Local-first software

Resilient and secure collaboration

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VolkswagenStiftung

COLLABORATIVE APPLICATIONS

Figma

Wide range of domain-specific collaboration software, e.g. for investigative journalism, medical records, data analysis, engineering/CAD, ...

CLOUD SOFTWARE

e.g. Google

amazon web services

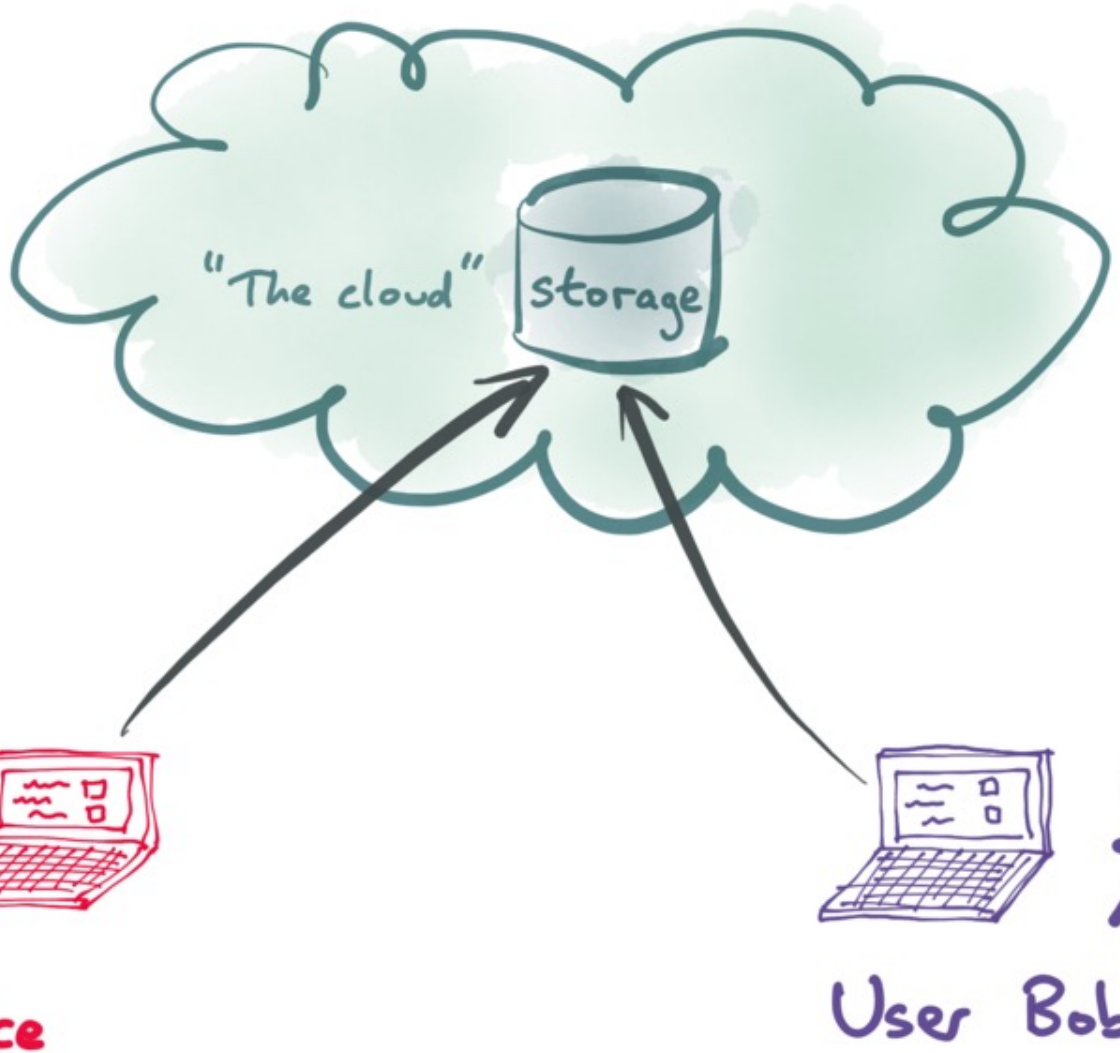
User Alice

User Bob

CLOUD SOFTWARE

e.g. Google

amazon web services



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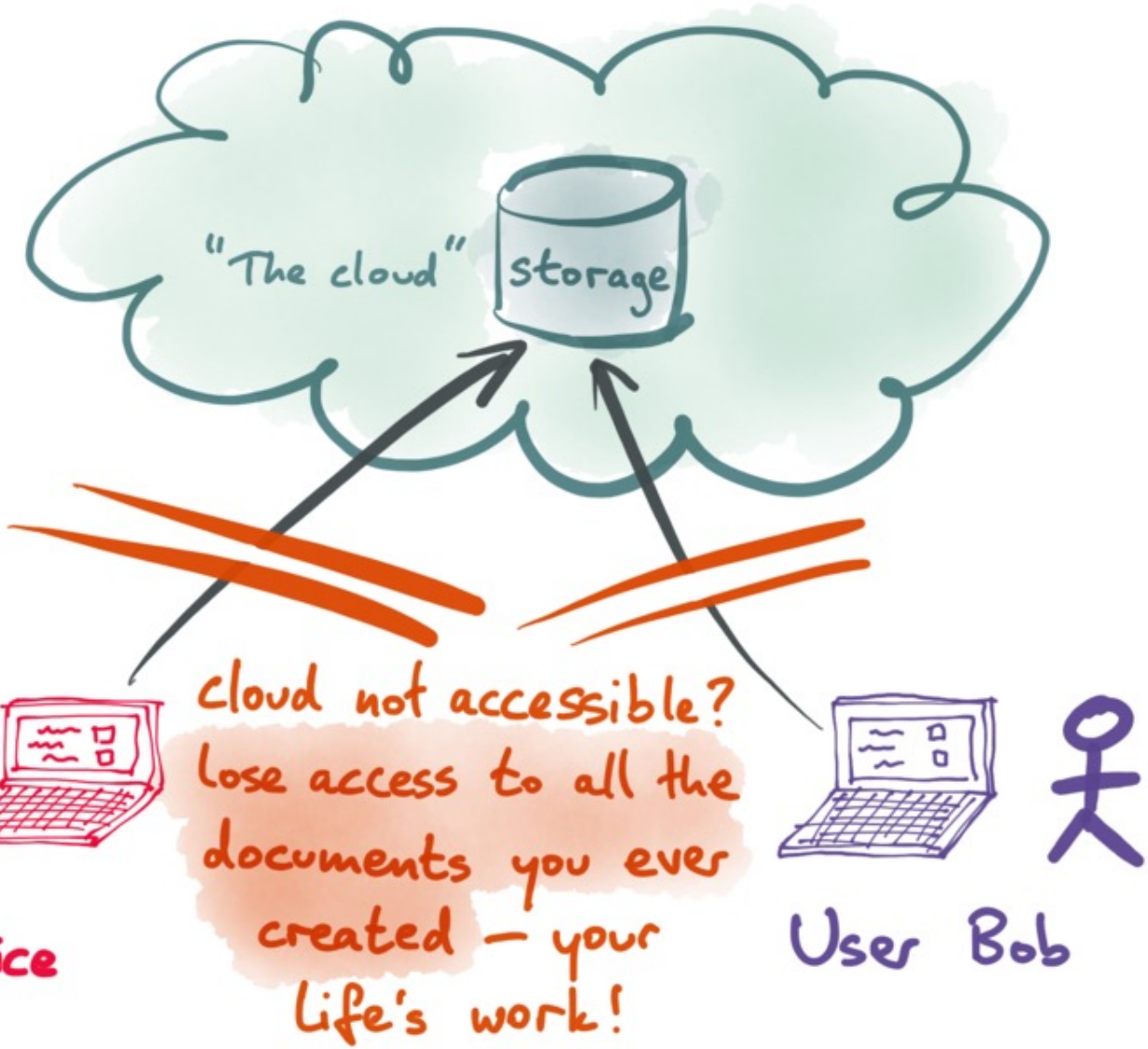


The Switch

A mysterious message is locking Google Docs users out of their files

(Loic Venance/AFP/Getty Images)

By **Brian Fung**
October 31, 2017

Imagine you're working on a Google Doc when, seemingly out of nowhere, your ability to edit the online file gets revoked. What you see instead is an error message indicating that you've violated Google's terms of service.

https://www.washingtonpost.com/news/the-switch/wp/2017/10/31/a-mysterious-message-is-locking-google-docs-users-out-of-their-files/

Technology

Google refuses to reinstate man's account after he took medical images of son's groin

Experts say case highlights dangers of automated detection of child sexual abuse images

Tech companies like Google have access to a vast trove of data – but no context for it, says an ACLU technologist. Photograph: Avishek Das/Sopa Images/Rex/Shutterstock

Johana Bhuiyan

Tue 23 Aug 2022 00.32 BST

Google has refused to reinstate a man's account after it wrongly flagged medical images he took of his son's groin as child sexual abuse material (CSAM), the New York Times first reported. Experts say it's an inevitable pitfall of trying to apply a technological solution to a societal problem.

https://www.theguardian.com/technology/2022/aug/22/google-csam-account-blocked

SUSPENDED ACCOUNTS

Microsoft: 182,000 in 2020

of which 730 (0.4%) were restored!

Google: "disables tens of millions of accounts per year"

"The vast majority are spammers and bots"

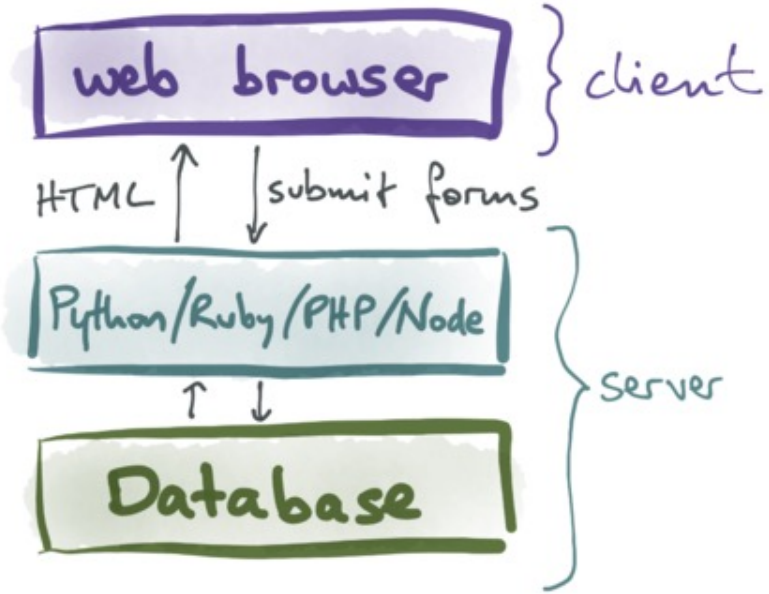
A precarious situation!

