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

Matthieu Nicolas

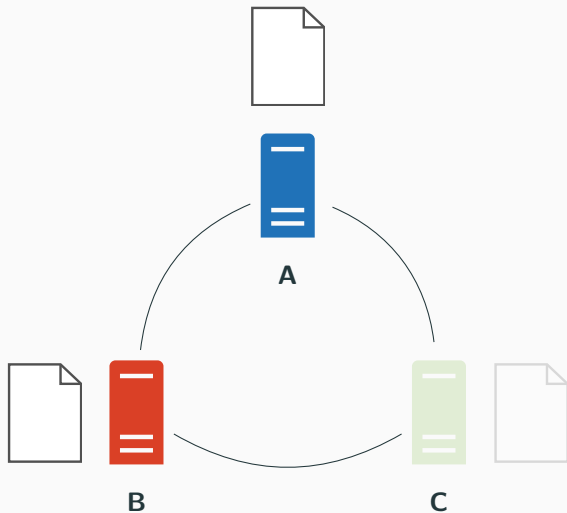COAST team

Supervised by Gérald Oster and Olivier Perrin

December 4, 2018
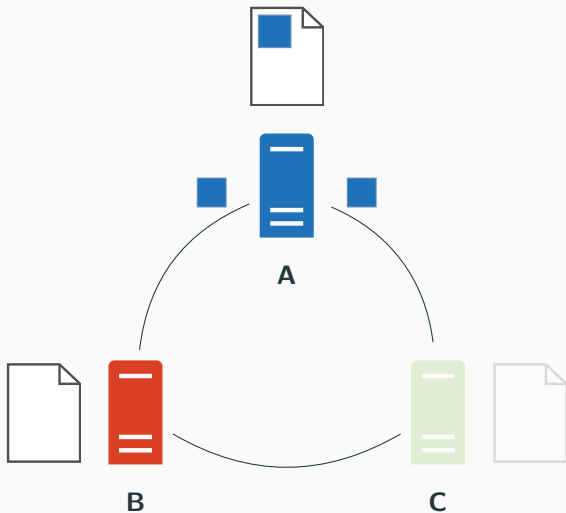
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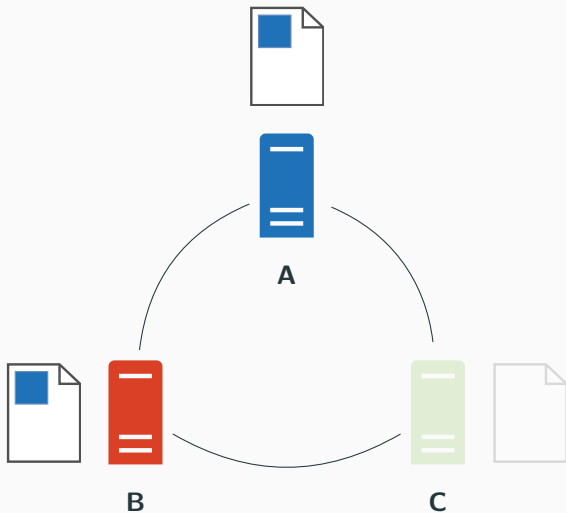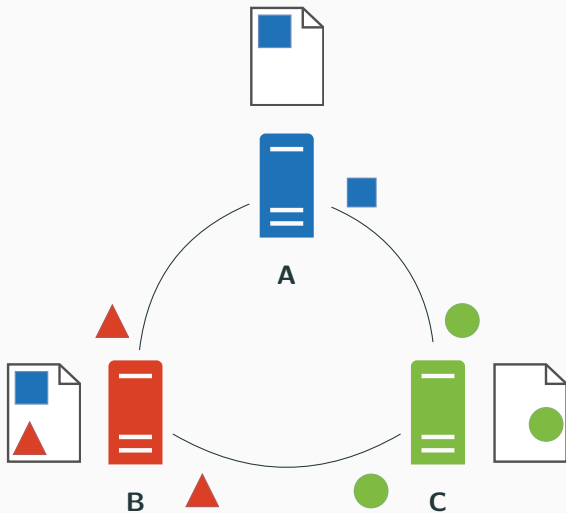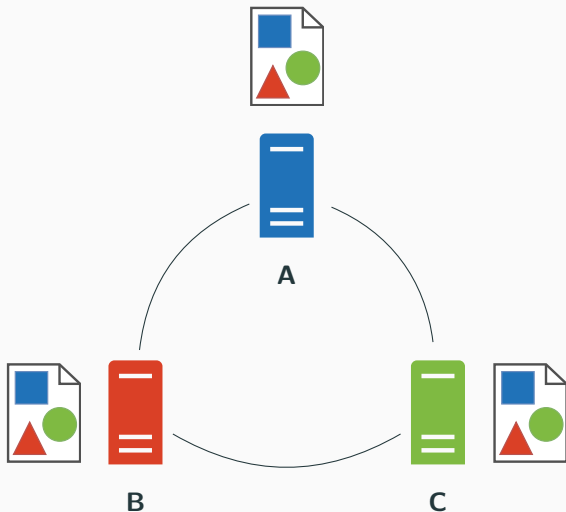
Conflict-free Replicated Data Types (CRDTs) [3]

