



HI 007 007

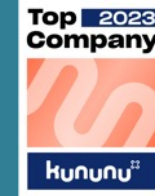
Offline data manipulations for everyone with Plug-Ins and SQLite

31.03.2023

Philipp Hartenfeller, Senior Consultant
APEX World 2023, Zeist

Facts and figures.

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Foundation 1994



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Ratingen

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> 360 Employees



approx. 48 Mio. €
Turnover in 2021



> 125 Customers
Cross-sector



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Training company,
Partner in dual studies

\$ whoami



Philipp Hartenfeller

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

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



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[@phartenfeller@mastodon.social](https://mstdn.social/@phartenfeller)



Oracle ACE
Associate

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 the technical details)

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 ?

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

How should it work ?

- Fast
- Handle lots of data
- Concept to merge changes back to DB
- Somewhat future proof

Proof of Concept: Not production ready!

Create App + PWA functionalities + Import Plug-Ins

App Builder

apex.phartenfeller.de/ords/f?p=4000:1500:13850835133261:::

APEX

App Builder

SQL Workshop

Team Development

Gallery

Search

admin plugins

+

Create

↑

Import

Dashboard

Workspace Utilities

Go

Actions

Reset

Create

AG Grid Test

114

Flows for APEX

115

FF

Flows for APEX

984339

Holiday Approval

(demo app to show

how to integrate

984341

Offline First AG

Grid

120

Rich File Preview

Plugin

322

Slide-Over /

Drawer

106

World Map Plugin

105

1 - 8

About

The App Builder enables you to design, develop and deploy applications which are beautiful and responsive.

Learn More ...

Recent

Offline First AG Gri - 120

AG Grid Test - 114

Flows for APEX - 115

World Map Plugin - 105

Slide-Over / Drawer - 106

Flows for APEX - 984339

Holiday Approval (de - 984341

Rich File Preview PI - 322

Tasks

Manage Backups

Browse by Facets

admin plugins

en

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Oracle APEX 22.1.0

Setup Sync Plug-In

App Builder

Offline APEX Demo

apex.phartenfeller.de/ords/f?p=4000:1:13850835133261::RP:FB_FLOW_ID,F4000_P1_FLOW:123,123

APEX

App Builder

SQL Workshop

Team Development

Gallery

Search

admin plugins

Application 123

Edit Page 1

Application 123 - Offline APEX Demo

Edit Application Definition

Run Application

Supporting Objects

Shared Components

Utilities

Export / Import

Go

Actions

Create Page

0 - Global Page

1 - Home

9999 - Login Page

About

Tasks

Recently Edited Pages

Use the Application home page to run, edit, import, export, copy, or delete an application. Select a page to edit the page properties, or click **Create Page** to add a page to the application.

Learn More ...

Delete this Application

Copy this Application

Add Feature Page

Manage Backups

Browse by Facets

0. Global Page

9999. Login Page

1. Home

Setup Plug-Ins that use offline storage

Page Designer

Offline APEX Demo

apex.phartenfeller.de/ords/f?p=4000:4500:13850835133261:::FB_FLOW_ID,FB_FLOW_PAGE_ID:123,1

APEX

App Builder

SQL Workshop

Team Development

Gallery

Search

AD

Application 123

Page Designer

1

Go

Save

Page 1: Home

Pre-Rendering

Components

Breadcrumb Bar

Offline APEX Demo

Body

Post-Rendering

Layout

Page Search

Help

Home

BANNER

AFTER LOGO

BEFORE NAVIGATION BAR

AFTER NAVIGATION BAR

TOP NAVIGATION

BREADCRUMB BAR

Offline APEX Demo

REGION BODY

REGION CONTENT

SUB REGIONS

Action

Filter

1

PK Column

ID

Last Changed Column

LAST_CHANGED

Rows to fetch per request

500

Sync timeout minutes

60

Execution Options

Sequence

10

https://apex.phartenfeller.de/ords/f?p=4000:4500:13850835133261:::FB_FLOW_ID,FB_FLOW_PAGE_ID:123,1#renderTree_container

Go offline, change something and sync to DB

Page DesignerOffline APEX Demo

apex.phartenfeller.de/ords/r/plugins/offline-apex-demo/home?session=13850835133261

Offline APEX Demoadmin

Offline APEX Demo

People List

Selected Id

Search

Ward Moncure

Marvella Moncure

Peggie Loera

Noelle Gervin

Lola Loera

Adam Binette Hello

Daphine Dardar

Rosemarie Moncure

Form

Id

Email

Salary

Company

Skillset

App 123

Page 1

Session

Debug

Quick Edit

Customize

it

What I didn't show

You actually need packages

- For Plug-Ins
- Code to merge your data back to the source (more on tha later)