Source: https://tweakers.net/reviews/9094/all/account-geblokkeerd-wat-nu.html [in Dutch]

Cuneiform script on clay tablet, ca. 3000 BCE. Image from Wikimedia Commons.
https://commons.wikimedia.org/wiki/File:Early_writing_tablet_recording_the_allocation_of_beer.jpg

WEB APP ARCHITECTURE THROUGH THE AGES

ca. 2000–2010



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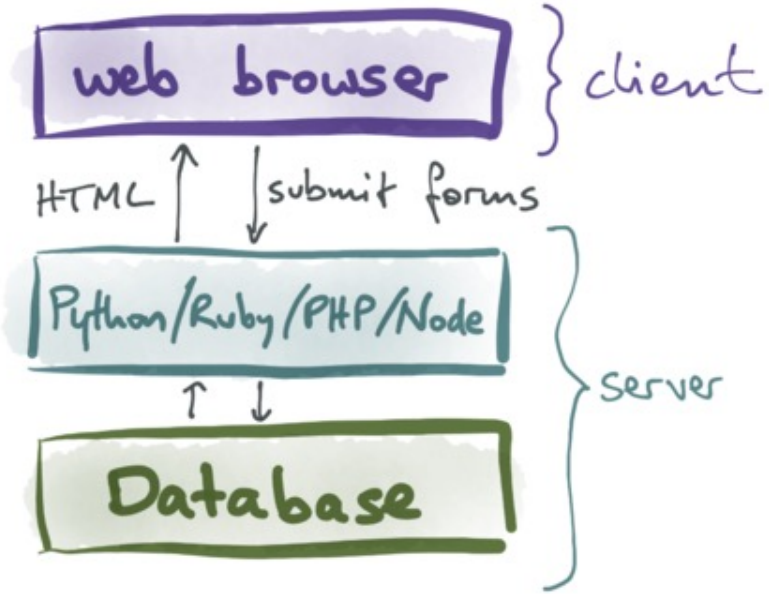
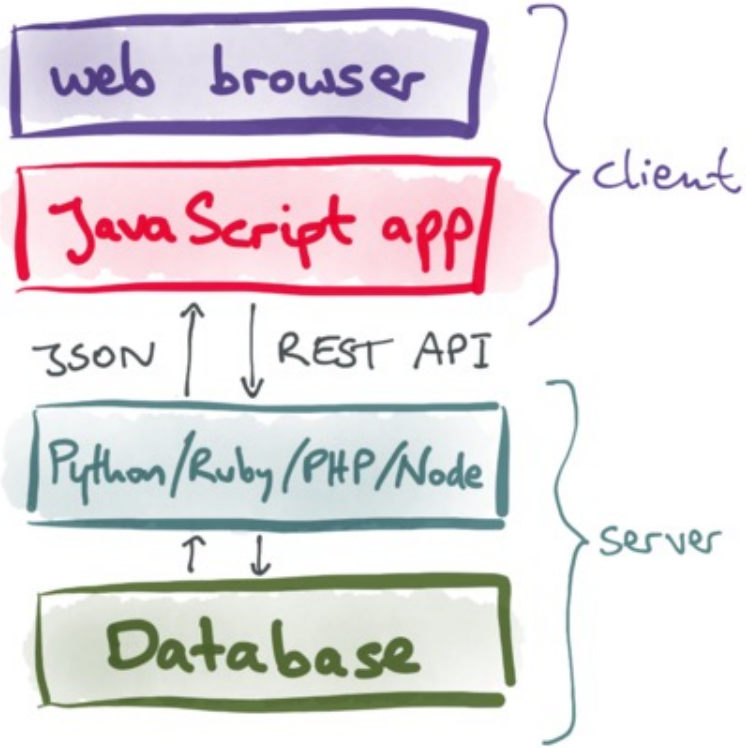


ca. 2010–2020

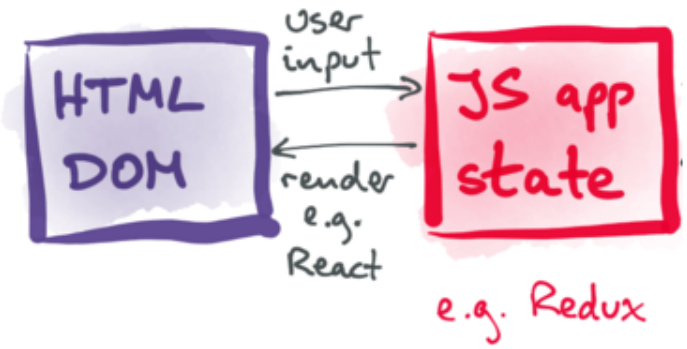


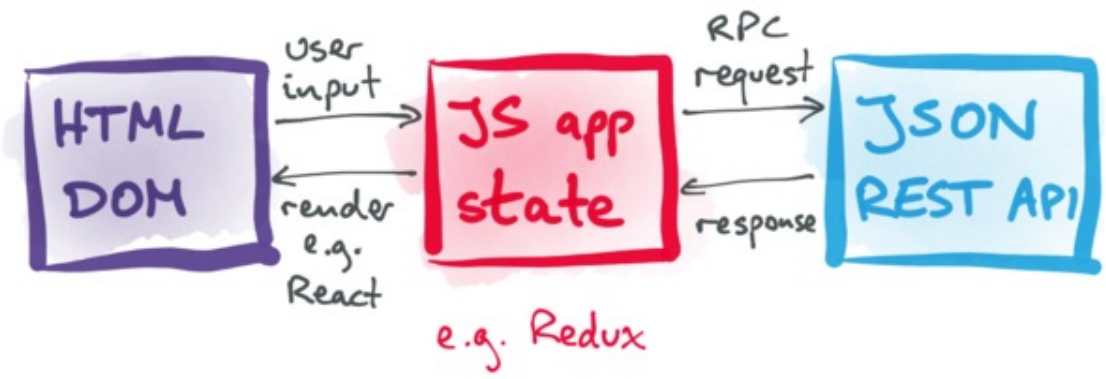
Google Docs

Office 365

Figma

Trello


HTML
DOM
User
input
render
e.g.
React
JS app
state
e.g. Redux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RPC request
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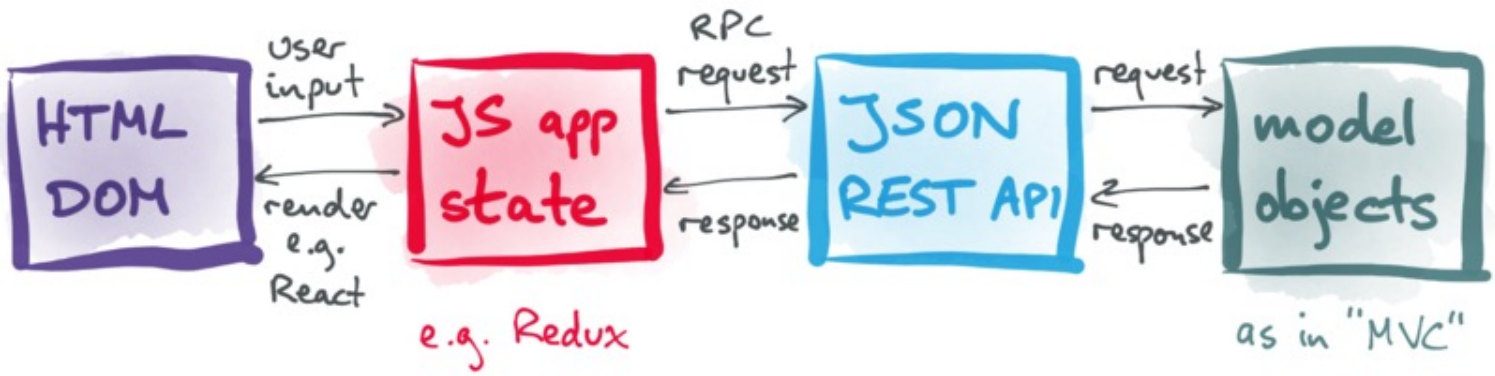
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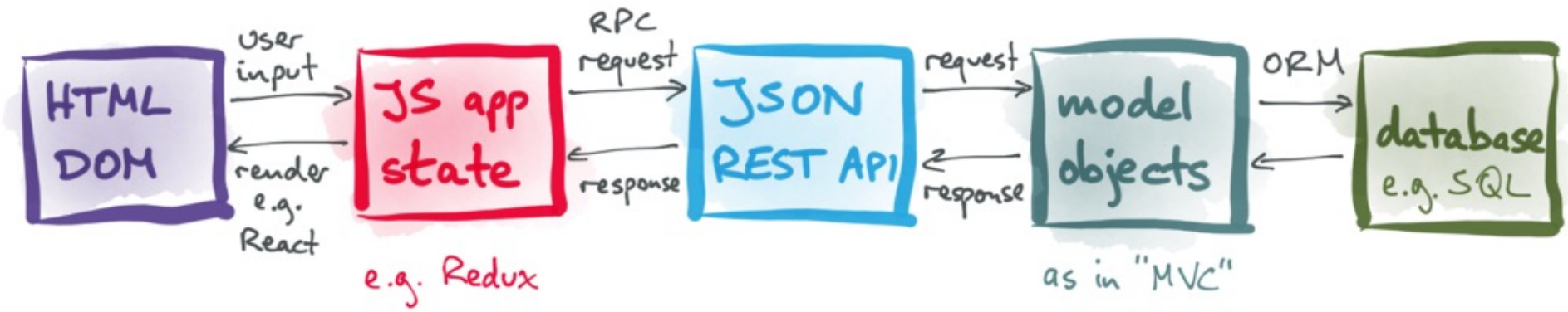
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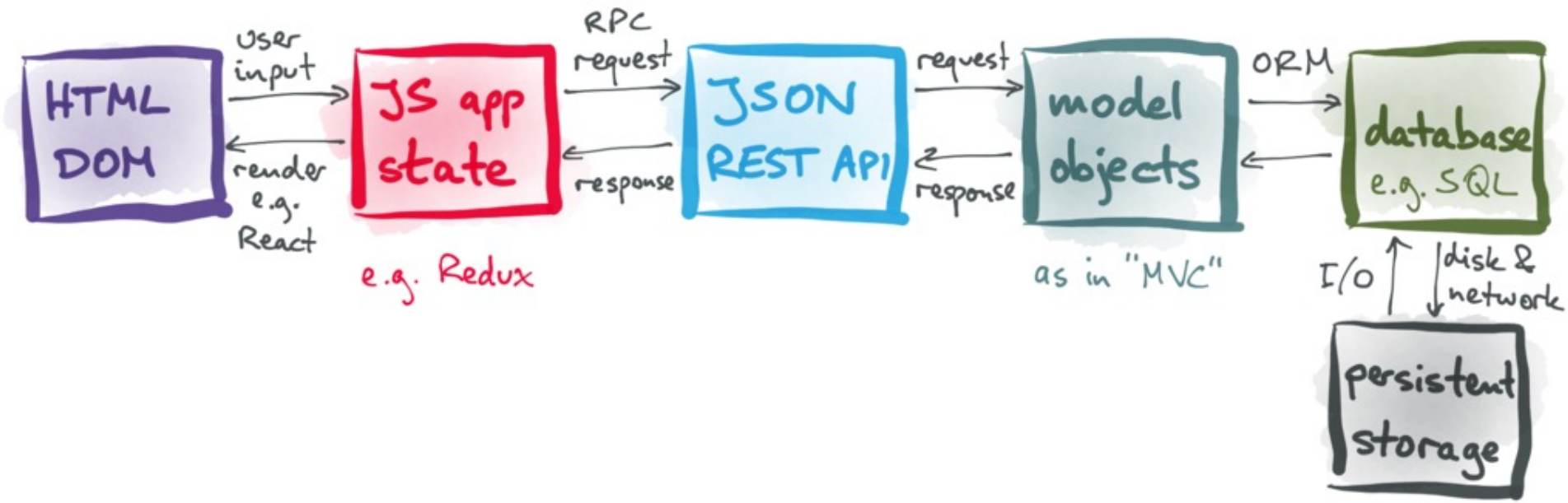
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model objects
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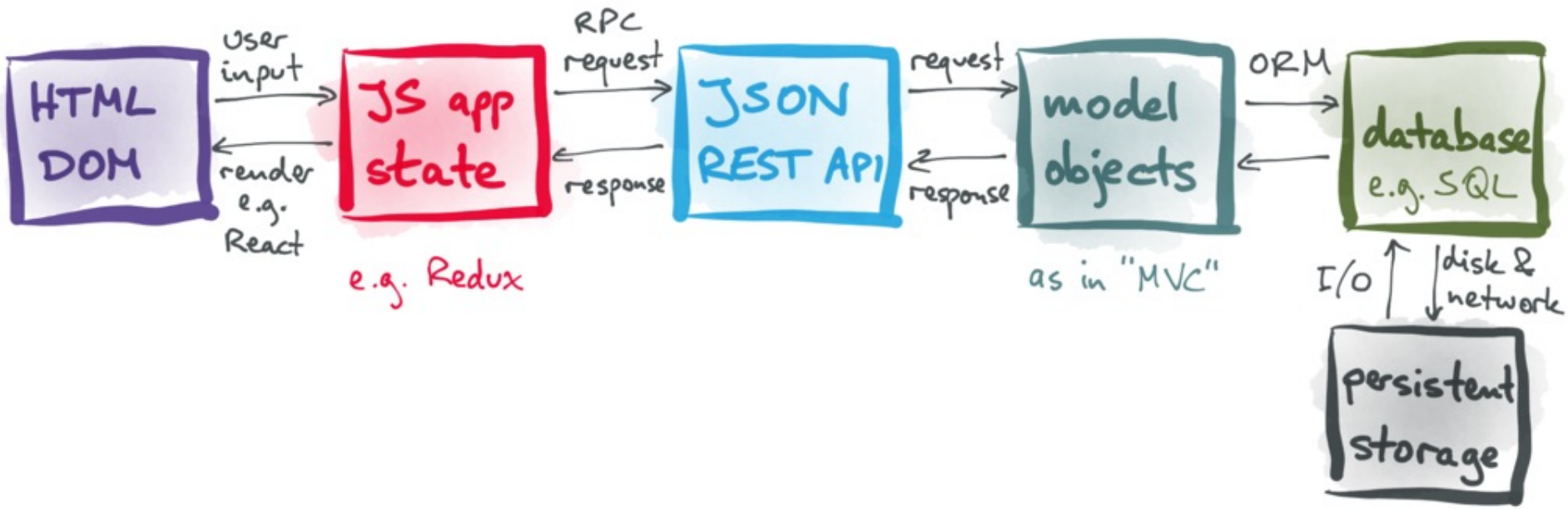
ORM
database e.g. SQL
I/O
disk & network
persistent storage

