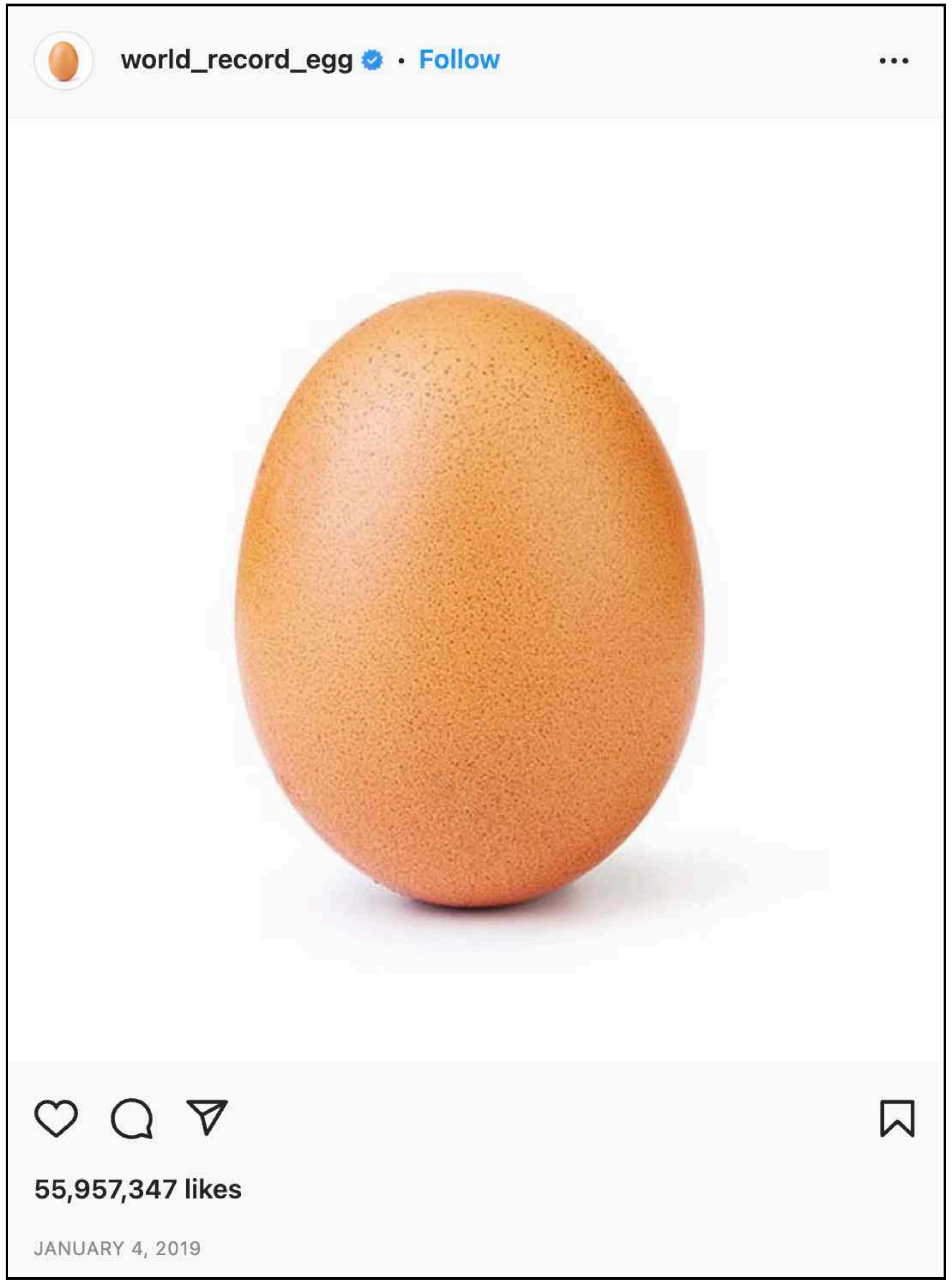
Cassandra - CQL

Big Data Systems

Dr. Rubi Boim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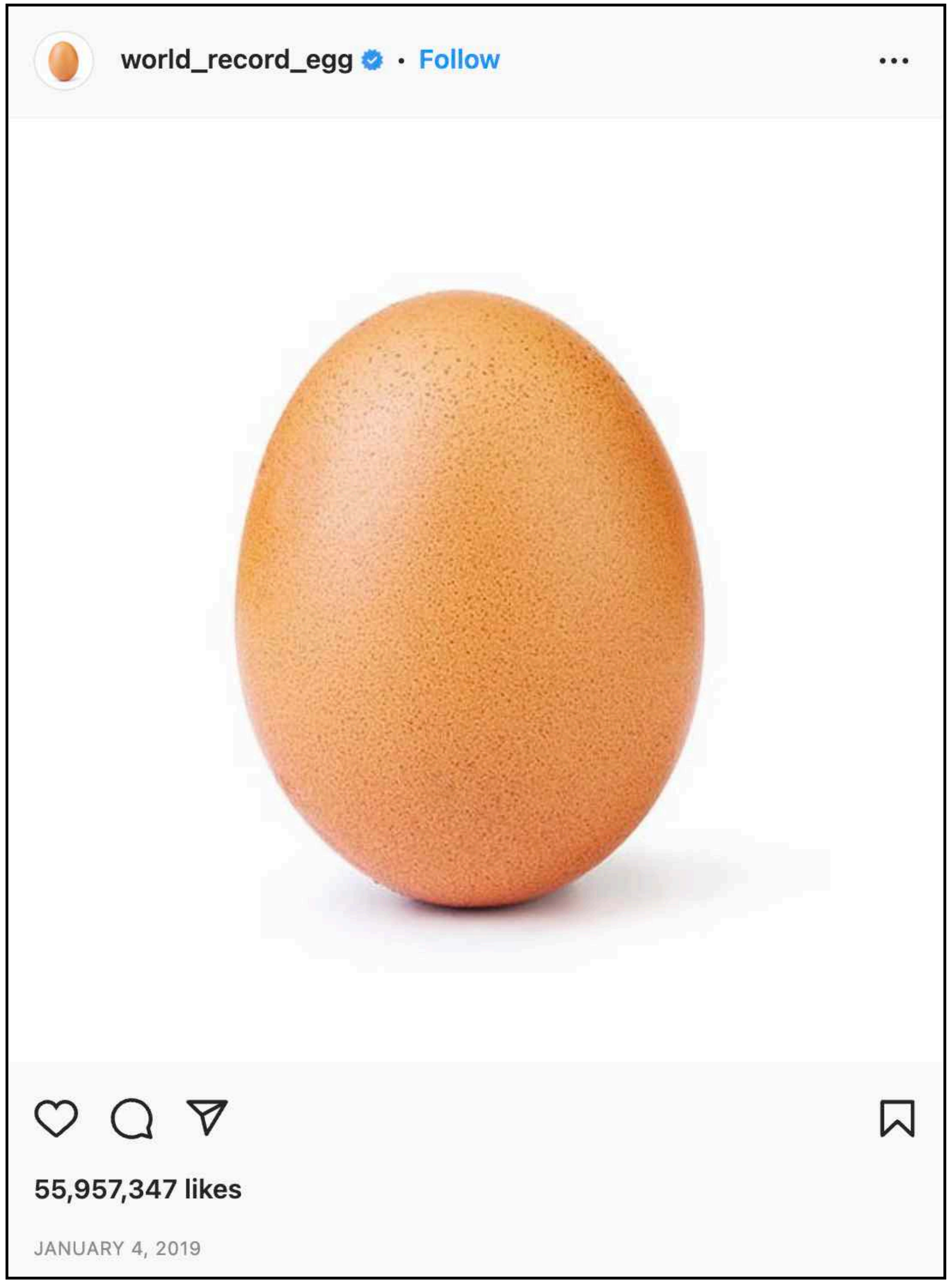
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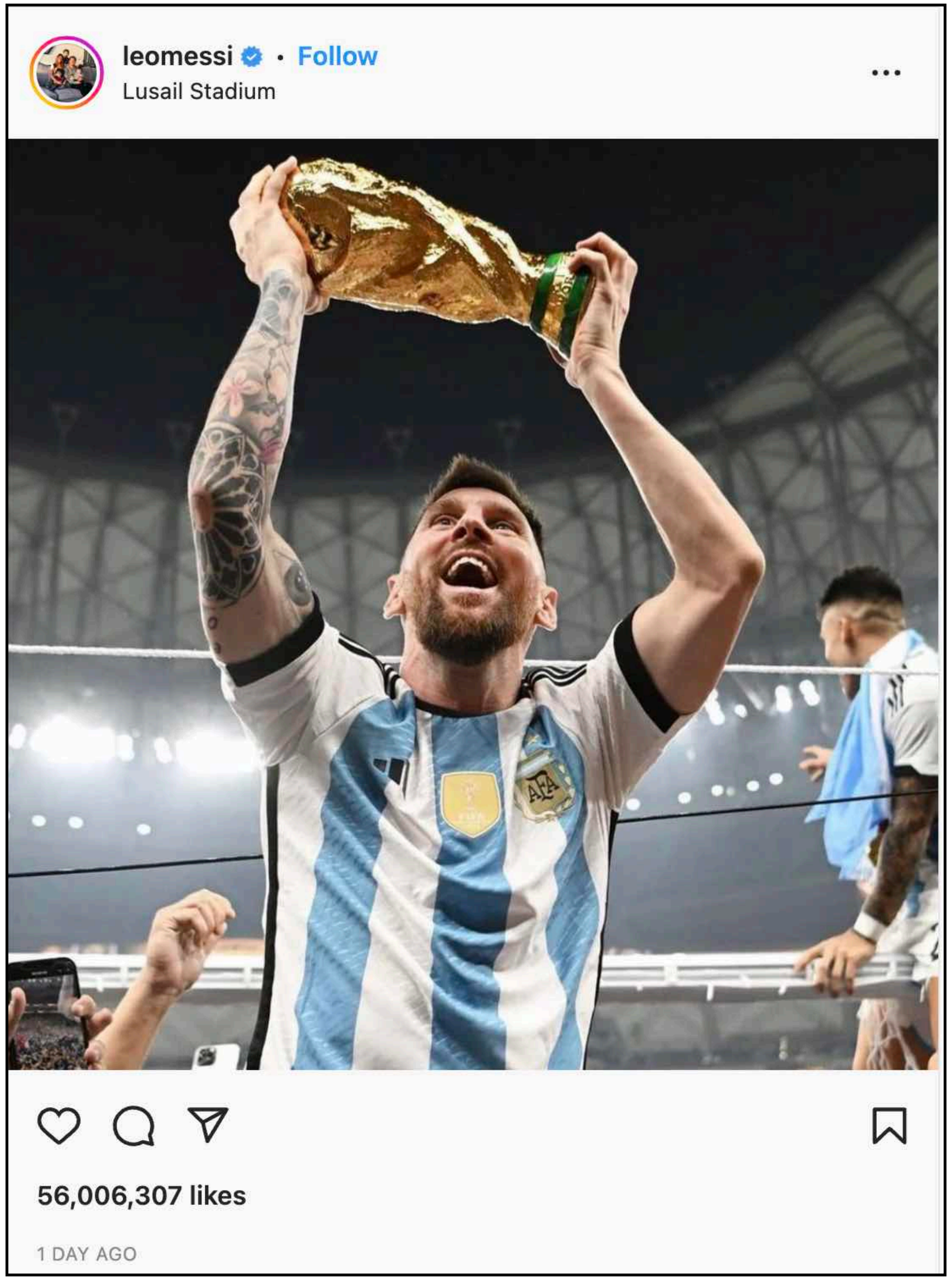
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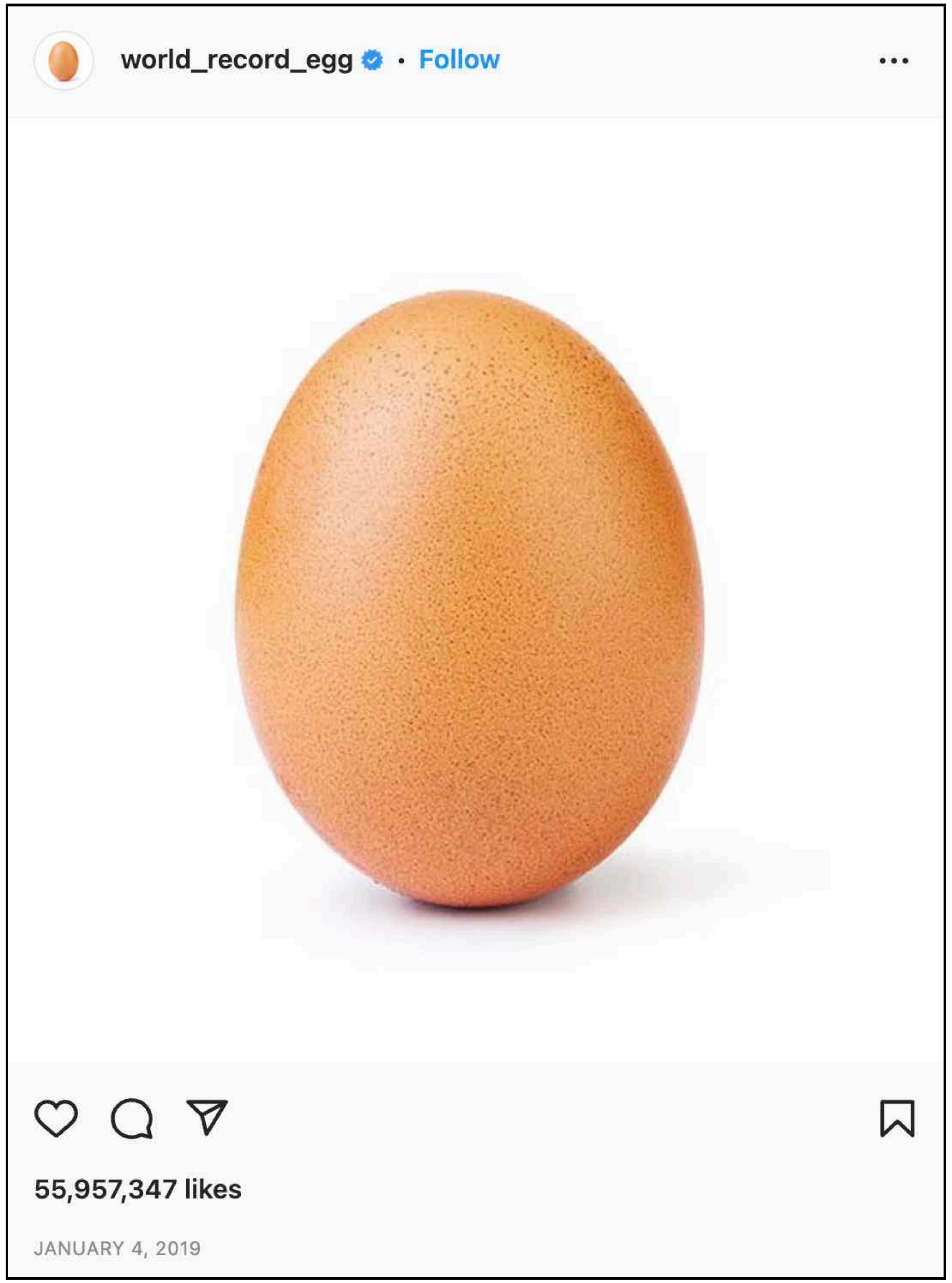
Lusail Stadium

