Joining Infinity — Windowless Stream Processing with Flink

Sanjar Akhmedov, Software Engineer, ResearchGate

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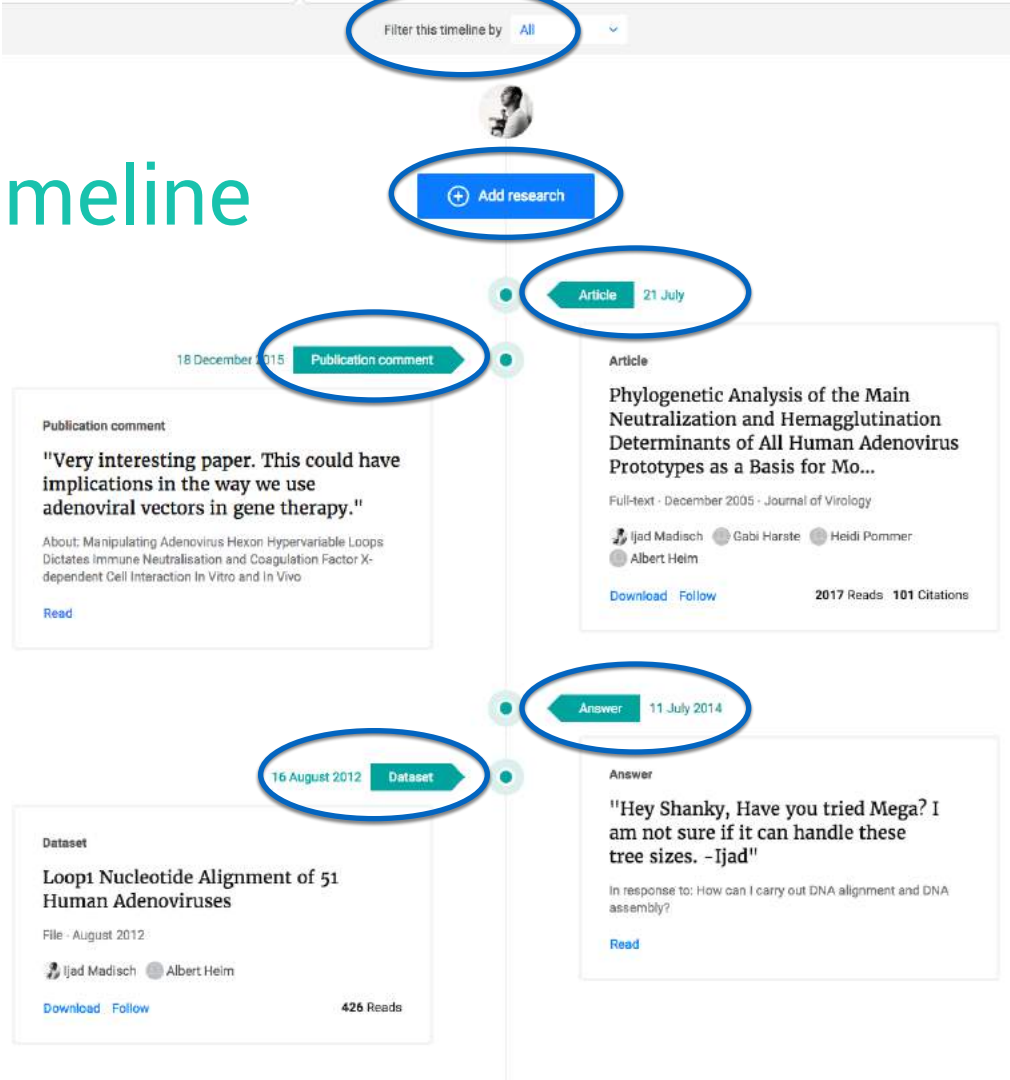

Feature: Research Timeline

Article

Phylogenetic Analysis of the Main Neutralization and Hemagglutination Determinants of All Human Adenovirus Prototypes as a Basis for Mo...

Full-text · December 2005 · Journal of Virology

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18 December 2015 Publication comment

Publication comment

"Very interesting paper. This could have implications in the way we use adenoviral vectors in gene therapy."

About: Manipulating Adenovirus Hexon Hypervariable Loops Dictates Immune Neutralisation and Coagulation Factor X-dependent Cell Interaction In Vitro and In Vivo

Read

Answer 11 July 2014

Answer

"Hey Shanky, Have you tried Mega? I am not sure if it can handle these tree sizes. -Ijad"

In response to: How can I carry out DNA alignment and DNA assembly?

Read

16 August 2012 Dataset

Dataset

Loop1 Nucleotide Alignment of 51 Human Adenoviruses

File · August 2012

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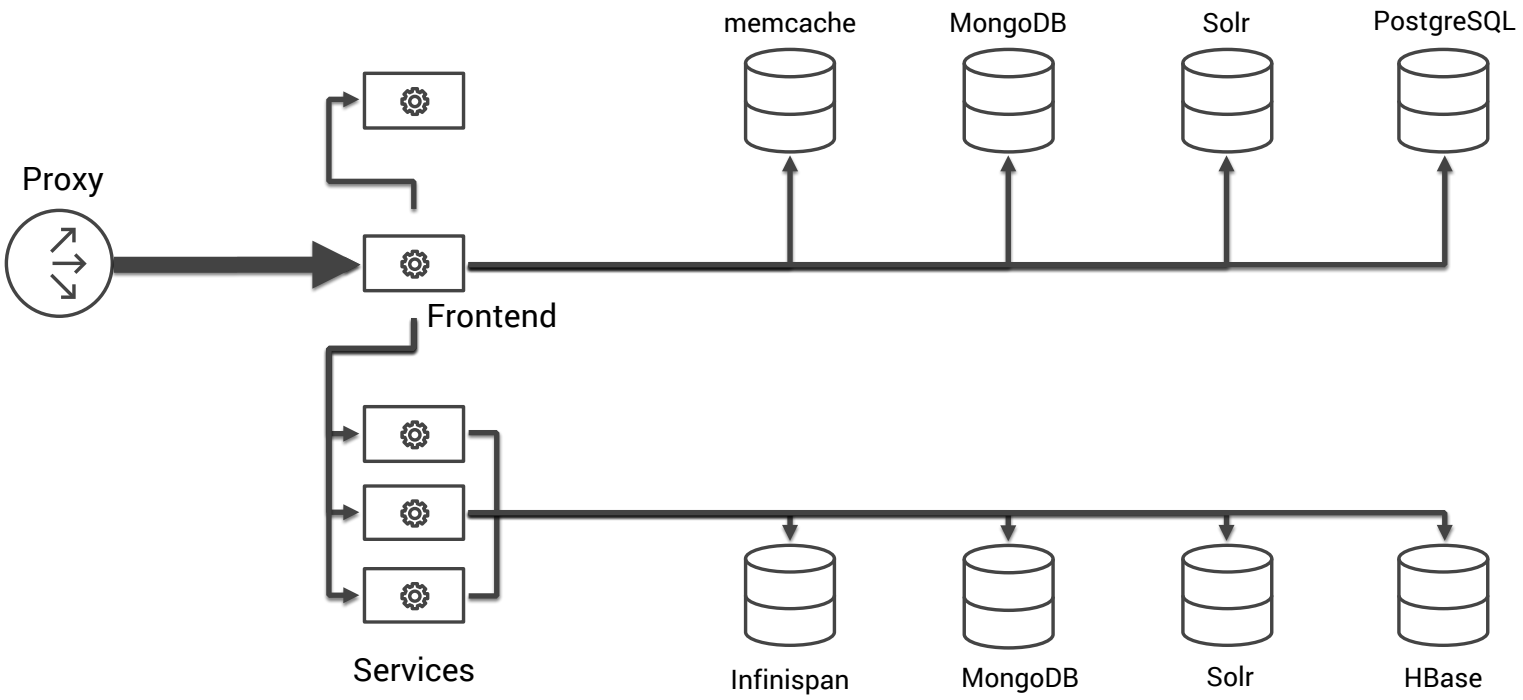
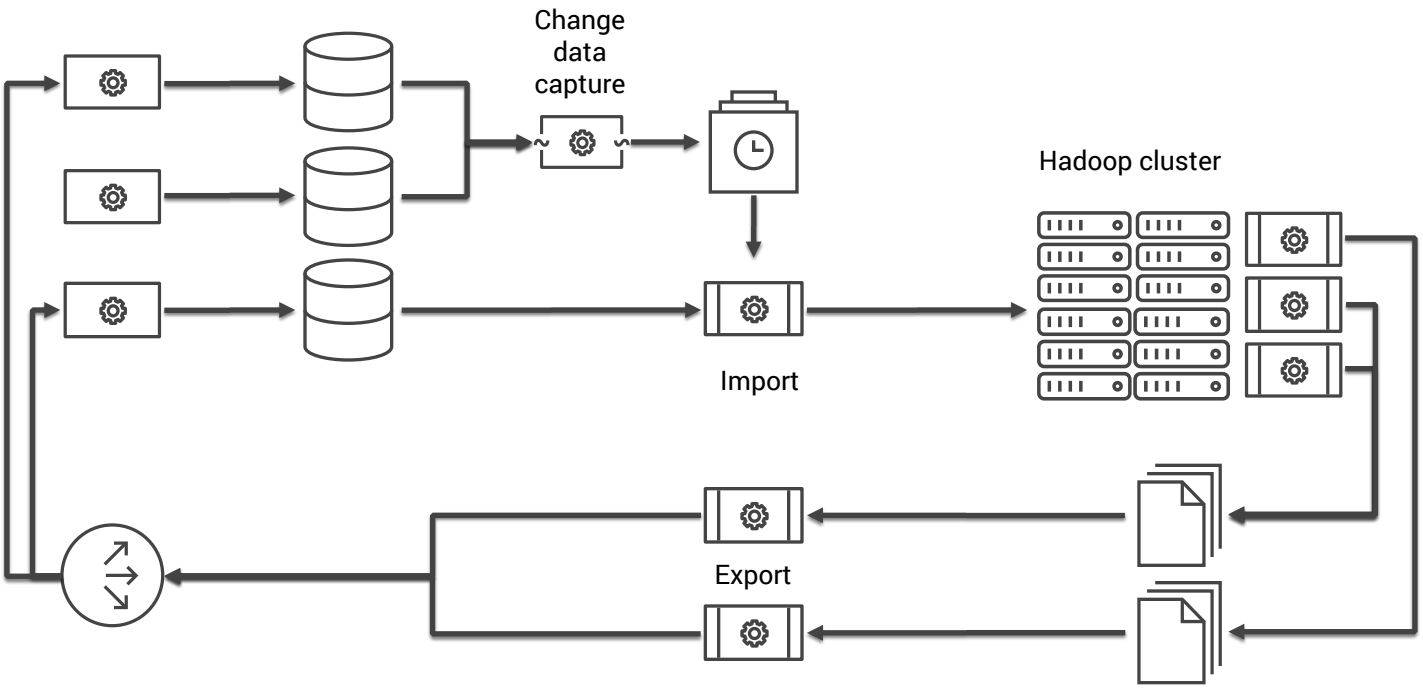
Diverse data sources



Big data pipeline



Data Model

Hypothetical SQL

```sql
CREATE TABLE accounts (
  id                 SERIAL PRIMARY KEY,
  claimed_author_ids INTEGER[]
);

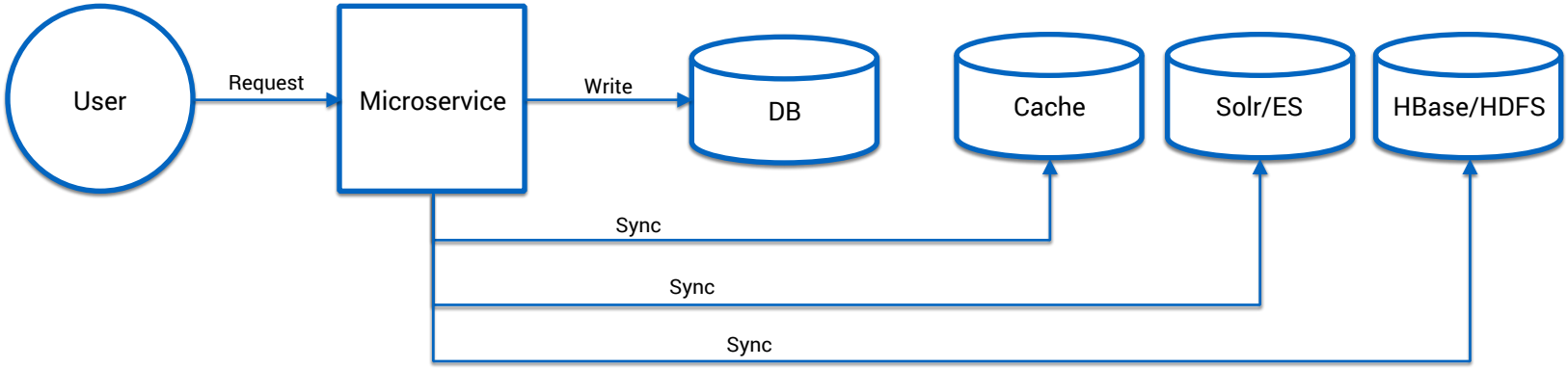
CREATE TABLE publications (
  id         SERIAL PRIMARY KEY,
  author_ids INTEGER[]
);

CREATE MATERIALIZED VIEW account_publications
REFRESH FAST ON COMMIT
AS
  SELECT
    accounts.id     AS account_id,
    publications.id AS publication_id
  FROM accounts
    JOIN publications
      ON ANY (accounts.claimed_author_ids) = ANY (publications.author_ids);
```

Challenges

- Data sources are **distributed** across different DBs
- Dataset **doesn't fit in memory** on a single machine
- Join process must be **fault tolerant**
- **Deploy** changes fast
- Up-to-date join result in **near real-time**
- Join result must be **accurate**

Change data capture (CDC)



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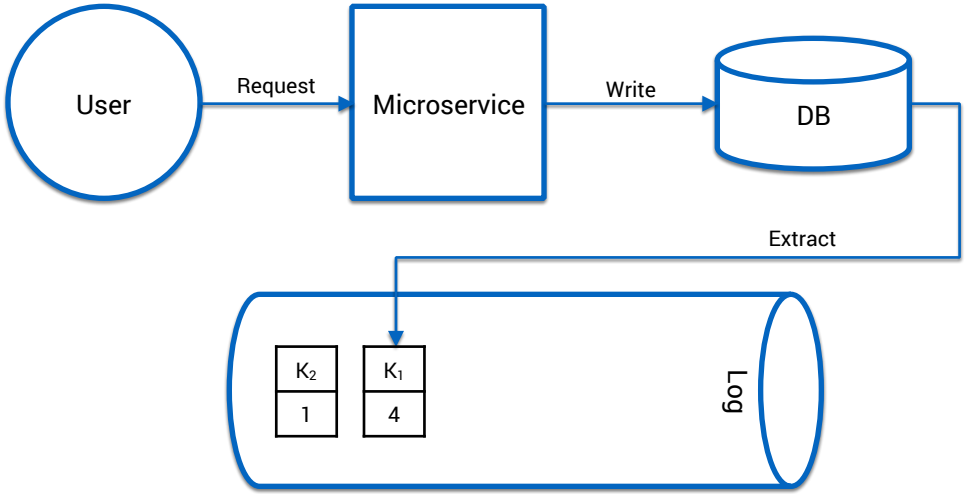

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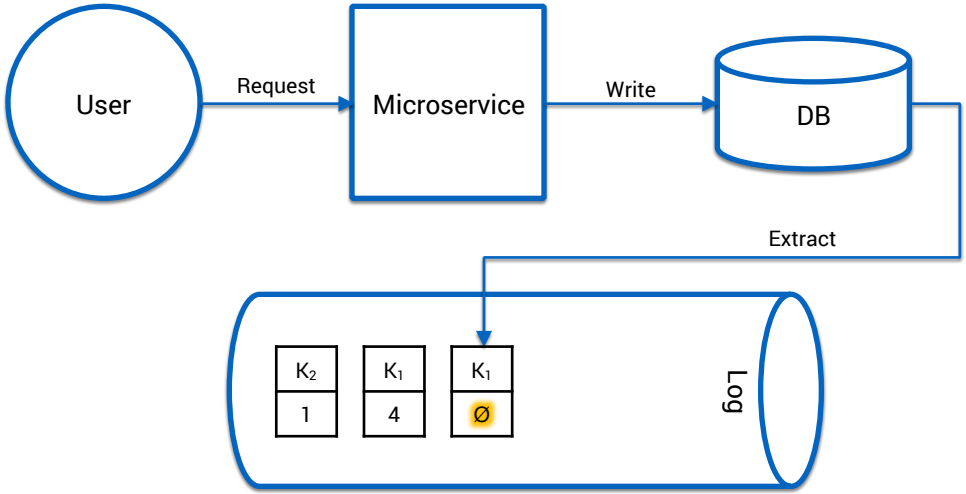

