

Work in Parallel, Without Fear

Conflict Tolerance for Local-First Collaboration

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 - ... avoid interruptions
 - ... work offline
 - ... keep ideas to myself

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- Working alone means concurrent edits pile up
- When CRDTs eventually merge them, automatic conflict resolution can silently discard my edits

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- ⇒ Despite its usefulness, branching & merging is rare in local-first apps

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 - Defer the resolution decision
 - Share conflicts with others
 - Resolve conflicts collaboratively

¹<https://www.inkandswitch.com/universal-version-control/>

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- Lazy merging: Integrate syntax, history, and conflicts in one CRDT [1]

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 - Lazy merging: Integrate syntax, history, and conflicts in one CRDT [1]
- ⇒ Is conflict tolerance one of the missing pieces for universal version control¹?

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Version Control



Version Control



Conflict Representation

```
...  
targetID: {  
  "tag": "choice",  
  "options": ["fed6", "2d4f"]  
}  
...  
Cinco lazy merge driver
```

Version Control



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Cinco lazy merge driver

Conflict Visualization



Conflict projection in the
Cinco model editor

Version Control



Automerge

Version Control



Automerge

Conflict Representation

```
Automerge.getConflicts(  
  node.inputs,  
  inputName  
)  
  ||  
{  
  "1@a1b2": "silhouette",  
  "2@c3d4": "checkerboard"  
}
```

Conflicts Object

Version Control



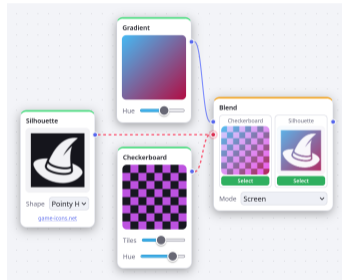
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Conflicts Object

Conflict Visualization



Conflict projection in
React Flow

How to develop a conflict-tolerant local-first app



1. Implement a conflict-tolerant CRDT



2. Make the rest of the app conflict-tolerant

- Conflict tolerance is a pervasive cross-cutting concern
- Similar to error handling

²<https://www.inkandswitch.com/project/amsheets/live25/>

- Conflict tolerance is a pervasive cross-cutting concern
- Similar to error handling
- How can we make it easy?
 - Conflict-tolerant UI frameworks
 - Conflict-tolerant databases/query languages
 - Conflict-tolerant APIs/programming languages (see Ambsheets²)

²<https://www.inkandswitch.com/project/amsheets/live25/>

Thank You!

Slides & Links



<https://jonas-schuermann.name/talks/2026-local-first-conf/>

References

- [1] Jonas Schürmann and Bernhard Steffen. “**Lazy Merging: From a Potential of Universes to a Universe of Potentials**”. en. In: *Electronic Communications of the EASST* Volume 82: 11th International Symposium on Leveraging Applications of Formal Methods (2023). DOI: [10.14279/tuj.eceasst.82.1226](https://doi.org/10.14279/tuj.eceasst.82.1226).
- [2] Jonas Schürmann and Bernhard Steffen. “**Lazy Three-Way Model Merging in Cinco Cloud: A Lattice-Theoretic Approach**”. In: *Formal Methods for Industrial Critical Systems: 30th International Conference, FMICS 2026, Liverpool, United Kingdom, September 03-04, 2026, Proceedings*. Ed. by Anne Remke and Bernhard Steffen. [to appear]. Springer Nature Switzerland, 2026.
- [3] Konrad Wieland et al. “**Turning Conflicts into Collaboration**”. In: *Computer Supported Cooperative Work (CSCW) 22.2-3* (Sept. 2012), pp. 181–240. ISSN: 1573-7551. DOI: [10.1007/s10606-012-9172-4](https://doi.org/10.1007/s10606-012-9172-4).