MySQL 5.7 + JSON
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日本オラクル株式会社
MySQL Global Business Unit

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Program Agenda

1. Introduction
2. JSON datatype
3. Indexing of JSON data
4. Functions to handle JSON data
5. Misc Supporting Features

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Why JSON support in MySQL?

JSON（JavaScript Object Notation）ドキュメントデータへの
効率的なアクセスを可能にするネイティブJSONデータ･タイプ

- シリアルフォーマットの便利なオブジェクト
- 効果的にJSONデータを処理する為
- JavaScriptアプリケーションのネイティブサポート
- リレーショナルデータとスキーマレスデータのシームレスな統合
- 既存のデータベース・インフラストラクチャを新しいアプリケーションへの活用

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ストレージオプション

- Text
  - 高速なinsert処理
  - ヒューマンリーダブル
  - 検証が必要
  - 構文解析が必要
  - Updateが困難
- Binary (JSON型)
  - 1度のみ検証
  - 高速な参照
  - インプレースUpdate
  - Insert処理が遅い
  - そのままでは解読不可

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NEW JSONデータ型

- utf8mb4 文字セット
- 参照中心のワークロードに最適化
- INSERT時のみのパースと構文検証
- 効率の良い、バイナリーフォーマット
- ディクショナリー
  - ソートされたオブジェクトキー
  - インデックスによる高速データアクセス

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NEW JSONデータ型: サポート

- JSONで表現する全てのデータ型をサポート
  - 数値, 文字列, bool(true,false)
  - オブジェクト, 配列
- 拡張
  - 日付(date), 時刻, 日付(datetime), タイムスタンプ
  - その他

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JSONデータ型: Create and Insert

JSONデータ型を指定して、テーブル内に列を作成

```
CREATE TABLE employees (data JSON);
INSERT INTO employees VALUES ('{"id": 1, "name": "Jane"}');
INSERT INTO employees VALUES ('{"id": 2, "name": "Joe"}');

SELECT * FROM employees;
+----------------------------+
| data                       |
+----------------------------+
| {"id": 1, "name": "Jane"} |
| {"id": 2, "name": "Joe"}  |
+----------------------------+
2 rows in set (0,00 sec)
```

メモ:JSON配列は内カンマで区切られ、囲まれた値のリスト[と]の文字が含まれています。JSONオブジェクトは、{と}文字以内カンマで区切られ、囲まれたキー/値のペアのセットが含まれています。

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utf8mb4 文字セット

JSONに変換した文字列はグローバル対応の一環として, utf8mb4の文字セットとutf8mb4_binの照合がDefaultです。utf8mb4_binがバイナリ照合であるため、JSON値の比較では、大文字と小文字が区別されます。

```
SET @j = JSON_OBJECT('key', 'value');

 [NEW57]> SELECT @j;
+-------------------+
| @j                |
+-------------------+
| {"key": "value"} |
+-------------------+
1 row in set (0.00 sec)

 [NEW57]> SELECT CHARSET(@j), COLLATION(@j);
+-------------+---------------+
| CHARSET(@j) | COLLATION(@j) |
+-------------+---------------+
| utf8mb4     | utf8mb4_bin   |
+-------------+---------------+
1 row in set (0.00 sec)
```

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JSON Comparator

- 多相性挙動
- シームレスかつ一貫性のある比較
  - JSON vs JSON, JSON vs SQL
  - 異なるデータは常に等しくない
  - 自動的な型変換は行いません
- 堅牢性
- キャッシングの広範な使用

```
SELECT CAST(1 AS JSON) = 1;
+-----------------------+
| CAST(1 AS JSON) = 1 |
+-----------------------+
|                     1 |
+-----------------------+
1 row in set (0.00 sec)
```

JSON 1の値は1と等しい

```
SELECT CAST(1 AS JSON) = '1';
+-------------------------+
| CAST(1 AS JSON) = '1' |
+-------------------------+
|                       0 |
+-------------------------+
1 row in set (0.00 sec)
```

JSON 1の値は'1'と不等

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TEXT/VARCHARと比較した優位性

1. JSONドキュメントデータ形式の検証

```
INSERT INTO employees VALUES ('some random text');

ERROR 3130 (22032): Invalid JSON text:
"Expect a value here." at position 0 in value
(or column) 'some random text'.
```

2. 効率の良い、バイナリーフォーマット
   オブジェクトメンバと配列要素への参照性能が向上

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Real Lifeデータを用いた検証

位置情報を含む、サンフランシスコの区, 市, 郡を
表現した地域データを用いた検証

- Via SF OpenData
- 206,000件のJSONデータ

[検証用テーブル]

```
CREATE TABLE features (
id INT NOT NULL auto_increment primary key,
feature JSON NOT NULL );
```

[検証用データ]

https://github.com/zemirco/sf-city-lots-json + small tweaks

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```
{
   "type":"Feature",
   "geometry":{
      "type":"Polygon",
      "coordinates":[
         [
            [-122.42200352825247,37.80848009696725,0],
            [-122.42207601332528,37.808835019815085,0],
            [-122.42110217434865,37.808803534992904,0],
            [-122.42106256906727,37.80860105681814,0],
            [-122.42200352825247,37.80848009696725,0]
         ]
      ]
   },
   "properties":{
      "TO_ST":"0",
      "BLKLOT":"0001001",
      "STREET":"UNKNOWN",
      "FROM_ST":"0",
      "LOT_NUM":"001",
      "ST_TYPE":null,
      "ODD_EVEN":"E",
      "BLOCK_NUM":"0001",
      "MAPBLKLOT":"0001001"
   }
}
```

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シンプルなパフォーマンス比較

JSON とText型 によるデータ比較
インデックスの無い、206,000件のドキュメントデータ参照

```
# as JSON type

SELECT DISTINCT
 feature->"$.type" as json_extract
FROM features;
+--------------+
| json_extract |
+--------------+
| "Feature"    |
+--------------+
1 row in set (1.25 sec)
```

```
# as TEXT type

SELECT DISTINCT
 feature->"$.type" as json_extract
FROM features;
+--------------+
| json_extract |
+--------------+
| "Feature"    |
+--------------+
1 row in set (12.85 sec)
```

JSON形式のバイナリ形式は、非常に効率の良い検索を実装しています。
テキスト型でのトラバーサルと比較し、約10倍以上のパフォーマンス。

※ MySQLの5.7.9以降で->演算子はJSON_EXTRACT()関数の別名(省略形)として機能します。
左側は列identieferで右側 は JSONパスになります。

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シンプルなパフォーマンス比較

追加で json_extract()ファンクションにて条件を変更し参照

```
# as JSON type
[NEW57]> SELECT distinct
json_extract(feature,'$.type')
as feature FROM features;
+-----------+
| feature   |
+-----------+
| "Feature" |
+-----------+
1 row in set (1.25 sec)

# as JSON type
[NEW57]> SELECT count(feature)
FROM features where
json_extract(feature,'$.properties')
like '%BEACH%';
+----------------+
| count(feature) |
+----------------+
|            235 |
+----------------+
1 row in set (2.94 sec)
```

```
# as TEXT type
[NEW57]> SELECT distinct
json_extract(feature,'$.type')
as feature FROM features;
+-----------+
| feature   |
+-----------+
| "Feature" |
+-----------+
1 row in set (9.48 sec)

# as TEXT type
[NEW57]> SELECT count(feature)
FROM features where
json_extract(feature,'$.properties')
like '%BEACH%';
+----------------+
| count(feature) |
+----------------+
|            235 |
+----------------+
1 row in set (10.11 sec)
```

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Generated Columns(生成列)概要

id	my_integer	my_integer_plus_one
1	10	11
2	20	21
3	30	31
4	40	41

列は定義に基づいて、
自動的に生成されます。

```
CREATE TABLE t1 (
 id INT NOT NULL PRIMARY KEY auto_increment,
 my_integer INT,
 my_integer_plus_one INT AS (my_integer+1)
);
```

参照のみ可能

```
UPDATE t1 SET my_integer_plus_one = 10 WHERE id = 1;
ERROR 3105 (HY000): The value specified for generated
column 'my_integer_plus_one' in table 't1' is not allowed.
```

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Generated ColumnsによるIndexサポート

206,000件のドキュメントデータに対してのテーブルスキャンから,
マテリアライズされた206,000件のデータへのインデックススキャン。

```
ALTER TABLE features ADD feature_type VARCHAR(30) AS (feature->"$.type");
Query OK, 0 rows affected (0.01 sec)
Records: 0  Duplicates: 0  Warnings: 0
```

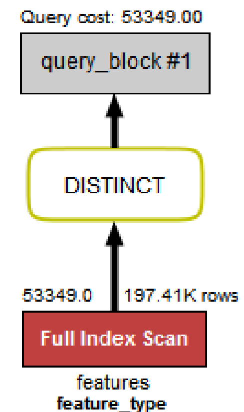
メタデータのみが変更されます(FAST). テーブルへのアクセスは不要

```
ALTER TABLE features ADD INDEX (feature_type);
Query OK, 0 rows affected (0.73 sec)
Records: 0  Duplicates: 0  Warnings: 0
```

Indexのみ作成
テーブルの行変更は行わない

```
SELECT DISTINCT feature_type FROM features;
+--------------+
| feature_type |
+--------------+
| "Feature"    |
+--------------+
1 row in set (0.06 sec)
```

1.25秒から 0.06秒
実行時間の短縮



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参考) Generated ColumnsによるIndexサポート

JSON_EXTRACT()で実行する場合

```
ALTER TABLE features ADD feature_type VARCHAR(30) AS (json_extract(feature,'$.type'));
Query OK, 0 rows affected (0.00 sec)
Records: 0  Duplicates: 0  Warnings: 0

ALTER TABLE features ADD INDEX (feature_type);
Query OK, 0 rows affected (1.59 sec)
Records: 0  Duplicates: 0  Warnings: 0

[NEW57]> desc features;
+--------------+-------------+------+-----+---------+-------------------+
| Field        | Type        | Null | Key | Default | Extra             |
+--------------+-------------+------+-----+---------+-------------------+
| id           | int(11)     | NO   | PRI | NULL    | auto_increment    |
| feature      | json        | NO   |     | NULL    |                   |
| feature_type | varchar(30) | YES  | MUL | NULL    | VIRTUAL GENERATED |
+--------------+-------------+------+-----+---------+-------------------+
3 rows in set (0.00 sec)

[NEW57]> SELECT distinct feature_type as feature FROM features;
+-----------+
| feature   |
+-----------+
| "Feature" |
+-----------+
1 row in set (0.09 sec)
```

1.25秒から 0.09秒
実行時間の短縮

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Generated ColumnsによるIndexサポート

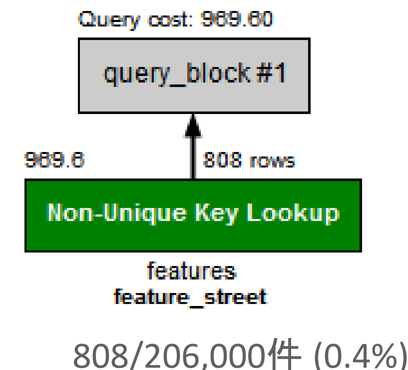
EXPLAINによるインデックス利用状況の確認

ALTER TABLE features ADD feature_street
VARCHAR(30) AS (json_extract(feature,'$.properties.STREET'));

ALTER TABLE features ADD INDEX (feature_street);

```
[NEW57]> desc features;
+----------------+-------------+------+-----+---------+-------------------+
| Field          | Type        | Null | Key | Default | Extra             |
+----------------+-------------+------+-----+---------+-------------------+
| id             | int(11)     | NO   | PRI | NULL    | auto_increment    |
| feature        | json        | NO   |     | NULL    |                   |
| feature_type   | varchar(30) | YES  | MUL | NULL    | VIRTUAL GENERATED |
| feature_street | varchar(30) | YES  | MUL | NULL    | VIRTUAL GENERATED |
+----------------+-------------+------+-----+---------+-------------------+
```

select feature from features where
json_extract(feature,'$.properties.STREET') = '"MARKET"';



808/206,000件 (0.4%)

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Generated Columns (続き)

- Functional Index(関数インデックス)を使用
- VIRTUAL (規定値)の他にSTOREDが利用可能

```
ALTER TABLE features ADD feature_type varchar(30) AS
(feature->"$.type") STORED;
Query OK, 206560 rows affected (4.70 sec)
Records: 206560  Duplicates: 0  Warnings: 0
```

- どちらの生成列もインデックス追加が可能

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使用可能なインデックスオプション

STORED	VIRTUAL
Primary and Secondary	Secondary Only
BTREE, Fulltext, GIS	BTREE Only
Mixed with fields	Mixed with virtual column only
Requires table rebuild	No table rebuild
Not Online	INSTANT Alter
	Faster Insert

Bottom Line: 主キー, FULLTEXTまたは仮想GISインデックスを必要とする場合を除きDefaultのVIRTUALを選択した方が良いケースが多い。

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Virtual vs. Stored パフォーマンスの違い

テーブルスキャンが発生する場合のパフォーマンス比較:

```
SELECT DISTINCT feature_type
FROM features;
+----------------+
| feature_type |
+----------------+
| "Feature"      |
+----------------+
```

```
VIRTUAL TEXT型 (9.89 sec)
STORED  TEXT型 (0.22 sec)
VIRTUAL JSON型 (0.85 sec)
STORED  JSON型 (0.24 sec)
```

Clarification: Since indexes are materialized (*stored*) themselves, the real-life case for STORED is when generating the column is computationally expensive *and* you can not use indexes effectively.

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JSONファンクション:Handle JSON Data

5.7では、CREATE, SEARCH, MODIFY and RETURN等の
JSONファンクションをサポートしています

- Info
  - JSON_VALID()
  - JSON_TYPE()
  - JSON_KEYS()
  - JSON_LENGTH()
  - JSON_DEPTH()
  - JSON_CONTAINS()
  - JSON_CONTAINS_PATH()
- Modify
  - JSON_REMOVE()
  - JSON_APPEND()
  - JSON_SET()
  - JSON_INSERT()
  - **JSON_REPLACE()**
  - JSON_ARRAY_INSERT()

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JSONファンクション:Handle JSON Data

- Create
  - JSON_MERGE()
  - **JSON_ARRAY()**
  - **JSON_OBJECT()**
- Get data
  - **JSON_EXTRACT()**
  - **JSON_SEARCH()**
- Helper
  - JSON_QUOTE()
  - **JSON_UNQUOTE()**

参照）https://dev.mysql.com/doc/refman/5.7/en/json-functions.html

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JSON Data Extract

JSONドキュメントからデータを抽出

```
SELECT json_extract(feature,'$.type') as
json_extract FROM features limit 1;
+--------------+
| json_extract |
+--------------+
| "Feature"    |
+--------------+

SELECT feature->"$.type" as
json_extract FROM features limit 1;
+--------------+
| json_extract |
+--------------+
| "Feature"    |
+--------------+
```

->演算子はJSON_EXTRACT()の省略形として機能し、 左側は列識別子で右側 は JSONパス

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参考) JSON_EXTRACT()のエイリアス

- <field> **->** <JSON path expression string>
  data->'$.some.key[3].from.doc'
- Syntactic sugar over JSON_EXTRACT function
- SELECT * FROM employees WHERE data->'$.id'= 2;
- ALTER … ADD COLUMN id INT AS (data->'$.id') …
- CREATE VIEW .. AS SELECT data->'$.id', data->'$.name' FROM …
- UPDATE employees SET data->'$.name'='Samantha' WHERE …

※ MySQLの5.7.9以降で->演算子はJSON_EXTRACT()関数の別名(省略形)として機能します。
左側は列identieferで右側 は JSONパスになります。

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参考) JSON_EXTRACT()のエイリアス:制限

	JSON_EXTRACT エイリアス	JSON_EXTRACT関数
Data source	A table's field only	Any JSON-typed value
Path expression	A string constant only	Any string-typed value
Number of path expressions	Only one	Multiple

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Unquote JSON String

特殊文字のエスケープシーケンス

```
SELECT
 DISTINCT JSON_UNQUOTE(feature->"$.type")
 as feature_type FROM features;
+-----------------+
| feature_type    |
+-----------------+
| Feature         |
+-----------------+
```

```
SELECT DISTINCT json_extract(feature,'$.type'),
JSON_UNQUOTE (json_extract(feature,'$.type'))
as JSON_UNQUOTE FROM features;
+-------------------------------+--------------+
| json_extract(feature,'$.type') | JSON_UNQUOTE |
+-------------------------------+--------------+
| "Feature"                      | Feature      |
+-------------------------------+--------------+
```

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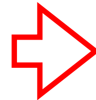
JSON Path Search

JSON形式のドキュメント内の指定された値のパスを返します。

To retrieve via: *[[database.]table.]column->"$<path spec>"*

feature: {"type": "Feature", "geometry": {"type": "Polygon", "coordinates": [[[-122.39790233801507, 37.790726654724864, 0], [-122.39823963293078, 37.79099174693105, 0], [-122.39835208359005, 37.79090296883558, 0], [-122.3986901921814, 37.79116869825866, 0], [-122.39823249443299, 37.7915300431353, 0], [-122.39756221186288, 37.79099545718336, 0], [-122.39790233801507, 37.790726654724864, 0]]]}, "properties": {"TO_ST": "425", "BLKLOT": "3709016", "STREET": "MARKET", "FROM_ST": "425", "LOT_NUM": "016", "ST_TYPE": "ST", "ODD_EVEN": "O", "BLOCK_NUM": "3709", "MAPBLKLOT": "3709014"}}


```
SELECT JSON_SEARCH(feature,
 'one', 'MARKET') AS
 extract_path
FROM features
WHERE id = 121254;
+-------------------------+
| extract_path            |
+-------------------------+
| "$.properties.STREET"   |
+-------------------------+
1 row in set (0.00 sec)
```



```
SELECT
feature->"$.properties.STREET"
 AS property_street
FROM features
WHERE id = 121254;
+-----------------+
| property_street |
+-----------------+
| "MARKET"        |
+-----------------+
1 row in set (0.00 sec)
```

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JSON Array Creation

値の(空を含む)リストを評価し、それらの値を含むJSON配列を返します。

```
SELECT JSON_ARRAY(
id,feature->"$.properties.STREET",
feature->"$.type") AS json_array
FROM features ORDER BY RAND() LIMIT 3;
+----------------------------------+
| json_array                       |
+----------------------------------+
| [126213, "FOLSOM", "Feature"]    |
| [78171, "44TH", "Feature"]       |
| [148660, "UNDERWOOD", "Feature"] |
+----------------------------------+
3 rows in set (1.21 sec)
```

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JSON Object Creation

キー/値のペアの（空を含む）リストを評価し、それらのペアを含むJSONオブジェクトを返します。任意のキー名がNULLであるか引数の数が奇数である場合、エラーが発生します。

```
SELECT JSON_OBJECT(
'id', id,
'street', feature->"$.properties.STREET",
'type', feature->"$.type"
) AS json_object FROM features ORDER BY RAND() LIMIT 3;
+----------------------------------------------------------+
| json_object                                              |
+----------------------------------------------------------+
| {"id": 181215, "type": "Feature", "street": "ROUSSEAU"} |
| {"id": 81215, "type": "Feature", "street": "QUINTARA"}  |
| {"id": 113788, "type": "Feature", "street": "NOE"}      |
+----------------------------------------------------------+
3 rows in set (2.02 sec)
```

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JSON_REPLACE

JSON文書の既存の値を置き換え、その結果を返します。

```
SELECT json_extract(feature,'$.type'),JSON_ARRAY('feature',
'bug') as json_object FROM features LIMIT 1;
```

```
+--------------------------------+---------------------+
| json_extract(feature,'$.type') | json_object         |
+--------------------------------+---------------------+
| "Feature"                      | ["feature", "bug"]  |
+--------------------------------+---------------------+
```



```
SELECT JSON_REPLACE(feature, '$.type', JSON_ARRAY('feature',
'bug')) as json_object FROM features LIMIT 1;
+------------------------------------------------------+
| json_object                                          |
+------------------------------------------------------+
| {"type": ["feature", "bug"], "geometry": {"type": ..}} |
+------------------------------------------------------+
```

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Program Agenda

1. Introduction
2. JSON datatype
3. Indexing of JSON data
4. Functions to handle JSON data
5. Misc Supporting Features

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JSON or Column(列)?

- JSONまたはColumnにするかは用途による
- 両方共にそれぞれのアプローチの利点

```
+--------------+-------------+---------------+
|   id         |     type    |    street     |
+--------------+-------------+---------------+
| 190838       | Feature     | FARALLONES    |
| 153676       | Feature     | ELLSWORTH     |
| 143094       | Feature     | JENNINGS      |
+--------------+-------------+---------------+

+--------------------------------------------------------------+
| json_object                                                  |
+--------------------------------------------------------------+
| {"id": 190838, "type": "Feature", "street": "FARALLONES"} |
| {"id": 153676, "type": "Feature", "street": "ELLSWORTH"}  |
| {"id": 143094, "type": "Feature", "street": "JENNINGS"}   |
+--------------------------------------------------------------+
```

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Storing as a Column

- アプリケーションに対し、スキーマの適用が容易
- スキーマにより長期的にアプリケーションの変更管理がコントロールしやすい。
  - 多くの順列を考慮しなくても良い
  - データにいくつかの制約設定を可能

```
+--------------+-------------+---------------+
|   id         |     type    |    street     |
+--------------+-------------+---------------+
| 190838       | Feature     | FARALLONES    |
| 153676       | Feature     | ELLSWORTH     |
```

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Storing as JSON

- スキーマ内でモデル化する事が困難であるデータを表現する為のより柔軟な方法。

- 例えば,多くのお客様へSaaSアプリケーション提供してる場合
- 強力なユースケースとしてカスタムフィールドをサポート
- 歴史的に エンティティ属性値モデル(EAV)が使われているが、必ずしも十分に機能していない場合等

```
+-----------------------------------------------------------+
| json_object                                               |
+-----------------------------------------------------------+
| {"id": 190838, "type": "Feature", "street": "FARALLONES"} |
| {"id": 153676, "type": "Feature", "street": "ELLSWORTH"}  |
```

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Storing as JSON (続き.)

- 容易な非正規化
  特定の状況 において重要である最適化手法
- 労力を伴うスキーマ変更不要*
- 容易なプロトタイピング
  - 考慮すべき型 が少なくて済む
  - スキーマの強制不要,直ぐに値を格納

* MySQL 5.6からはオンラインDDLが実装されているため、
  MySQL5.6以降をご利用の場合は,以前程大きな影響はありません。

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その他) Schema + Schemaless

ColumnとJSONの連携

```
CREATE TABLE pc_components (
 id INT NOT NULL PRIMARY KEY,
 description VARCHAR(60) NOT NULL,
 vendor VARCHAR(30) NOT NULL,
 serial_number VARCHAR(30) NOT NULL,
 attributes JSON NOT NULL
);
```

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JSONドキュメントの圧縮

- 圧縮効率が良い
  - スキーマレスの為、キーは各ドキュメント内で繰り返されて使われている。
- 反復は圧縮効率を高めます。
- MySQL 5.7 では32KBと64KB pagesをサポート (improved compression)

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MySQL 5.7 Page 圧縮

- InnoDB MySQL 5.1のプラグインから圧縮を実装
- MySQL 5.7 からはシンプルで新しいページの圧縮方法を実装しました

  (制限:対応カーネル等が必要です)

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圧縮パフォーマンス (16K Page)

```
SELECT name, ((file_size-
allocated_size)*100)/file_size as compressed_pct
from information_schema.INNODB_SYS_TABLESPACES
WHERE name like 'test/features';
+----------------+-----------------+
| name           | compressed_pct |
+----------------+-----------------+
| test/features |         59.2634 |
+----------------+-----------------+
1 row in set (0.01 sec)
```

Using real-life data set from earlier

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補足)　制限事項

- JSONの列に格納されるJSON文書のサイズは、
max_allowed_packetシステム変数の値に制限されています。

(While the server manipulates a JSON value internally in memory, it can be larger; the limit applies when the server stores it.)

- JSONの列はデフォルト値を持つことができません。

max_allowed_packet

Command-Line Format	--max_allowed_packet=#	
System Variable	Name	max_allowed_packet
	Variable Scope	Global
	Dynamic Variable	Yes
Permitted Values	Type	integer
	Default	4194304
	Min Value	1024
	Max Value	1073741824

The maximum size of one packet or any generated/intermediate string, or any parameter sent by the mysql_stmt_send_long_data() C API function. The default is 4MB.

参照： https://dev.mysql.com/doc/refman/5.7/en/json.html
https://dev.mysql.com/doc/refman/5.6/ja/server-system-variables.html#sysvar_max_allowed_packet

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今後のロードマップ

- In-place partial update of JSON/BLOB *(performance)*
- Partial streaming of JSON/BLOB (*replication*)
- Full text and GIS index on virtual columns
  - Currently works for "STORED"
- Improved performance through condition pushdown
- Online alter for virtual columns
- Advanced JSON functions

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参考)

- http://mysqlserverteam.com/
- http://mysqlserverteam.com/tag/json/
- https://dev.mysql.com/doc/refman/5.7/en/mysql-nutshell.html
- http://dev.mysql.com/doc/relnotes/mysql/5.7/en/
- https://dev.mysql.com/doc/refman/5.7/en/json.html
- https://dev.mysql.com/doc/refman/5.7/en/json-functions.html
- http://www.thecompletelistoffeatures.com

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