Noria:
Partially-Stateful Data-flow

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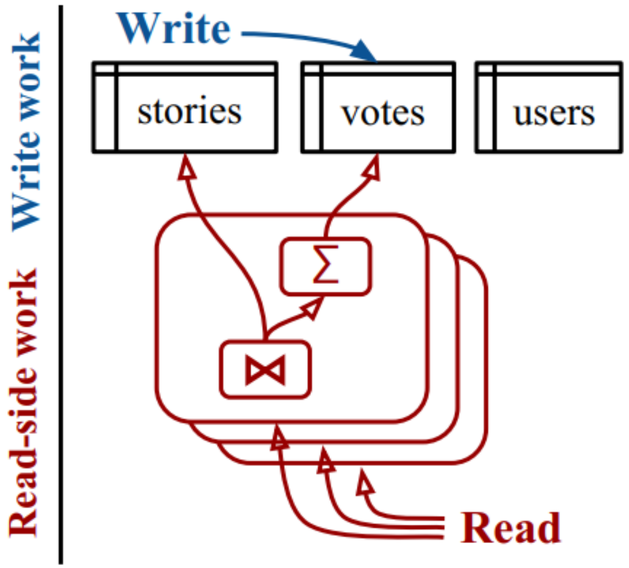
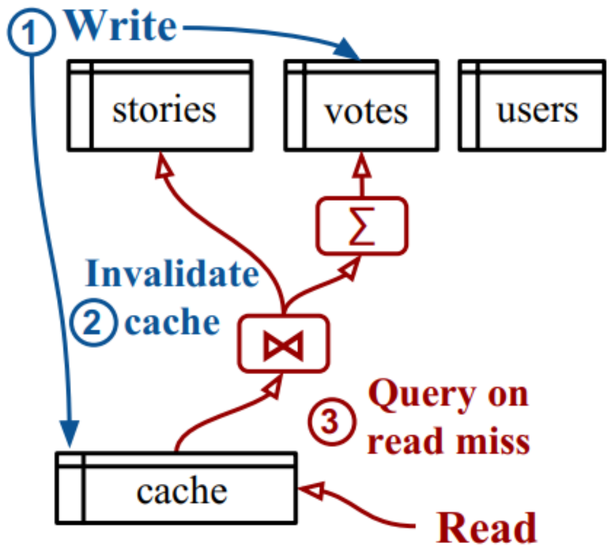
Motivation

Modern web apps add an in-memory cache in front of traditional databases for high performance



Classic database
reads are expensive

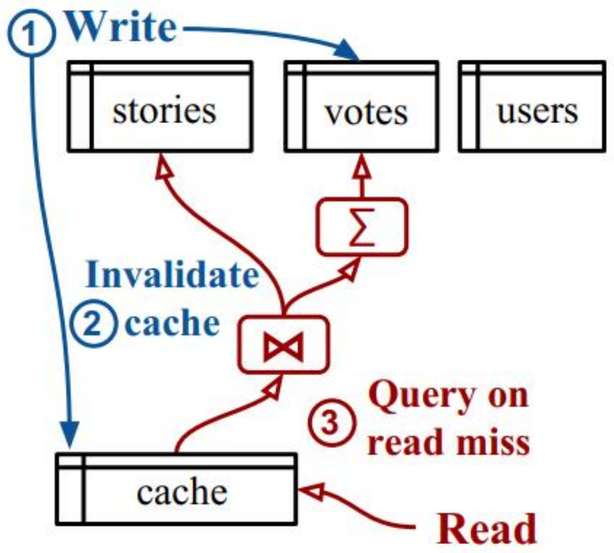


Database + in-memory cache
reads are fast

Motivation

In-memory cache work well, but programmer needs to handle invalidations correctly

Incorrect design may lead to stale data in caches forever



Database + in-memory cache
reads are fast

Motivation

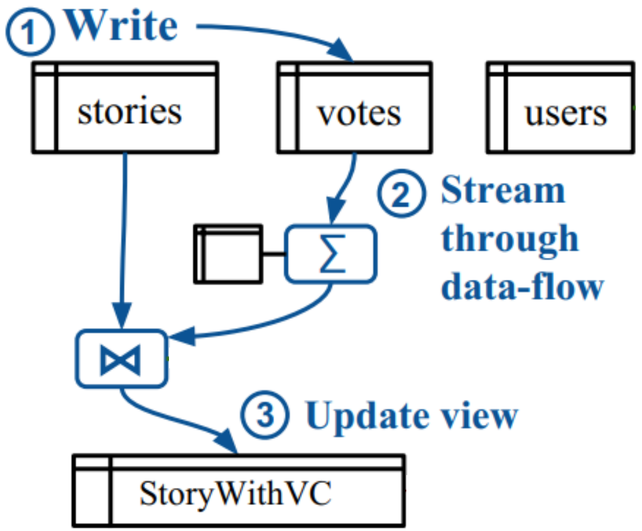
What about using a dataflow/streaming database?

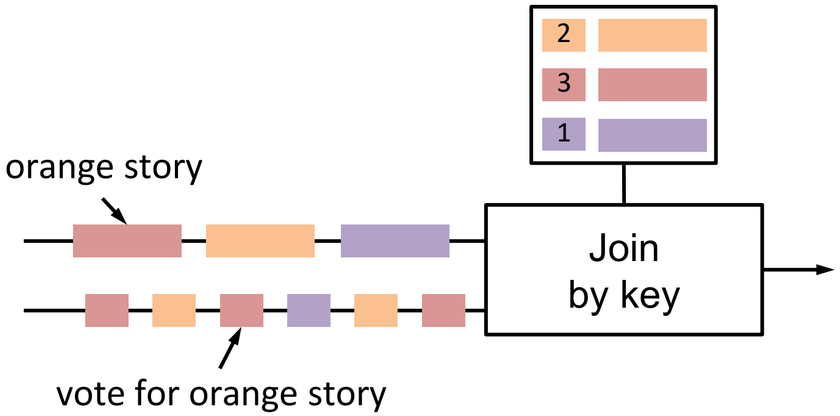
Write path is expensive

Primarily support window operations

Generate data that may never be read

Require significant memory for caching





Key Idea in Noria

Use a partial-state dataflow model

Cache state on reads: Like traditional cache

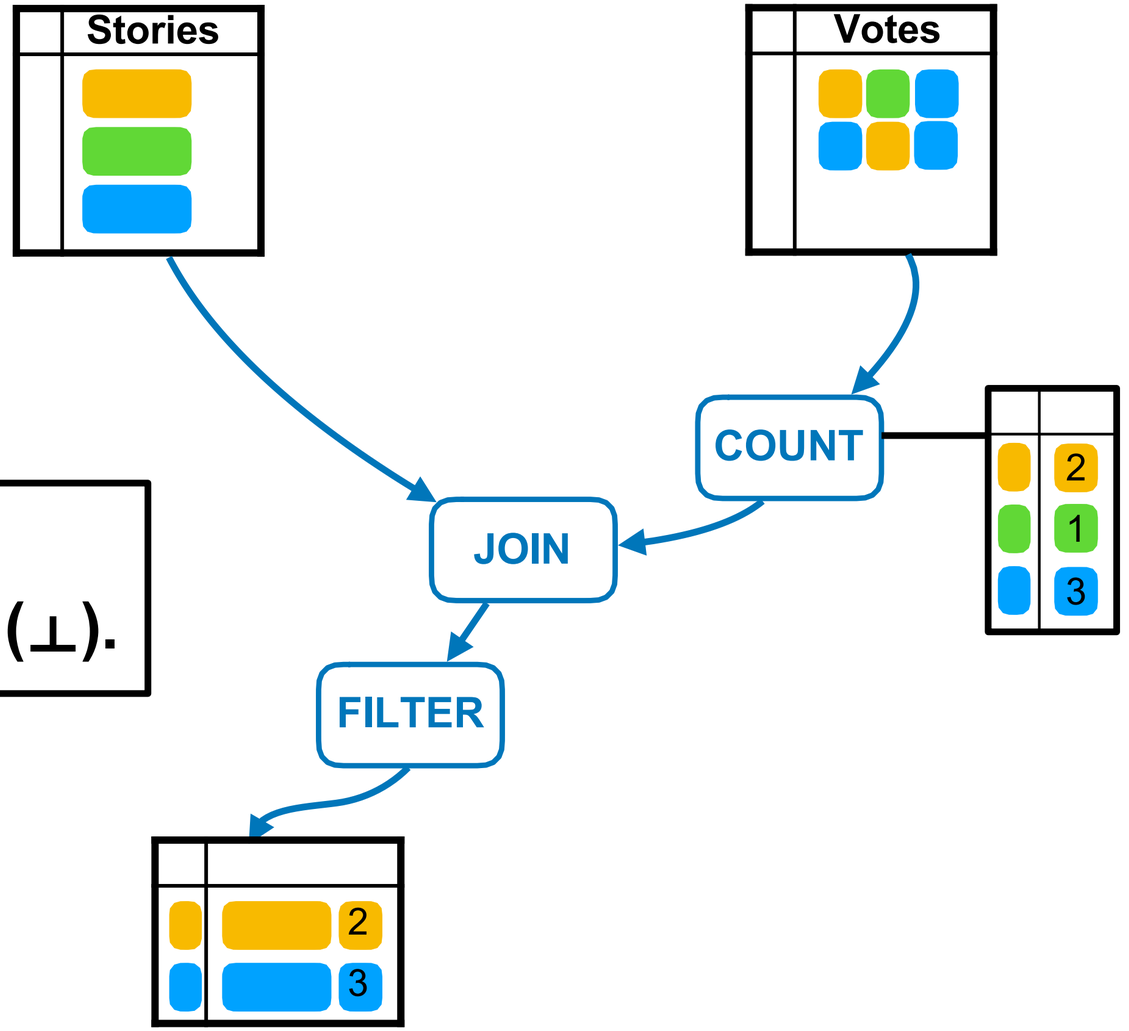
Update cached state on writes: Like dataflow databases