56,006,307 likes

1 DAY AGO



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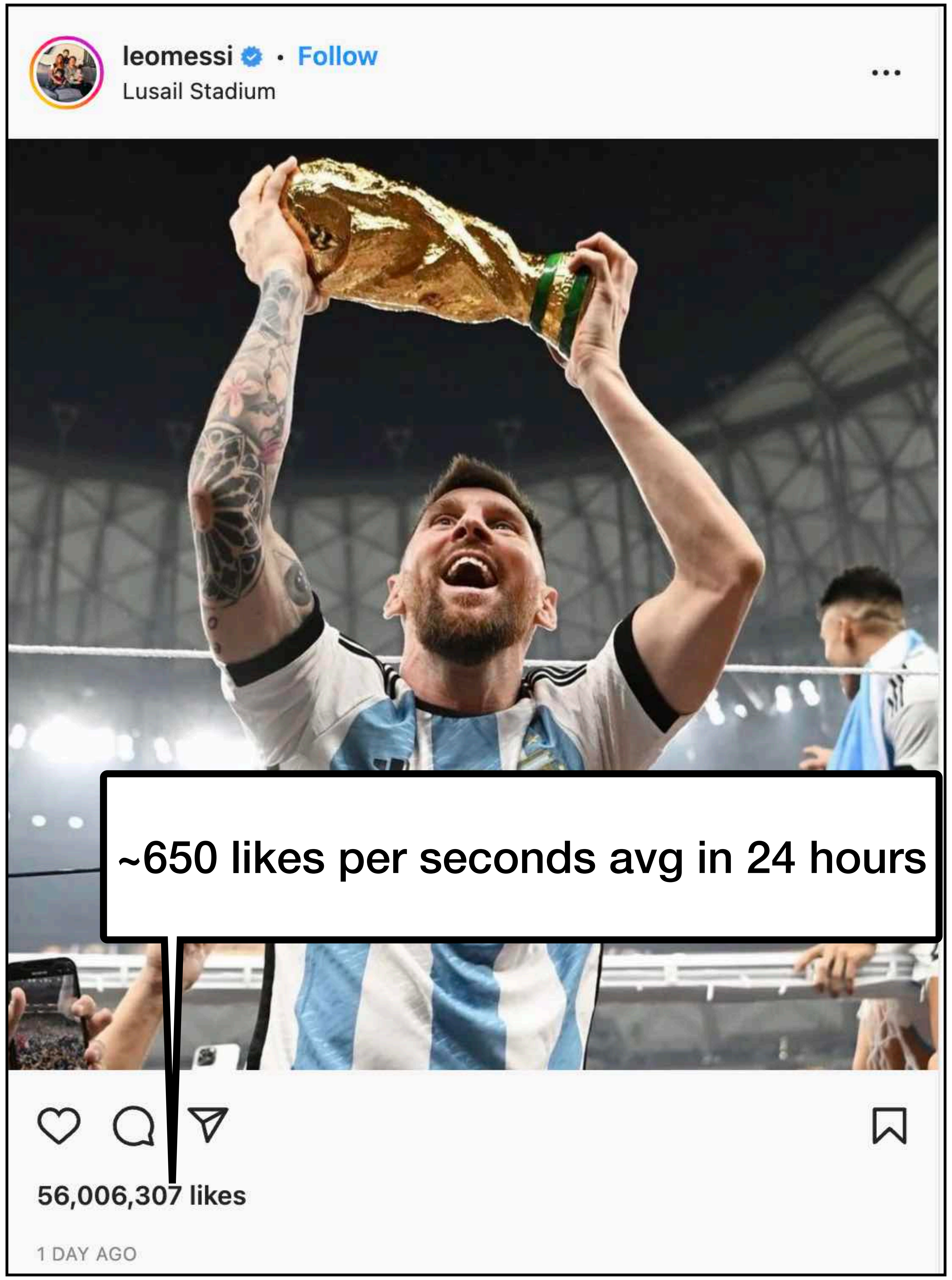

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~650 likes per seconds avg in 24 hours

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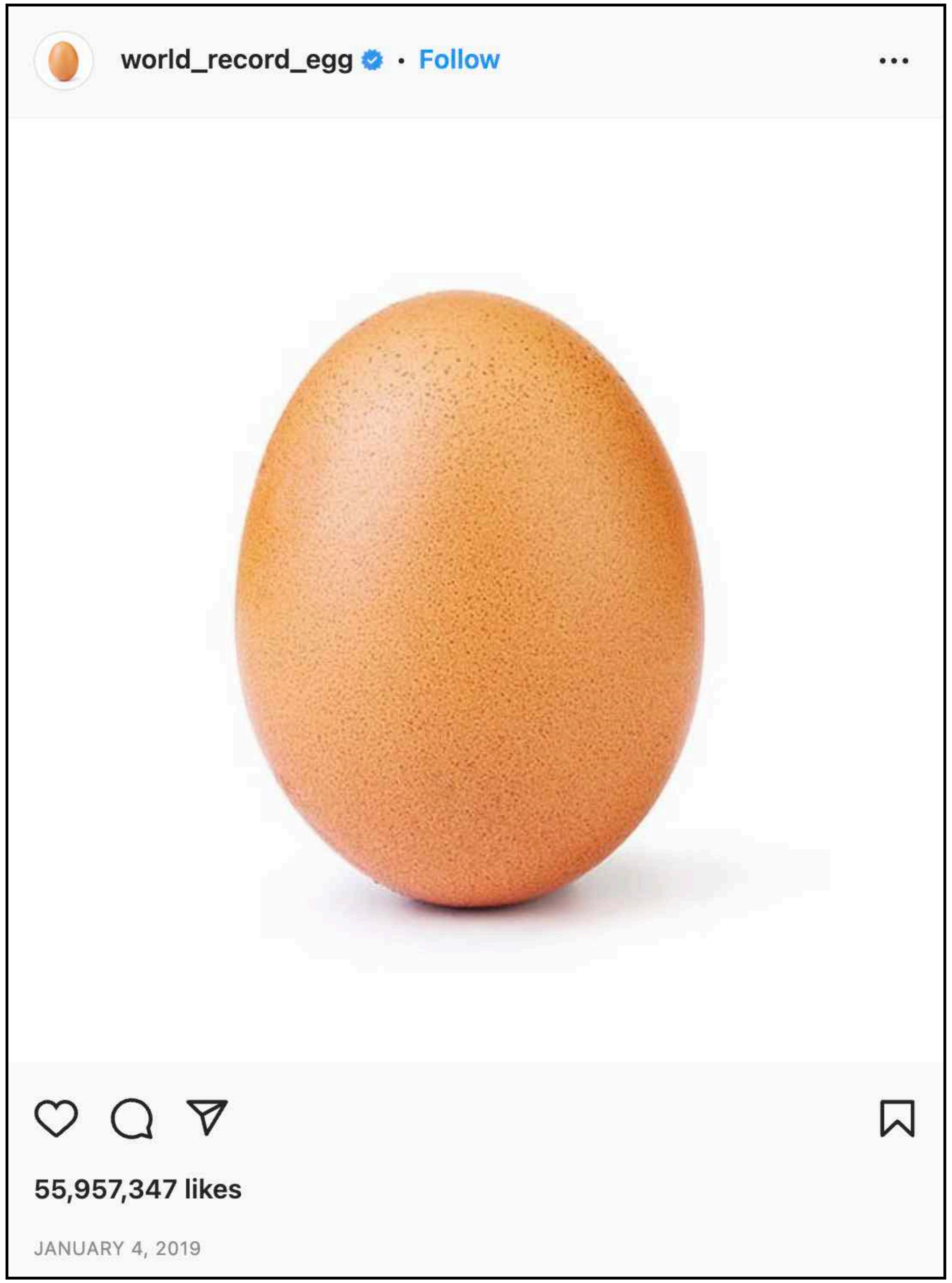
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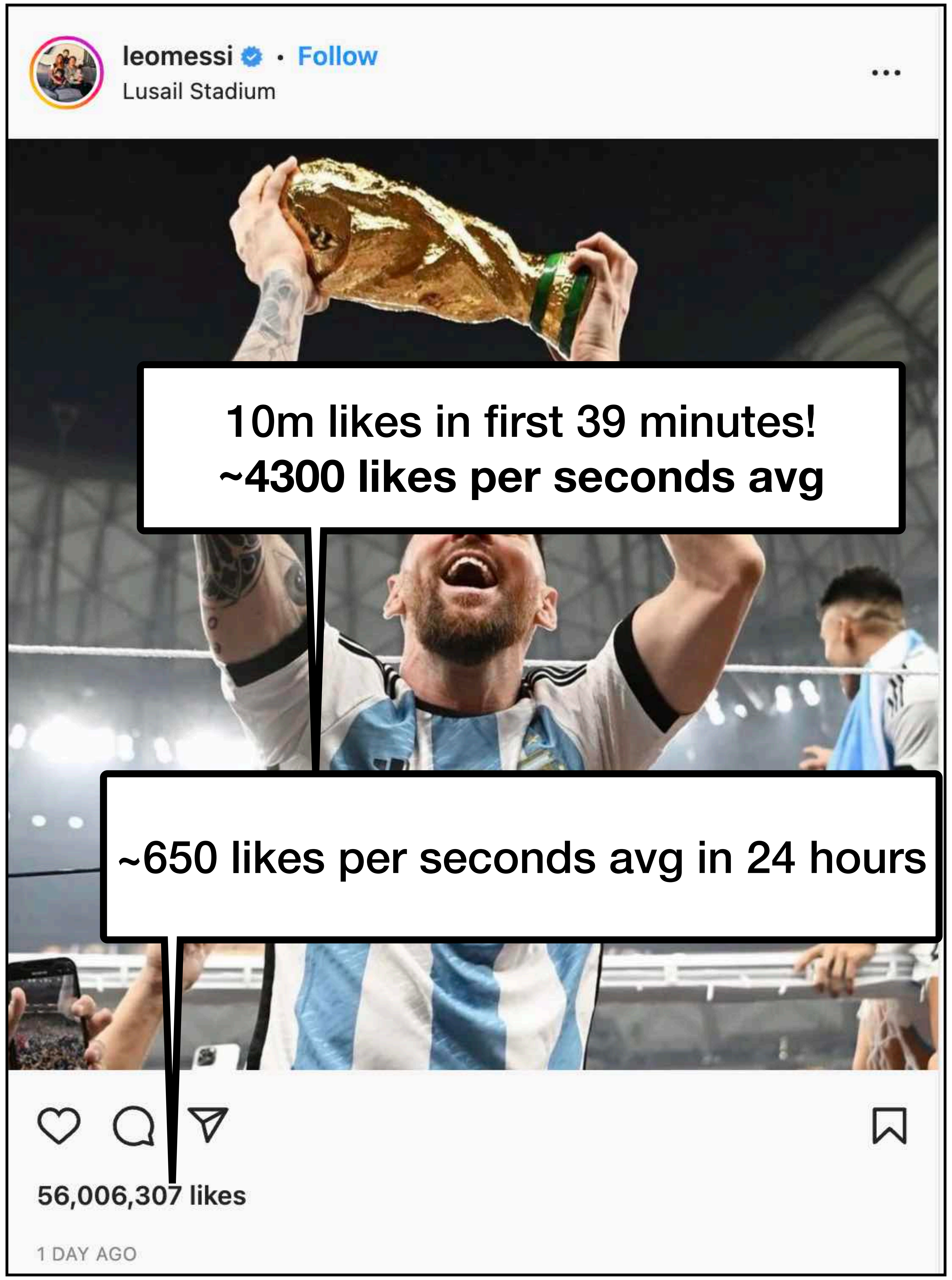
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10m likes in first 39 minutes!
~4300 likes per seconds avg

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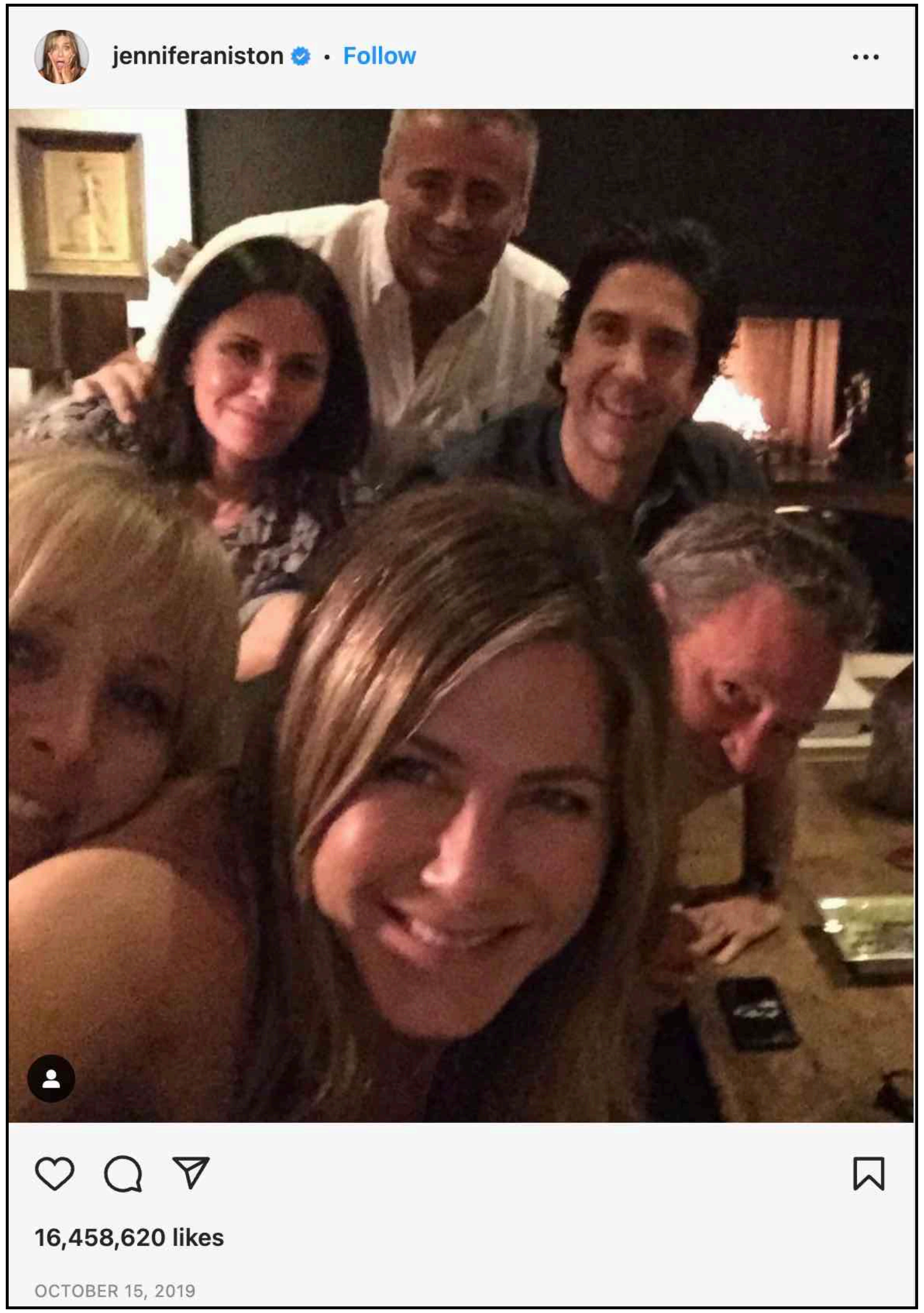

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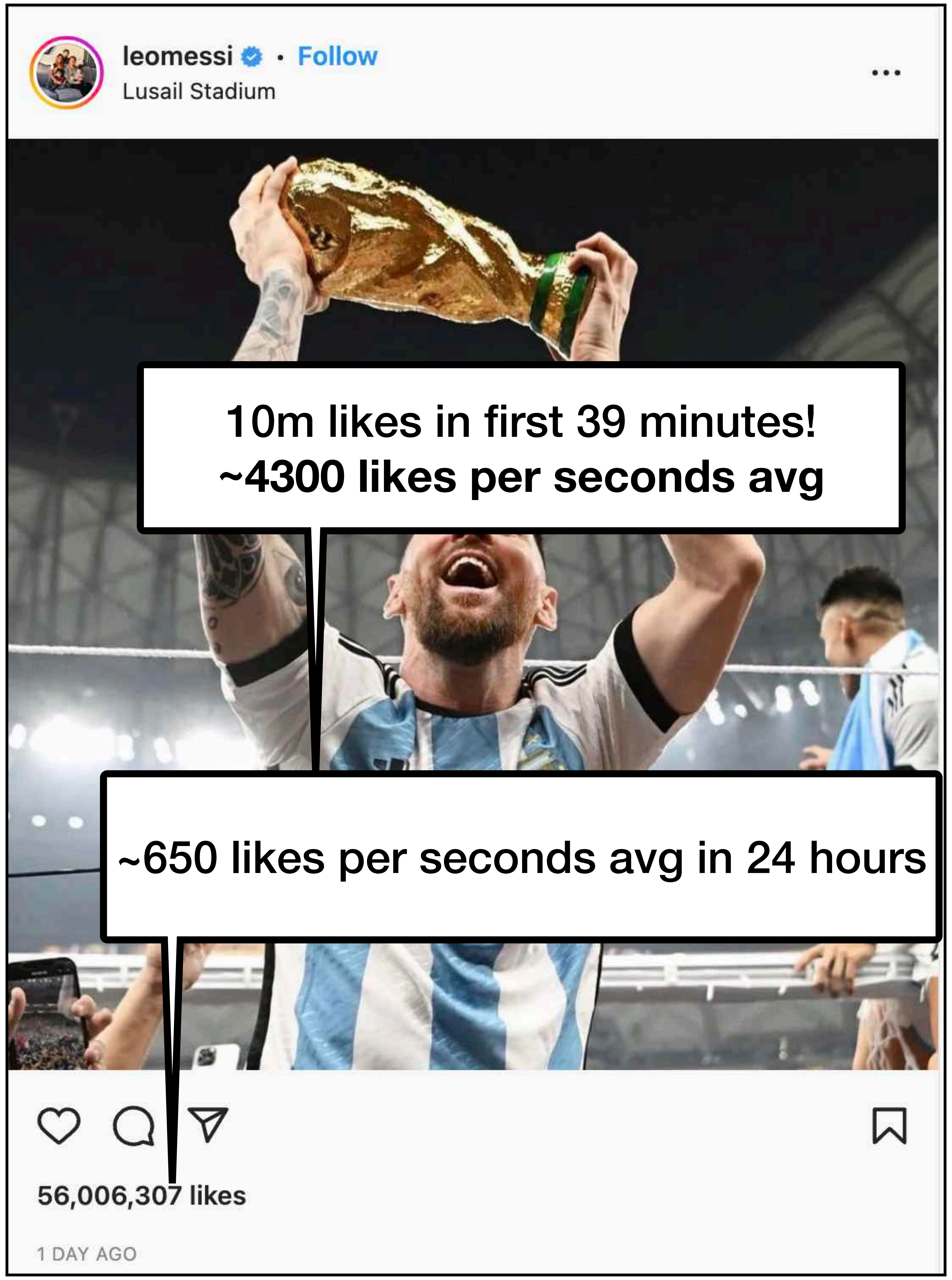
16,458,620 likes

