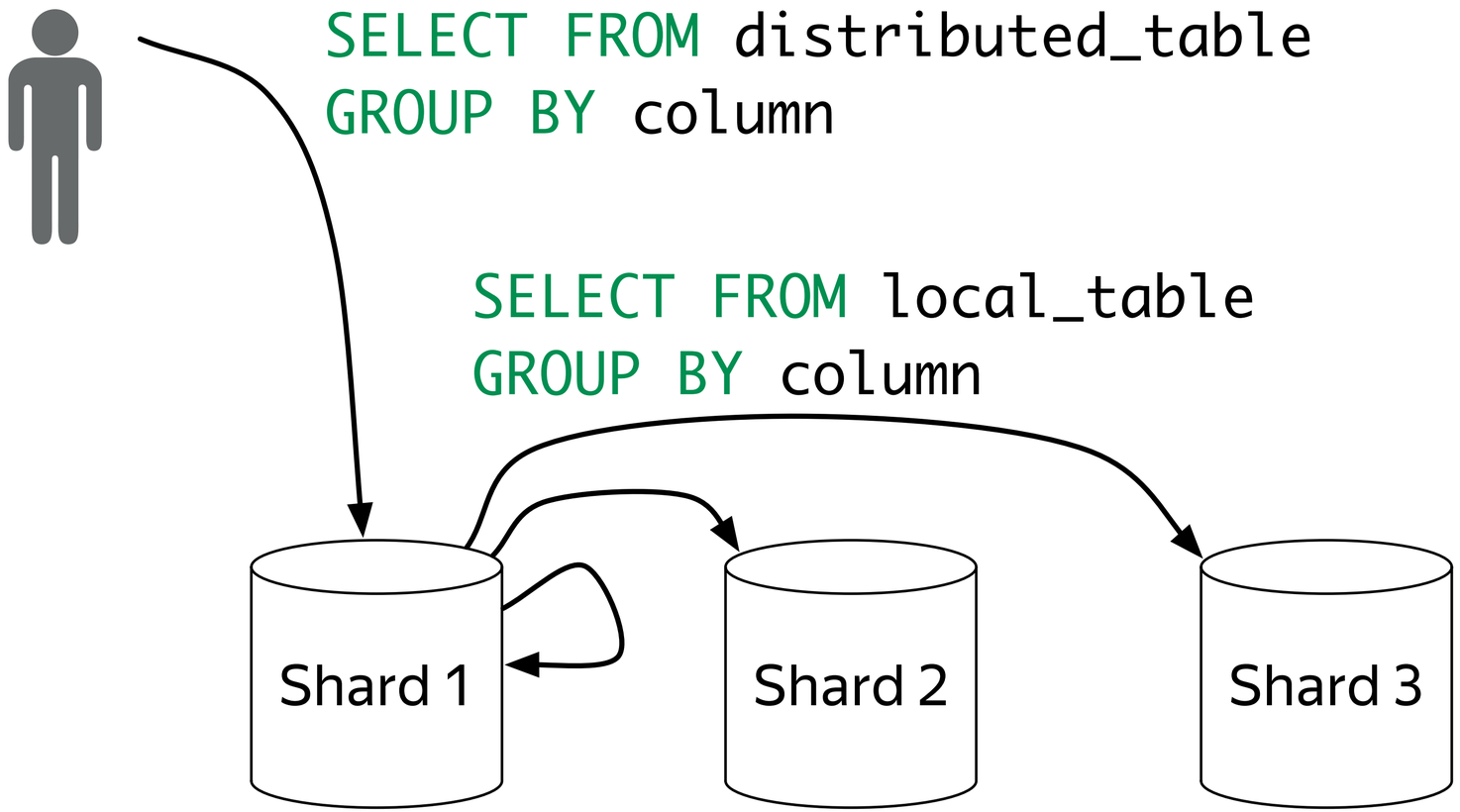
- The data won’t fit on a single server…
- You want to increase performance by adding more servers…
- Multiple simultaneous queries are competing for resources…