Evict cache state if needed: Limits memory requirements

No need to update evicted state: Reduces cost of writes

Adapt dataflow dynamically: Simplifies adding/removing queries that need caching

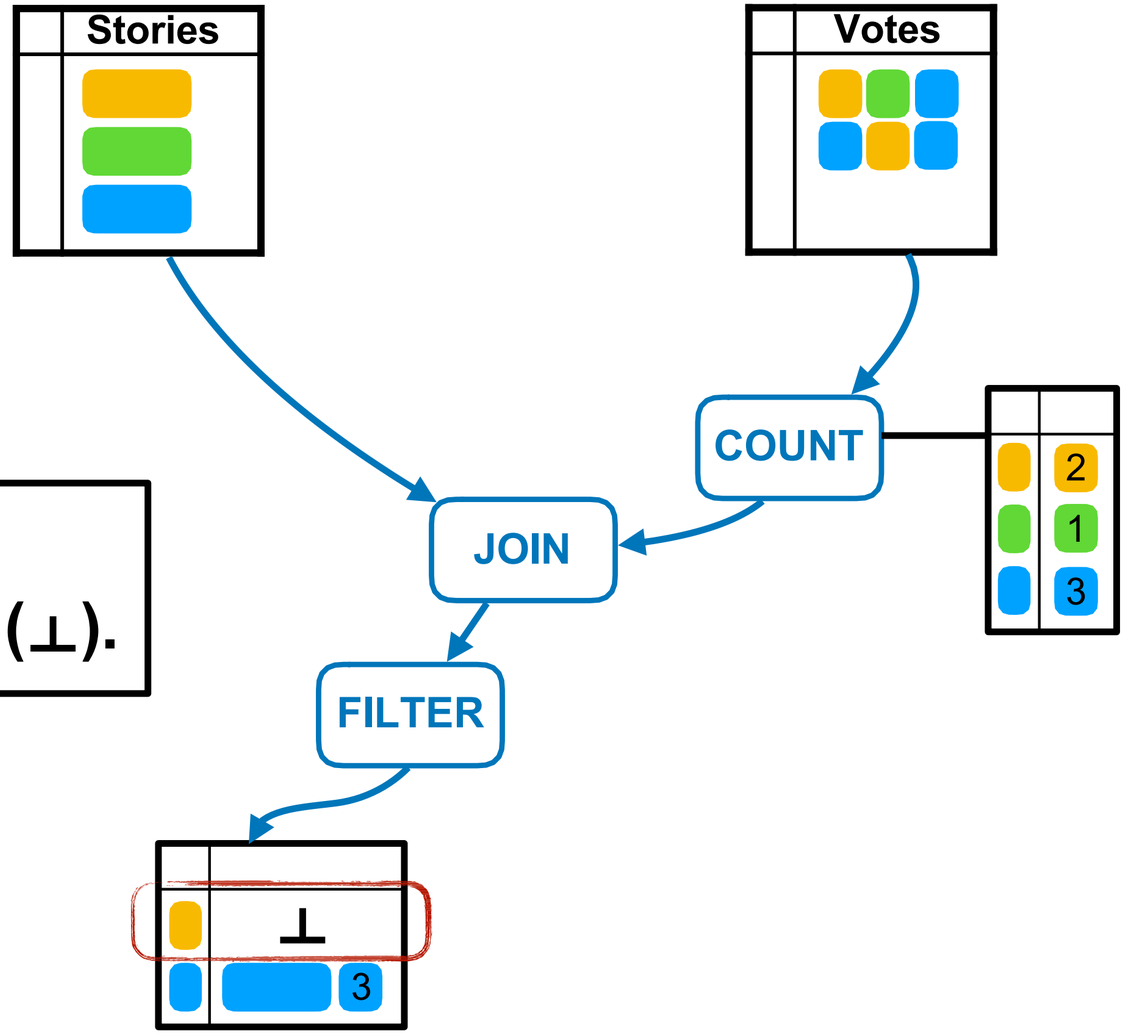
Partially-stateful data-flow



Data-flow state is *partial*:
entries for some keys are absent (⊥).

Frontend

Partially-stateful data-flow



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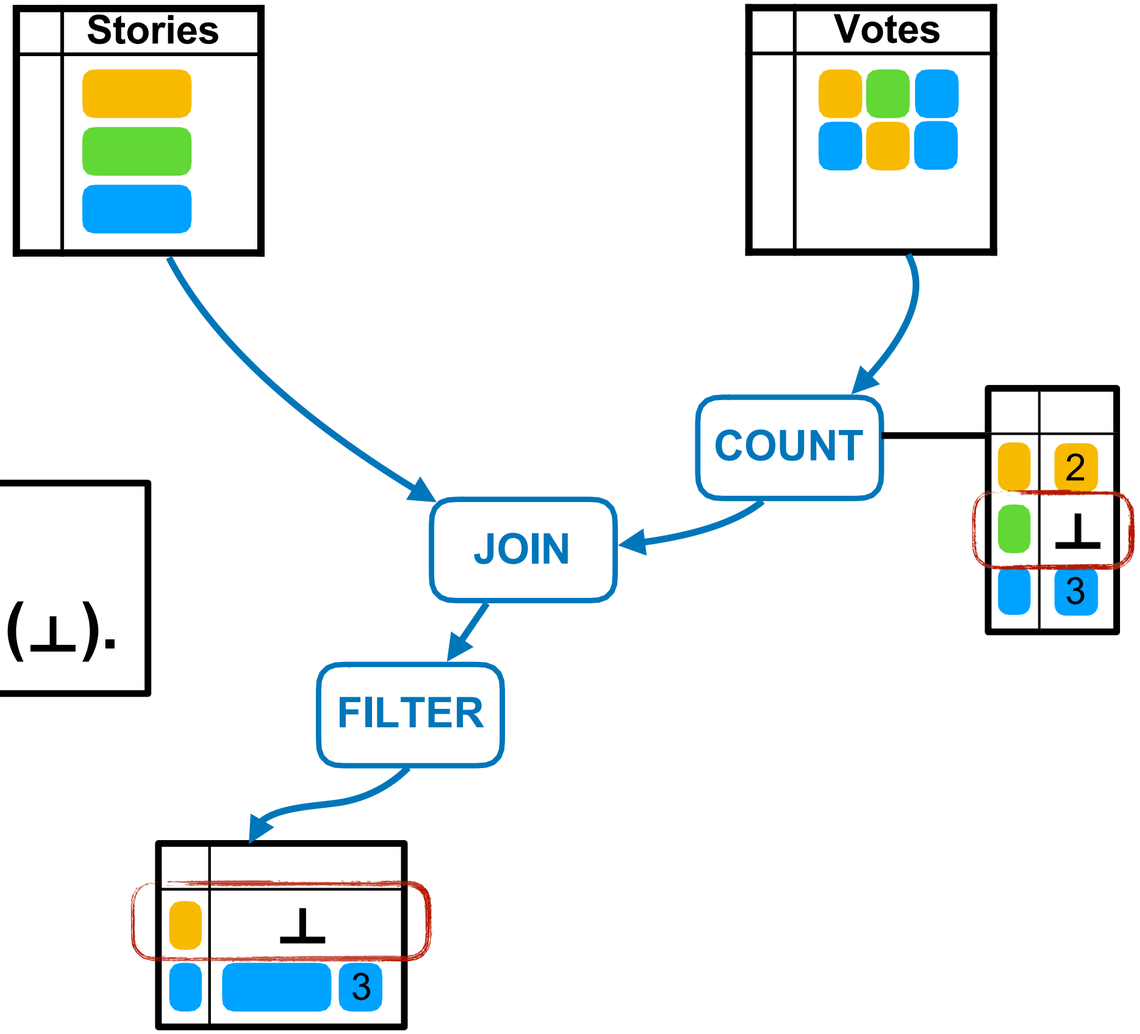

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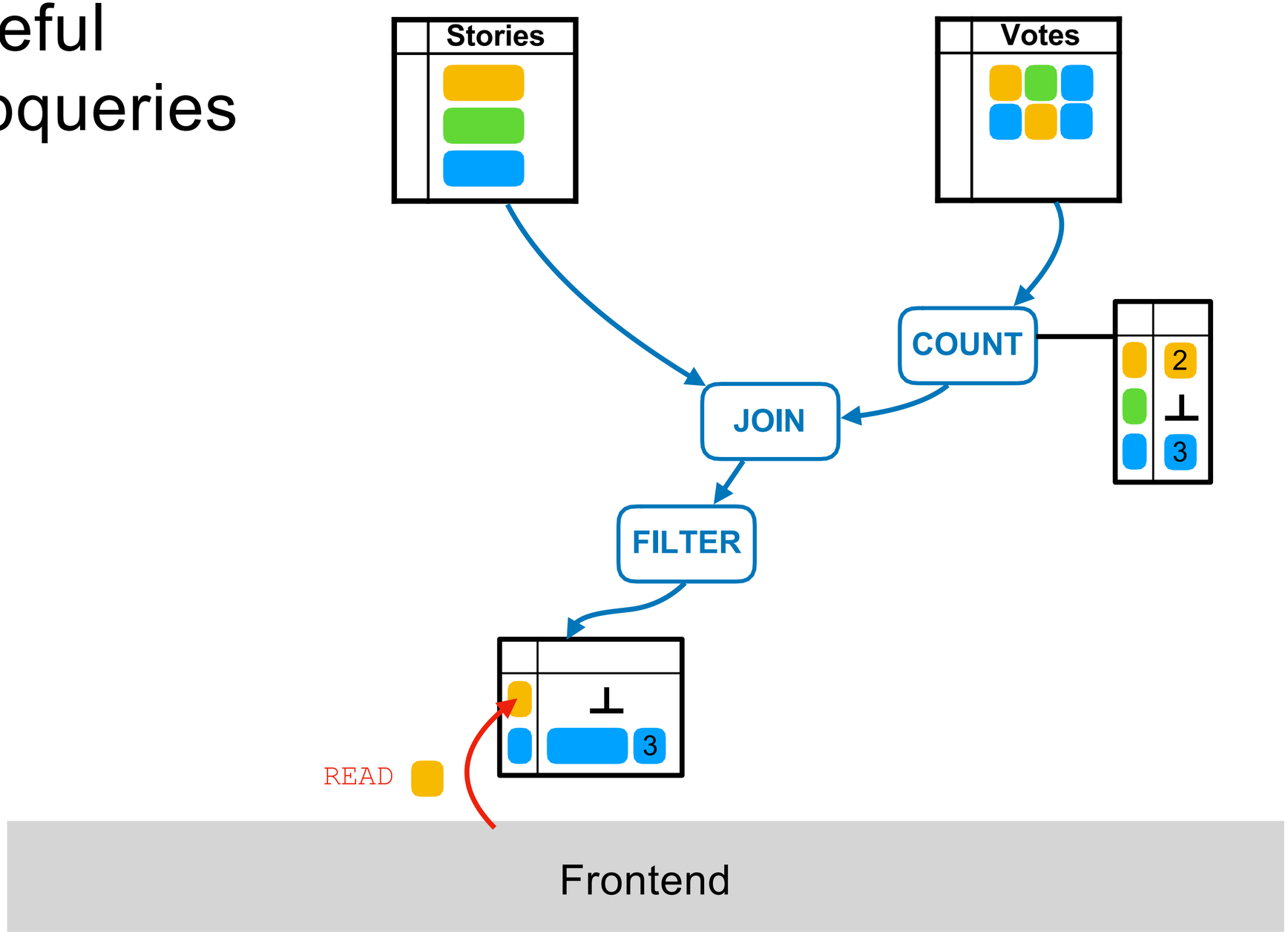
Partially-stateful data-flow: upqueries