OCTOBER 15, 2019



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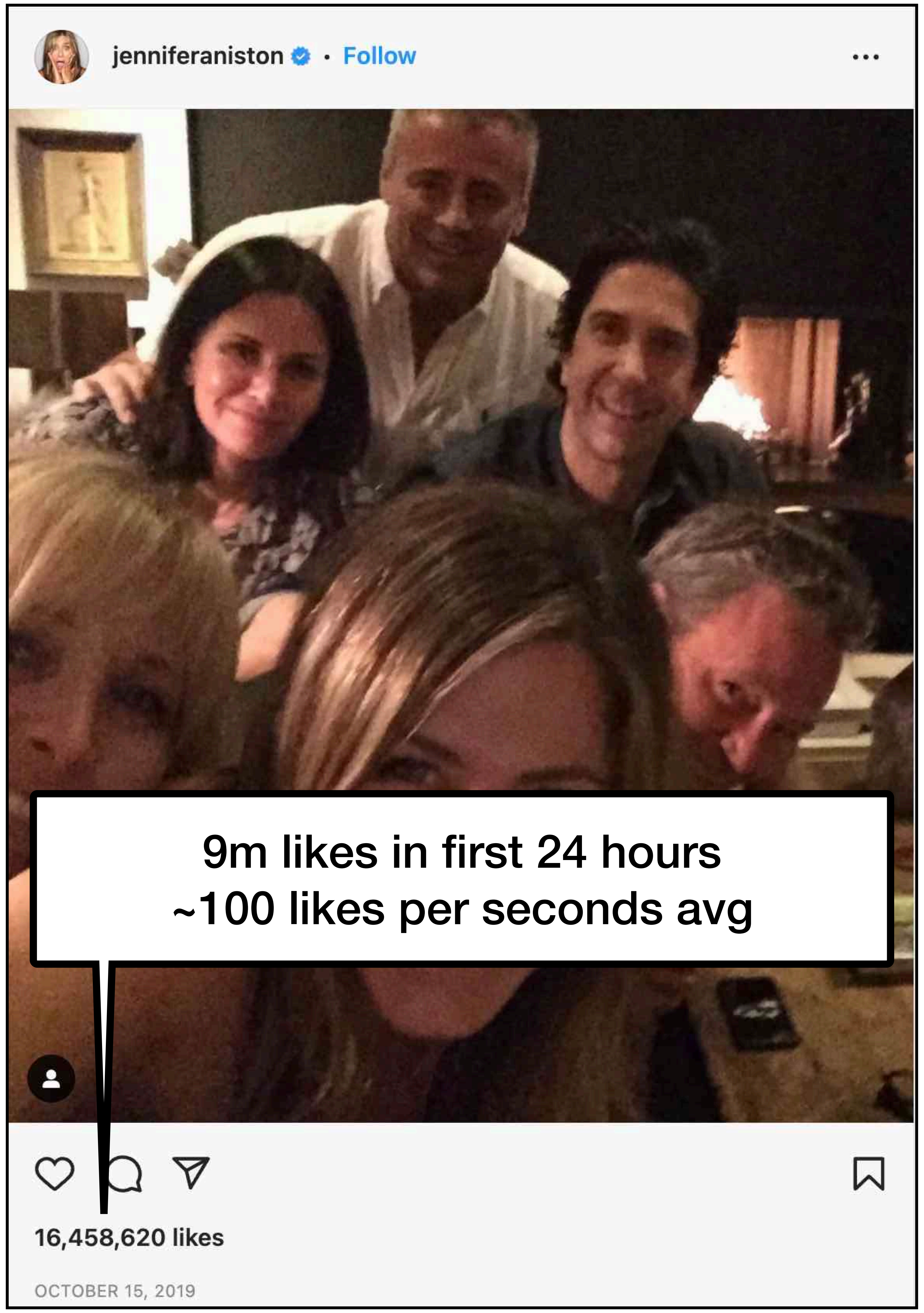

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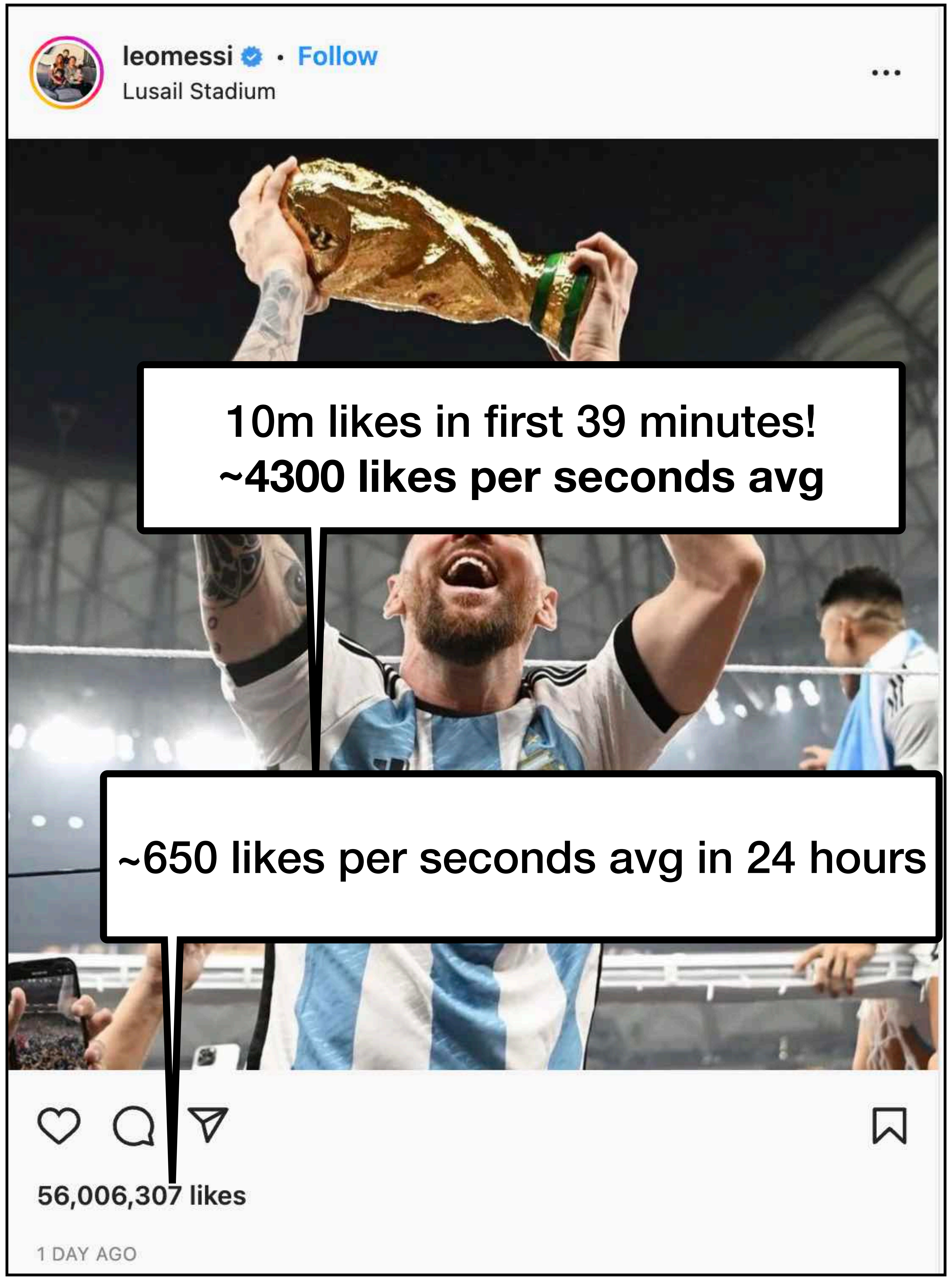

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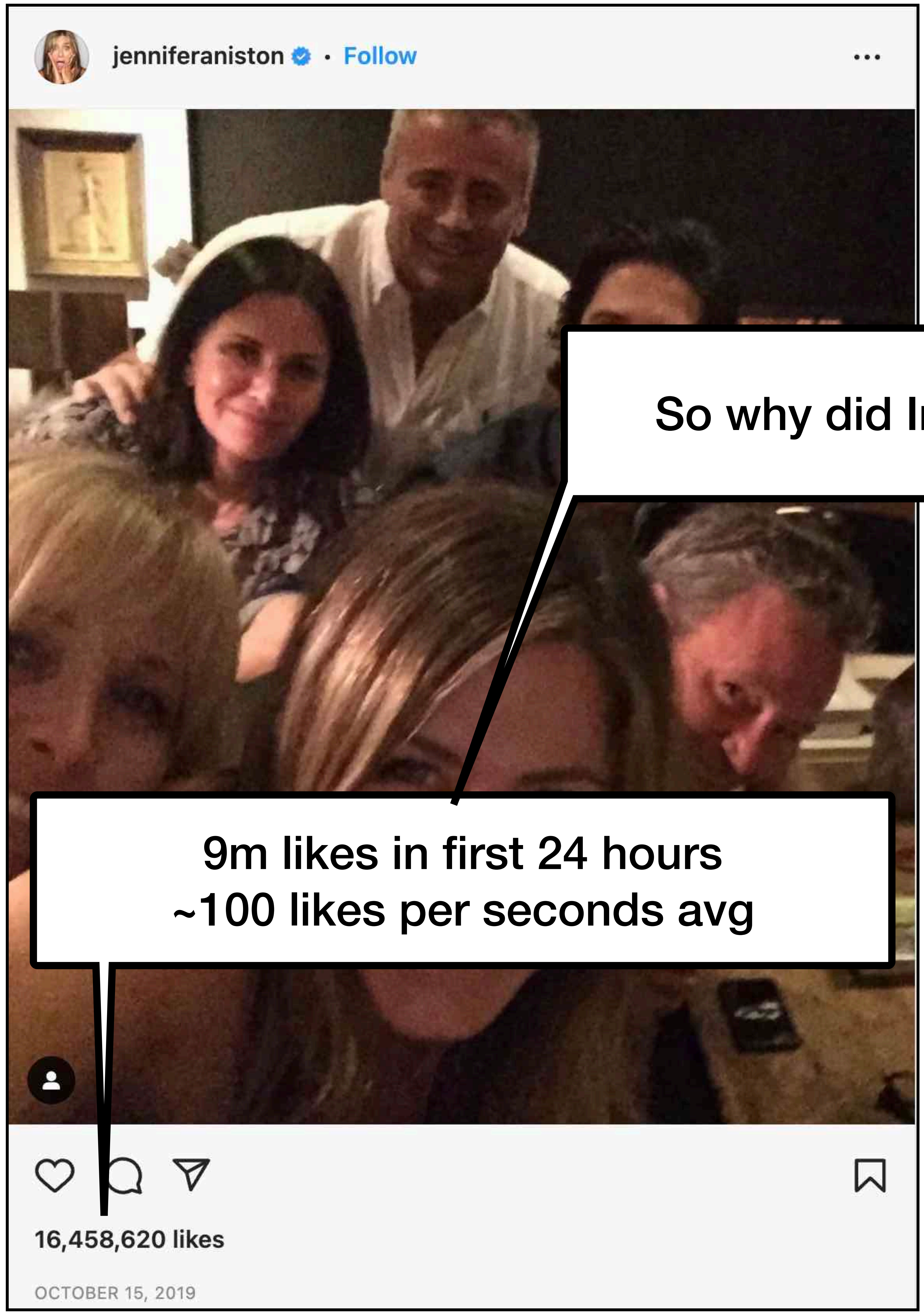

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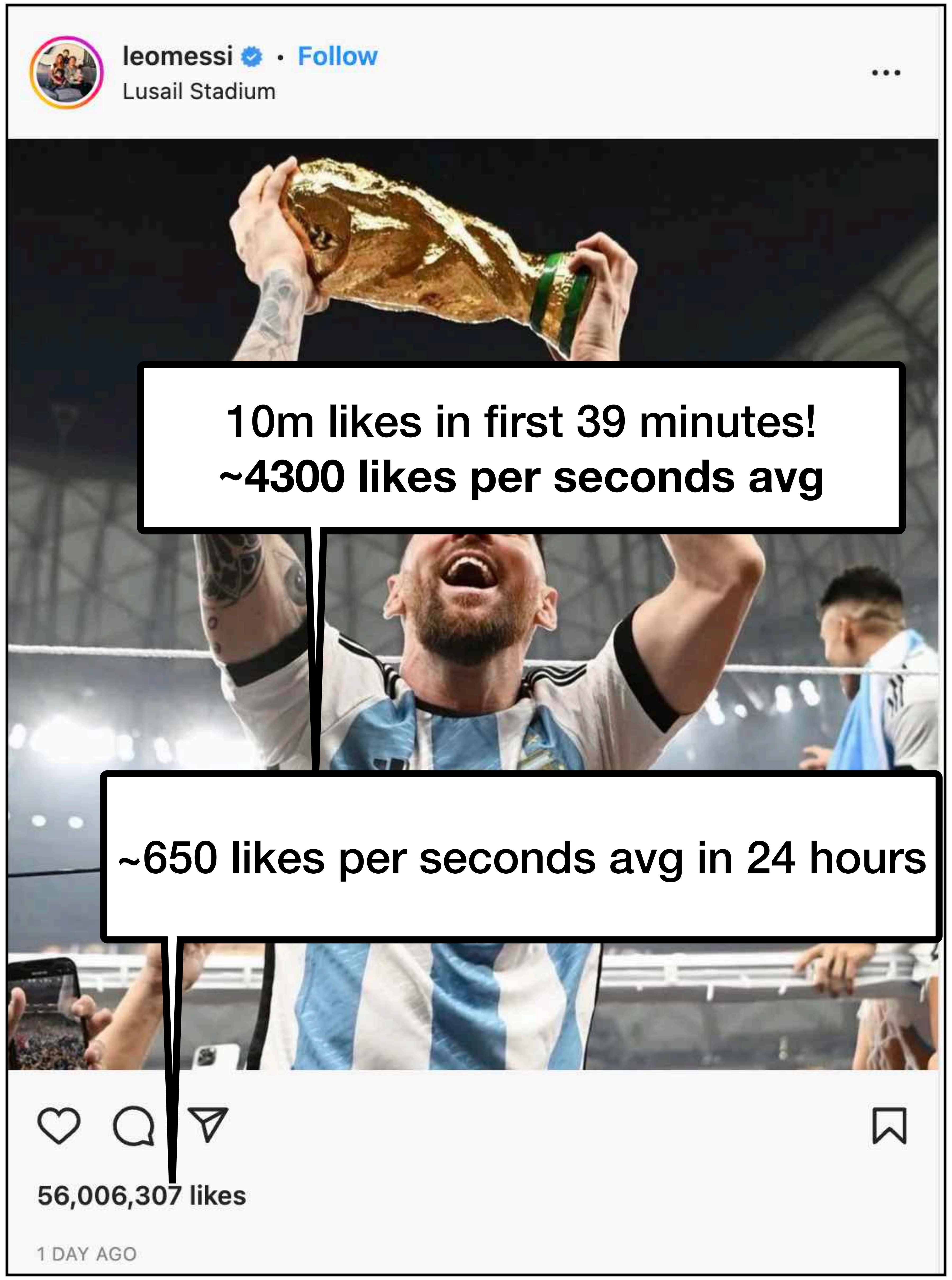
So why did Instagram crashed?



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Top 20 [edit]

Lionel Messi and Cristiano Ronaldo make up 14 out of the top 20 most-liked posts, with posts mainly released around the 2022 FIFA World Cup.