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

Setup Sync

▼ 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) 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



- Dynamic Action Plug-In on page-load:
Handles all the sync
- Changes to query -> Increase version
- Last Changed column needed for conflict management (more on that later)

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

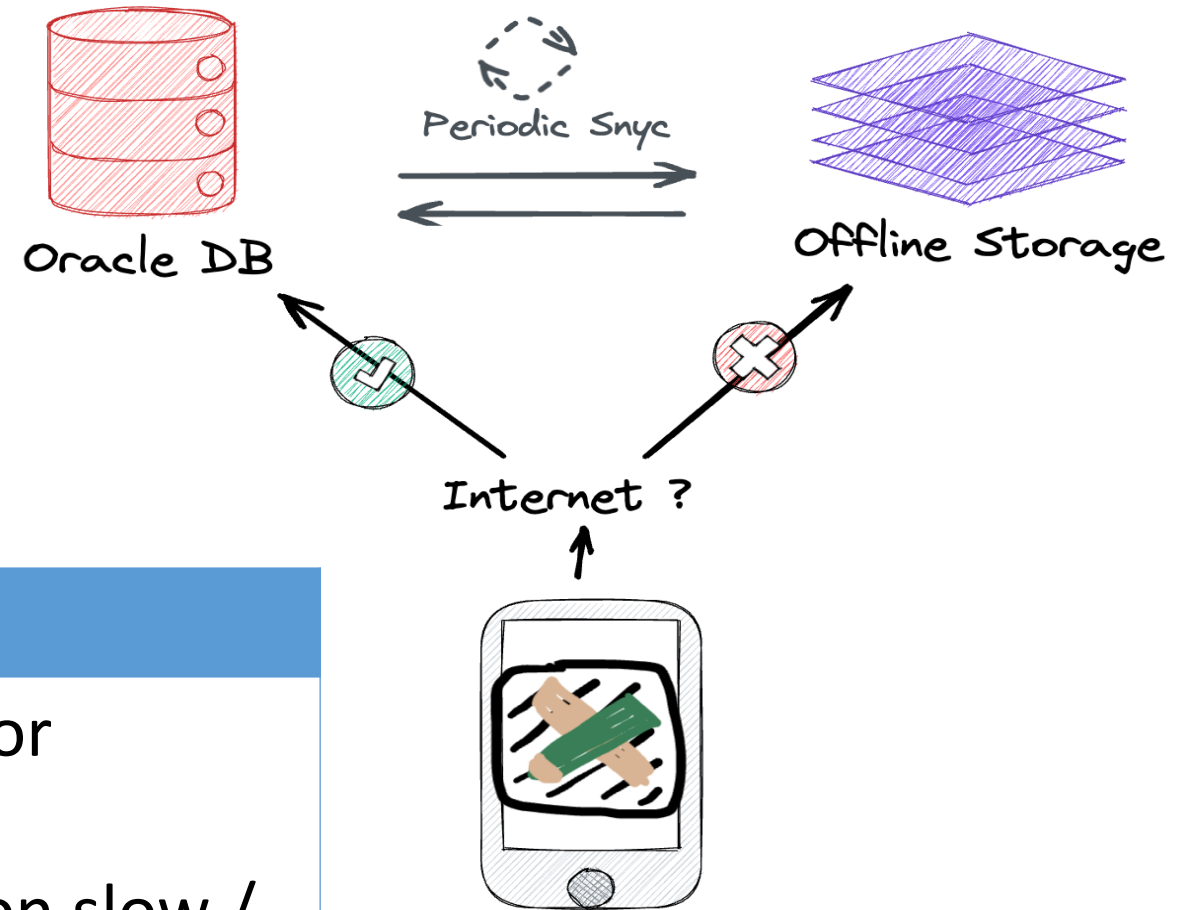
Sync Timeline - 2

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

Data Access Strategies - Online First

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



Pros

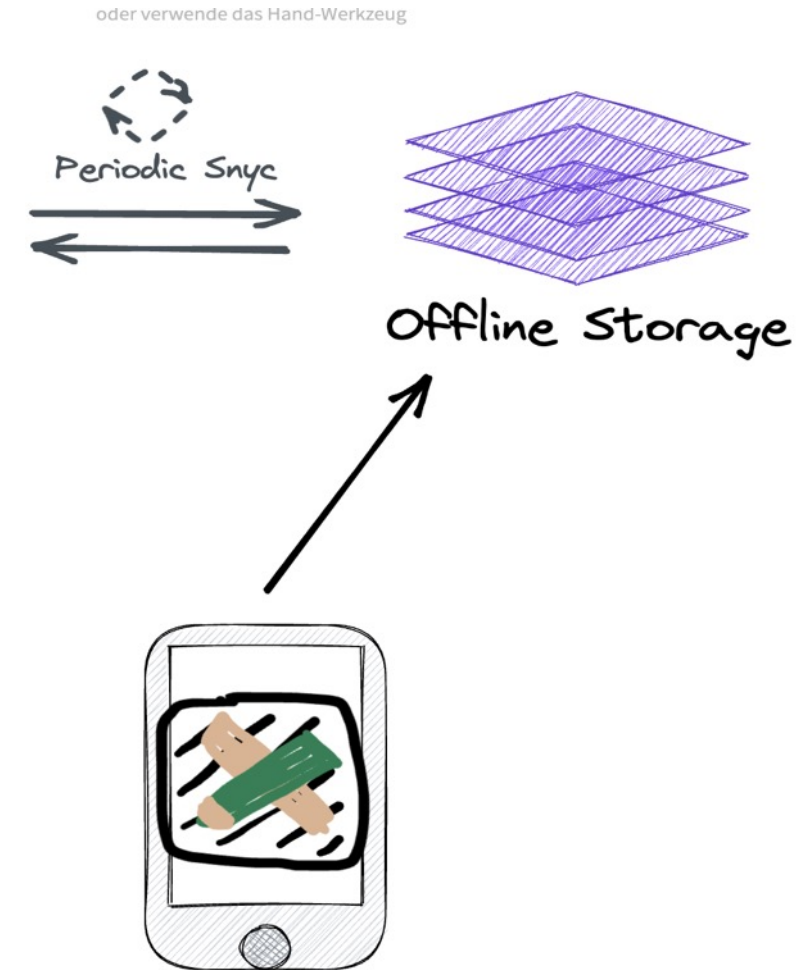
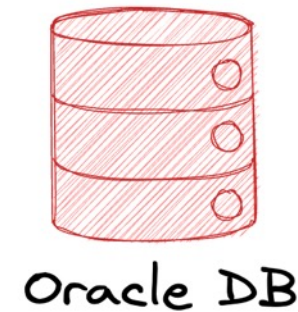
- “Normal APEX Mode”
- Less conflicts
- Live data

Cons

- Much logic for consumers
- What to do on slow / unreliable connections

Data Access Strategies - Offline First

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



Pros

- Reliable Experience
- **Less logic for consumers**

Cons

- Only updates after re-sync
- More conflicts

*I chose this approach
because of this*

💡 Build different experiences for different use cases

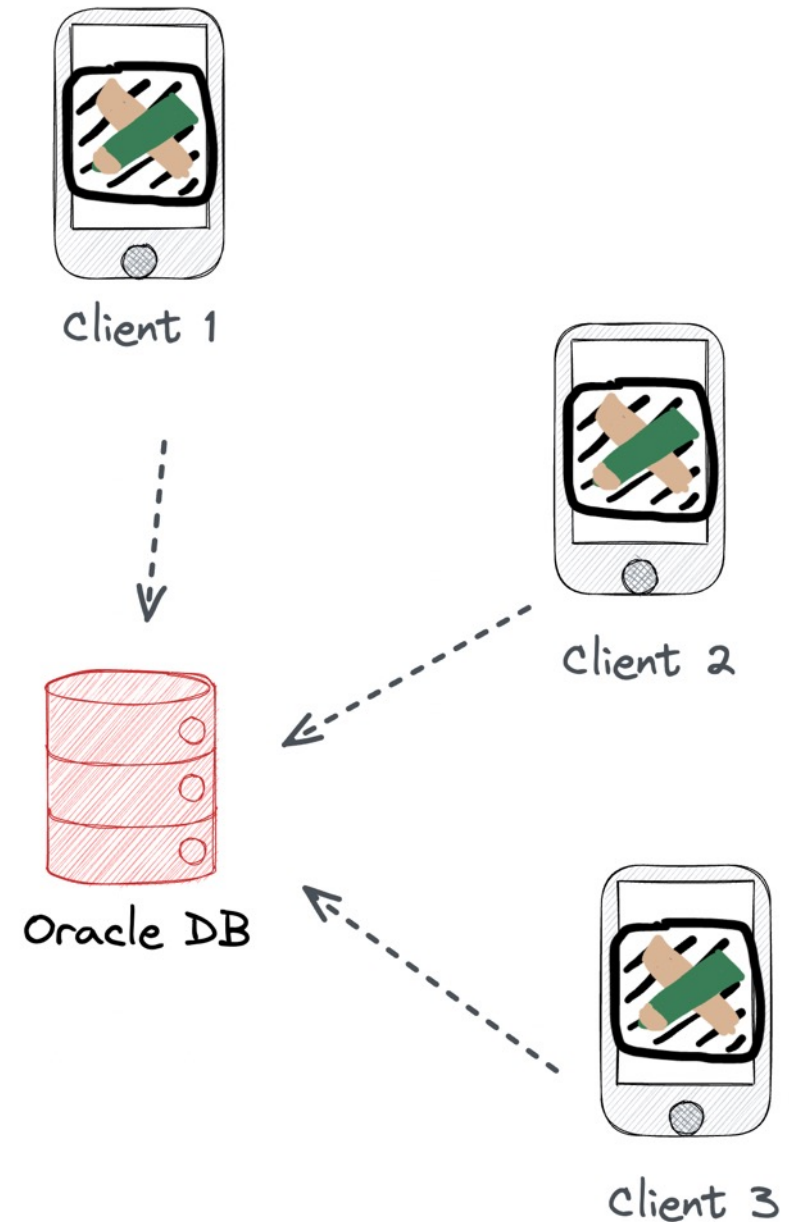
- Offline-first has downsides
- Make sure only people who need offline access use it
- Field technician gets offline App / Page
- Office worker gets online App / Page



Photo by [MIOPS Trigger](#) from [Unsplash](#)

Change Synchronization

- Local changes need to be written back to the central DB
- Ensure all local updates are properly saved in the central DB
- Different scenarios



Change Synchronization - Potential outcomes

a: Single Client Row Update (✓)

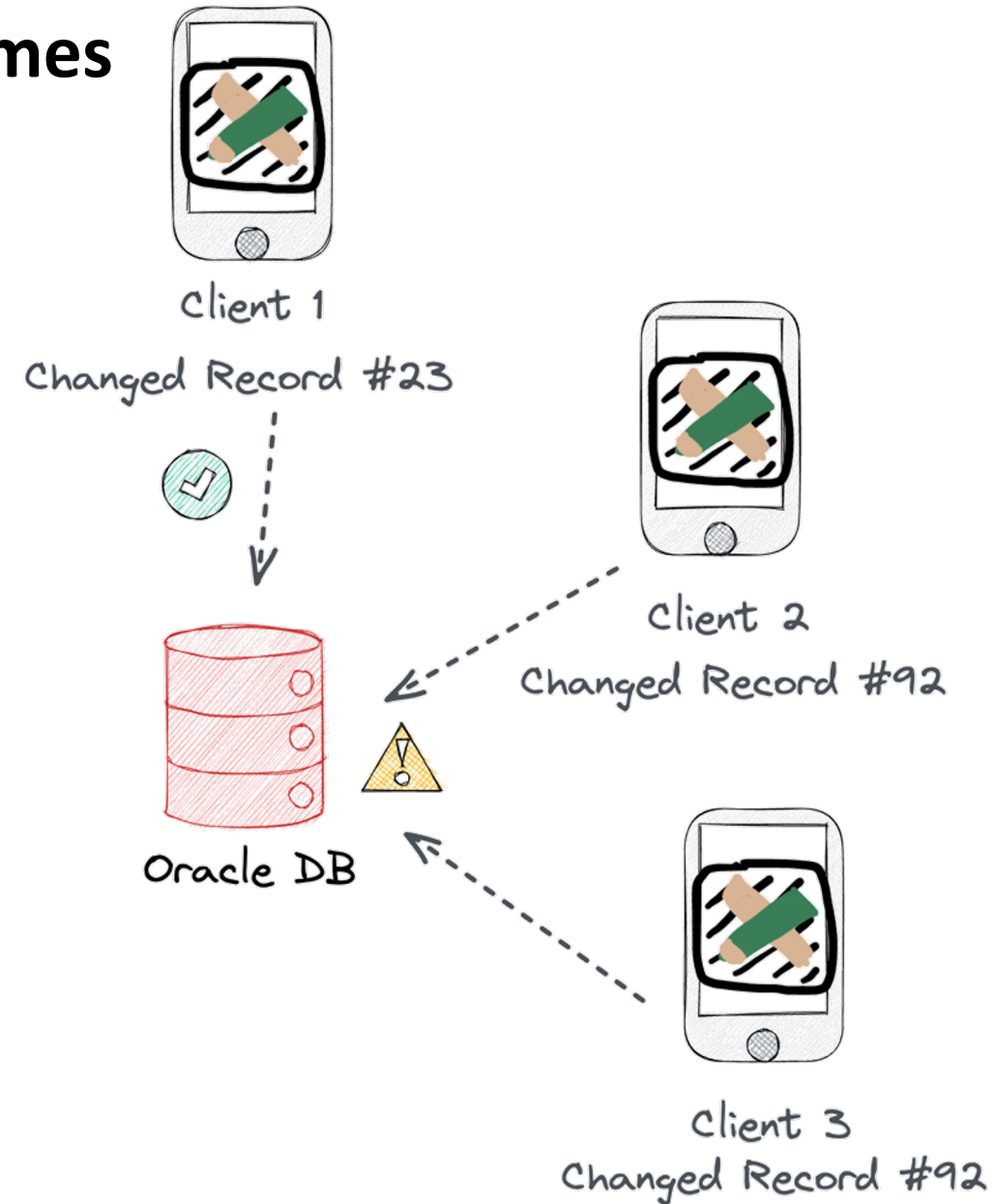
- Only one client modifies the row, straightforward synchronization

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
.....				
...				

How changes are processed

- Package gets called where you can implement your own logic
 - Resolve the conflicts
 - Call your existing Table- / Transaction-APIs
- Future consideration: Bulk Processing with Transaction IDs
 - No trigger, instead directly call a process package
 - Add transaction IDs so you can bulk process all changes

← Up to you how to do it

Conflict Resolution #1 – Last Write Wins

Design Decision

Nothing to consider:
Just write changes



Photo by [Matthias Speicher](#) from [Unsplash](#)




Photo by [Ryan Moreno](#) from [Unsplash](#)

Conflict Resolution #2 – 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

Conflict Resolution #2 – 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 #2 – How to do a merge

- On conflict:
 - don't delete row from changes table and set failed = 1
- User must do merge manually
 - Show current row next to changed row (like Git 3-way-merge)

192....0003

Firstname: Peter

Lastname: Parka



Age: 23



....

192....5843

Firstname: Peter

Lastname: Parker



Age: NULL



....

After Merge Row

Firstname: Peter

Lastname: ???

Age: ???

....

Technical Implementation



Where to store data

Browser Storage Options:

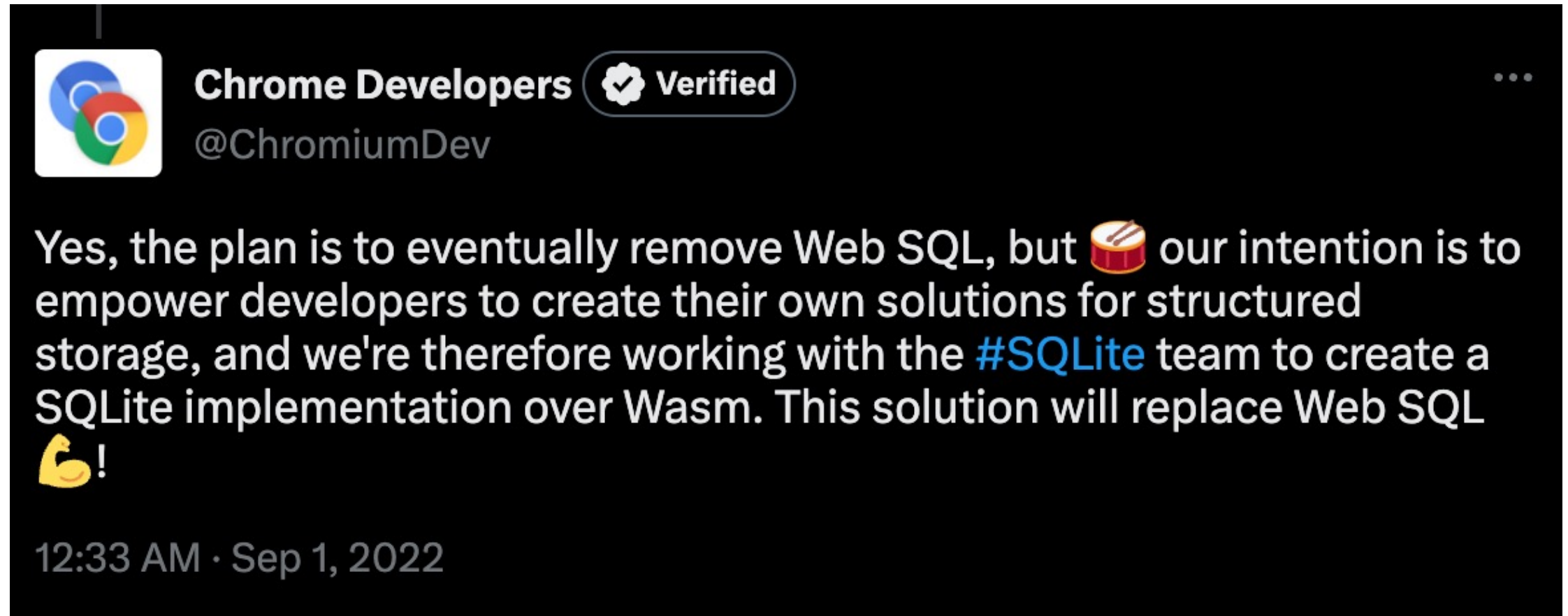
- LocalStorage
 - Key-Value object-store, slow, designed for small amounts
- WebSQL
 - Deprecated
- IndexedDB
 - For large data, transactions, Key-Value object-store

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



[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

Desktop					Mobile					
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](#)

Implement into APEX

WebAssembly & JavaScript

[sqlite-wasm-3410200.zip](#)
(702.24 KiB)

A precompiled bundle of `sqlite3.wasm` and its JavaScript APIs, ready for use in web applications.
(SHA3-256: 1713c3a4c25b09f5d52ed25fb81948f6081e9eeefb5a6d449aead1cd848e962c)

[Link](#)

- OPFS requires these headers:

```
Cross-Origin-Embedder-Policy: require-corp
Cross-Origin-Opener-Policy: same-origin
```

- APEX bug: `.wasm` invalid mime-type in header

```
✖ Uncaught (in promise) TypeError: Failed to execute 'compile' on
  'WebAssembly': Incorrect response MIME type. Expected 'application/wasm'.
```

Response Headers

```
cache-control: max-age=315360000, immutable
content-disposition: inline; filename="sqlite3.wasm"; filename*=UTF-8''sqlite3.wasm
content-language: en
content-type: application/wasm; charset=utf-8
date: Mon, 16 Jan 2023 12:27:26 GMT
```

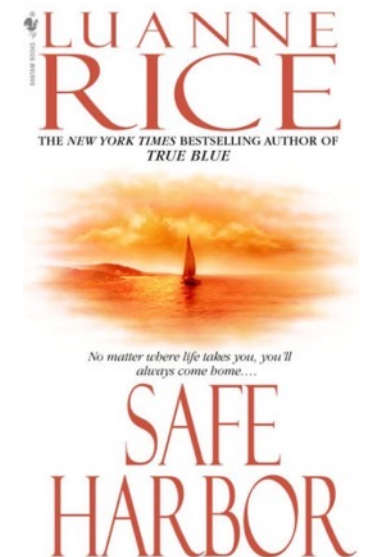
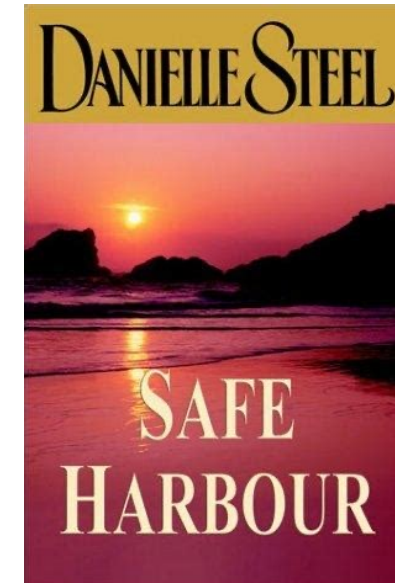
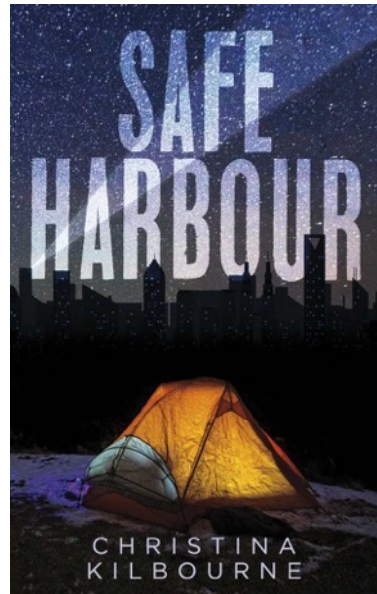
Will be fixed in 23.1

- Thanks to [Stefan](#) !!!

For now proxy magic:



```
- "traefik...traefik-plugin-rewrite-headers.rewrites[0].header=Content-Type"  
- "traefik...traefik-plugin-rewrite-headers.rewrites[0].regex=application.*wasm.*"  
- "traefik...traefik-plugin-rewrite-headers.rewrites[0].replacement=application/wasm"
```



How develop Plug-Ins

```
> window.hartenfeller_dev.plugins.sync_offline_data.storages.people_v1
< ▼ {config: {...}, getColInfo: f, getRowByPk: f, getRows: f, getRowCount: f, ...} ⓘ
  ▶ config: {pageSize: 500}
  ▶ getColInfo: () => _getColInfo(storageId, storageVersion, apex)
  ▶ getRowByPk: (pk) => _getRowByPk(storageId, storageVersion, pk, apex)
  ▶ getRowCount: ({ searchTerm }) => {...}
  ▶ getRows: ({ offset = 0, maxRows = 100, orderByCol, orderByDir, searchTerm, }) => {...}
  ▶ sync: () => {...}
  ▶ writeChanges: (rows) => {...}
```

Offline Data List

Search

Ward Moncure

Marvella Moncure

Peggie Loera

Noelle Gervin

Lola Loera

Adam Binette 1234

Dave Gervin

Daphine Dardar

Rosemarie Moncure

Dean Koschnitzki

<<

<

Page 1

>

>>

`getRows({ searchTerm: "xyz" })`

`getRows({ offset: 10 })`

`getRowCount()`

Wrapping Up



What still needs to be done

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

- Notify when sync completed with data changes
- Expand Plug-In Ecosystem

AG Grid Plugin Demo
Right click to insert / delete. Data gets reset every hour.

Grid Save

	ID	Name	JOB	Salary	Commission
<input type="checkbox"/>	1	Gricelda Luebberts	Receptionist	\$3,938.00	\$76.00
<input type="checkbox"/>	2	Dean Bollich	Network Architect	\$8,426.00	\$92.00
<input type="checkbox"/>	3	Milo Manoni	System Operations	\$4,144.00	\$46.00
<input type="checkbox"/>	4	Laurice Karl	Programmer	\$5,440.00	\$11.00
<input type="checkbox"/>	5	August Rupel	Receptionist	\$3,375.00	\$99.00
<input type="checkbox"/>	6	Salome Guisti	Systems Administrator	\$10,906.00	\$73.00
<input type="checkbox"/>	7	Lovie Ritacco	Network Architect	\$4,893.00	\$73.00
<input type="checkbox"/>	8	Chaya Greczkowski	Sustaining Engineering	\$10,260.00	\$38.00
<input type="checkbox"/>	9	Twila Coolbeth	Evangelist	\$9,540.00	\$27.00
<input type="checkbox"/>	10	Carlotta Achenbach	Usability Engineer	\$10,621.00	\$95.00
<input type="checkbox"/>	11	Jeraldine Audet	Analyst	\$3,315.00	\$97.00

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

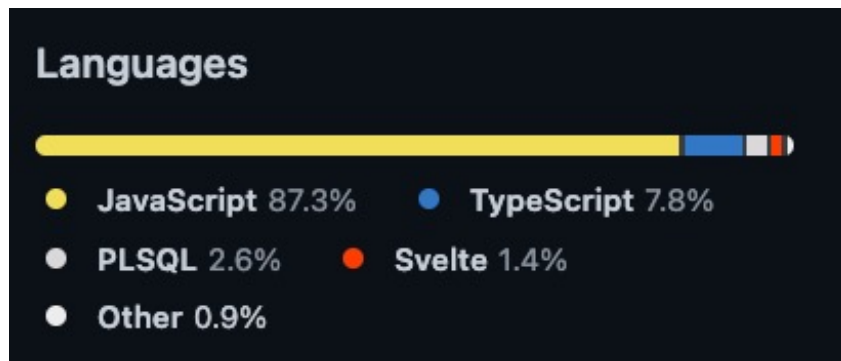


Photo by [JESHOOOTS.COM](https://www.jeshoots.com) from [Unsplash](https://unsplash.com)

Where can I get this ?

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

- Needs Documentation
- Needs Refactoring
- Contributions welcome 😊



Conclusion

- I am quite happy with the result
- Sync-Plug-In easy to use, hides complexity
- Confident that SQLite is a great choice for small to large data sizes
- Great browser support
- Not sure about header requirements



Photy by [Sebastian Herrmann](#) from [Unsplash](#)

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

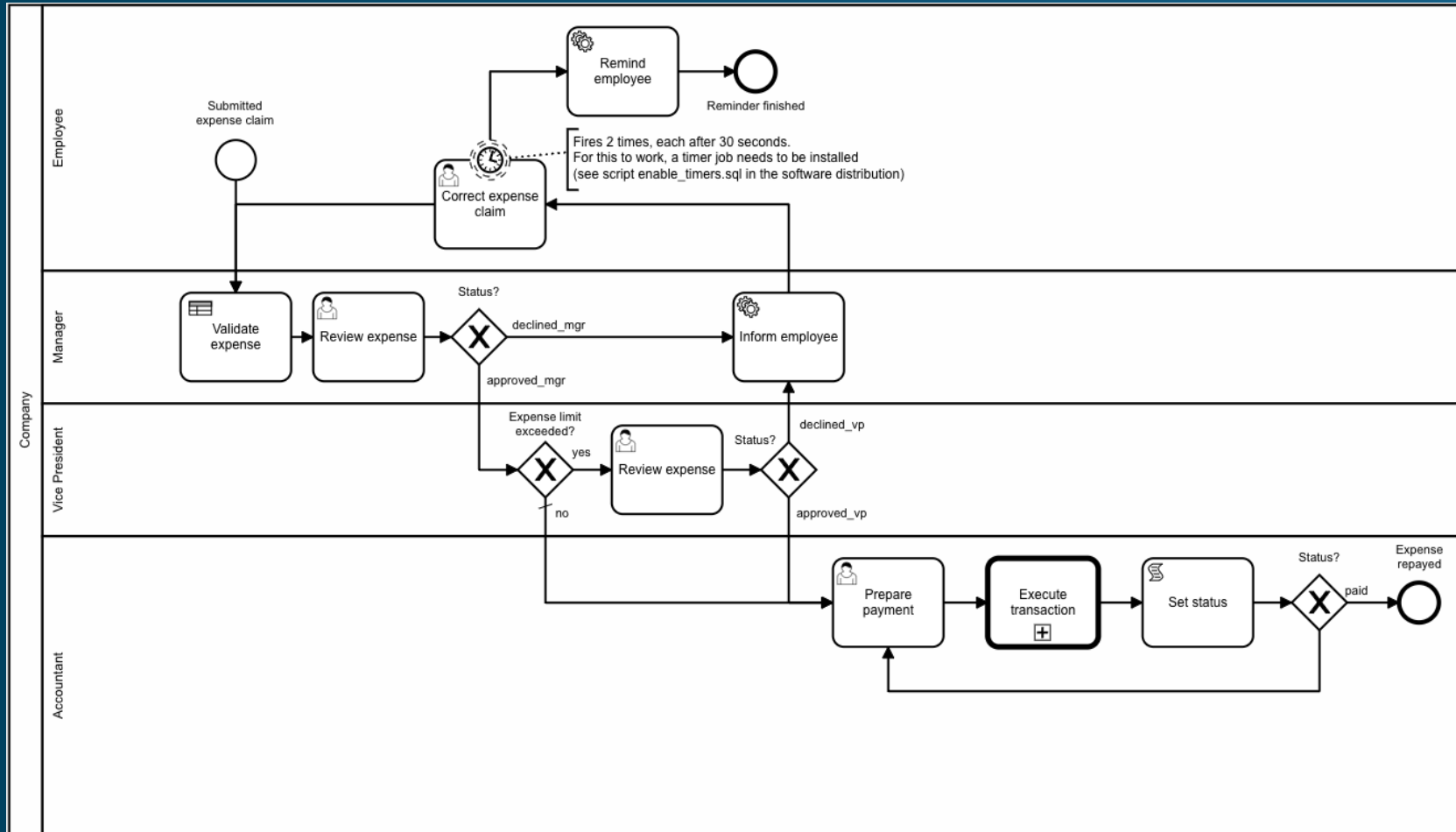


LCT



Flows for APEX

BPMN 2.0 Workflows for APEX



- Open Source
- Community Driven
- Support available



RATE ME!



Offline data manipulations in APEX for everyone with Plug-Ins and SQLite

Philipp Hartenfeller

The logo for 'a'pèks world' is located in the bottom right corner. It features a circular emblem with a blue and red design, possibly representing a globe or a stylized face. The text 'a'pèks' is written in a bold, black, sans-serif font across the middle of the circle, and the word 'world' is written in a smaller, black, sans-serif font below it. The entire logo is overlaid on a dark blue background with a grid of light blue lines and white dots, resembling a digital or network theme.

a'pèks
world