Six different representations of app state?!



Lots of code is just converting data from one representation to another.

CLOUD APPS / WEB APPS / SAAS

Pros:

- Real-time collaboration
- Access from any device, anywhere

Cons:

- Service shuts down?
  ⇒ everything lost
- Weak offline support
- Server, not user, owns data

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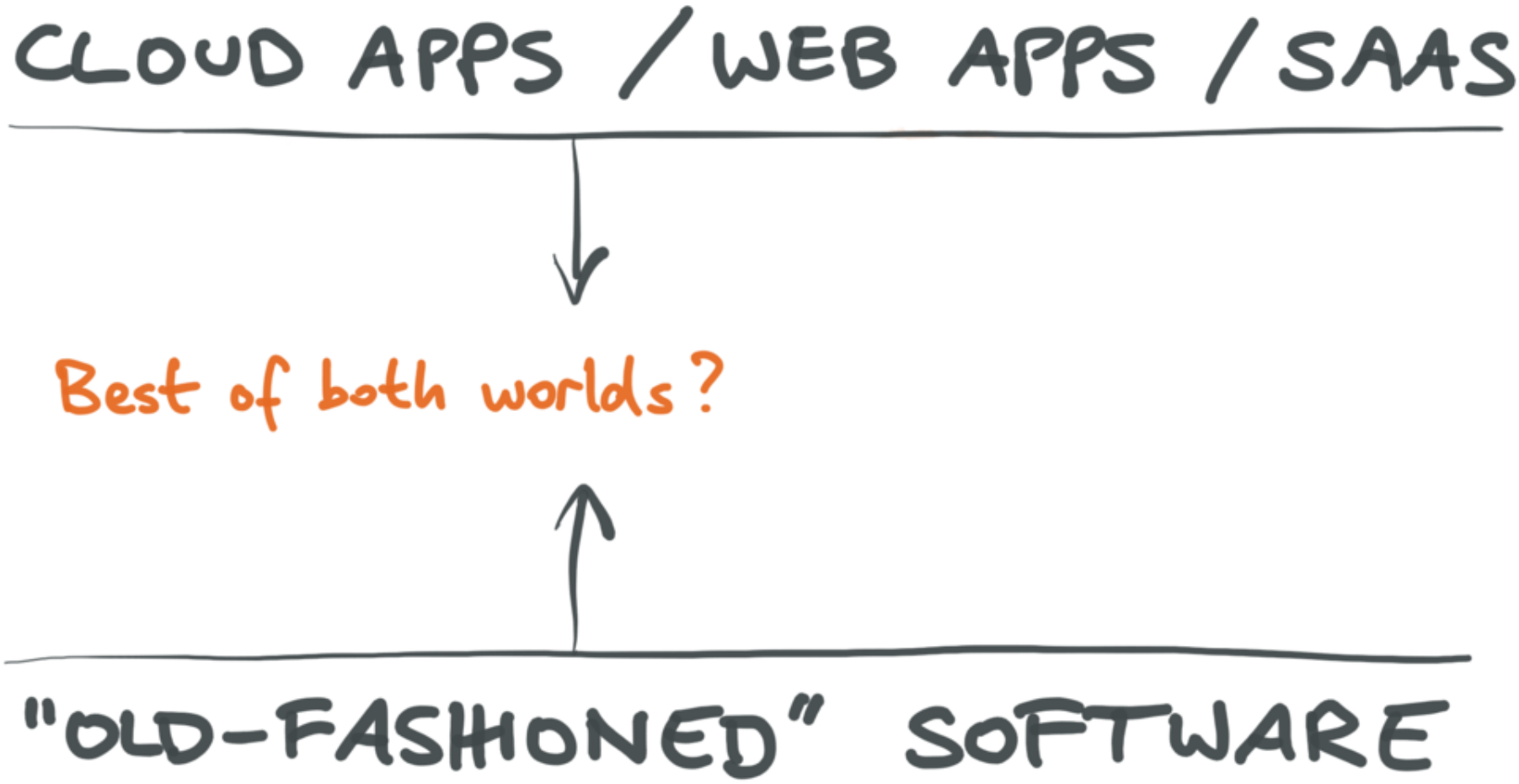
"OLD-FASHIONED" SOFTWARE

Pros:

- Data & software on your own device: works offline, full control, backups, run software forever (in VM)

Cons:

- Manual file copying between devices + collaborators
- Only one person at a time can edit file (or manual merge)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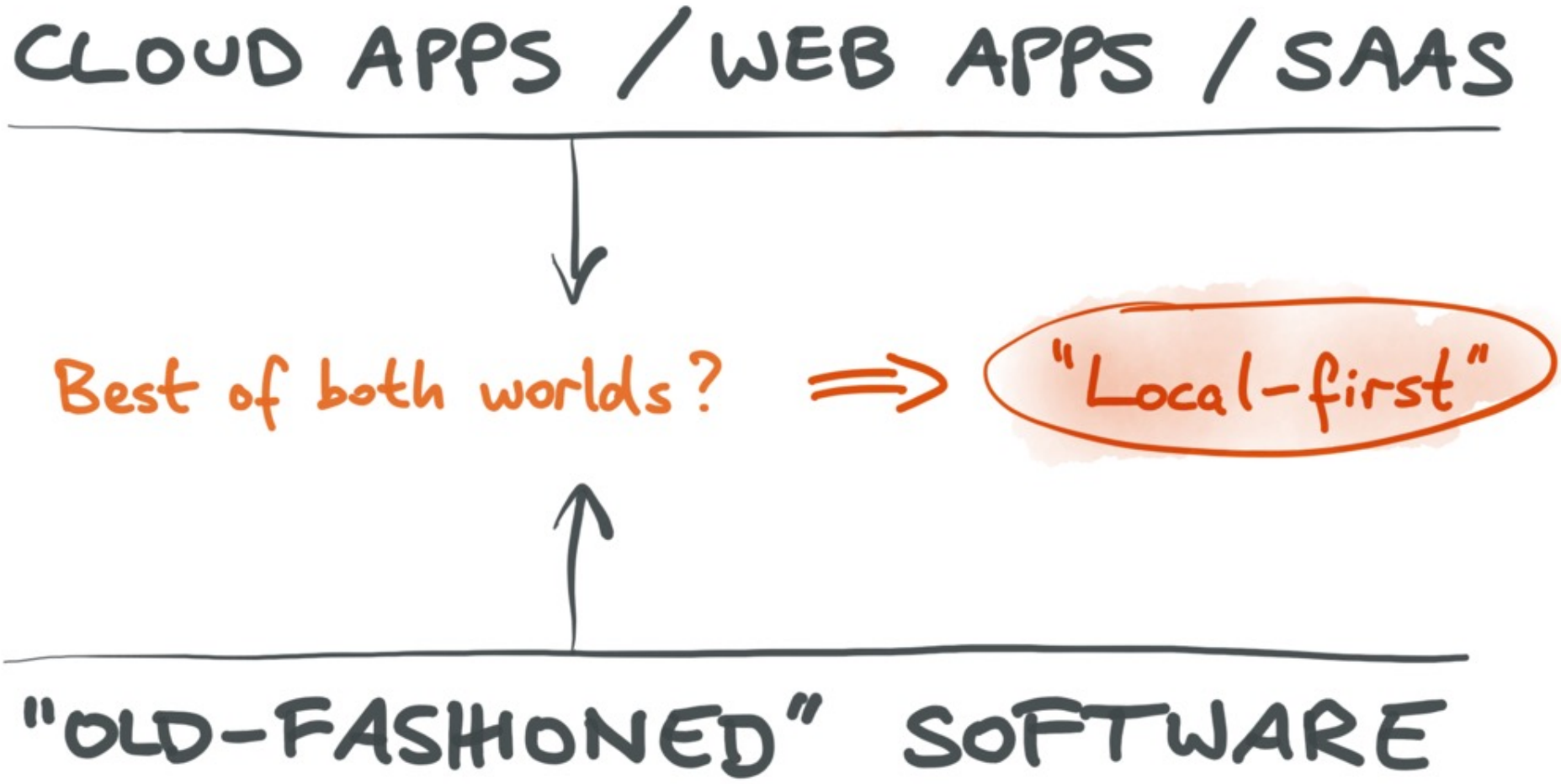
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Best of both worlds?
"Local-first"
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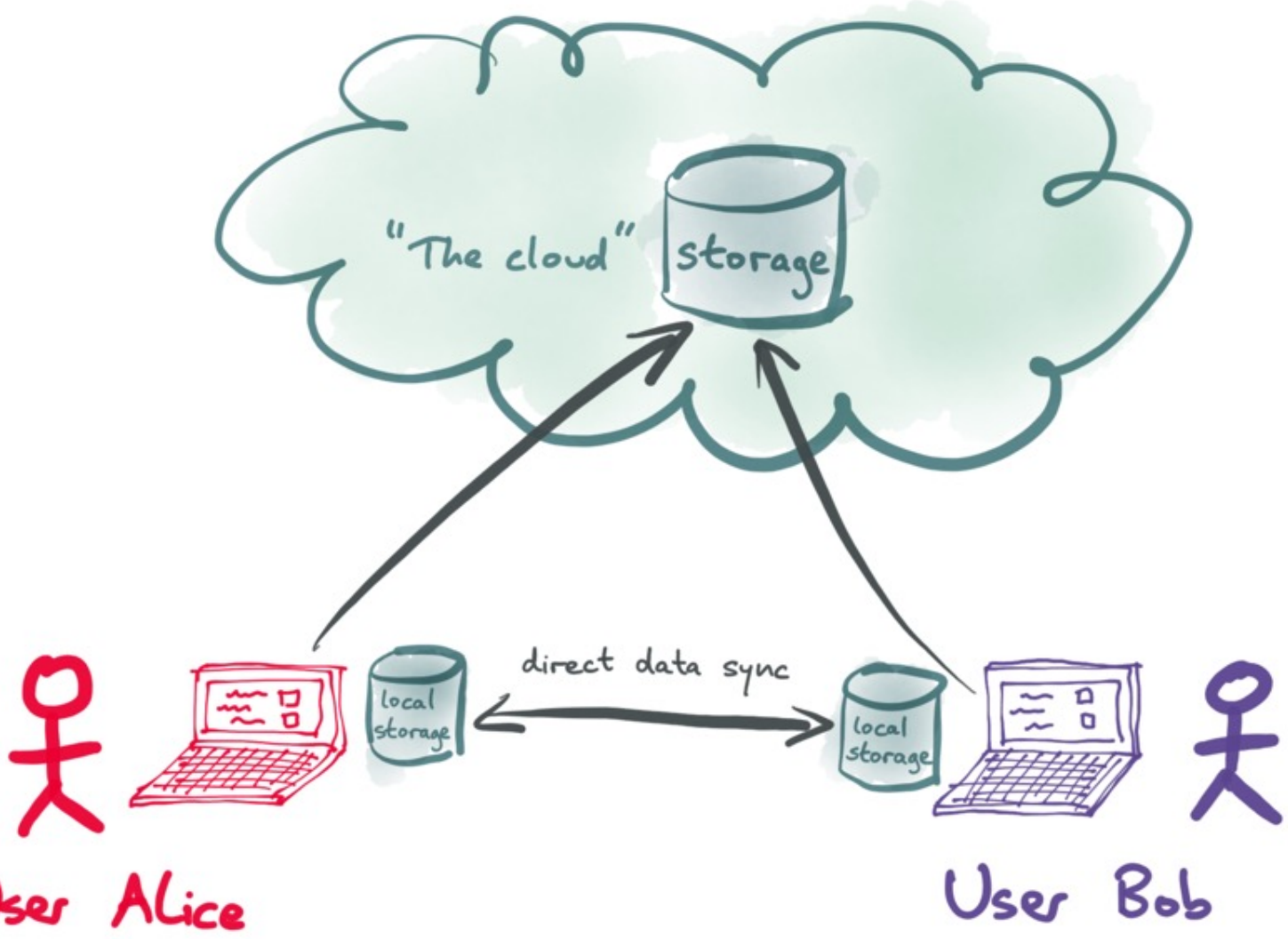
LOCAL-FIRST SOFTWARE



TRADITIONAL WEB APP MODEL:

"If it's not stored in the server database, it didn't really happen"

Can't reach the server? Can't do anything!

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LOCAL-FIRST MODEL:

"The client's local storage is what matters — the server is just for multi-user sync and backup"

Don't care if we're online or offline right now!

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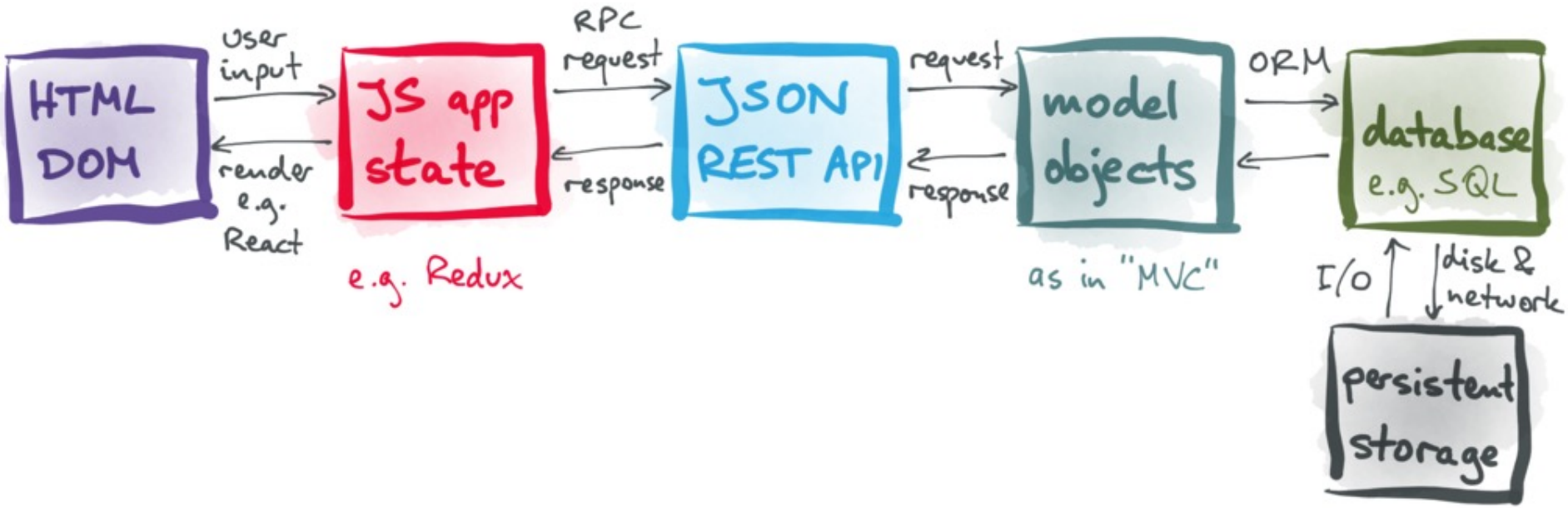

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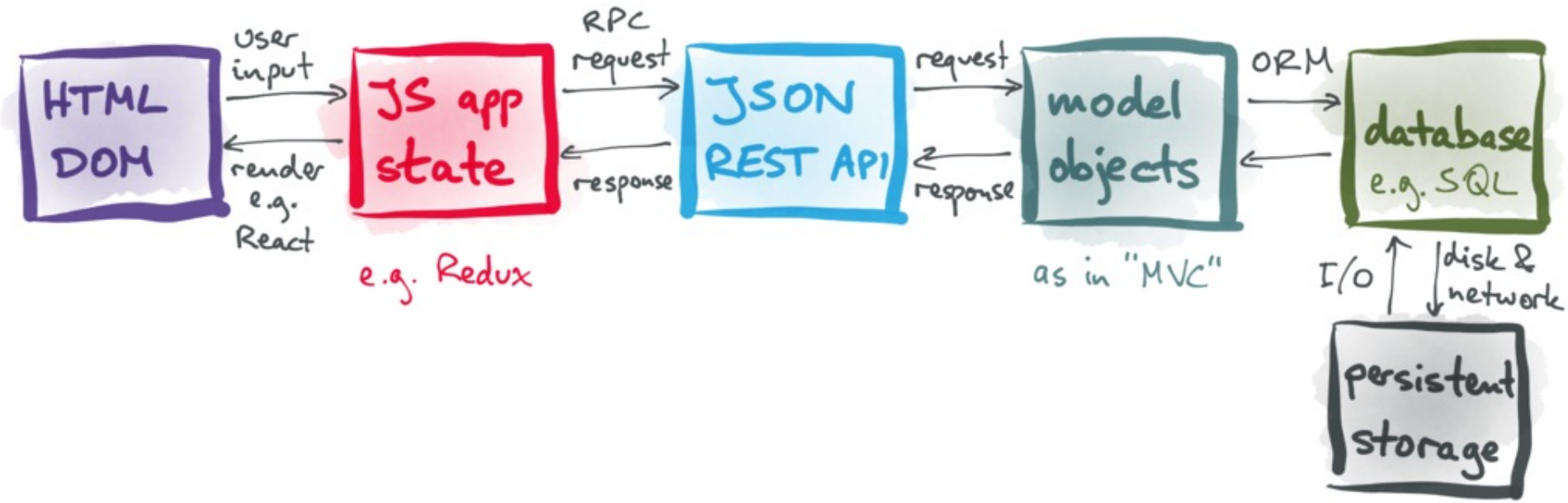