When one server is not enough

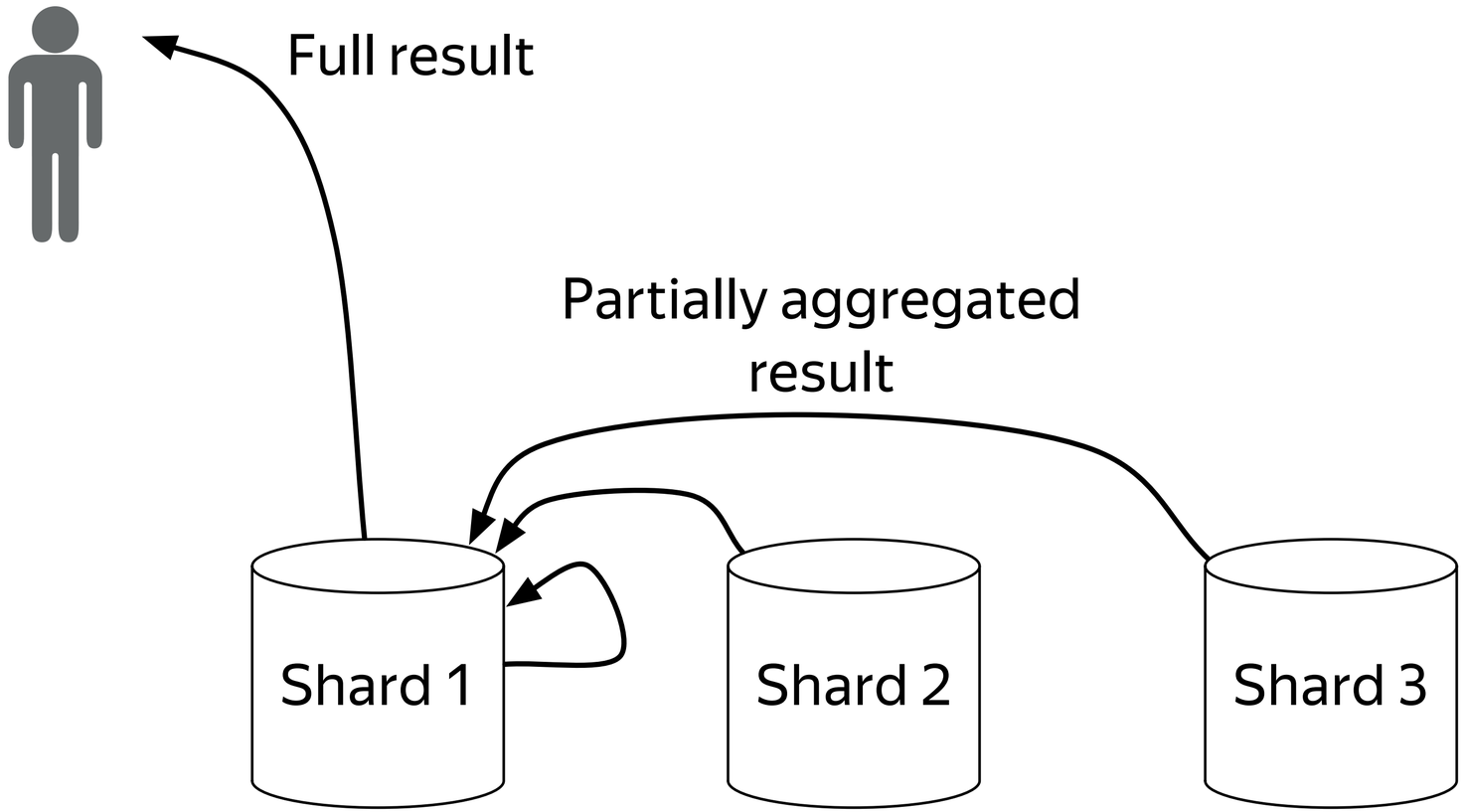
- The data won’t fit on a single server…
- You want to increase performance by adding more servers…
- Multiple simultaneous queries are competing for resources…

ClickHouse: Sharding + Distributed tables!

