Conflict-free Replicated Hypergraphs

Aruna Bansal

Indian Institute of Technology Delhi, India
Contact email: aruna.bansal.iitd@gmail.com

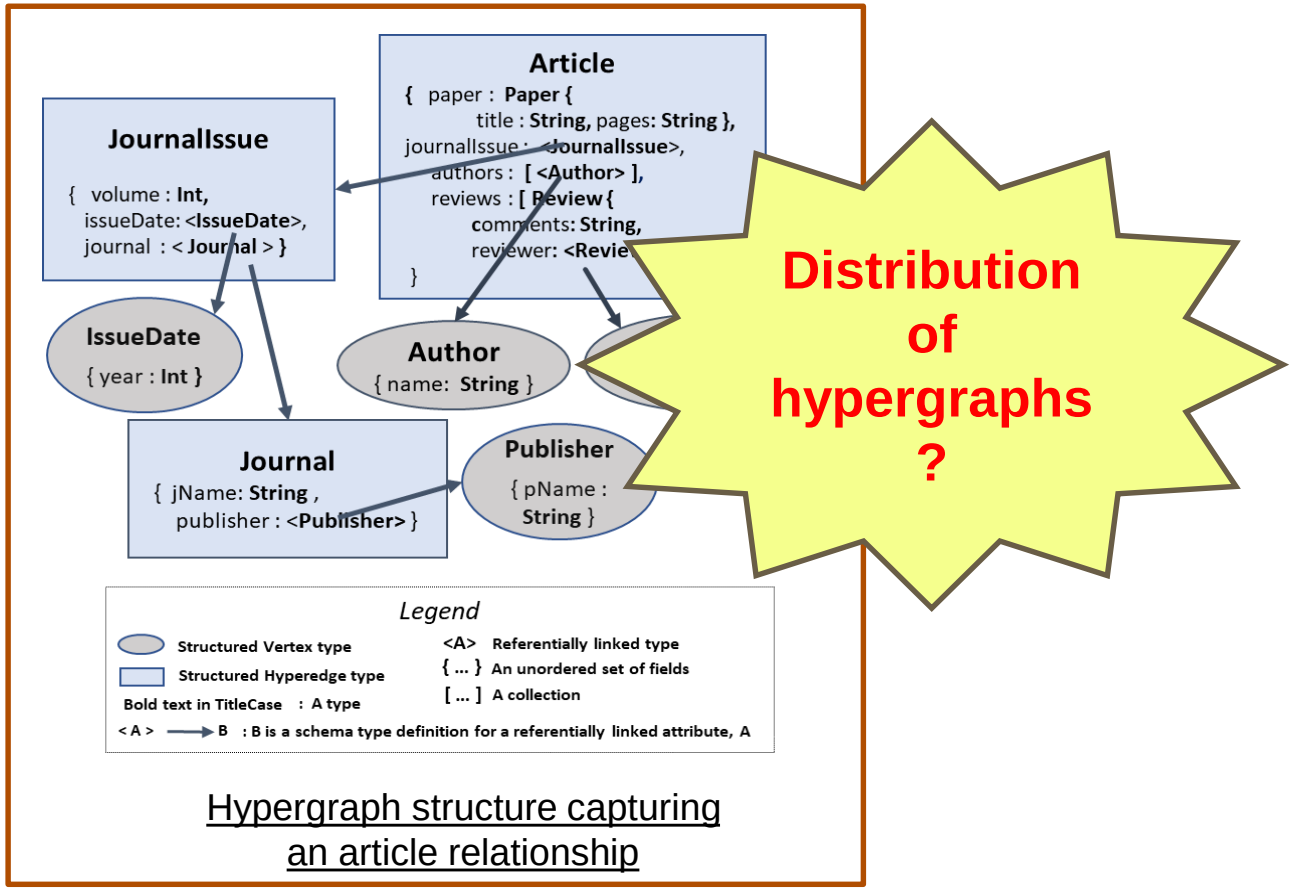
About presenter:

