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

Matthieu Nicolas
COAST team
Supervised by Gérald Oster and Olivier Perrin

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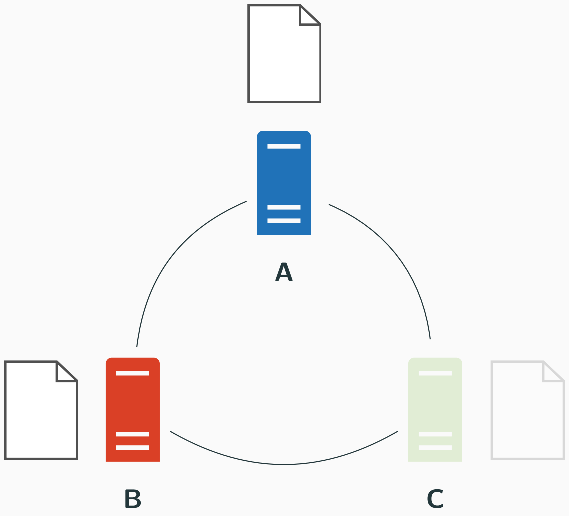
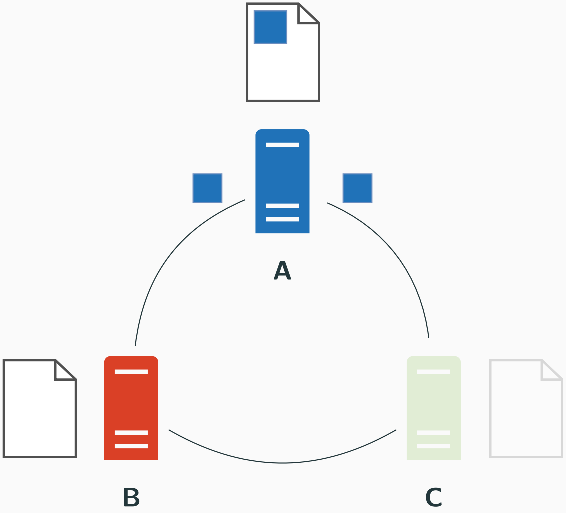
Conflict-free Replicated Data Types (CRDTs) [3]



- Replicated data structure

Conflict-free Replicated Data Types (CRDTs) [3]



- Replicated data structure
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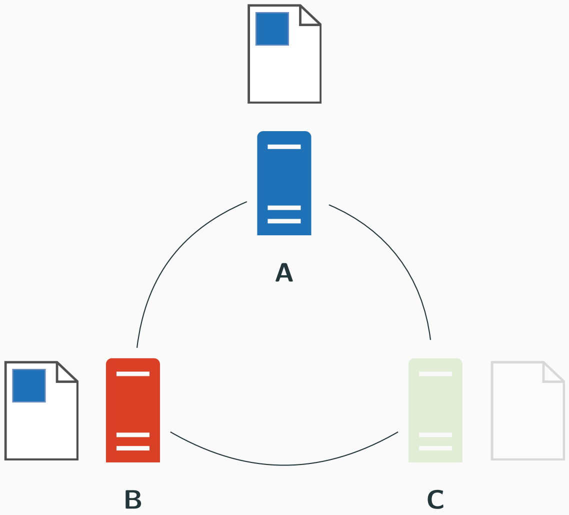

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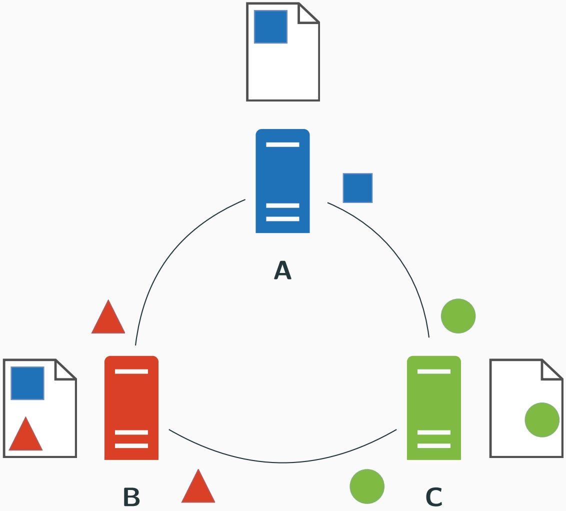