Reading from a Distributed table



Reading from a Distributed table



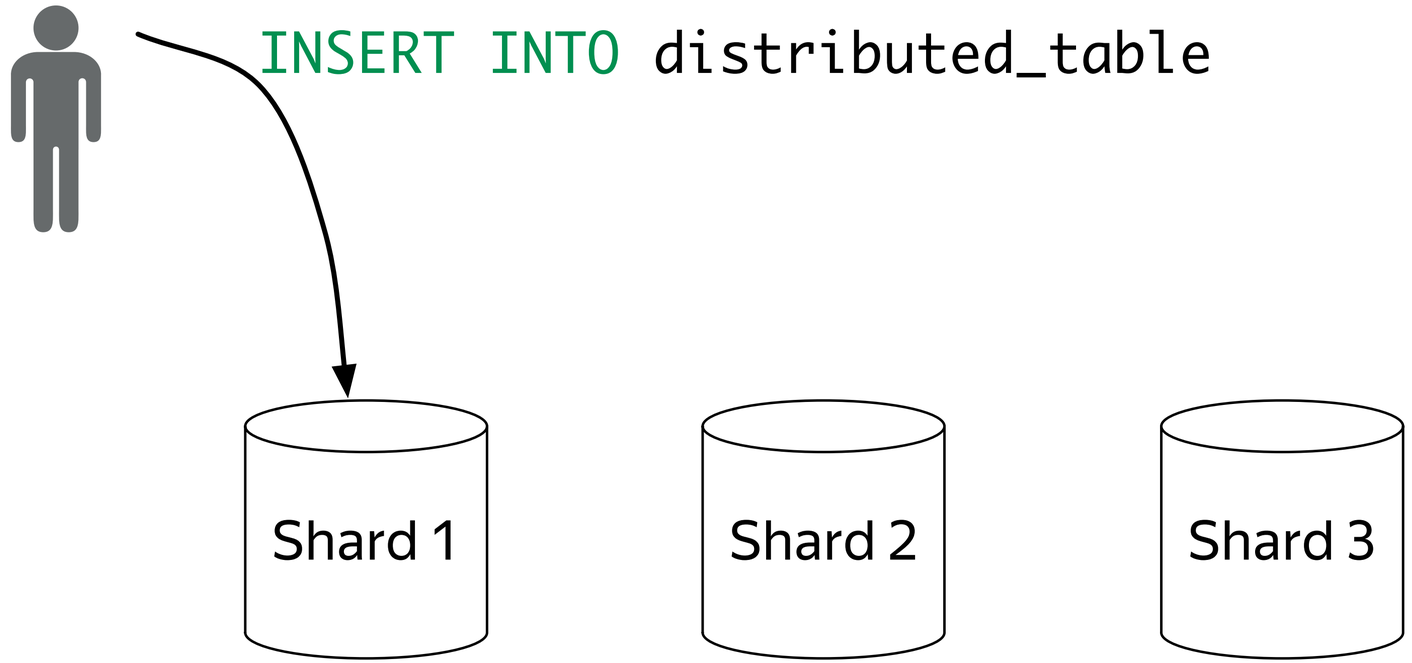
NYC taxi benchmark

CSV 227 Gb, ~1.3 bln rows

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

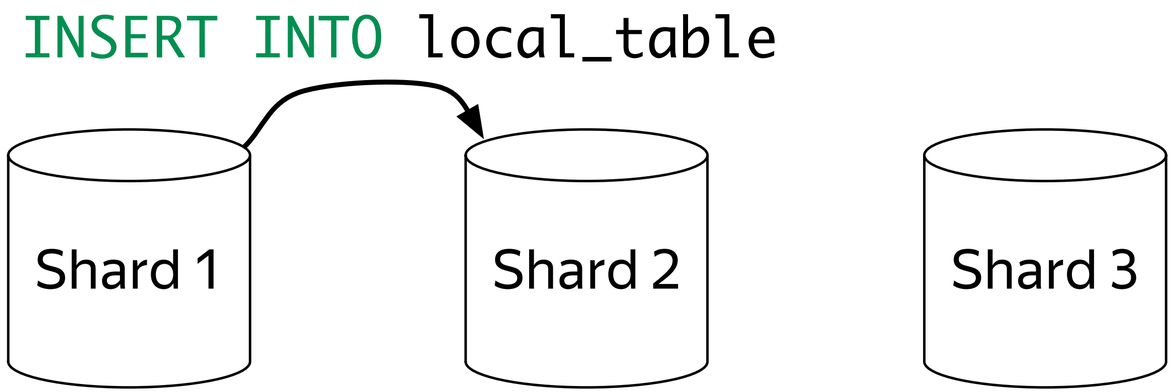
Shards	1	3	140
Time, s.	1,224	0,438	0,043
Speedup		x2.8	x28.5