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

Identifier-based CRDTs

Main idea
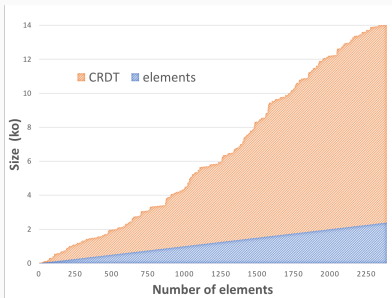
- Attach an identifier to each element

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 [1]

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- Elements are ordered by their identifier, noted here as lowercase letters

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H	E	L	O
f	g	h	i

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

LogootSplit [1]

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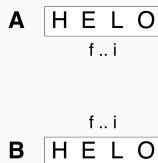

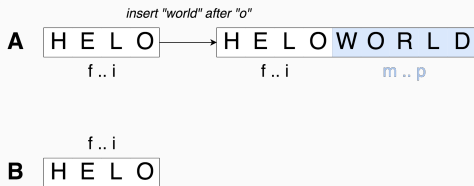**Figure 2:** State of a sequence which contains the elements "helo" and their corresponding identifiers

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

Example

A | H E L O |
        f .. i
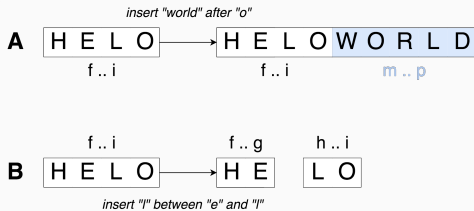
        f .. i
B | H E L O |

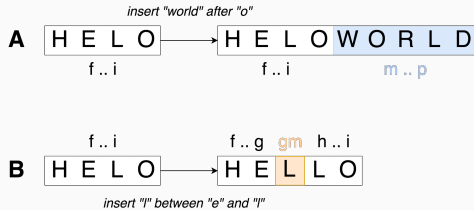**Figure 4:** Example of concurrent *insert* operations

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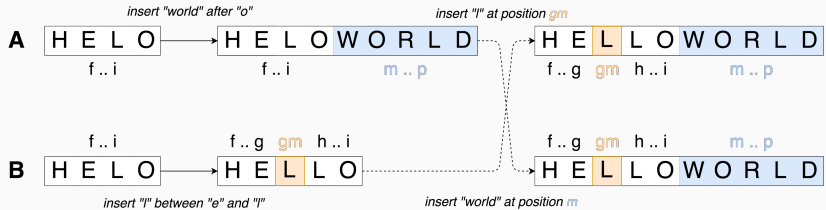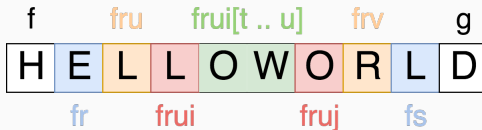**Figure 4:** Example of concurrent *insert* operations

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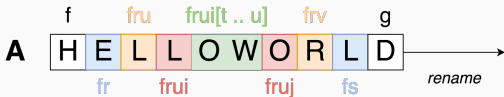- Updates performed may lead to an inefficient internal representation