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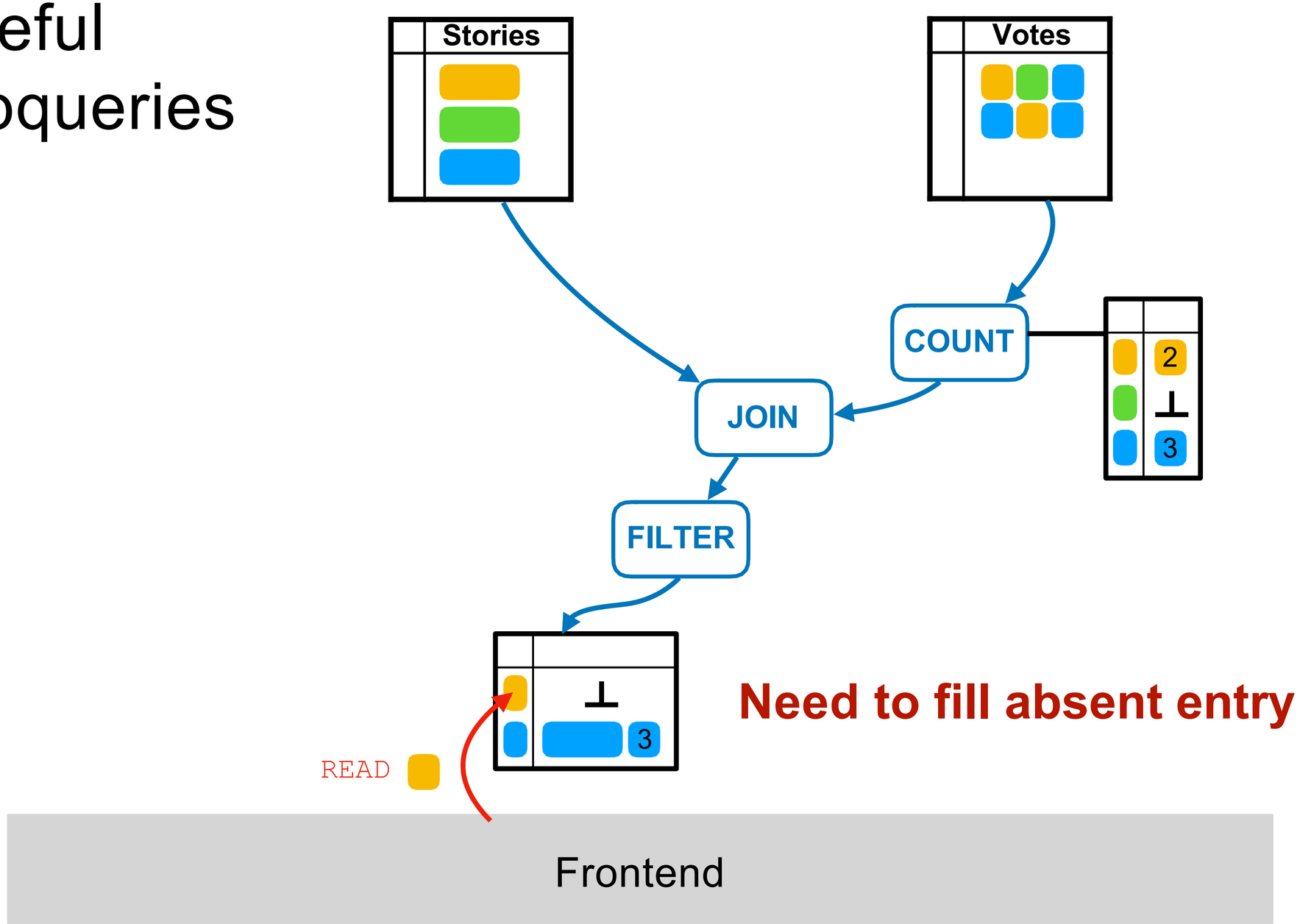

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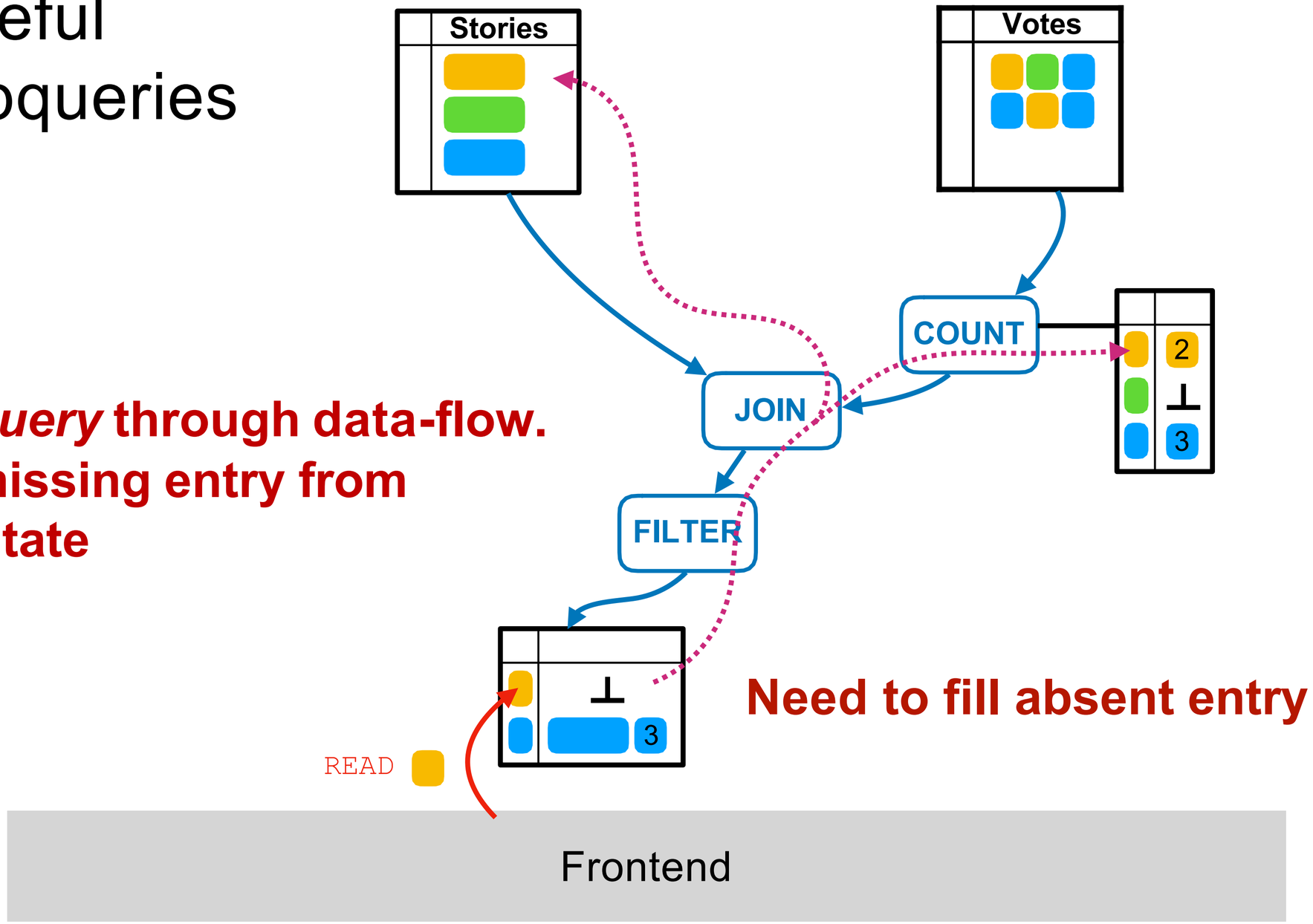
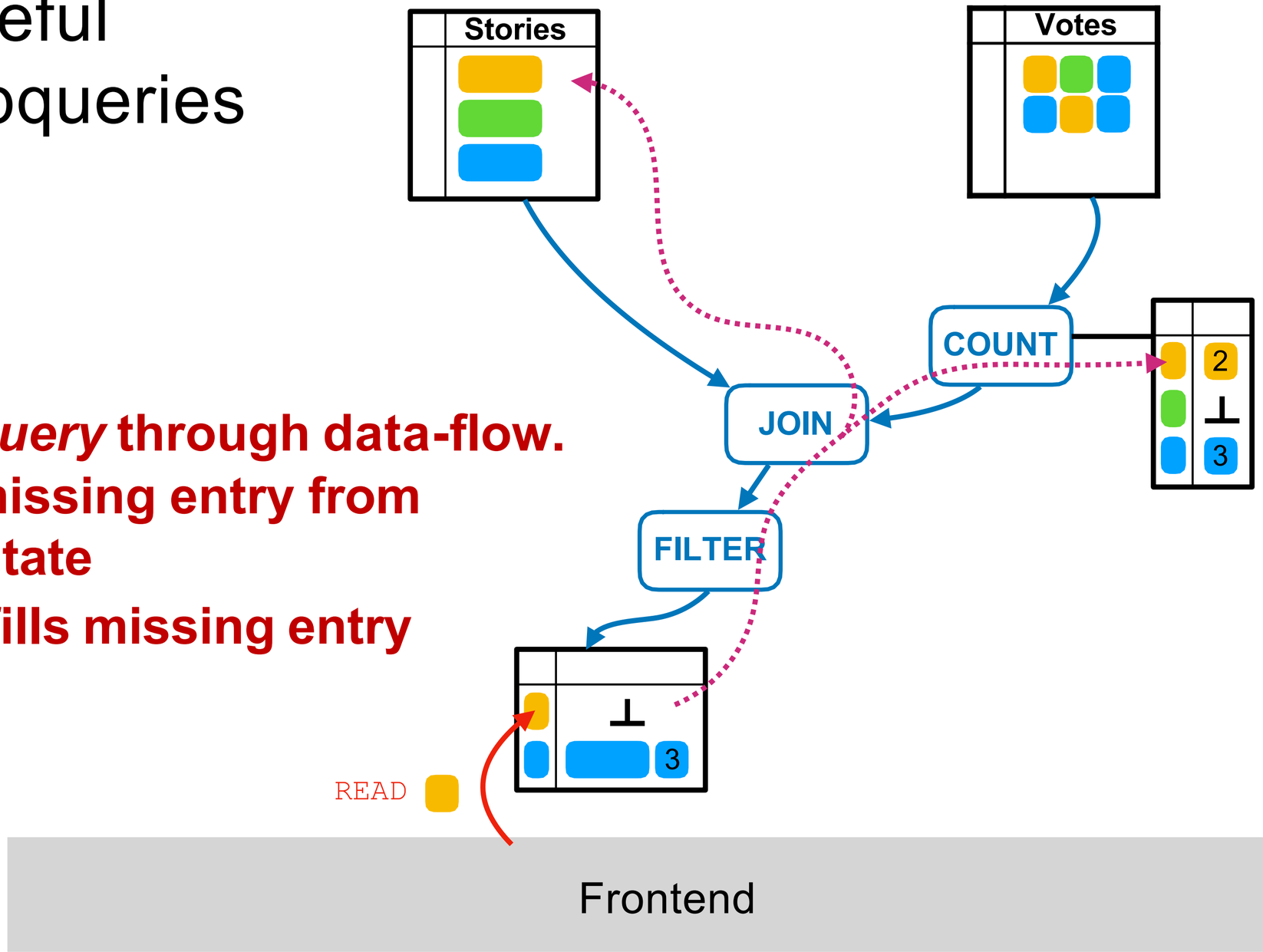