Inserting into a Distributed table

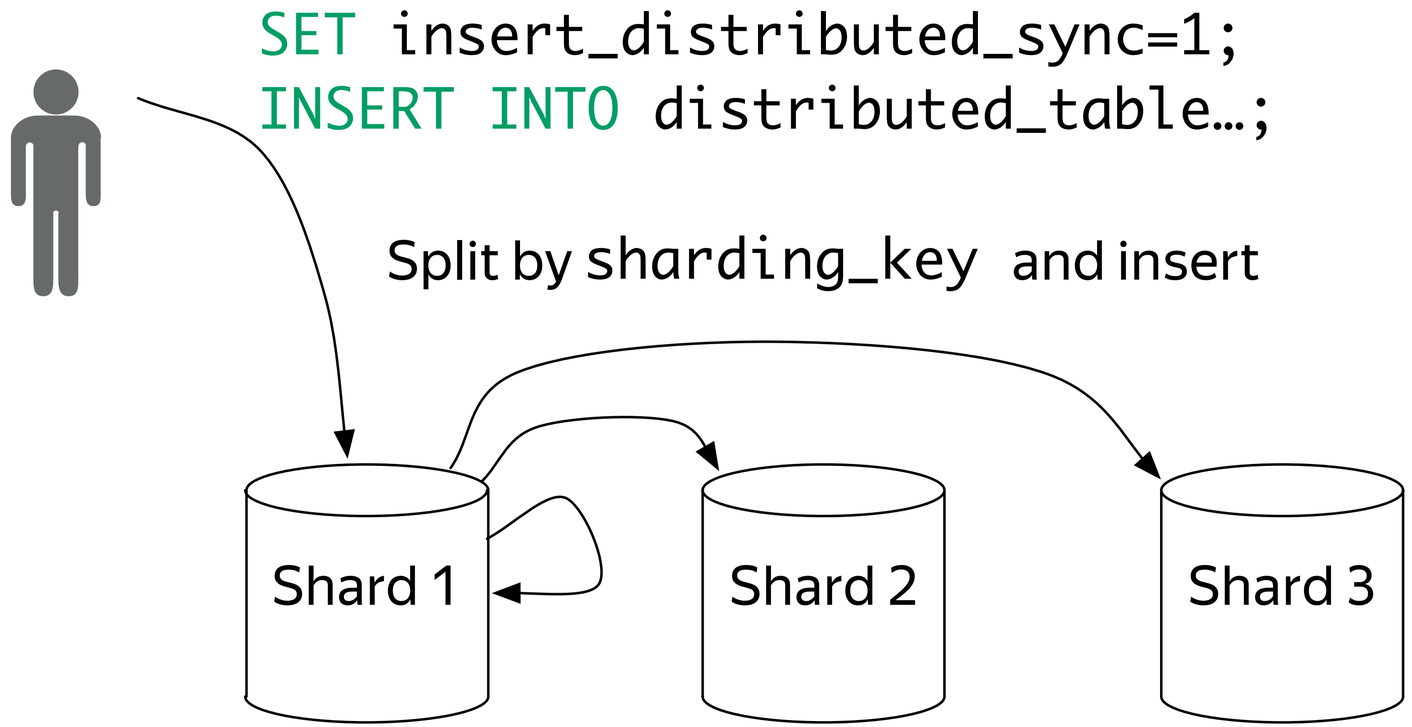


Inserting into a Distributed table

Async insert into shard #
`sharding_key % 3`



Inserting into a Distributed table



Things to remember about Distributed tables

It is just a view

- Doesn’t store any data by itself

Will always query all shards

Ensure that the data is divided into shards uniformly

- either by inserting directly into local tables
- or let the Distributed table do it
  (but beware of async inserts by default)

When failure is not an option

- Protection against hardware failure
- Data must be always available for reading *and* writing