Aruna Bansal is currently a *Ph.D. Research Scholar* in the *Khosla School of Information Technology, Indian Institute of Technology Delhi (IIT Delhi), India*, working under the guidance of Prof. Sanjiva Prasad, IIT Delhi.
She obtained master's degrees in *Computer Science & Engineering (M.Tech.)*, and *Information Technology (M.Sc.)* from *Motilal Nehru National Institute of Technology*, and *Sam Higginbottom University of Agriculture, Technology and Sciences*, *India* in 2010, and 2002, respectively. She has also received a Bachelors' degree in *Commerce* from *University of Delhi, India*.
Her research interests include databases, mHealth, and distributed systems.

This paper is about…

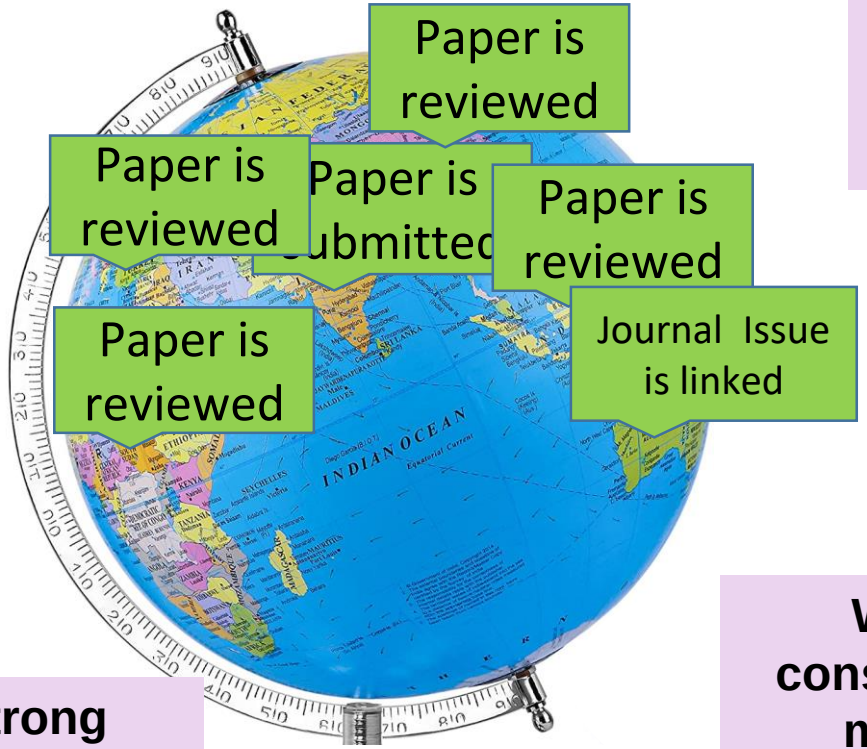
Proposing hypergraphs as a *conflict-free replicated data type.*