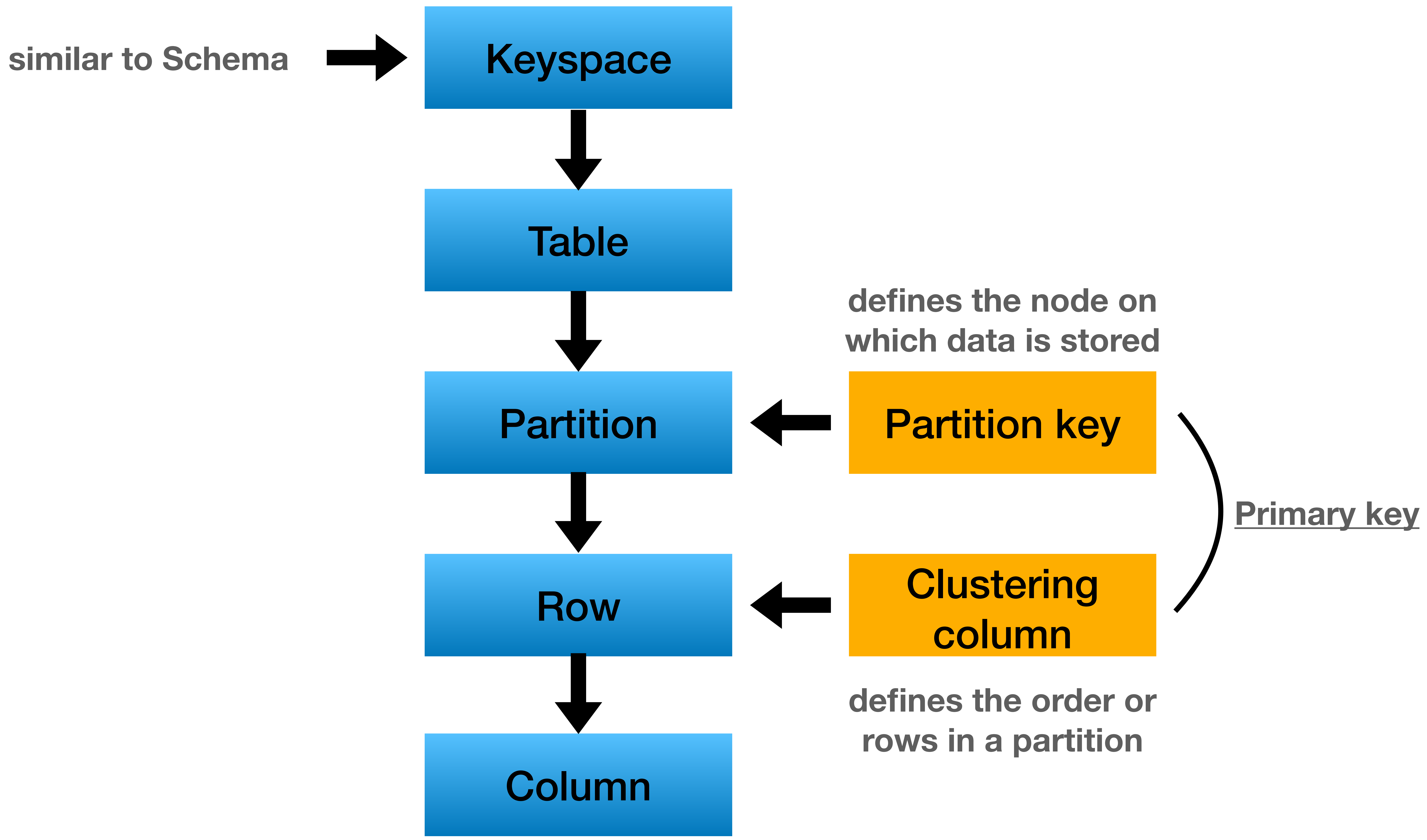
Rank	Account name	Owner	Post description	Post	Likes (millions)	Date posted (UTC)
1	@leomessi	Lionel Messi	Celebrating winning the 2022 FIFA World Cup	[1]	75.0	December 18, 2022
2	@world_record_egg	Chris Godfrey	Photo of an egg	[2]	60.9	January 4, 2019
3	@leomessi	Lionel Messi	Lionel Messi in bed with the FIFA World Cup Trophy	[3]	54.1	December 20, 2022
4	@cristiano	Cristiano Ronaldo	Lionel Messi and Cristiano Ronaldo playing chess, advertising for Louis Vuitton	[4]	42.0	November 19, 2022
5	@leomessi	Lionel Messi	Lionel Messi on an airplane with the FIFA World Cup Trophy	[5]	41.5	December 19, 2022
6	@leomessi	Lionel Messi	Celebrating the 2022 FIFA World Cup win in Argentina	[6]	33.9	December 21, 2022
7	@cristiano @alnassr	Cristiano Ronaldo Al Nassr FC	Announcement of Cristiano Ronaldo joining Al Nassr FC	[7]	33.8	December 30, 2022
8	@xxxtentacion	XXXTentacion	Final post before his death	[8]	33.6	May 19, 2018
9	@jiangzhibin24	liz_6	Reel of a sunset	[9]	33.6	August 5, 2023
10	@cristiano	Cristiano Ronaldo	After elimination of Portugal from the 2022 FIFA World Cup	[10]	33.6	December 11, 2022
11	@leomessi	Lionel Messi	Lionel Messi and Cristiano Ronaldo playing chess, advertising for Louis Vuitton	[11]	32.3	November 19, 2022
12	@cristiano @georginagio	Cristiano Ronaldo Georgina Rodríguez	Pregnancy announcement	[12]	32.0	October 28, 2021
13	@cristiano	Cristiano Ronaldo	Post in remembrance of Pelé	[13]	31.8	December 29, 2022
14	@pop_cj6	pop_cj6	Taking off animal masks in front of animal mothers	[14]	31.2	February 27, 2024
15	@leomessi	Lionel Messi	After 2022 FIFA World Cup match against Croatia	[15]	29.3	December 14, 2022
16	@cristiano	Cristiano Ronaldo	Cristiano Ronaldo being presented to Al Nassr FC fans	[16]	27.4	January 3, 2023
17	@cristiano	Cristiano Ronaldo	Friendly match against PSG	[17]	27.4	January 19, 2023
18	@zendaya	Zendaya	Happy birthday post to Tom Holland	[18]	26.2	June 1, 2022
19	@leomessi	Lionel Messi	Post in remembrance of Pelé	[19]	25.6	December 29, 2022
20	@k.mbappe	Kylian Mbappé	Kylian Mbappé signing with Real Madrid CF	[20]	25.5	June 3, 2024
As of 28 December 2024						

Cassandra CQL

- Terminology
- Keyspaces
- Tables
- Data types
- DDL / DML

Spoiler - most slides will be on SELECT

Terminology (Cassandra)



Keyspace

- High level container - AKA “schemas” from rDB
- **replication factor strategy**
    - “`SimpleStrategy`”: entire cluster
    - “`NetworkTopologyStrategy`”: different settings for each DS

Keyspace

```
CREATE KEYSPACE BigDataCourse WITH REPLICATION = {
 'class'                : 'SimpleStrategy',
 ‘replication_factor': 1
};


CREATE KEYSPACE BigDataCourse WITH REPLICATION = {
 'class'                :'NetworkTopologyStrategy',
 ‘israel'               : 3 , // Datacenter 1
 'us'                   : 2   // Datacenter 2
};
```

Use & Describe

- USE: switch between key spaces in CQL

```
                  USE bigdatacourse
JAVA:
CassandraConnectionPool connectionPool.setKeyspace(“bigdatacourse”)
```

- DESCRIBE: display detailed information in CQL
  (see manual for more options)

```
DESCRIBE KEYSPACES/KEYSPACE/TABLES/TABLE/...
```

CREATE TABLE

```
CREATE TABLE students (
   column1    TEXT,
   column2    INT,
   column3    UUID,
   PRIMARY KEY (column1)
);
```

```
CREATE TABLE [IF NOT EXISTS] [keyspace_name.]table_name (
   column_definition [, ...]
   PRIMARY KEY (column_name [, column_name ...])
[WITH table_options
   | CLUSTERING ORDER BY (clustering_column_name order])
   | ID = 'table_hash_tag'
   | COMPACT STORAGE]
```

Data types (basic)

`TEXT`	utf8
`INT`	signed 32bits
`BIGINT`	signed 64bits
`TIMESTAMP`	64bits
`FLOAT`	32bits floating point
`DOUBLE`	64bits floating point
`DECIMAL`	variable-precision decimal
`UUID`	universally unique identifier, 128bits
`TIMEUUID`	sortable UUID, embedded timestamp
`BLOB`	arbitrary bytes

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Unique across all nodes,
regardless of the number of nodes

Note on generating unique IDs

- Not trivial for distributed systems
- UUID / TIMEUUID are great
    - Downside - requires 128bit

      what’s the problem with java primitives?

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Max primitive is 64bit (long)

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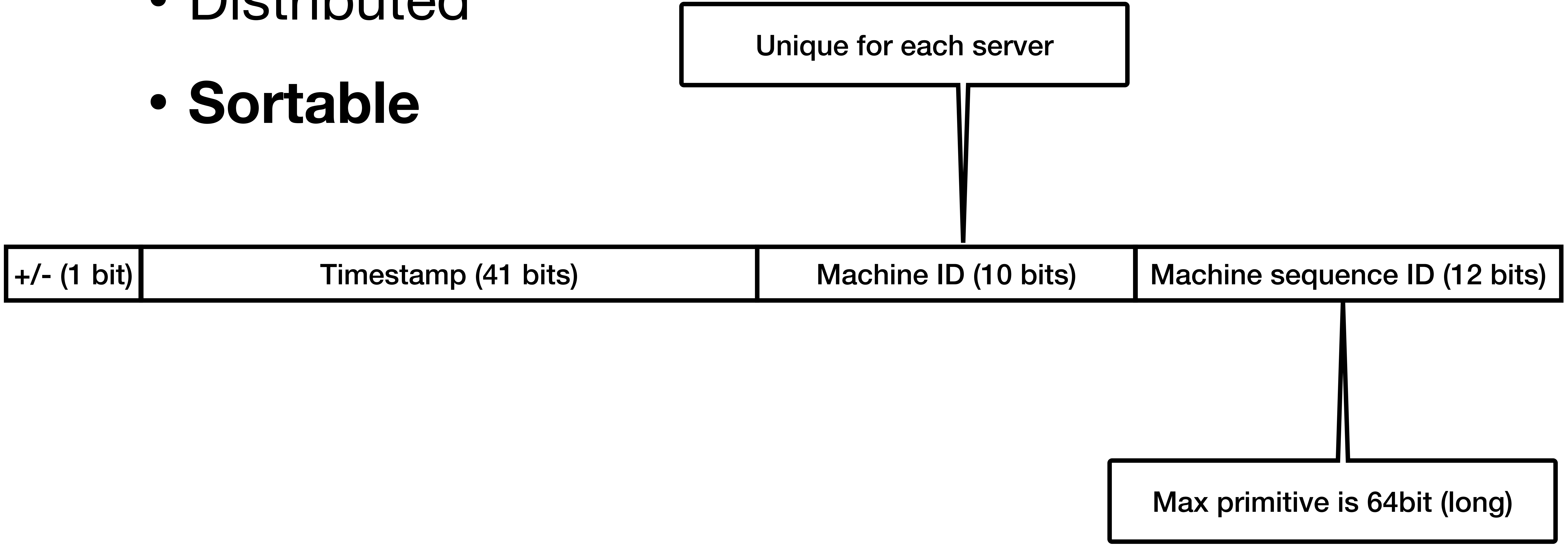
Max primitive is 64bit (long)

So how to do it with 64bit?

Twitter's Snowflake ID

- 64 bit
- Distributed
- **Sortable**



Twitter's Snowflake ID

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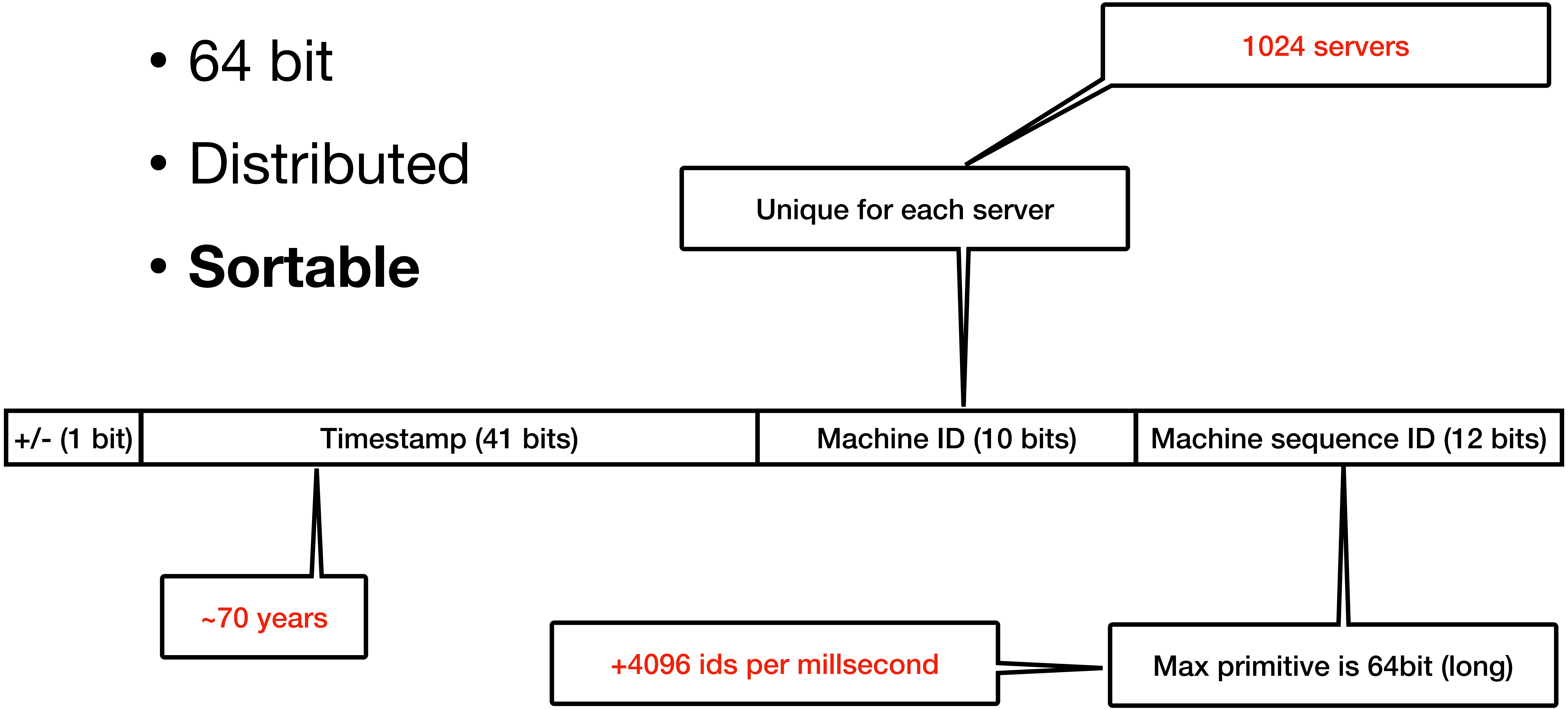

More data types

- `COUNTER`
- `LIST`
- `SET`
- `MAP`
- More on these later…

SELECT

```
SELECT * FROM BigDataCourse

SELECT column1,column2 FROM BigDataCourse

SELECT column1,column2 FROM BigDataCourse
WHERE column1 = "1234" LIMIT 100

SELECT count(*) FROM BigDataCourse
```

- "Limited" compared to RDBMS
  sum / avg / min / max or only supported on new versions
  no joins / having / union…

SELECT

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What will happen in this query?

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ANTI PATTERN - but valid
Can be very slow and expensive - when?

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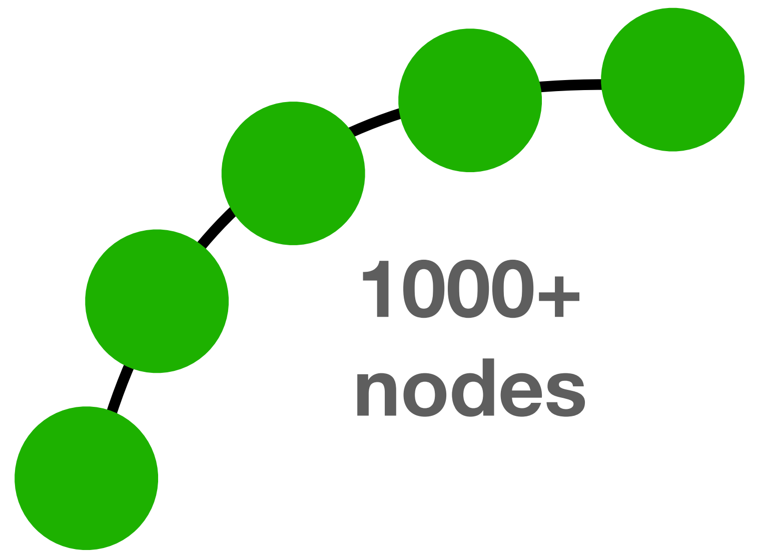

SELECT

```
SELECT * FROM BigDataCourse

SELECT column1,column2 FROM BigDataCourse

SELECT column1,column2 FROM BigDataCourse
WHERE column1 = "1234" LIMIT 1

SELECT count(*) FROM BigDataCourse
```

Even if counting a single row, it can be expensive (on a really big wide row)

ANTI PATTERN - but valid
Can be very slow and expensive - when?

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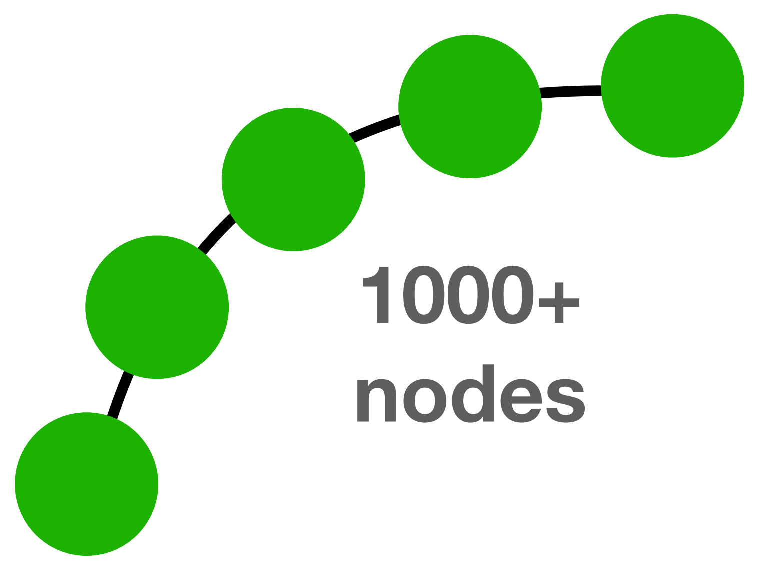
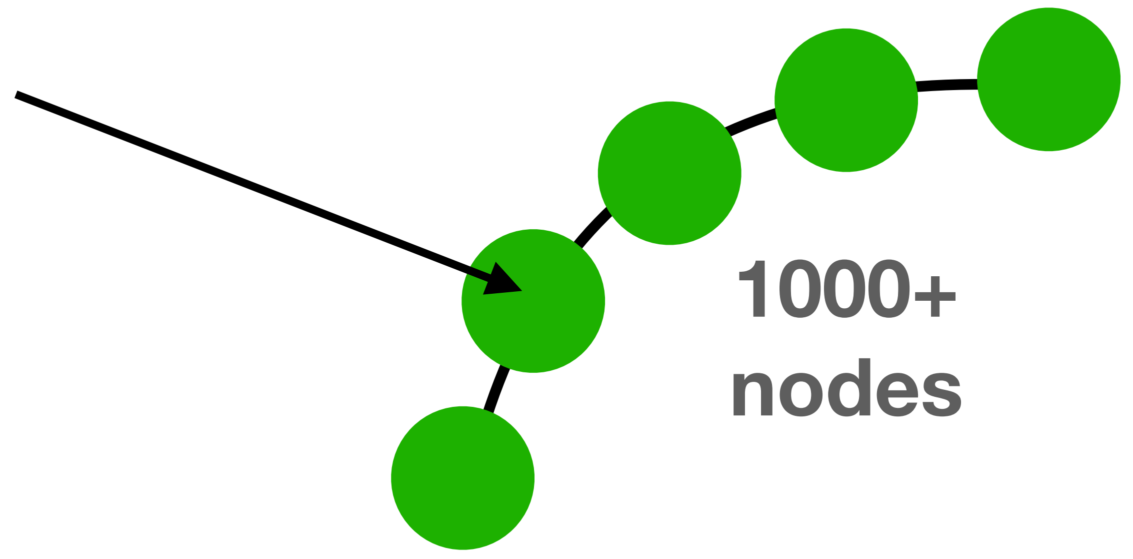


SELECT - partitions and keys

- TLDR; **provide the partition key to the query**

```
SELECT * FROM users
WHERE user_id = “1234”
```



users	
user_id	K
name	
birth_year	
…	

SELECT - partitions and keys

- What happens if no partition is given?

```
SELECT * FROM users
```

users	
user_id	K
name	
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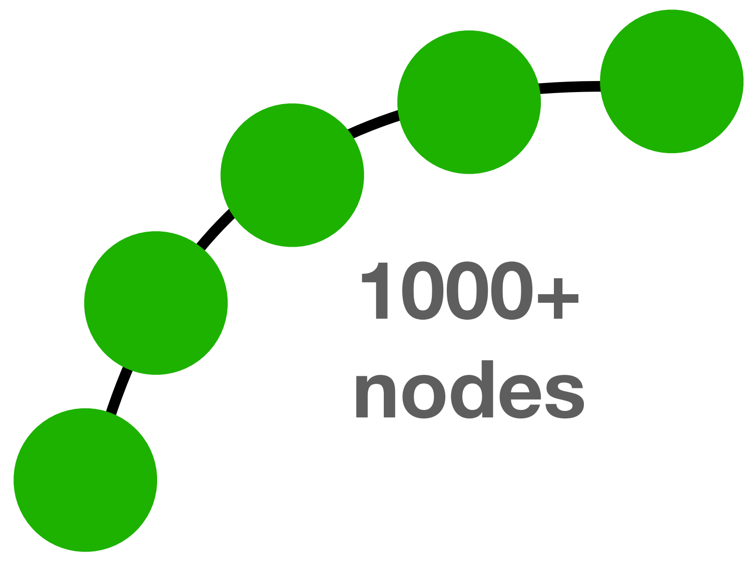

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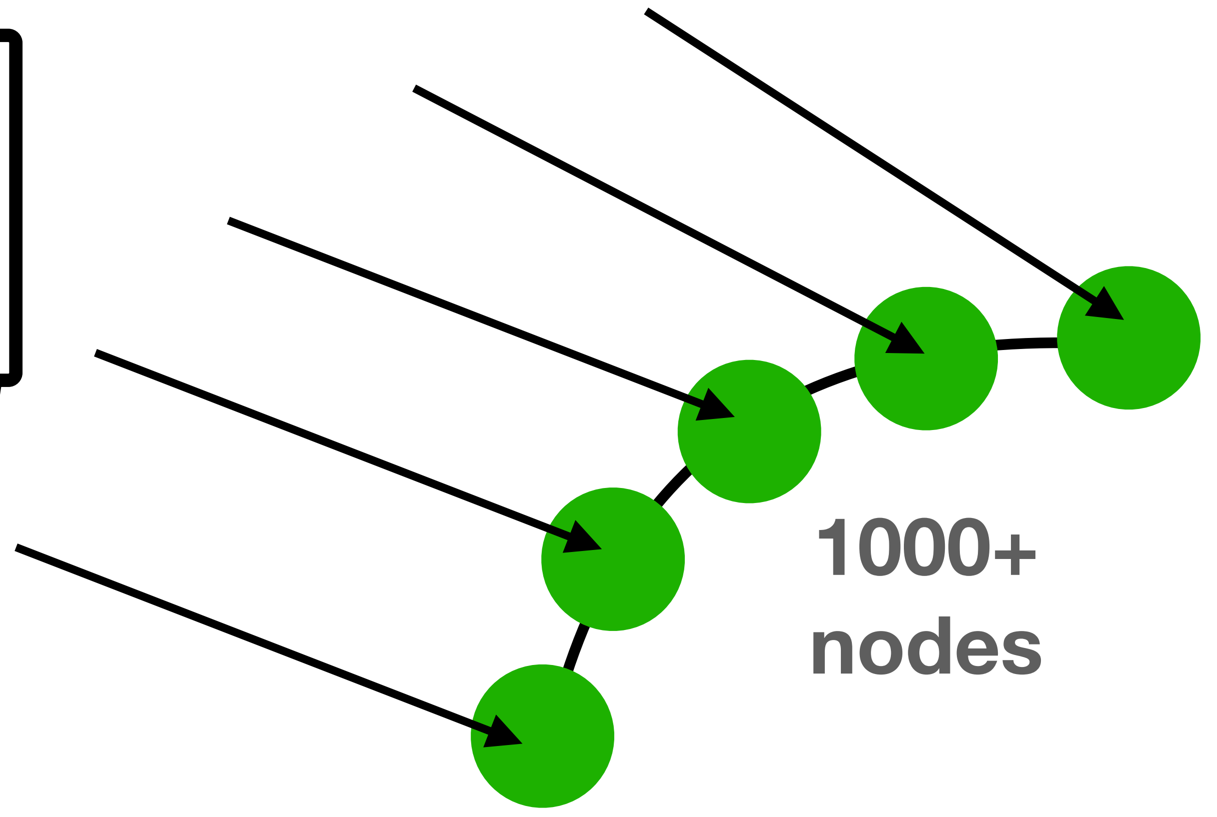
We need to contact all servers
(as all partitions are valid)



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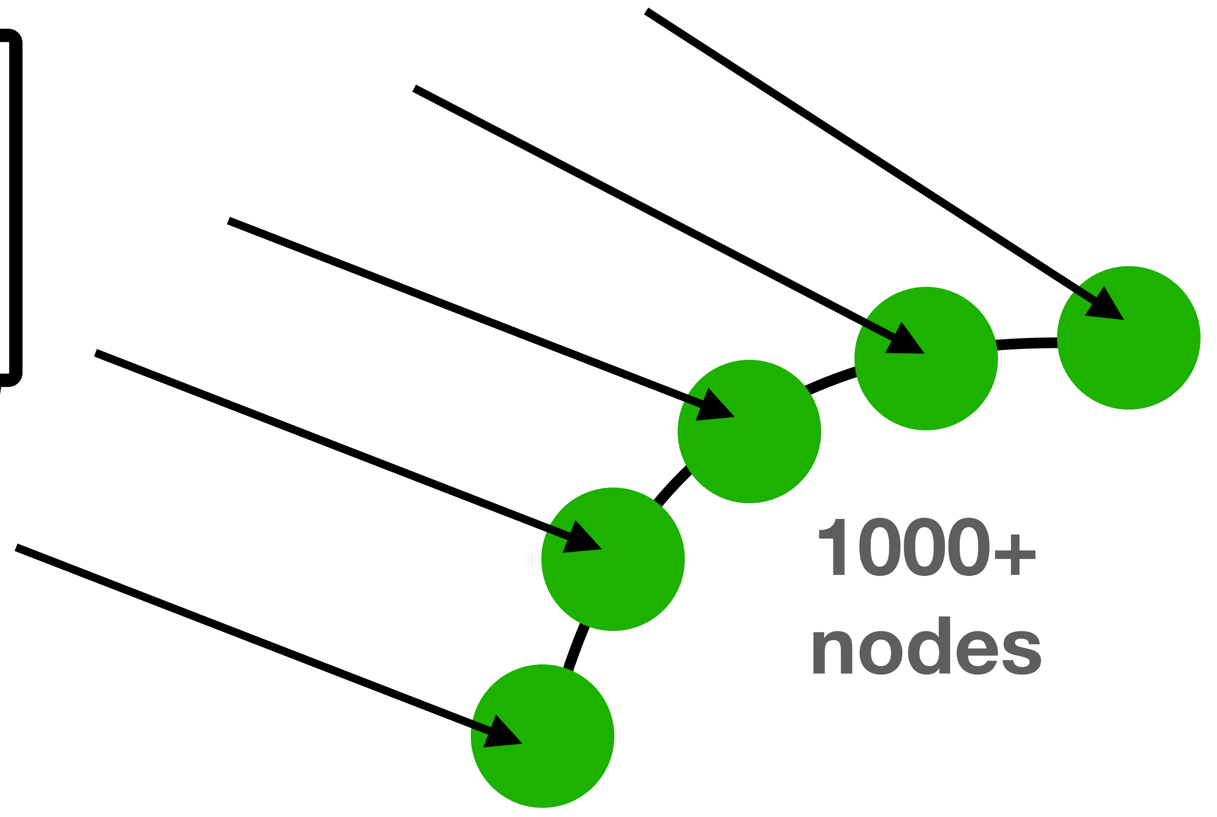


users	
user_id	K
name	
birth_year	
…	

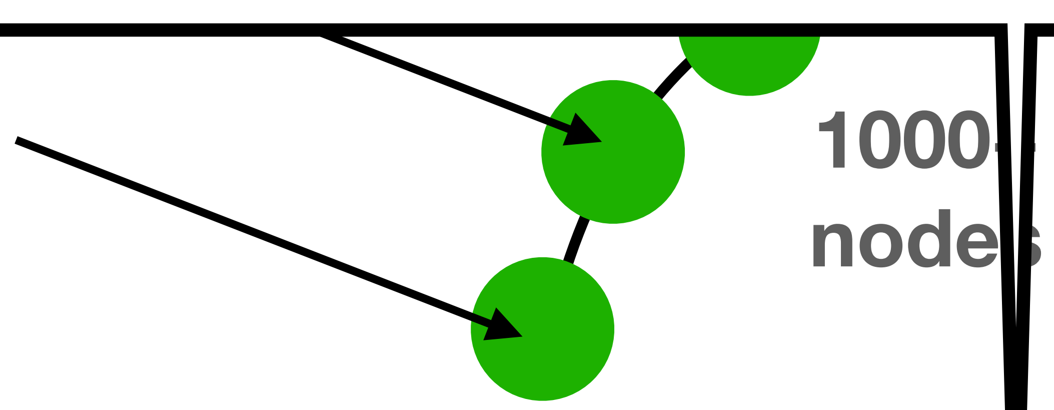
This is valid!
Lets see some examples

SELECT - partitions and keys

Each user “creates” a partition (user_id is partition_key)

Assume there are **10k nodes** in the cluster and **no replication**
- If there are **100k users**, would the query be optimal?
  (that is, we would not check unnecessary nodes/partitions)

?



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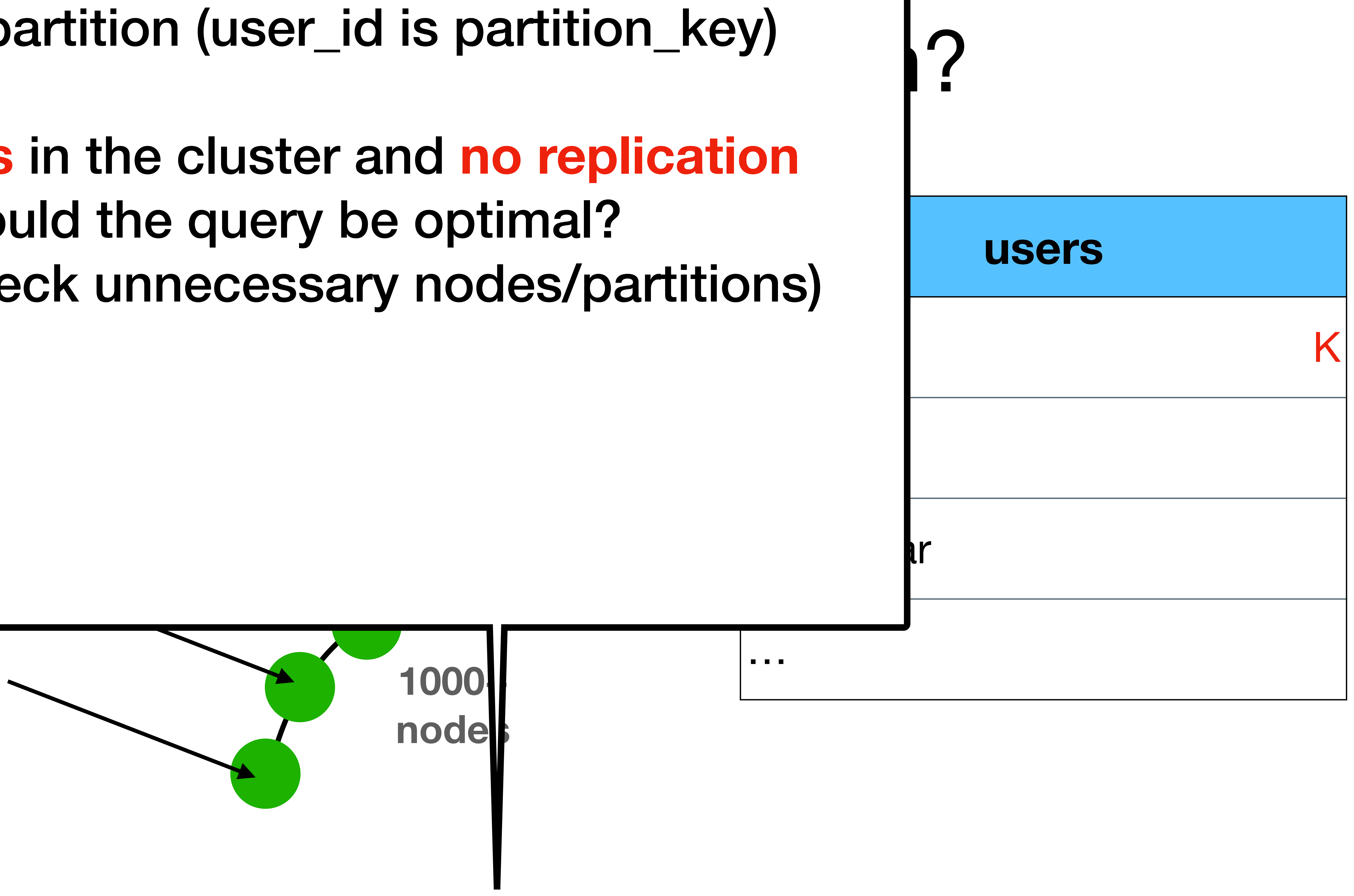