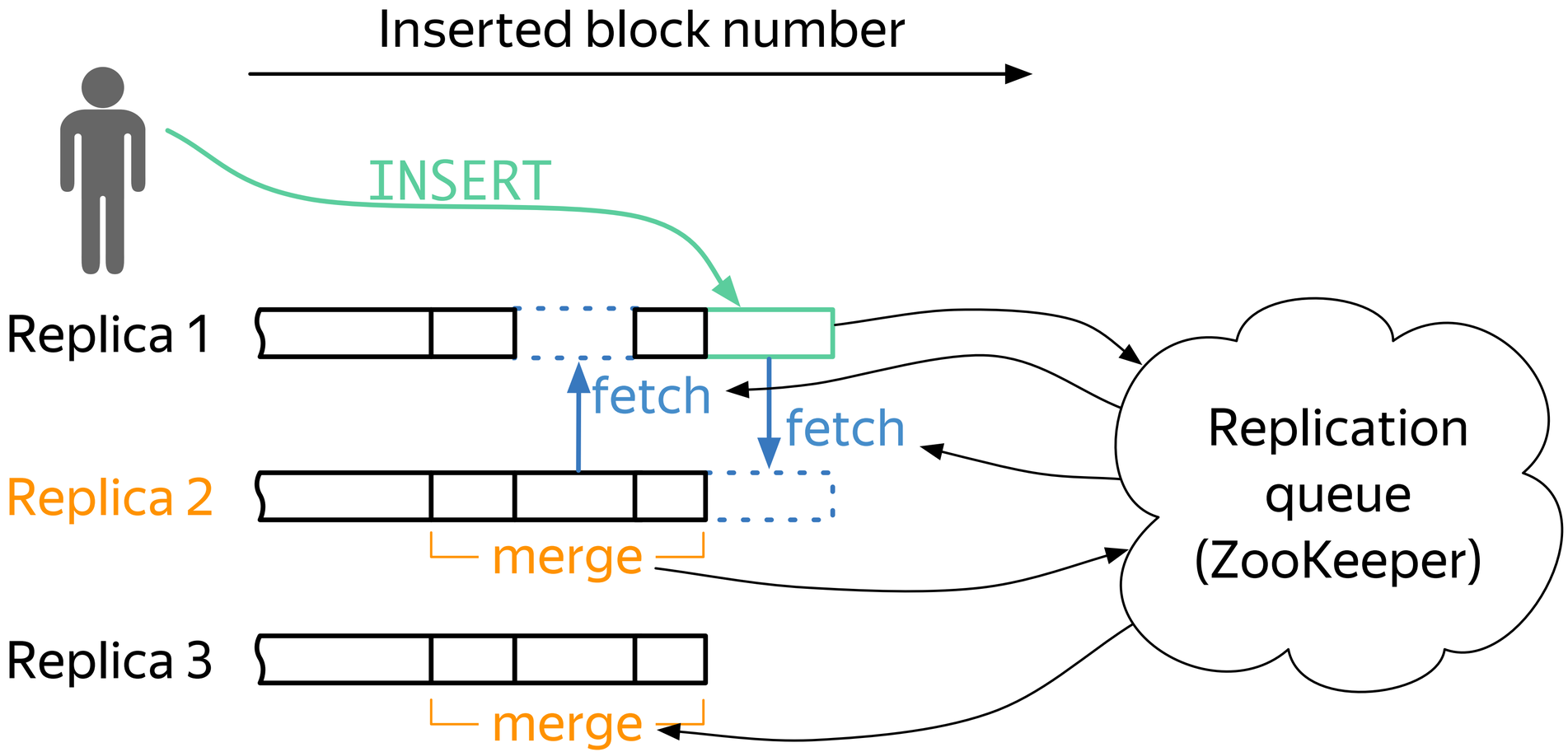
When failure is not an option

- Protection against hardware failure
- Data must be always available for reading *and* writing

ClickHouse: ReplicatedMergeTree engine!

- Async master-master replication
- Works on per-table basis

Replication internals



Replication and the CAP–theorem

What happens in case of network failure (partition)?