Solution: *upquery* through data-flow.

- **Compute missing entry from upstream state**

Need to fill absent entry

Partially-stateful data-flow: upqueries



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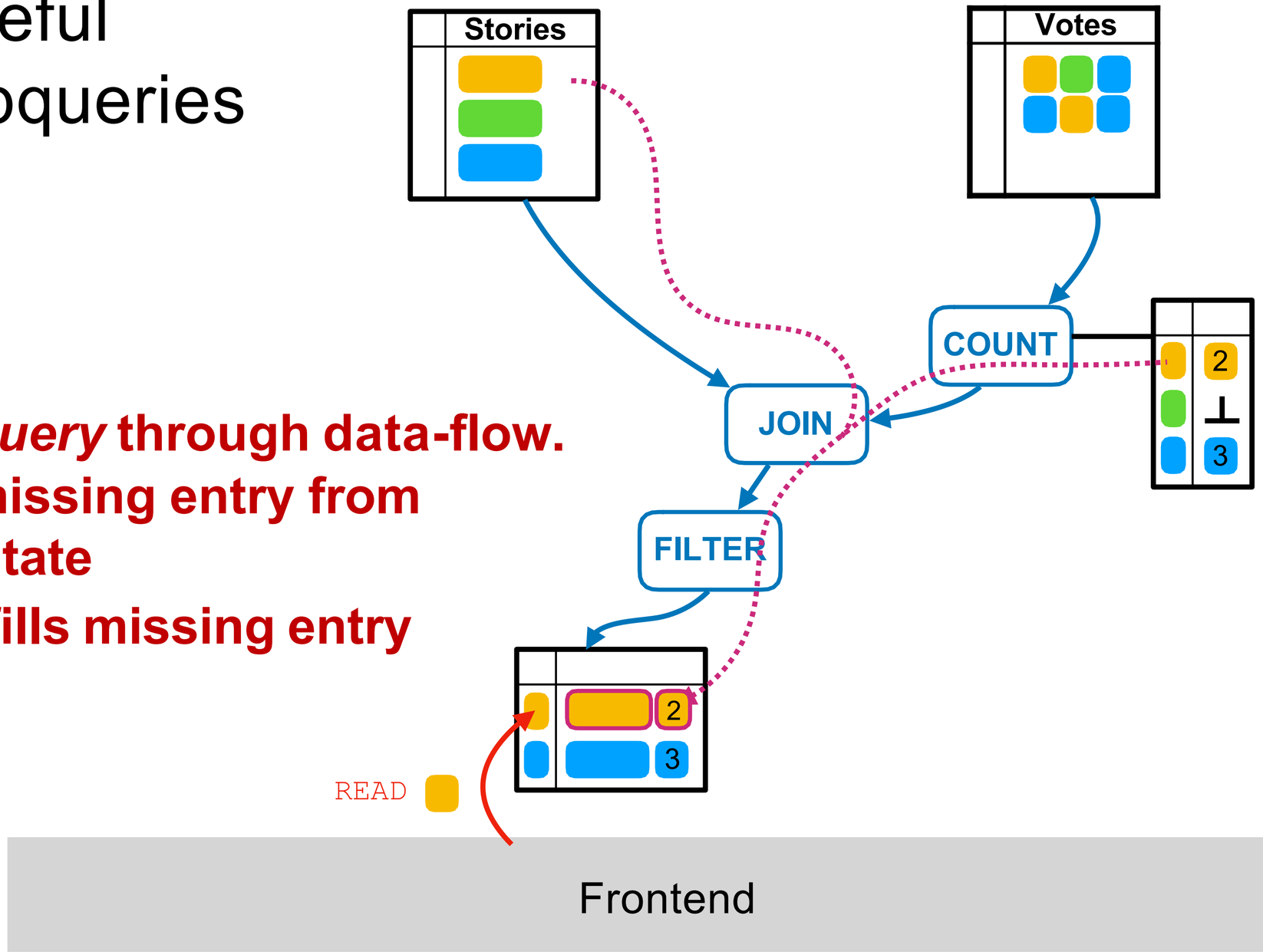

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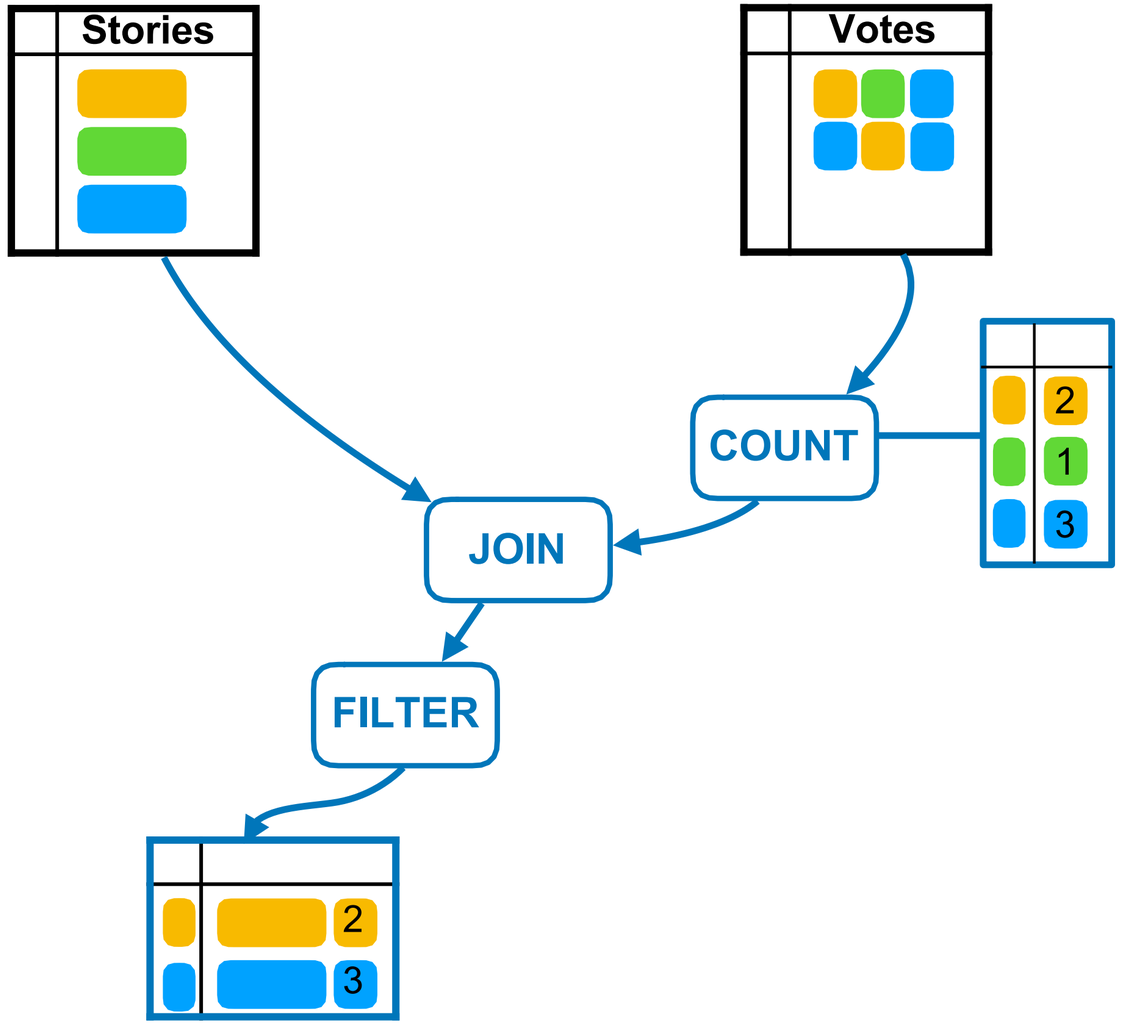
Partial state enables live data-flow changes

Start new views with **empty** operator state, **fill via upqueries**.



