Offline data manipulations for everyone with Plug-Ins and SQLite

23.11.2023

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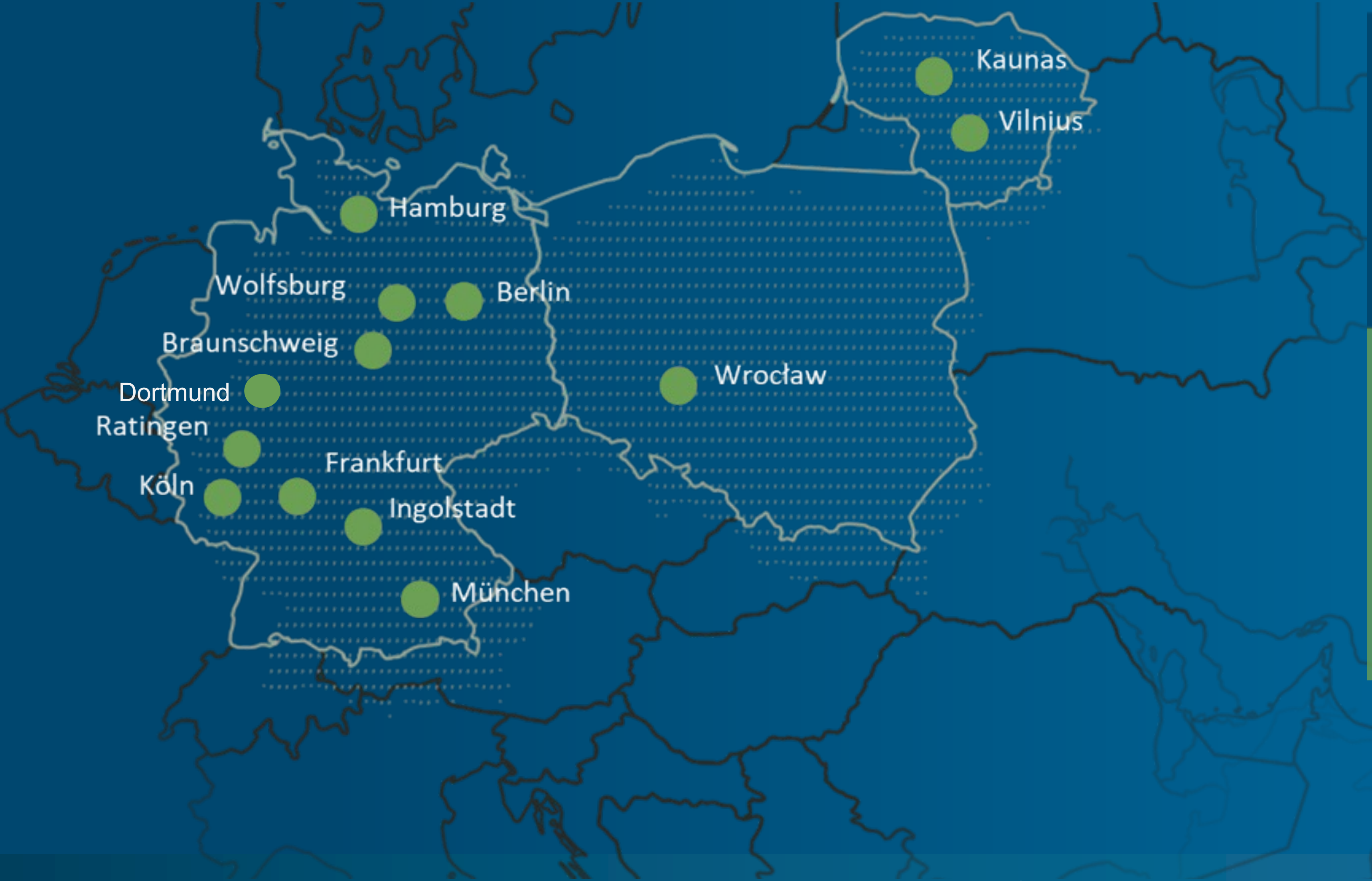
DOAG 2023, Nuremberg, Germany

We are one of the top 20 IT service providers in Germany!



MT - IT SOLUTIONS

GOD

- > 800 employees
- 14 offices globally
- > 150 customers
- > 10 industries

$ whoami

Philipp Hartenfeller

- Düsseldorf, Germany
- Master IT-Management
- Since 2016 @ MT ~~AG~~ GmbH
- Senior Consultant – Oracle APEX
- Mostly doing WebDev, DBs and APEX Testing (https://lct.software)

Blog: https://hartenfeller.dev/blog/

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What this talk is about

- Offline APEX is no new topic, there have been a few methods already
- I am interested in **HOW** it should be usable in APEX (and tech stuff)

What this talk is about

How should it be accessible ?

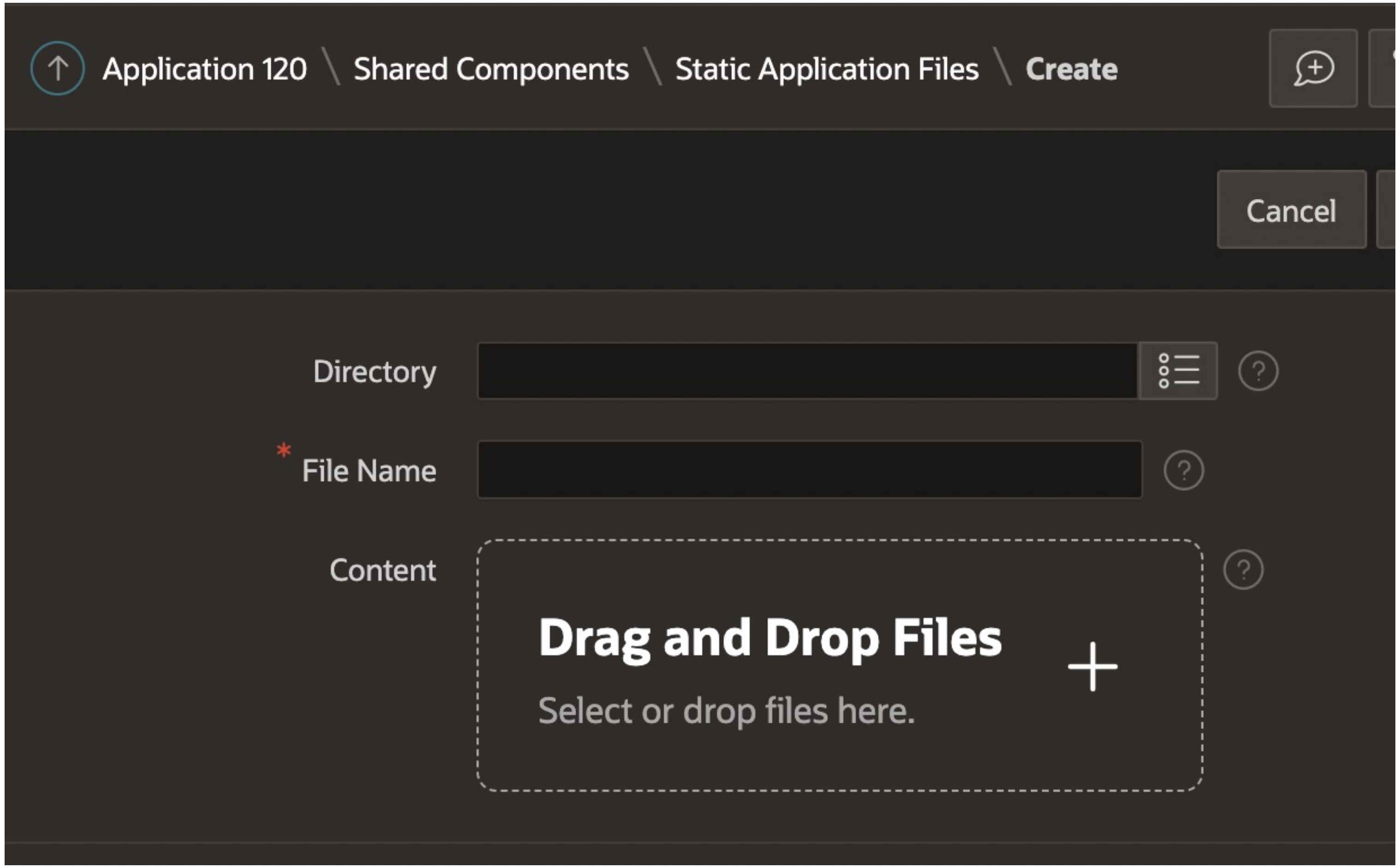
- Low Code Interface -> No JavaScript Code wrangling
  - **APEX Plug-Ins**
- Easy to configure
  - Enter your Query and let’s go!

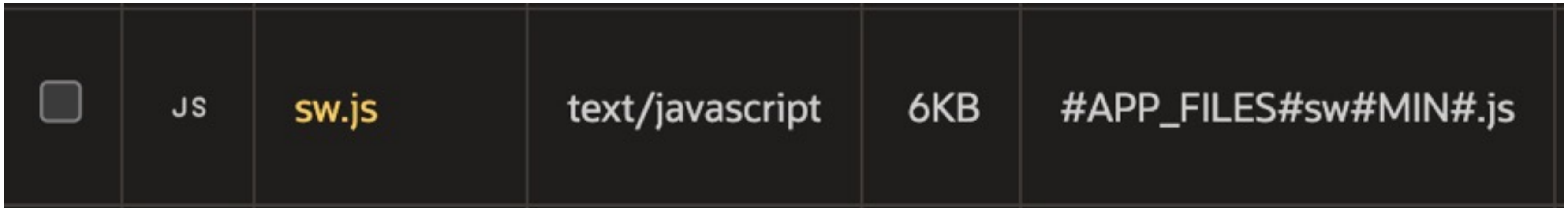
What this talk is about

How should it be accessible ?	How should it work ?
• Low Code Interface -> No JavaScript Code wrangling • **APEX Plug-Ins** • Easy to configure • Enter your Query and let’s go!	• Fast • Handle lots of data • Concept to merge changes back to DB • Somewhat future proof

Proof of Concept: Not production ready!