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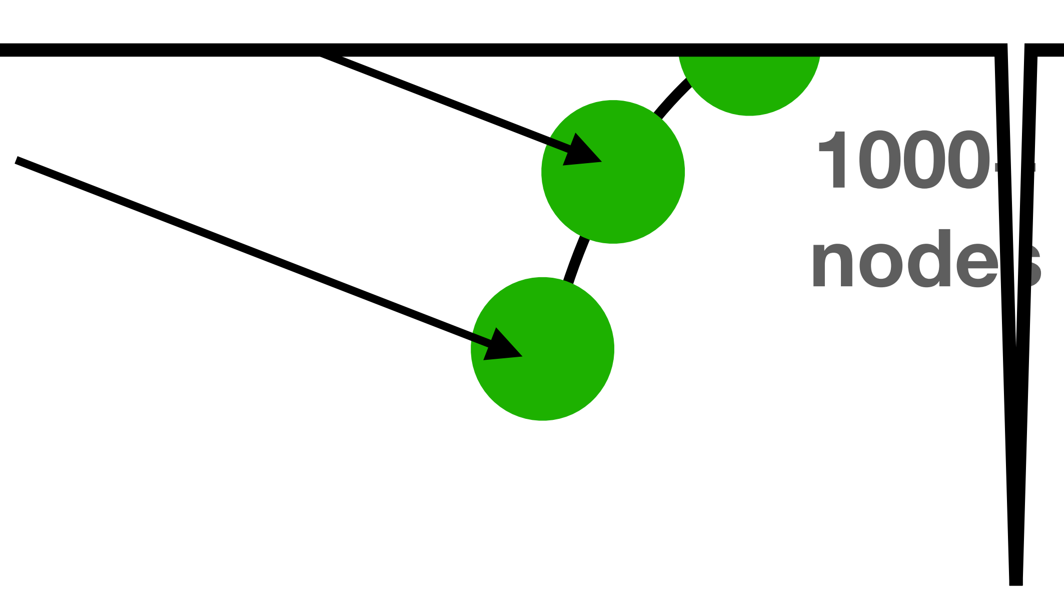
YES - why?
There are 100k partitions which are distributed on 10k nodes



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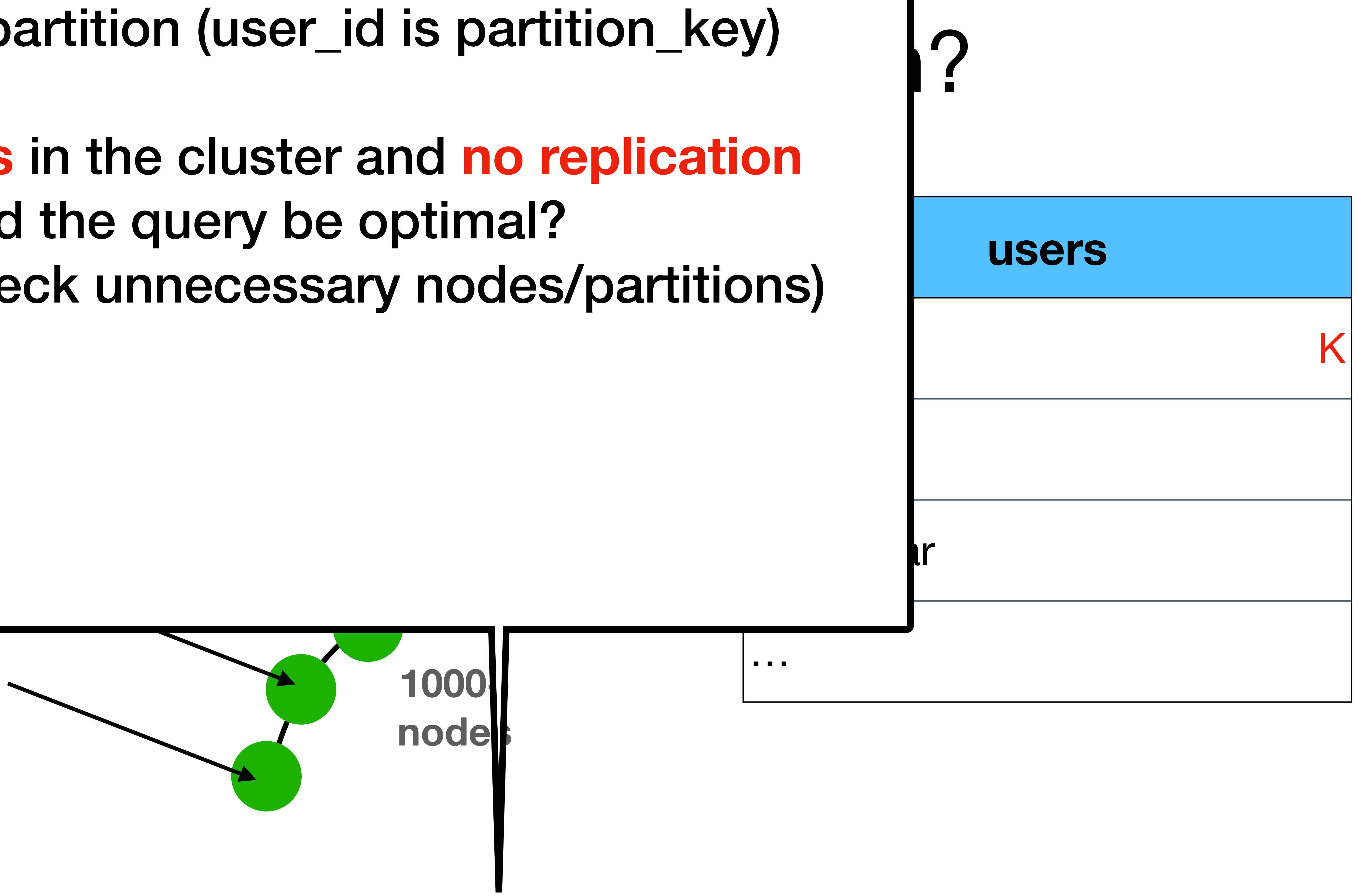

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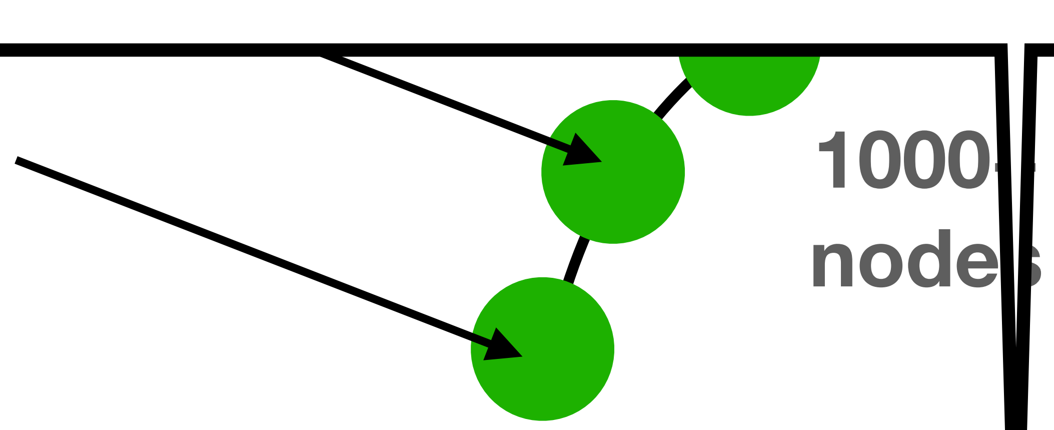

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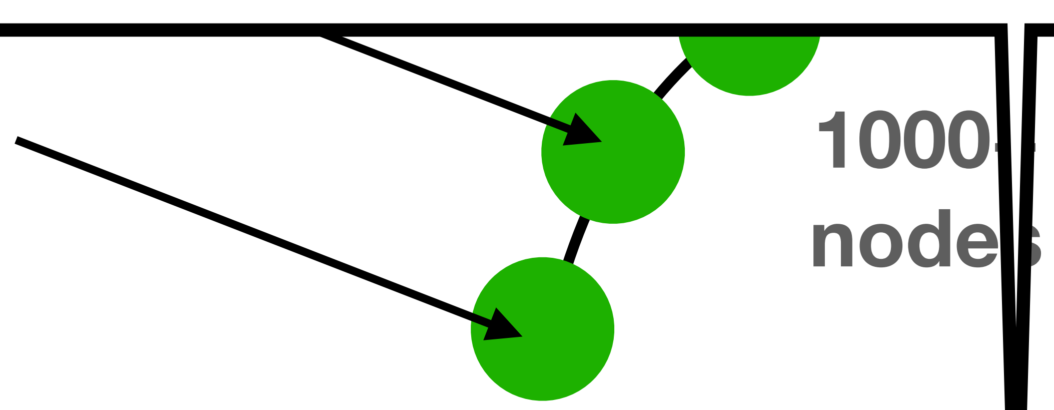
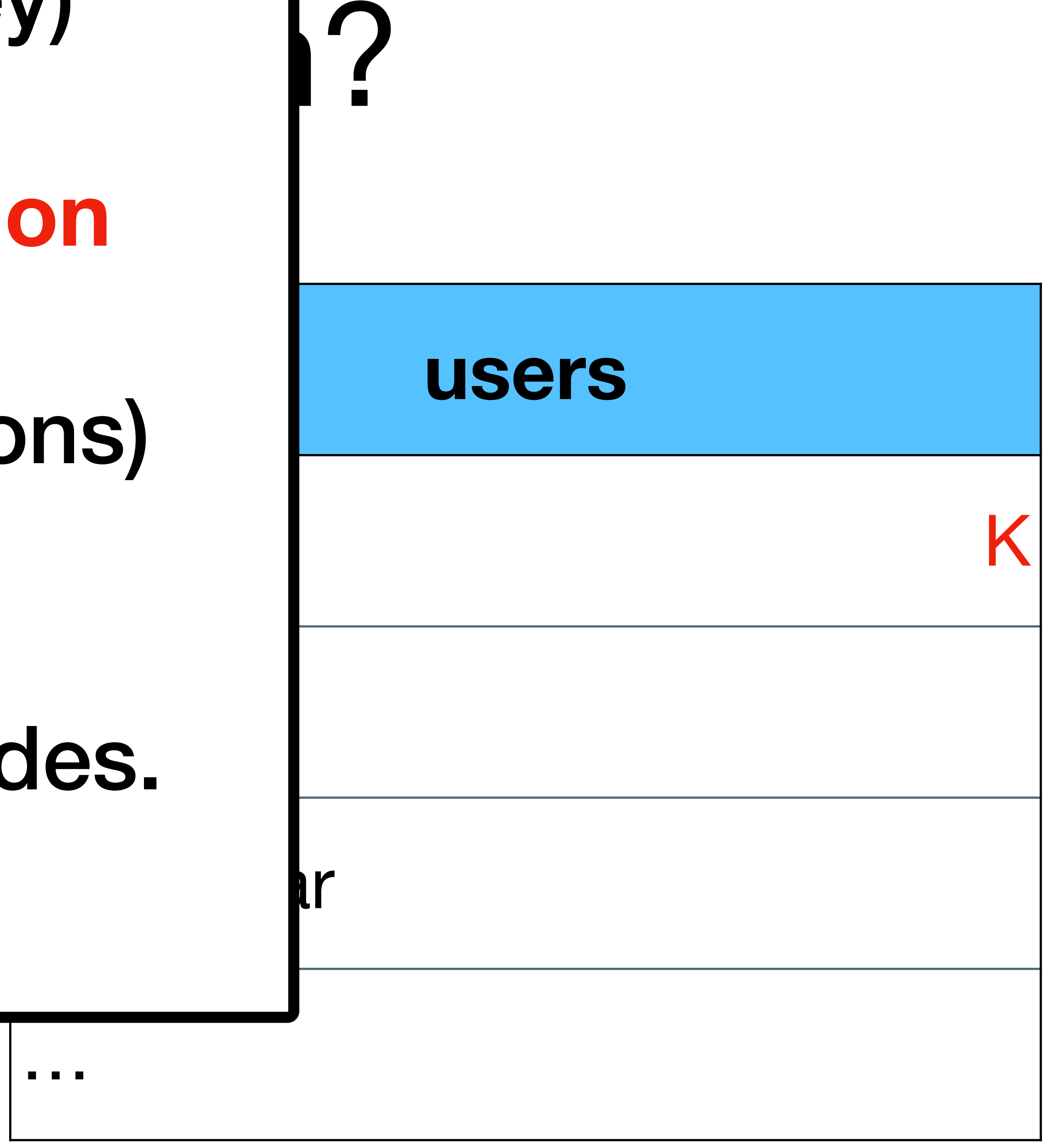
NO - why?
There are 10 partitions which are distributed on 10k nodes.
We will initiate 9990 unnecessary calls





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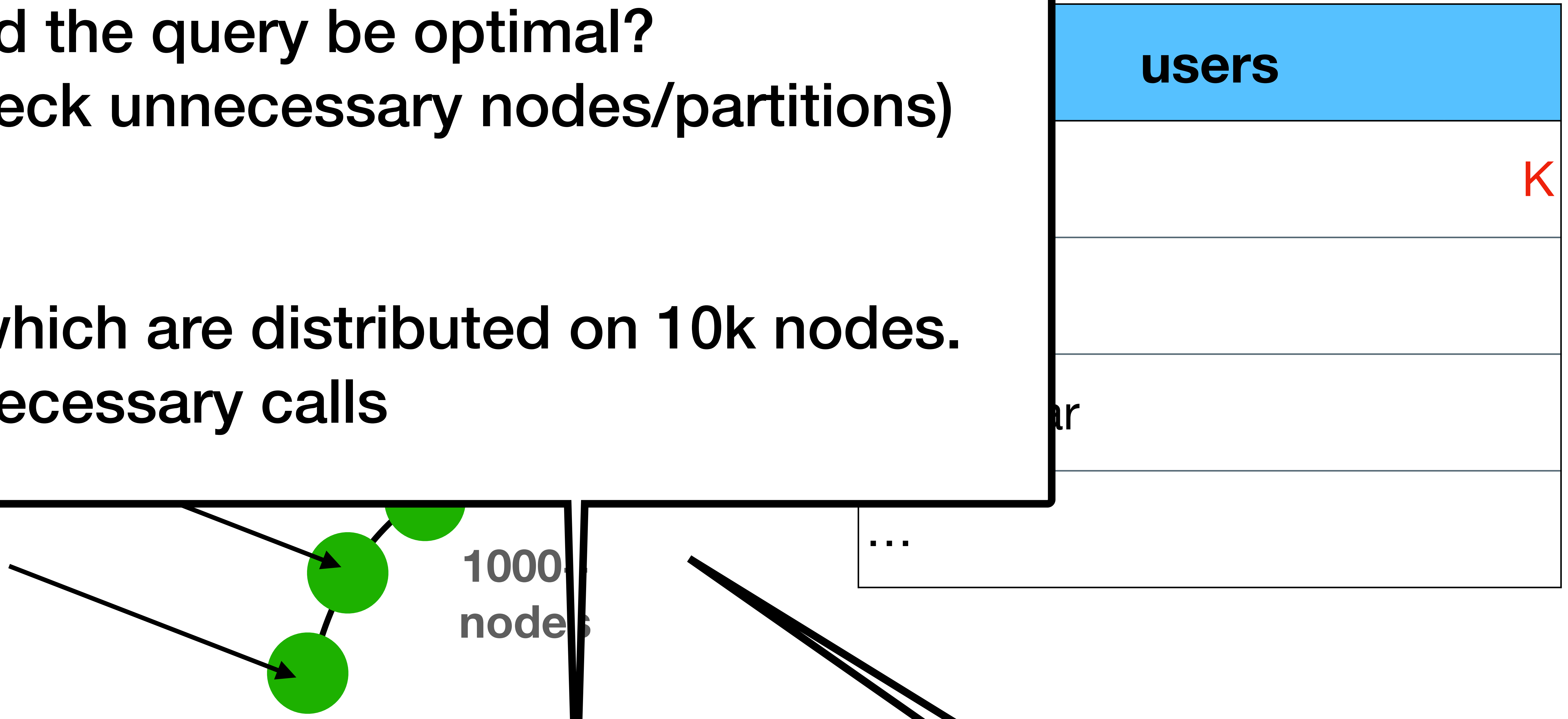

The right way for this scenario is to create a single partition for these 10 users, then read 1 partition

SELECT - partitions and keys

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- If there are 10 u

(that is, we wo

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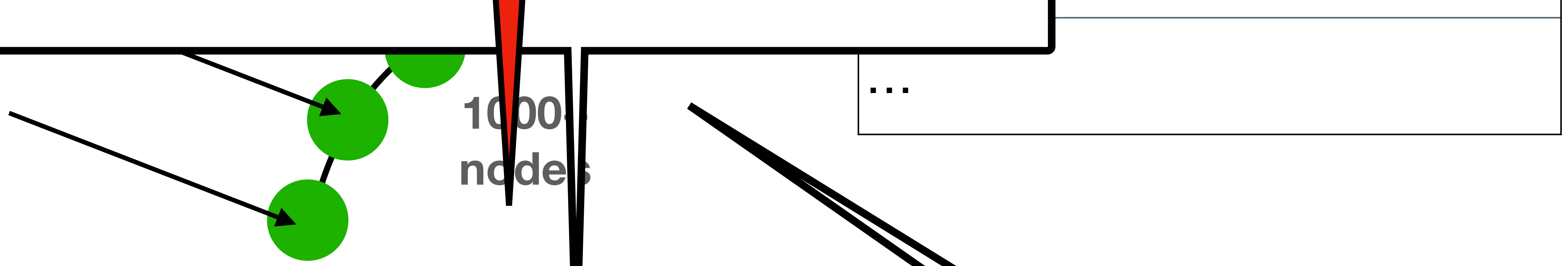
nodes. We wi

?