Hypergraphs



Hypergraph structure capturing an article relationship

A motivating scenario …



Information availability

Replication

Consistency

Strong Consistency

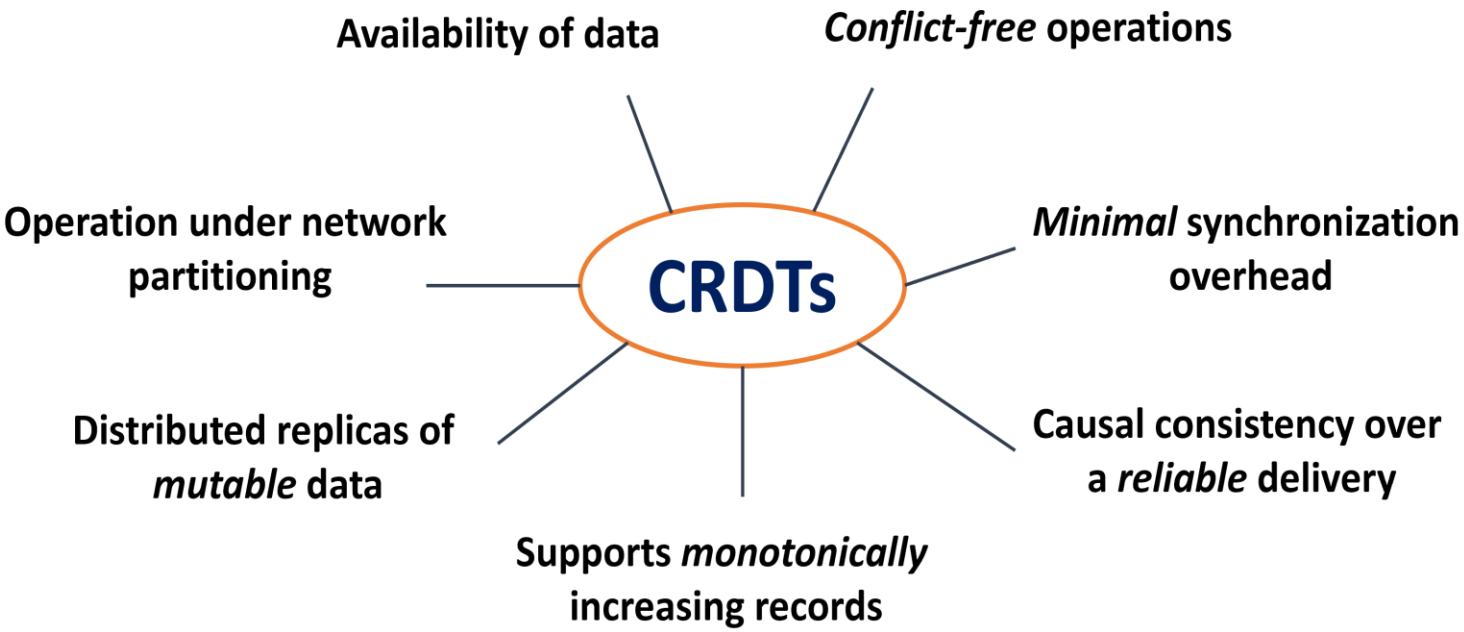
Conflict-free replicated data types (CRDTs)