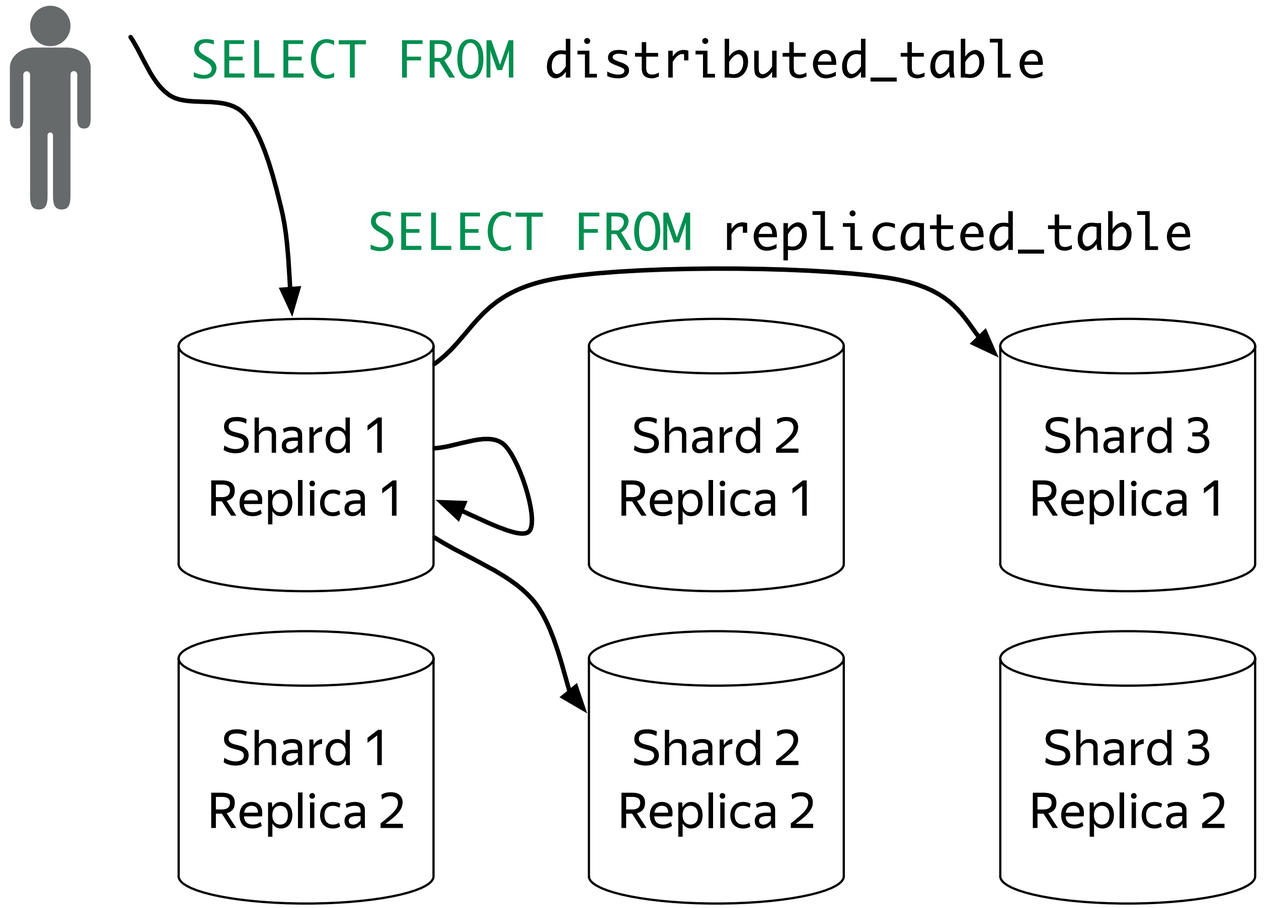
- Not consistent*
  As is any system with async replication

  *But you can turn linearizability on

- Highly available (almost)*
  Tolerates the failure of one datacenter, if ClickHouse replicas are in min 2 DCs and ZK replicas are in 3 DCs.

  *A server partitioned from ZK quorum is unavailable for writes

Putting it all together



Things to remember about replication

Use it!

- Replicas check each other
- Unsure if INSERT went through?
  Simply retry - the blocks will be deduplicated
- ZooKeeper needed, but only for INSERTs
  (No added latency for SELECTs)

Monitor replica lag

- `system.replicas` and `system.replication_queue` tables are your friends

Brief recap

- Column-oriented
- Fast interactive queries on real time data
- SQL dialect + extensions
- Bad fit for OLTP, Key-Value, blob storage
- Scales linearly
- Fault tolerant
- Open source!

Thank you

Questions? Or reach us at:

- clickhouse-feedback@yandex-team.com
- **Telegram:** https://t.me/clickhouse_en
- **GitHub:** https://github.com/yandex/ClickHouse/
- **Google group:** https://groups.google.com/group/clickhouse