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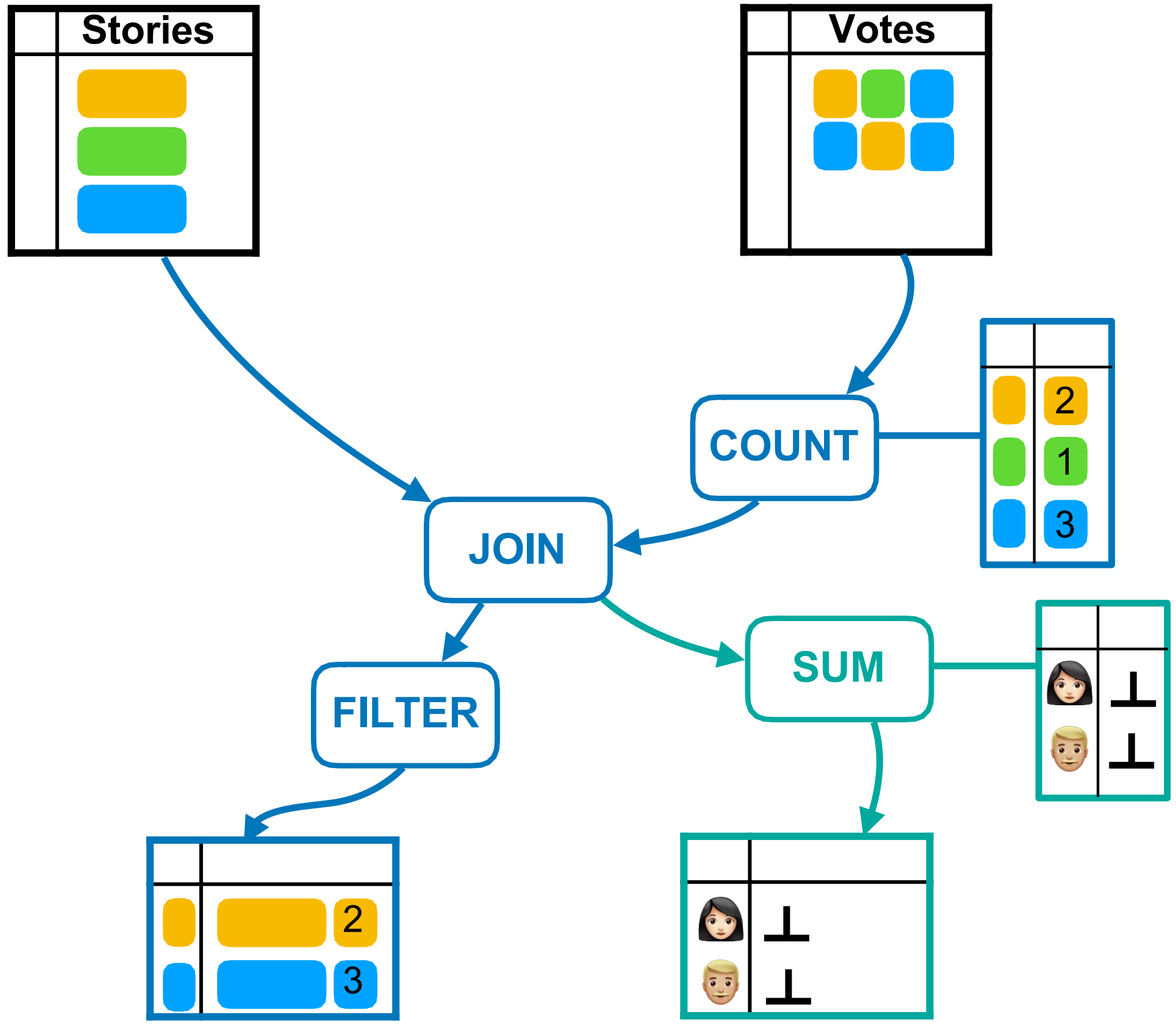

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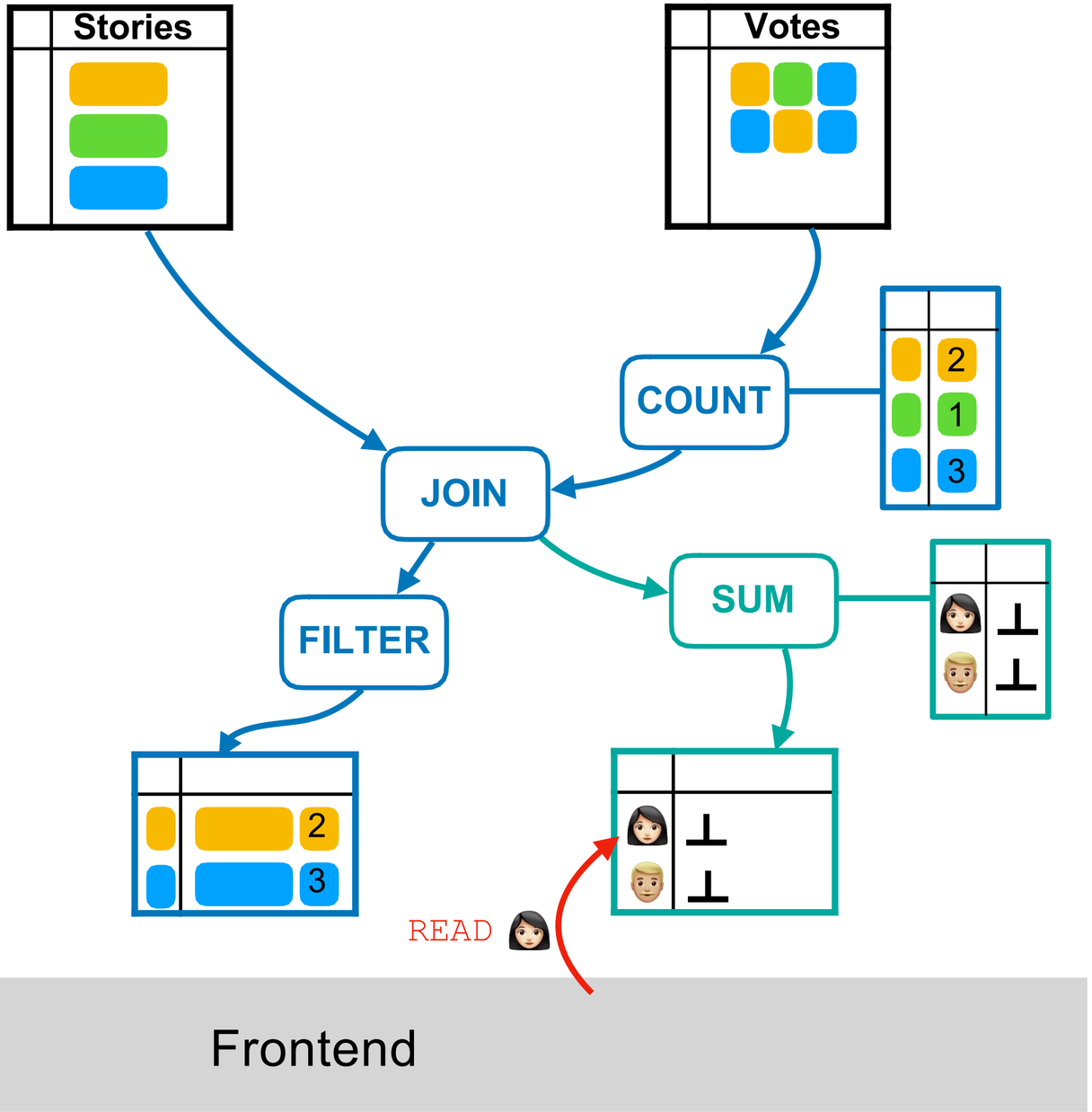

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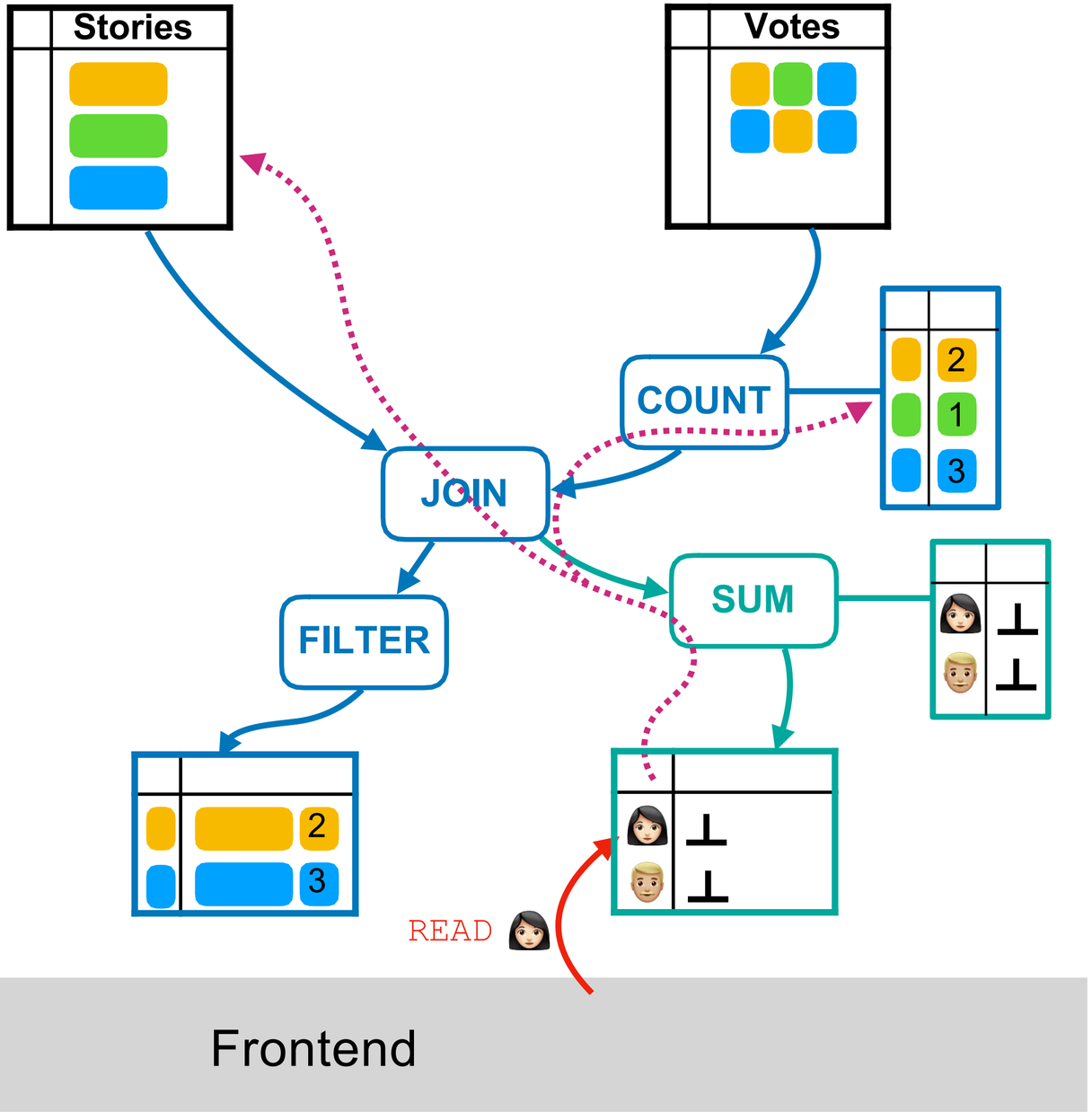

