Quick Tour of ClickHouse Internals

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v1.1

ClickHouse use cases

A stream of events

- Actions of website visitors
- Ad impressions
- Financial transactions
- DNS queries
- ...

> 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 + lots of extensions

Sample query in a web analytics system

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

```
SELECT Referer, count(*) AS count
FROM hits
WHERE CounterID = 1234 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

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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

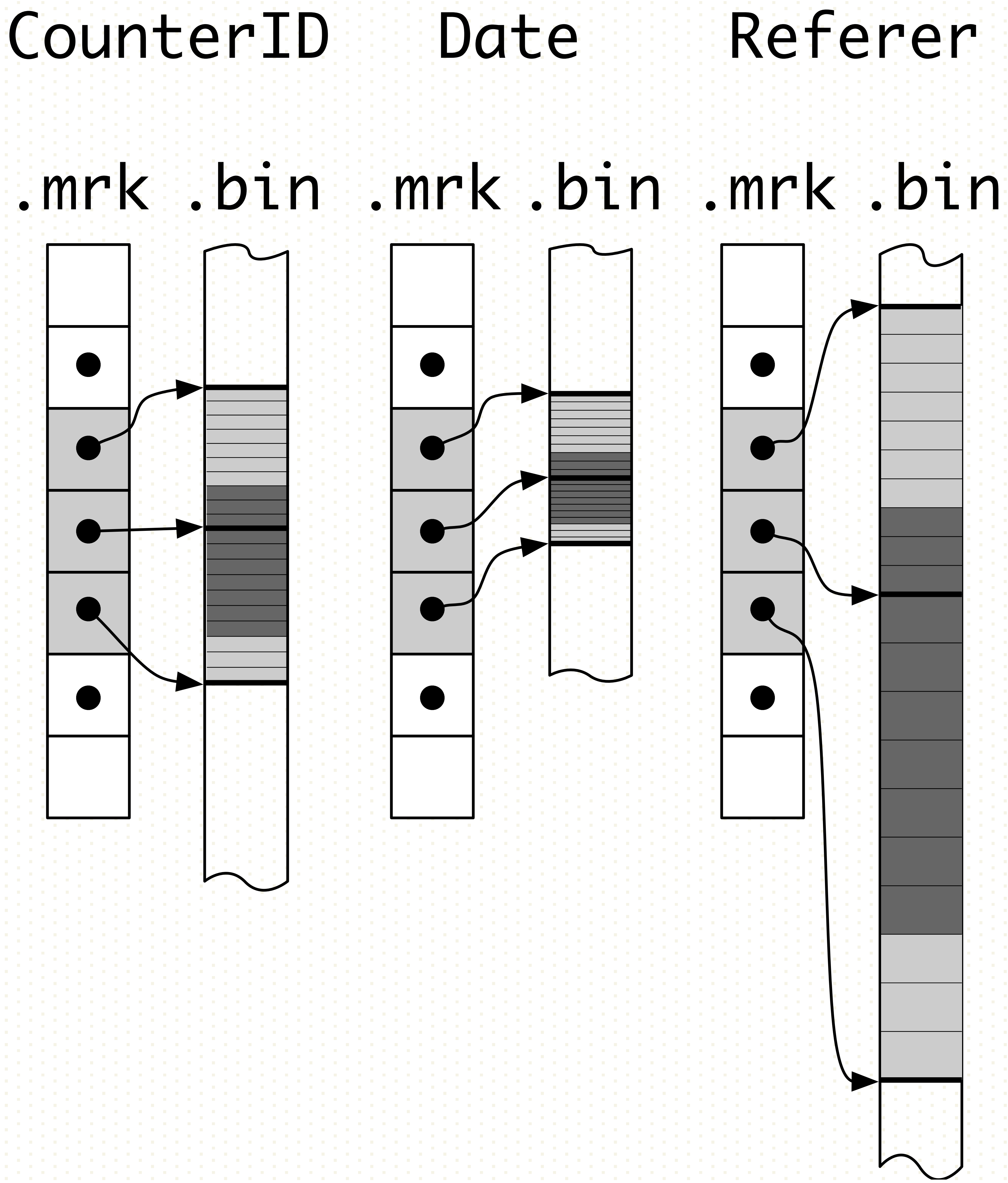
Index internals

(CounterID, Date)

primary.idx

	…	…
	1234	2017-09-11
N	1234	2017-09-21
N+8192	1234	2017-09-27
N+16384	1235	2013-02-16
	1235	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
- Poor performance for point queries

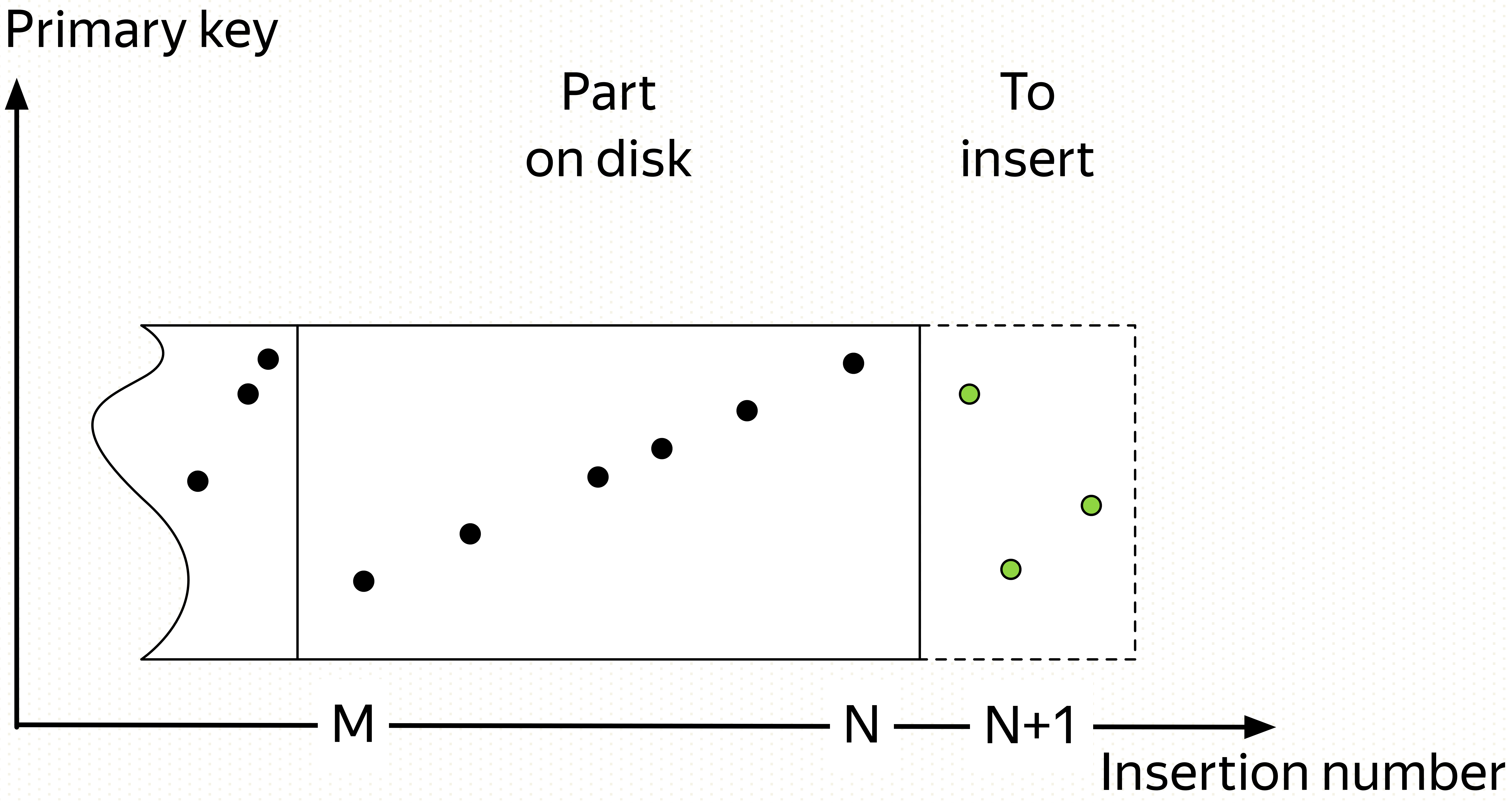
Table is sorted according to the index

- 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



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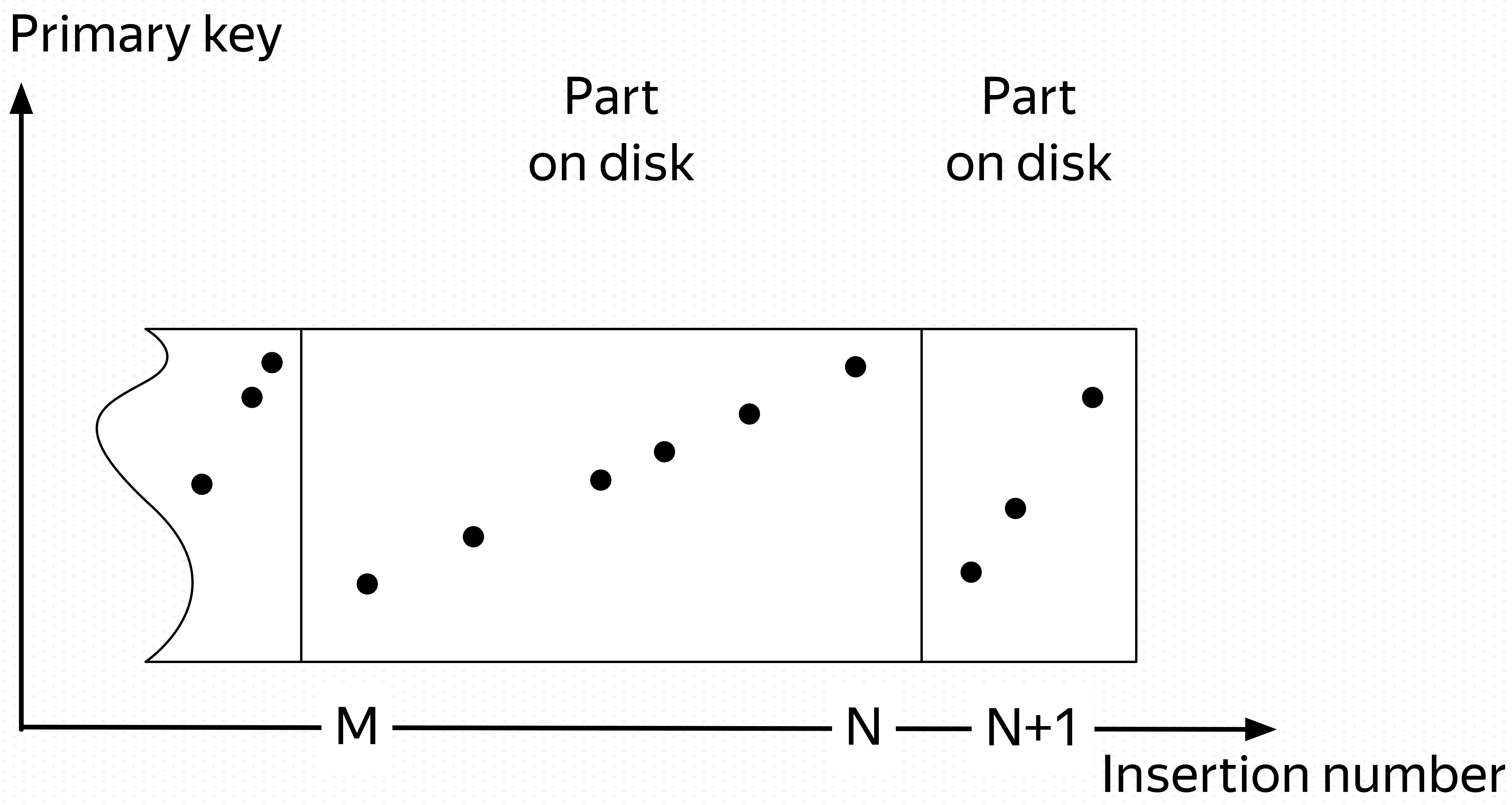

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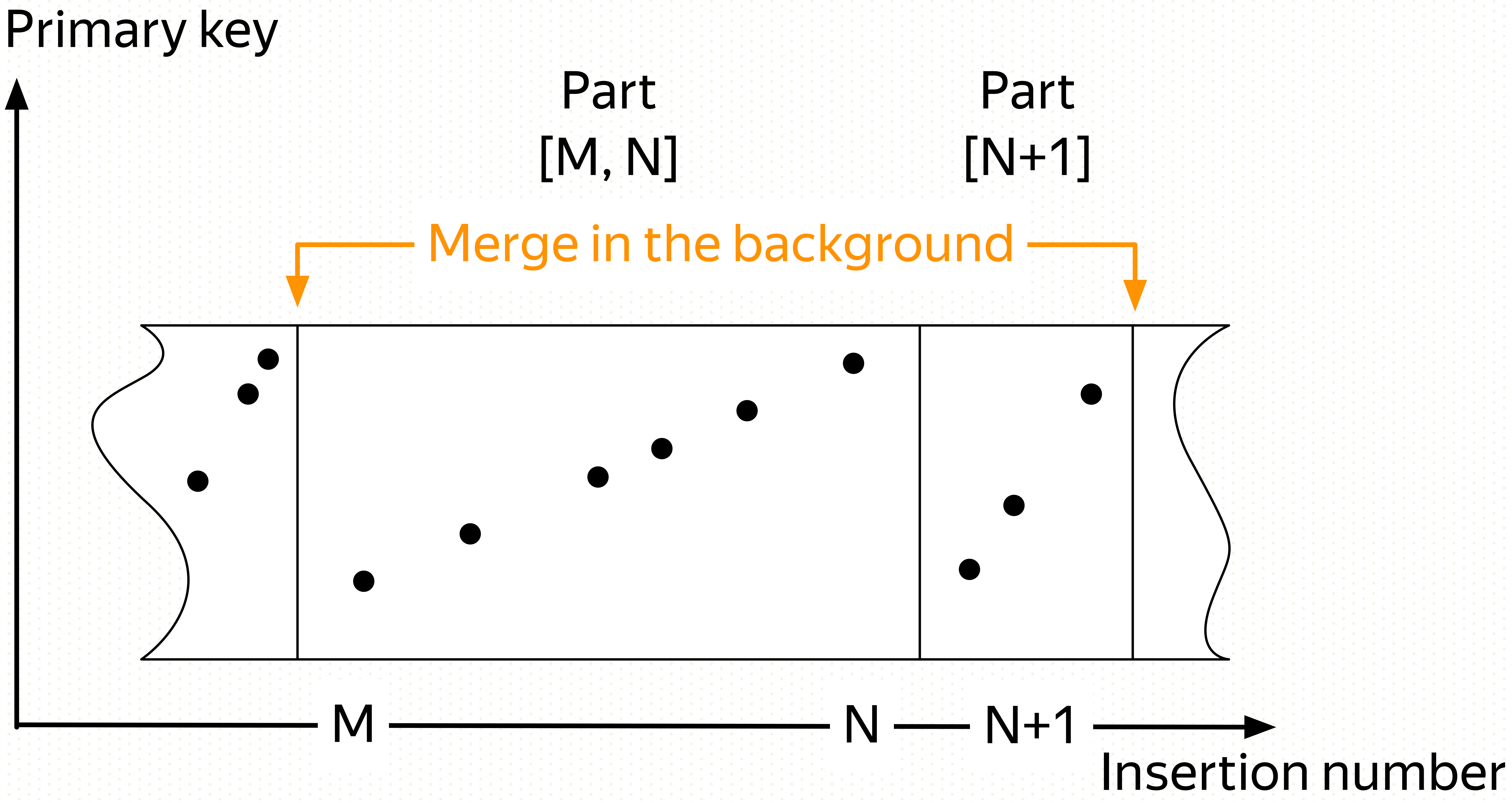

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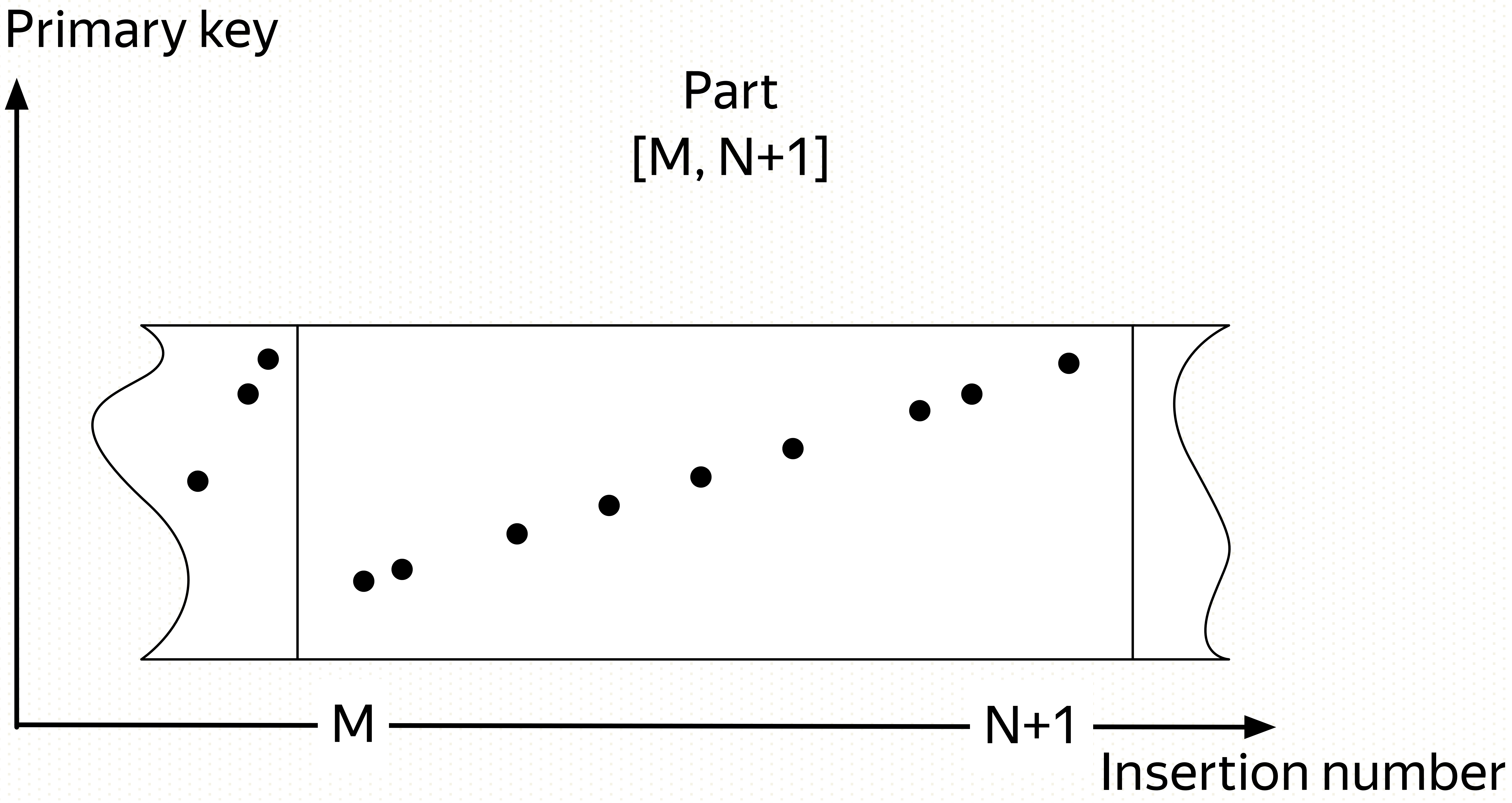

Things to do while merging

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

MergeTree partitioning

```
ENGINE = MergeTree(Date,… )
```

- Table is partitioned by month or (soon) by any expression
- 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…

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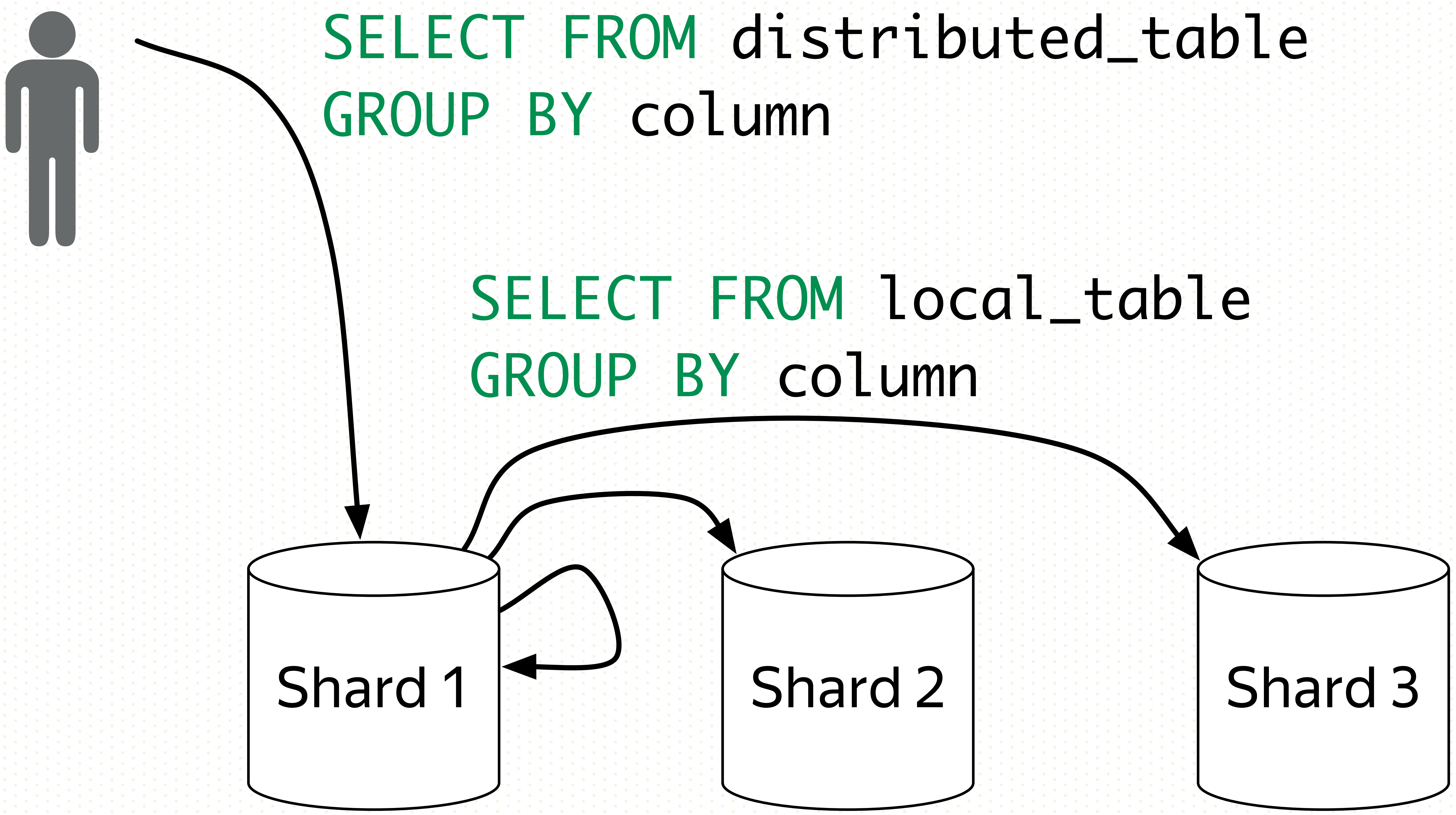
ClickHouse: Sharding + Distributed tables!

Reading from a Distributed table



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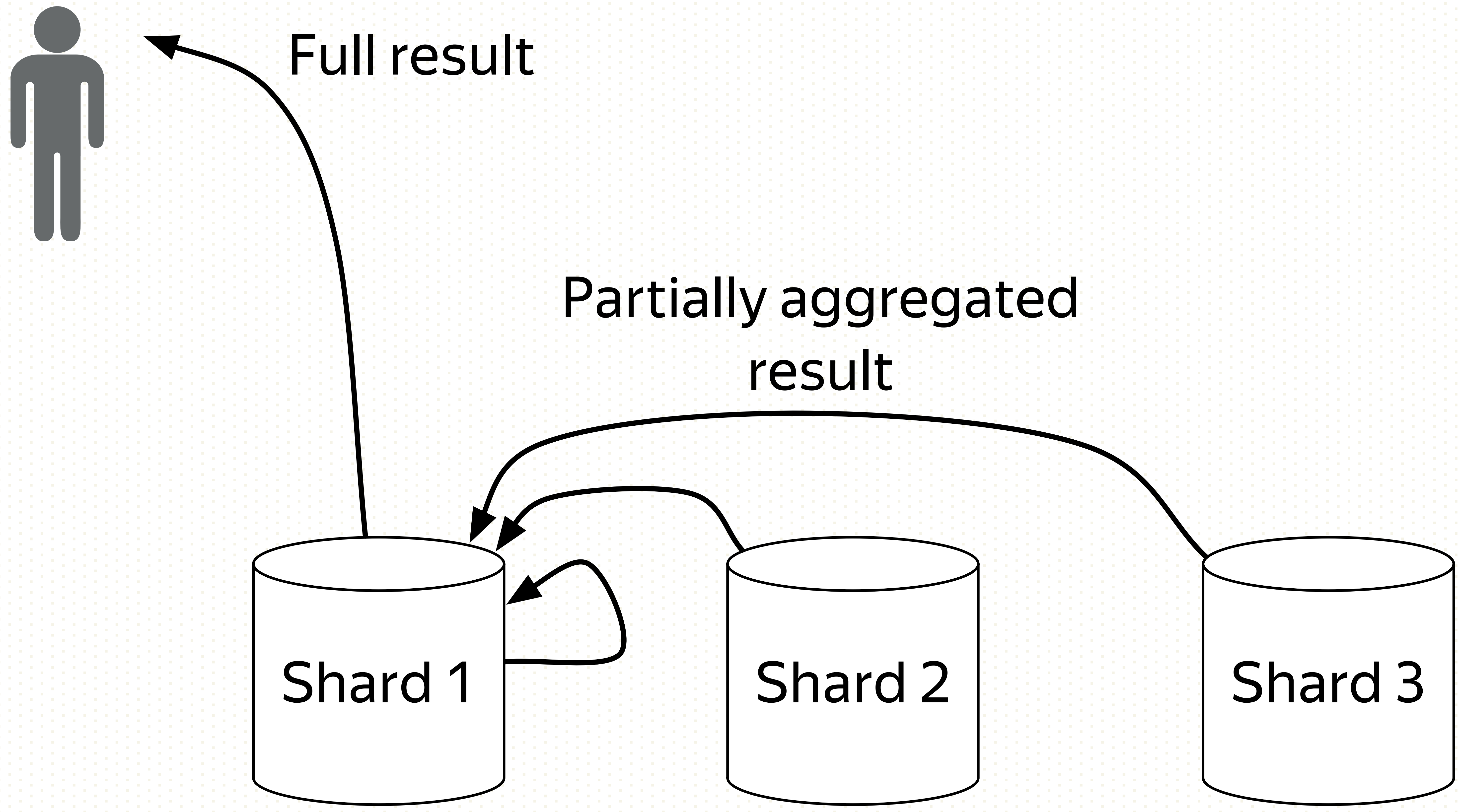

NYC taxi benchmark

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

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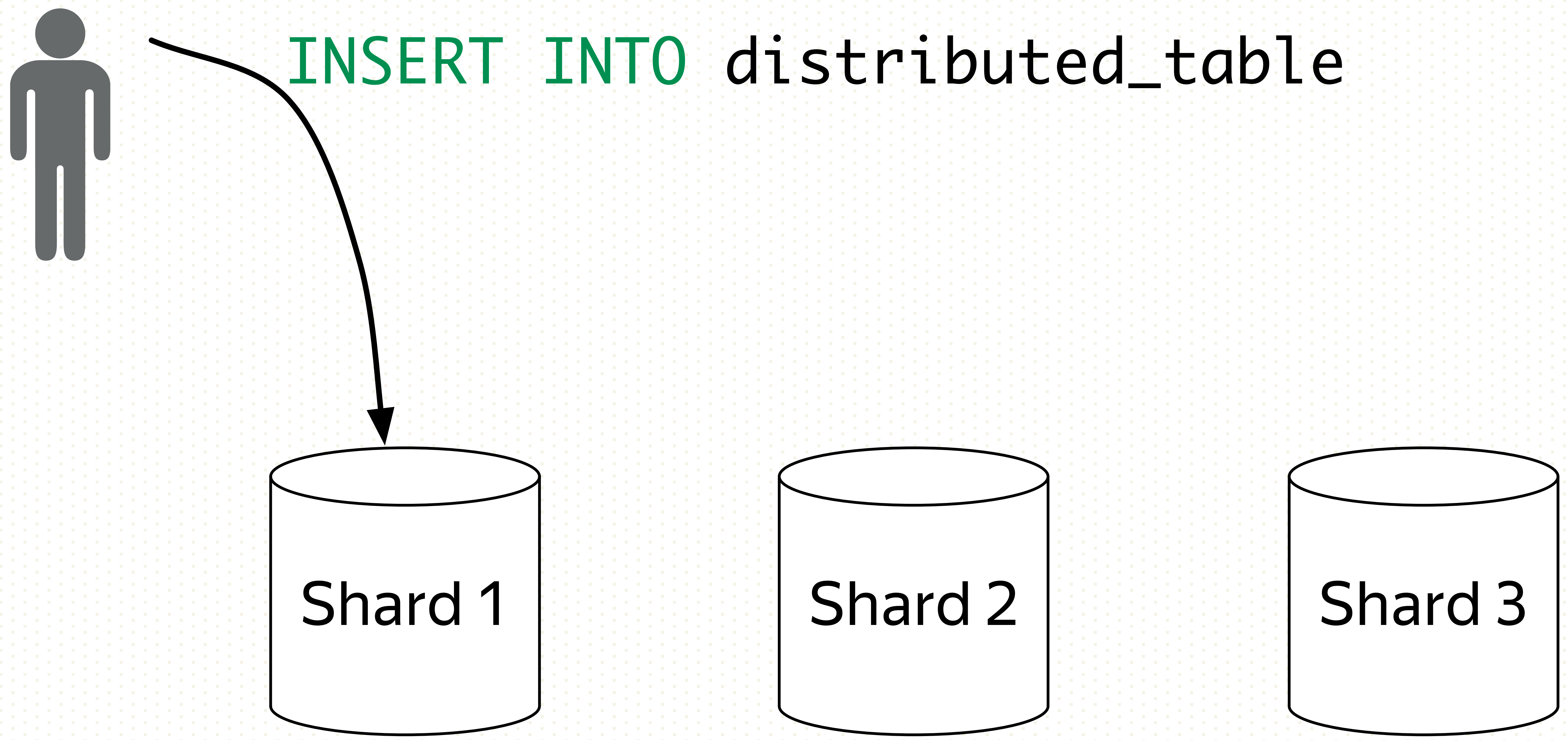
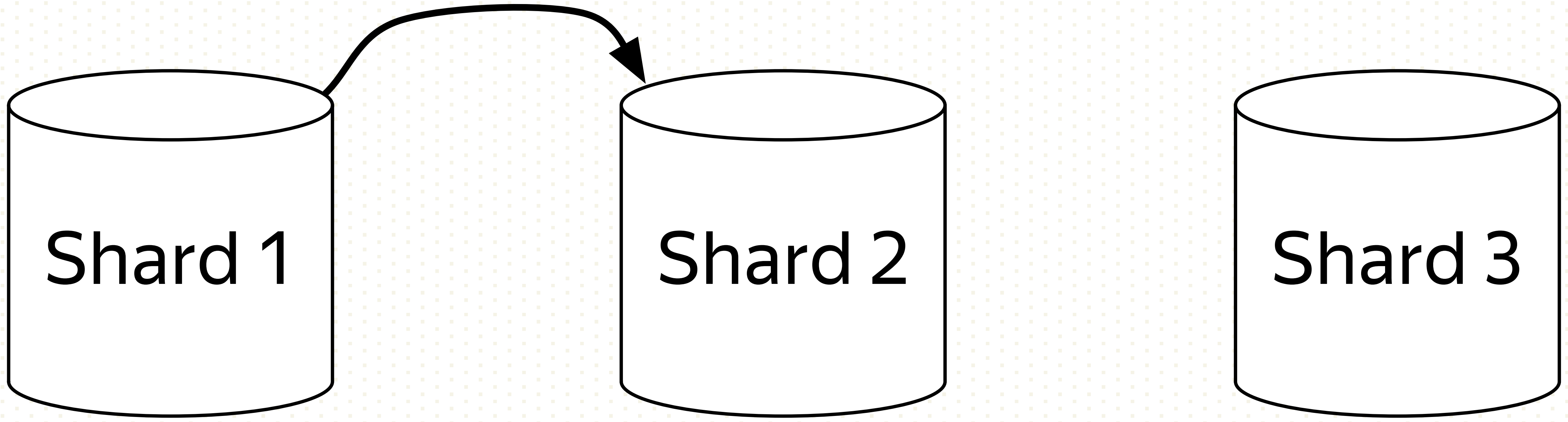
Inserting into a Distributed table



Inserting into a Distributed table

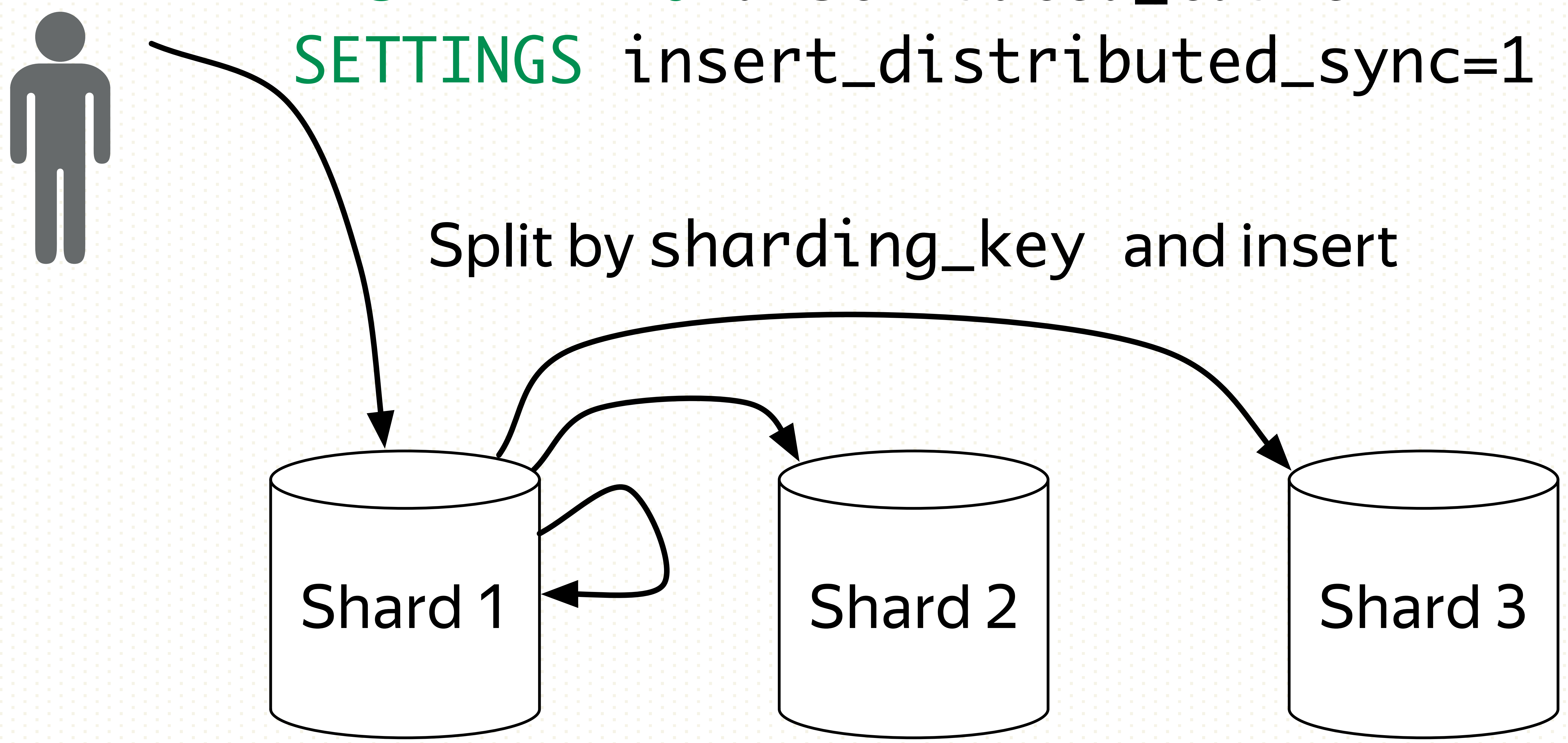
Async insert into shard #
`sharding_key % 3`

`INSERT INTO local_table`



Inserting into a Distributed table

```
INSERT INTO distributed_table
SETTINGS insert_distributed_sync=1
```



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

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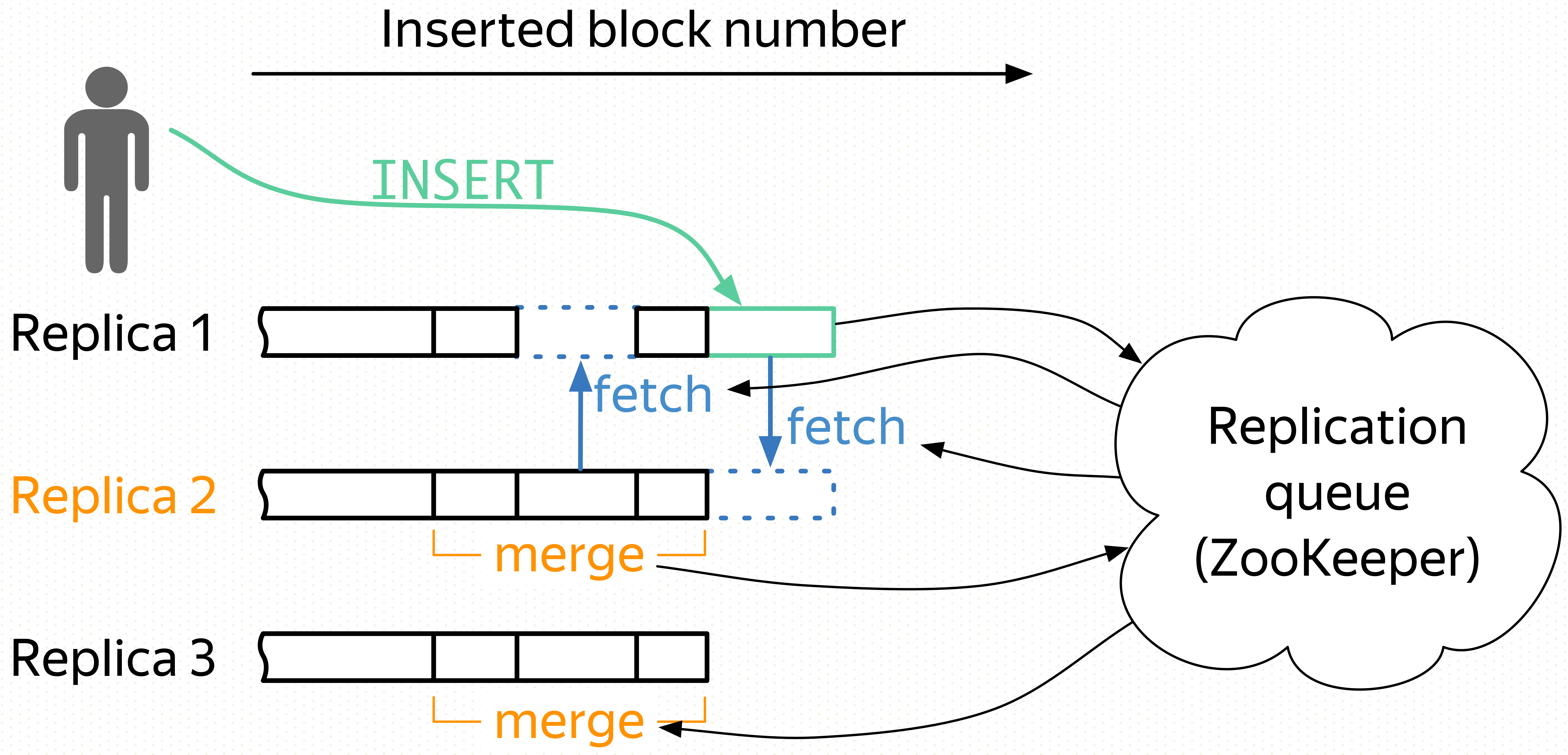
ClickHouse: ReplicatedMergeTree engine!

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

Replication internals



Replication and the CAP–theorem

What happens in case of network failure (partition)?

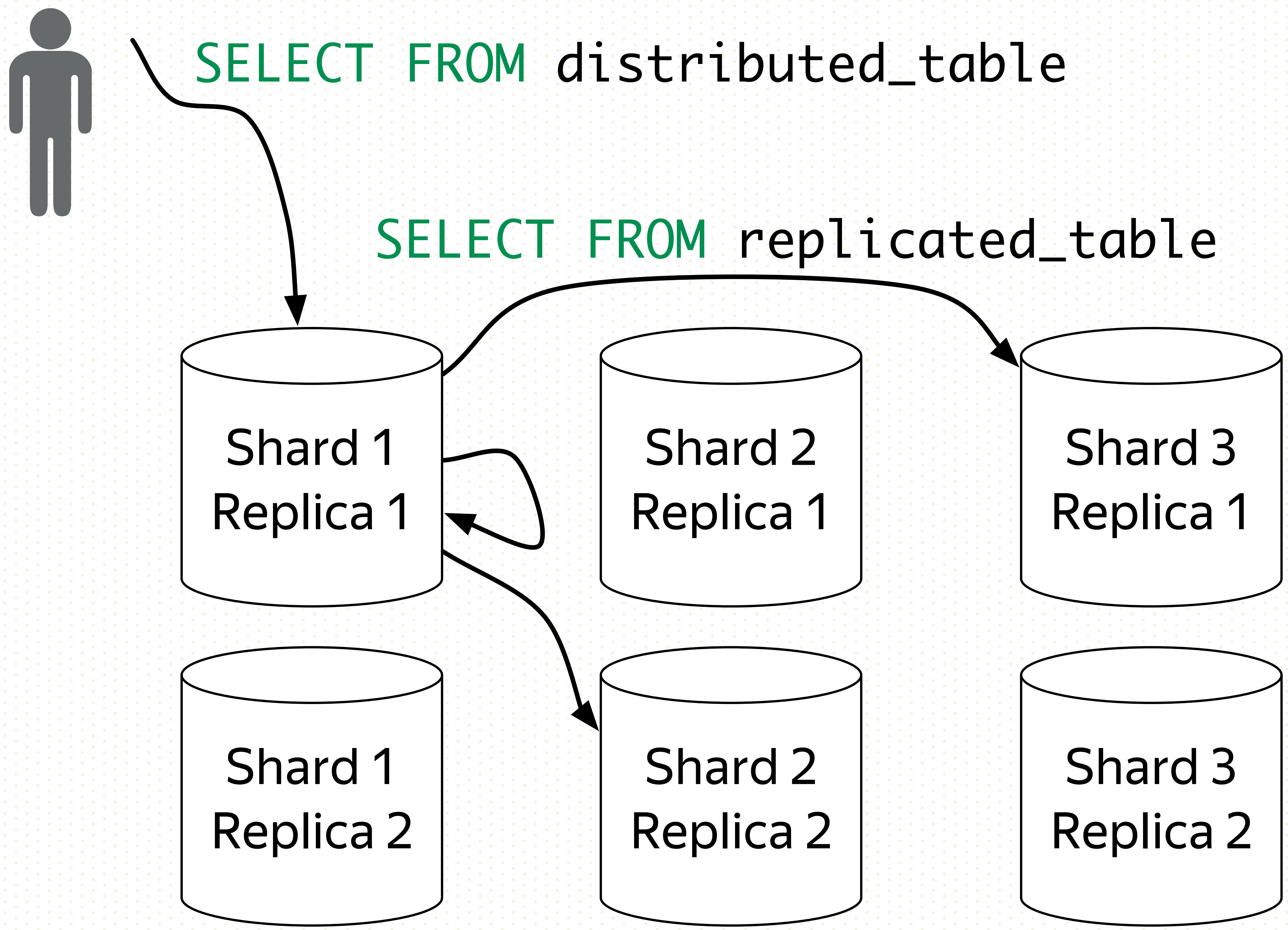
- Not consistent*
  As is any system with async replication

  *But you can turn sequential consistency 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

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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

Start using ClickHouse today!

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

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