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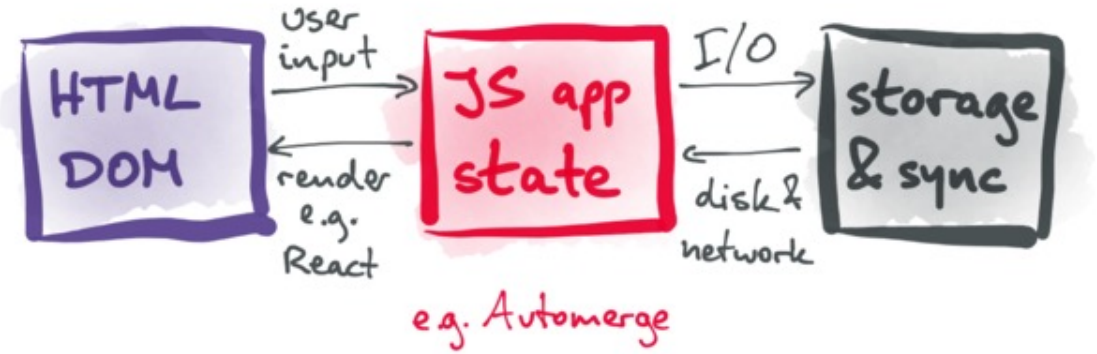


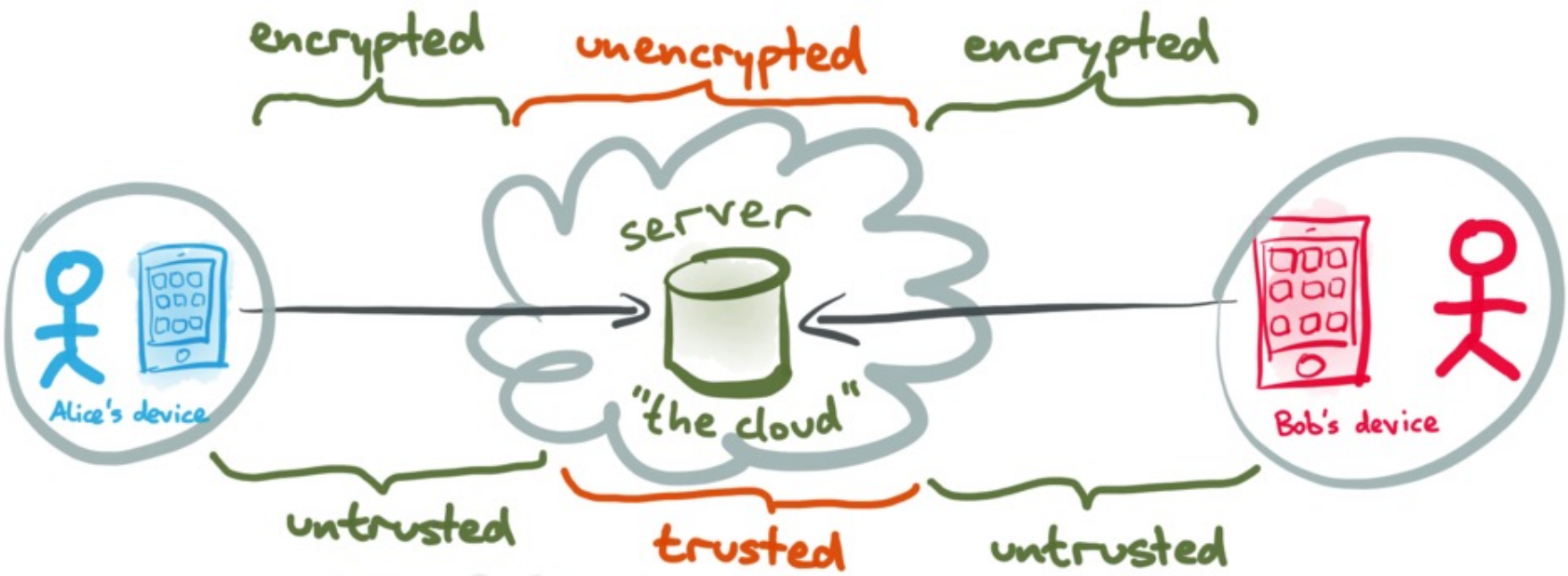
Self-contained!

End-to-end encryption for billions of users

WhatsApp

Signal

iMessage



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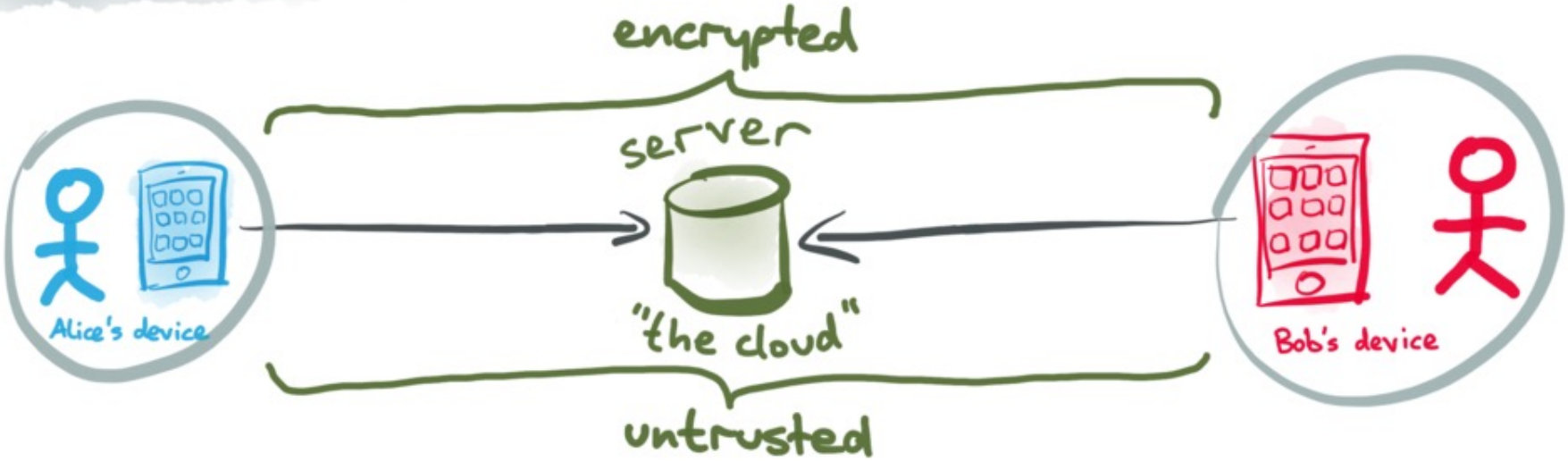

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☹ Real-time collaboration is hard to implement	☺ Built for real-time sync
☹ Does not work offline	☺ Works offline
☹ Service shuts down? Lose everything!	☺ Users can continue using local copy of software + data
☹ Custom service for each app (infra, ops, on-call rotation, ...)	☺ Sync service is generic ⇒ outsource to cloud vendor

Local-first is a good fit for:

"File editing" software

(text editor, word processor, spreadsheet, presentation slides, graphics editor, video editing, music production, CAD software for engineering, Jupyter notebooks, ...)

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Basically, apps where the user can edit the data however they like.

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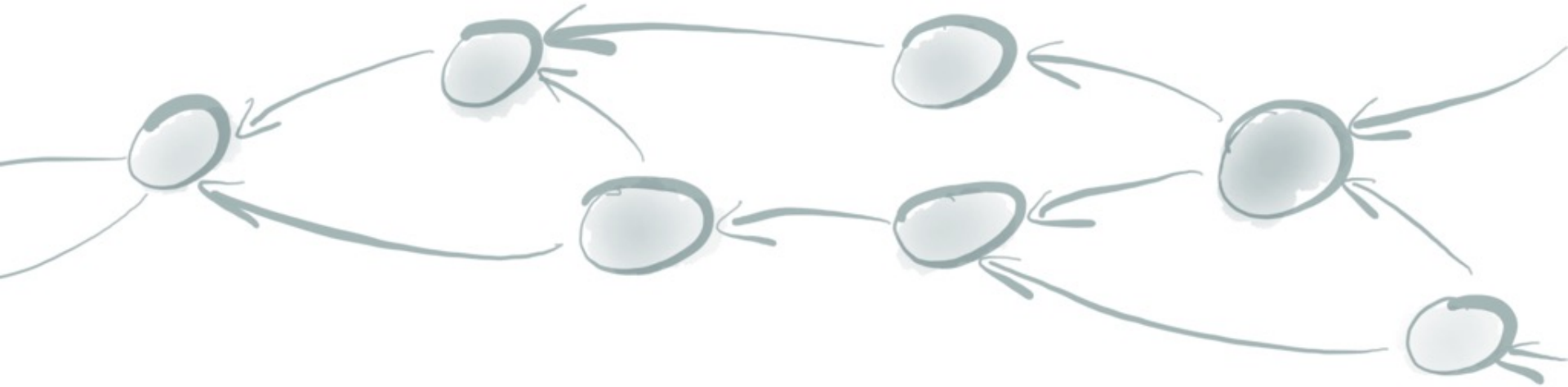
Local-first is a bad fit for:

Managing a real-world resource, e.g.

- **money** (bank account, payments, ad impressions)
- **physical products** (e-commerce, warehouse inventory)
- **vehicles** (car-sharing/rental, freight/logistics)

For these apps, a centralised cloud/server model works best.