Eventual consistency

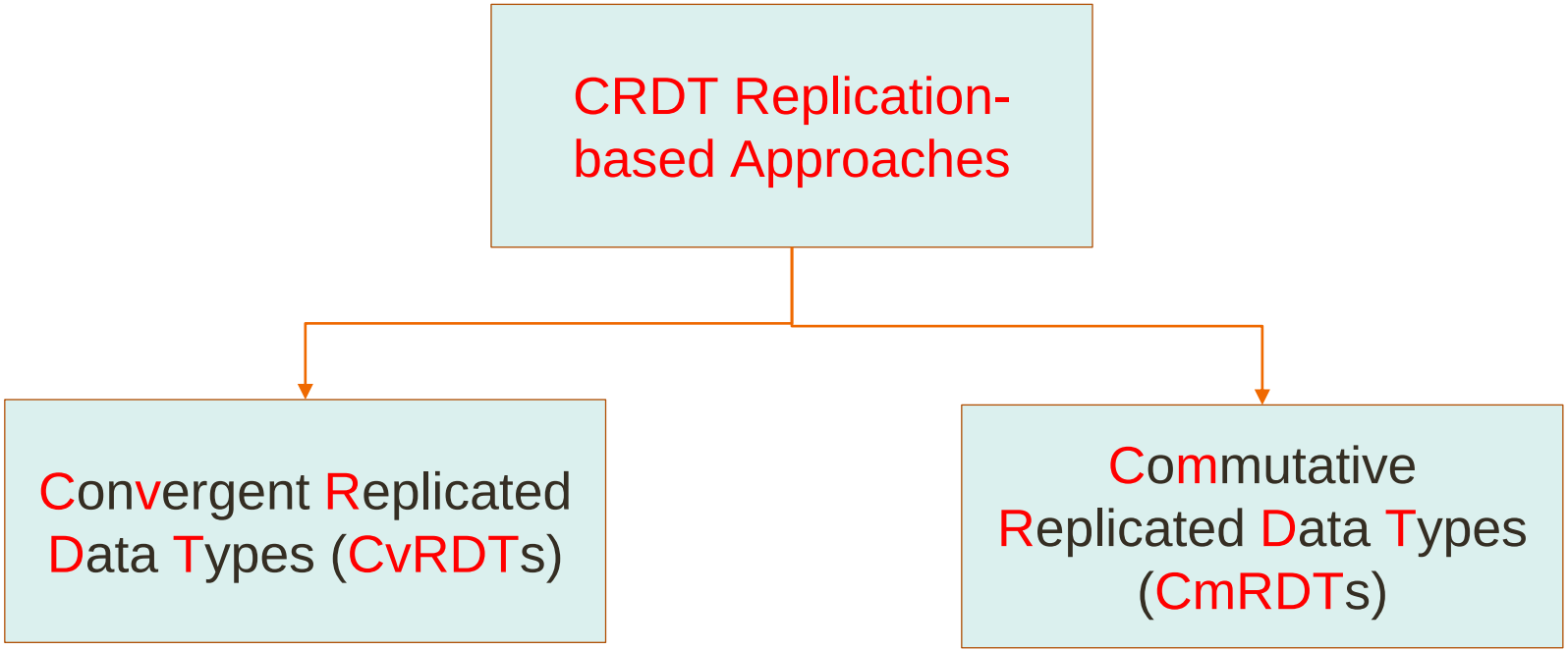
Weak consistency model

1. Shapiro, Marc, et al. "Conflict-free replicated data types." *Symposium on Self-Stabilizing Systems*. Springer, 2011.

Conflict-free Replicated Data Types (CRDTs)

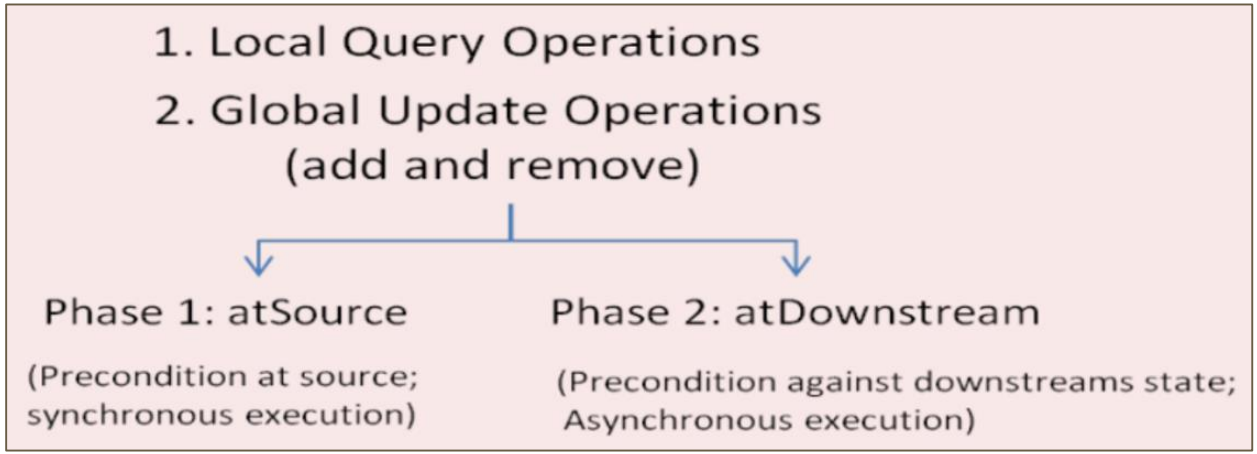


About CRDT ....