`SELECT * from <TABLE>` - Summary

Although this is allowed - this is in general anti pattern

Use with caution

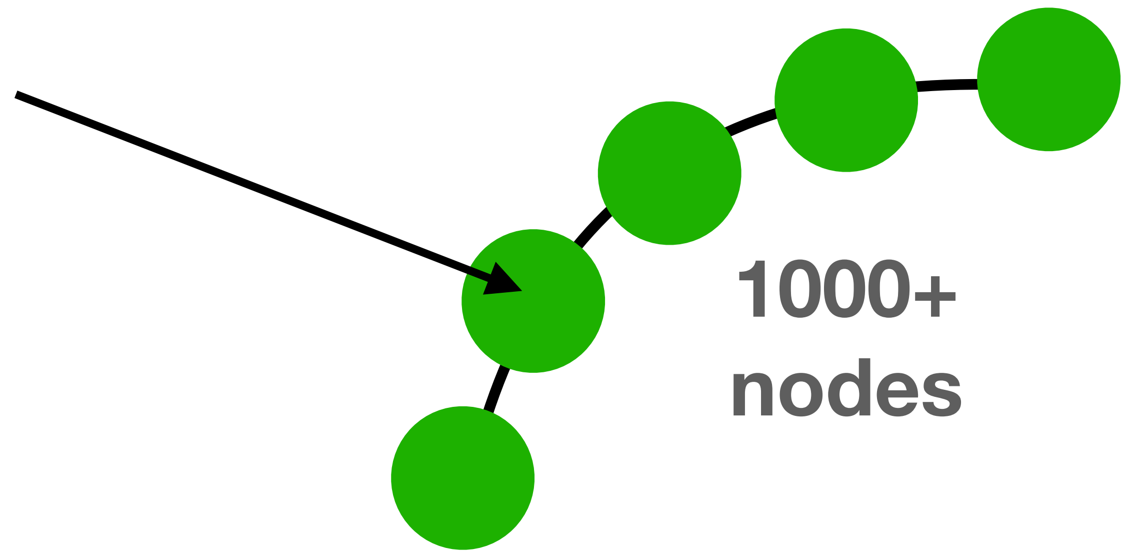


The right way for this scenario is to create a single partition for these 10 users, then read 1 partition

SELECT - partitions and keys

- Try a different model

```
SELECT * FROM users
WHERE country = “israel”
```



Note
K is the partition key (NOT the key)
🔻C is the clustering column,
Together both are the key

users	
country	K
user_id	🔻C
name	
birth_year	
…	

SELECT - partitions and keys

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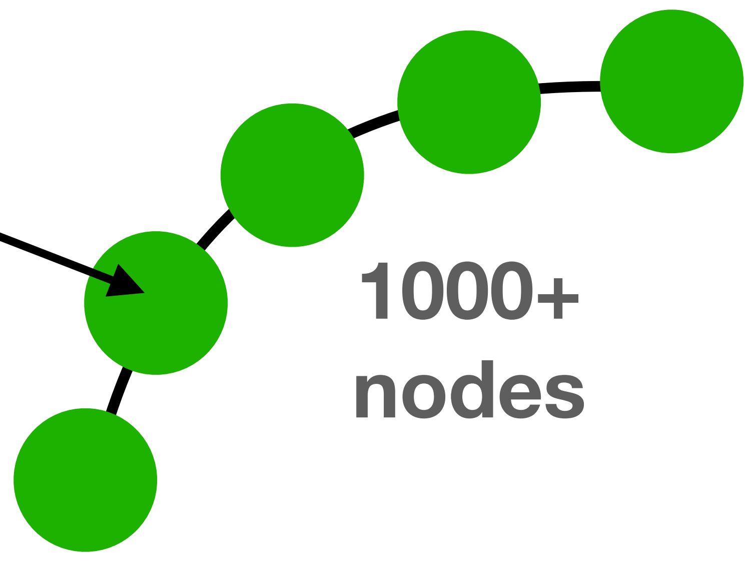
Reading the users from Israel is fast



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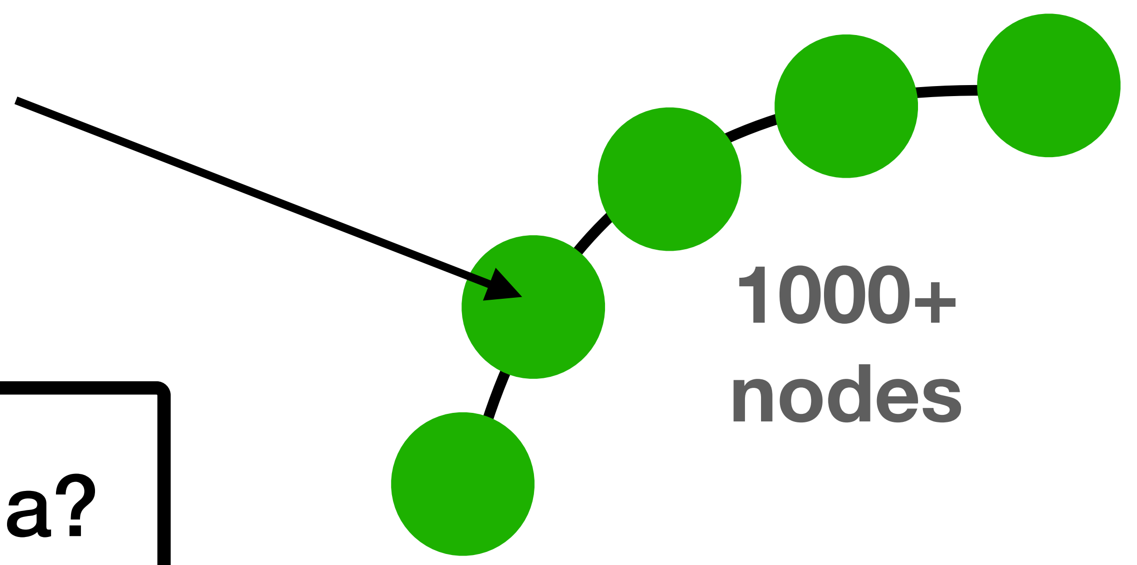
What happen if the country is India?



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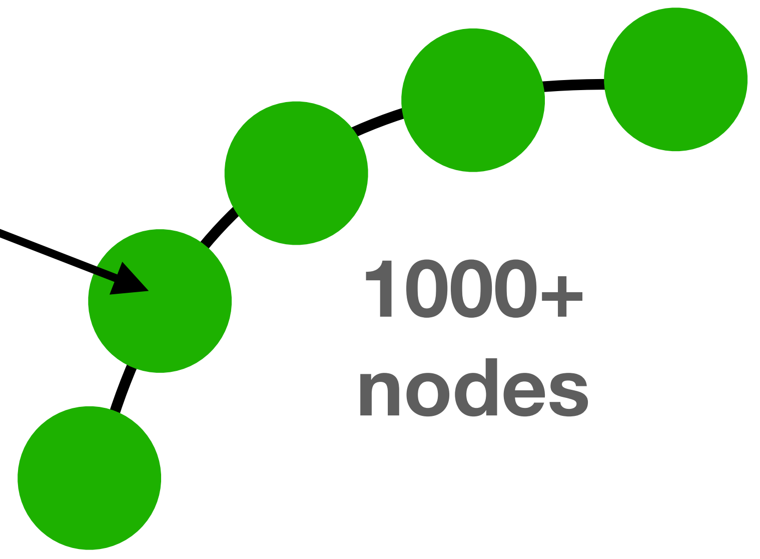

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How can you solve this issue?

SELECT - partitions and keys

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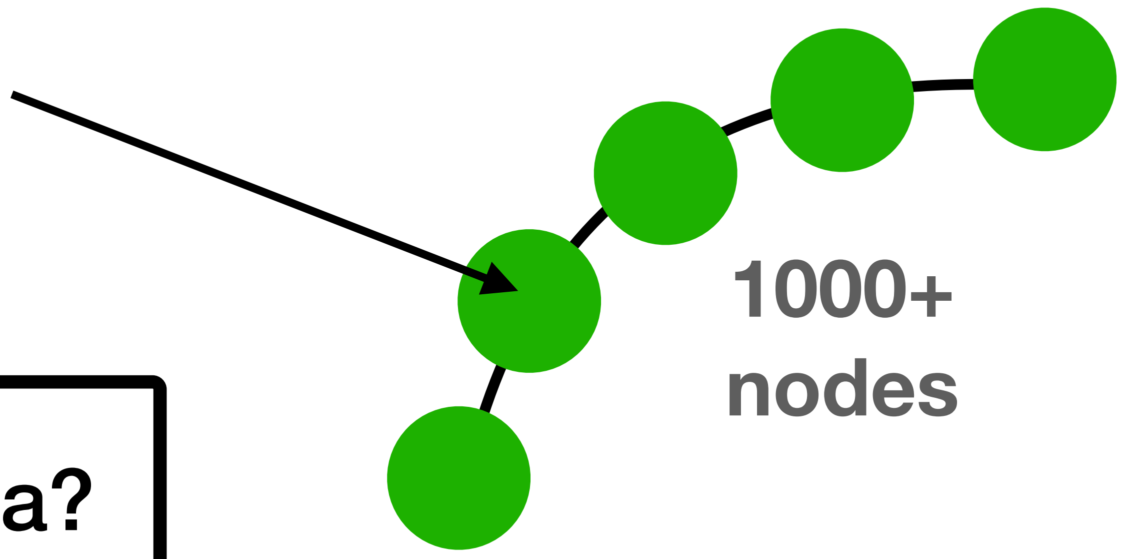


What happen if the country is India?

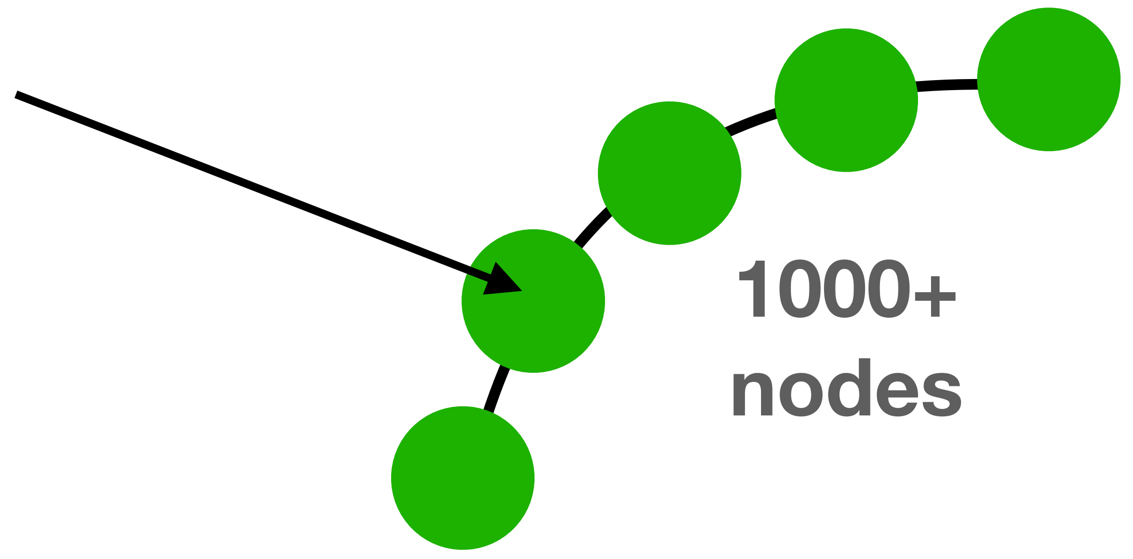
How can you solve this issue?

We can add “buckets” - more on this later

SELECT - partitions and keys

- What happens now?

```
SELECT * FROM users
WHERE country = “israel”
AND birth_year = 1982
```

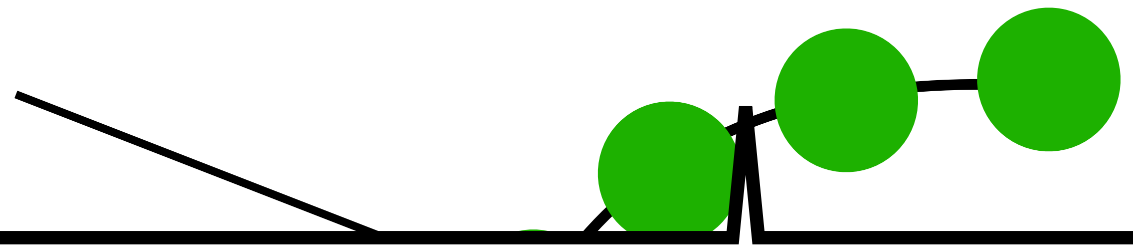


users	
country	K
user_id	▼C
name	
birth_year	
…	

SELECT - partitions and keys

- What happens now?

```
SELECT * FROM users
WHERE country = “israel”
AND birth_year = 1982
```



Error - why?

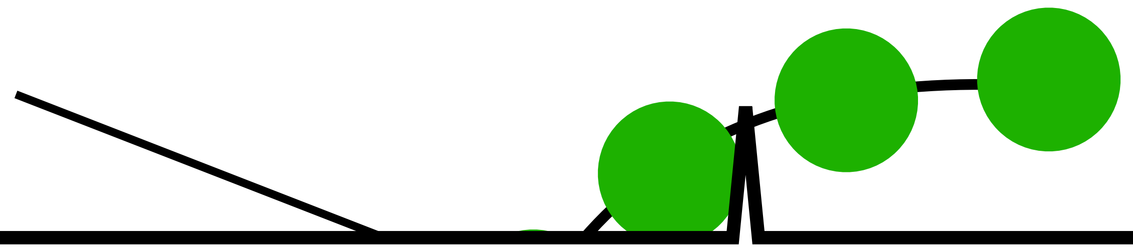
users	
country	K
user_id	▼C
name	
birth_year	
…	

SELECT - partitions and keys

- What happens now?

```
SELECT * FROM users
WHERE country = “israel”
AND birth_year = 1982
```

users	
country	K
user_id	▼C
name	
birth_year	
…	



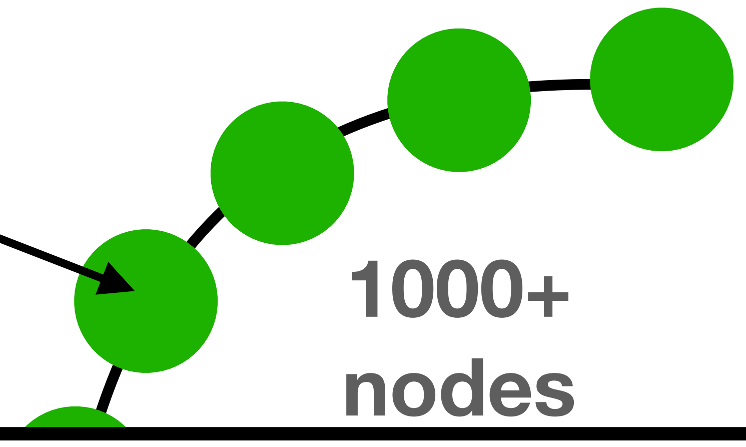
Error - why?

Cassandra will need to read the entire partition.
If there are 1m users, and only 10k were born in 1982,
there would be an unnecessary read/filter of 990k users

SELECT - partitions and keys

- What happens now?

```
SELECT * FROM users
WHERE country = “israel”
AND birth_year = 1982
ALLOW FILTERING
```



users	
country	K
user_id	▼C
name	
birth_year	

With “ALLOW FILTERING” Cassandra will approve the query
(ANTI PATTERN)

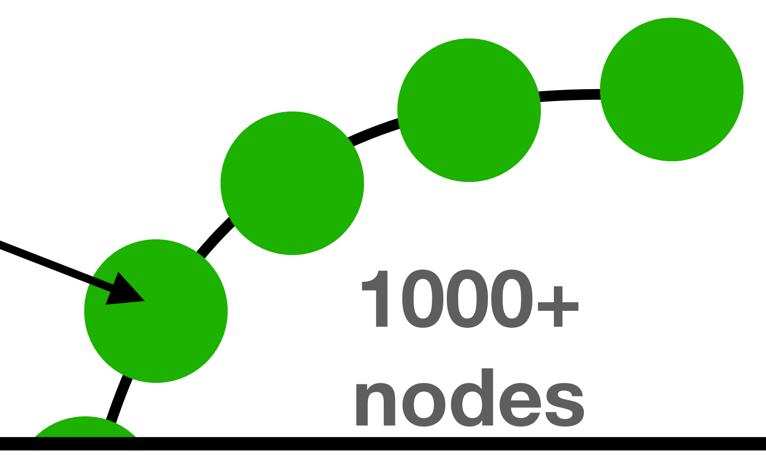
SELECT - partitions and keys

- What happens now?

```
SELECT * FROM users
WHERE country = “israel”
AND birth_year = 1982
ALLOW FILTERING
```

How can you support the query without “ALLOW FILTERING”?

users	
country	K
user_id	▼C
name	
birth_year	

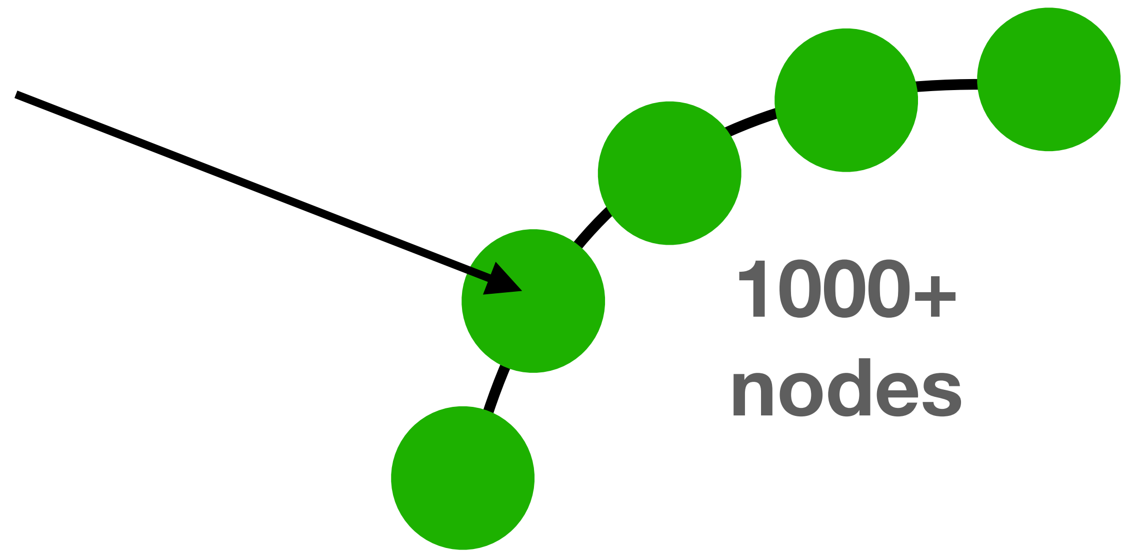


With “ALLOW FILTERING” Cassandra will approve the query (ANTI PATTERN)

SELECT - partitions and keys

- Solved with denormalization

```
SELECT * FROM users_by_birth_year
WHERE country = “israel”
AND birth_year = 1982
```



- (we will talk about correct modeling later)

users	
country	K
user_id	▼C
name	
birth_year	
…	

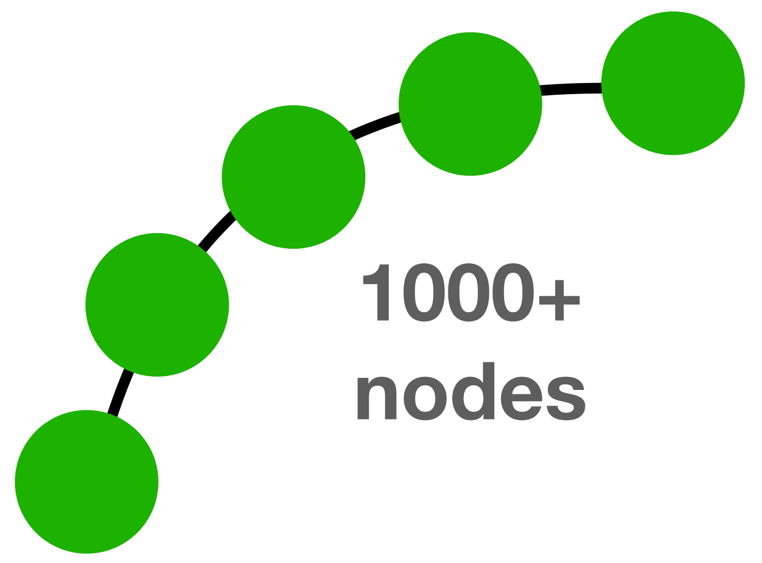
users_by_birth_year	
country	K
birth_year	▼C
user_id	▼C
name	
…	

SELECT - partitions and keys

- And what about this case?

```
SELECT * FROM users
WHERE city = “tel aviv”
```

users	
country	K
city	K
neighborhood	K
user_id	🔻C
name	
birth_year	



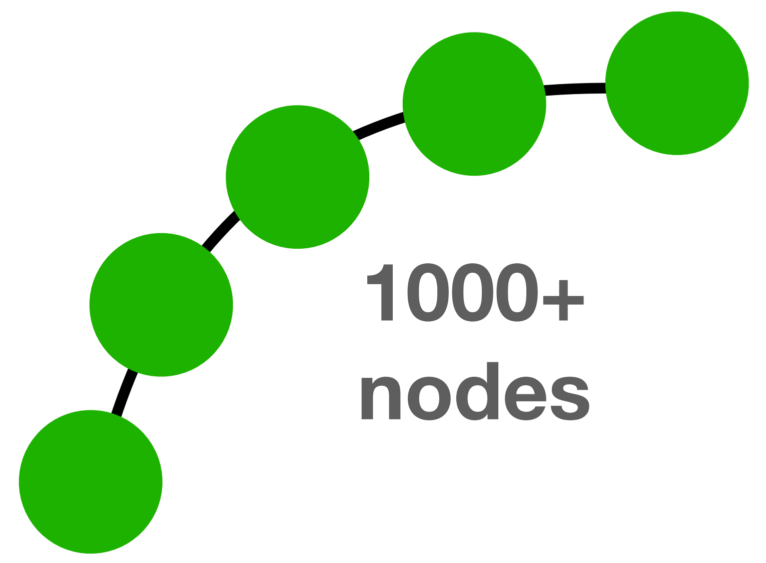
SELECT - partitions and keys

- And what about this case?

```
SELECT * FROM users
WHERE city = "tel aviv"
```

Error - why?

users	
country	K
city	K
neighborhood	K
user_id	▼C
name	
birth_year	



SELECT - partitions and keys

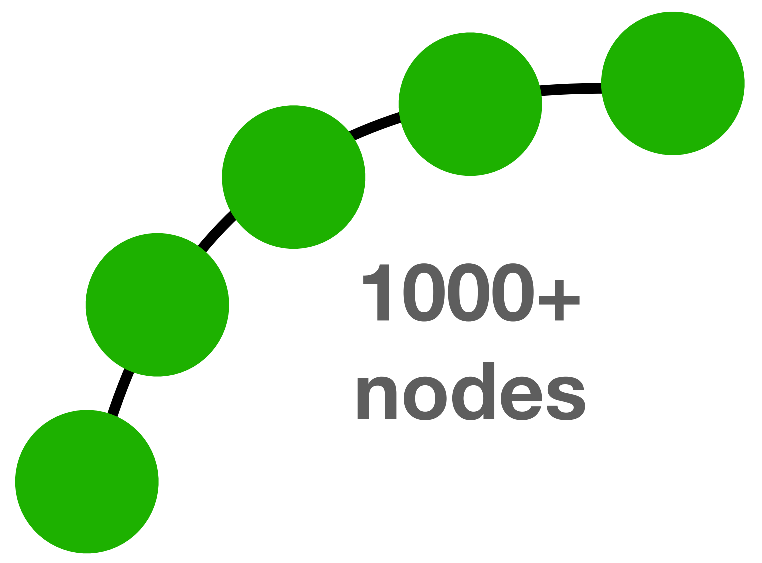
- And what about this case?

```
SELECT * FROM users
WHERE city = “tel aviv”
```

Error - why?

Cassandra will need to contact all nodes and to check if such partition exists

users	
country	K
city	K
neighborhood	K
user_id	▼C
name	
birth_year	



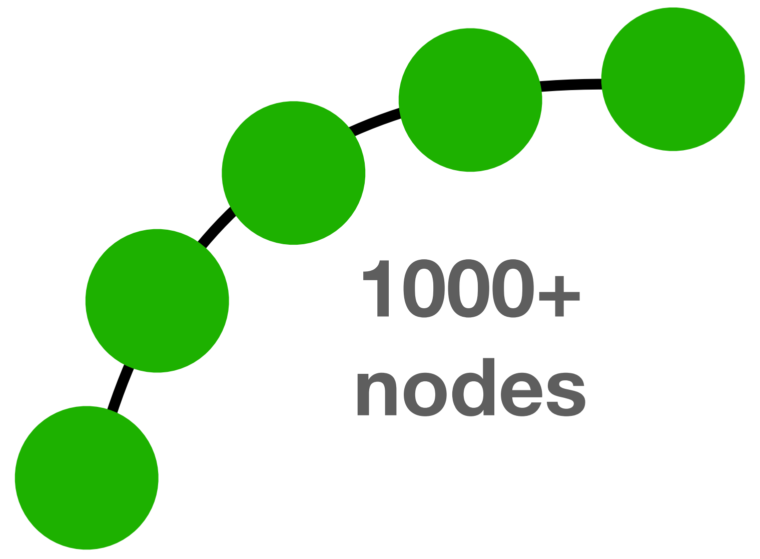
SELECT - partitions and keys

- And what about this case?

```
SELECT * FROM users
WHERE city = "tel aviv"
ALLOW FILTERING
```

With "ALLOW FILTERING" Cassandra will approve the query (again - ANTI PATTERN)

users	
country	K
city	K
neighborhood	K
user_id	▼C
name	
birth_year	

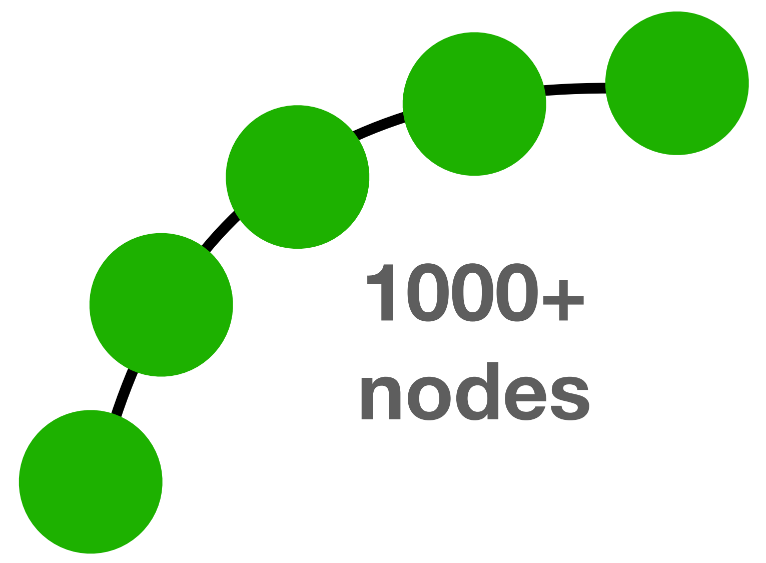


SELECT - ALLOW FILTERING

- Almost always ANTI PATTERN

- We saw these use cases
    - To “filter” columns in a single partition
    - To “filter” partitions across nodes

users	
country	K
city	K
neighborhood	K
user_id	▼C
name	
birth_year	

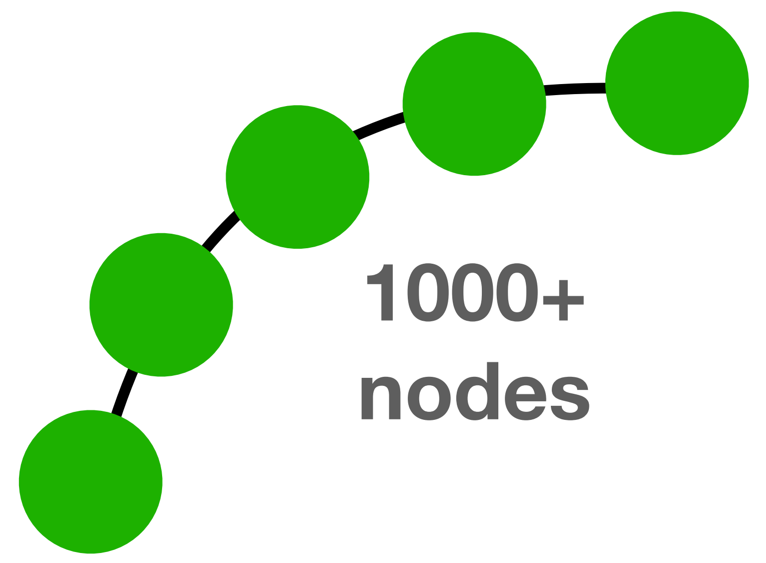


SELECT - ALLOW FILTERING

- Almost always ANTI PATTERN

- We saw these use cases
  - To "filter" columns in a single partition
  - To "filter" partitions across nodes
  - Can you think of another example?

users	
country	K
city	K
neighborhood	K
user_id	▼C
name	
birth_year	



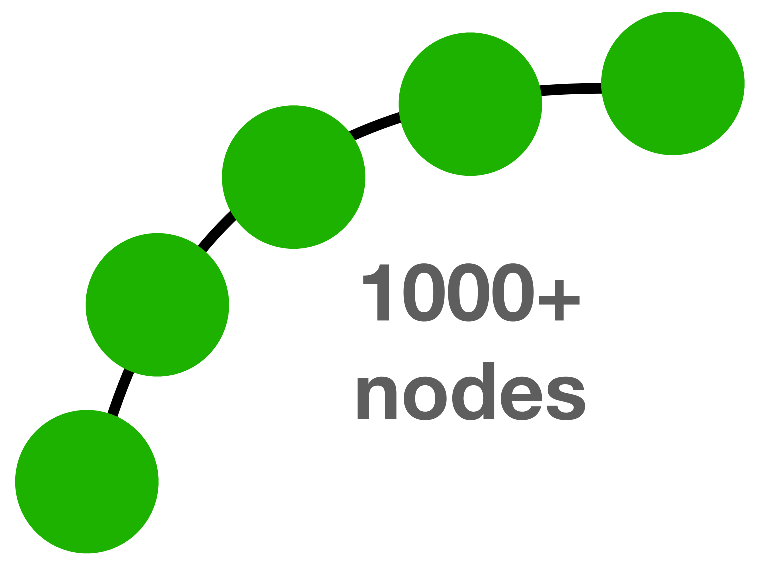
SELECT - ALLOW FILTERING

- Almost always ANTI PATTERN

```
SELECT * FROM users
WHERE name = "rubi boim"
ALLOW FILTERING
```

- We sav
  - To “filter” columns in a single partition
  - To “filter” partitions across nodes
  - To “filter” columns across partitions

users	
country	K
city	K
neighborhood	K
user_id	▼C
name	
birth_year	



INSERT

- Primary key is obviously required

```
INSERT INTO BigDataCourse(column1,column2)
VALUES (123,"name")
```

INSERT - IF NOT EXISTS

- Requires read before write!
- Use with caution

```
INSERT INTO BigDataCourse(column1,column2)
IF NOT EXSITS
VALUES (123,"name")
```

INSERT - IF NOT EXISTS

- Requires read before write!
- Use with caution

```
INSERT INTO BigDataCourse(column1,column2)
IF NOT EXSITS
VALUES (123,"name")
```

Note - **writes are cheaper than reads.** If there are not too many writes, it is better to overwrite the same data instead of using "if not exists"

INSERT - USING TTL

- Time To Live - allows for automatic expiration (delete) in seconds

```
INSERT INTO BigDataCourse(column1,column2)
VALUES (123,"name")
USING TTL 86400     // 24 hours
```

INSERT - USING TTL

- Time To Live - allows for automatic expiration (delete)
  in seconds

```
INSERT INTO BigDataCourse(column1,column2)
VALUES (123,”name”)
USING TTL 86400     // 24 hours
```

Creates tombstones
more on this later

UPDATE

- Primary key is obviously required

```
UPDATE BigDataCourse
SET column2 = “name”, column3 = “abc”
WHERE column1 = 123
```

DELETE

- Warning:
  DELETEs in distributed databases are NOT TRIVIAL
- In Cassandra in particular
- Deleted data is not removed immediately
  a tombstone is created
- More on this later

DELETE

- Delete data from a row

```
DELETE name FROM users
WHERE country = “israel”
AND user_id = “123”
```

- Delete an entire row

```
DELETE FROM users
WHERE country = “israel”
```

users	
country	K
user_id	▼C
name	
birth_year	
…	

DELETE

Creates 1 tombstone

- Delete data from a row

```
DELETE name FROM users
WHERE country = “israel”
AND user_id = “123”
```

- Delete an entire row

```
DELETE FROM users
WHERE country = “israel”
```

Creates 1 tombstone

users	
country	K
user_id	▼C
name	
birth_year	
…	

Truncate

- Removes all SSTables holding data
- Use with care
- (Avoids tombstones)

```
TRUNCATE users
```

ALTER TABLE

- Add / drop / rename existing columns
- *change datatypes (with restrictions)
- Change table properties
- Can NOT alter PRIMARY KEY columns
- RTFM :)

```
ALTER TABLE [keyspace_name.] table_name
[ALTER column_name TYPE cql_type]
[ADD (column_definition_list)]
[DROP column_list | COMPACT STORAGE ]
[RENAME column_name TO column_name]
[WITH table_properties];
```