

# Specification and Implementation of Replicated List

## — The Jupiter Protocol Revisited

(Brief Announcement at PODC'2018)

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# Background

## Collaborative Text Editing Systems



(a) Google Docs



(b) Apache Wave



(c) Wikipedia



(d)  $\text{\LaTeX}$  Editor

# Replication (for availability)



## Replication (for availability)



- ▶ Replicas respond to user operations **immediately**
  - ▶ Updates are propagated **asynchronously**

## Replicated List

$\text{INS}(a, p)$  : Insert  $a$  at position  $p$ .

$\text{DEL}(p)$  : Delete an element at position  $p$ .

$\text{READ}$  : Return the list.

## Replicated List

$\text{INS}(a, p)$  : Insert  $a$  at position  $p$ .

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$\text{READ}$  : Return the list.

To implement a highly available replicated list object.

## Definition (Eventual Convergence)

The final lists at all replicas are identical *at quiescence*.



## Definition (Strong Eventual Consistency)

The lists at the replicas that *have executed the same set of user operations* are identical.



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Specify little on *intermediate states* going through by replicas.

# Specification and Complexity of Collaborative Text Editing

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Technion

Sebastian Burckhardt  
Microsoft Research

Alexey Gotsman  
IMDEA Software Institute

Adam Morrison  
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Hongseok Yang  
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Marek Zawirski<sup>\*</sup>  
Inria & Sorbonne Universités,  
UPMC Univ Paris 06, LIP6

## Strong/Weak List Specification

Global properties on all possible states at all replicas.

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<sup>1</sup>CRDT: Conflict-free Replicated Data Types [?]

<sup>2</sup>OT: Operational Transformation [?]

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## Strong/Weak List Specification

Global properties on all possible states at all replicas.

**Proved:** CRDT <sup>1</sup>-based RGA [?] protocol satisfies the strong list spec.

**Conjecture:** OT <sup>2</sup>-based *Jupiter* [?] protocol satisfies the weak list spec.

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<sup>1</sup>CRDT: Conflict-free Replicated Data Types [?]

<sup>2</sup>OT: Operational Transformation [?]

Does Jupiter satisfy the weak list specification?



Does Jupiter satisfy the weak list specification?



Yes, it does.

# Weak List Specification

## Definition (Weak List Specification $\mathcal{A}_{\text{weak}}$ [?])

Informally,  $\mathcal{A}_{\text{weak}}$  requires the ordering between **elements that are not deleted** to be consistent across the system.

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### Definition (Pairwise State Compatibility Property)

$$\forall \sigma, \sigma' : a, b \in \sigma \cap \sigma' \implies (a \prec_{\sigma} b \iff a \prec_{\sigma'} b)$$



## Definition (Pairwise State Compatibility Property)

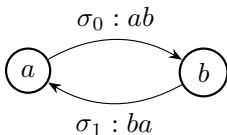
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$\sigma_0 : ab$

$\sigma_1 : ba$

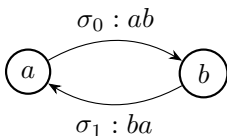


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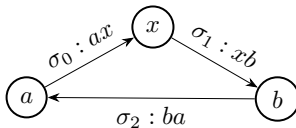
$\sigma_1 : ba$



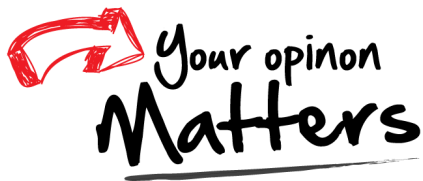
$\sigma_0 : ax$

$\sigma_1 : xb$

$\sigma_2 : ba$



Thank  
You!



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