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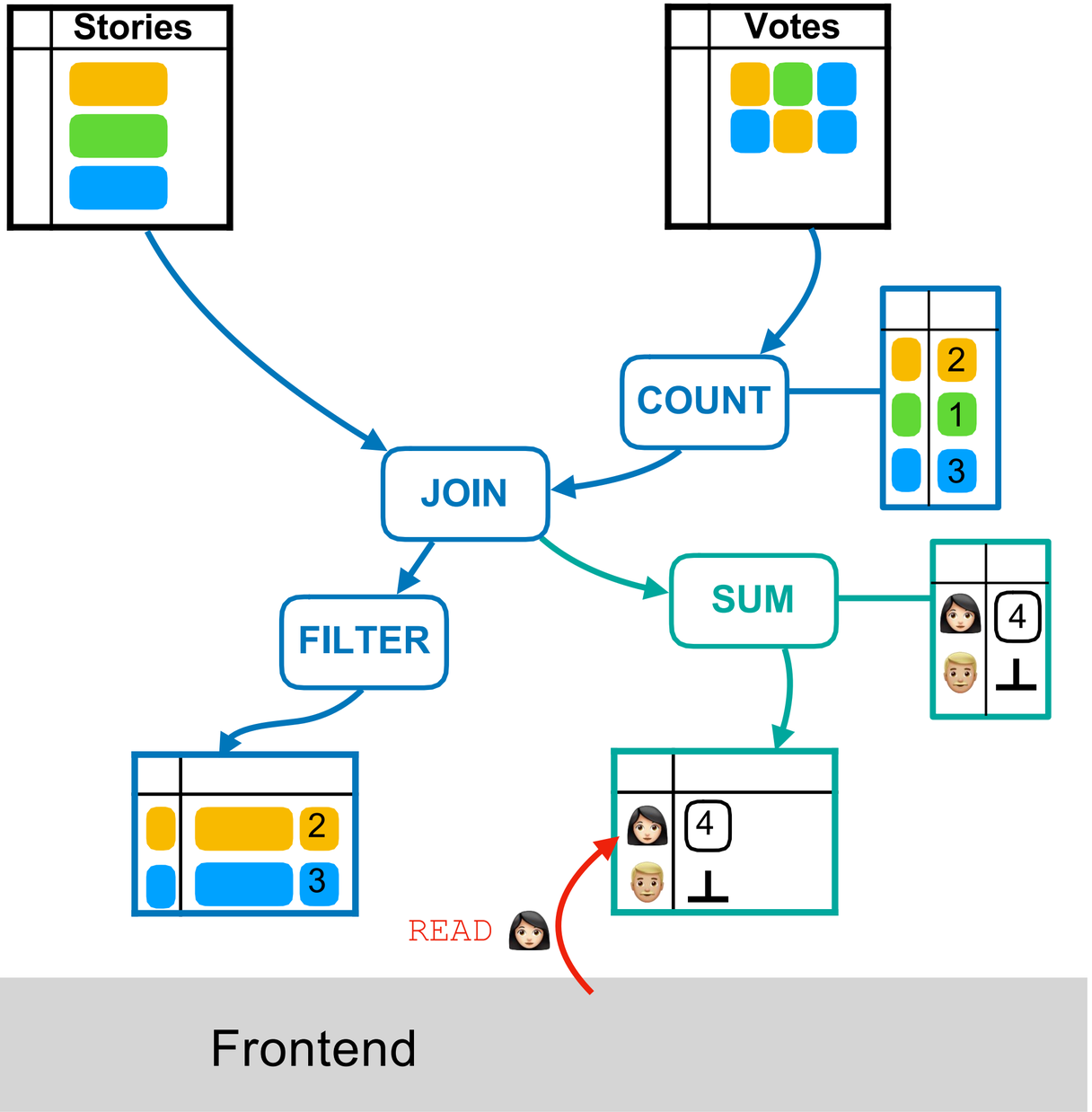
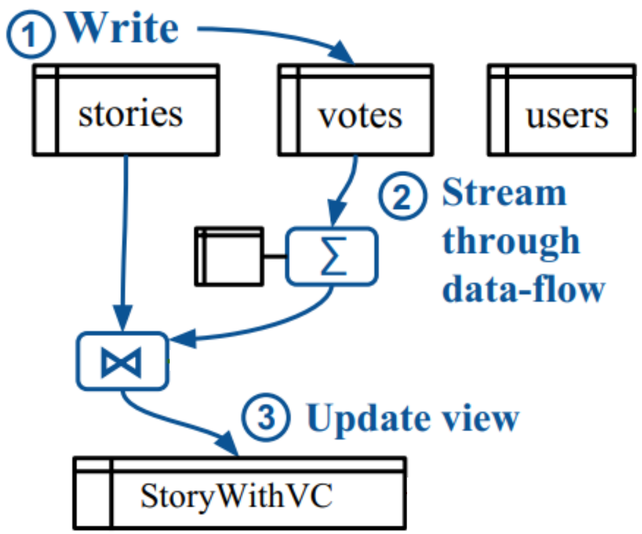
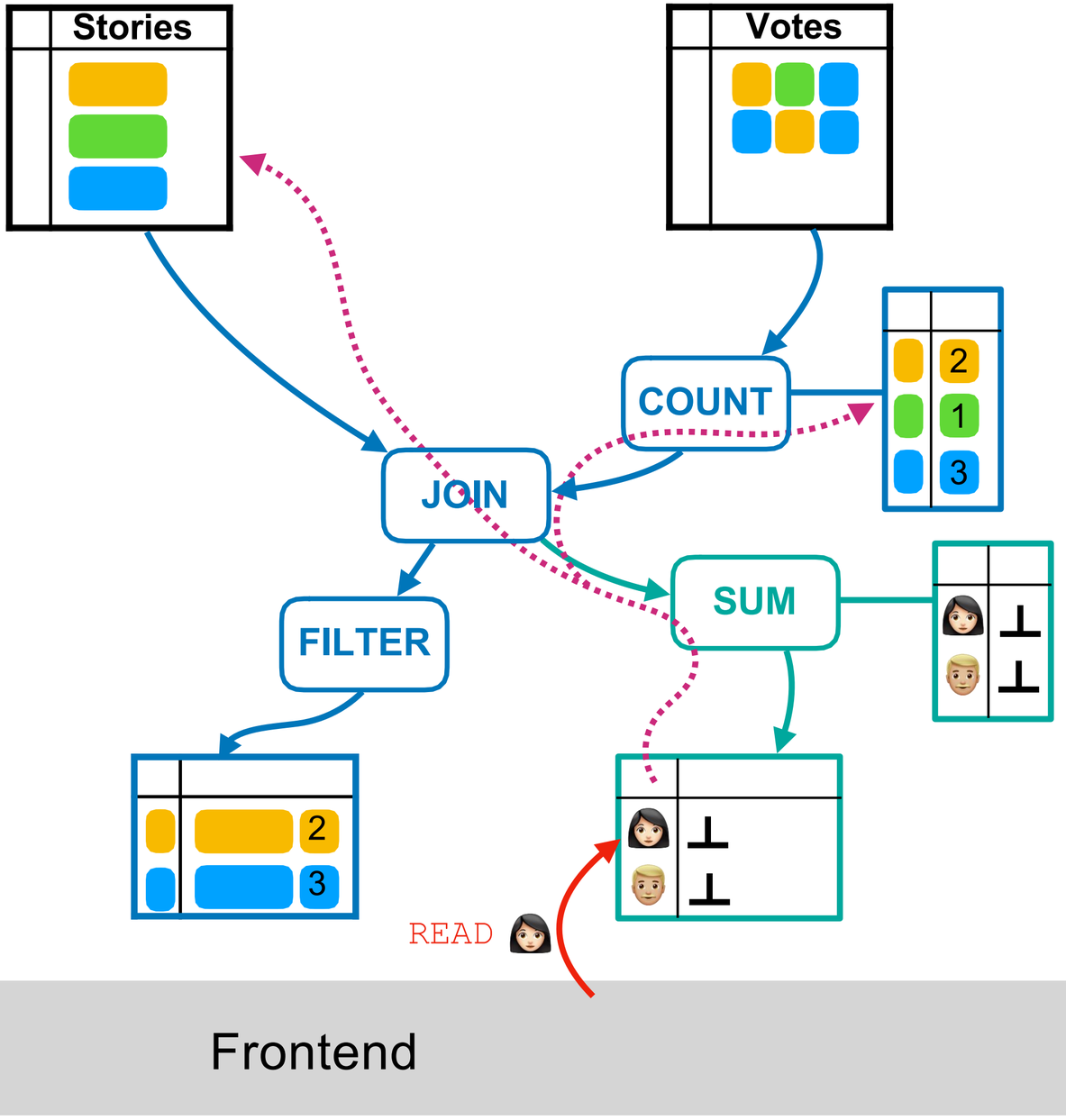


Updates and upqueries





Challenges implementing partially-stateful data-flow

Concurrent upqueries, update processing causes races

Must maintain **correctness** under concurrency!