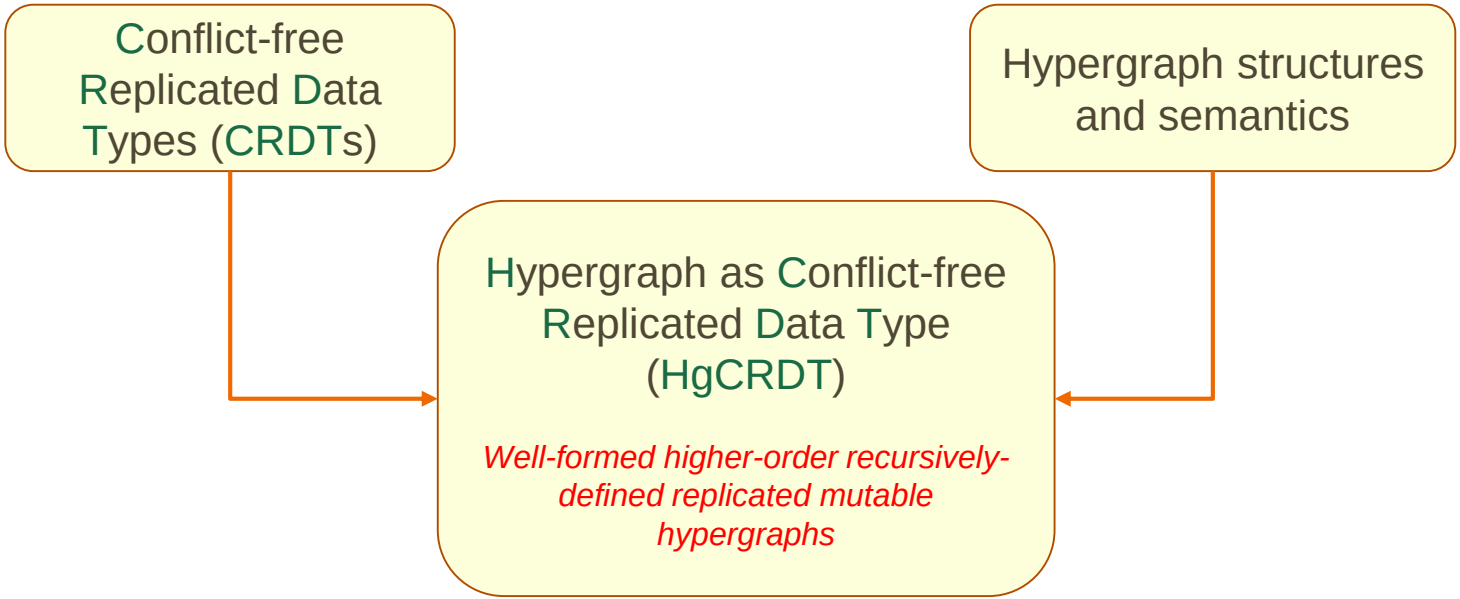

CRDT Replication-based Approaches
Convergent Replicated Data Types (CvRDTs)
Commutative Replicated Data Types (CmRDTs)

About CRDT ....

CRDT operations:



Contribution of the paper …



Hypergraphs in HgCRDT

Schema-oriented

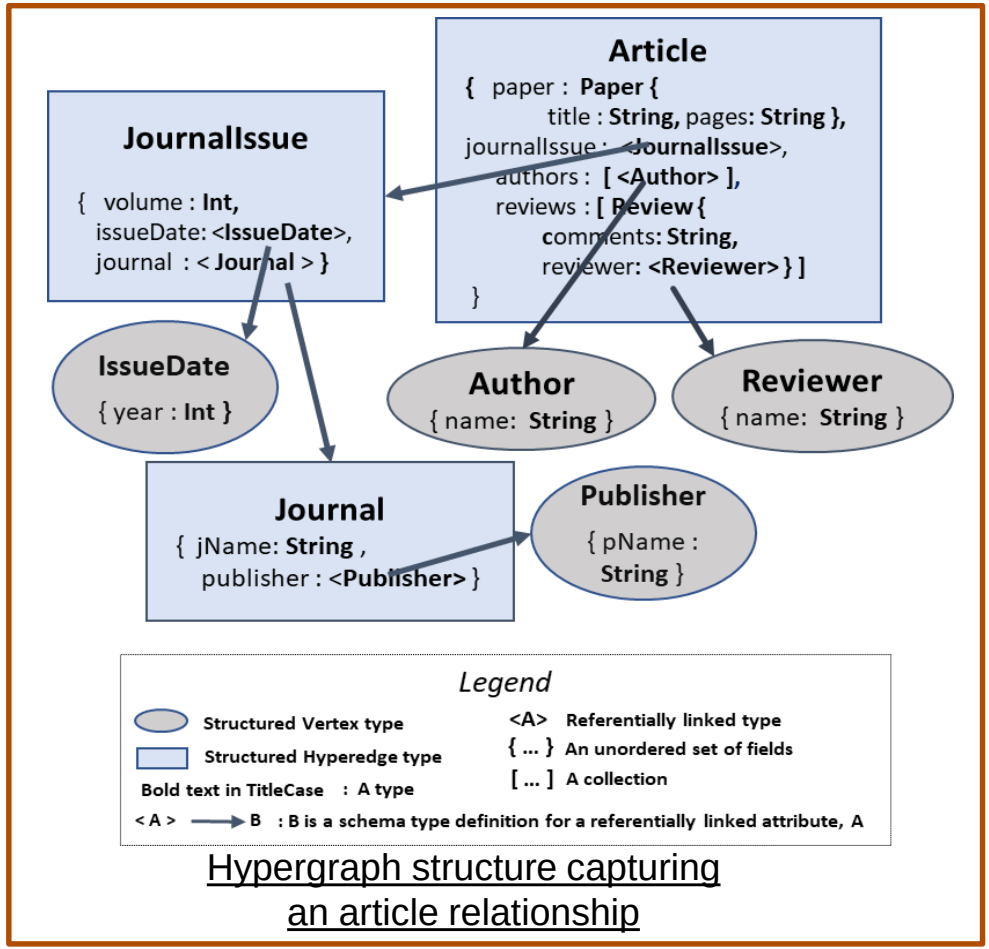
Typed

Vertices – base case

Directed hyperedges

Higher-ordered

N-ary relations



Hypergraph structure capturing an article relationship

Well-founded

Acyclic

Well-formed

Mutable

Hypergraphs as a CRDT- HgCRDT

Hypergraph CRDTs (HgCRDTs)

Higher-order recursively-defined mutable hypergraphs

Hypergraph:
Schematic and Typed

Method:
2P2P sets of CRDTs

Hyperedges:

he(**mutable** atom set *U*)
Directed, Mutable & **Higher-order**

Operations:
- Local **query**
- Global **update**
  - **add, remove** & **modify**

