Efficient renaming in Conflict-free Replicated Data Types (CRDTs)

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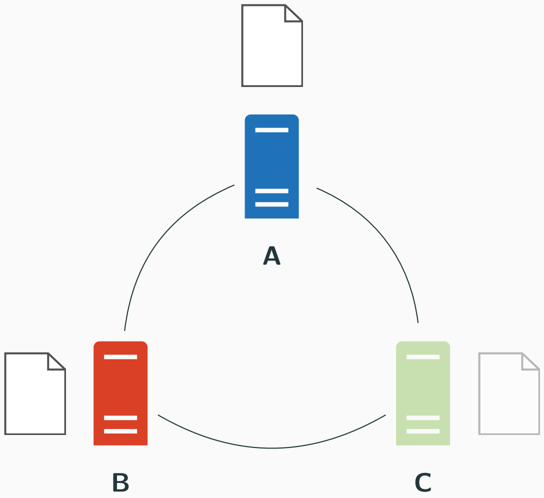
December 5, 2018

Conflict-free Replicated Data Types (CRDTs)[1]



- Replicated data structure

[1] Marc Shapiro et al. Conflict-free replicated data types. In *International Symposium on Stabilization, Safety, and Security of Distributed Systems*, 2011 .

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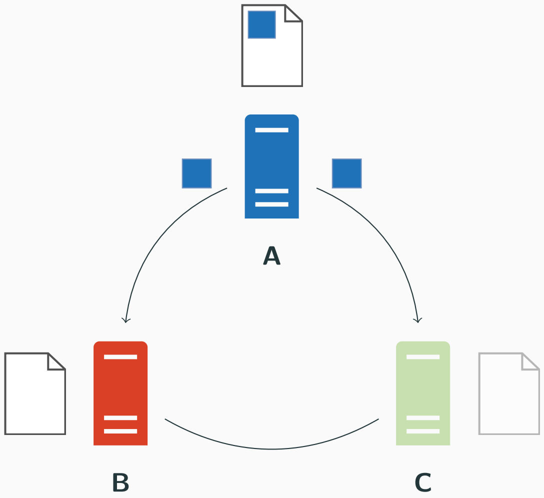

- Replicated data structure
- Updates performed without coordination

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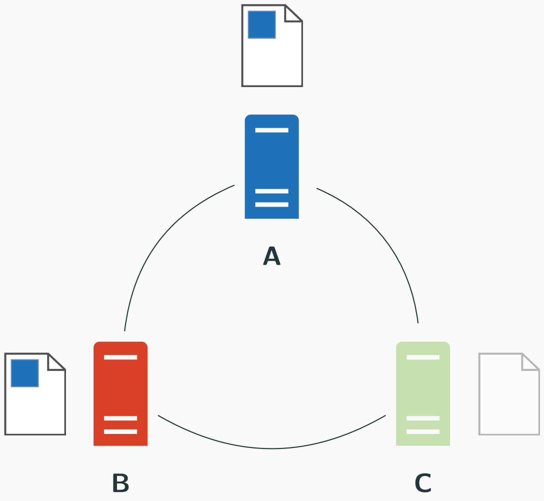

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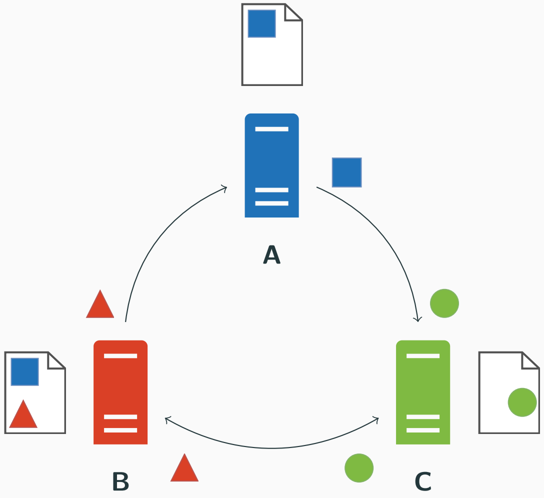

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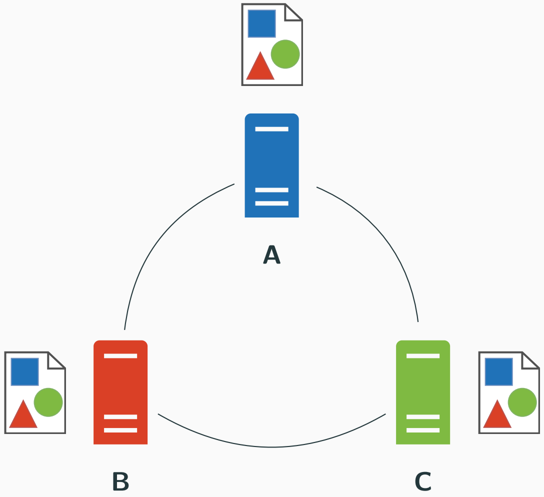

- Replicated data structure
- Updates performed without coordination
- Strong Eventual Consistency

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Identifier-based CRDTs

Main idea

- Attach an identifier to each element

Allow to design commutative updates

- Identifying uniquely elements
- Ordering updates causally
- ...

Research issue

Limits

- Unbounded size of identifiers
- Overhead of the data structure increasing over time

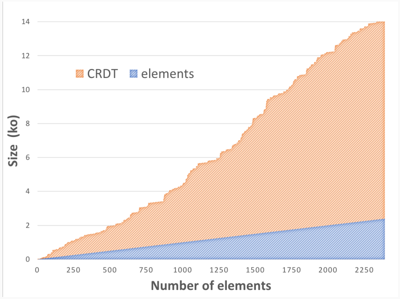

Figure 1: Evolution of the footprint of the data structure

How to reduce the overhead introduced by the data structure ?

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Reassign shorter identifiers in a fully distributed manner

LogootSplit[2]

- State of the art of *Sequence CRDTs*
- Elements are ordered by their identifier, noted here as lowercase letters

[2]Luc André et al. Supporting adaptable granularity of changes for massive-scale collaborative editing. In *International Conference on Collaborative Computing: Networking, Applications and Worksharing - CollaborateCom 2013*, 2013 .

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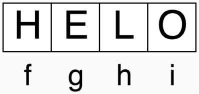

Figure 2: State of a sequence which contains the elements "helo" and their corresponding identifiers

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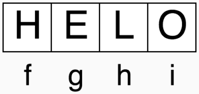

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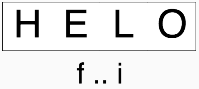

Figure 3: State of a sequence which contains the block "helo"

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Example

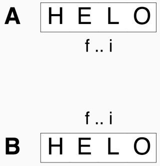
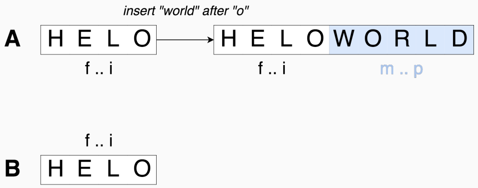


Figure 4: Example of concurrent *insert* operations

Example



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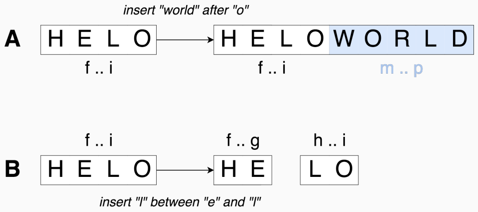

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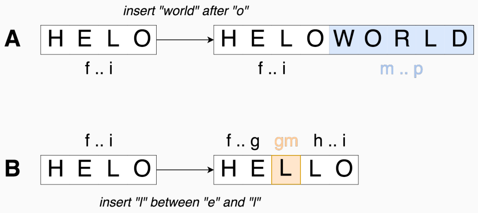

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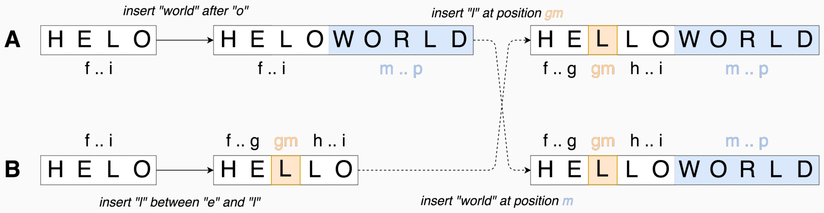

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Declining performances

- Updates performed may lead to an inefficient internal representation

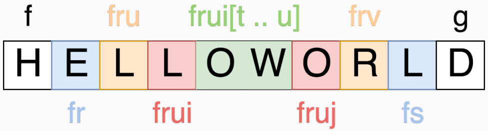

Figure 5: Example of inefficient internal representation

- The more blocks we have:
  - The more metadata we store
  - The longer it takes to browse the sequence to *insert* or *delete* an element

Renaming mechanism

- Introduce a *rename* operation

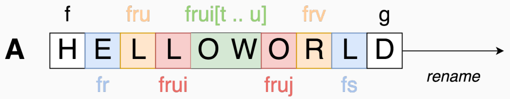

Figure 6: Example of renaming

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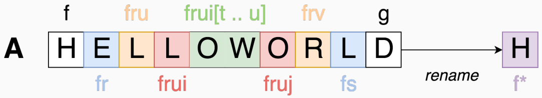

