{ JSON }
in MySQL and MariaDB Databases

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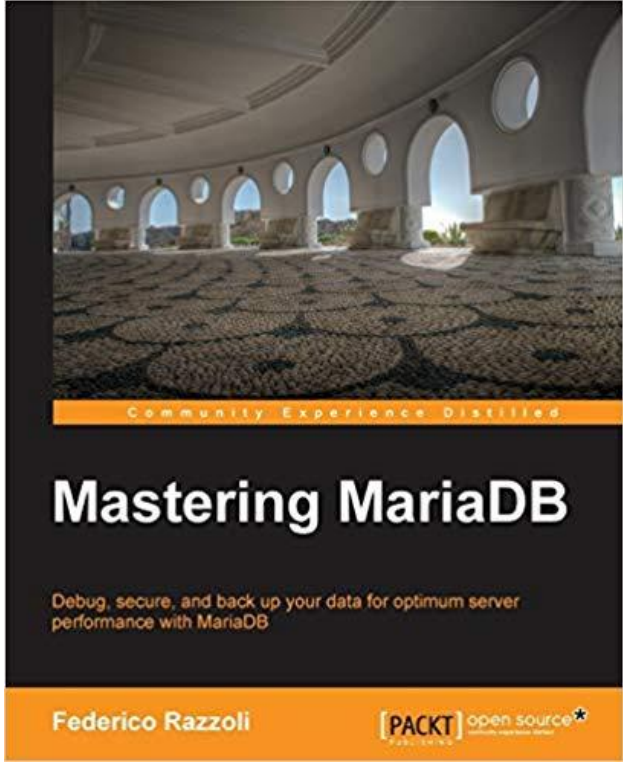

- I worked as a consultant for Percona and Ibuildings (mainly MySQL and MariaDB)
- I worked as a DBA for fast-growing companies like Catawiki, HumanState, TransferWise

JSON Support

JSON Support

- MySQL 7.0 has a JSON type and JSON functions
- MariaDB 10.2 has JSON alias (LONGTEXT) and JSON functions
  - From MariaDB 10.4 JSON columns must contain valid JSON data

JSON Type Benefits

- Persons from both MySQL and MariaDB state that their approach is faster
  - Surprise, surprise!
- MySQL format is smaller
- When updating a property, MySQL does not rewrite the whole JSON document
- MySQL binary log only contains the modified properties
  - `binlog_row_value_options = 'PARTIAL_JSON'`
- However, in MySQL 8, make sure that:
  - `Default_tmp_storage_engine = 'TEMPTABLE'`

JSON Features Comparison

- Let’s compare JSON features, and more generic features that are useful working with JSON
- MySQL 8.0 / MariaDB 10.5
- MySQL only:
  - Index arrays (requires multi-valued indexes)
  - Schema validation
  - JSON_TABLE()
  - Functional index / Index on VIRTUAL column
- MariaDB only:
  - CONNECT (use a JSON file as a table)
  - Stored aggregate functions

Use Cases

JSON in relational databases?

- Relational databases are **schemaful**
- All rows must have the same columns (name, type)
  - (though `NULL` is often use to relax the schema)
- `CHECK` constraints:
  - email VARCHAR(100) CHECK (email LIKE '_%@_%._%')
  - birth_date DATE, death_date DATE, CHECK (birth_date <= death_date)
- `UNIQUE` constraint
- Referential constraints (foreign keys):
  - Each row in a *child* table matches a row in a *parent* table

JSON in relational databases?

- JSON is usually **schemaless**
- Two different objects can have different structures:

```
{
   "product-type": "shirt",
   "cost": 10.0,
   "size": "M"
}
{
   "product-type": "phone",
   "cost": 69.99,
   "size": [6.37, 2.9, 0.3],
   "os": "Android"
}
```

JSON in relational databases?

- How would you store heterogeneous products in a relational database?

JSON in relational databases?

- How would you store heterogeneous products in a relational database?
- One table per product type?
  - Cannot enforce UNIQUE constraint
  - Try to find a product that could be of any type…
  - Try to get the min and max costs...

JSON in relational databases?

- How would you store heterogeneous products in a relational database?
- One table with one column for each property, NULL where it is not used?
  - Adding a product implies a slow, painful ALTER TABLE
  - If products type is deleted, obsolete columns tend to remain forever
  - Big table is bad for operations (backup, repair…)
  - INSERTs are slow
  - SELECT *

JSON in relational databases?

- How would you store heterogeneous products in a relational database?
- One main table with common properties, and one separate table for each product type?
  - You can now see min/max costs, or find a product of any type
  - Many JOINs

JSON in relational databases?

- How would you store heterogeneous products in a relational database?
- Entity-Attribute-Value pattern (EAV)?
  - Store all data as texts
  - Crazy amount of JOINs

JSON in relational databases?

- How would you store heterogeneous products in a relational database?
- Single table, where all non-common property are stored as JSON
  - Still not perfect
  - But it’s good enough

JSON in relational databases?

```
CREATE TABLE product (
    id INT UNSIGNED AUTO_INCREMENT PRIMARY KEY,
    type VARCHAR(50) NOT NULL,
    name VARCHAR(50) NOT NULL,
    cost DECIMAL(10, 2) NOT NULL,
    quantity INT UNSIGNED NOT NULL,
    attributes JSON NOT NULL
);
```

Indexing Properties

Materialising Properties

```
CREATE TABLE product (
    id INT UNSIGNED AUTO_INCREMENT PRIMARY KEY,
    type VARCHAR(50),
    name VARCHAR(50) NOT NULL,
    cost DECIMAL(10, 2) NOT NULL,
    quantity INT UNSIGNED NOT NULL,
    attributes JSON NOT NULL,
    colour VARCHAR(50) AS
        (JSON_UNQUOTE(
            JSON_EXTRACT(attributes, '$.colour')
        )) STORED
);
```

MySQL shortcut

```
CREATE TABLE product (
    id INT UNSIGNED AUTO_INCREMENT PRIMARY KEY,
    type VARCHAR(50),
    name VARCHAR(50) NOT NULL,
    cost DECIMAL(10, 2) NOT NULL,
    quantity INT UNSIGNED NOT NULL,
    attributes JSON NOT NULL,
    colour VARCHAR(50) AS
        (attributes->>'$.colour') VIRTUAL
);
```

Index on a Property

```
CREATE TABLE product (
    id INT UNSIGNED AUTO_INCREMENT PRIMARY KEY,
    type VARCHAR(50),
    name VARCHAR(50) NOT NULL,
    cost DECIMAL(10, 2) NOT NULL,
    quantity INT UNSIGNED NOT NULL,
    attributes JSON NOT NULL,
   colour VARCHAR(50) AS
      (attributes->>'$.colour') VIRTUAL,
    INDEX idx_colour (type, colour)
);
```

Index on a Property

```
SELECT id FROM product
    WHERE type = 'FURNITURE'
    AND colour = 'grey'
;

-- only uses the index in MySQL
SELECT id FROM product
    WHERE type = 'FURNITURE'
    AND attributes->>'$.colour' = 'grey'
;
```

Indexing Properties

```
CREATE TABLE product (
    id INT UNSIGNED AUTO_INCREMENT PRIMARY KEY,
    type VARCHAR(50),
    name VARCHAR(50) NOT NULL,
    cost DECIMAL(10, 2) NOT NULL,
    quantity INT UNSIGNED NOT NULL,
    attributes JSON NOT NULL,
    furniture_colour VARCHAR(50) AS
        (IF(type = 'FURNITURE',
            attributes->>'$.colour',
            NULL
        )) VIRTUAL,
    INDEX idx_colour (furniture_colour)
);
```

Indexing Arrays

Indexing ARRAYS

- MySQL and MariaDB historically don’t support arrays
- Now they can use JSON arrays as “regular” arrays
- MySQL 8.0 supports Multi-Valued Indexes, that allow to index these arrays
  - Can be used to index JSON objects, *not covered here*

Indexing Arrays

```
CREATE TABLE `order` (
    id INT UNSIGNED AUTO_INCREMENT PRIMARY KEY,
    customer_id INT UNSIGNED NOT NULL,
    product_ids JSON NOT NULL,
    INDEX idx_products (
        (CAST(product_ids AS UNSIGNED ARRAY))
    )
);

INSERT INTO `order` (customer_id, product_ids) VALUES
   (24, JSON_ARRAY(10, 20, 30));
```

Indexing Arrays

```
SELECT DISTINCT customer_id
    FROM `order`
    WHERE 20 MEMBER OF (product_ids);
```

- JSON_CONTAINS()
- JSON_OVERLAPS()

Relationships

Foreign Keys on Properties

```
CREATE TABLE product (
    id INT UNSIGNED AUTO_INCREMENT PRIMARY KEY,
    type VARCHAR(50),
    ...
    furniture_colour INT UNSIGNED AS
        (IF(type = 'FURNITURE',
            attributes->>'$.colour',
            NULL
        )) STORED,
    INDEX idx_furniture_colour (furniture_colour),
    FOREIGN KEY fk_furniture_colour (furniture_colour)
        REFERENCES furniture_colour (id)
);
```

Not suggesting to use Foreign Keys

- They come with several penalties
  - Slower writes
  - Propagated locks (for CASCADE FKs)
  - Limitations (only InnoDB, no partitions)
  - Cannot run **safe** online migrations
- Google for:
  Federico Razzoli "Foreign Key bugs in MySQL and MariaDB"

But...

- But you can do the same without foreign keys
- You can easily add extra columns to `furniture_colour`
- You don’t have to mind about colour name details (case, extra spaces…)
- You can easily change a colour name
- You keep the JSON documents smaller

Basically, you can use the relational databases philosophy
While keeping some semi-structured data inside them

Validating JSON documents

Validating Against a JSON Schema

- Both MySQL and MariaDB only accept valid JSON documents in JSON columns
- The `CHECK` clause defines the rules that determine if a row is valid
- JSON_SCHEMA_VALID() in MySQL validates a JSON document against a JSON Schema
  - json-schema.org
  - Draft 4
  - But from my tests we can use drafts 6 or 7

Validating Schema

```
SELECT JSON_SCHEMA_VALID(@schema, @document);

SELECT JSON_SCHEMA_VALID((
        SELECT schema
            FROM schemas
            WHERE type = 'furniture'
    ), document)
    FROM product
    WHERE id = 24
;
```

Validating Schema

Suppose we want to validate objects of this type:

```
{
    "material": "iron",
    "colour": "grey",
    "size": [1.5, 1.5, 1.0]
}
```

```
{
    "$id": "https://federico-razzoli.com/schemas/furniture",
    "$schema": "http://json-schema.org/draft-07/schema#",
    "type": "object",
    "properties": {
        "material": {
            "type": "string",
            "enum": ["iron", "wood"]
        },
        "size": {
            "type": "array",
            "items": {
                "type": "number",
                "minItems": 3,
                "maxItems": 3
            }
        },
        "colour": {
            "type": "string"
        }
    },
    "required": ["material", "size"]
}
```

Debugging a JSON Schema

- SELECT JSON_SCHEMA_VALID() + SHOW WARNINGS
- JSON_SCHEMA_VALIDATION_REPORT()

Default Properties

Default Properties

- We can have a JSON document with the default properties
- And only store non-default values in each regular JSON document
- This is useful:
  - For large JSON objects (eg. software configuration)
  - For objects whose defaults may change (eg. software whose settings can be set per user and per team)

Merging Documents

```
-- get user settings
SET @user_conf := (
    SELECT json_settings FROM user_configuration
        WHERE id = 24
);
-- get team settings
SET @team_conf := (
    SELECT json_settings FROM team_configuration
        WHERE id = 123
);
-- merge them. user settings overwrite team settings
SELECT JSON_MERGE_PATCH(@team_conf, @user_conf);
```

JSON_MERGE_PATCH() example

```
mysql> SELECT JSON_MERGE_PATCH(
    '{"items-per-page": 24, "suppress_warnings": true}',
    '{"suppress_warnings": false}')
    AS configuration;
+-----------------------------------------------------+
| configuration                                       |
+-----------------------------------------------------+
| {"items-per-page": 24, "suppress_warnings": false} |
+-----------------------------------------------------+
```

JSON_ARRAYAGG()
JSON_OBJECTAGG()

JSON_ARRAYAGG(), JSON_OBJECTAGG()

- Available in:
  - MySQL 5.7
  - MariaDB 10.5, currently not GA
- However, they are:
  - Simple to emulate with `GROUP_CONCAT()`
  - Easy to code with MariaDB **Stored Aggregate Functions** (10.3)

JSON_ARRAYAGG()

```
mysql> SELECT type, JSON_ARRAYAGG(colour) AS colours
    -> FROM product
    -> GROUP BY type
    -> ORDER BY type;
+-------+----------------------------------+
| type  | colours                          |
+-------+----------------------------------+
| chair | ["green", "blue", "red", "black"] |
| shelf | ["white", "brown"]               |
| table | ["white", "gray", "black"]       |
+-------+----------------------------------+
```

JSON_OBJECTAGG(): one document

```
mysql> SELECT
    ->  JSON_PRETTY(
    ->      JSON_OBJECTAGG(variable, value)
    ->  ) AS settings
    ->  FROM config \G
*************************** 1. row ***************************
settings: {
  "datadir": "/var/mysql/data",
  "log_bin": "1",
  "general_log": "0",
  "slow_query_log": "0",
  "innodb_log_file_size": "1G",
  "innodb_log_buffer_size": "16M",
  "innodb_buffer_pool_size": "16G"
}
```

JSON_OBJECTAGG()
nested objects

```
mysql> SELECT
    ->  JSON_PRETTY(
    ->      JSON_OBJECTAGG(
    ->          variable,
    ->          JSON_OBJECT(
    ->              'type', type,
    ->              'value', value
    ->          )
    ->      )
    ->  ) AS settings
    ->  FROM config;
```

JSON_OBJECTAGG()
nested objects

```
settings: {
  "datadir": {
    "type": "string",
    "value": "/var/mysql/data"
  },
  "log_bin": {
    "type": "bool",
    "value": "1"
  },
  ...
}
```

JSON_OBJECTAGG(): one document per row

```
mysql> SELECT JSON_OBJECTAGG(variable, value) AS settings
    ->  FROM config
    ->  GROUP BY variable;
+-----------------------------------+
| settings                          |
+-----------------------------------+
| {"datadir": "/var/mysql/data"}    |
| {"general_log": "0"}              |
| {"innodb_buffer_pool_size": "16G"} |
| {"innodb_log_buffer_size": "16M"}  |
| {"innodb_log_file_size": "1G"}    |
| {"log_bin": "1"}                  |
| {"slow_query_log": "0"}           |
+-----------------------------------+
```

JSON_TABLE()

JSON_TABLE()

- Only MySQL 8
- Transforms a JSON document into a table
- Each property, or some properties, become a table column
- Properties are identified by JSON Path expressions

JSON_TABLE() example

```
{
     "customers": [
          {
               "name": "John Doe",
               "emails": ["john@doe.com"],
               "phone": "123456"
          },
          {
               "name": "Jane Dee",
               "emails": ["Jane@dee.com"],
               "phone": "987654"
          },
          {
               "name": "Donald Duck",
               "emails": []
          }
     ],
     "products": [],
     "orders": []
}
```

JSON_TABLE() example

```
SELECT *
    FROM JSON_TABLE(
    @customers,
    '$.customers[*]'
    COLUMNS (
        id FOR ORDINALITY,
        name VARCHAR(50) PATH '$.name',
        primary_email VARCHAR(50) PATH '$.emails[0]',
        phone VARCHAR(50) PATH '$.phone'
            DEFAULT '"UNKNOWN"' ON EMPTY
            NULL ON ERROR
    )
) AS customers;
```

JSON_TABLE() example

```
+------+-------------+---------------+---------+
| id   | name        | primary_email | phone   |
+------+-------------+---------------+---------+
|   1  | John Doe    | john@doe.com  | 123456  |
|   2  | Jane Dee    | Jane@dee.com  | 987654  |
|   3  | Donald Duck | NULL          | UNKNOWN |
+------+-------------+---------------+---------+
```

MariaDB CONNECT

What CONNECT is

- Connect is a storage engine for MariaDB
  - Won’t compile on MySQL or Percona Server
- Reads data from different data sources:
  - Remote tables (MySQL protocol, ODBC, JDBC)
  - Files in various formats (JSON, XML, CSV, custom formats…)
  - Special data sources
  - Transformed data from other tables (pivot, …)

CONNECT and JSON

- JSON Table Type (10.1)
- On Windows, can read data from REST APIs (not easy to do)
- CONNECT comes with a library of JSON UDFs
    - Probably not battle-tested as the current built-in functions

Thank you for listening!

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