Correctness under concurrency

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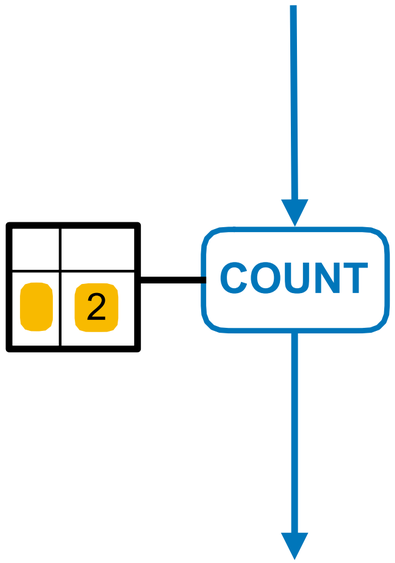

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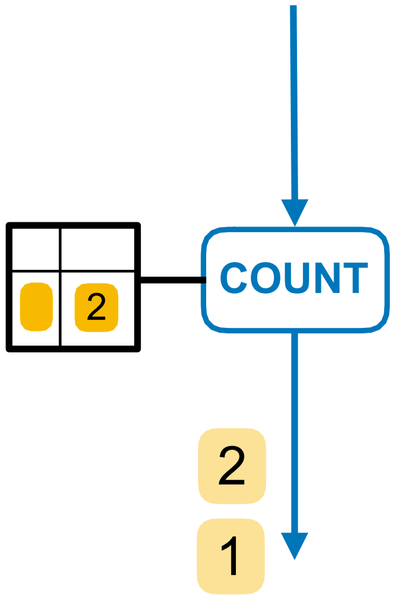

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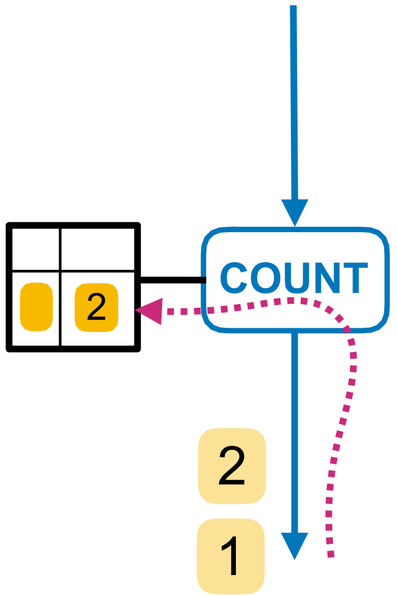

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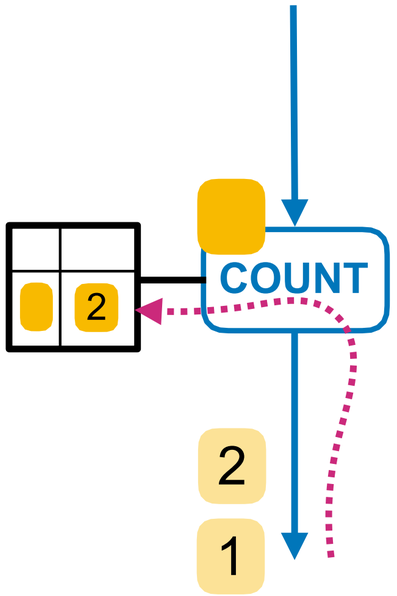

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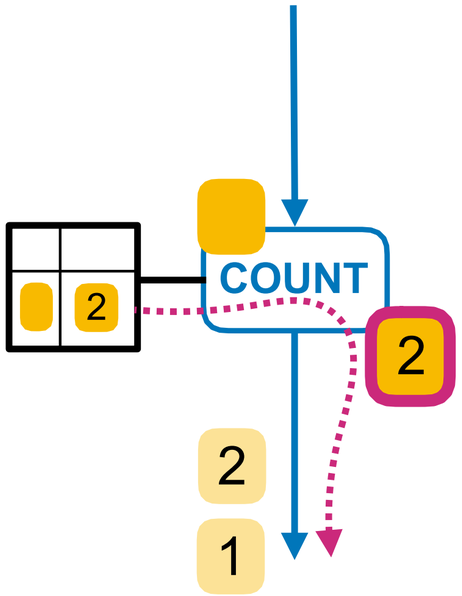

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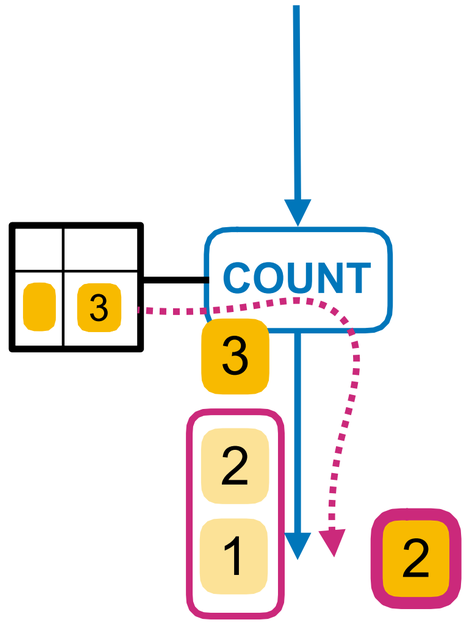

Upquery response is a **snapshot** of state

includes 2 1

does **not** include

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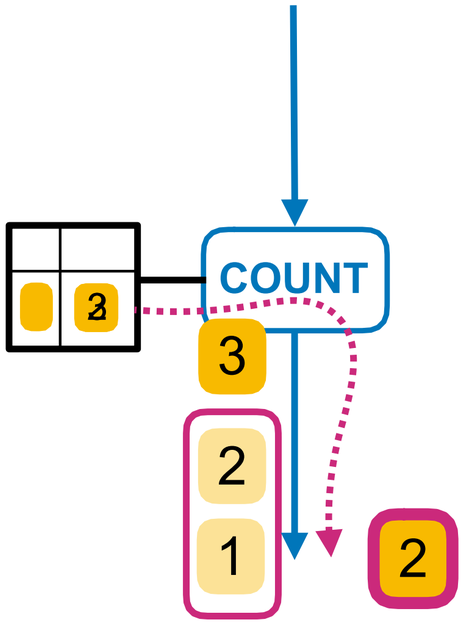

Upquery response is a **snapshot** of state

includes 2 1

does **not** include

Solution: Maintain **order** of upquery response and surrounding updates, despite lack of global coordination.

Challenges implementing partially-stateful data-flow

1. Concurrent upqueries and forward processing — races!

Must maintain **correctness** under concurrency!

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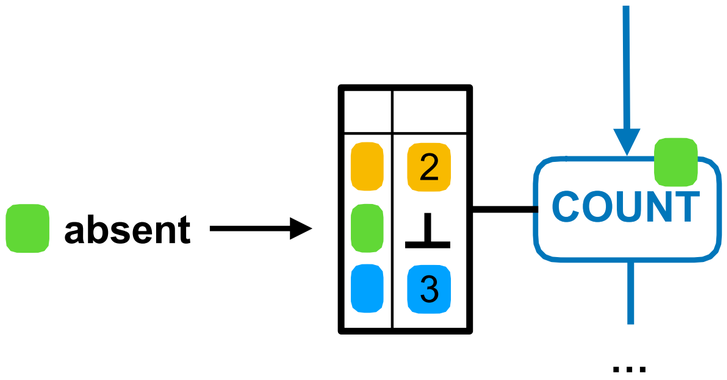

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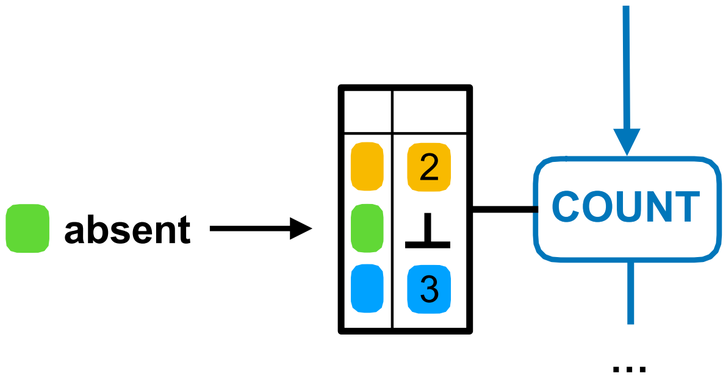
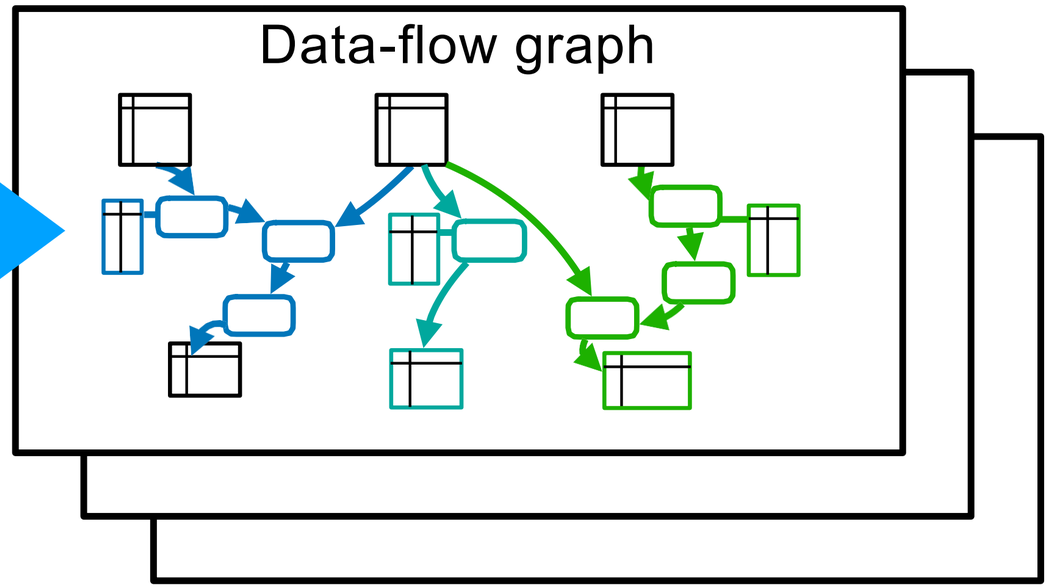


Drop updates that touch absent state, future upquery will refill.