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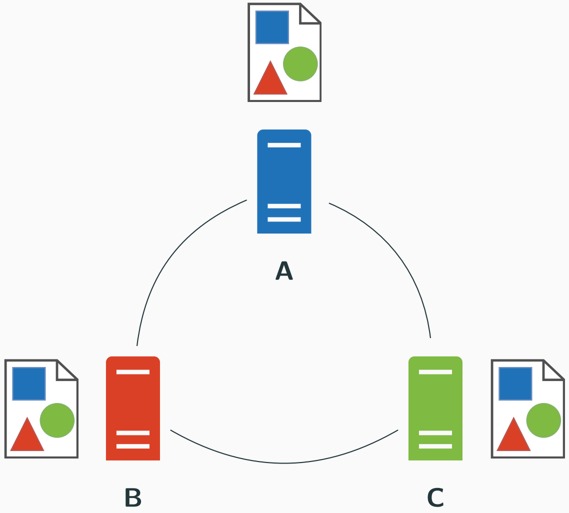

- Replicated data structure
- Updates performed without coordination
- Strong Eventual Consistency [3]

Identifier-based CRDTs

Main idea

- Attach an identifier to each inserted element

Allow to achieve commutative updates

- By identifying uniquely elements
- By ordering them relatively to each other

LogootSplit [1]

- State of the art of *Sequence CRDTs*
- Relies on *identifiers* to ensure convergence, noted here as letters and words
- Elements are ordered by their identifier

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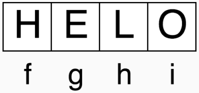

Figure 1: The state of a sequence which contains the elements "helo" and their corresponding identifiers

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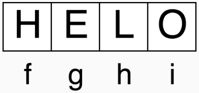

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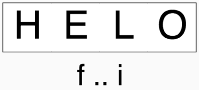

Figure 2: The state of a sequence which contains the block "helo"

Example

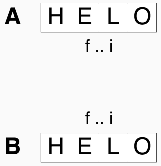

Figure 3: Example of concurrent *insert* operations

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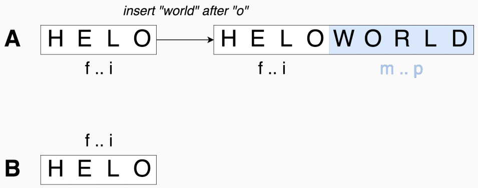

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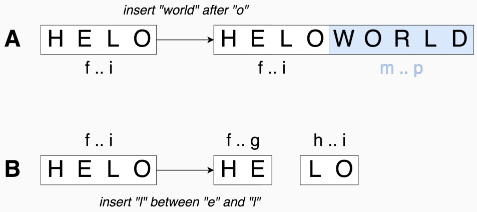

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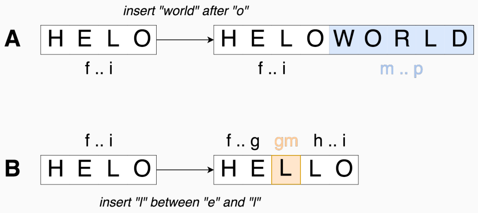

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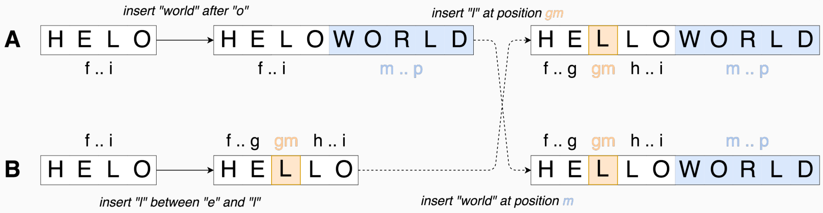

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Declining performances

- Operations performed may lead to an inefficient internal representation

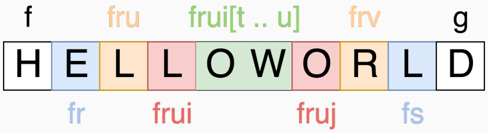


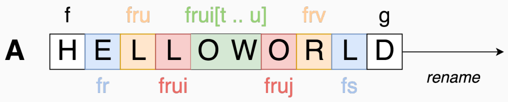
Figure 4: Example of inefficient internal representation

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

How to reduce the footprint of the metadata ?

Renaming mechanism

- Introduce a *rename* operation



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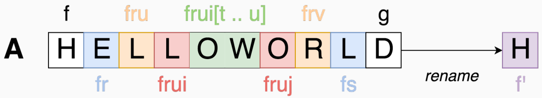

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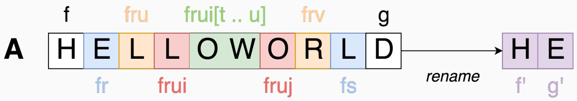

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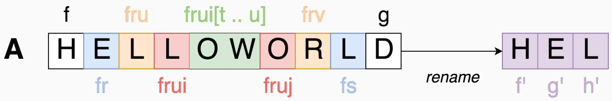

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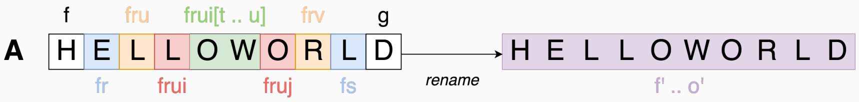

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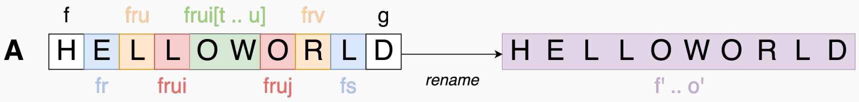

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- Then generates contiguous identifiers for all following elements
- Each *rename* marks the beginning of a new *epoch*

Handling concurrent operations

- Others can perform updates concurrently to a *rename* operation
- Apply them as such could lead to inconsistencies

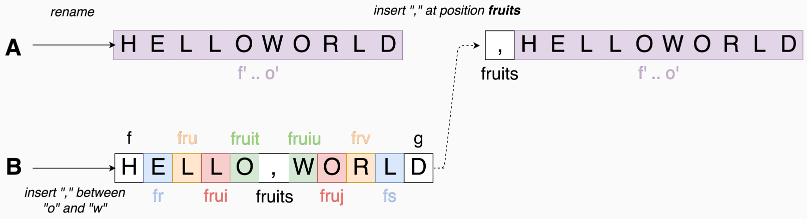

Figure 6: Example of inconsistency

Rewriting concurrent operations

- Define rewriting rules to transform identifiers from one *epoch* to another
- Upon reception of concurrent operations, rewrite identifiers before applying them

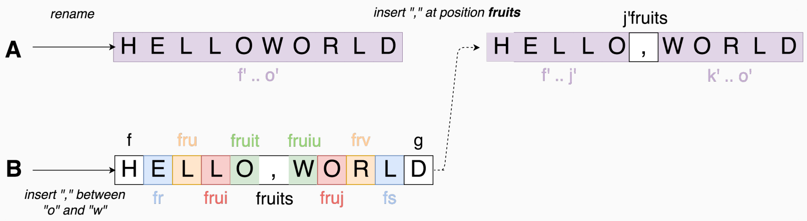

Figure 7: Example of rewriting

Handling concurrent rename

- 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

Conclusion

- Propose a fully distributed renaming mechanism for *LogootSplit*
- Allows to reinitialize the footprint of the CRDT without coordination

- Implemented in MUTE [2], our P2P collaborative text editor

Next steps

Provide a formal proof

- Need to ensure the correctness of our algorithm

Benchmark the mechanism

- Measure its impact on the performances
- Compare different strategies

Generalize the approach to other CRDTs

Thanks for your attention, any questions?

References i

[1] L. André, S. Martin, G. Oster, and C.-L. Ignat.
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[2] M. Nicolas, V. Elvinger, G. Oster, C.-L. Ignat, and F. Charoy.
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References ii

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