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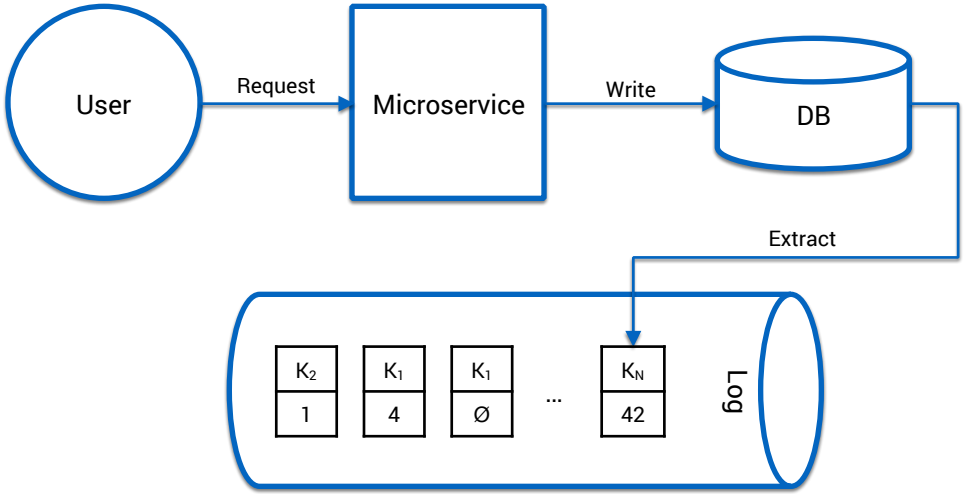

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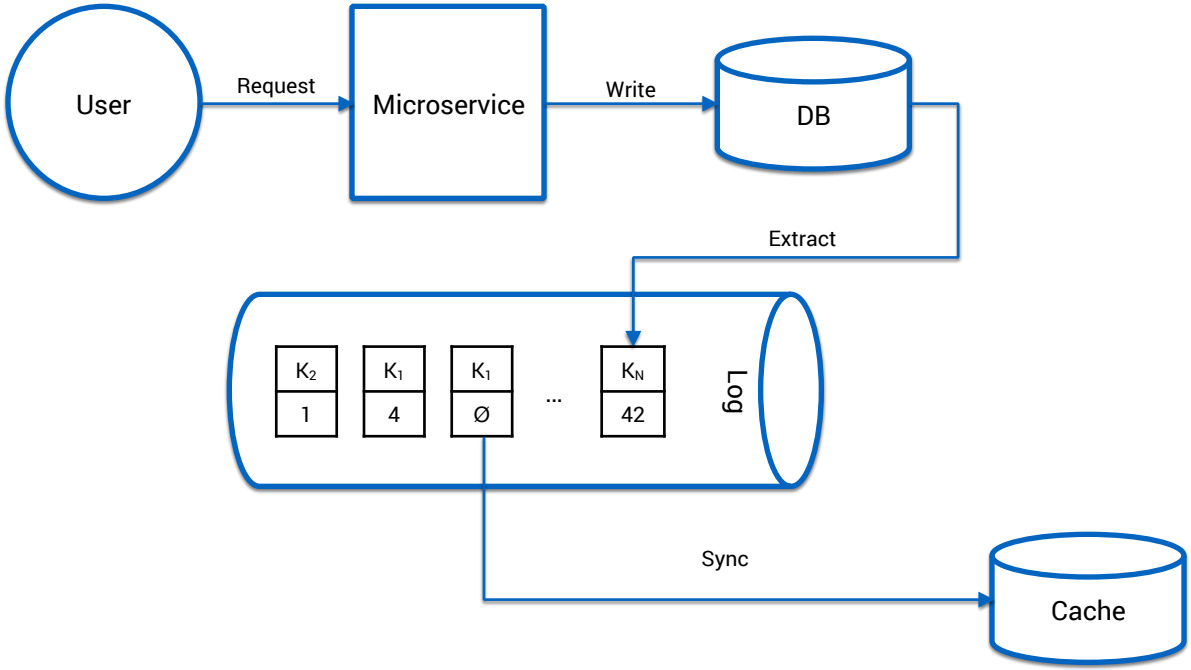

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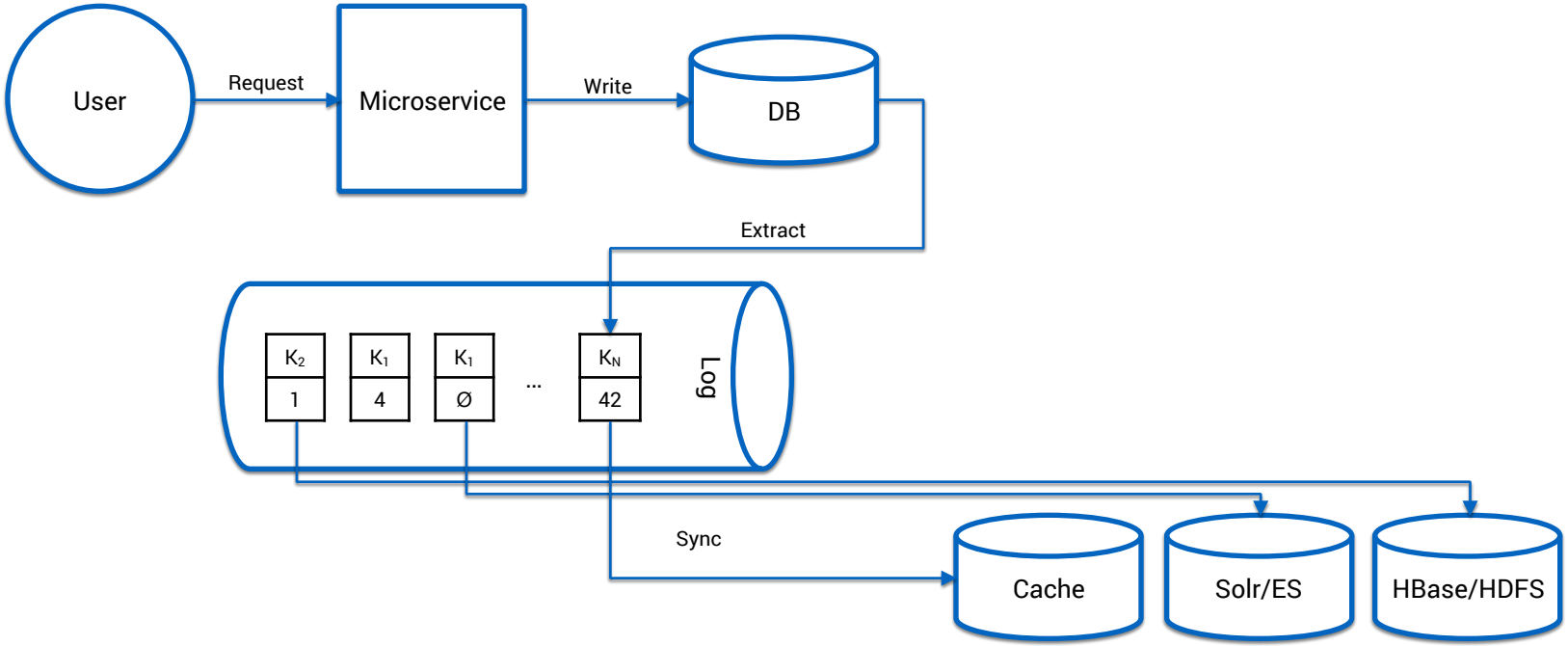
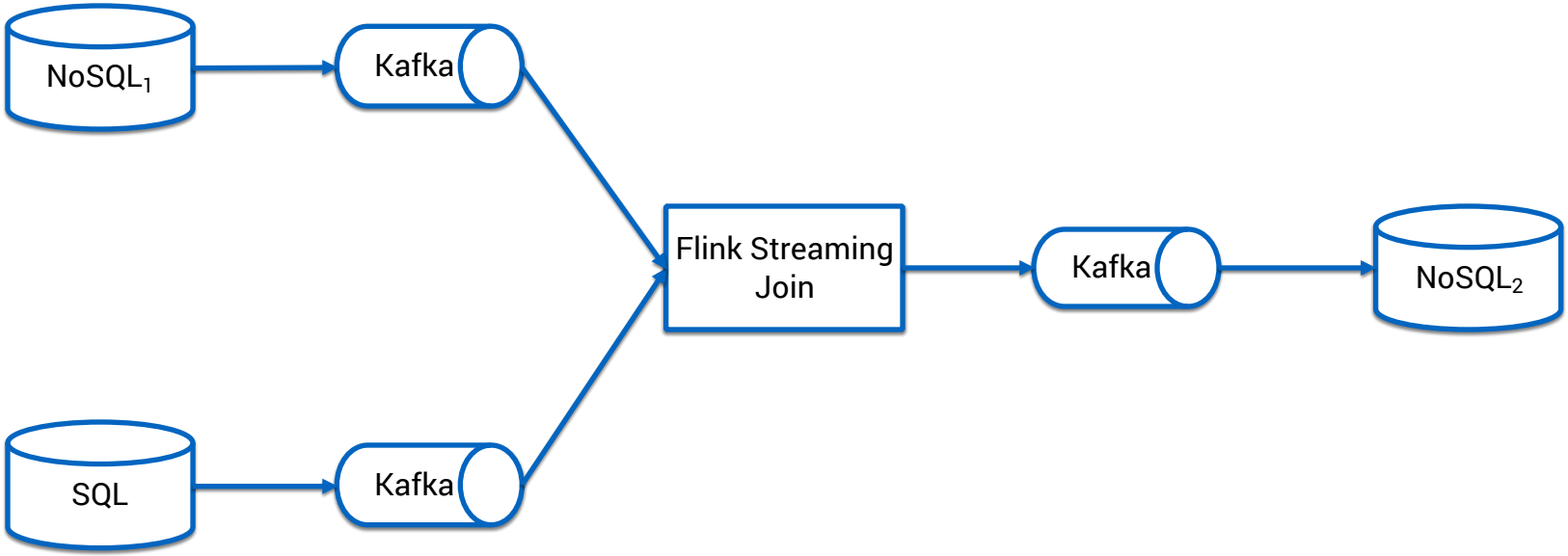
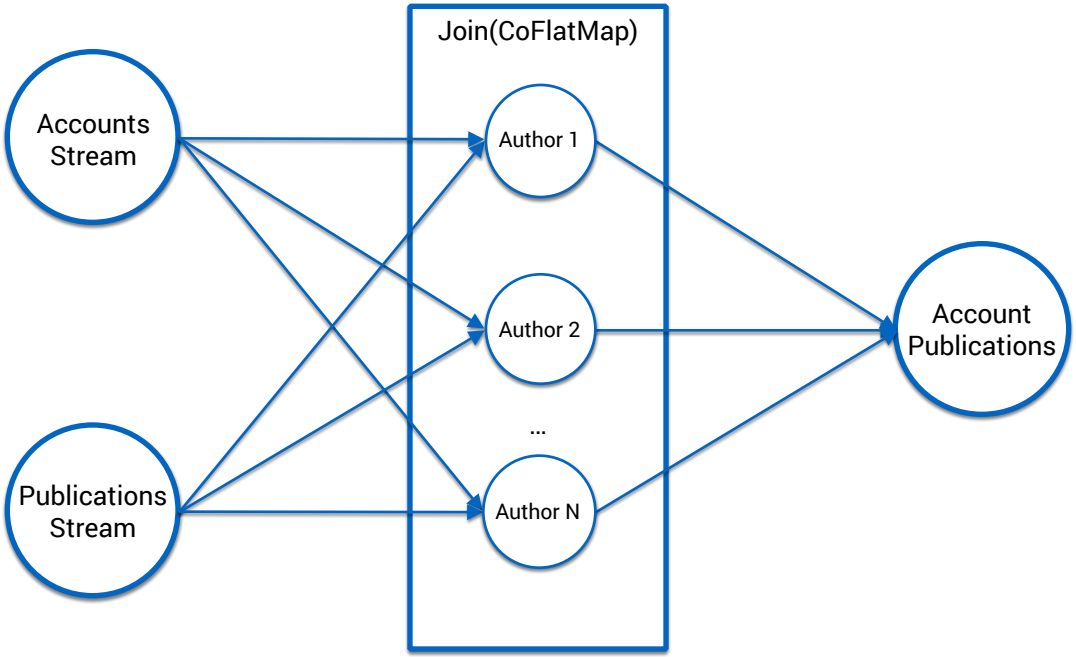