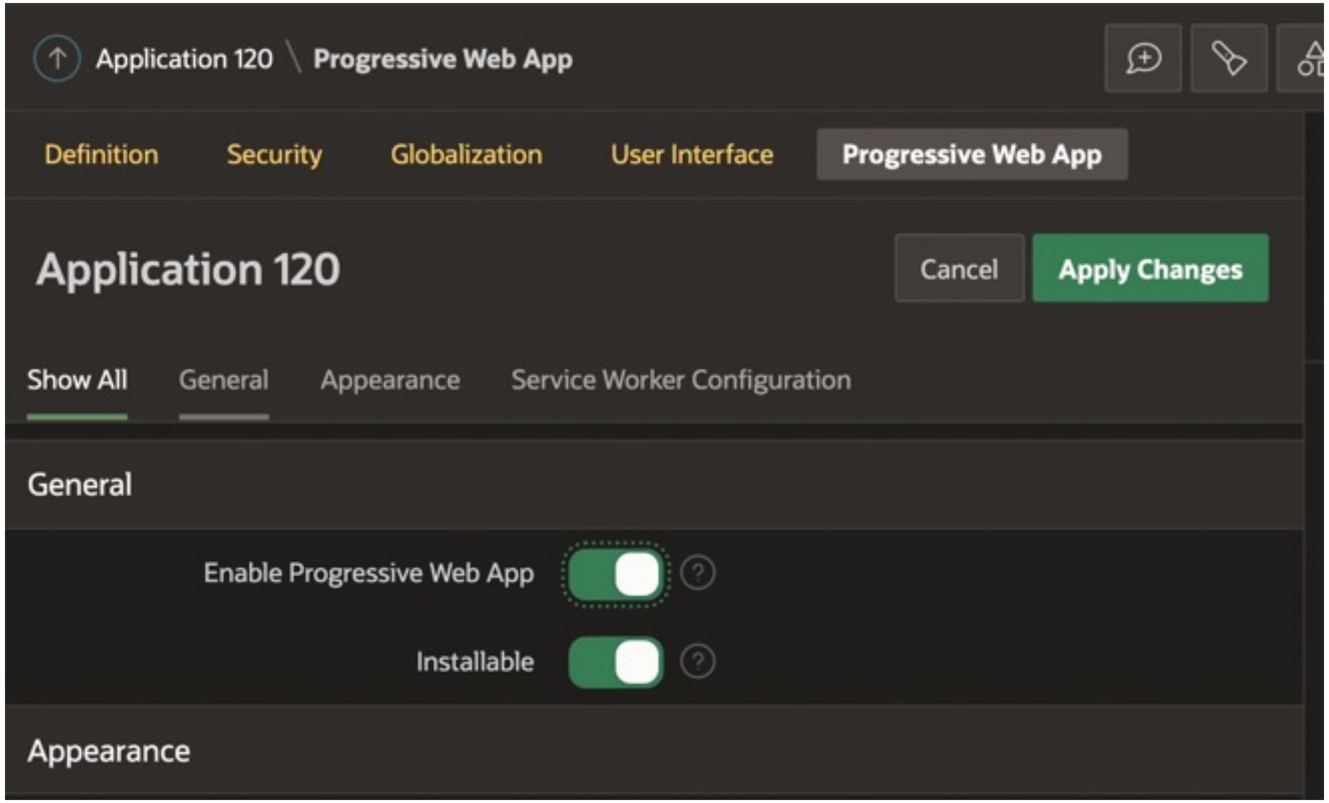
Upload sw.js


Application 120 \ Shared Components \ Static Application Files \ Create
Cancel
Directory
* File Name
Content
Drag and Drop Files
Select or drop files here.



□	JS	sw.js	text/javascript	6KB	#APP_FILES#sw#MIN#.js

Enable PWA features



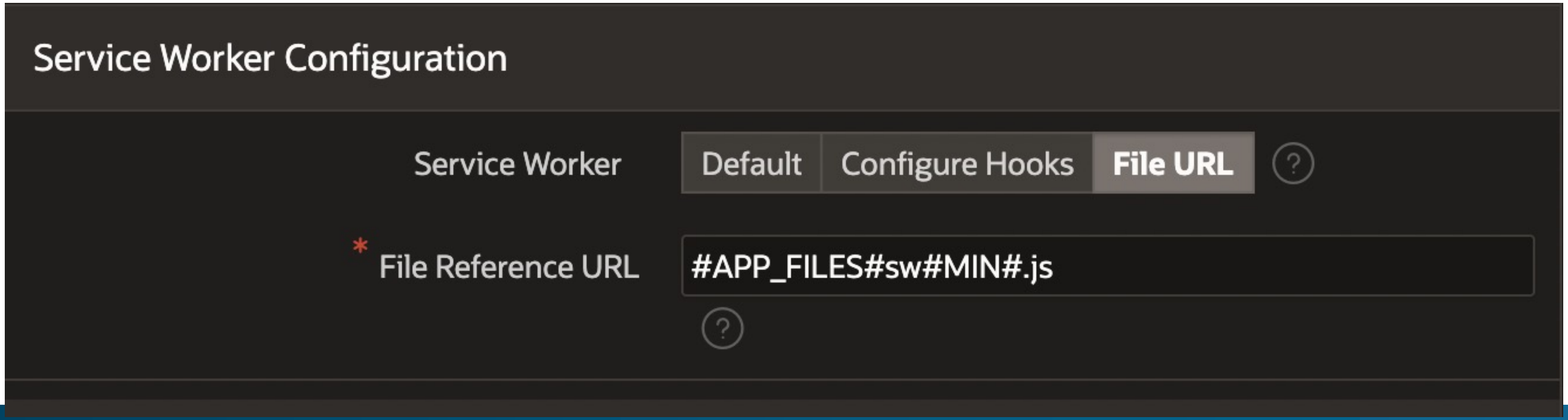
Application 120

General

Enable Progressive Web App: On

Installable: On

Appearance



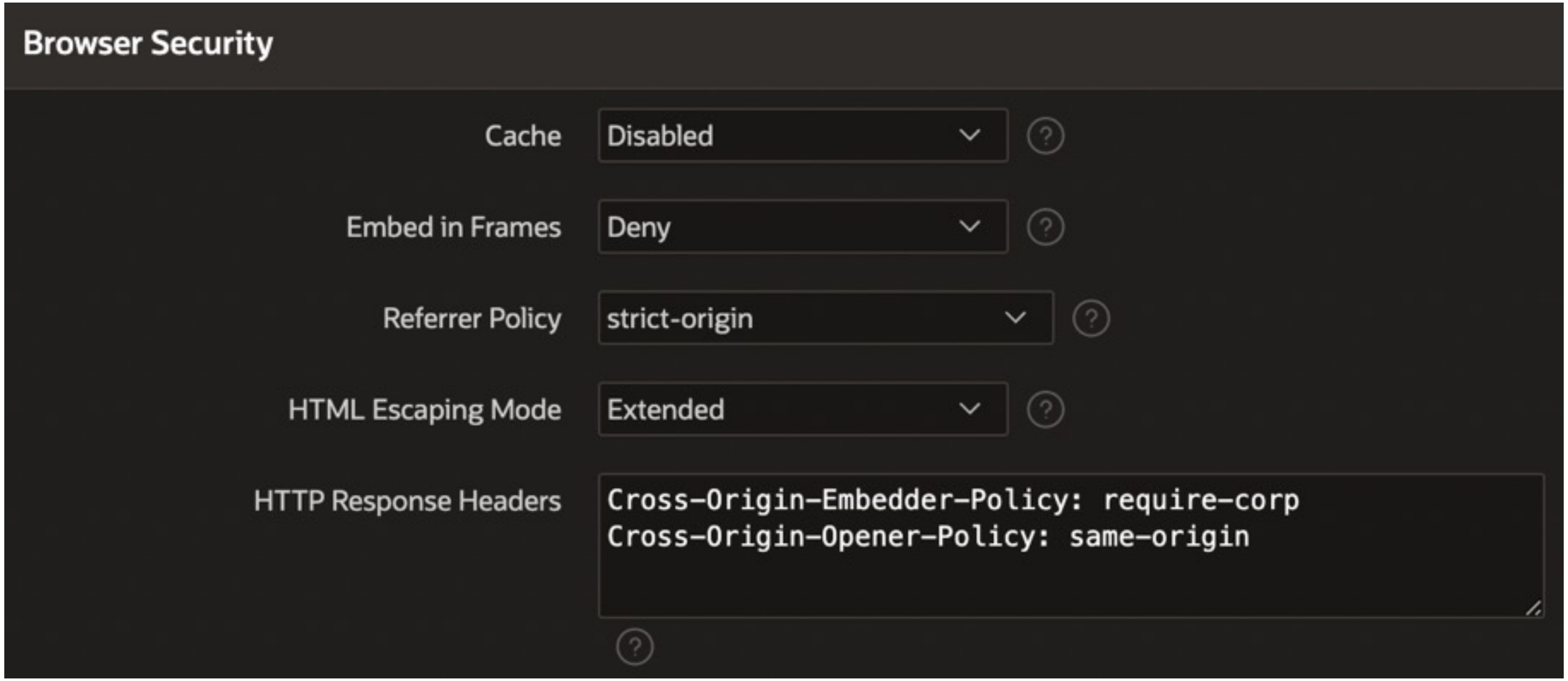
Service Worker Configuration

Service Worker: File URL

* File Reference URL: #APP_FILES#sw#MIN#.js

Also enable Persistent Auth!

Set required Headers



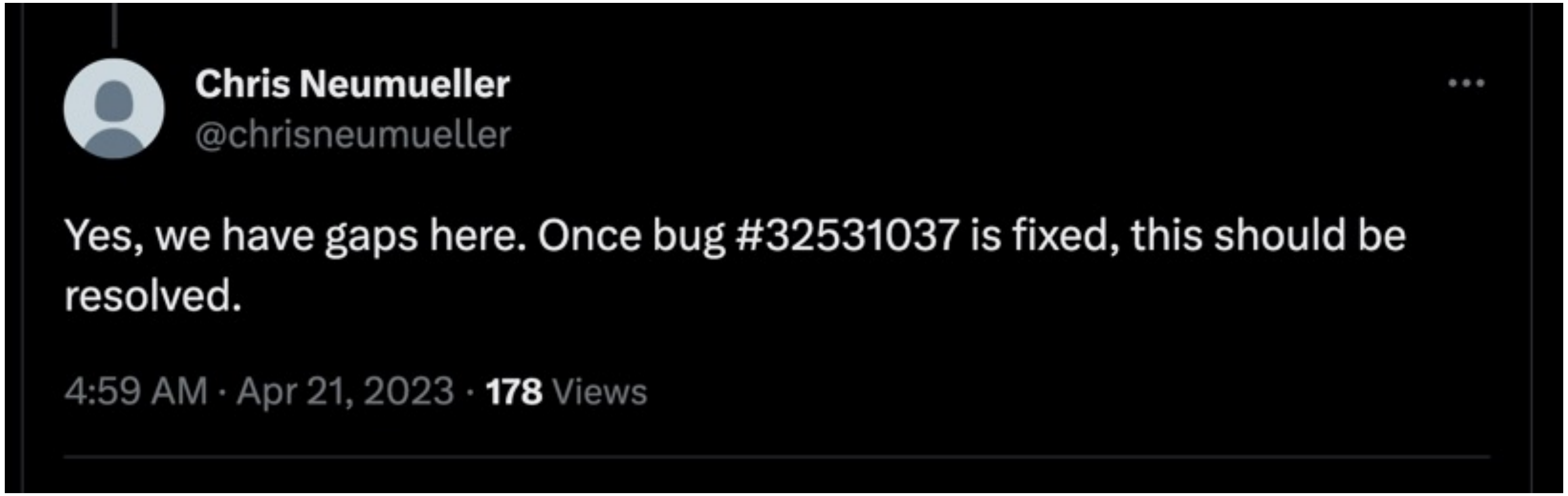
Browser Security

Cache	Disabled
Embed in Frames	Deny
Referrer Policy	strict-origin
HTML Escaping Mode	Extended
HTTP Response Headers	Cross-Origin-Embedder-Policy: require-corp Cross-Origin-Opener-Policy: same-origin

Restricts how other websites can access data of APEX pages

Currently a bug in APEX (does not apply to Plug-In files)

A bug is filed



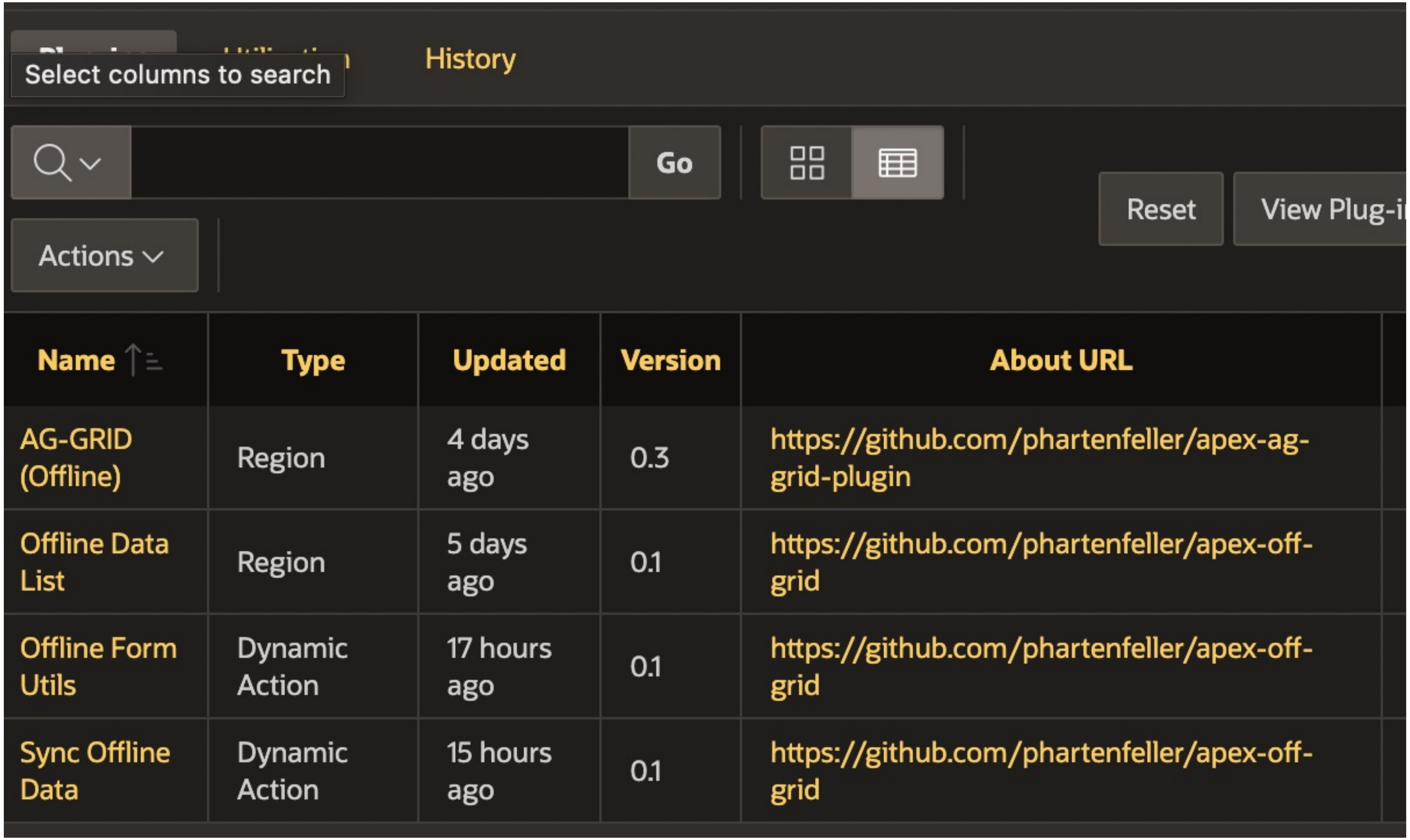
Chris Neumueller
@chrisneumueller

Yes, we have gaps here. Once bug #32531037 is fixed, this should be resolved.

4:59 AM · Apr 21, 2023 · 178 Views

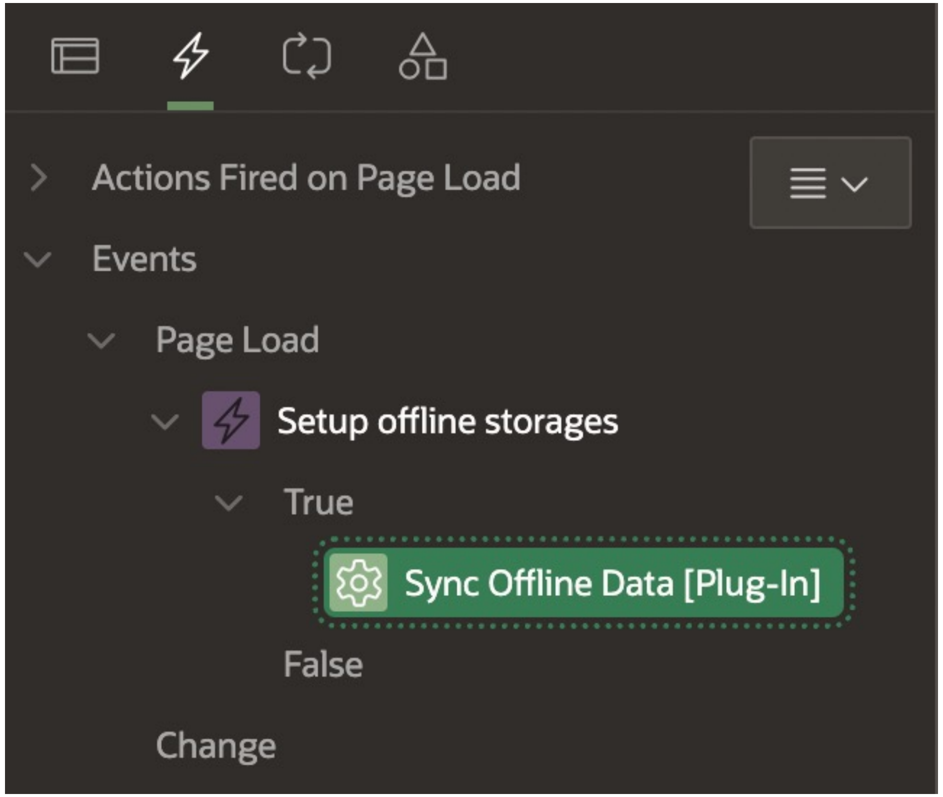
For now, you need to set it on Proxy / Webserver

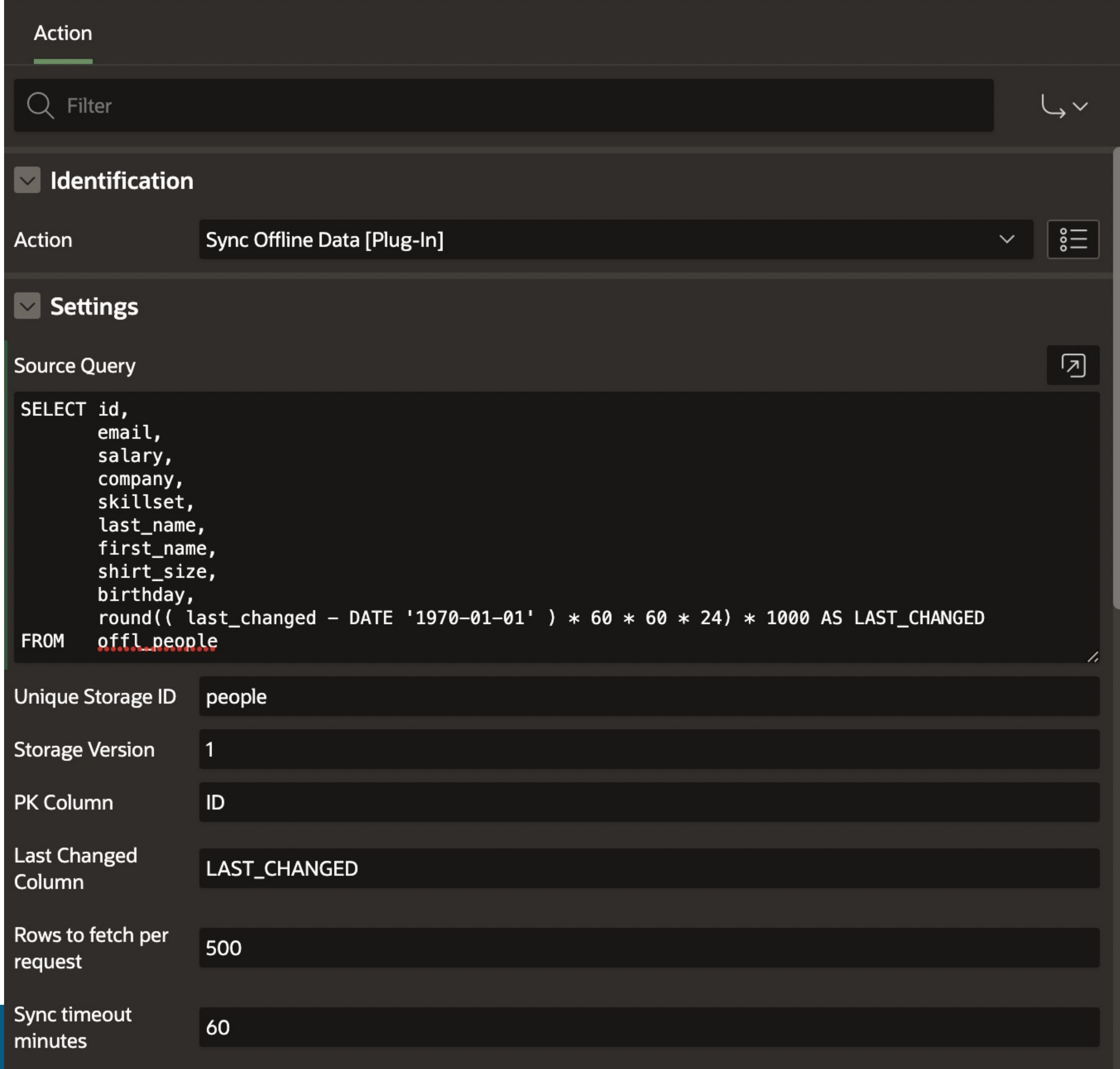
Import Plug-Ins



Name	Type	Updated	Version	About URL
AG-GRID (Offline)	Region	4 days ago	0.3	https://github.com/phartenfeller/apex-ag-grid-plugin
Offline Data List	Region	5 days ago	0.1	https://github.com/phartenfeller/apex-off-grid
Offline Form Utils	Dynamic Action	17 hours ago	0.1	https://github.com/phartenfeller/apex-off-grid
Sync Offline Data	Dynamic Action	15 hours ago	0.1	https://github.com/phartenfeller/apex-off-grid

Setup Sync-Plug-In





Identification

Action	Sync Offline Data [Plug-In]

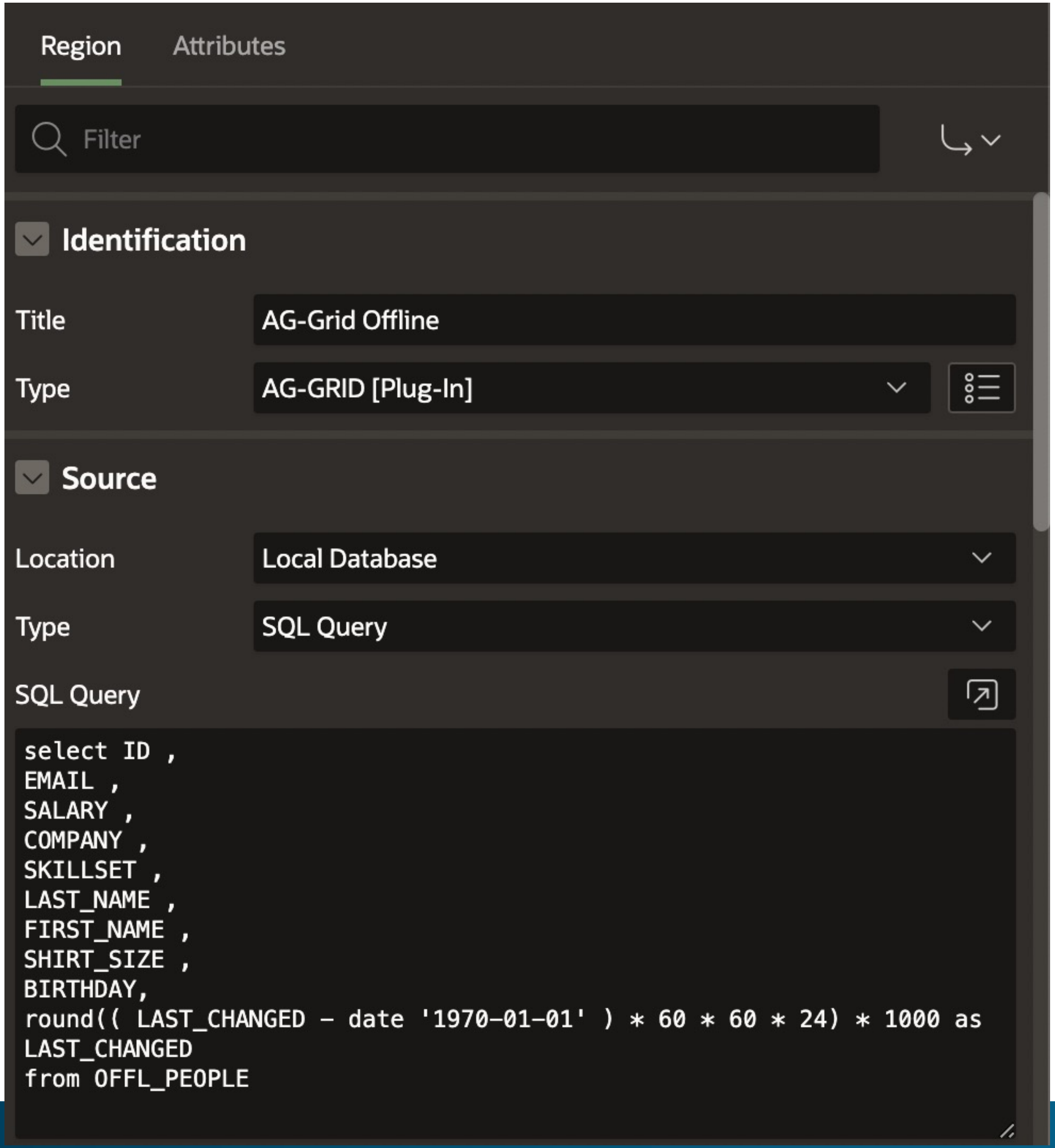
Settings

Source Query

```
SELECT id,
       email,
       salary,
       company,
       skillset,
       last_name,
       first_name,
       shirt_size,
       birthday,
       round(( last_changed - DATE '1970-01-01' ) * 60 * 60 * 24) * 1000 AS LAST_CHANGED
FROM   offl_people
```

Unique Storage ID	people
Storage Version	1
PK Column	ID
Last Changed Column	LAST_CHANGED
Rows to fetch per request	500
Sync timeout minutes	60

Add consumer Plug-In



Identification

Title: AG-Grid Offline

Type: AG-GRID [Plug-In]

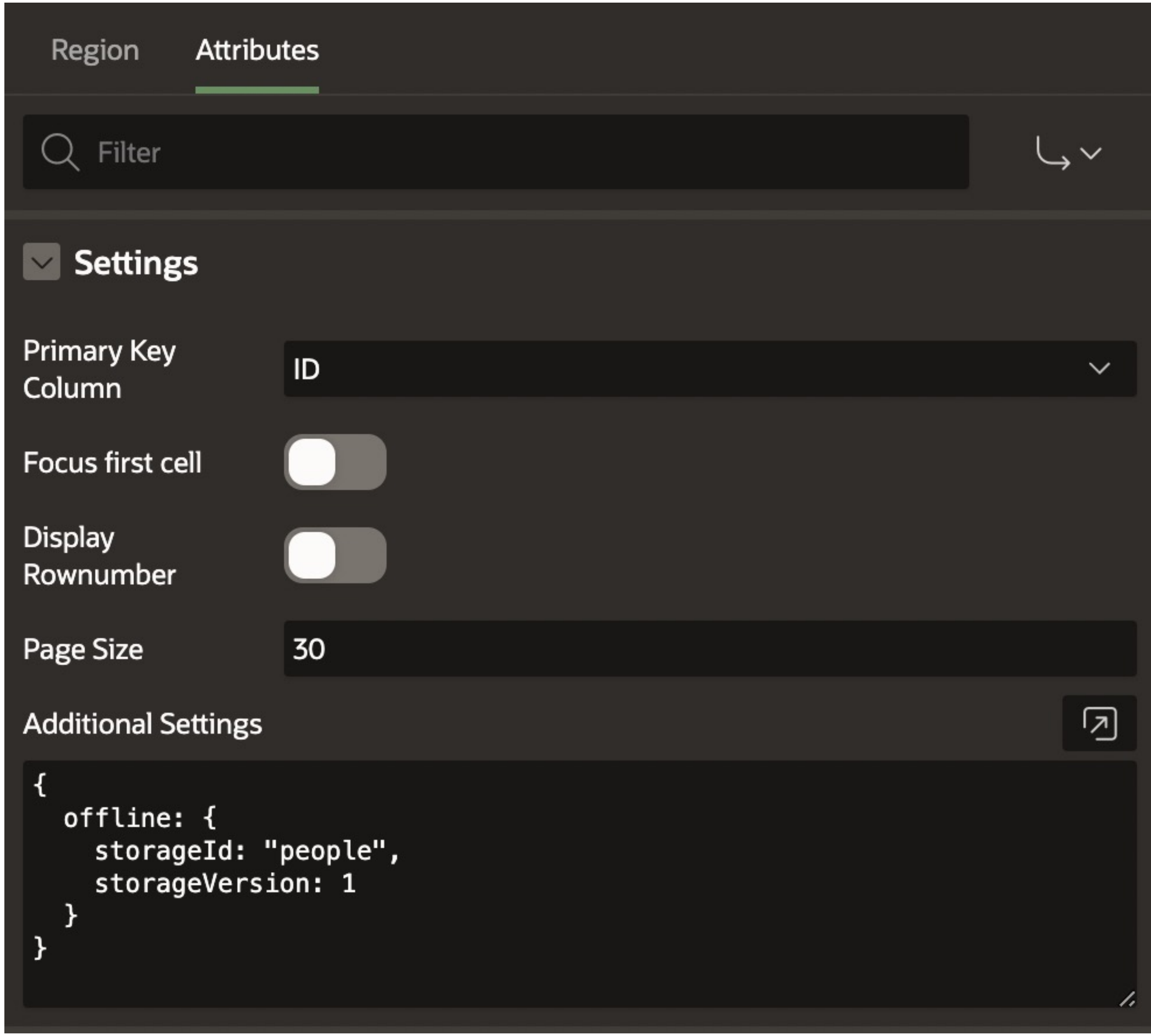
Source

Location: Local Database

Type: SQL Query

SQL Query

```
select ID ,
EMAIL ,
SALARY ,
COMPANY ,
SKILLSET ,
LAST_NAME ,
FIRST_NAME ,
SHIRT_SIZE ,
BIRTHDAY,
round(( LAST_CHANGED - date '1970-01-01' ) * 60 * 60 * 24) * 1000 as
LAST_CHANGED
from OFFL_PEOPLE
```



Settings

Primary Key Column: ID

Focus first cell: ○

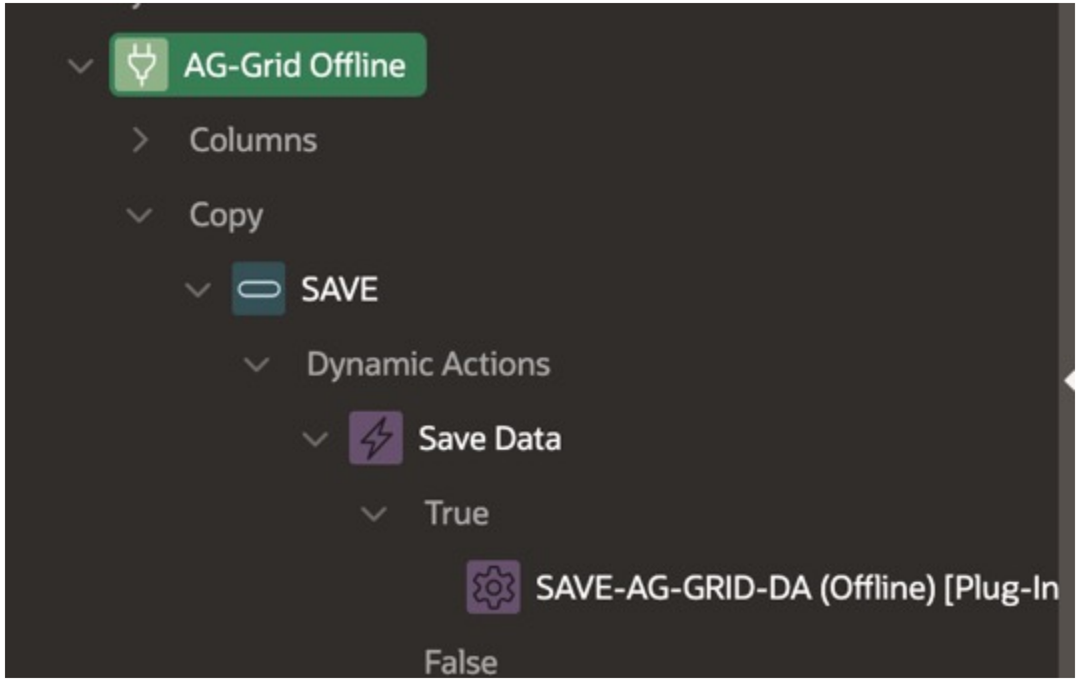
Display Rownumber: ○

Page Size: 30

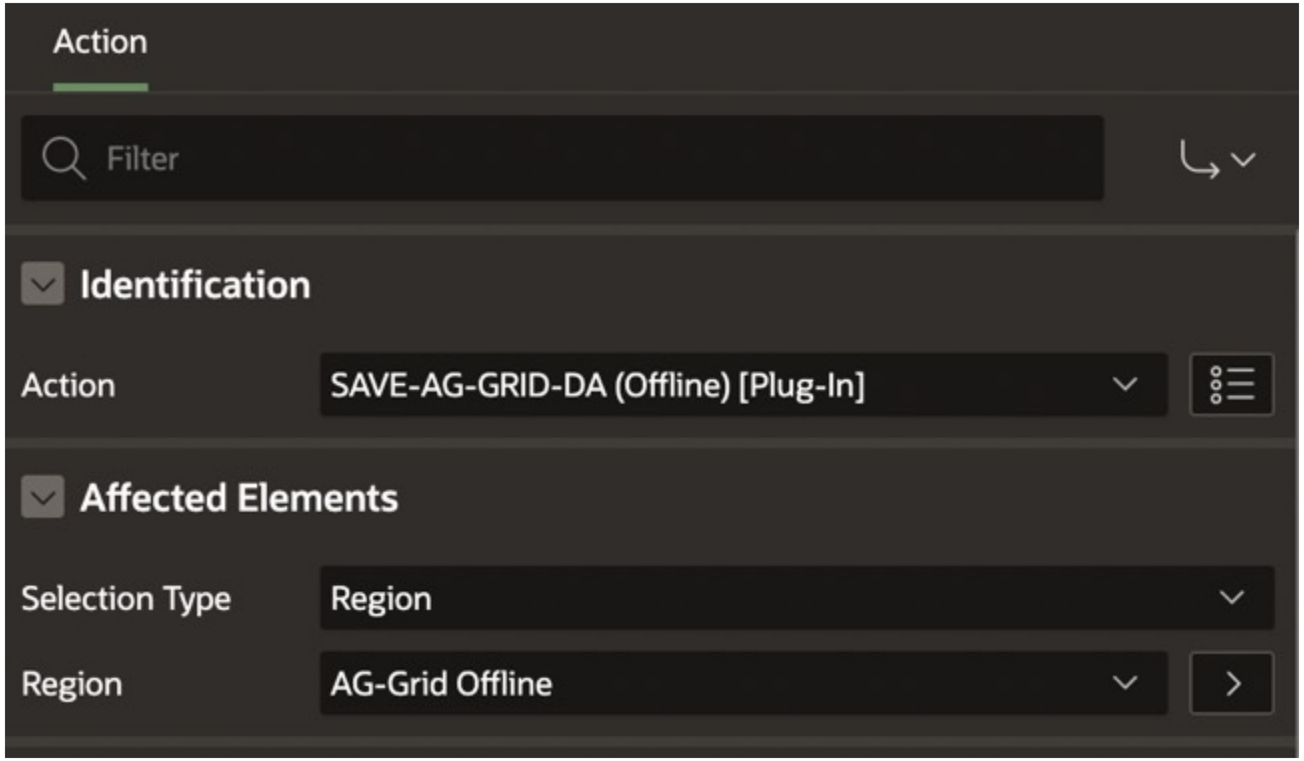
Additional Settings

```
{
  offline: {
    storageId: "people",
    storageVersion: 1
  }
}
```

Add save Action



AG-Grid Offline
Columns
Copy
SAVE
Dynamic Actions
Save Data
True
SAVE-AG-GRID-DA (Offline) [Plug-In
False



Identification

Action: SAVE-AG-GRID-DA (Offline) [Plug-In]

Affected Elements

Selection Type: Region

Region: AG-Grid Offline

Additionally

You need to install packages and a table

You need to write Code to merge your data back to the source (more on that later)

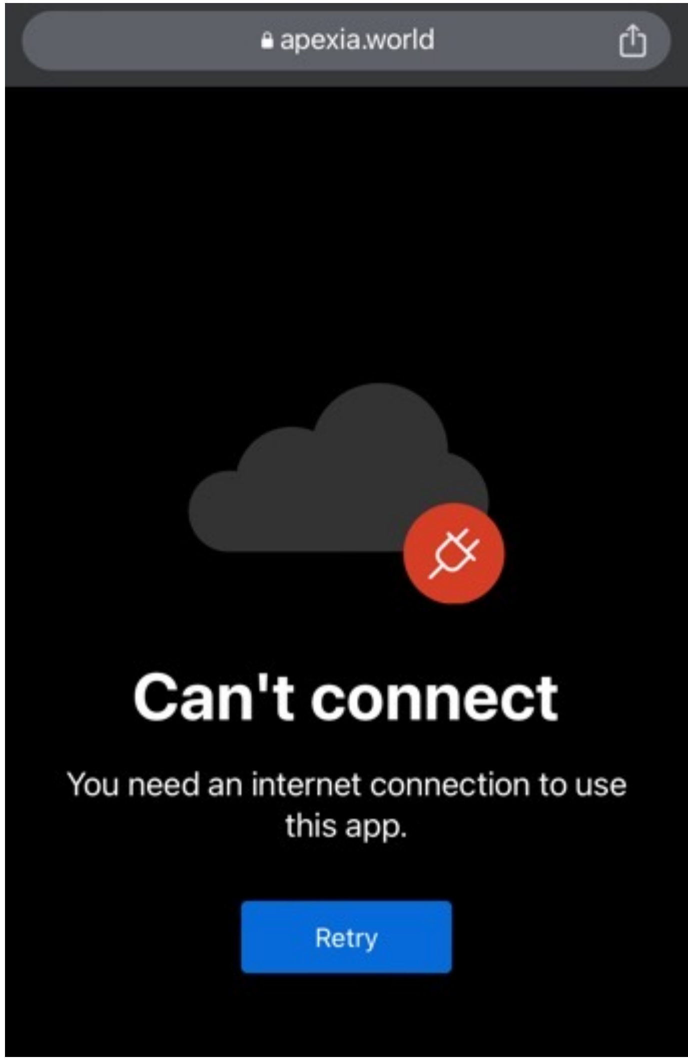
Demo - Basic offline data editing

Photo by Jakob Owens from Unsplash

Design Decisions

How far can offline go

- Level 1 (APEX currently)
  - Custom Offline Page instead of Browser Error
- Level 2
  - Cache Static Content (HTML, Assets, …)
  - In-app Navigation
  - No Interactivity (paginations, filters, save etc.)
- Level 3/4 (reading vs. editing)
  - Everything works as if you were online
  - **You need to store the data on the client**



Can't connect

You need an internet connection to use this app.

Don‘t work against APEX

- APEX Components are designed to work with a live-connection to the Database
- It is not trivial to hook into this and **APEX is not designed to do this**
- I don’t want to mess with that

→ Own Plug-Ins where I have full control

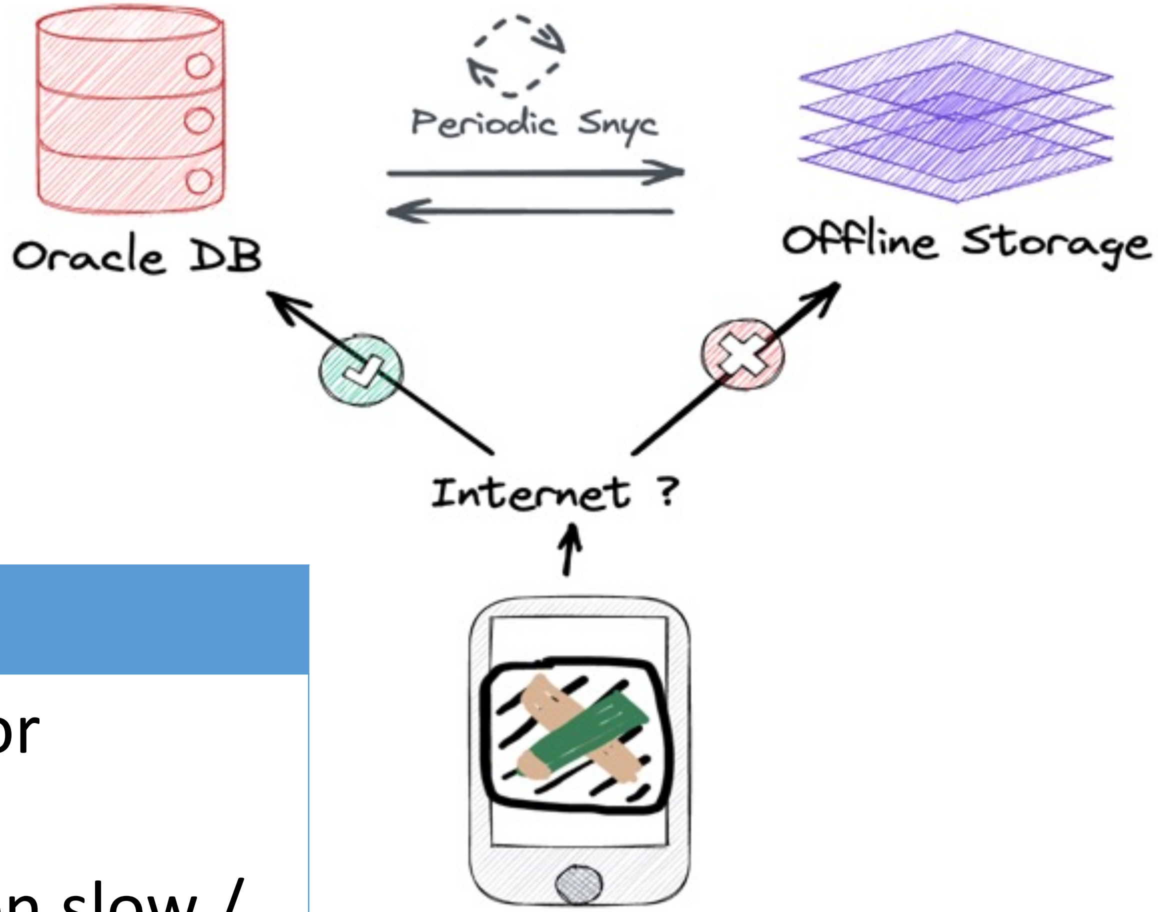
SQL + Relational

- Same data storage as the central database
- Reusability
- Performance
- Analytical functions
- Data Integrity

Original Photo by Eye for Ebony from Unsplash

Data Access Strategies - Online First

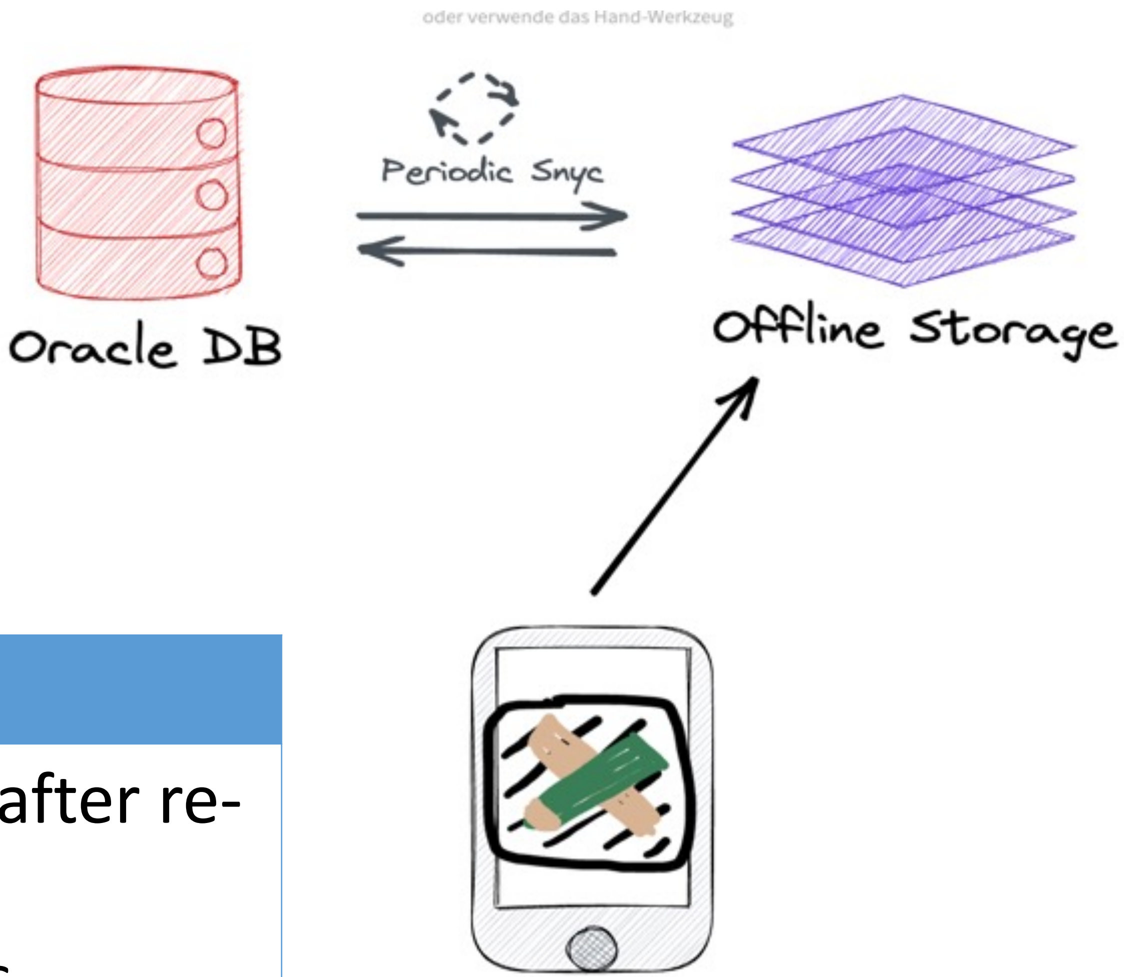
- First try to get data from the DB
- Only when no connection available use offline storage



Pros	Cons
• Online = “Normal APEX Mode“ • Less conflicts (APEX locking while online) • Live data	• Much logic for consumers • What to do on slow / unreliable connections

Data Access Strategies - Offline First

- Always use Offline Storage for your components



Pros	Cons
• Reliable Experience • Fast • **Less logic for consumers**	• Only updates after re-sync • More conflicts

I chose this approach because of this

💡 Build different experiences for different use cases

- Make sure only people who need offline access use it
- Field technician gets offline App / Page
- Office worker gets online App / Page

Original Photo by MIOPS Trigger from Unsplash

Technical Implementation

Where to store data

Browser Storage Options:

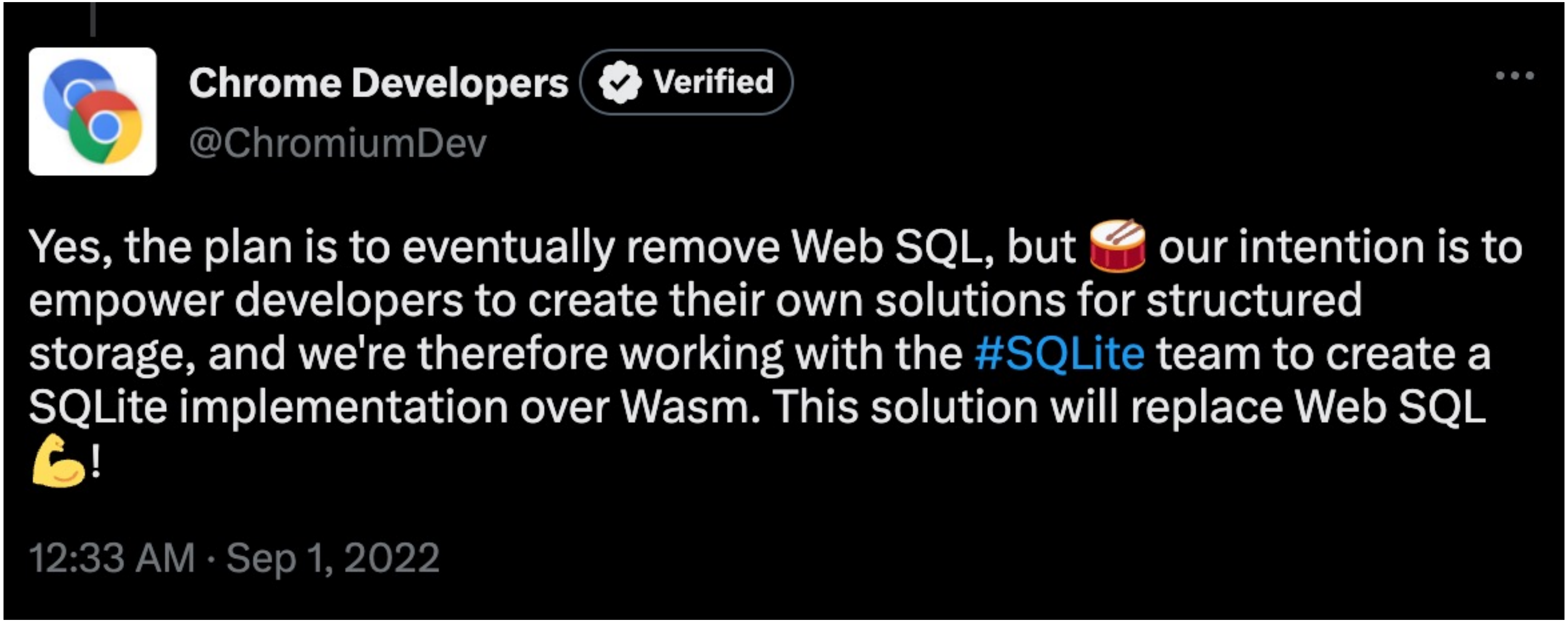
- LocalStorage
  - Key-Value object-store, slow, designed for small amounts of data
- WebSQL
  - Deprecated
- IndexedDB
  - For large data, transactions, Key-Value object-store

The thing with IndexedDB:

- Complex API
- No support for complex queries
- History of nasty bugs (mostly Safari)
- Not ACID compliant

The pain and anguish of using IndexedDB: problems, bugs and oddities

Not the DB we deserve, but the hero we need



Chrome Developers Verified
@ChromiumDev

Yes, the plan is to eventually remove Web SQL, but 🥁 our intention is to empower developers to create their own solutions for structured storage, and we're therefore working with the #SQLite team to create a SQLite implementation over Wasm. This solution will replace Web SQL 💪!

12:33 AM · Sep 1, 2022

Source

Wait a minute… What is SQLite?

- Most used DB, top 5 most deployed software ever (estimated one trillion active DBs)
- Full-featured SQL
- Serverless (not the cloud thing)
- Transactional
- ACID
- Public Domain
- Really fast
- Stores data in a single file
- Recommended Storage Format by the US Library of Congress

More on SQLite

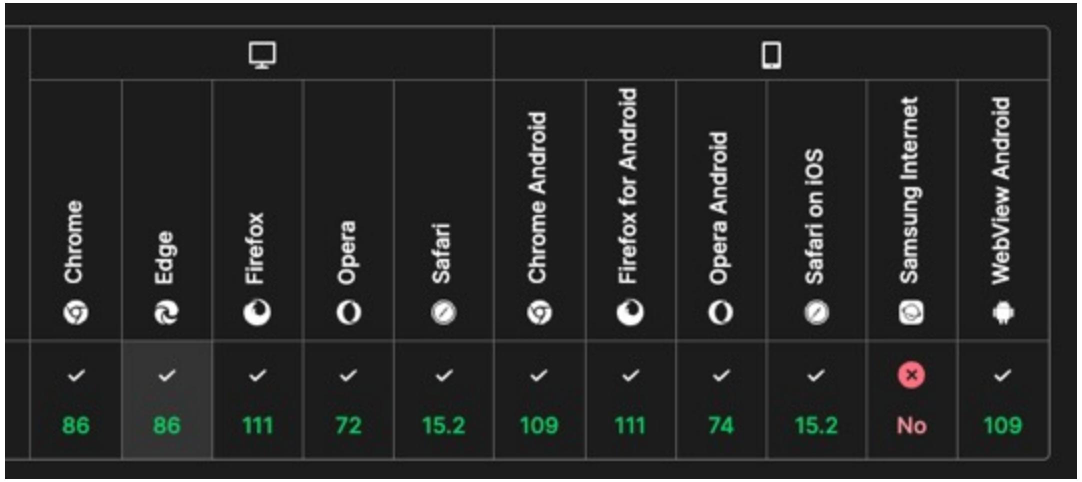
How does it run in the browser

WEBASSEMBLY

Compile existing software to hardware-near browser understood layer

Origin Private File System (OPFS)

- Sites get a private file system
- SQLite directly writes to here



🖥					📱					
Chrome	Edge	Firefox	Opera	Safari	Chrome Android	Firefox for Android	Opera Android	Safari on iOS	Samsung Internet	WebView Android
✓ 86	✓ 86	✓ 111	✓ 72	✓ 15.2	✓ 109	✓ 111	✓ 74	✓ 15.2	✗ No	✓ 109

Source

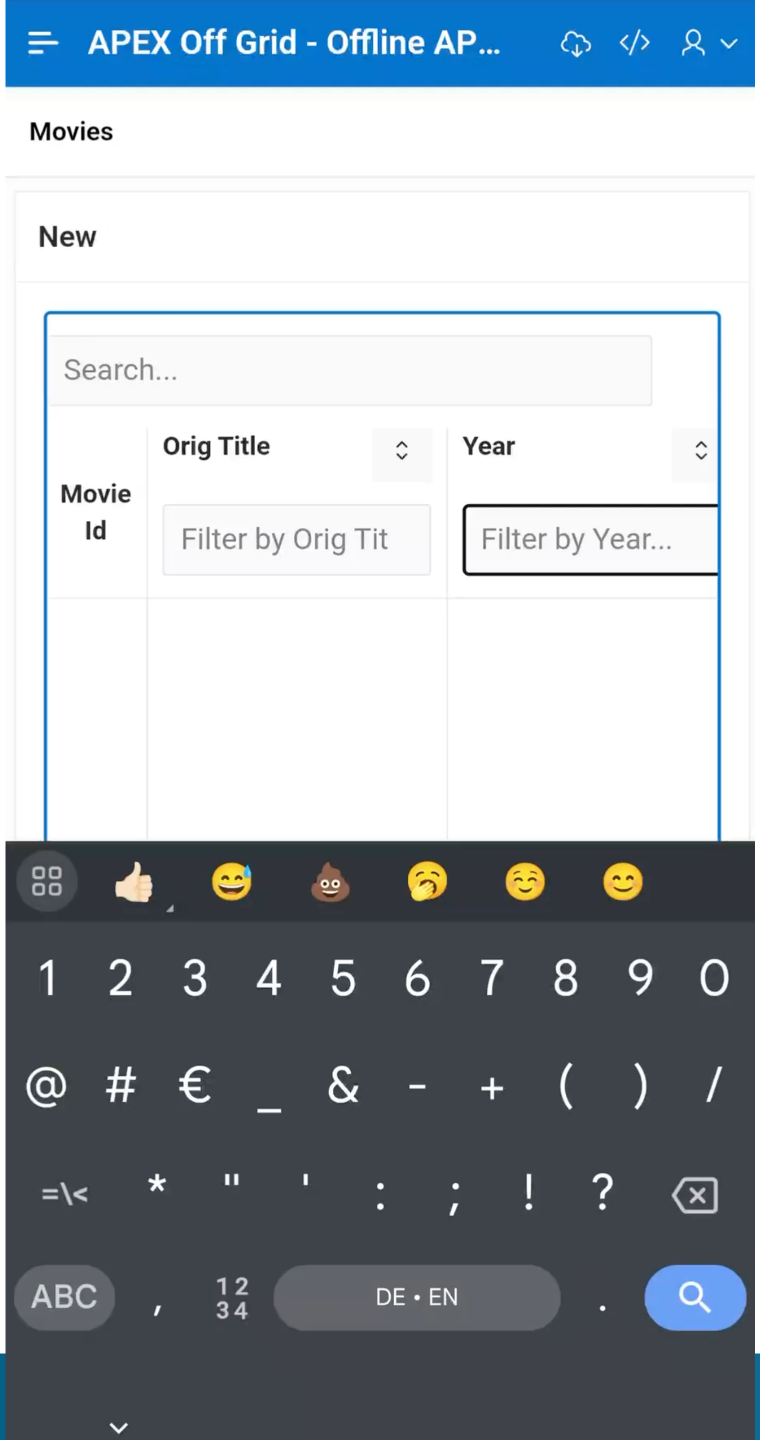
How fast is it ? - Demo

Photo by Jakob Owens from Unsplash

SQLite file - Demo

Photo by Jakob Owens from Unsplash

On a Phone? (Pixel 6)



APEX Off Grid - Offline AP...

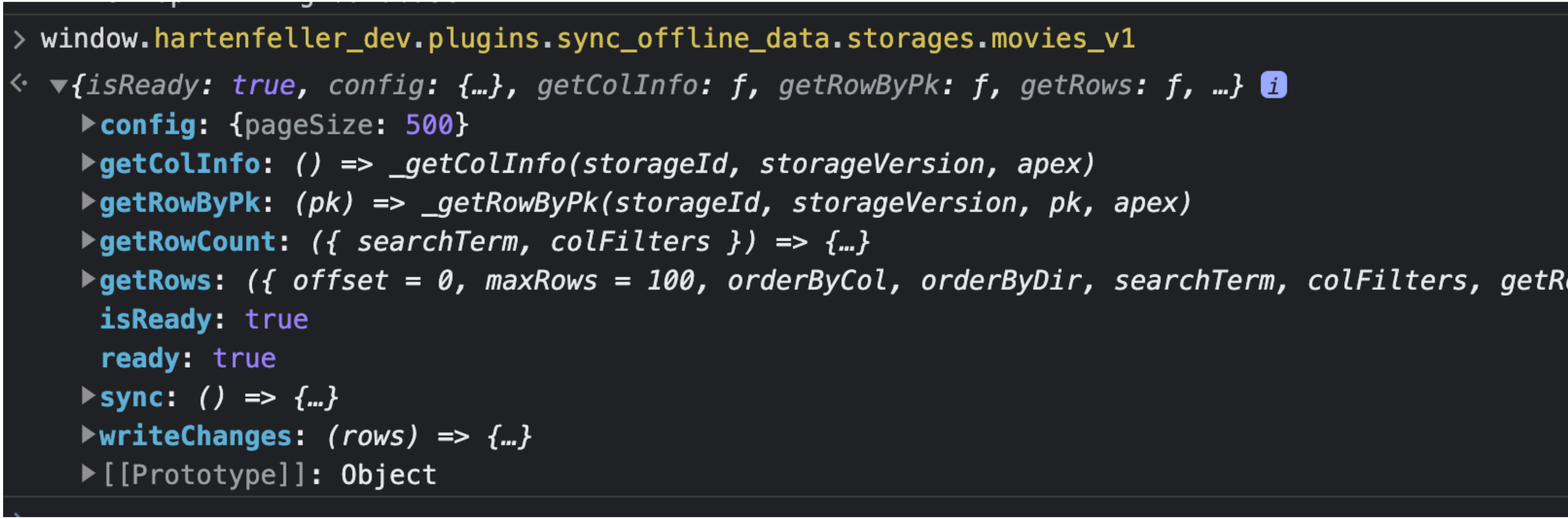
Movies

New

Search...

Movie Id	Orig Title	Year
	Filter by Orig Tit	Filter by Year...

How develop Plug-Ins



```
> window.hartenfeller_dev.plugins.sync_offline_data.storages.movies_v1
< ▼{isReady: true, config: {…}, getColInfo: f, getRowByPk: f, getRows: f, …} i
    ▶config: {pageSize: 500}
    ▶getColInfo: () => _getColInfo(storageId, storageVersion, apex)
    ▶getRowByPk: (pk) => _getRowByPk(storageId, storageVersion, pk, apex)
    ▶getRowCount: ({ searchTerm, colFilters }) => {…}
    ▶getRows: ({ offset = 0, maxRows = 100, orderByCol, orderByDir, searchTerm, colFilters, getR
     isReady: true
     ready: true
    ▶sync: () => {…}
    ▶writeChanges: (rows) => {…}
    ▶[[Prototype]]: Object
```

Data Synchronization

Why this topic is important

- Allowing users to edit data without a connection to the DB has effects of decentralization
- You still want a single source of truth

-> This results in new challenges for data consistency (🚀 complexity to 🌔)

Sync Timeline - 1

1. Cache current HTML page

2. Synchronize Client Changes with DB

- Send client updates to central DB
- Delete corresponding rows on the client
- It is now in the control of the DB what will happen with these rows

Sync Timeline - 2

3. Synchronize DB Changes with Client

- DB sends PK + Timestamp for each row:
    - PK known and Timestamp matches: ✅
    - PK unknown or Timestamp mismatch: ⚠️ request full row -> insert / update
- Delete rows not present in central DB anymore:
    - Store every PK received from server in a temp table
    - After receiving all rows, delete local rows where PK not in temp table

Change Synchronization - Potential outcomes

a: Single Client Row Update (✅)

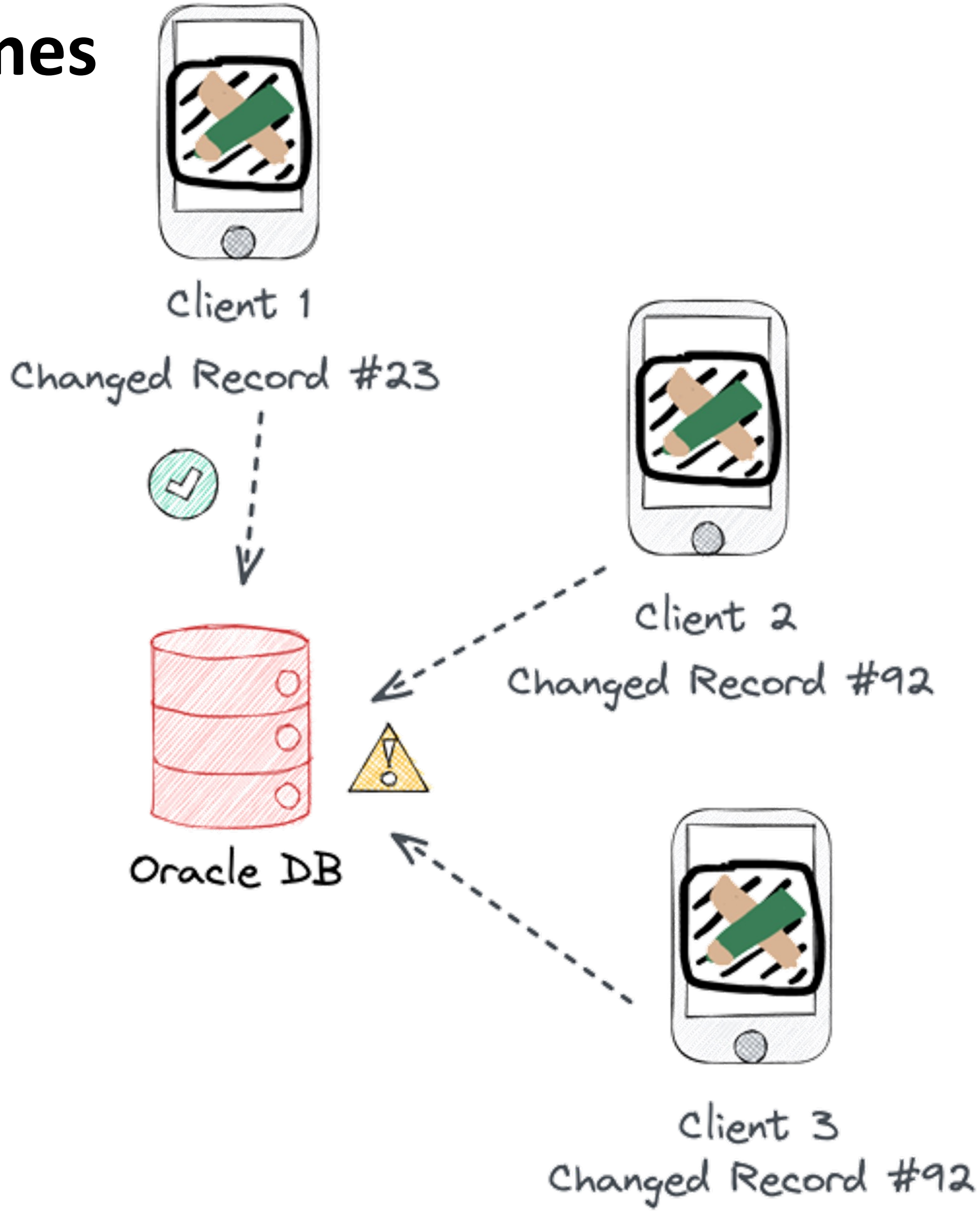
- Only one client modifies the row, straightforward synchronization

b: Sequential Client Row Updates (✅)

- Client 2 updates row after receiving Client 1's changes, preserving data integrity

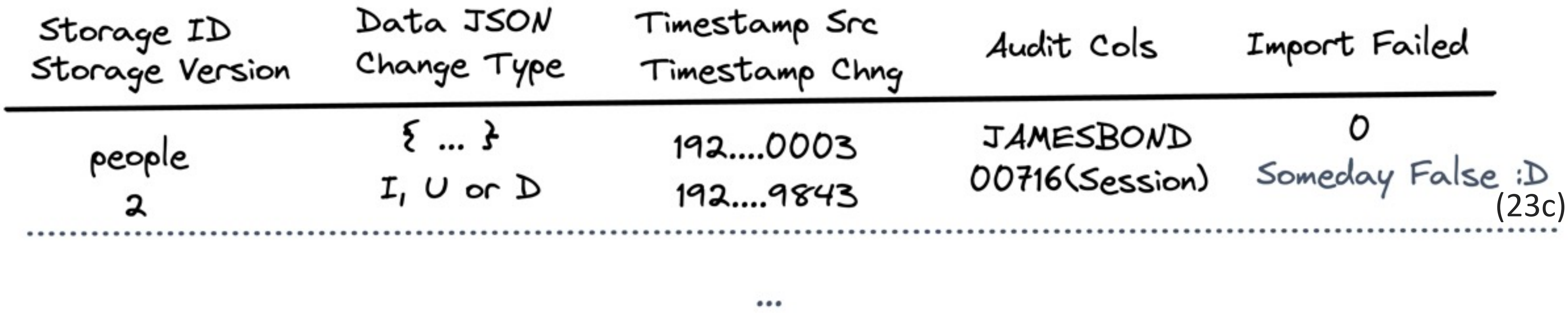
c: Concurrent Client Row Updates (⚠️)

- Two clients modify the same row version simultaneously, potential data conflict



How changes are stored

- Don‘t directly insert into source table to handle conflicts
- Generic changes table



Storage ID Storage Version	Data JSON Change Type	Timestamp Src Timestamp Chng	Audit Cols	Import Failed
people 2	{ ... } I, U or D	192....0003 192....9843	JAMESBOND 00716(Session)	0 Someday False :D

(23c)

...

Merge Conflict Detection

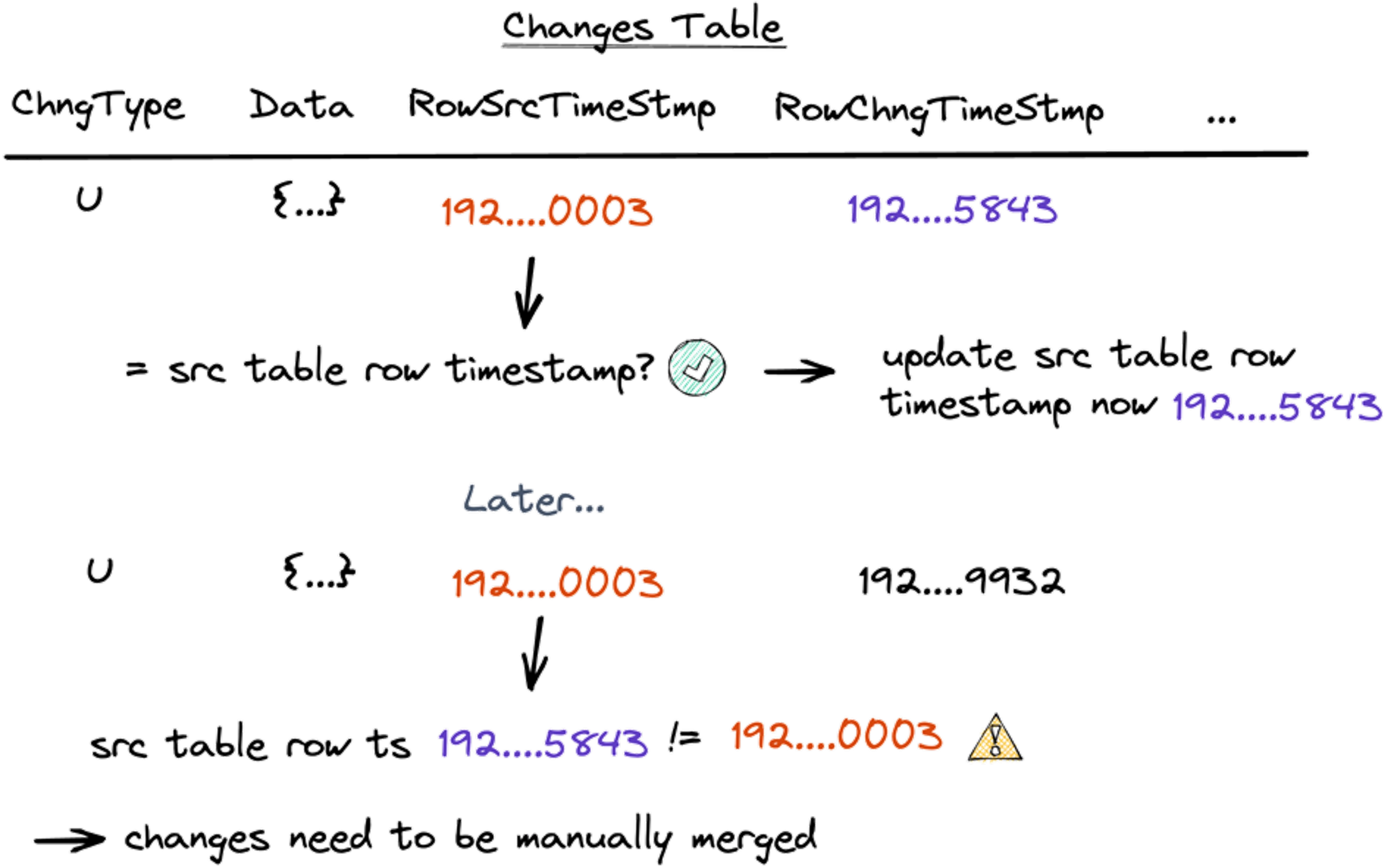
Changes Table

ChngType	Data	RowSrcTimeStmp	RowChngTimeStmp	...
U	{...}	192....0003	192....5843	

↓

= src table row timestamp? ✓ → update src table row timestamp now 192....5843

Merge Conflict Detection



Changes Table

ChngType	Data	RowSrcTimeStmp	RowChngTimeStmp	...
U	{...}	192....0003	192....5843	

↓

= src table row timestamp? ✓ → update src table row timestamp now 192....5843

Later...

U	{...}	192....0003	192....9932	

↓

src table row ts 192....5843 != 192....0003 ⚠

→ changes need to be manually merged

Conflict Resolution #1 – Last Write Wins

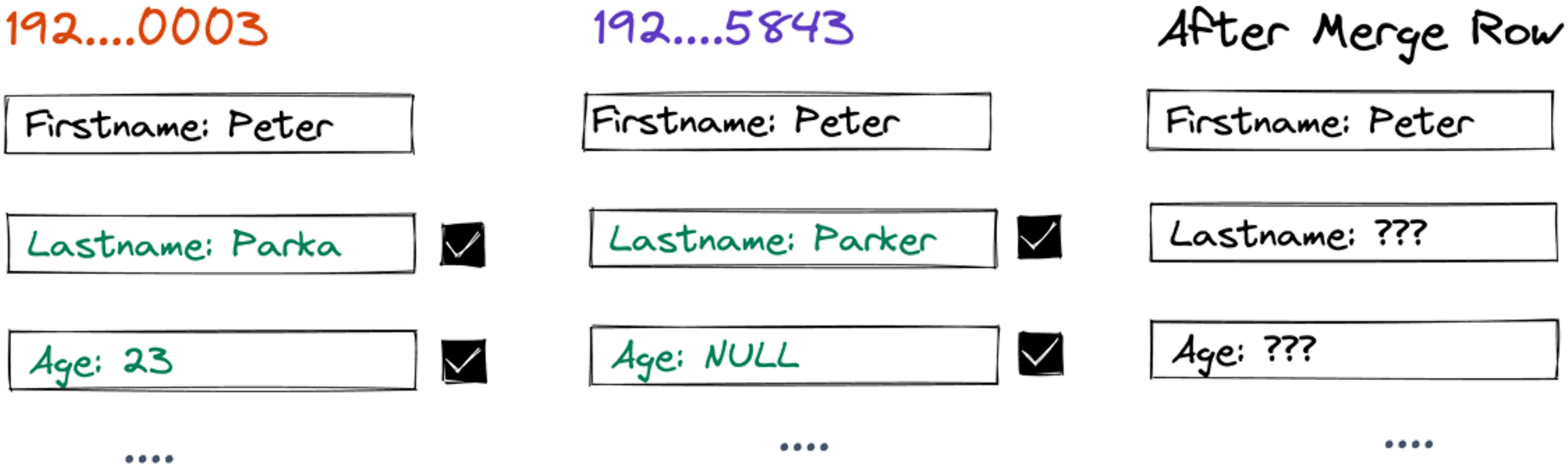
Nothing to consider:
Just write changes

Photo by Matthias Speicher from Unsplash

Photo by Ryan Moreno from Unsplash

Conflict Resolution #2 - manual merge

- User must do merge manually
  - Show current row next to changed row (like Git 3-way-merge)



192....0003		192....5843		After Merge Row
Firstname: Peter		Firstname: Peter		Firstname: Peter
Lastname: Parka	☑	Lastname: Parker	☑	Lastname: ???
Age: 23	☑	Age: NULL	☑	Age: ???
....		....		....

Let us create chaos

https://tinyurl.com/kspc23-offl

Demo – Merge Code

Photo by Jakob Owens from Unsplash

Wrapping Up

What can be improved

- Data type handling
  - Dates, Timestamps …
  - Images, other BLOBs
- LOVs (Select Lists, Popup LOV, Shuttle, Checkboxes…)
- Apply more table rules to client (FKs, check constraints, indexes, defaults…)

- Error message improvements and error handling
- Expand Plug-In Ecosystem
- Consider JSON-Duality features for data merging (only 23c)

Why you may not want to use this

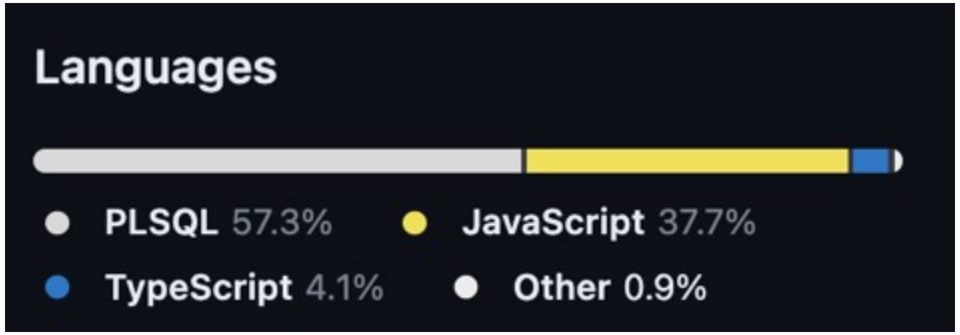
- You lose authority over your data
  - Data on the client can easily be duplicated / shared
- Merge conflicts / Inconsistent data state
- Divergent development approach for offline apps
- Increased complexity
- Scalability: Synchronization processes can demand significant data transfers
- SQLite as fast as the device using it
- Proof of Concept + No Support

Photo by JESHOOTS.COM from Unsplash

Where can I get this ?

https://github.com/phartenfeller/apex-off-grid

- Needs Documentation
- Needs Refactoring
- Contributions welcome 😄



Languages

● PLSQL 57.3% ● JavaScript 37.7%
● TypeScript 4.1% ● Other 0.9%

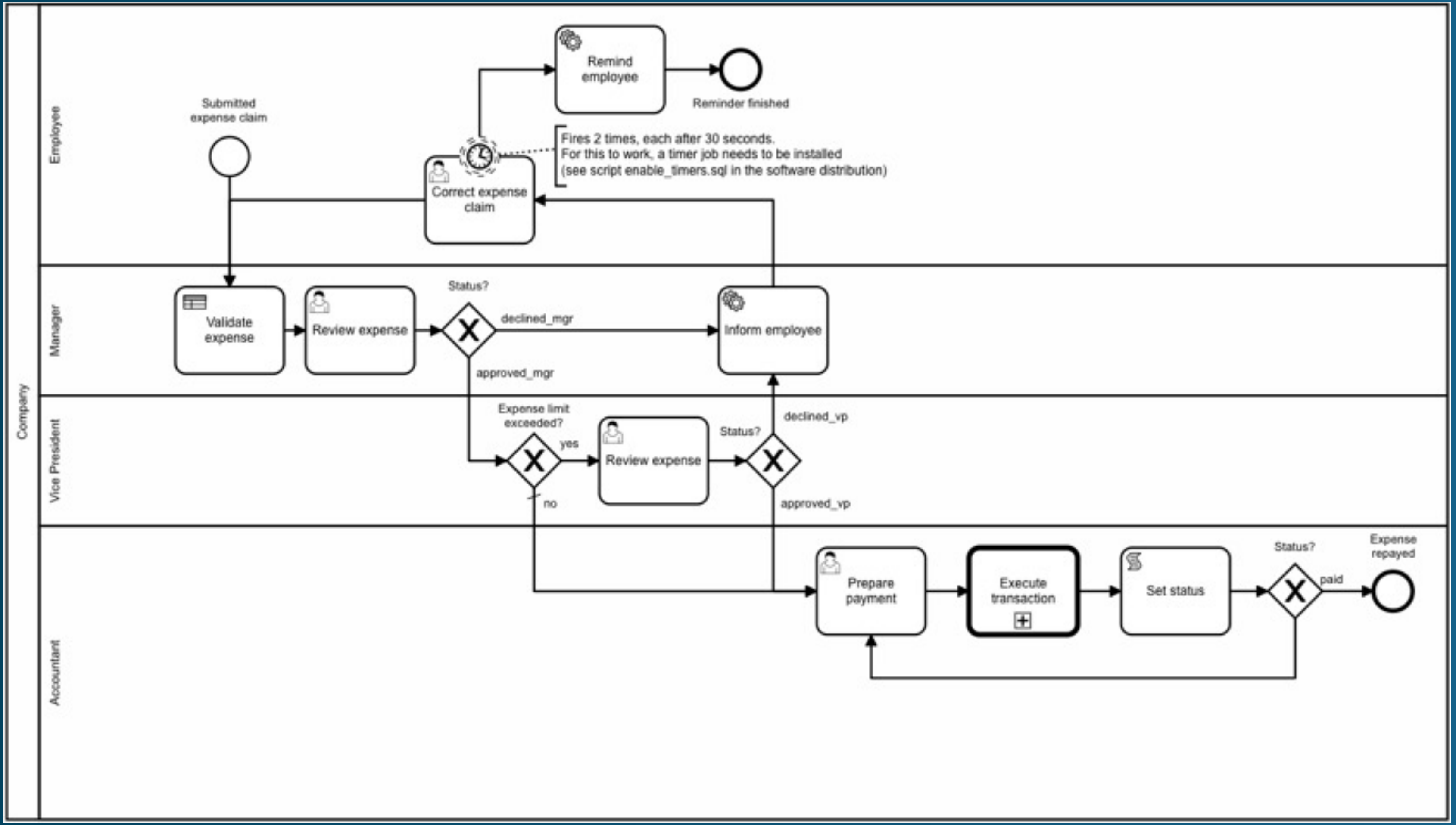
Conclusion

- I am quite happy with the result
- Plug-Ins easy to use, hide complexity well
- Confident that SQLite is a great choice for small to large data sizes
- Great browser support

Photy by Sebastian Herrmann from Unsplash

Flows for APEX

BPMN 2.0 Workflows for APEX



- Open Source
- Community Driven
- Support available

Testing APEX Apps is now as easy as creating them.

- Tailored to APEX
- Save a lot of time on regression tests
- Use our intuitive LCT-App and don‘t write any test code
- Testing on multiple platforms simultaneously

LCT