Automerge

https://automerge.org

AUTOMERGE: "Git for your app's data"

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{"todos": [
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record exactly what changed

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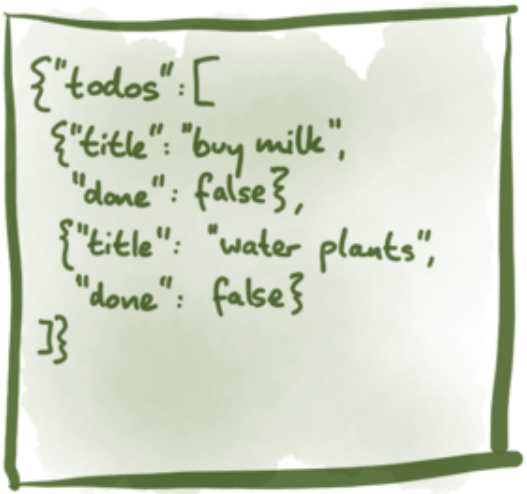
append item to list

AUTOMERGE: Branching and merging



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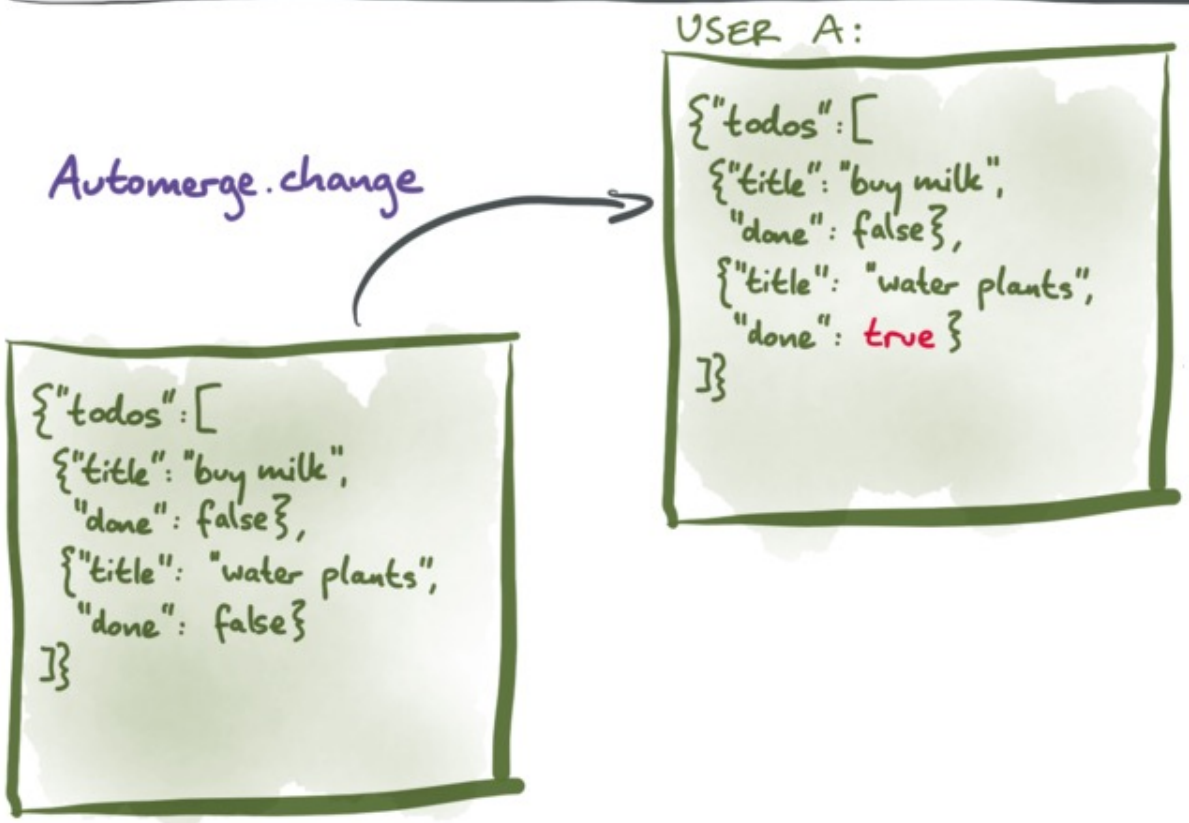

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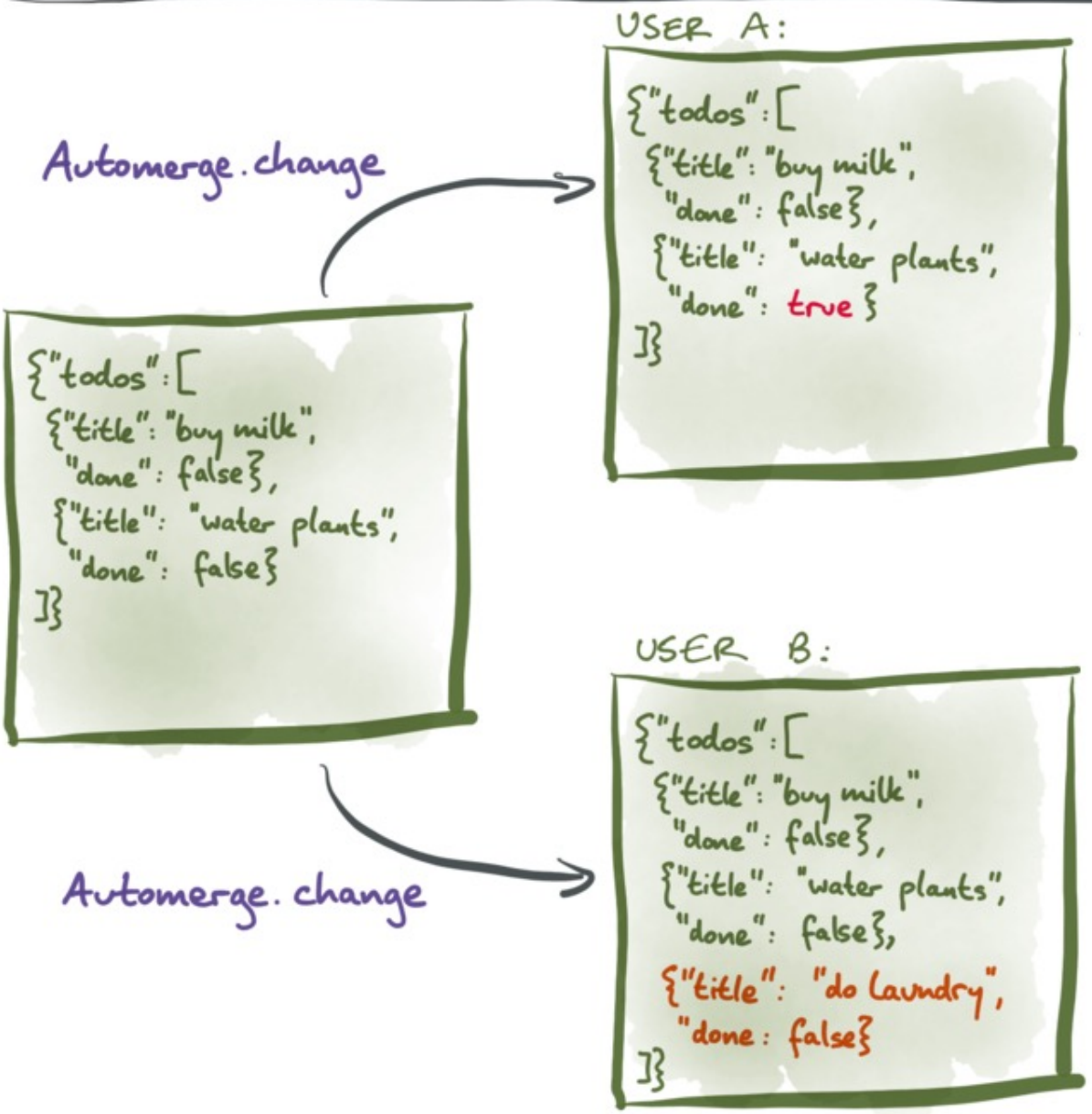

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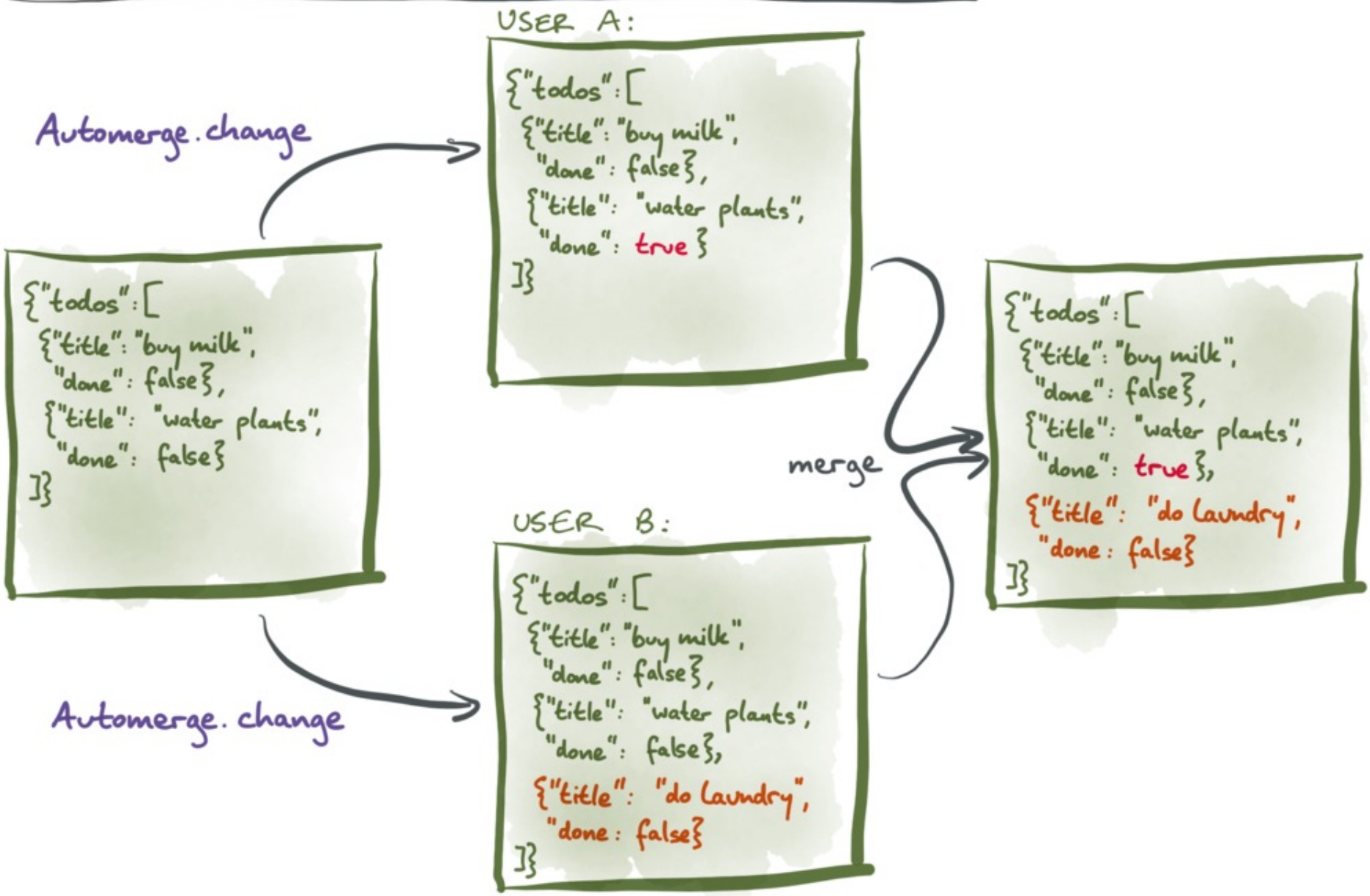