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

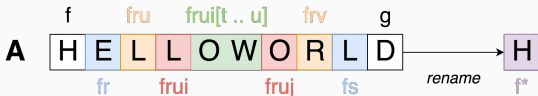# Renaming mechanism

- Introduce a *rename* operation

Figure 6: Example of renaming

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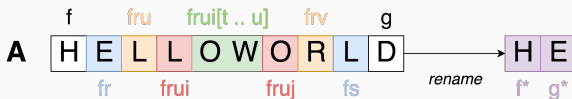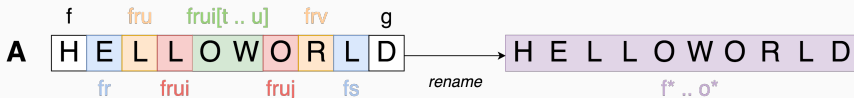

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- Generates a new identifier to the first element, based on its previous identifier
- Then generates contiguous identifiers for all following elements

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

Figure 7: Example of concurrent insert
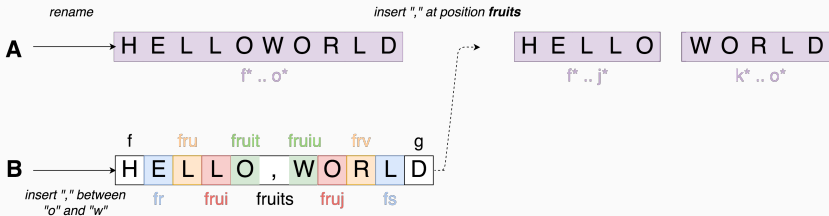
Handling concurrent operations

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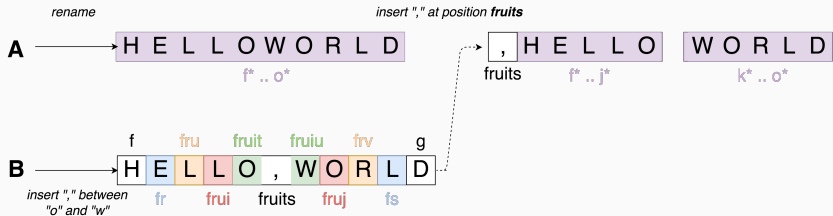- May lead to inconsistencies

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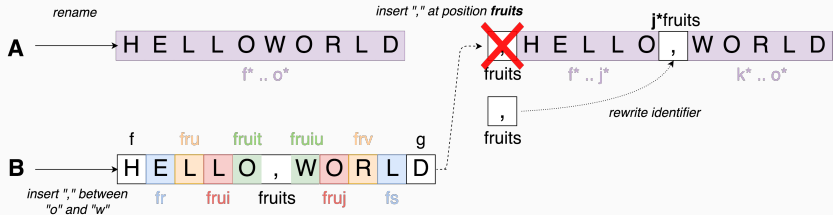
- Define rewriting rules to transform identifiers from one *epoch* to another

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

To wrap up

Done

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

Work in progress

- Implementation in MUTE [2], our P2P collaborative text editor
- Design the strategy to trigger the renaming

To do

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

Next steps

Generalize the approach

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

Thanks for your attention, any questions?

[1] L. André, S. Martin, G. Oster, and C.-L. Ignat.
Supporting adaptable granularity of changes for massive-scale collaborative editing.
In *International Conference on Collaborative Computing: Networking, Applications and Worksharing - CollaborateCom 2013*, pages 50–59, Austin, TX, USA, Oct. 2013. IEEE Computer Society.

[2] M. Nicolas, V. Elvinger, G. Oster, C.-L. Ignat, and F. Charoy.
MUTE: A Peer-to-Peer Web-based Real-time Collaborative Editor.
In *ECSCW 2017 - 15th European Conference on Computer-Supported Cooperative Work*, volume 1 of *Proceedings of 15th European Conference on Computer-Supported Cooperative Work - Panels, Posters and Demos*, pages 1–4, Sheffield, United Kingdom, Aug. 2017. EUSSET.

[3] M. Shapiro, N. M. Preguiça, C. Baquero, and M. Zawirski.
Conflict-free replicated data types.
In *Proceedings of the 13th International Symposium on Stabilization, Safety, and Security of Distributed Systems*, SSS 2011, pages 386–400, 2011.