Noria implementation

```
/* base tables */
CREATE TABLE stories
  (id int, author int, title text, url text);
CREATE TABLE votes (user int, story_id int);
CREATE TABLE users (id int, username text);
/* internal view: vote count per story */
CREATE INTERNAL VIEW VoteCount AS
  SELECT story_id, COUNT(*) AS vcount
    FROM votes GROUP BY story_id;
/* external view: story details */
CREATE VIEW StoriesWithVC AS
  SELECT id, author, title, url, vcount
    FROM stories
    JOIN VoteCount ON VoteCount.story_id = stories.id
   WHERE stories.id = ?;
```

Transform



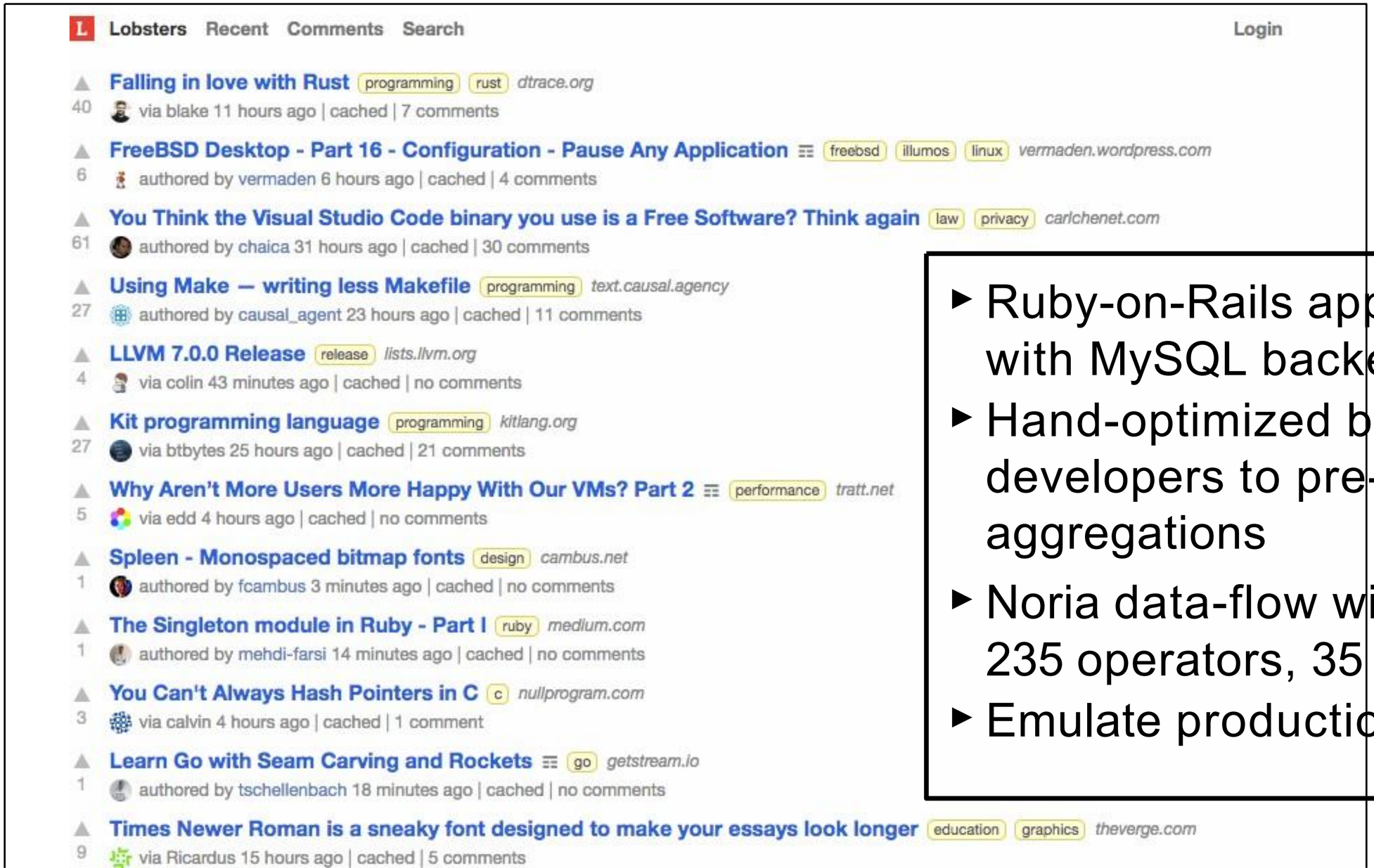
MySQL adapter

- 45k lines of Rust + 15k libraries
- RocksDB for base table storage
- ZooKeeper for leader election

Evaluation

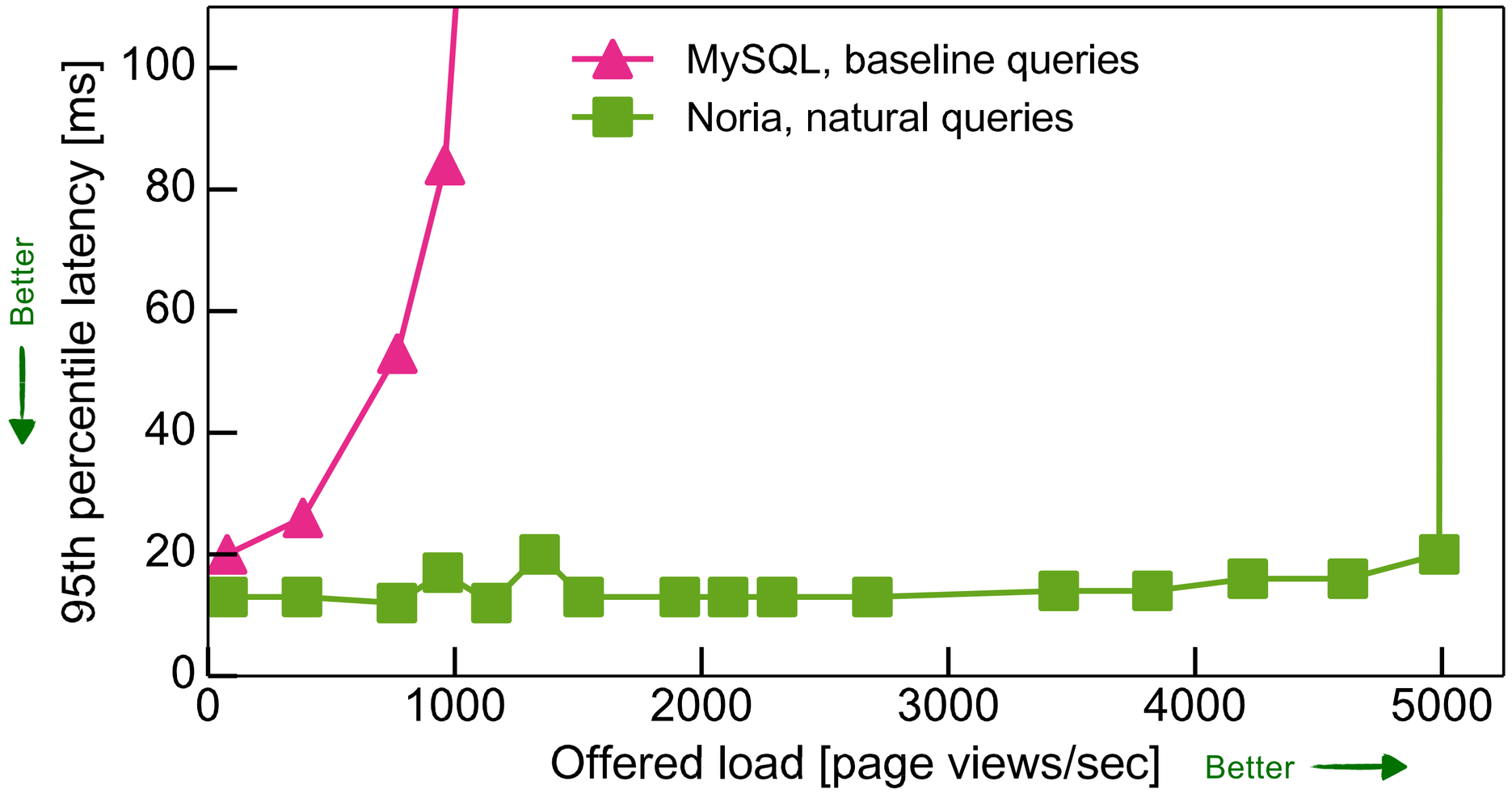
1. Can Noria improve a real web application's performance?

Case study: Lobsters (http://lobste.rs)



- Ruby-on-Rails application with MySQL backend
- Hand-optimized by developers to pre-compute aggregations
- Noria data-flow with 235 operators, 35 views
- Emulate production load

Can Noria improve Lobsters' performance?



Noria with **natural queries** supports **5x** MySQL's throughput.

Noria — Summary

- New partially-stateful data-flow model
- Noria: new web application backend based on data-flow
- Partial state saves space and allows live change
- Supports high throughput on one or more machines
- Open source, try it out!

Q1

Noria ensures that clients read eventually consistent data. What problem are they trying to solve? Why is eventual consistency okay?

Q2

How does Noria ensure eventual consistency?

Consider the following example: say there is an update u that update two views, and a upquery uq issued by the user also updates these views.

base table:

```
view1 (upstream)   op1:
view2 (downstream) op2:
```

Q3

What complicates Join processing in Noria?

Consider the following example: