# MariaDB Temporal Tables

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# $ whoami

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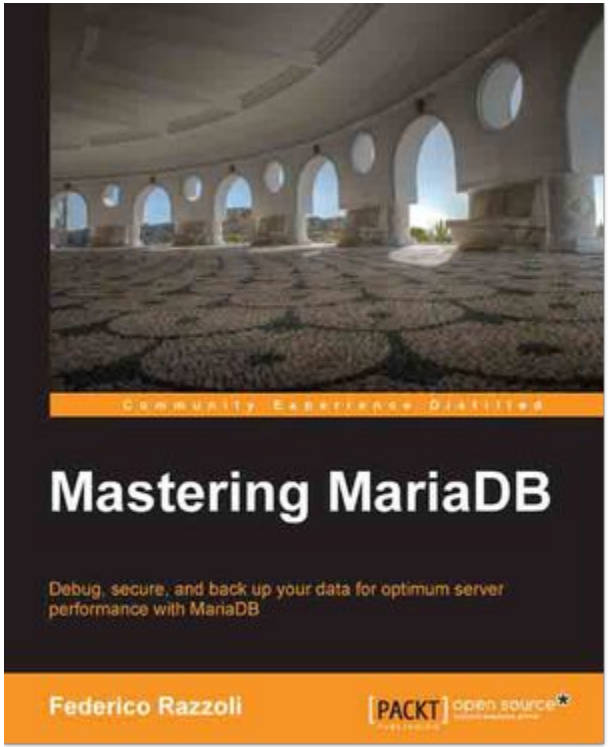

# Temporal Tables Implementations

# Proprietary DBMSs


- Oracle 11g (2007)
- Db2 (2012)
- SQL Server 2016
- Snowflake

In Db2, a temporal table can use system-period or application-period

# Open source databases


- PostgreSQL has a temporal_tables extension
  - not available from the main cloud vendors
- CockroachDB
  - with limitations
- CruxDB (NoSQL)
- HBase stores old row versions and you can retrieve them

# MariaDB


MariaDB supports both types of Temporal Tables:

- MariaDB 10.3: system_time
- MariaDB 10.4: application_time

Tables are bitemporal

# Application Time

# Example

```
CREATE OR REPLACE TABLE ticket (
    id INT PRIMARY KEY NOT NULL AUTO_INCREMENT,
    state ENUM('OPEN', 'VERIFIED', 'FIXED', 'INVALID') NOT NULL
        DEFAULT 'OPEN',
    summary VARCHAR(200) NOT NULL,
    description TEXT NOT NULL
)
    ENGINE InnoDB
;
```

- We want to start to track changes to bugs over time

# Making the table Application-Timed


```
ALTER TABLE ticket
     LOCK = SHARED,
     ALGORITHM = COPY,
     ADD COLUMN valid_from DATETIME NOT NULL,
     ADD COLUMN valid_to DATETIME NOT NULL,
     ADD PERIOD FOR time_period (valid_from, valid_to) ;
```

We can use...

- Any temporal data type that includes a date (DATE, DATETIME, TIMESTAMP)
- Any storage engine

# Inserting rows

```
MariaDB [test]> INSERT INTO ticket (summary, description) VALUES
    ->   ('I cannot login', 'Why is this happening to me?');
ERROR 1364 (HY000): Field 'valid_from' doesn't have a default value

MariaDB [test]> INSERT INTO ticket (summary, description,valid_from, valid_to)
VALUES
    -> ('I cannot login', 'Why is this happening to me?',
    -> '1994-01-01', '2010-01-01');
Query OK, 1 row affected (0.003 sec)
```

# A better Application-Timed table


```
CREATE TABLE ticket_tmp LIKE ticket;
ALTER TABLE ticket_tmp
    ADD COLUMN valid_from DATETIME NOT NULL
        DEFAULT NOW(),
    ADD COLUMN valid_to DATETIME NOT NULL
        DEFAULT '2038-01-19 03:14:07.999999' ,
    ADD INDEX idx_valid_from (valid_from),
    ADD INDEX idx_valid_to (valid_to),
   ADD PERIOD FOR time_period(valid_from, valid_to);
```

# A better Application-Timed table


```
ALTER TABLE ticket_tmp
    DROP PRIMARY KEY,
    ADD PRIMARY KEY (id, valid_to)
;

-- populate the table

RENAME TABLE ticket TO ticket_old, ticket_tmp TO ticket;
```

- You will need to do similar operations with UNIQUE indexes
- RENAME TABLE is an atomic operation

# Reading rows


```
MariaDB [test]> SELECT id, summary, valid_from, valid_to FROM ticket;
+----+---------------+---------------------+---------------------+
| id | summary       | valid_from          | valid_to            |
+----+---------------+---------------------+---------------------+
|  1 | I cannot login | 1994-01-01 00:00:00 | 2010-01-01 00:00:00 |
+----+---------------+---------------------+---------------------+
1 row in set (0.001 sec)


MariaDB [test]> SELECT id, summary, valid_from, valid_to FROM ticket
     -> WHERE NOW() BETWEEN valid_from AND valid_to;
Empty set (0.001 sec)
```

# Deleting rows properly


```
CREATE OR REPLACE PROCEDURE ticket_delete(p_id INT)
    MODIFIES SQL DATA
    COMMENT 'Makes a row obsolete by changing its timestamp'
BEGIN
    UPDATE ticket
        SET valid_to = NOW()
        WHERE id = p_id AND valid_to > NOW();
END;
```

# Deleting rows properly


```
MariaDB [test]> SELECT id, valid_from, valid_to FROM ticket WHERE id = 1;
+----+---------------------+---------------------+
| id | valid_from          | valid_to            |
+----+---------------------+---------------------+
|  1 | 2020-08-23 14:32:22 | 2038-01-19 03:14:07 |
+----+---------------------+---------------------+

MariaDB [test]> CALL ticket_delete(1);

MariaDB [test]> SELECT id, valid_from, valid_to FROM ticket WHERE id = 1;
+----+---------------------+---------------------+
| id | valid_from          | valid_to            |
+----+---------------------+---------------------+
|  1 | 2020-08-23 14:32:22 | 2020-08-23 14:32:34 |
+----+---------------------+---------------------+
```

# Deleting/updating periods


```
MariaDB [test]> SELECT id, valid_from, valid_to FROM ticket;
+----+---------------------+---------------------+
| id | valid_from          | valid_to            |
+----+---------------------+---------------------+
|  1 | 1994-01-01 00:00:00 | 2010-01-01 00:00:00 |
+----+---------------------+---------------------+

MariaDB [test]> DELETE FROM ticket
     ->   FOR PORTION OF time_period FROM '1990-01-01' TO '2000-01-01'
     ->   WHERE id = 1;

MariaDB [test]> SELECT id, valid_from, valid_to FROM ticket;
+----+---------------------+---------------------+
| id | valid_from          | valid_to            |
+----+---------------------+---------------------+
|  2 | 2000-01-01 00:00:00 | 2010-01-01 00:00:00 |
+----+---------------------+---------------------+
```

# System Versioning

# Back to our example...


```
CREATE OR REPLACE TABLE ticket (
     id INT PRIMARY KEY NOT NULL AUTO_INCREMENT,
     state ENUM('OPEN', 'VERIFIED', 'FIXED', 'INVALID') NOT NULL
     DEFAULT 'OPEN',
     summary VARCHAR(200) NOT NULL,
     description TEXT NOT NULL
)
     ENGINE InnoDB
;
```

# Making the table System-Versioned


```
ALTER TABLE ticket
     LOCK = SHARED,
     ALGORITHM = COPY,
     ADD SYSTEM VERSIONING;
```

# Making the table System-Versioned


```
ALTER TABLE ticket
     LOCK = SHARED,
     ALGORITHM = COPY,
     ADD COLUMN inserted_at TIMESTAMP(6) GENERATED ALWAYS AS ROW START INVISIBLE,
     ADD COLUMN deleted_at TIMESTAMP(6) GENERATED ALWAYS AS ROW END INVISIBLE,
     ADD PERIOD FOR SYSTEM_TIME(inserted_at, deleted_at),
     ADD SYSTEM VERSIONING;
```

Limitations:

- Temporal columns don’t have to be INVISIBLE, if they’re often needed
- MDEV-15968: System versioning and CONNECT engine don't work well together: current data is not returned
- MDEV-17448: Support DATETIME(6) for ROW START, ROW END

# Querying a Sysver Table


```
-- get current version of the rows
-- without the temporal columns (they're INVISIBLE)
SELECT * FROM ticket;

-- get current version of the rows
-- with the temporal columns
SELECT *, inserted_at, deleted_at FROM ticket;

-- all current and old data
SELECT *, inserted_at, deleted_at
     FROM ticket FOR SYSTEM_TIME ALL;
```

# Get old versions of the rows


```
-- get deleted rows
SELECT *, inserted_at, deleted_at
     FROM ticket FOR SYSTEM_TIME
          FROM '1970-00-00' TO NOW() - 1 MICROSECOND;

SELECT *, inserted_at, deleted_at
     FROM ticket FOR SYSTEM_TIME
          BETWEEN '1970-00-00' AND NOW() - 1 MICROSECOND;

SELECT *, inserted_at, deleted_at
     FROM ticket FOR SYSTEM_TIME ALL
     WHERE deleted_at < NOW();
```

# History of a row

```
SELECT id, state, inserted_at, deleted_at
     FROM ticket FOR SYSTEM_TIME ALL
     WHERE id = 3
     ORDER BY deleted_at;
```

# Read a row from a specific point in time


```
SELECT id, state
     FROM ticket FOR SYSTEM_TIME AS OF TIMESTAMP'2020-08-22 08:52:36'
     WHERE id = 3;

SELECT id, state
     FROM ticket FOR SYSTEM_TIME ALL
     WHERE id = 3 AND
     '2020-08-22 08:52:36' BETWEEN inserted_at AND deleted_at;
```

# Temporal JOINs


```
-- rows that were present on 07/01
-- whose state did not change after one month

SELECT t1.id, t1.inserted_at, t1.deleted_at
    FROM ticket       FOR SYSTEM_TIME ALL AS t1
    LEFT JOIN ticket  FOR SYSTEM_TIME ALL AS t2
        ON
            t1.id = t2.id
            AND t1.state = t2.state
    WHERE
            '2020-07-01 00:00:00' BETWEEN t1.inserted_at AND t1.deleted_at
        AND '2020-08-01 00:00:00' BETWEEN t2.inserted_at AND t2.deleted_at
        AND t2.id IS NULL
    ORDER BY t1.id;
```

# Indexes


The ROW END column is automatically appended to:

- The Primary Key;
- All UNIQUE indexes.

Queries can use a whole index of its leftmost part,
so once a regular table becomes System Versioned queries performance will not degrade.

For Application Timed tables, indexes remain unchanged.

# The power of [bi]Temporal Tables

# Hints about things you can do


- A table can be both system-versioned and application-timed (**bitemporal**)
- Stats on added/deleted rows by year, month, weekday, day, daytime…
- Stats on rows lifetime
- Get rows that never changed
- Get rows that change too often, or change at “strange” times
- Examine history of a row to find problems
- …

# Hints about things that you should do


- PK should never change, or tracking rows history will be impossible
  - If necessary, use a trigger that throws an error if OLD.id != NEW.id
- Application Time tables: no hard deletions/updates
- If you have to drop a column, move it to a new table to avoid losing the history
- If you have to add a column that is not often read/written, consider putting it into a new table
- If you run stats or complex queries involving temporal columns, add PERSISTENT columns and indexes on them to make queries faster

# What we left out


This was a short introductory session, so we left out some features:

- ALTER TABLEs
  - They may erase or change parts of the history, so they’re disabled by default
- Partitioning
  - You can record the history in a separate partition, or multiple partitions
- Backups
  - Check the docs for problems with Sysver Tables and mysqldump
- Replication / binlog
  - Check the documentation for possible problems with Sysver Tables
  - MariaDB can be a replica of a MySQL server, and make use of Temporal Tables to let analysts run certain analyses that they couldn’t run on MySQL

Thanks for attending!
Question time :-)


Vetta Base ltd.