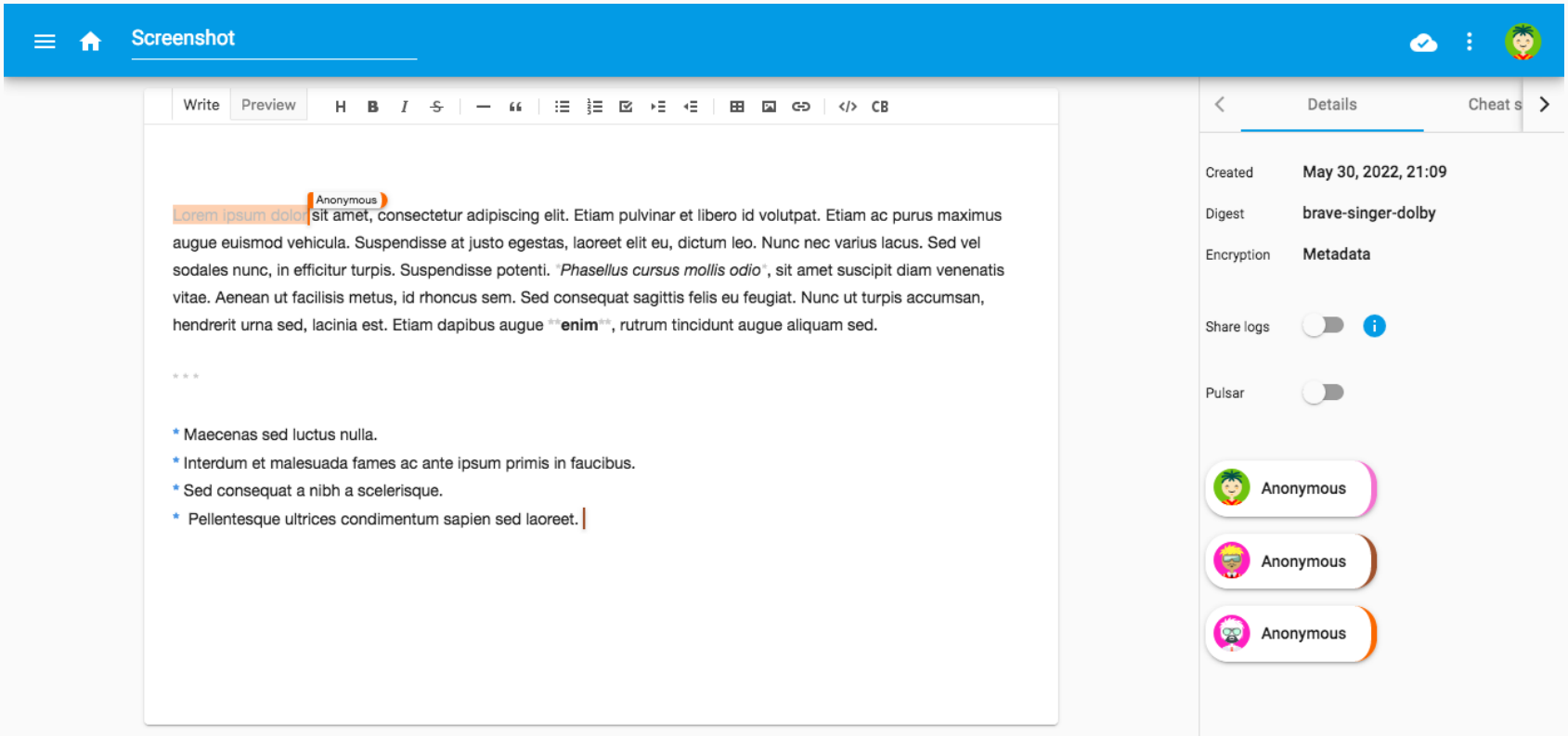
Conflict-free Replicated Data Types (CRDTs)

An Overview

Matthieu Nicolas (matthieu.nicolas@inria.fr)

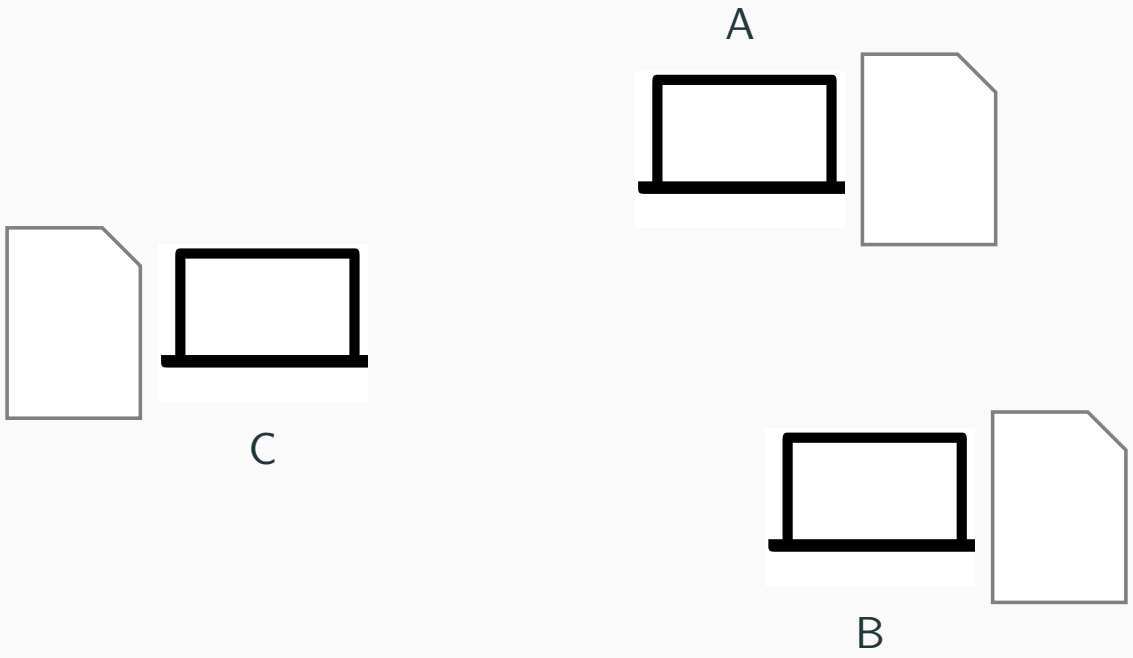
02/05/2024

MUTE



- Peer-to-Peer (P2P) application
- Allow to edit collaboratively text documents
- Ensure ownership and privacy of data
- Part of the Local-First Software [Kle+19] trend

Data replication in P2P systems



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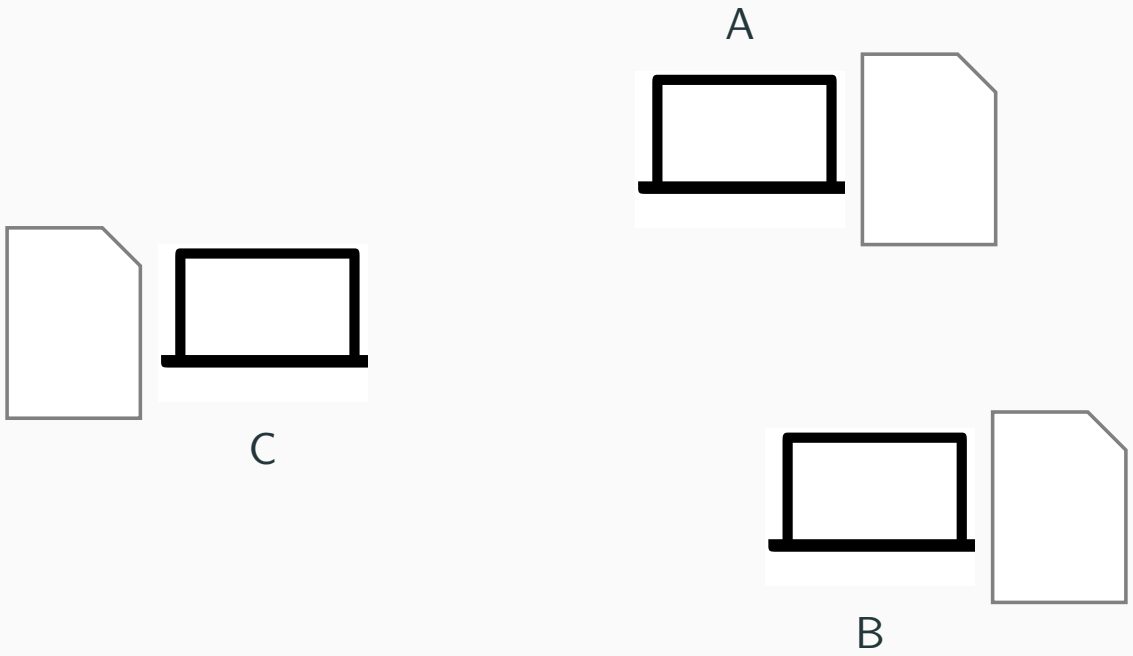

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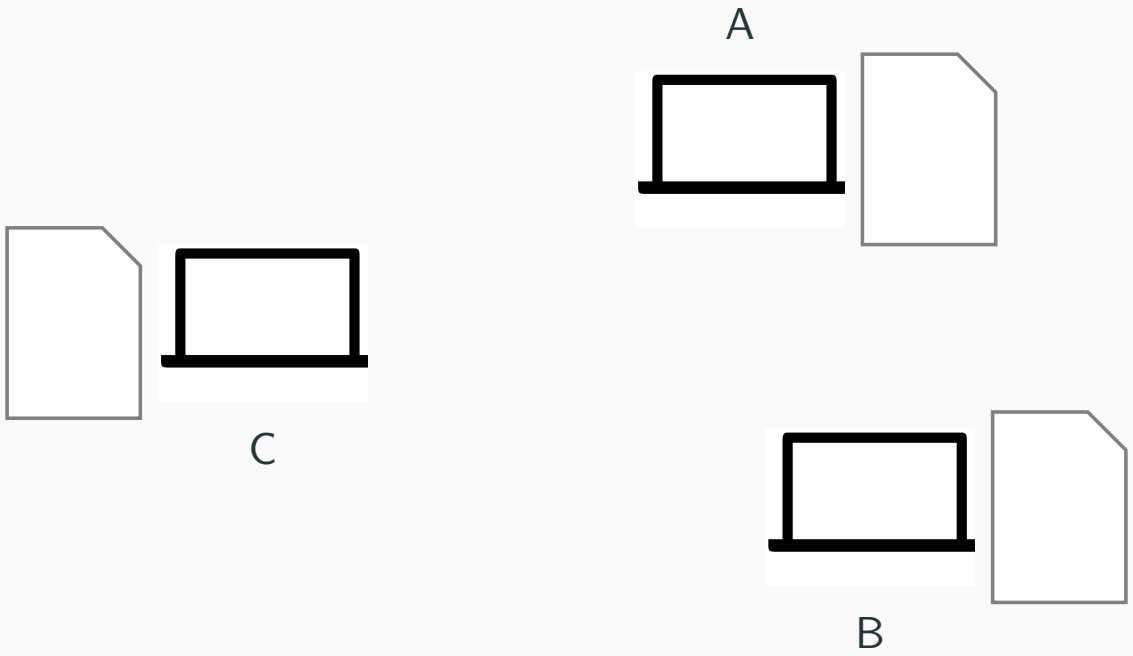

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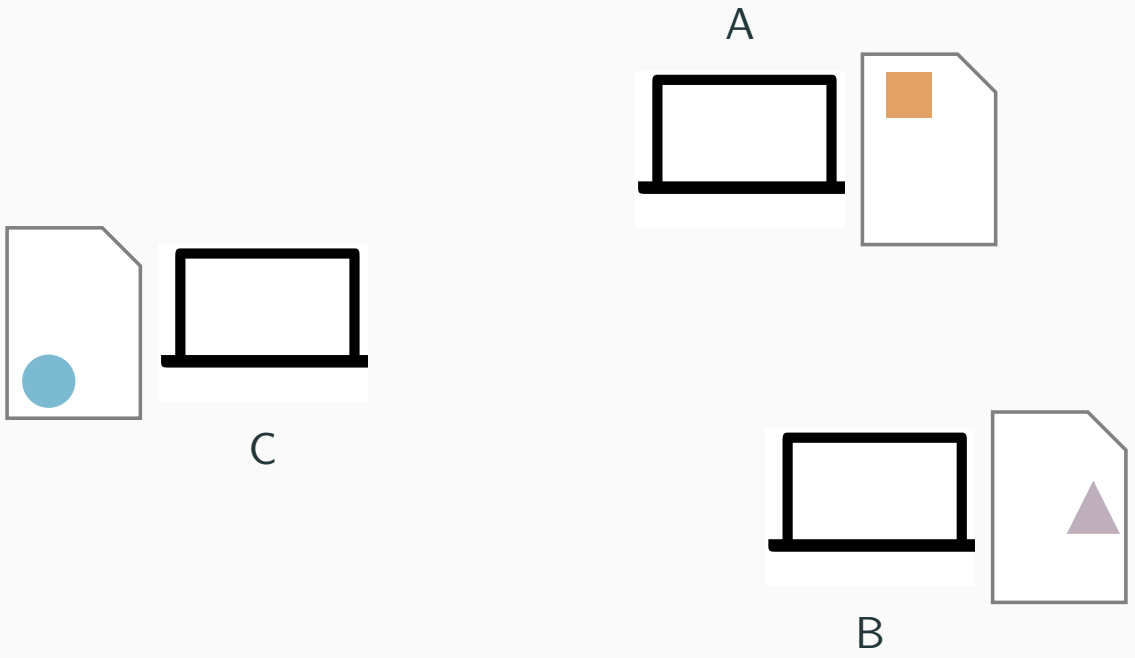

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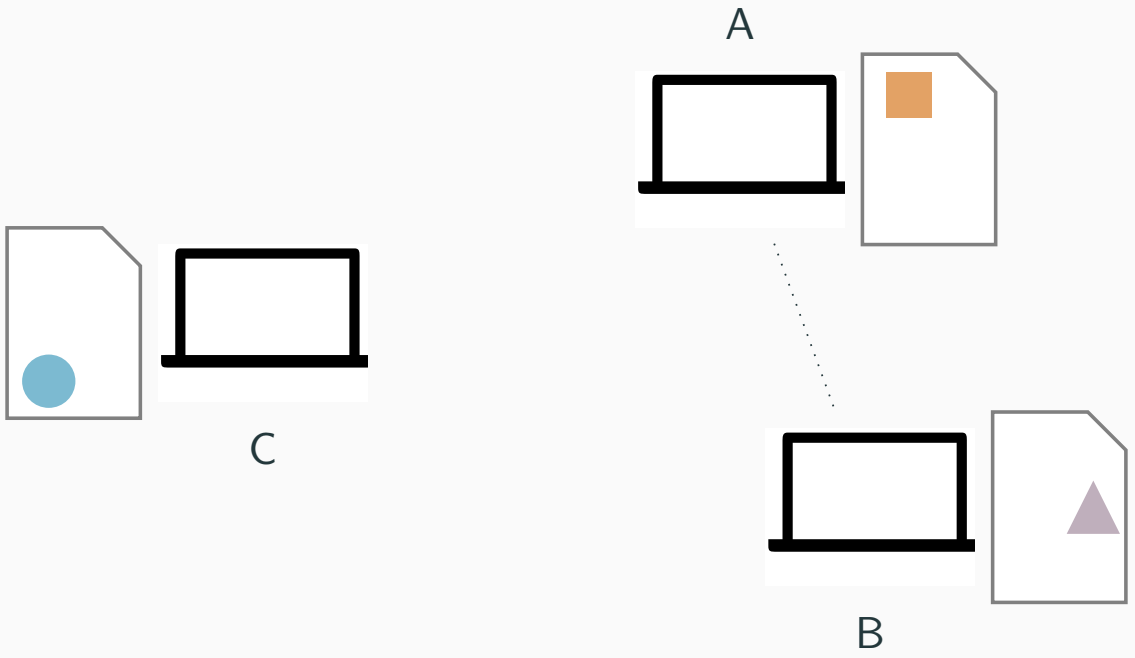

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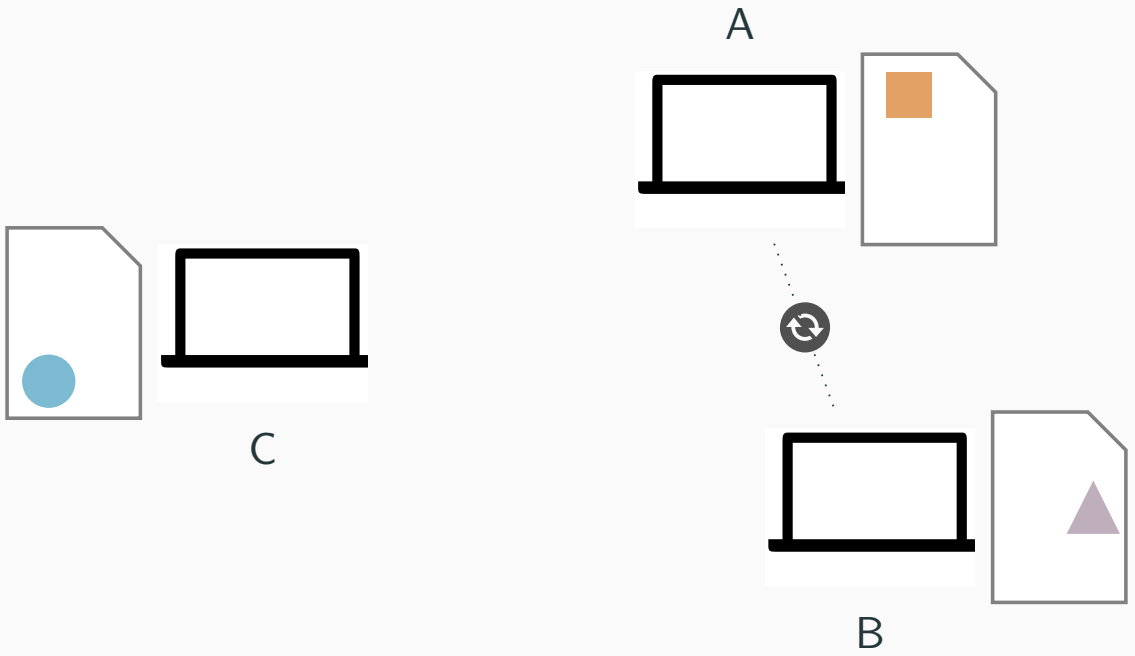

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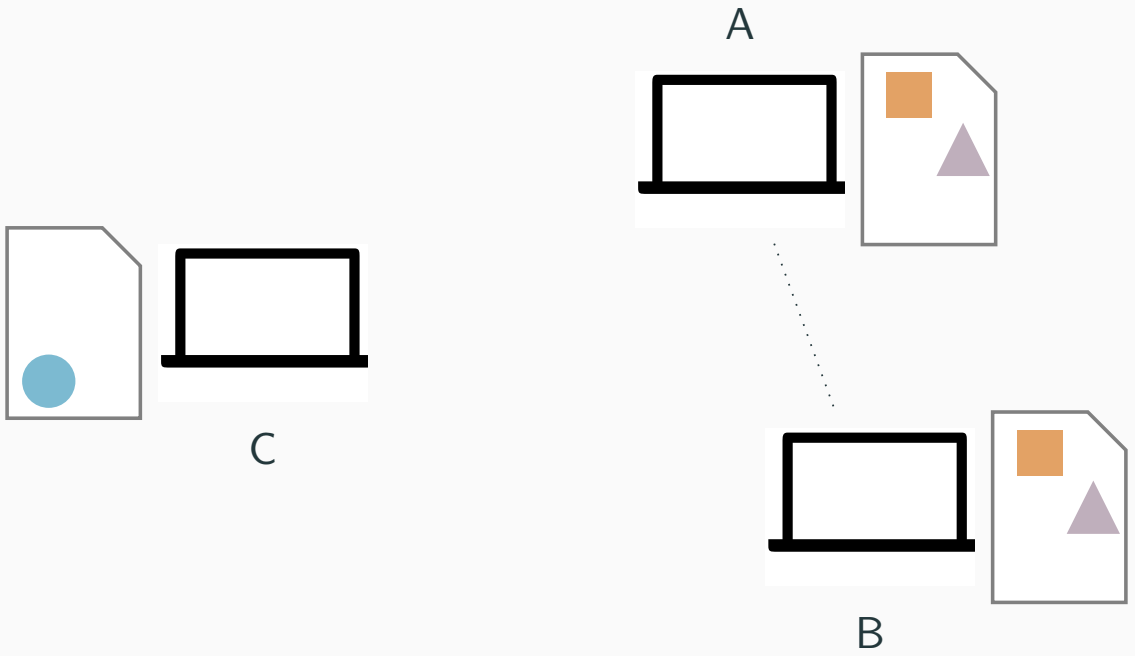

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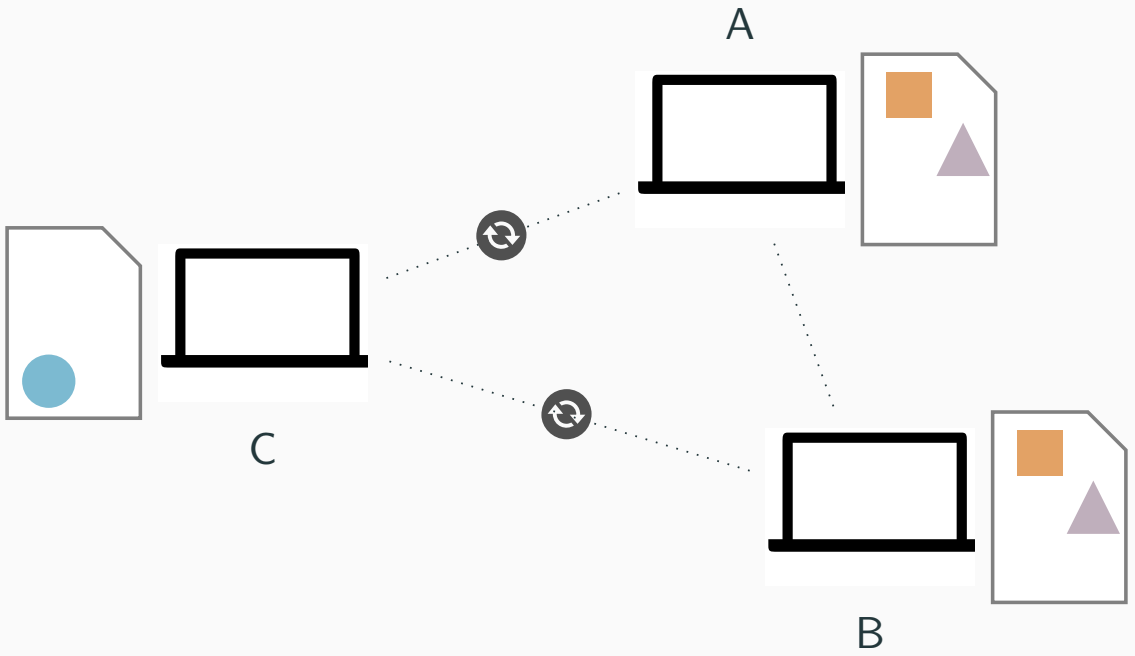

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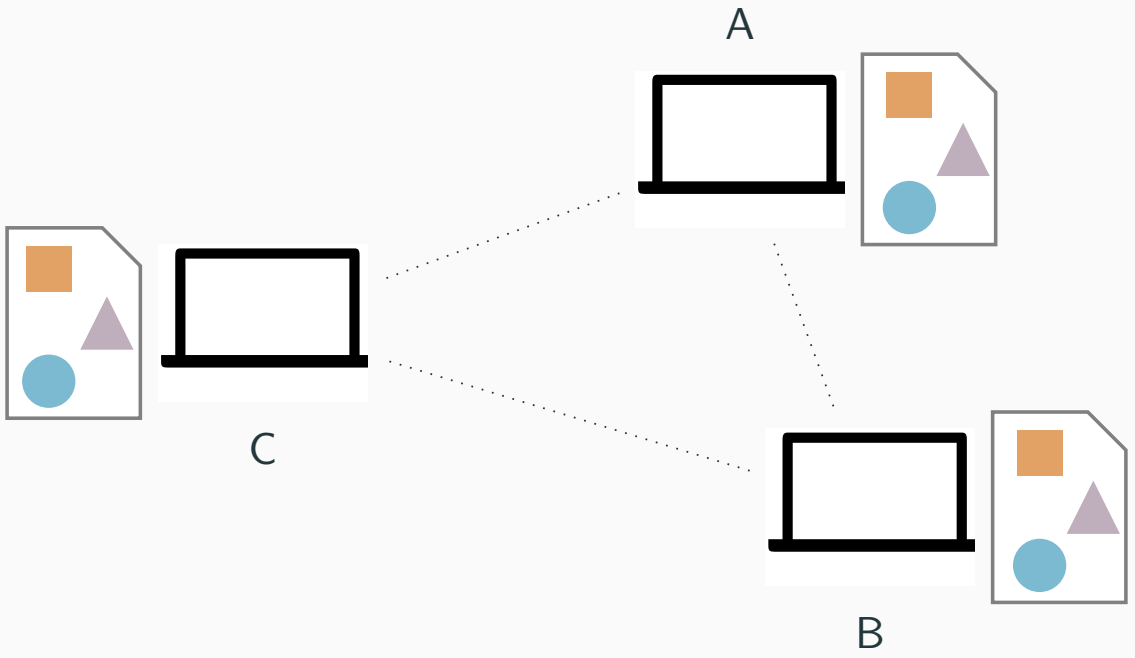

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- ...Despite different integration orders of updates

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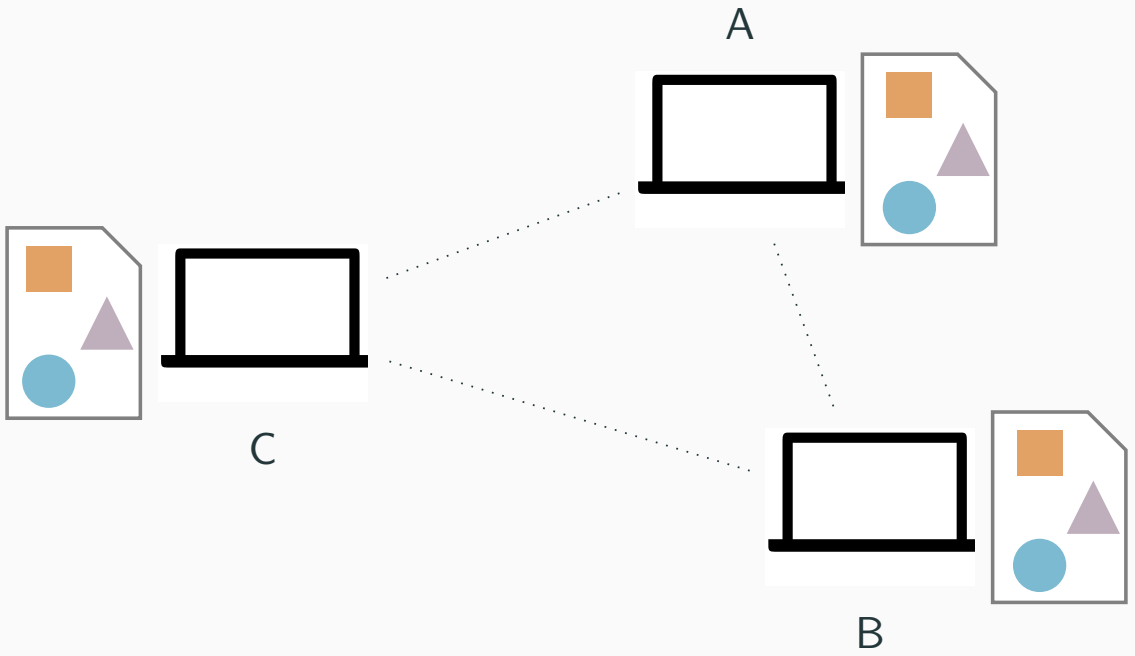

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Require *conflict resolution mechanisms*

Conflict-free Replicated Data Types (CRDTs) are a family of conflict resolution mechanisms

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- Rely on the lattice theory ...
- ... More specifically, CRDTs are join-semilattice

Design of CRDTs

- Several CRDTs may be designed for a given data type ...
- ... Each offering different trade-offs

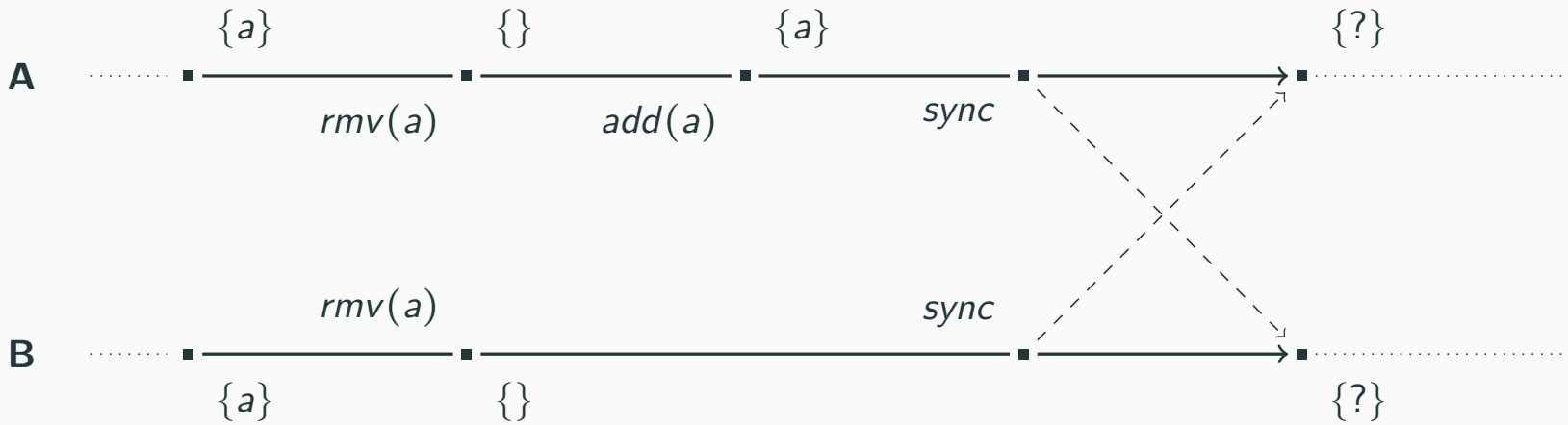
What impact the design of a given CRDT are its

- Conflict Resolution Semantics
- Synchronisation Model

- Impact their overhead in terms of computation, memory and bandwidth

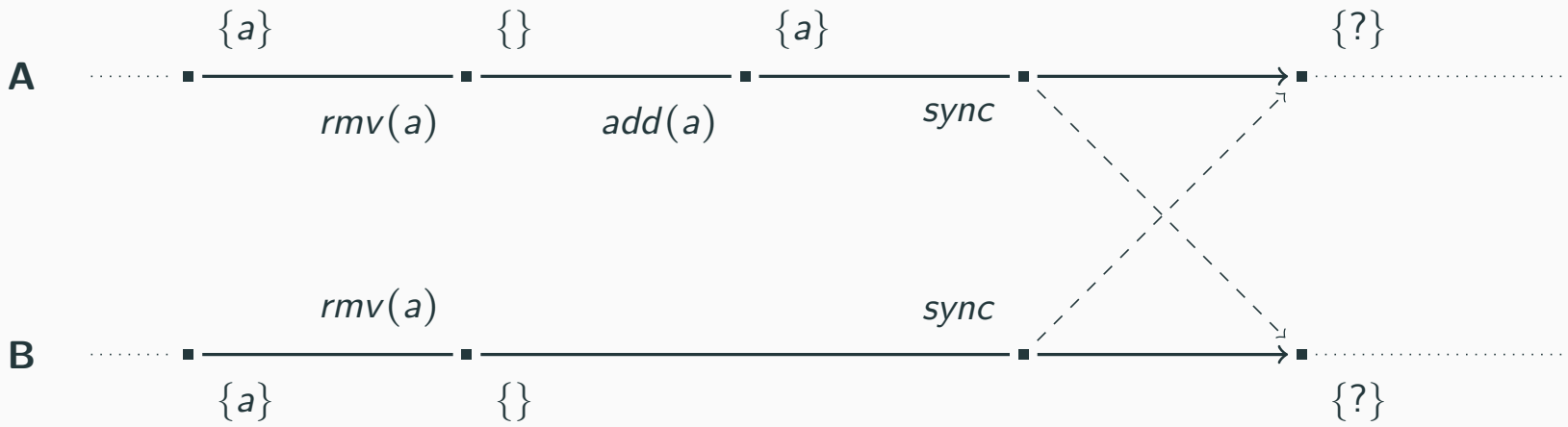
Conflict Resolution Semantics

- Distributed setting allows new scenarios



- Results of these executions are undefined
- Designing a CRDT consists in defining its behaviour in such cases

Conflict Resolution Semantics - Case study of the Set



Several semantics were proposed:

- *Add-Wins*: $add(a)$ has priority over concurrent $rmv(b) \implies \{a\}$
- *Remove-Wins*: $rmv(a)$ has priority over concurrent $add(b) \implies \{\}$
- *Causal-Length* [YR20]: The last action of the longuest chain of sequential updates determines the presence (or not) of the element $\implies \{a\}$

Bibliographie i

[Kle+19] Martin Kleppmann et al. **"Local-First Software: You Own Your Data, in Spite of the Cloud".** In: *Proceedings of the 2019 ACM SIGPLAN International Symposium on New Ideas, New Paradigms, and Reflections on Programming and Software*. Onward! 2019. Athens, Greece: Association for Computing Machinery, 2019, pp. 154–178. ISBN: 9781450369954. DOI: 10.1145/3359591.3359737. URL: https://doi.org/10.1145/3359591.3359737.

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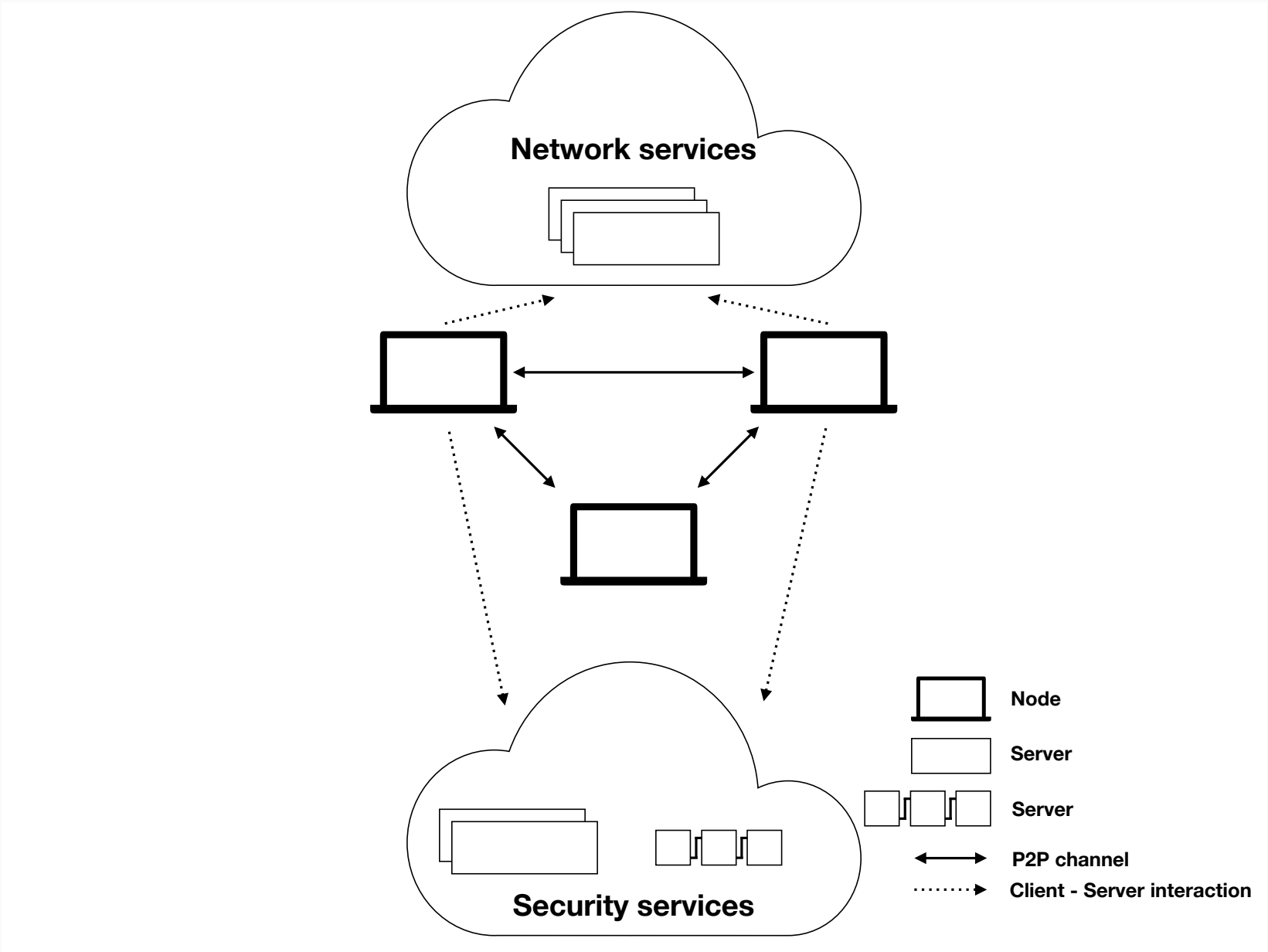
[YR20] Weihai Yu et al. **"A Low-Cost Set CRDT Based on Causal Lengths".** In: *Proceedings of the 7th Workshop on Principles and Practice of Consistency for Distributed Data*. New York, NY, USA: Association for Computing Machinery, 2020. ISBN: 9781450375245. URL: https://doi.org/10.1145/3380787.3393678.

Back-up slides

MUTE System Architecture



MUTE Software Architecture