Storing JSON in Relational Database Best Practices

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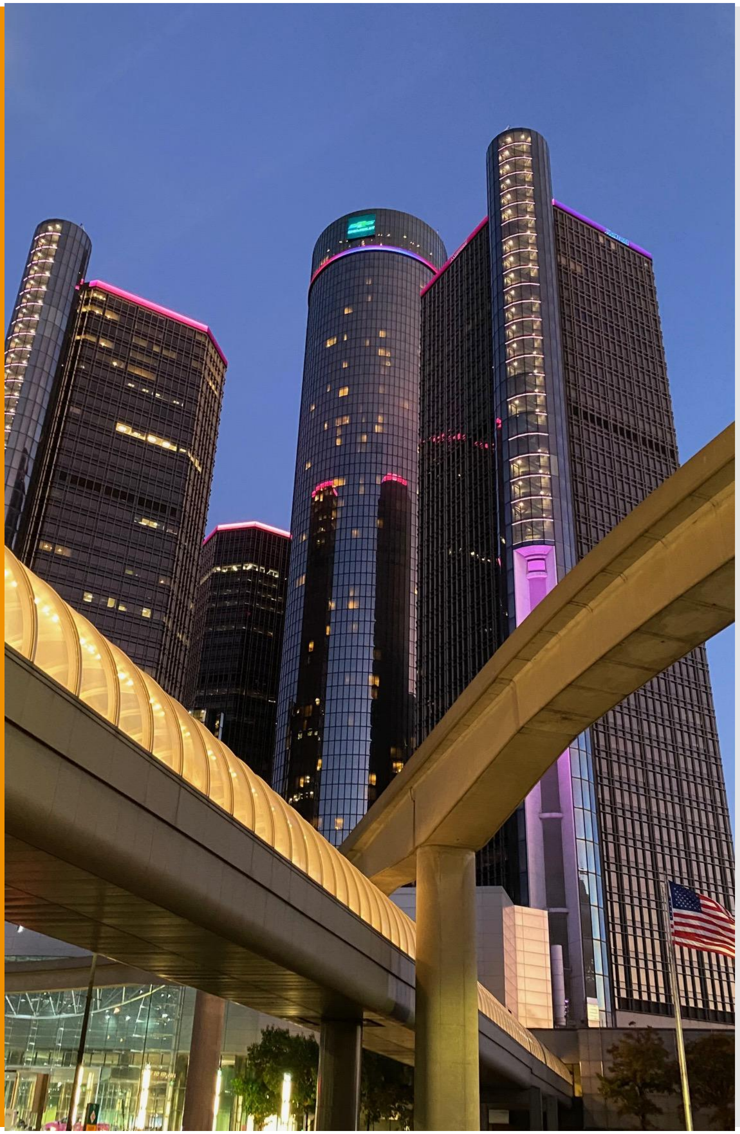

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Description from schedule

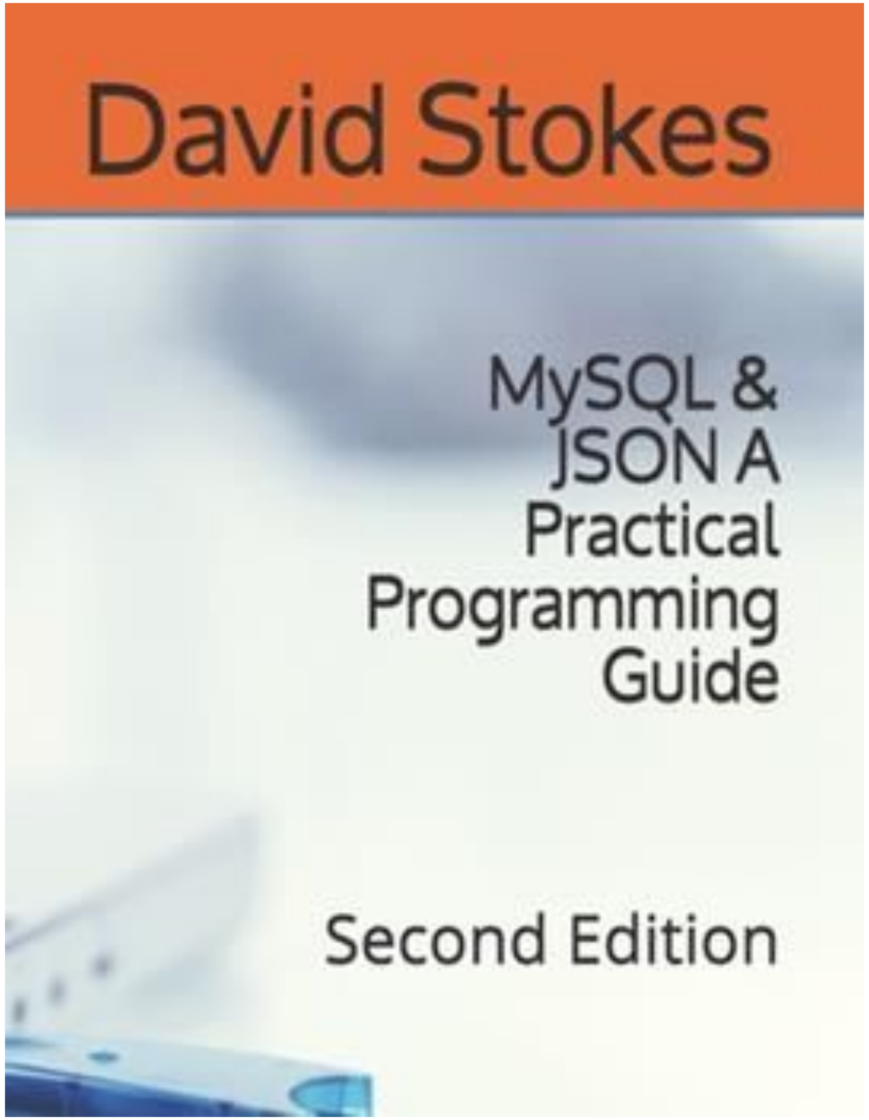
Most modern application are using JSON in their applications, however they store their data in traditional data types within their database. Dave will highlight how to store and access JSON directly in both MySQL and PostgreSQL to enable faster development cycles and show you the tips and tricks to ensure scalability and performance.

About me

Technology Evangelist at Percona

Long time open source advocate

Author



David Stokes

MySQL & JSON A Practical Programming Guide

Second Edition

Differences - SQL versus NoSQL

Traditional Relational Databases

1. Normalized data - Database normalization is the process of structuring a relational database in accordance with a series of so-called normal forms in order to reduce data redundancy and improve data integrity.

2. Present the data to the user as relations with logical connection between different tables.

3. Provide relational operators to manipulate the data in tabular form.

4. Strict Data Types enforce ‘rigor’ on data.

5. Data decisions upfront.

NoSQL JSON Databases

1. **Freeform & Flexible - data stored in key/value pairs.**
2. **No rigor on data.**
3. **Many different formats in same schema.**
4. **Data decisions on output.**

Quiz Time! (MySQL)

```
SQL >CREATE TABLE q1 (question1 INT, question2 CHAR(5));
SQL >insert into q1 values (1,'All things open');
ERROR: 1406: Data too long for column 'question2' at row 1
SQL > insert into q1 values ('1oo','ATO');
ERROR: 1265: Data truncated for column 'question1' at row 1
```

What is in table q1?

```
SQL > select * from q1;
Empty set (0.0009 sec)
```

Quiz 1 (PostgreSQL)

```
test=# create table q1 (question1 int, question2 char(5));
CREATE TABLE
test=# insert into q1 (question1, question2) values ('5','All Things Open!');
ERROR:  value too long for type character(5)
test=# insert into q1 (question1, question2) values ('5','ATO');
INSERT 0 1
```

What is in table q1?

```
test=# select * from q1;
 question1 | question2
-----------+-----------
         5 | ATO
(1 row)
```

~ 10 years ago

NoSQL vendors claimed JSON solved many problems with Structured Query Language (SQL)!

Then they announced they were going to support relational features like transactions.

Somewhat succeeded.

Relational Databases Added JSON support

So, What is JSON?

JavaScript Object Notation - https://en.wikipedia.org/wiki/JSON

JSON (**JavaScript Object Notation**, pronounced /ˈdʒeɪsən/; also /ˈdʒeɪˌsɒn/) is an open standard file format and data interchange format that uses human-readable text to store and transmit data objects consisting of attribute–value pairs and arrays (or other serializable values). It is a common data format with diverse uses in electronic data interchange, including that of web applications with servers.

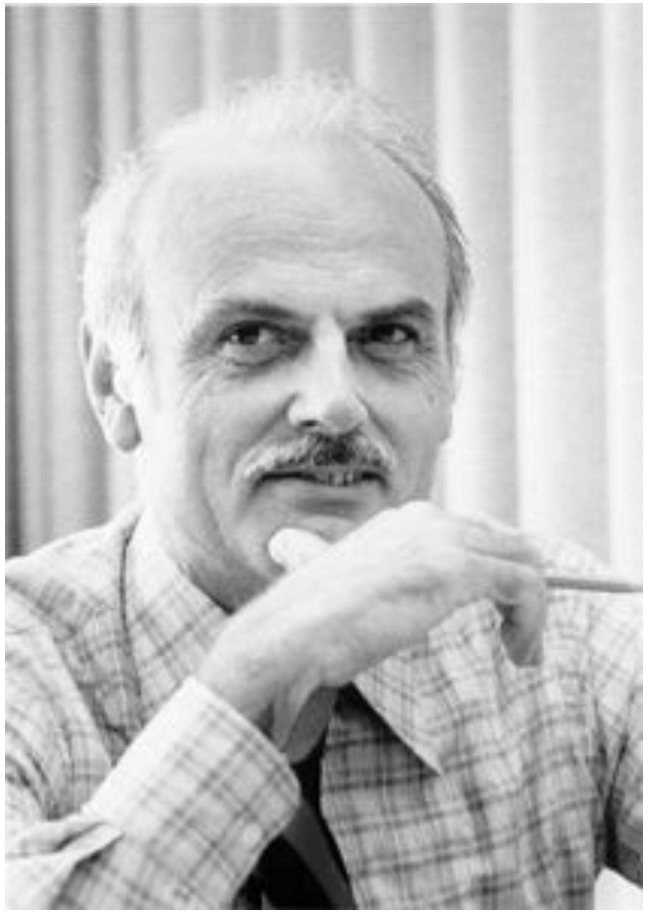
The difference between how Developers and DBAs view data

```
{
  “id”:   12345,
  “name”: “A. Programmer”,
  “age”:  21,
  “languages”: [“PHP”,”GO”]
}
```

```
CREATE TABLE staff (
id                INTEGER AUTO_INCREMENT,
name            CHAR(100) NOT NULL,
department INT UNSIGNED NOT NULL,
languages    CHAR(255))
;
```

Relational Model

Dr. Edgar F. Codd



Structured Query Language

➔ Only Programming language from the 1970s still heavily used

➔ It introduced the concept of accessing many records with one single command

➔ Data divvied up into logical groupings - customer, product, order, etc.

➔ Originally designed to minimize data duplication
(disk drives were slow and expen$ive in 1970s/80s)

➔ particularly useful in handling structured data, i.e. data incorporating relations among entities and variables

A Word About ORMs

AVOID!

Object Relational Mapper introduce significant overheads:

- Extra layer of complexity
- May require multiple database round-trips to manipulate a single app-tier object
- Do not take full advantage of the capabilities of the database engine
- Do not manage concurrency control very well
- Extremely poor at batch or bulk operations that must insert or modify many app-tier objects. (think in rows not data *sets*)
- Application-tier ORM frameworks can introduce the possibility of divergent semantics across modules and microservices unless all of them share exactly the same mapping information.

AVOID!

So why didn’t JSON Document Databases Replace Relational Systems?

QUIZ 2 (PostgreSQL)

```
test=# create table q2 (foo JSONB);
CREATE TABLE
test=# insert into q2 values ('{ "A" : 1, "A": "a", "A": [1,2]}');
INSERT 0 1
```

What actually makes it into the database?

```
test=# select * from q2;
     foo
---------------
 {"A": [1, 2]}
(1 row)
```

QUIZ 2 (MySQL)

```
SQL > create table q2 (foo JSON);
Query OK, 0 rows affected (0.0096 sec)
SQL > insert into q2 values ('{ "A" : 1, "A": "a", "A": [1,2]}');
Query OK, 1 row affected (0.0080 sec)
```

Does MySQL do something different?

```
 SQL > select * from q2;
+---------------+
| foo           |
+---------------+
| {"A": [1, 2]} |
+---------------+
1 row in set (0.0005 sec)
```

JSON is free form

UTF8MB4!

Do not have to change tables to add new field - DDL operations can be expensive with a RDMS

Documents not rows

Data too easily duplicated, gets outdated

Many-to-many relationships are very hard to manage

Nested Objects

May not meet systemic data usage needs

Consistency-ish.

No rigor applied to data :

- email
- eMail
- e-mail
- electronicMail
- electonicMail

Easy to abandon old data

Agile style practices are not optimized for database operations

What is the biggest priority - development ease or using data?

Two Different Approaches to JSON in a Relational Database

MySQL & PostgreSQL

MySQL added a JSON datatype with MySQL 5.7 - 2015

- **Data stored in a binary blob**
  - Sorted by key
  - ~1gb payload

Postgresql added JSON support in 9.2 - 2012

- 1gb payload

Postgresql added JSONB in 9.4 - 2014

- **This is not MongoDB's BSON (16mb maximum document size)**
- 255mb payload

Confession:

You could store a JSON document in a database ***BEFORE*** there was a JSON data

- ➔ Document was stored in a TEXT field
- ➔ To search you use REGEX
- ➔ Hard to extract just one or a few components of the string
- ➔ Expensive to read, process and rewrite the entire revised string

MySQL JSON Example

```
CREATE TABLE ato (id INT UNSIGNED AUTO_INCREMENT PRIMARY KEY, data JSON);

INSERT INTO ato (data) VALUES ('{"Name": "Dave", "Answer": 42}');
```

```
 SELECT id, data FROM ato\G
*************************** 1. row ***************************
  id: 1
data: {"Name": "Dave", "Answer": 42}
1 row in set (0.0012 sec)
```

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PostgreSQL JSON Example

```
test=# CREATE TABLE ato (id SERIAL NOT NULL PRIMARY KEY, data JSON);
CREATE TABLE
test=# INSERT INTO ato (data) VALUES ('{ "Name": "Dave", "Answer": 42}');
INSERT 0 1
test=# SELECT id, data FROM ato;
 id |              data
----+---------------------------------
  1 | { "Name": "Dave", "Answer": 42}
(1 row)
```

PostgreSQL JSON*B*

```
test=# CREATE TABLE atob (id SERIAL NOT NULL PRIMARY KEY, data JSONB);
CREATE TABLE
test=# INSERT INTO atob (data) VALUES ('{ "Name": "Dave", "Answer": 42}');
INSERT 0 1
test=# SELECT id, data FROM atob;
 id |              data
----+--------------------------------
  1 | {"Name": "Dave", "Answer": 42}
(1 row)
```

Why have JSONB??

JSON data is stored as an exact copy of the JSON input text

JSONB stores data in a decomposed binary form; that is, not as an ASCII/UTF-8 string, but as binary code. (kinda like what MYSQL does)

- more efficiency,
- significantly faster to process,
- supports indexing (which can be a significant advantage, as we'll see later),

MySQL

```
SELECT data->>'$.Answer' FROM ato\G
*************************** 1. row ***************************
data->>'$.Answer': 42
1 row in set (0.0008 sec)
```

PG

```
test=# SELECT data -> 'Answer' FROM ato;
 ?column?
----------
 42
(1 row)


test=# SELECT data -> 'Answer' FROM atob;
 ?column?
----------
 42
```

MySQL

SELECT data->'$.Name' FROM ato;

```
+----------------+
| data->'$.Name' |
+----------------+
| "Dave"         |
+----------------+
1 row in set (0.0010 sec)
```

SELECT data->>'$.Name' FROM ato;

```
+-----------------+
| data->>'$.Name' |
+-----------------+
| Dave            |      → strips the “ ‘s
+-----------------+
1 row in set (0.0010 sec)
```

PG

```
test=# SELECT data -> 'Name' FROM ato;
 ?column?
----------
 "Dave"
(1 row)
```

```
test=# SELECT data ->> 'Name' FROM ato;
 ?column?
----------
 Dave
(1 row)
```

Same thing for ‘B’

JSON Functions

These functions make handing of JSON data very easy and are very robust

PostgreSQL

Path expressions XPath based

Lots of operators

Regex filters

Just different enough from MySQL to make you RTFM

MySQL

Path expressions XPath based

Lots of operators

Just different enough from PG to make your RTFM

MySQL's JSON Functions

PG Has More!!

Name	Description
->	Return value from JSON column after evaluating path; equivalent to JSON_EXTRACT().
->>	Return value from JSON column after evaluating path and unquoting the result; equivalent to JSON_UNQUOTE(JSON_EXTRACT()).
JSON_ARRAY()	Create JSON array
JSON_ARRAY_APPEND()	Append data to JSON document
JSON_ARRAY_INSERT()	Insert into JSON array
JSON_CONTAINS()	Whether JSON document contains specific object at path
JSON_CONTAINS_PATH()	Whether JSON document contains any data at path
JSON_DEPTH()	Maximum depth of JSON document
JSON_EXTRACT()	Return data from JSON document
JSON_INSERT()	Insert data into JSON document
JSON_KEYS()	Array of keys from JSON document
JSON_LENGTH()	Number of elements in JSON document
JSON_MERGE()	Merge JSON documents, preserving duplicate keys. Deprecated synonym for JSON_MERGE_PRESERVE()
JSON_MERGE_PATCH()	Merge JSON documents, replacing values of duplicate keys
JSON_MERGE_PRESERVE()	Merge JSON documents, preserving duplicate keys
JSON_OBJECT()	Create JSON object
JSON_OVERLAPS()	Compares two JSON documents, returns TRUE (1) if these have any key-value pairs or array elements in common, otherwise FALSE (0)
JSON_PRETTY()	Print a JSON document in human-readable format
JSON_QUOTE()	Quote JSON document
JSON_REMOVE()	Remove data from JSON document
JSON_REPLACE()	Replace values in JSON document
JSON_SCHEMA_VALID()	Validate JSON document against JSON schema; returns TRUE/1 if document validates against schema, or FALSE/0 if it does not
JSON_SCHEMA_VALIDATION_REPORT()	Validate JSON document against JSON schema; returns report in JSON format on outcome on validation including success or failure and reasons for failure
JSON_SEARCH()	Path to value within JSON document
JSON_SET()	Insert data into JSON document
JSON_STORAGE_FREE()	Freed space within binary representation of JSON column value following partial update
JSON_STORAGE_SIZE()	Space used for storage of binary representation of a JSON document
JSON_TABLE()	Return data from a JSON expression as a relational table
JSON_TYPE()	Type of JSON value
JSON_UNQUOTE()	Unquote JSON value
JSON_VALID()	Whether JSON value is valid
JSON_VALUE()	Extract value from JSON document at location pointed to by path provided; return this value as VARCHAR(512) or specified type 8.0.21
MEMBER OF()	Returns true (1) if first operand matches any element of JSON array passed as second operand, otherwise returns false (0) 8.0.17

MySQL supports two aggregate JSON functions JSON_ARRAYAGG() and JSON_OBJECTAGG()

Indexing JSONB

```
test=#  select data -> 'Name' from atob;
 ?column?
----------
 "Dave"
(1 row)


test=# explain select data -> 'Name' from atob;
                       QUERY PLAN
---------------------------------------------------------
 Seq Scan on atob  (cost=0.00..25.88 rows=1270 width=32)
(1 row)
```

```
test=# CREATE INDEX data_idx ON atob USING GIN (data);
CREATE INDEX
test=# explain select data -> 'Name' from atob;
                  QUERY PLAN
------------------------------------------------------
 Seq Scan on atob  (cost=0.00..1.01 rows=1 width=32)
(1 row)
```

MySQL - Generated Column Extract Data to be Indexed

```
ALTER TABLE ato ADD COLUMN h CHAR(25) GENERATED ALWAYS as (data->"$.Name");

CREATE INDEX h_index on ato(h);
Query OK, 0 rows affected (0.0324 sec)

Records: 0  Duplicates: 0  Warnings: 0
explain format=tree select data->>"$.Name" FROM ato WHERE h = 'Dave'\G
*************************** 1. row ***************************
EXPLAIN: -> Filter: (ato.h = 'Dave')  (cost=0.35 rows=1)
    -> Index lookup on ato using h_index (h='Dave')  (cost=0.35 rows=1)

1 row in set (0.0011 sec)
```

Need to create an index on PG JSONB data??

```
CREATE INDEX idx_appmaps_name
 ON appmaps USING BTREE
 ((data->'metadata'->>'name'));
```

Multi-Valued Indexes - Great for Arrays

```
mysql> CREATE TABLE s (id INT UNSIGNED
AUTO_INCREMENT PRIMARY KEY,
    -> name CHAR(20) NOT NULL,
    -> j JSON,
    -> INDEX nbrs( (CAST(j->'$.nbr' AS UNSIGNED ARRAY)))
    -> );

mysql> SELECT * FROM s;
+----+-------+---------------------+
| id | name  | j                   |
+----+-------+---------------------+
|  1 | Moe   | {"nbr": [1, 7, 45]} |
|  2 | Larry | {"nbr": [2, 7, 55]} |
|  3 | Curly | {"nbr": [5, 8, 45]} |
|  4 | Shemp | {"nbr": [3, 6, 51]} |
+----+-------+---------------------+
```

Previously you were limited to a 1:1 index:row limit!

Using Multi-value Indexed Field

```
mysql>  SELECT * FROM s WHERE 7 MEMBER OF (j->"$.nbr");
+----+-------+---------------------+
| id | name  | j                   |
+----+-------+---------------------+
|  1 | Moe   | {"nbr": [1, 7, 45]} |
|  2 | Larry | {"nbr": [2, 7, 55]} |
+----+-------+--------------------
```

MEMBER OF(), JSON_CONTAINS() & JSON_OVERLAP()

PostgreSQL Has Many Types of Indexes

- **B-Tree - General**
- **GIN - Only works on top level JSON keys**
- **Hash - Equalities only**
- **GIN - Trigrams**
- **GIN - Array**

JSON Table - Unstructured data temporarily structured

```
mysql> select country_name, IndyYear from countryinfo,
json_table(doc,"$" columns (country_name char(20) path "$.Name",
        IndyYear int path "$.IndepYear")) as stuff
where IndyYear > 1992;
+----------------+----------+
| country_name   | IndyYear |
+----------------+----------+
| Czech Republic |     1993 |
| Eritrea        |     1993 |
| Palau          |     1994 |
| Slovakia       |     1993 |
+----------------+----------+
4 rows in set, 67 warnings (0.00 sec)
```

Now the JSON data can be process with SQL!

JSON Table - Handle missing data

```
mysql> SELECT name,
          Info->>"$.Population",
          Pop FROM city2,
          JSON TABLE(Info,"$" COLUMNS
          ( Pop INT PATH "$.Population"
          DEFAULT '999'
          ON ERROR DEFAULT
          '987' ON EMPTY))
         AS x1;
+-------+----------------------+------+
| name  | Info->>"$.Population" | Pop  |
+-------+----------------------+------+
| alpha | 100                  |  100 |
| beta  | fish                 |  999 |
| delta | 15                   |   15 |
| gamma | NULL                 |  987 |
+-------+----------------------+------+
4 rows in set, 1 warning (0.00 sec)
```

Add Rigor To Your JSON Data

JSON-Schema .org's work shown in MySQL - Use a template to define properties of a Key & their Values

The document properties are checked against this template and rejected if they do not pass muster!

```
set @s='{"type": "object",
    "properties": {
      "myage": {
      "type" : "number",
      "minimum": 28,
      "maximum": 99
   }
 }
}';
```

And here is our test document where we use a value for 'myage' what is between the minimum and the maximum.

```
set @d='{  "myage": 33}';
```

Test

Now we use JSON_SCHEMA_VALID() to test if the test document passes the validation test, with 1 or true as a pass and 0 or false as a fail.

select JSON_SCHEMA_VALID(@s,@d);

```
+--------------------------+
| JSON_SCHEMA_VALID(@s,@d) |
+--------------------------+
|                        1 |
+--------------------------+
1 row in set (0.00 sec)
```

```
set @s='{"type": "object",
    "properties": {
      "myage": {
      "type" : "number",
      "minimum": 28,
      "maximum": 99
   }
 }
}';
```

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And here is our test document where we use a value for 'myage' what is between the minimum and the maximum.

```
set @d='{  "myage": 33}';
```

Now we use JSON_SCHEMA_VALID() to test if the test document passes the validation test, with 1 or true as a pass and 0 or false as a fail.

Duality?

Oracle 23c

JSON Relational Duality

Create views with GraphQL on relational data that return JSON formatted data

lock-free or optimistic concurrency control architecture that enables developers to manage their data consistently across stateless operations (get/put)

Recommendations

(from the PostgreSQL manual)

Representing data as JSON can be considerably more flexible than the traditional relational data model, which is compelling in environments where requirements are fluid.

It is quite possible for both approaches to co-exist and complement each other within the same application.

However, even for applications where maximal flexibility is desired, it is still recommended that JSON documents have a somewhat fixed structure.

The structure is typically unenforced (though enforcing some business rules declaratively is possible), but having a predictable structure makes it easier to write queries that usefully summarize a set of “documents” (datums) in a table.

JSON data is subject to the same concurrency-control considerations as any other data type when stored in a table.

Although storing large documents is practicable, keep in mind that any update acquires a row-level lock on the whole row.

Consider limiting JSON documents to a manageable size in order to decrease lock contention among updating transactions.

Ideally, JSON documents should each represent an atomic datum that business rules dictate cannot reasonably be further subdivided into smaller datums that could be modified independently.

Wrap up!

Use JSON in your relational tables!

For speed use relational columns.

PLAN your schemas by how you want to use the data.

Use JSON_TABLE() to temporarily make unstructured data structured for use with SQL.

Use generated columns to materialize JSON data into structured columns.

Do not use JSON as a ‘junk drawer’ or an excuse for your lack of planning.

DO NOT overly embed data in your JSON document - the more complext the path the higher the probability of an oops! Complication is not your friend down the road.

Thank you!

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https://github.com/DaveStokesPercona/slides

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