Example: Text editing

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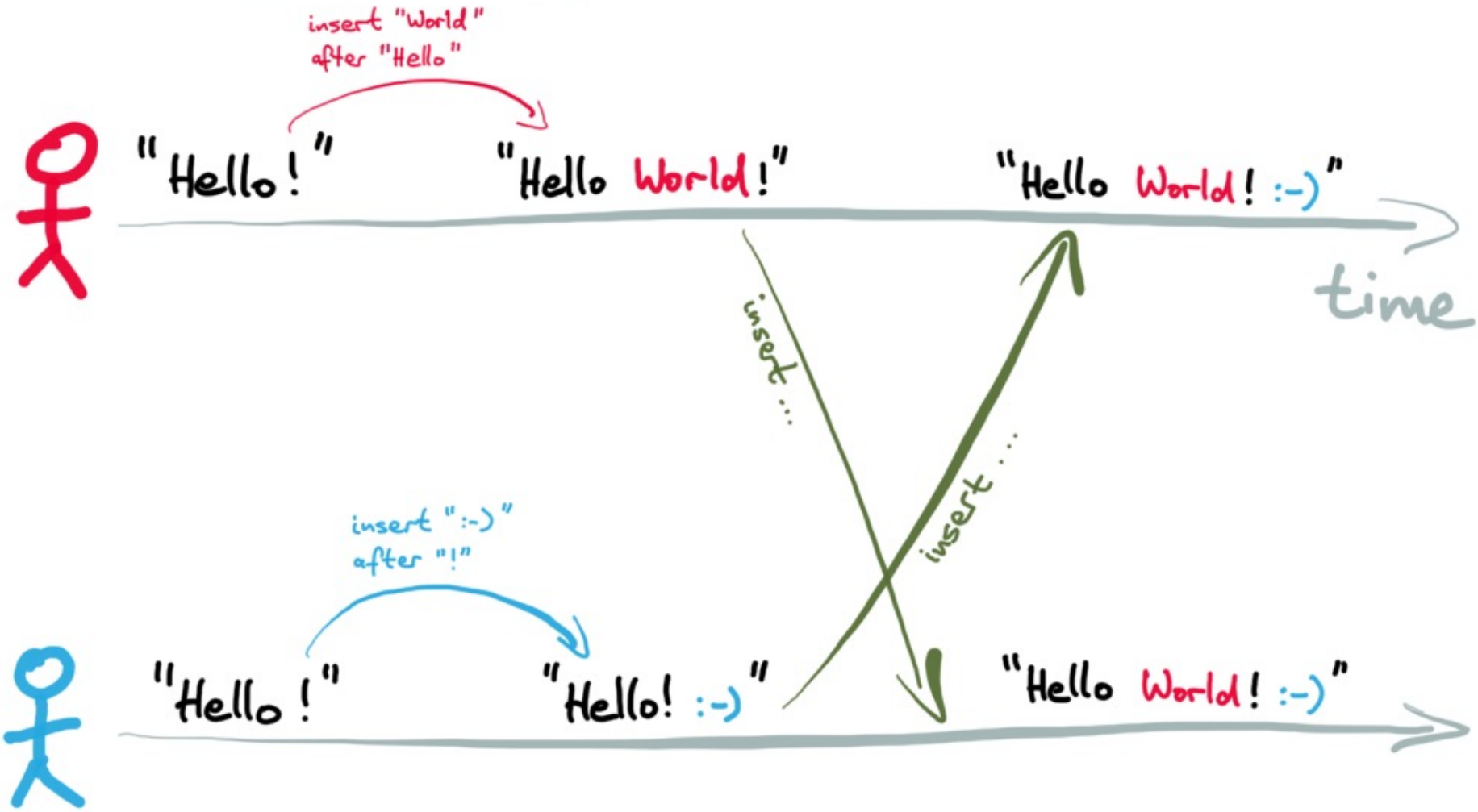


Automerge guarantees:

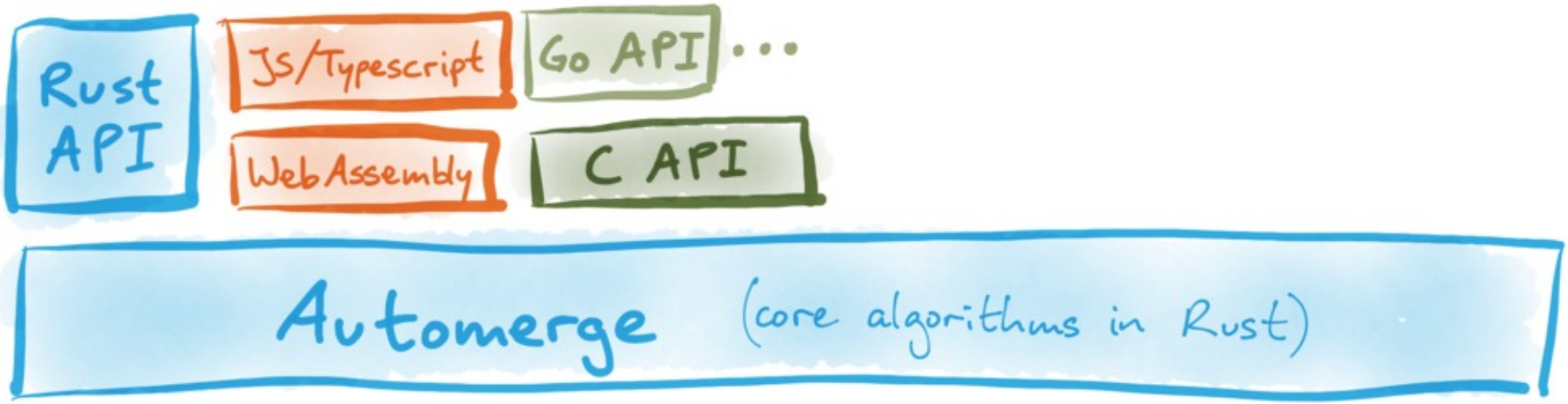
- All changes are preserved
- If two users have seen the same set of changes (in any order), then they are in the same state
- Branches (=concurrent updates) can be merged automatically
- Can branch & merge arbitrarily, can inspect/compare versions

Automerge is a CRDT

(conflict-free replicated data type)


Rust
API
Automerge (core algorithms in Rust)