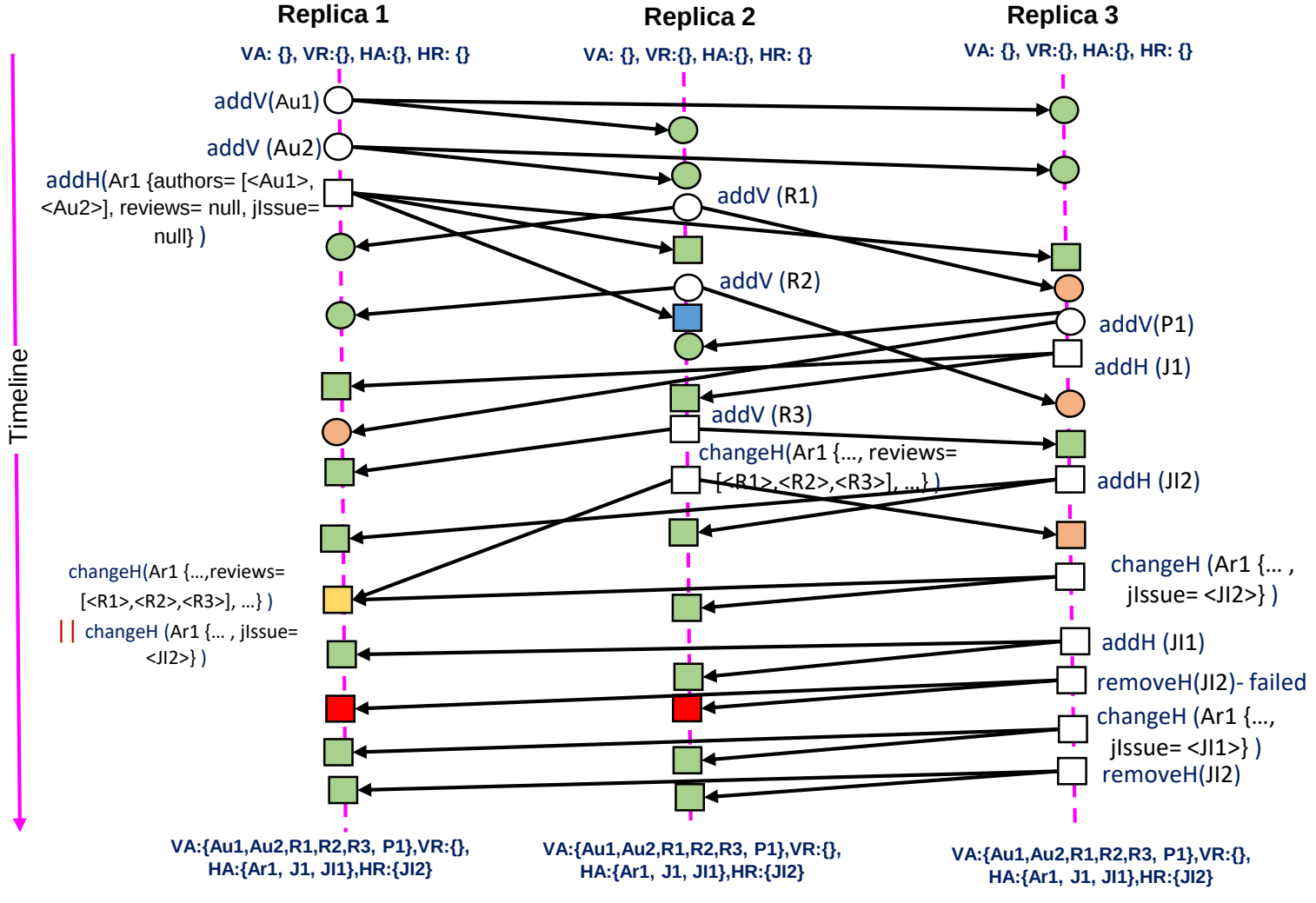
Replication Approach:
Operation-based

Causal delivery of operations over a **reliable** delivery

HgCRDT …

- Well-founded recursive structures
- Set incident on a hyperedge – mutable 2P- Set
- Atom - typed objects
- Implicit object ids, internal attributes, and atom type ➔ atoms different

Distribution of in-process article records using HgCRDT operations



Legend

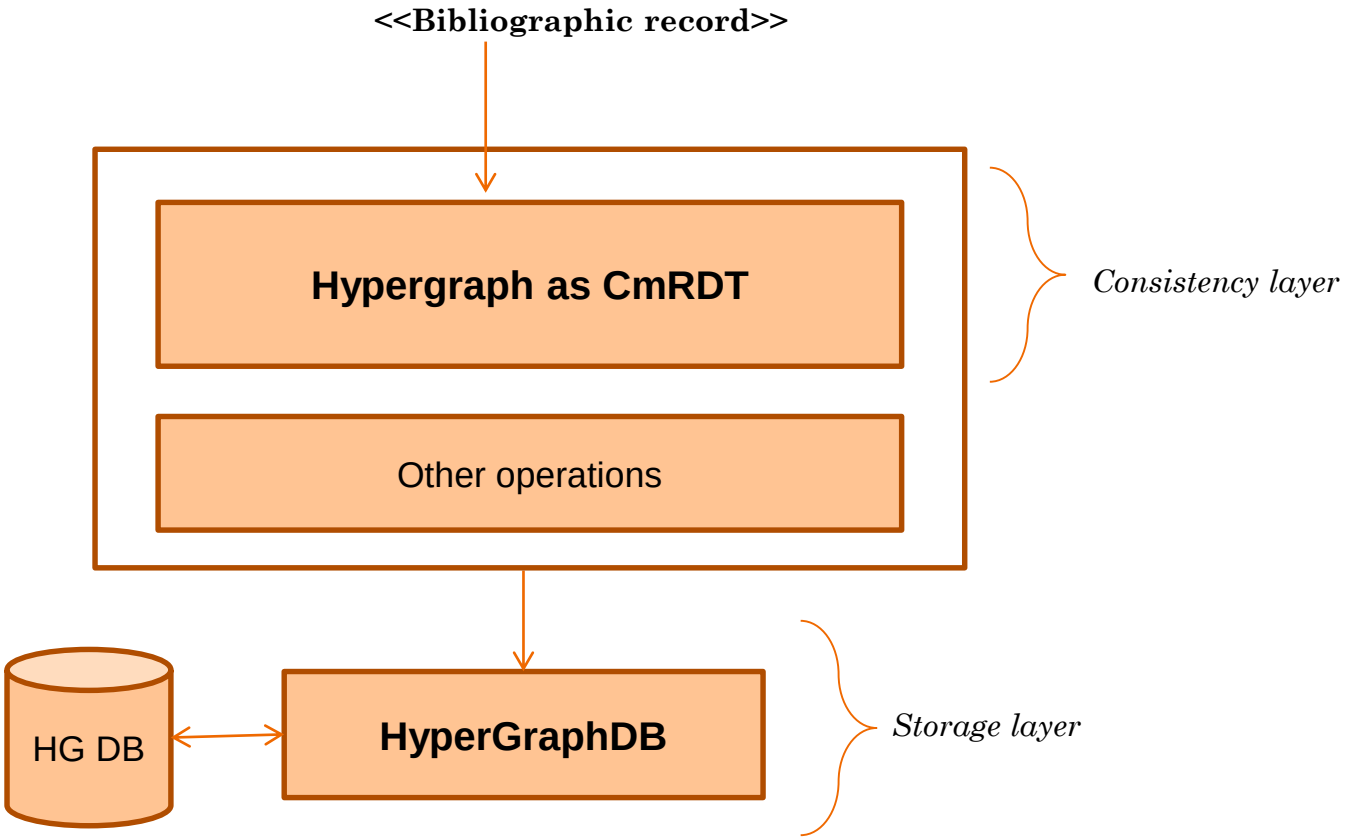
- Vertex
- Hyperedge
- Successful operation
- Conflicting operation
- Failed operation
- Redundant operation
- Delayed operation
- A → B A sends op. to B

addV- addVertex
addH – addHyperedge
removeV- removeVertex
removeH - removeHyperedge
changeH – changeHyperedge

Hypergraphical Objects

Au1= Author {name ="A"}
Au2= Author{name="B"}
R1= Review {status= "Accept"}
R2= Review{status="Weak Accept"}
R3= Review{status="Weak Reject"}
P1= Publisher {pName= "ACM"}
J1= Journal {publisher=<P>}
JI1= JournalIssue{journal=<J1>}
JI2= JournalIssue{journal=<J1>}
Ar1= Article {authors= [<Au1>, <Au2], reviews= [<R1>, <R2>, <R3>], jIssue= <JI1>}

Implementation



Conclusion & Future Perspectives

- Hypergraph can represent semi-structured, hierarchical, navigational, complex, higher-order relationships in distributed settings.
- Introduced HgCRDT- a well-formed higher-order recursively-defined mutable hypergraphs.
- Proposed HgCRDT specification that uses operations-based replication using 2P2P sets.
- Future work includes:
  - Partial replication on HgCRDT in a hypergraph-oriented databases system
  - Study of the performance of the replicated hypergraphs- scalability, and complexity on real data
  - Comparison of our proposed HgCRDT specification with other CRDT-based variations

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Aruna Bansal, Khosla SIT, IIT Delhi, India
Contact email: aruna.bansal.iitd@gmail.com