Join two CDC streams into one



Flink job topology



Prototype implementation

```
DataStream<Account> accounts = kafkaTopic("accounts");
DataStream<Publication> publications = kafkaTopic("publications");
DataStream<AccountPublication> result = accounts.connect(publications)
  .keyBy("claimedAuthorId", "publicationAuthorId")
  .flatMap(new RichCoFlatMapFunction<Account, Publication, AccountPublication>() {

    transient ValueState<String> authorAccount;
    transient ValueState<String> authorPublication;

    public void open(Configuration parameters) throws Exception {
      authorAccount = getRuntimeContext().getState(new ValueStateDescriptor<>("authorAccount", String.class, null));
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    }

    public void flatMap1(Account account, Collector<AccountPublication> out) throws Exception {
      authorAccount.update(account.id);
      if (authorPublication.value() != null) {
        out.collect(new AccountPublication(authorAccount.value(), authorPublication.value()));
      }
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    public void flatMap2(Publication publication, Collector<AccountPublication> out) throws Exception {
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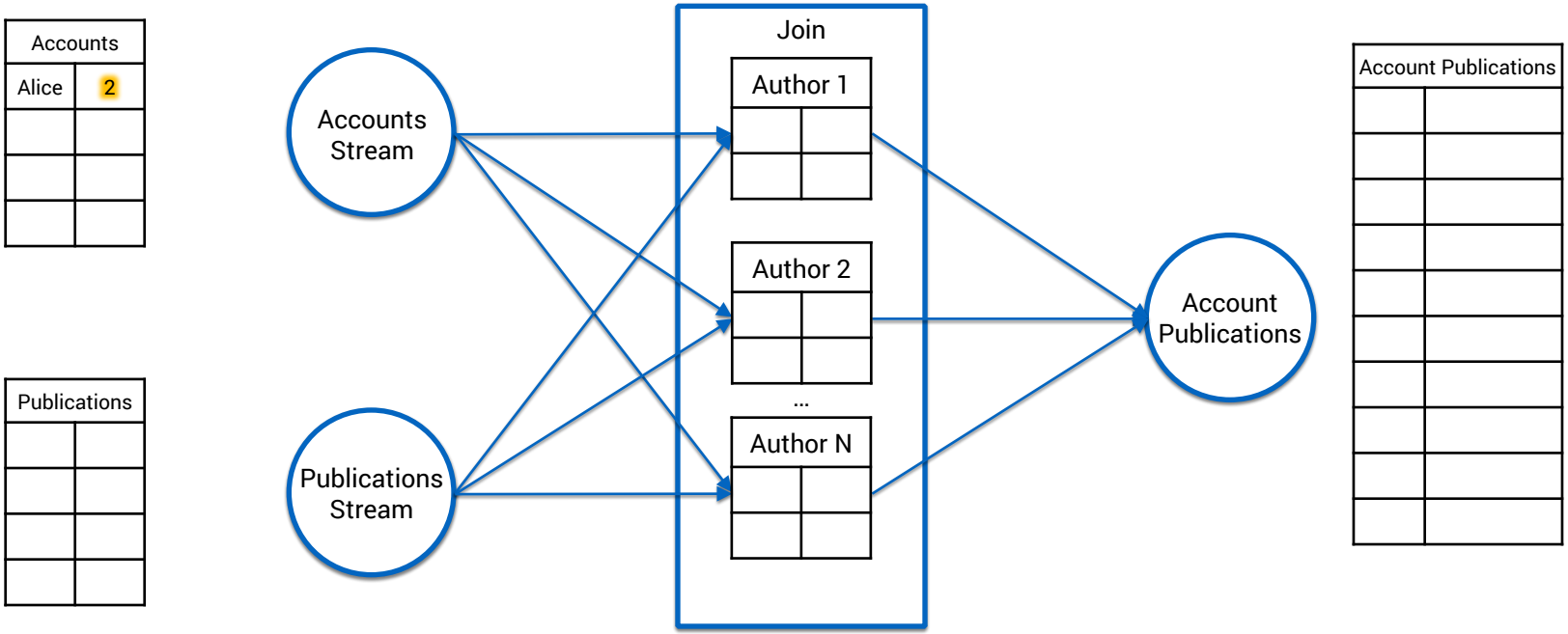
Example dataflow



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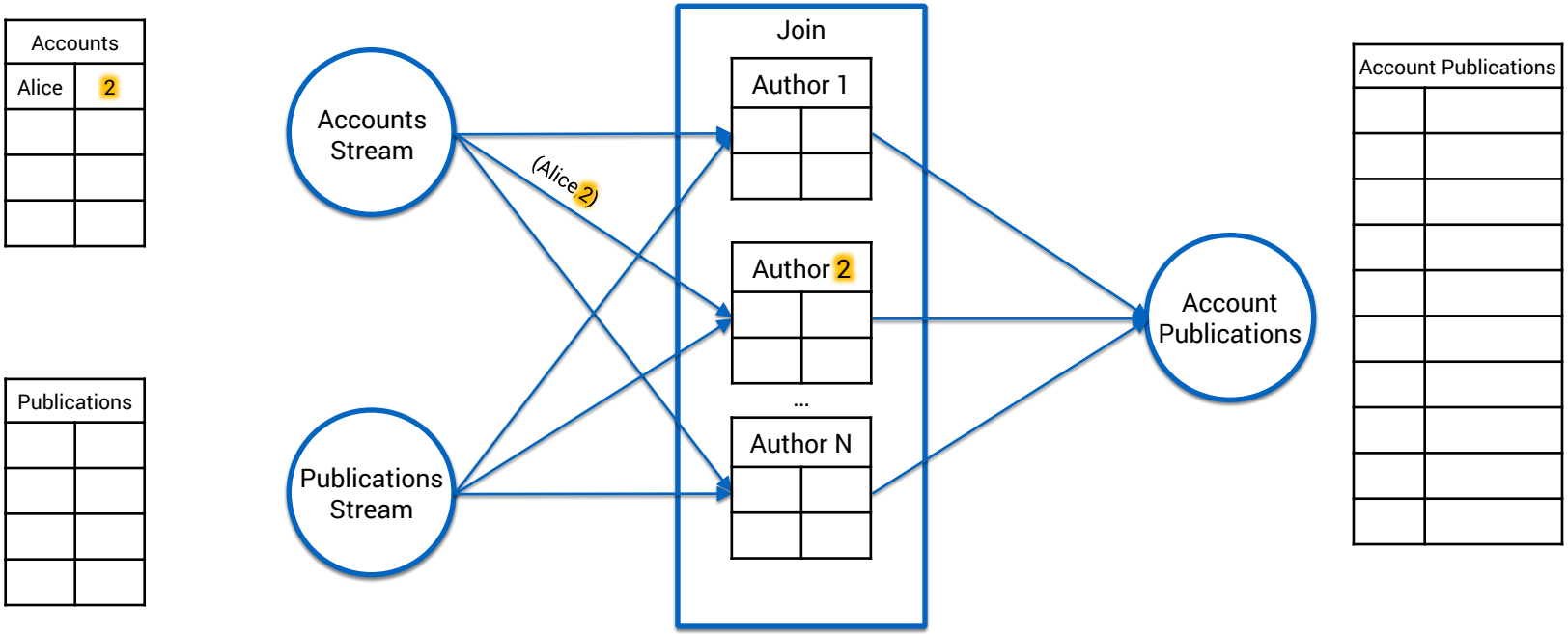
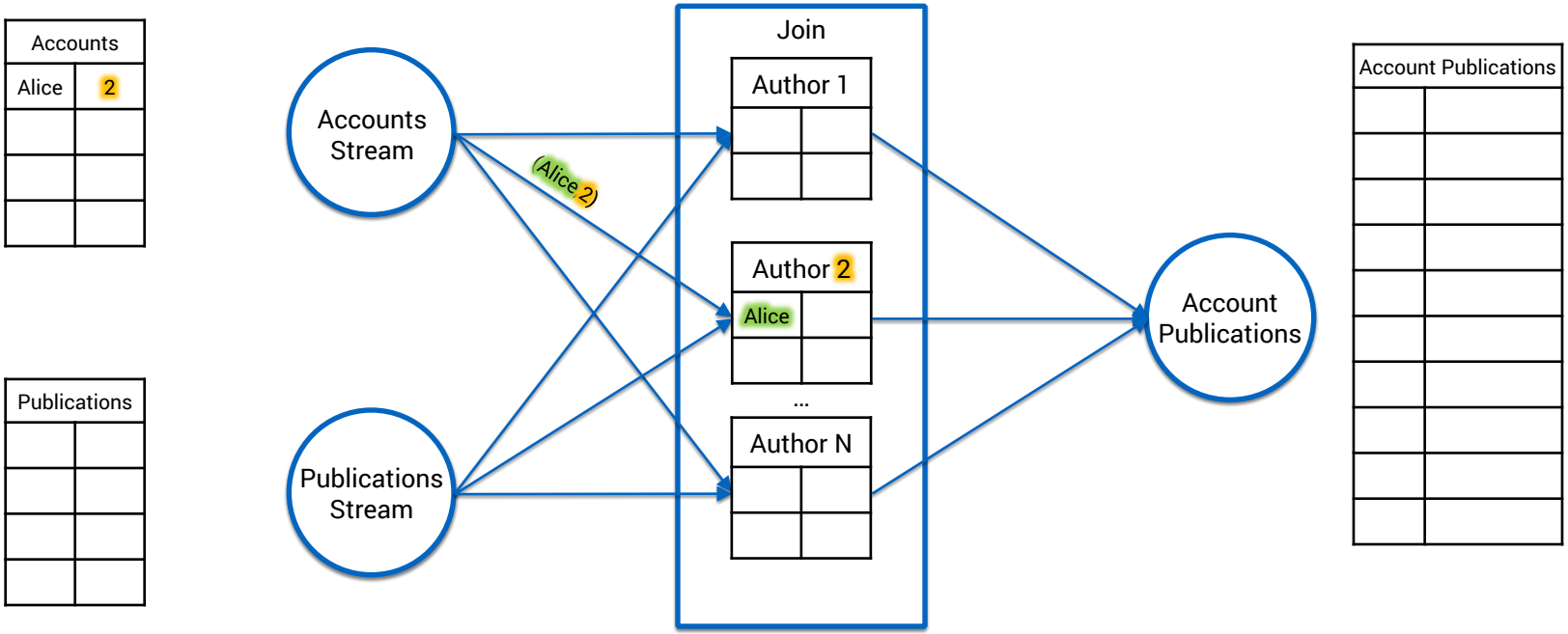
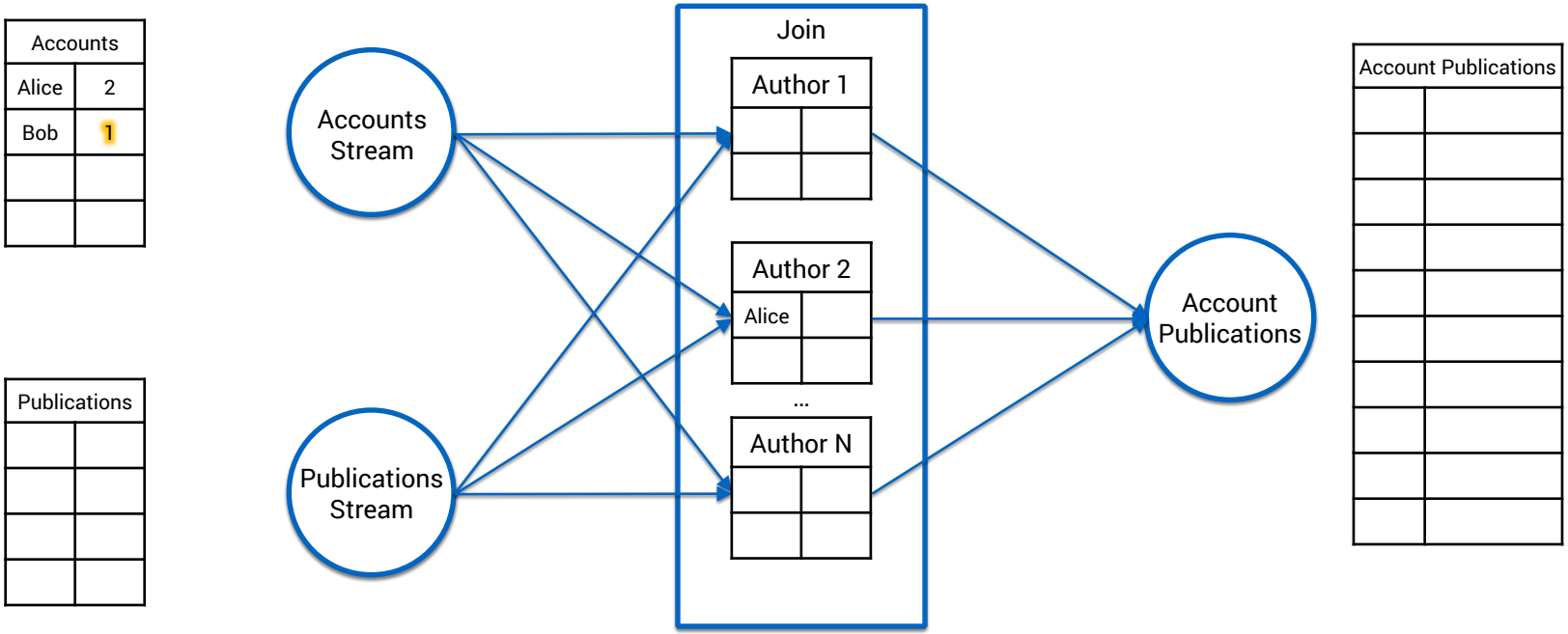


Example dataflow



Example dataflow



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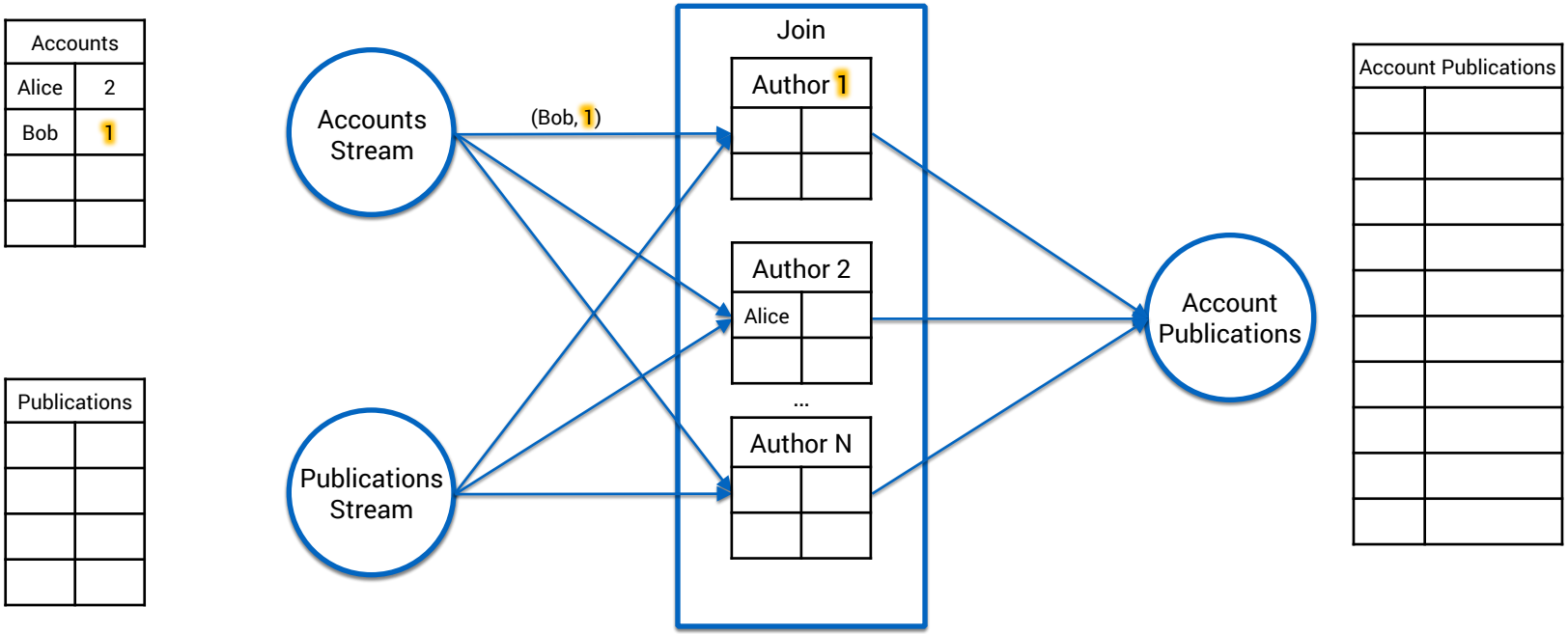

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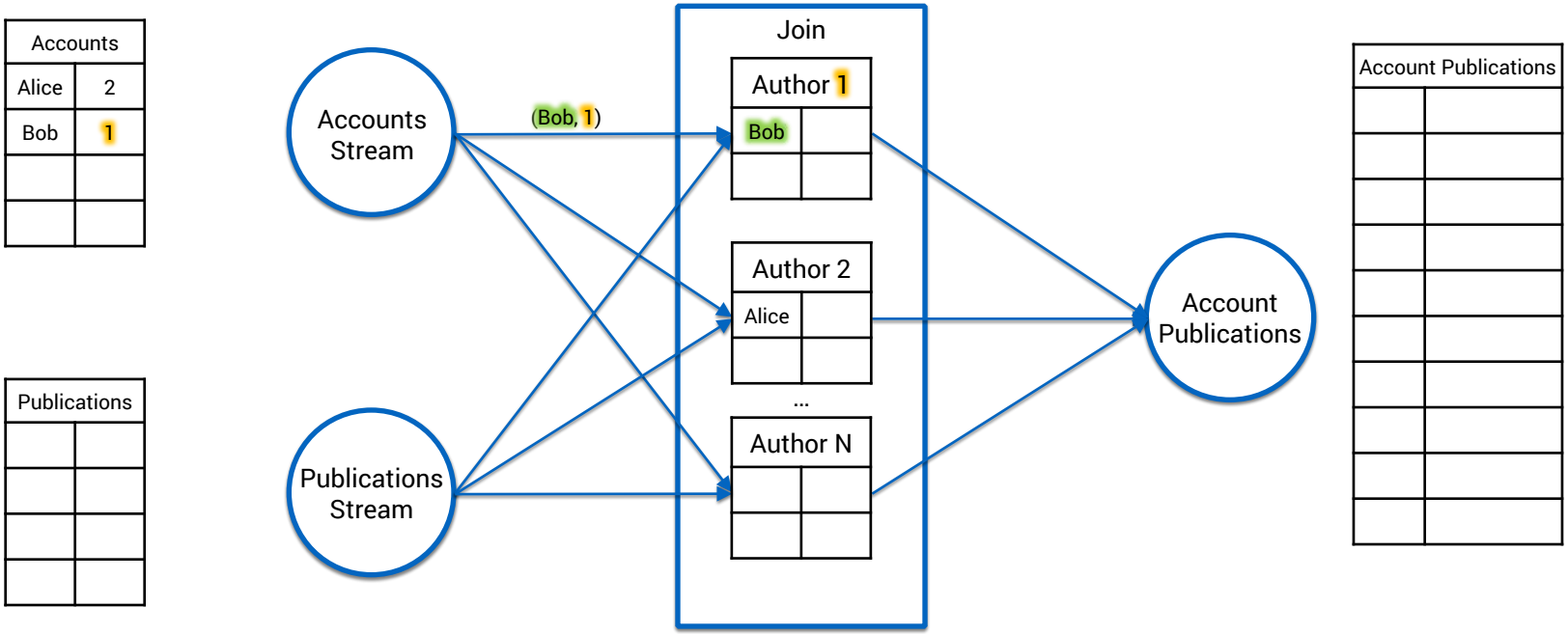

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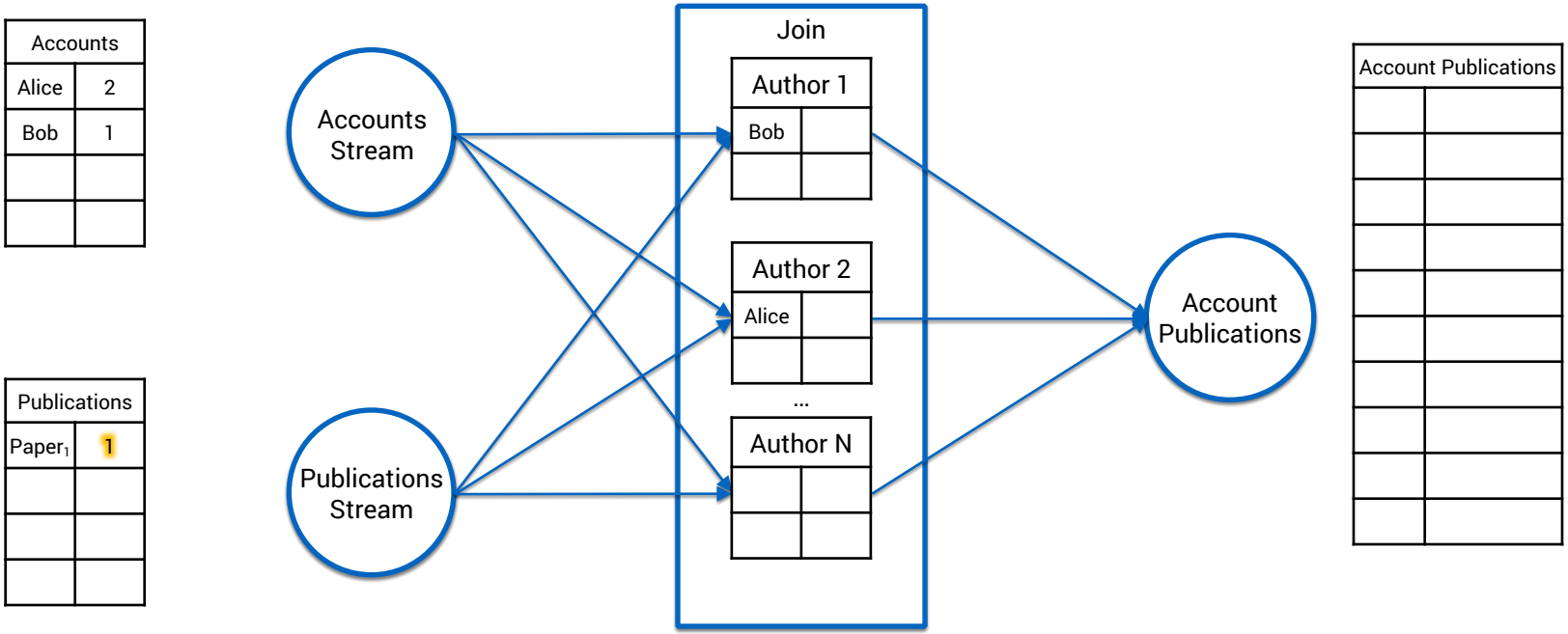

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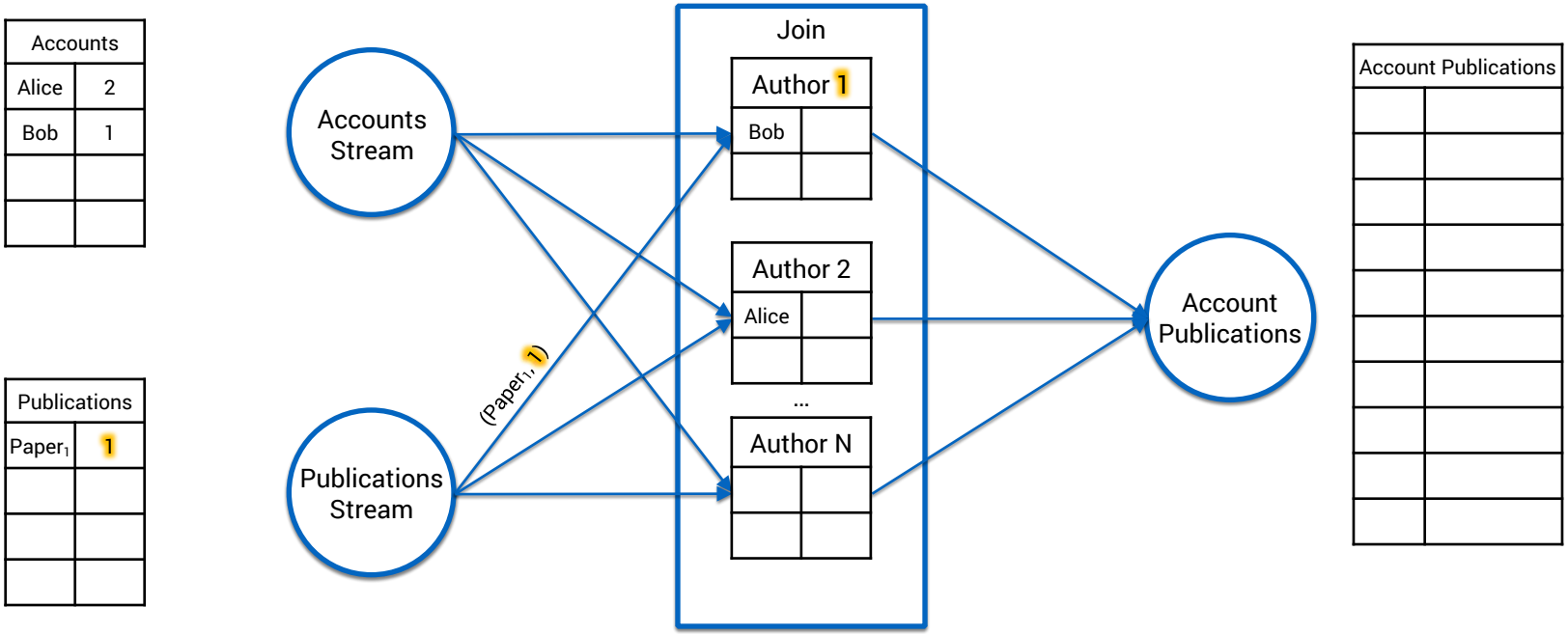

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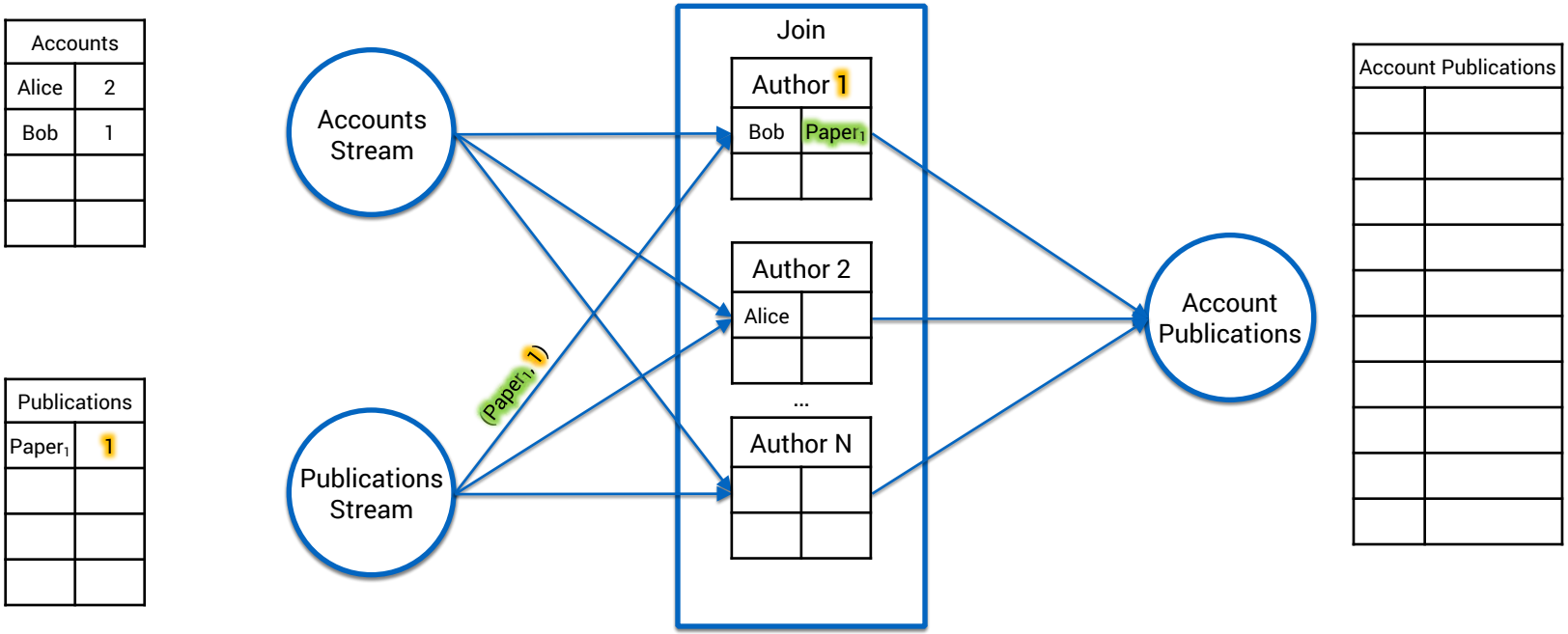

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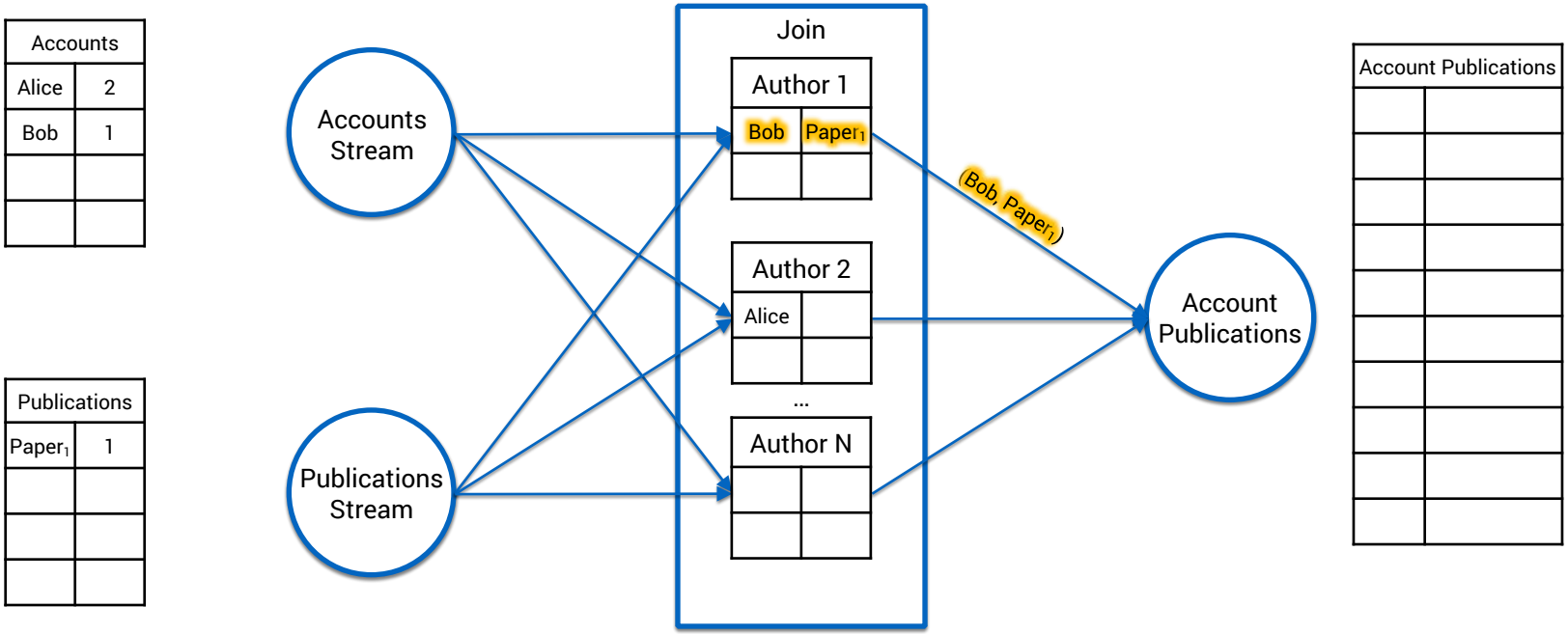
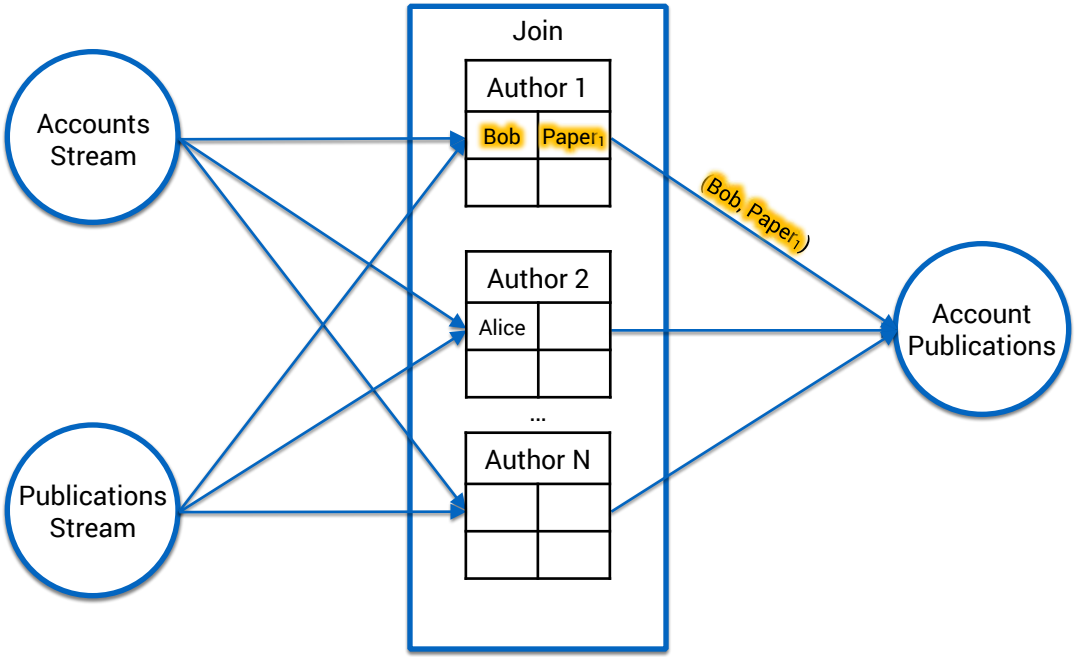


Example dataflow

Accounts	
Alice	2
Bob	1

Publications	
$Paper_1$	1



Account Publications	
K_1	(Bob, $Paper_1$)

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- ✔ Data sources are **distributed** across different DBs
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$Paper_1$ gets deleted

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Bob	1

Publications	
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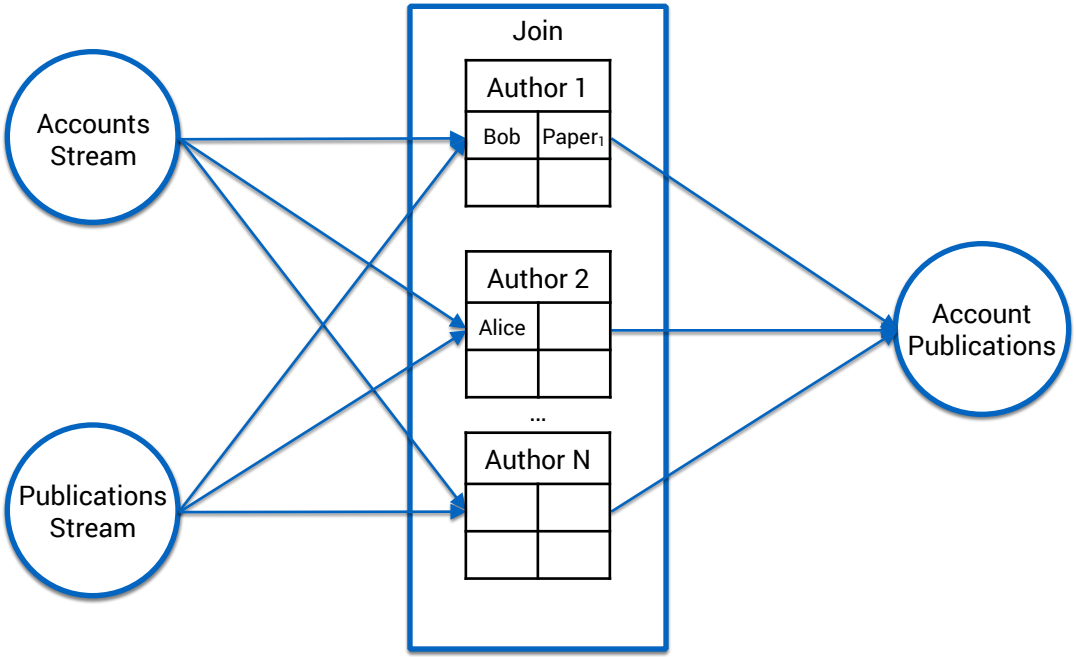
$Paper_1$	Ø



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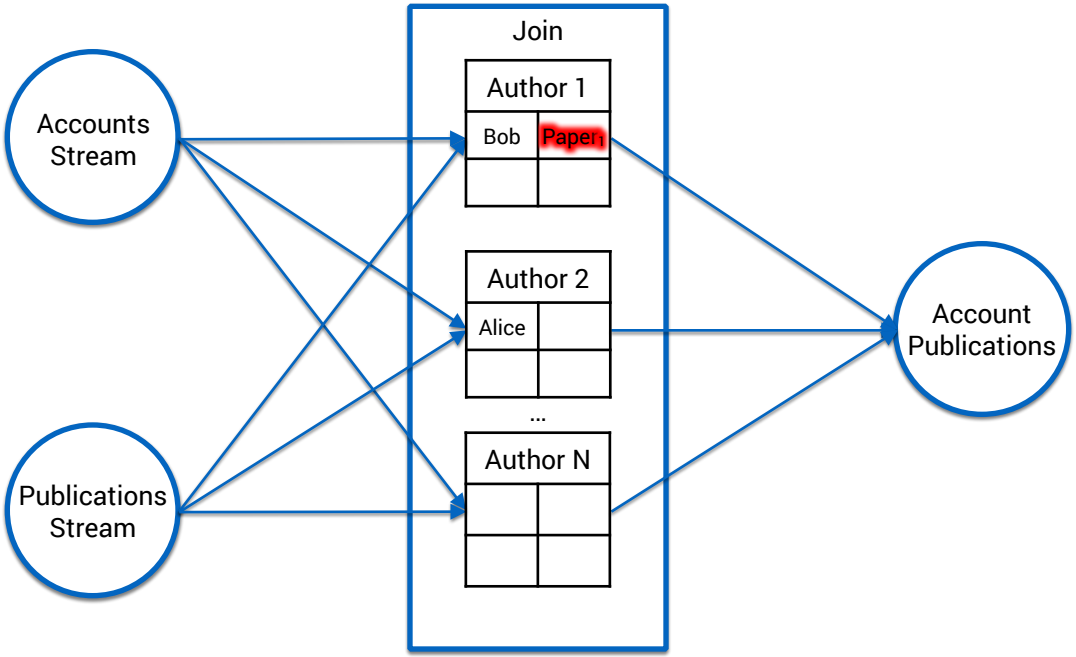

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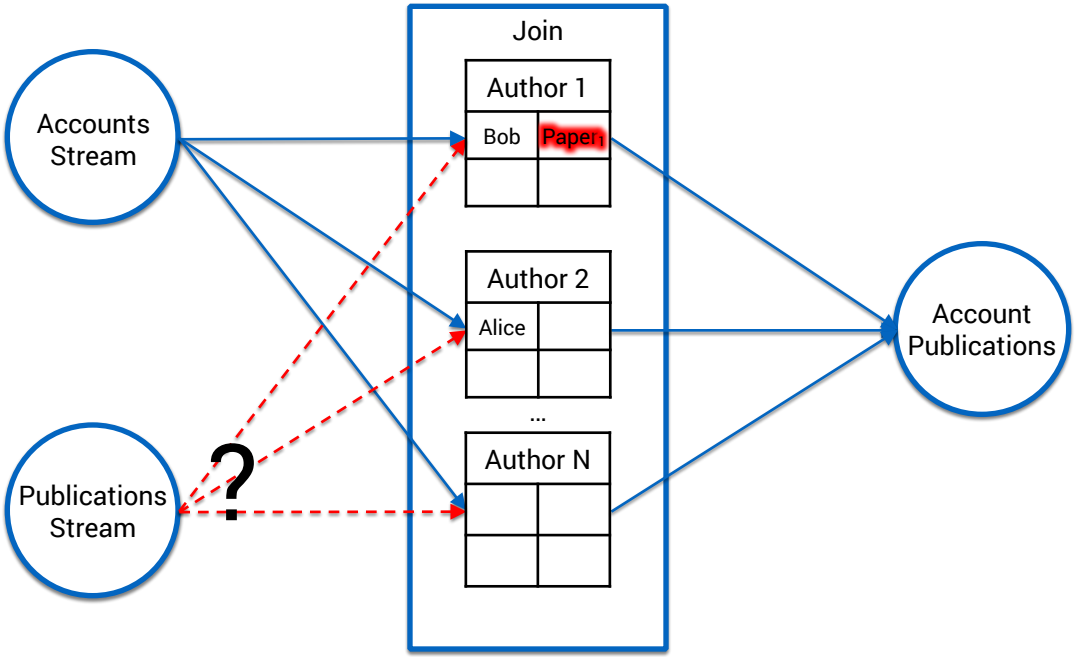

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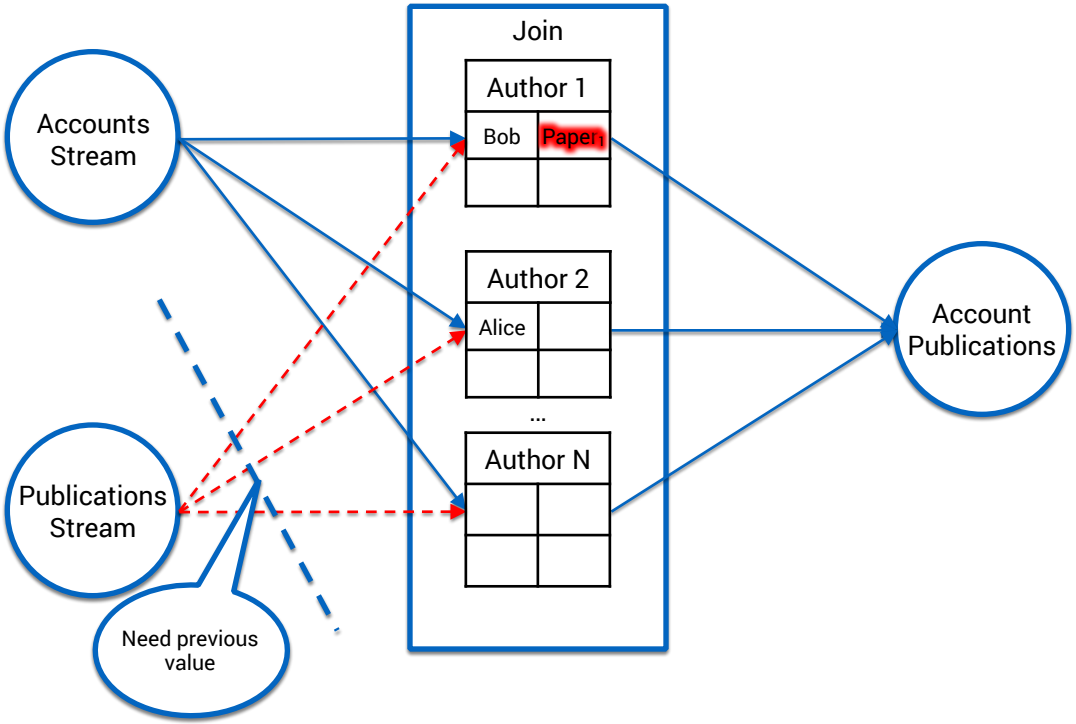

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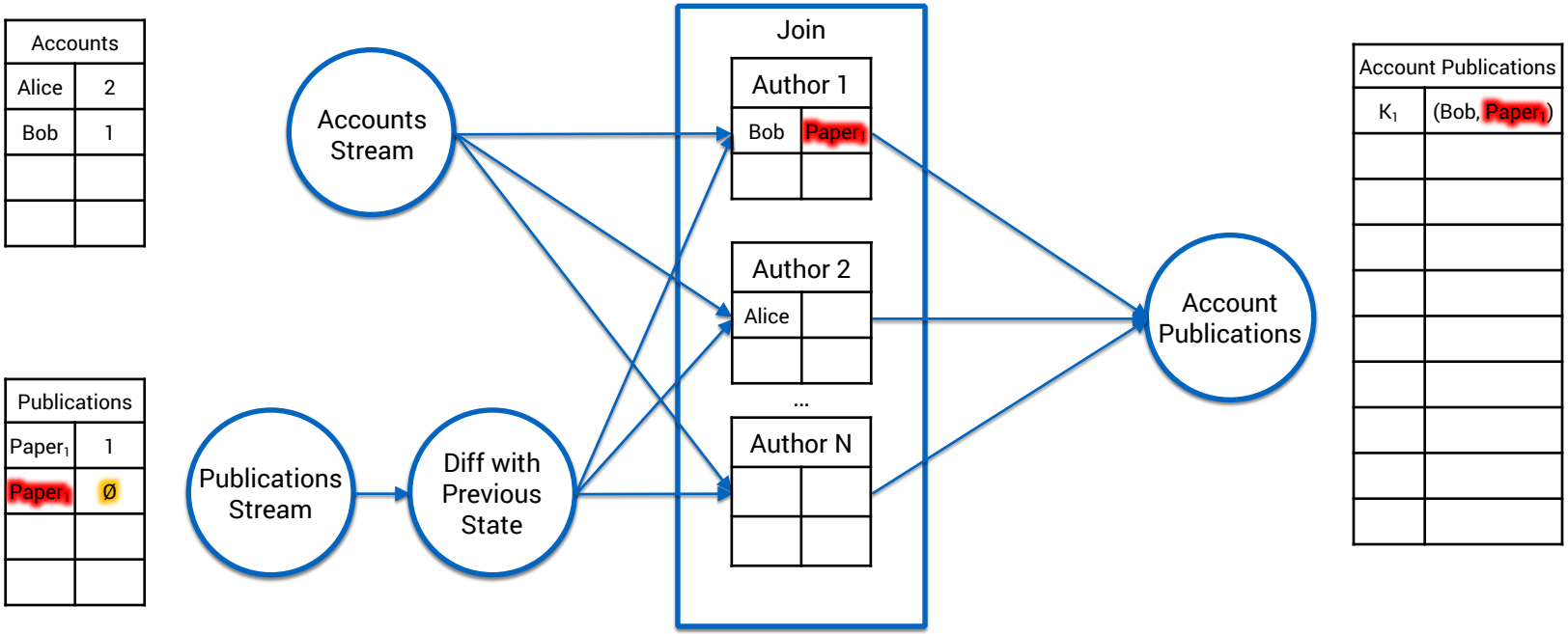

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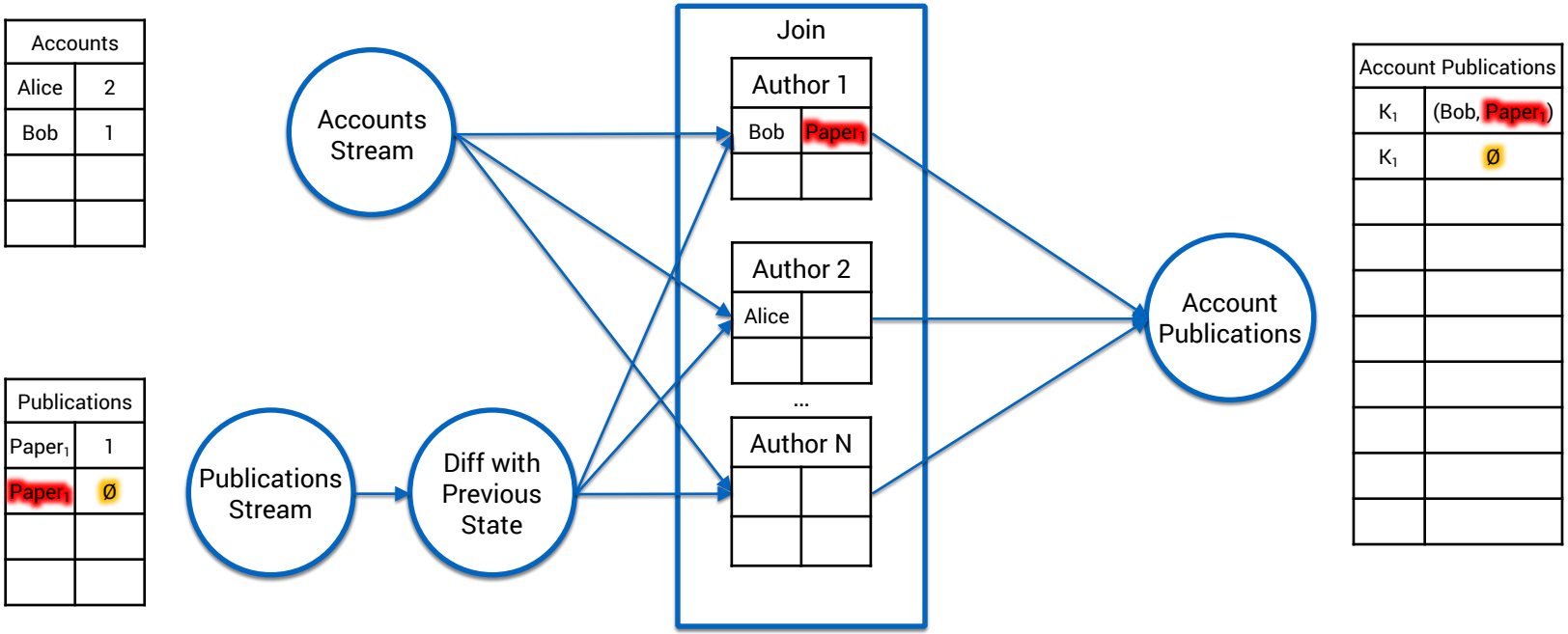

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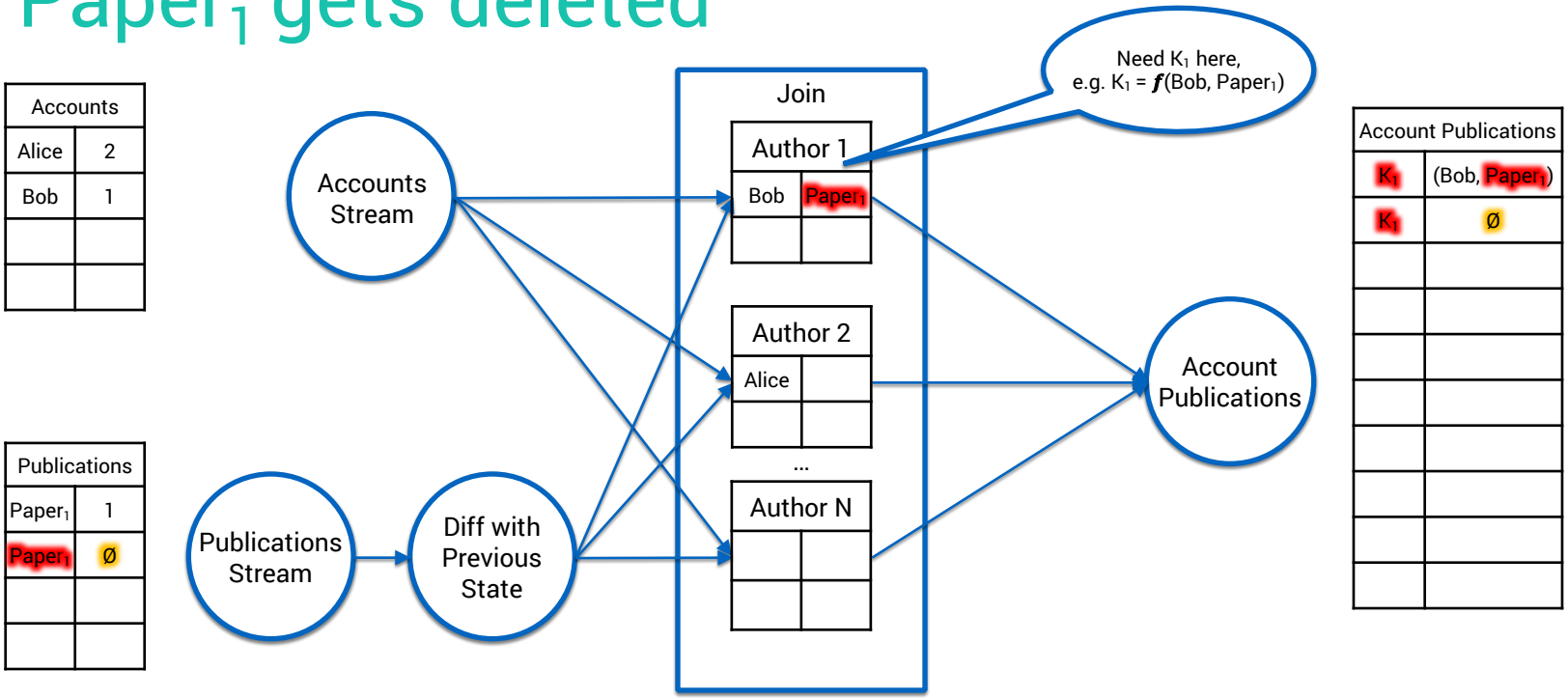

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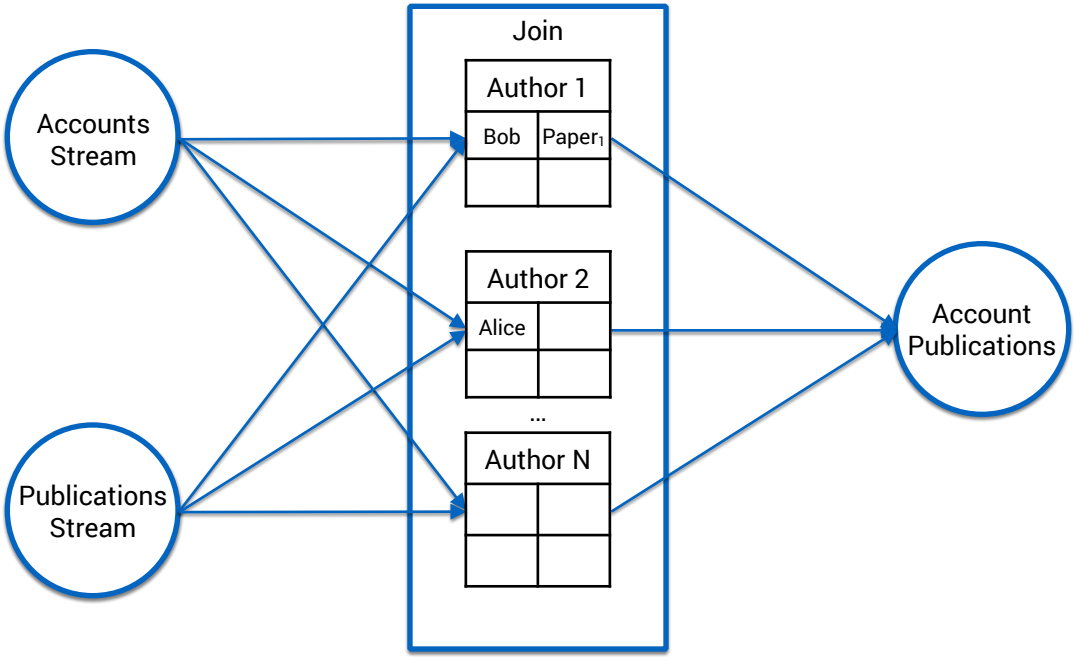

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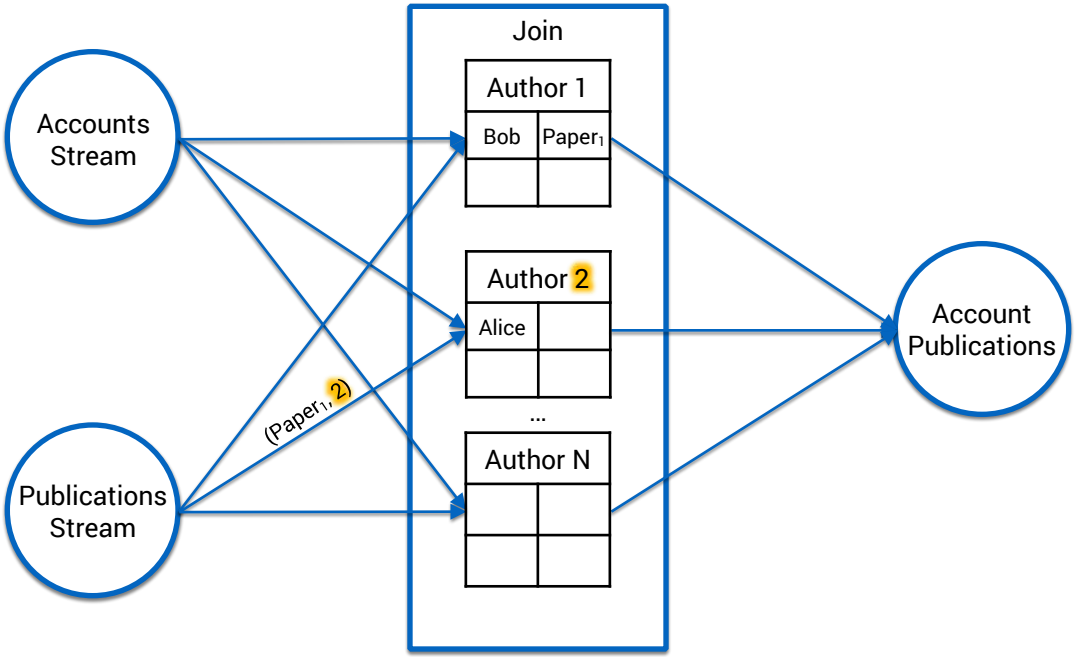

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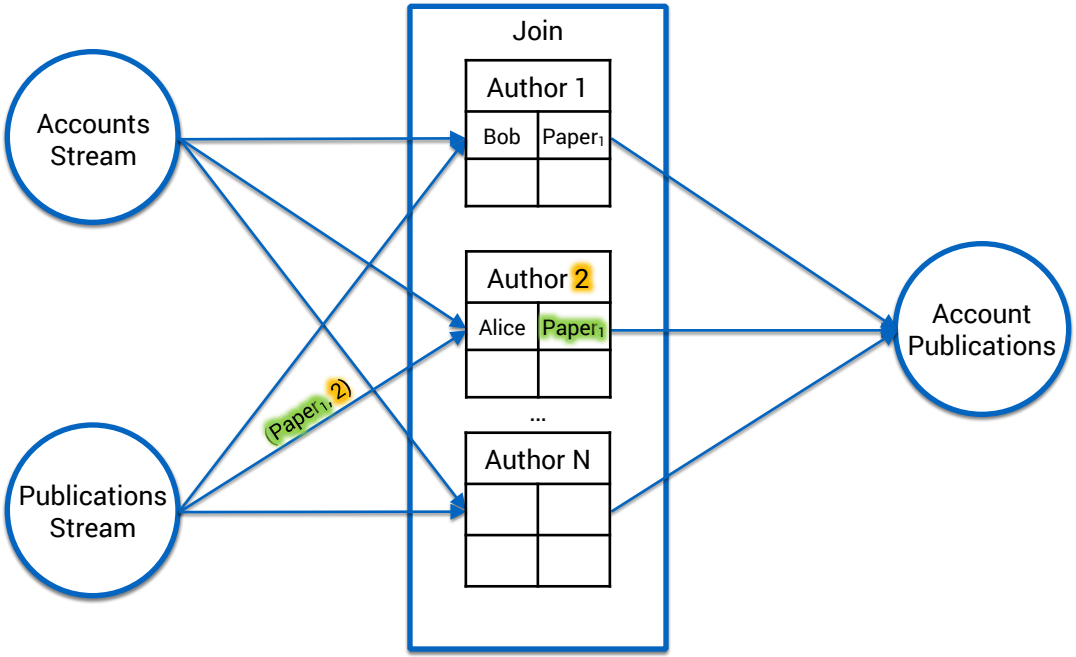
$Paper_1$	1
$Paper_1$	2

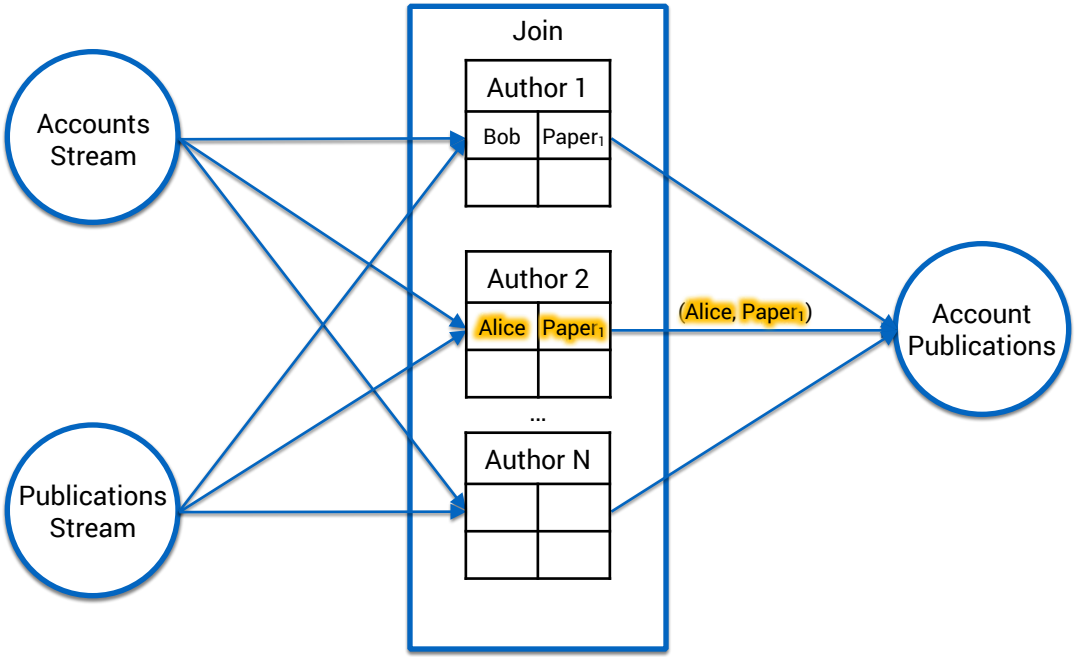


Account Publications	
K_1	(Bob, $Paper_1$)

$Paper_1$ gets updated

Accounts	
Alice	2
Bob	1

Publications	
$Paper_1$	1
$Paper_1$	2

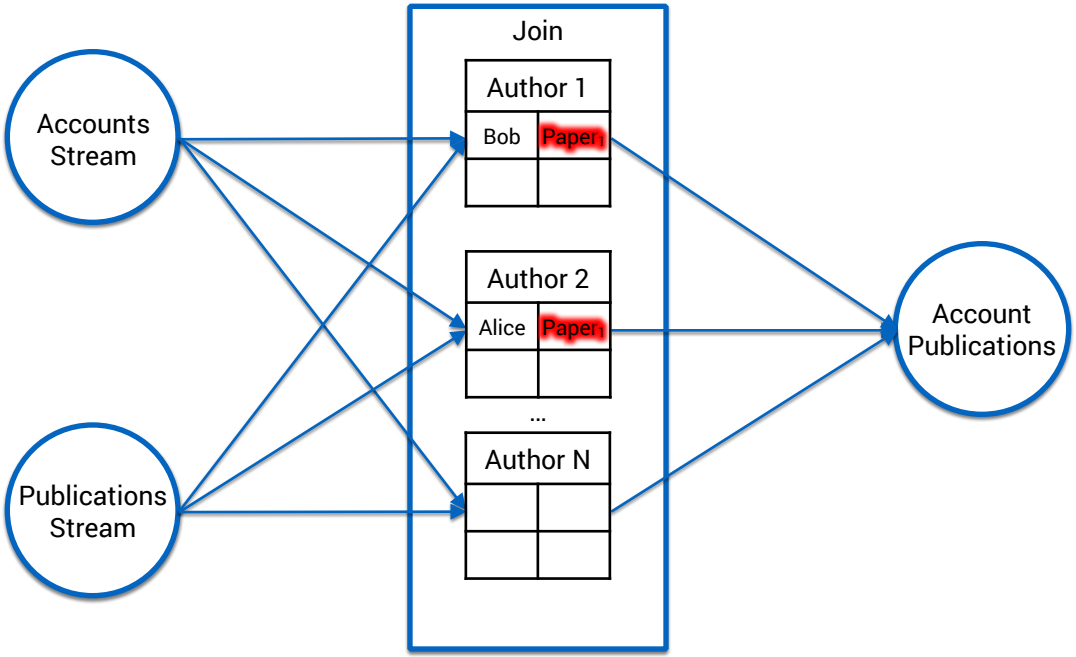


Account Publications	
K_1	(Bob, $Paper_1$)
	(Alice, $Paper_1$)

$Paper_1$ gets updated

Accounts	
Alice	2
Bob	1

Publications	
$Paper_1$	1
$Paper_1$	2

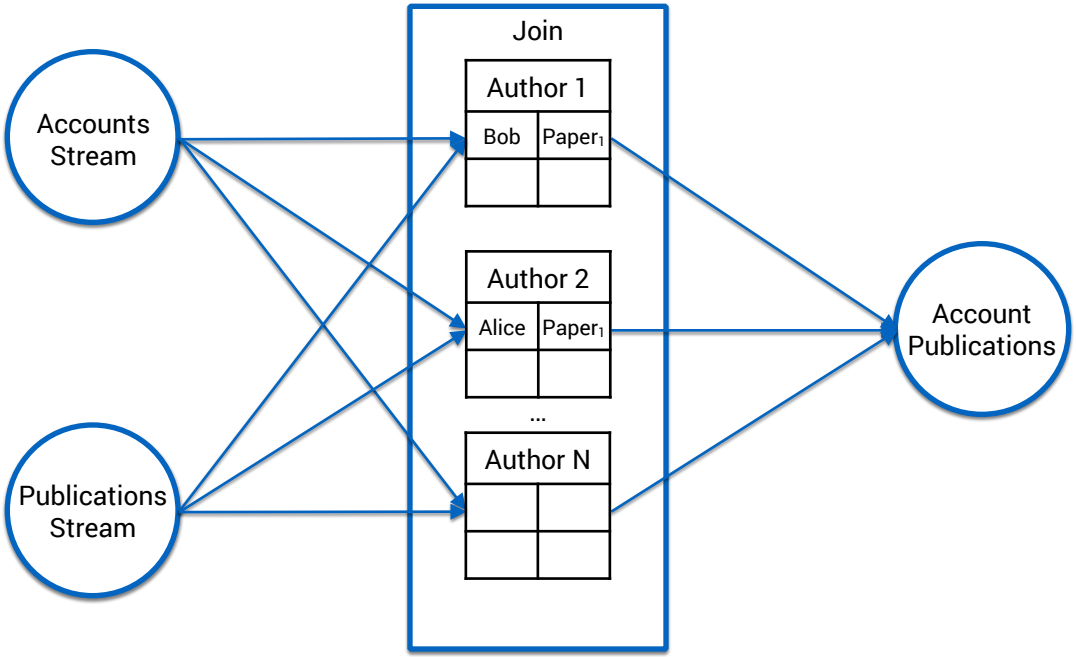


Account Publications	
K_1	(Bob, $Paper_1$)
??	(Alice, $Paper_1$)

Alice claims $Paper_1$ via different author

Accounts	
Alice	2
Bob	1

Publications	
$Paper_1$	1
$Paper_1$	(1, 2)

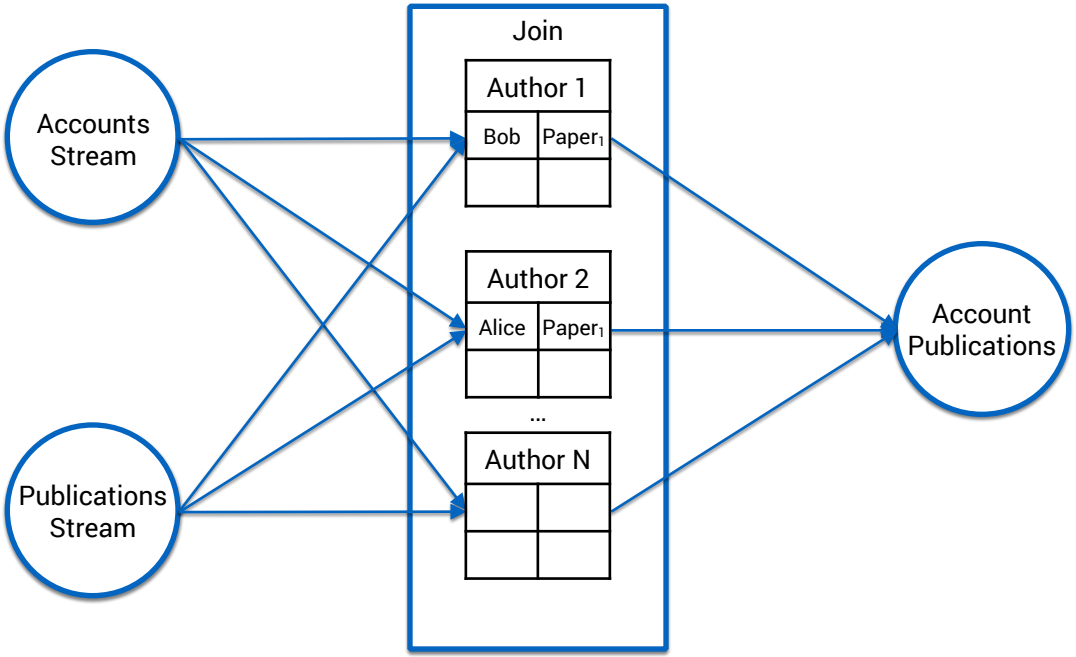


Account Publications	
K_1	(Bob, $Paper_1$)
K_2	(Alice, $Paper_1$)

Alice claims $Paper_1$ via different author

Accounts	
Alice	2
Bob	1
Bob	Ø

Publications	
$Paper_1$	1
$Paper_1$	(1, 2)

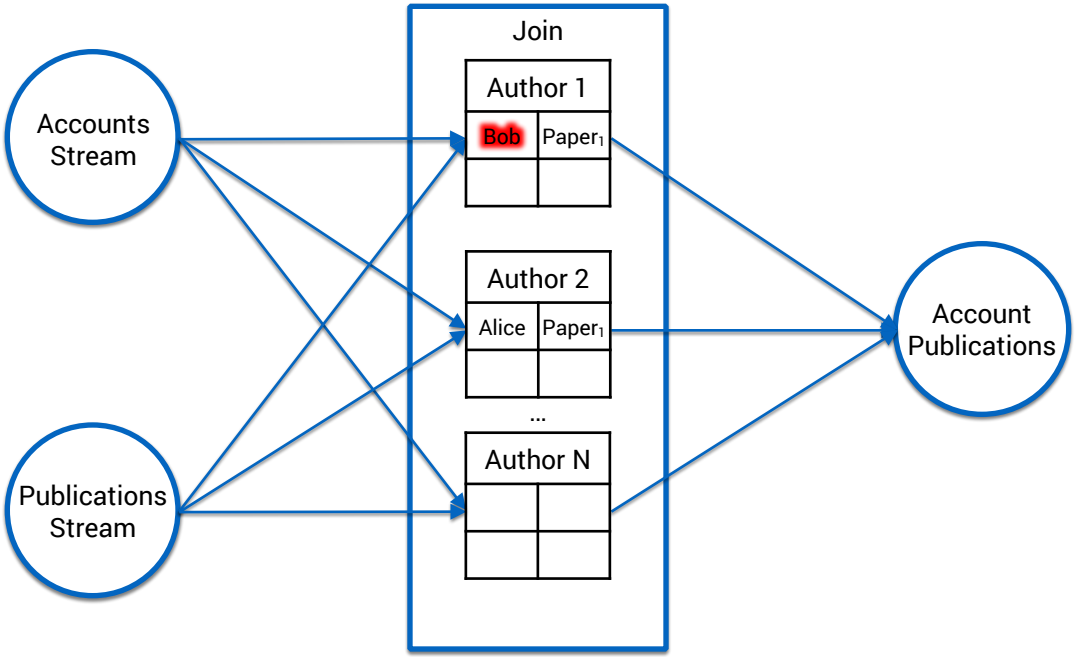


Account Publications	
K_1	(Bob, $Paper_1$)
K_2	(Alice, $Paper_1$)

Alice claims $Paper_1$ via different author

Accounts	
Alice	2
Bob	1
Bob	Ø

Publications	
$Paper_1$	1
$Paper_1$	(1, 2)

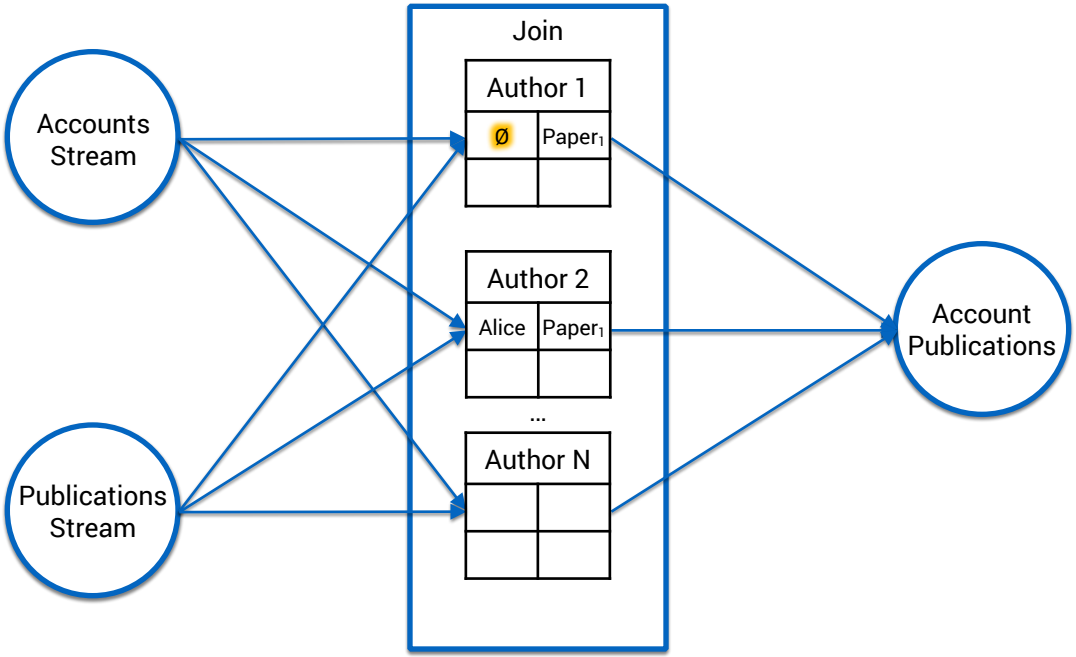


Account Publications	
K_1	(Bob, $Paper_1$)
K_2	(Alice, $Paper_1$)

Alice claims $Paper_1$ via different author

Accounts	
Alice	2
Bob	1
Bob	Ø

Publications	
$Paper_1$	1
$Paper_1$	(1, 2)

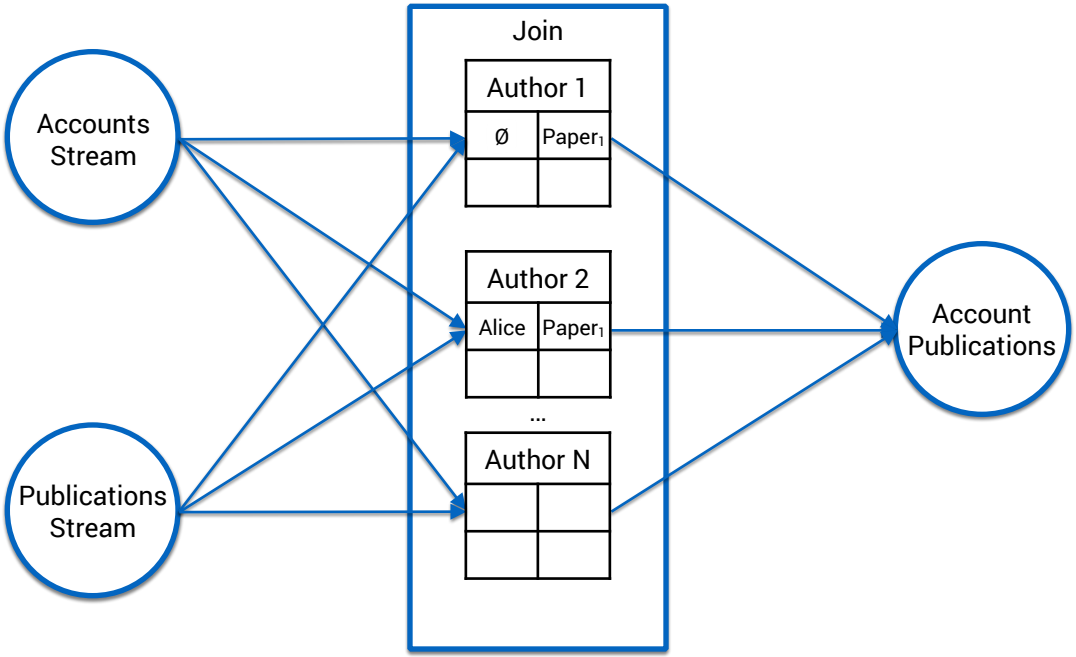


Account Publications	
K_1	(Bob, $Paper_1$)
K_2	(Alice, $Paper_1$)
K_1	Ø

Alice claims $Paper_1$ via different author

Accounts	
Alice	2
Bob	1
Bob	Ø

Publications	
$Paper_1$	1
$Paper_1$	(1, 2)

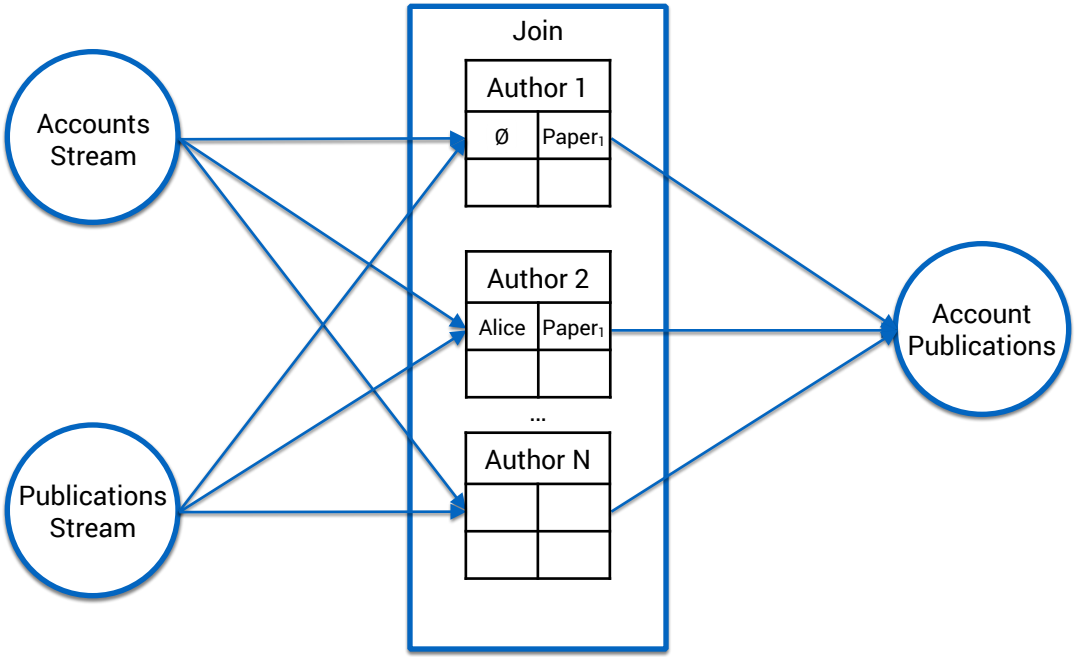


Account Publications	
K_1	(Bob, $Paper_1$)
K_2	(Alice, $Paper_1$)
K_1	Ø

Alice claims $Paper_1$ via different author

Accounts	
Alice	2
Bob	1
Bob	Ø
Alice	1

Publications	
$Paper_1$	1
$Paper_1$	(1, 2)

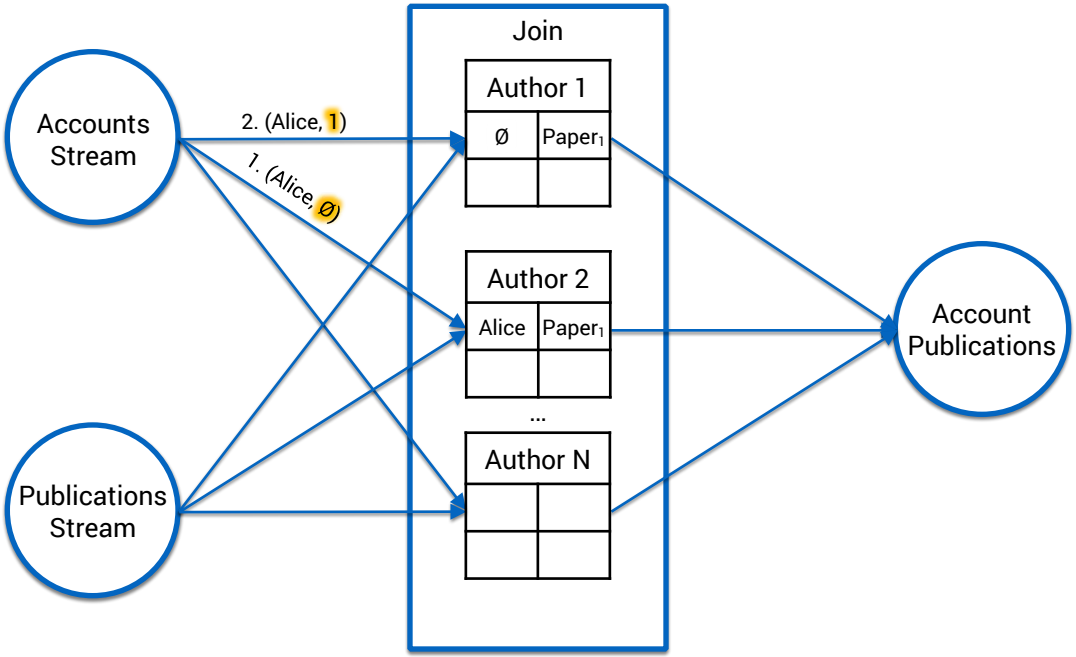


Account Publications	
K_1	(Bob, $Paper_1$)
K_2	(Alice, $Paper_1$)
K_1	Ø

Alice claims $Paper_1$ via different author

Accounts	
Alice	2
Bob	1
Bob	Ø
Alice	1

Publications	
$Paper_1$	1
$Paper_1$	(1, 2)

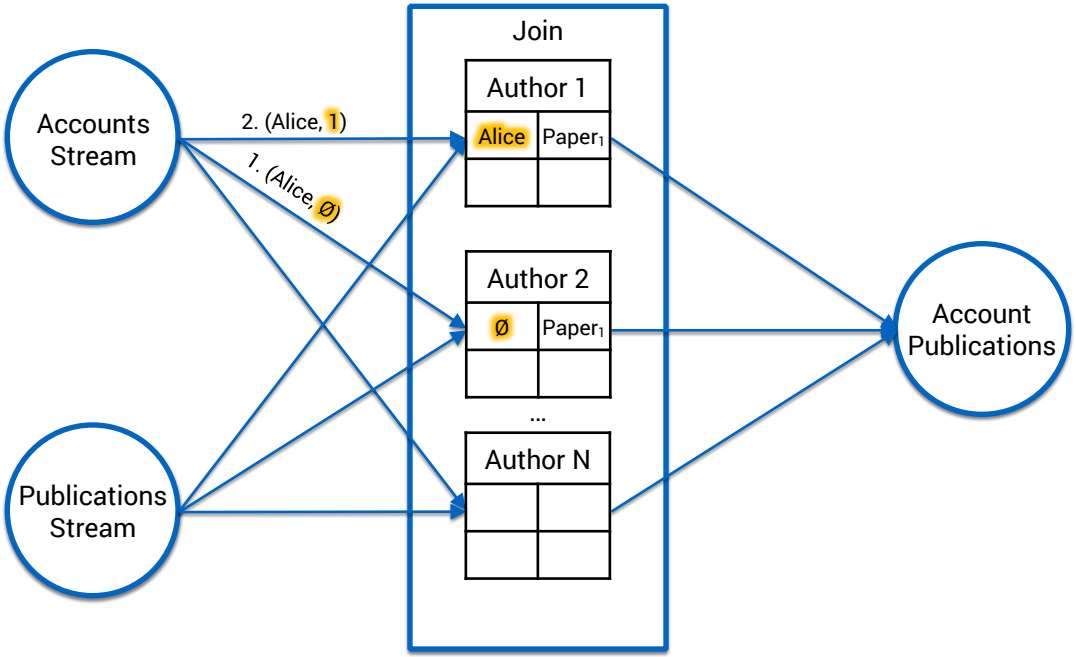


Account Publications	
K_1	(Bob, $Paper_1$)
K_2	(Alice, $Paper_1$)
K_1	Ø

Alice claims $Paper_1$ via different author

Accounts	
Alice	2
Bob	1
Bob	Ø
Alice	1

Publications	
$Paper_1$	1
$Paper_1$	(1, 2)

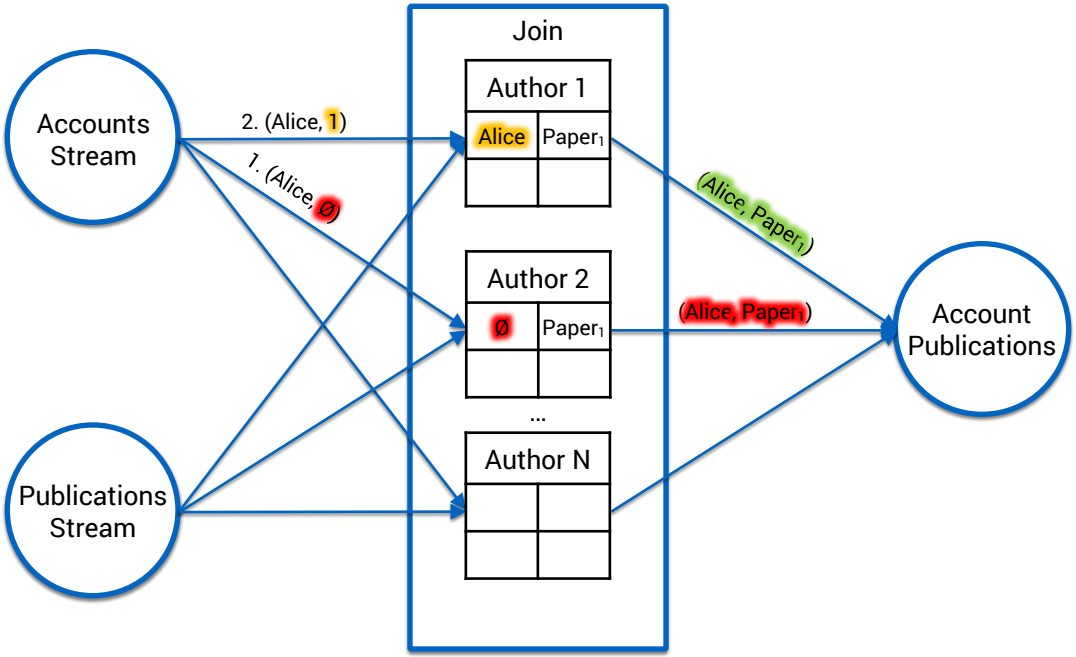


Account Publications	
K_1	(Bob, $Paper_1$)
K_2	(Alice, $Paper_1$)
K_1	Ø

Alice claims $Paper_1$ via different author

Accounts	
Alice	2
Bob	1
Bob	Ø
Alice	1

Publications	
$Paper_1$	1
$Paper_1$	(1, 2)

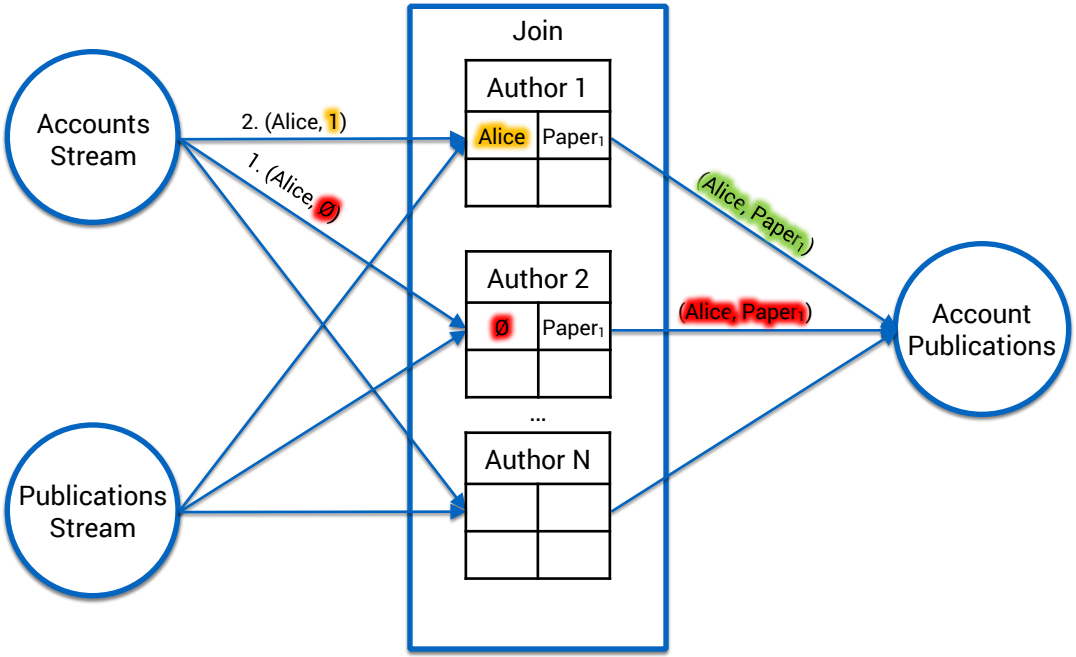


Account Publications	
K_1	(Bob, $Paper_1$)
K_2	(Alice, $Paper_1$)
K_1	Ø

Alice claims $Paper_1$ via different author

Accounts	
Alice	2
Bob	1
Bob	Ø
Alice	1

Publications	
$Paper_1$	1
$Paper_1$	(1, 2)

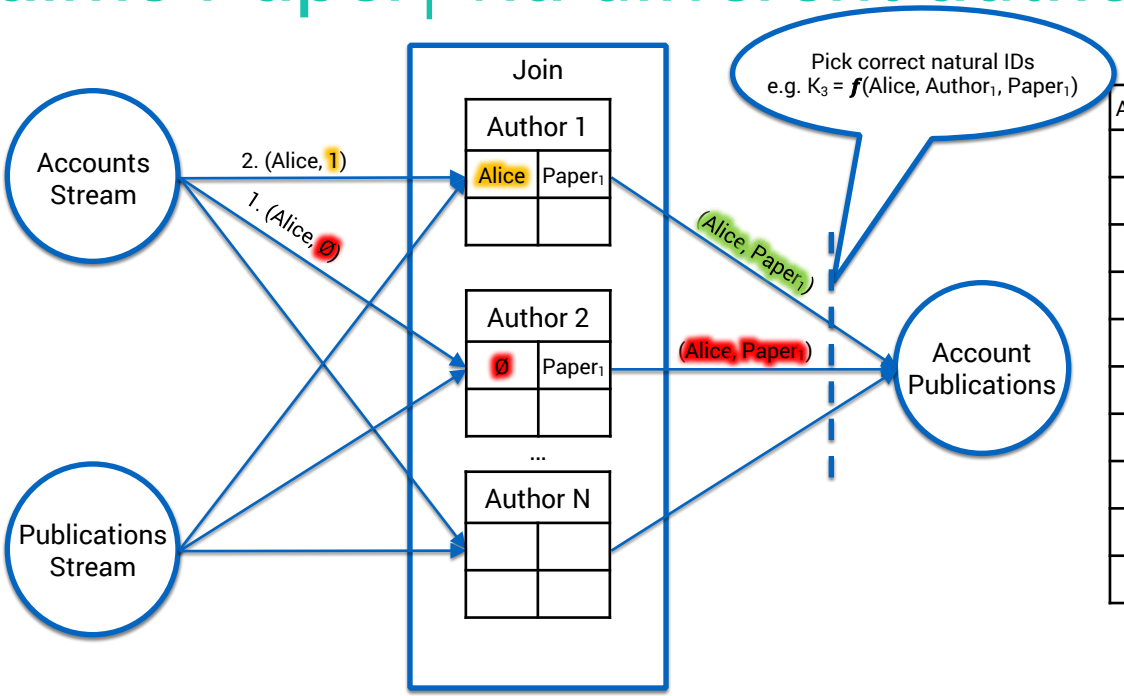


Account Publications	
K_1	(Bob, $Paper_1$)
K_2	(Alice, $Paper_1$)
K_1	Ø
K_2	(Alice, $Paper_1$)
K_2	Ø

Alice claims $Paper_1$ via different author

Accounts	
Alice	2
Bob	1
Bob	Ø
Alice	1

Publications	
$Paper_1$	1
$Paper_1$	(1, 2)

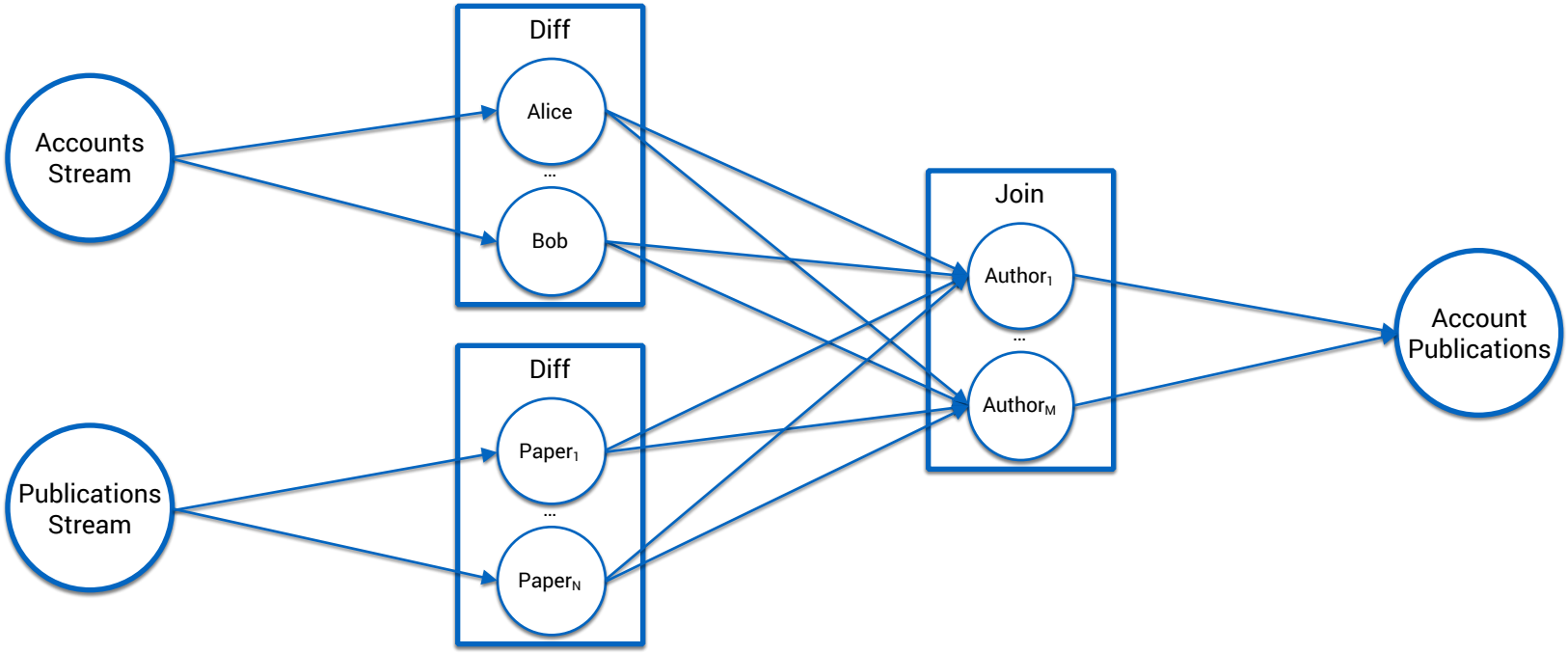


Account Publications	
K_1	(Bob, $Paper_1$)
K_2	(Alice, $Paper_1$)
K_1	Ø
K_3	(Alice, $Paper_1$)
K_2	Ø

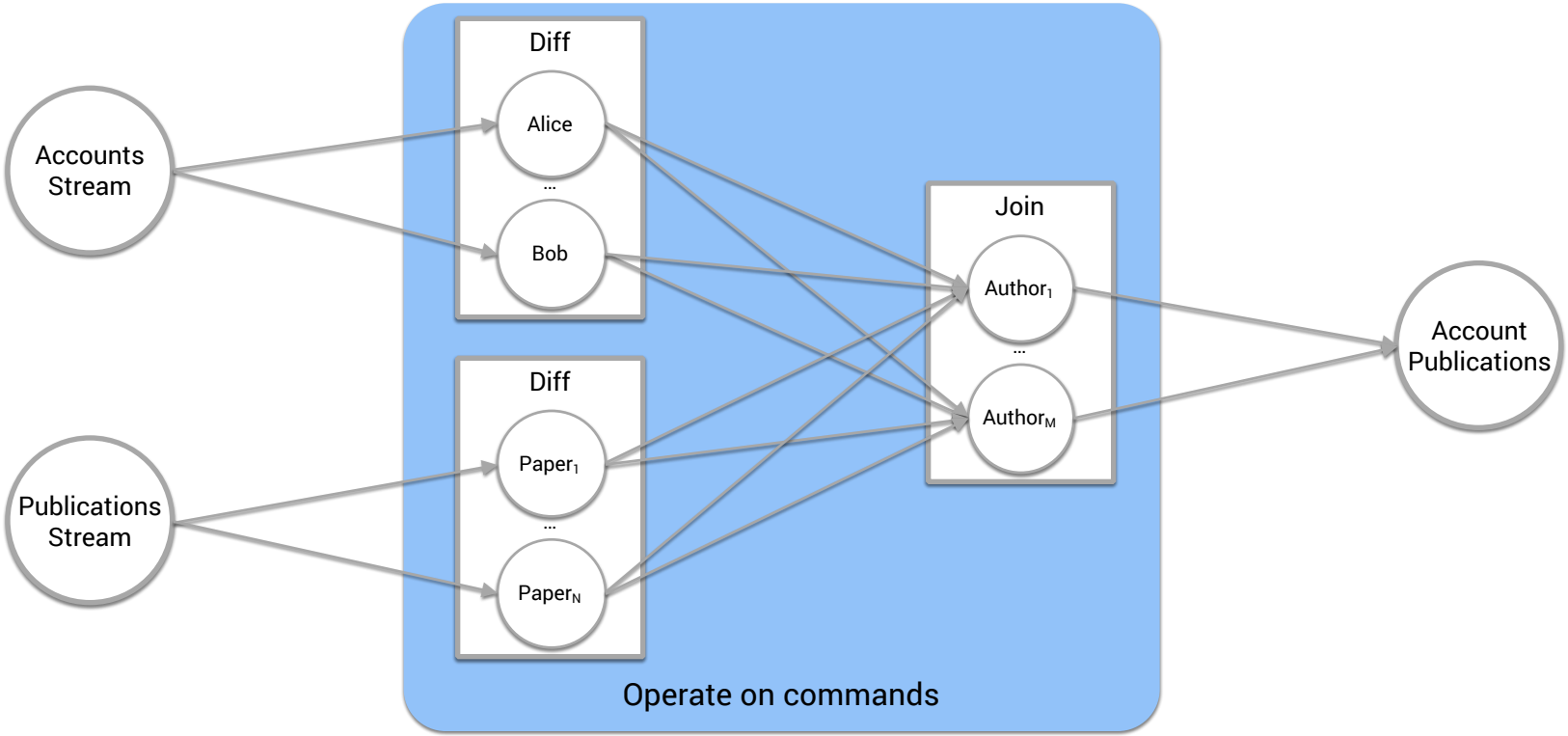
How to solve deletes and updates

- Keep **previous element state** to update previous join result
- Stream elements are not domain entities but **commands** such as delete or upsert
- Joined stream must have **natural IDs** to propagate deletes and updates

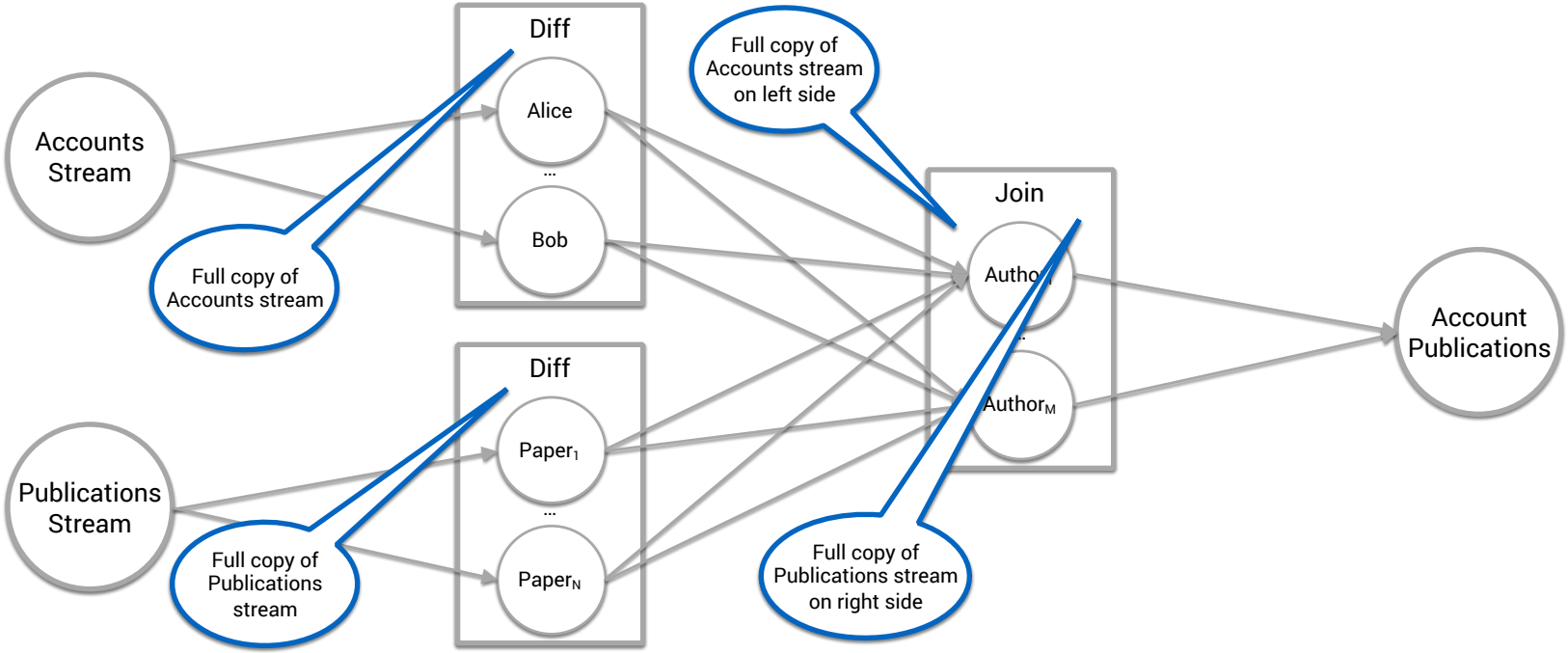
Generic join graph



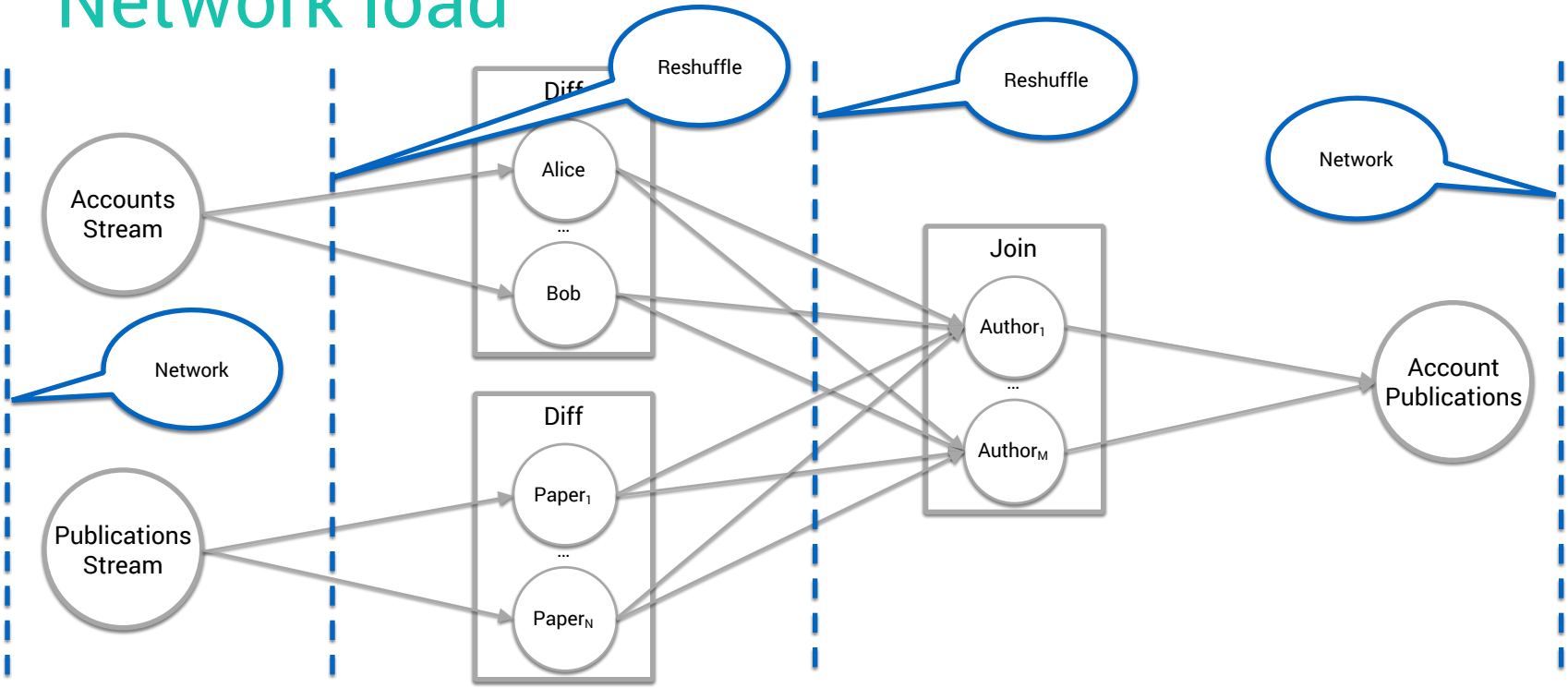
Generic join graph



Memory requirements



Network load



Resource considerations

- In addition to handling Kafka traffic we need to **reshuffle all data twice** over the network

- We need to **keep two full copies** of each joined stream in memory

Questions

We are hiring - www.researchgate.net/careers

ResearchGate

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Background

General properties

Human adenoviruses (HAdV) are causing a broad spectrum of diseases. One of the most severe forms of adenovirus infection is a disseminated disease resulting in significant morbidity and mortality. Several reports in recent years have identified HAdV-31 from species A (HAdV-A31) as a cause of disseminated disease in children following haematopoetic stem cell transplantation (hSCT) and liver transplantation. We sequenced and analyzed the complete genome of the HAdV-A31 prototype strain to uncover unique sequence motifs associated with its high virulence. Moreover, we sequenced coding regions[5] known to be essential for tropism and virulence (early transcription units E1A, E3, E4, the fiber knob and the penton base) of HAdV-A31 clinical isolates from patients with