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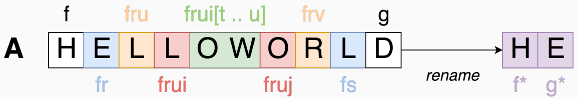

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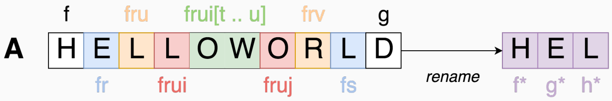

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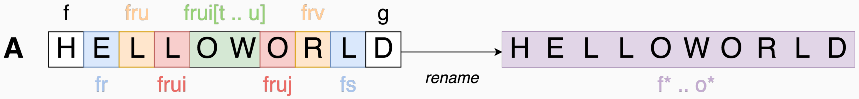

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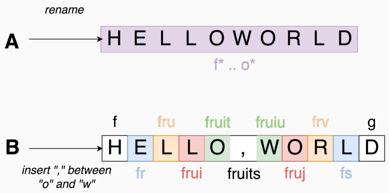
Handling concurrent operations

- Others may perform updates concurrently to a *rename* operation



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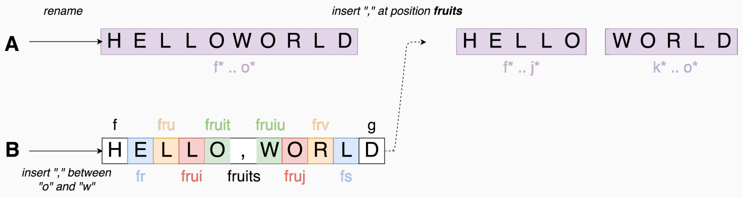

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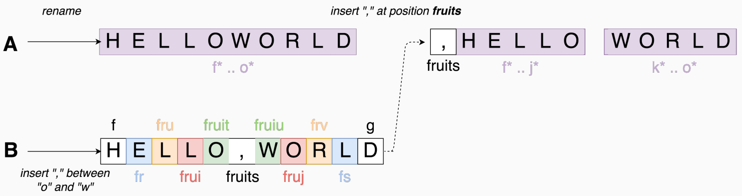

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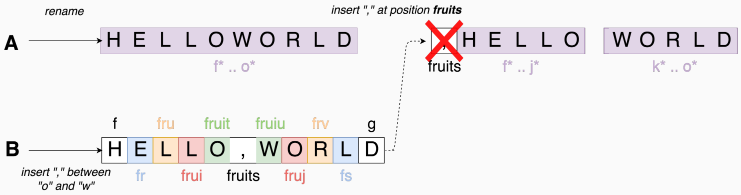

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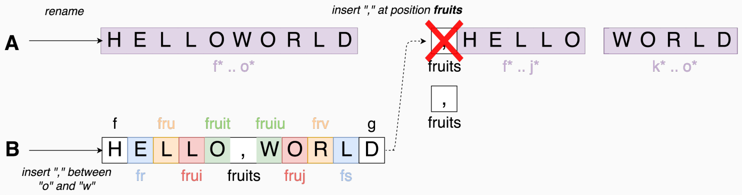

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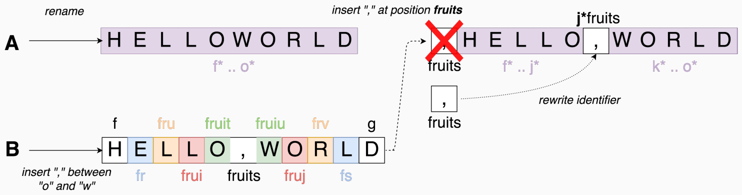

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- Track *epoch* of generation of operations
- Define rewriting rules to transform identifiers from one *epoch* to another

Handling concurrent rename

rename operation not commutative

- Define a total order between *rename* operations
- Pick a "winner" operation between concurrent *renames*
- Define additional rewriting rules to *undo* the effect of "losing" ones

To wrap up

Done

- Designed a *rename* operation for LogootSplit
- Defined rewriting rules to deal with concurrent updates

[3]Matthieu Nicolas et al. MUTE: A Peer-to-Peer Web-based Real-time Collaborative Editor. In Proceedings of European Conference on Computer-Supported Cooperative Work - Panels, Posters and Demos, 2017 .

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Work in progress

- Implementing in MUTE[3], our P2P collaborative text editor
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To do

- Prove formally the correctness of the mechanism
- Benchmark its performances

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Next steps

Generalize the approach

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- To other Sequence CRDTs

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Generalize the approach

- To other Sequence CRDTs
- To other types
    - Counter
    - Set
    - ...

Thanks for your attention, any questions?