Rust API
JS/Typescript
WebAssembly
Automerge (core algorithms in Rust)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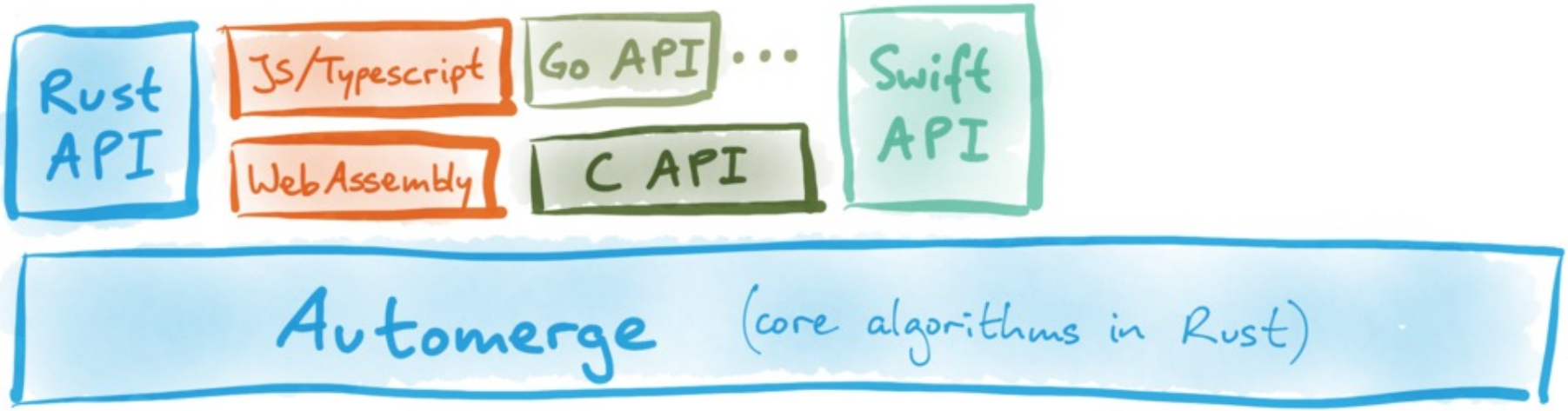
(core algorithms in Rust)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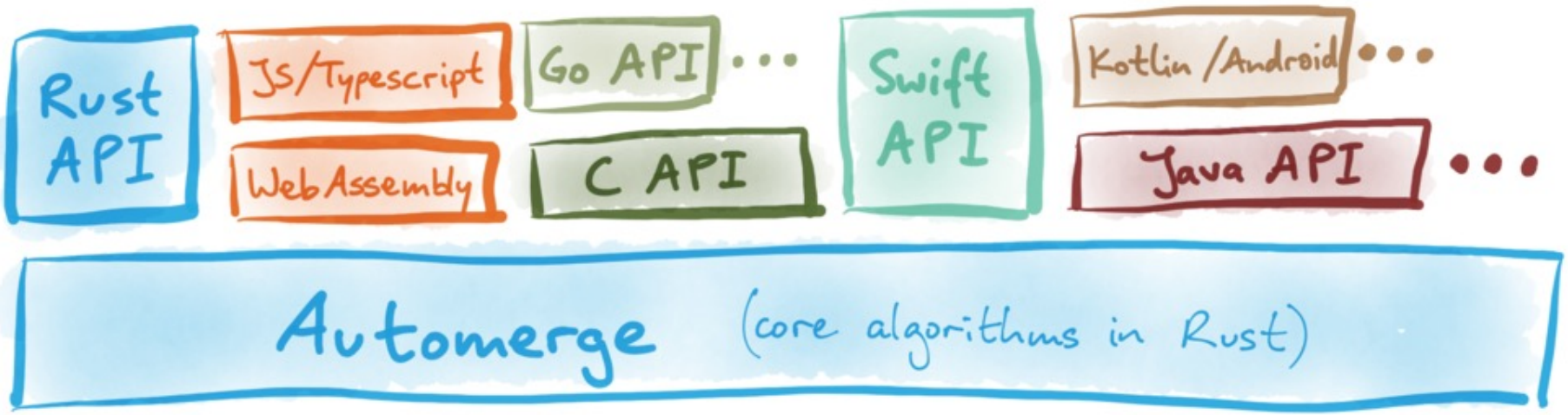
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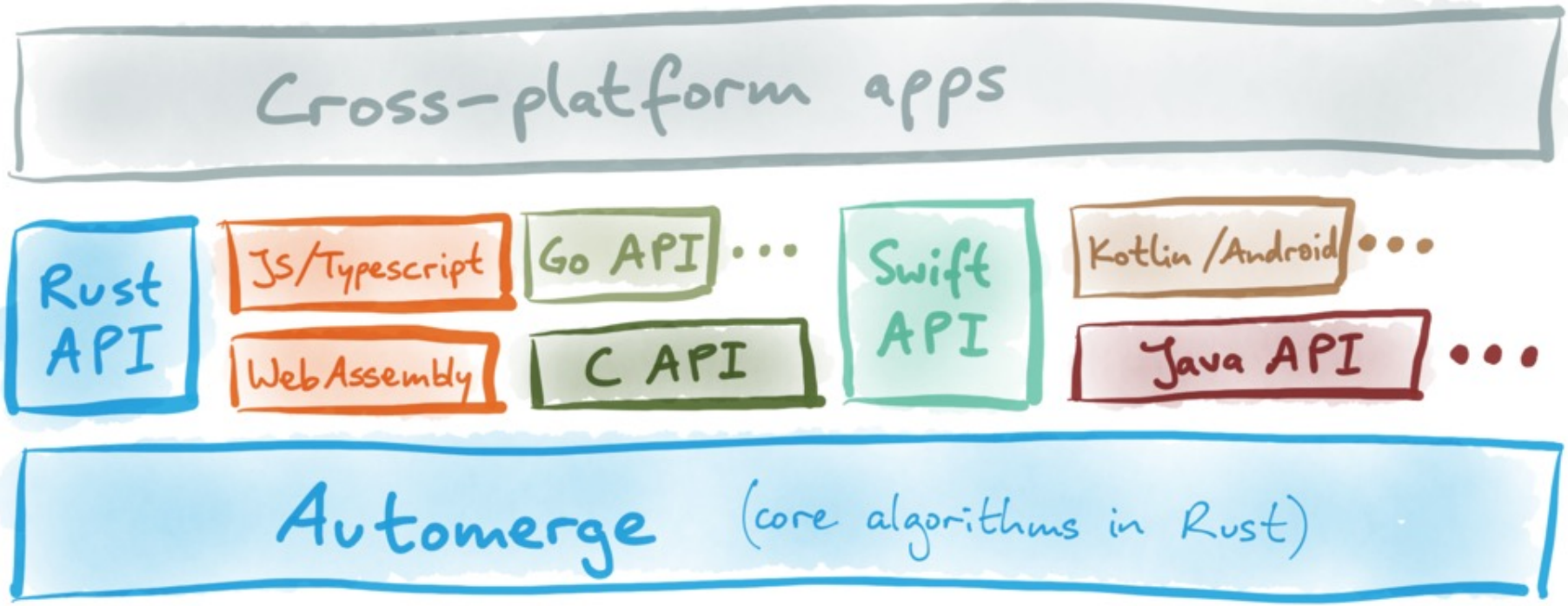
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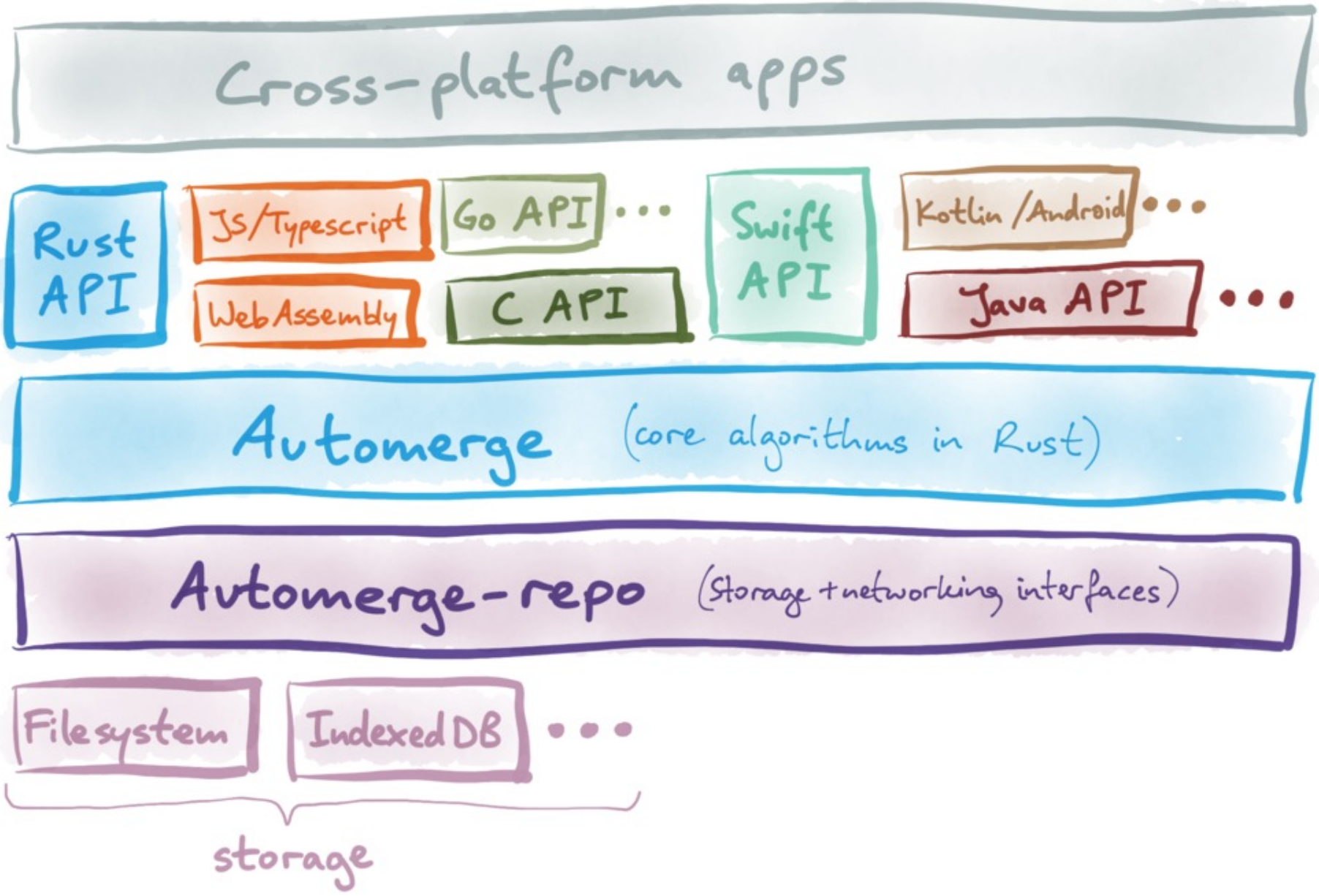
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(Storage + networking interfaces)
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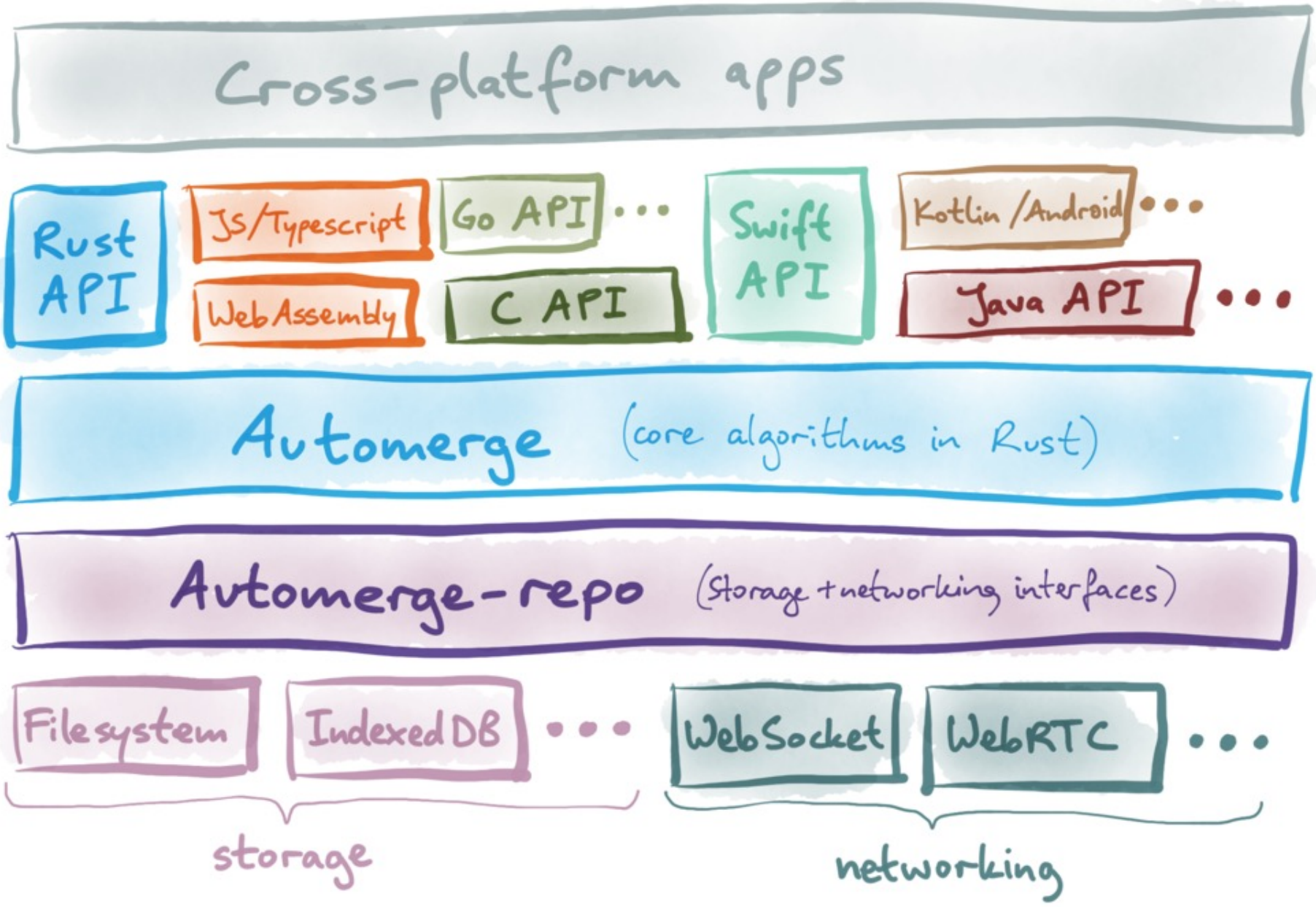
IndexedDB
storage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Resources

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Automerge	https://automerge.org/
My work	https://martin.kleppmann.com/
Email	martin@kleppmann.com
Bluesky	@martin.kleppmann.com
Mastodon	@martin@nondeterministic.computer

Huge thanks to the Automerge community and contributors, especially Alex Good, Peter van Hardenberg, Orion Henry, Andrew Jeffery, Herb Caudill, Alex Currie-Clark, Jason Kankiewicz, Conrad Irwin, and many others!

Thank you to my Patreon backers and institutional supporters: