Materialized Views for MySQL using Flexviews

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https://github.com/greenlion/swanhart-tools

http://flexvie.ws

Introduction

- Who am I?
- What do I do?
- What is this talk about?

What is Swanhart-Tools?

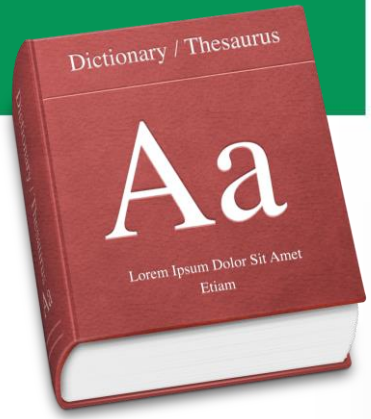
- Github repo containing multiple tools
  - **Flexviews** - Materialized Views for MySQL
  - **Shard-Query** - Sharding and parallel query (MPP)
  - **utils** - small utilities for MySQL
  - **bcmath UDF** - Arbitrary precision math UDFs

What is Flexviews?

A Materialized View toolkit with two parts:

- FlexCDC - pluggable change data capture
- Flexviews SQL API - stored routines for managing **materialized views**

materialize [məˈtɪərɪəˌlaɪz] vb



1. (intr) to become fact; actually happen our hopes never materialized
2. **to invest or become invested with a physical shape or form**
3. to cause (a spirit, as of a dead person) to appear in material form (intr)
4. to take shape; become tangible after hours of discussion, the project finally began
5. Physics - to form (material particles) from energy, as in pair production

Collins English Dictionary – Complete and Unabridged © HarperCollins Publishers 1991, 1994, 1998, 2000, 2003

What are Materialized Views?

- A materialized view is similar to a regular view
- Regular views are computed each time they are accessed
- Materialized views are computed *periodically* and the results are stored ***in a table***

A rose by any other name

- DB2 calls them “materialized query tables”
- Microsoft SQL Server calls them “indexed views”
- Oracle calls them “snapshots” or “materialized views”, depending on the version
- Vertica calls them “projections”

MySQL does not have native MVs

- Closest thing is:
  CREATE TABLE … AS SELECT
- There is no way to automatically update the resulting table when the original data changes
- Flexviews fills the gap providing 3rd party MVs

Why use Materialized Views (MV)?

- Speed!
  - A MV stores the results in a table, which can be indexed
  - Queries can sometimes be reduced from hours down to seconds or even milliseconds as a result
  - Great for dashboards, or cacheing important result sets

An MV is a cache

- The results of the MV are stored in a table, which is just a cache
- The cache gets out of data when underlying data changes
- The view must be refreshed periodically
  - This refresh should be as efficient as possible

Two materialized view refresh algos

- **COMPLETE** refresh
  - Supports all SELECT, including OUTER join
  - Rebuilds whole table from scratch when the view is refreshed (expensive)
- **INCREMENTAL** refresh
  - Only INNER join supported
  - Most aggregate functions supported
  - Uses the row changes collected since the last refresh to incrementally update the table (much

Flexviews Installation

- Download Swanhart-Tools
- Setup FlexCDC
  - Requires PHP 5.3+
  - ROW based binary log (not MIXED or STATEMENT!)
  - Full binary log images (5.6)
  - READ-COMMITTED tx_isolation (recommended)
- Setup Flexviews with setup.sql

FlexCDC - Change Data Capture

- FlexCDC uses *mysqlbinlog* to read the binary log from the server
- *mysqlbinlog* converts RBR into “pseudo-SBR” which FlexCDC decodes
- For each insert,update or delete, FlexCDC writes the change history into a ***change log***

FlexCDC - Why is it needed?

- FlexCDC reads the binary log created by the database server.
- Why not triggers?
  - Triggers can not capture commit order
  - Triggers add a lot of overhead
  - Triggers can’t be created by stored routines
  - MySQL allows only one trigger per table
  - ...

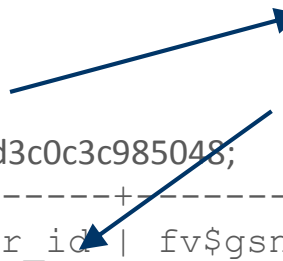
FlexCDC captures changes

```
CREATE TABLE `t1` (
 `c1` int(11) DEFAULT NULL
) ENGINE=InnoDB DEFAULT CHARSET=latin1;

CALL flexviews.create_mvlog('test','t1');

insert into test.t1 values (10);
select * from mvlog_7a52a7837df7b90fa91d3c0c3c985048;
+----------+--------+--------------+--------+------+
| dml_type | uow_id | fv$server_id | fv$gsn | c1   |
+----------+--------+--------------+--------+------+
|        1 |      7 |            1 |      2 |   10 |
+----------+--------+--------------+--------+------+
```

```
select * from flexviews.mvlogs
where table_name='t1'
***************************
table_schema: test
  table_name: t1
  mvlog_name:
mvlog_7a52a7837df7b90fa91d3c0c3c98504
 active_flag: 1
1 row in set (0.00 sec)
```



FlexCDC captures changes (cont)

```
+----------+--------+--------------+--------+------+
| dml_type | uow_id | fv$server_id | fv$gsn | c1   |
+----------+--------+--------------+--------+------+
|        1 |      7 |            1 |      2 |   10 |
+----------+--------+--------------+--------+------+
```

1 = INSERT
-1 = DELETE

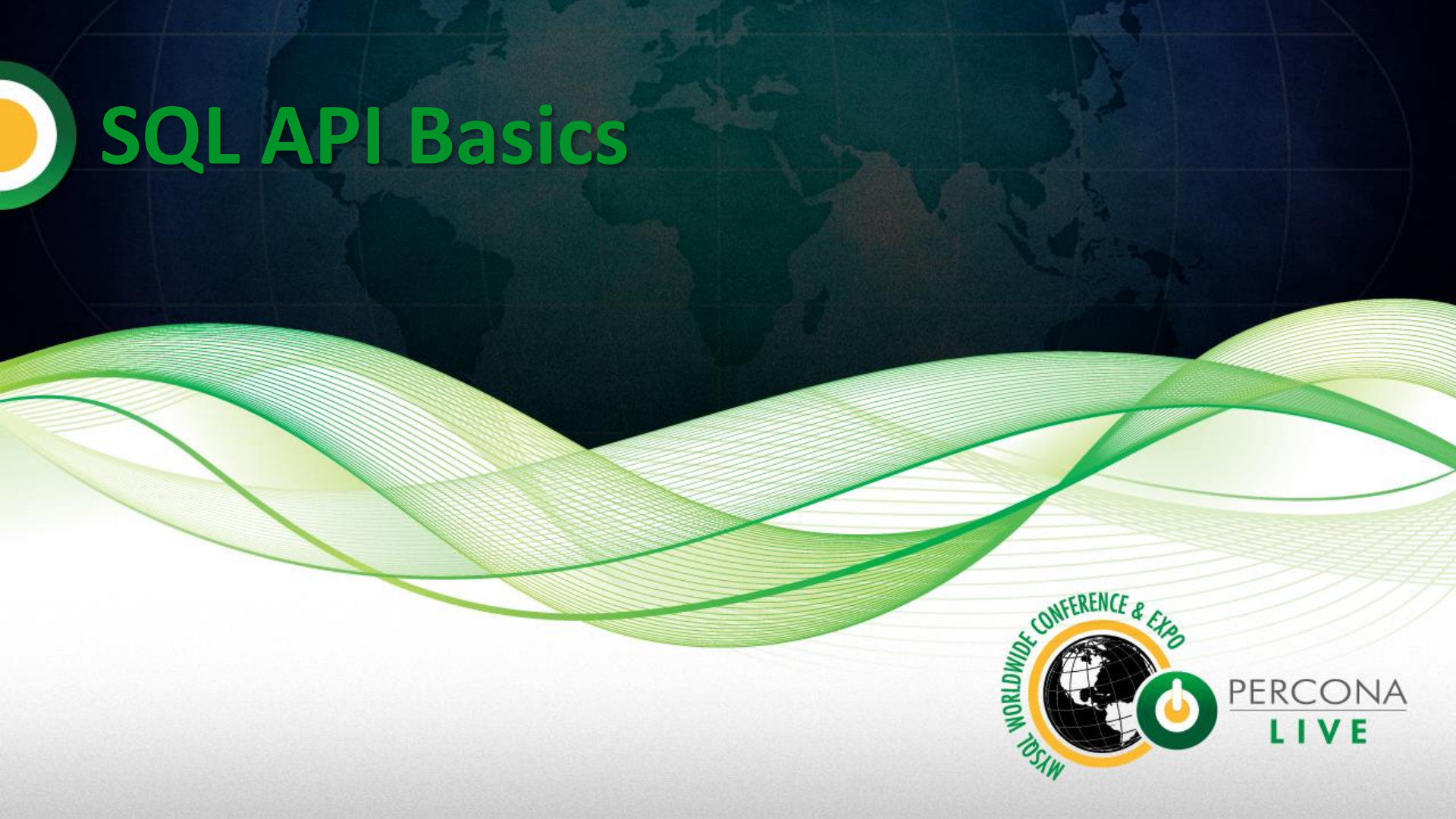
Transaction ID
aka Unit of Work ID

Server ID of server

Global Sequence Number

Inserted value

SQL API Basics



Creating Materialized Views

- Flexviews includes a set of stored routines called the Flexviews SQL API
- http://greenlion.github.io/swanhart-tools/flexviews/manual.html
- SQL API is used to “build” the SQL statement which is used to create the view

SQL API BASICS - CREATE VIEW

- Every MV has a “materialized view id”
- This ID is created by **flexviews.CREATE()**
- The ID is used in almost all other API calls

```
call flexviews.create('test','test_mv','INCREMENTAL');

set @mvid := last_insert_id();
```

SQL API BASICS - Add tables

Add tables using **flexviews.ADD_TABLE()**

```
call flexviews.add_table(@mvid,
   'test','t1','alias1',NULL);

Last parameter is the JOIN clause:
call flexviews.add_table(@mvid, 'test','t2','alias2','ON
   alias1.some_col = alias2.some_col');
```

SQL API Basics - Add expressions

SELECT clause and WHERE clause expressions can be added with **flexviews.ADD_EXPR()**

```
call flexviews.add_expr(@mvid,'GROUP','c1','c1');

call flexviews.add_expr(@mvid,'COUNT','*','cnt');
```

SQL API BASICS - Build the view

The materialized view doesn't exist until it is enabled with **flexviews.ENABLE()**

```
call flexviews.enable(@mvid);

select * from test.test_mv;
```

```
+----------+------+---------+
| mview$pk | c1   | cnt     |
+----------+------+---------+
|        1 |    1 | 1048576 |
|        2 |   10 | 1048576 |
+----------+------+---------+
```

What happens when data changes?

- The materialized view will become “stale” or “out of date” with respect to the data in the table
- Periodically, the MV can be “refreshed”, or brought up to date with the changes

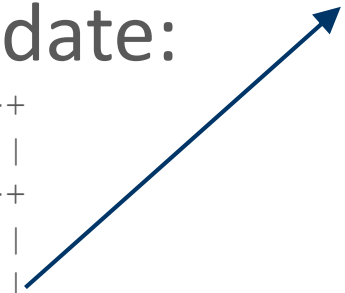
SQL API - Refreshing the view

Consider the following insertion into the **t1** table:

```
insert into test.t1 values (2);
```

Now MV is out of date:

```
+----------+------+---------+
| mview$pk | c1   | cnt     |
+----------+------+---------+
|        1 |    1 | 1048576 |
|        2 |   10 | 1048576 |
+----------+------+---------+
```



```
select c1, count(*) as cnt from t1
group by c1;
+------+---------+
| c1   | cnt     |
+------+---------+
|    1 | 1048576 |
|    2 |       1 |
|   10 | 1048576 |
+------+---------+
```

SQL API Basics - Refresh procedure

MV are refreshed with **flexviews.REFRESH()**

There are two steps to refreshing a MV

1. COMPUTE changes into delta tables
2. APPLY delta changes into the view
3. BOTH (do both steps at once)

SQL API Basics - Compute Deltas

```
call flexviews.refresh(@mvid,'COMPUTE',NULL);

select * from test.test_mv_delta;
+----------+--------+---------+------+-----+
| dml_type | uow_id | fv$gsn  | c1   | cnt |
+----------+--------+---------+------+-----+
|        1 |     39 | 2097154 |    2 |   1 |
+----------+--------+---------+------+-----+
```

SQL API Basics - Apply deltas

```
call flexviews.refresh(@mvid,'APPLY',NULL);
select * from test.test_mv;
+----------+------+---------+
| mview$pk | c1   | cnt     |
+----------+------+---------+
|        1 |    1 | 1048576 |
|        2 |   10 | 1048576 |
|        4 |    2 |       1 |
+----------+------+---------+
```

SQL API Basics - COMPLETE views

You can create views that can't be refreshed, but that can use all SQL constructs, including OUTER join.

CREATE TABLE … AS and RENAME TABLE are used by Flexviews to manage the view

SQL API Basics - COMPLETE (cont)

```
call flexviews.create('demo','top_customers','COMPLETE');
call flexviews.set_definition(
  flexviews.get_id('demo','dashboard_top_customers'),
  'select customer_id,
            sum(total_price) total_price,
            sum(total_lines) total_lines
       from demo.dashboard_customer_sales dcs
      group by customer_id
      order by total_price desc');
call
   flexviews.enable(flexviews.get_id('demo','top_customers'))
   ;
```

FlexCDC Plugins

FlexCDC is pluggable

- A PHP interface is provided for FlexCDC plugins
- Plugins receive each insert, update and delete
- take action such as writing the changes to a message queue

Example FlexCDC plugin*

```
require_once('plugin_interface.php');
class FlexCDC_Plugin implements FlexCDC_Plugin_Interface {
        static function begin_trx($uow_id, $gsn,$instance) {
                echo "START TRANSACTION: trx_id: $uow_id, Prev GSN: $gsn\n";
        }
        static function insert($row, $db, $table, $trx_id, $gsn,$instance) {
                echo "TRX_ID: $trx_id, Schema:$db, Table: $table, DML: INSERT, AT: $gsn\n"; print_r($row);
        }
        static function delete($row, $db, $table, $trx_id, $gsn,$instance) {
                echo "TRX_ID: $trx_id, Schema:$db, Table: $table, DML: DELETE, AT: $gsn\n"; print_r($row);
        }
        static function update_before($row, $db, $table, $trx_id, $gsn,$instance) {
                echo "TRX_ID: $trx_id, Schema:$db, Table: $table, DML: UPDATE (OLD), AT: $gsn\n"; print_r($row);
        }
        static function update_after($row, $db, $table, $trx_id, $gsn,$instance) {
                echo "TRX_ID: $trx_id, Schema:$db, Table: $table, DML: UPDATE (NEW), AT: $gsn\n"; print_r($row);
        }
}
```

* Not all functions represented

SQL API QUICK REFERENCE

- flexviews.create($schema, $table, $method);
- flexviews.get_id($schema, $table);
- flexviews.add_table($id, $schema, $table, $alias, $join_condition);
- flexviews.add_expr($id, $expr_type, $expr, $alias);
- flexviews.enable($id);
- flexviews.refresh($id, $method, $to_trx_id);
- flexviews.get_sql($id);

- flexviews.disable($id);

Example: Indexing JSON with Flexviews

- Sveta Smirnova wrote JSON UDF
- I also have JSON UDF (different functionality)

- RAPID_JSON UDF + Text index = Deep indexing
- JSON UDF + b-tree index = shallow indexing

Shallow indexing with Flexviews

```
call
flexviews.create('ssb_json','json_idx','INCREMENTAL');
Query OK, 0 rows affected (0.00 sec)

-- Save the just generated identifier for the view.
-- You can use GET_ID($schema,$mvname) later.
mysql> set @mvid := last_insert_id();
Query OK, 0 rows affected (0.00 sec)
```

Shallow indexing (cont)

call flexviews.**add_table**(@mvid,
'ssb_json','json','json',null);
Query OK, 1 row affected (0.00 sec)

Shallow indexing (cont)

```
mysql> call flexviews.add_expr(@mvid, 'COLUMN', "cast(json_extract(doc,'D_DateKey') as date)", 'D_DateKey');
Query OK, 1 row affected (0.00 sec)

mysql> call flexviews.add_expr(@mvid, 'COLUMN',"cast(json_extract(doc,'C_CustomerKey') as unsigned)",
'C_CustomerKey');
Query OK, 1 row affected (0.00 sec)

mysql> call flexviews.add_expr(@mvid, 'COLUMN',"cast(json_extract(doc,'S_SuppKey') as unsigned)", 'S_SuppKey');
Query OK, 1 row affected (0.01 sec)

mysql> call flexviews.add_expr(@mvid, 'COLUMN', 'id', 'id');
Query OK, 1 row affected (0.00 sec)
```

Shallow indexing (cont)

```
mysql> call flexviews.add_expr(@mvid,
'KEY',"LO_LineNumber", 'LO_LineNumber_Idx');
Query OK, 1 row affected (0.00 sec)

mysql> call flexviews.add_expr(@mvid, 'KEY',"LO_OrderKey",
'LO_OrderKey_Idx');
Query OK, 1 row affected (0.00 sec)

mysql> call flexviews.add_expr(@mvid, 'KEY',"P_PartKey",
'P_PartKey_Idx');
Query OK, 1 row affected (0.00 sec)
```

Shallow indexing (cont)

```
mysql> call flexviews.enable(@mvid);
Query OK, 2 rows affected (35 min 53.17 sec)

mysql> show tables;
+---------------------+
| Tables_in_ssb_json |
+---------------------+
| json                |
| json_idx            |
| json_idx_delta      |
+---------------------+
3 rows in set (0.00 sec)
```

Shallow indexing (cont)

```
mysql> call flexviews.enable(@mvid);
Query OK, 2 rows affected (35 min 53.17 sec)

mysql> show tables;
+--------------------+
| Tables_in_ssb_json |
+--------------------+
| json               |
| json_idx           |
| json_idx_delta     |
+--------------------+
3 rows in set (0.00 sec)

mysql> create view json_idx_v as select * from json
natural join json_idx;
Query OK, 0 rows affected (0.00 sec)
```

Shallow indexing (cont)

```
mysql> select * from json_idx_v limit 1G
*************************** 1. row ***************************
          id: 1
         doc:
{"LO_OrderKey":"35620","LO_LineNumber":"2","LO_CustKey":"6748","LO_PartKey":"178778","LO_SuppKey":"1","LO
_OrderDateKey":"19960808","LO_OrderPriority":"3-
MEDIUM","LO_ShipPriority":"0","LO_Quantity":"38","LO_ExtendedPrice":"7055726","LO_OrdTotalPrice":"1469180
4","LO_Discount":"8","LO_Revenue":"6491267","LO_SupplyCost":"111406","LO_Tax":"1","LO_CommitDateKey":"199
60909","LO_ShipMode":"REG
AIR","C_CustomerKey":"6748","C_Name":"Customer#000006748","C_Address":"RSPYBRlR7RX6 f7J8","C_City":"PERU
5","C_Nation":"PERU","C_Region":"AMERICA","C_Phone":"27-580-967-
4556","C_MktSegment":"AUTOMOBILE","S_SuppKey":"1","S_Name":"Supplier#000000001","S_Address":"sdrGnXCDRcfr
iBvY0KL,i","S_City":"PERU     0","S_Nation":"PERU","S_Region":"AMERICA","S_Phone":"27-989-741-
2988","D_DateKey":"19960808","D_Date":"Augest 8,
1996","D_DayOfWeek":"Friday","D_Month":"Augest","D_Year":"1996","D_YearMonthNum":"199608","D_YearMonth":"
Aug1996","D_DayNumInWeek":"6","D_DayNumInMonth":"8","D_DayNumInYear":"221","D_MonthNumInYear":"8","D_Week
NumInYear":"32","D_SellingSeason":"Summer","D_LastDayInWeekFl":"0","D_LastDayInMonthFl":"1","D_HolidayFl"
:"0","D_WeekDayFl":"1","P_PartKey":"178778","P_Name":"turquoise
powder","P_MFGR":"MFGR#1","P_Category":"MFGR#11","P_Brand":"MFGR#1125","P_Colour":"beige","P_Type":"STAND
ARD POLISHED NICKEL","P_Size":"25","P_Container":"JUMBO BAG"}
     mview$pk: 1
    D_DateKey: 1996-08-08
C_CustomerKey: 6748
    S_SuppKey: 1
    P_PartKey: 178778
  LO_OrderKey: 35620
LO_LineNumber: 2
   mview$hash: 3151656687
1 row in set (0.00 sec)
```

Deep indexing

- RAPID_FLATTEN_JSON(doc)
  - Found in udf/ subdir of greenlion/swanhart-tools on Github
  - Turns JSON documents of arbitrary depth into key/value pairs for searching

Deep indexing (cont)

Here is an example JSON document:

```
{
        "id": "0001",
        "type": "donut",
        "name": "Cake",
        "ppu": 0.55,
        "batters":
                {
                        "batter":
                                [
                                        { "id": "1001", "type": "Regular" },
                                        { "id": "1002", "type": "Chocolate" },
                                        { "id": "1003", "type": "Blueberry" },
                                        { "id": "1004", "type": "Devil's Food" }
                                ]
                },
        "topping":
                [
                        { "id": "5001", "type": "None" },
                        { "id": "5002", "type": "Glazed" },
                        { "id": "5005", "type": "Sugar" },
                        { "id": "5007", "type": "Powdered Sugar" },
                        { "id": "5006", "type": "Chocolate with Sprinkles" },
                        { "id": "5003", "type": "Chocolate" },
                        { "id": "5004", "type": "Maple" }
                ]
}
```

Flattened:

```
mysql> select RAPID_FLATTEN_JSON(load_file('/tmp/doc.json'))\G
*************************** 1. row ***************************
RAPID_FLATTEN_JSON(load_file('/tmp/doc.json')): id=0001
type=donut
name=Cake
ppu=0.55
id=1001
type=Regular
id=1002
type=Chocolate
id=1003
type=Blueberry
id=1004
type=Devil's Food
type=Devil's
type=Food
id=5001
type=None
id=5002
type=Glazed
id=5005
type=Sugar
id=5007
type=Powdered Sugar
type=Powdered
type=Sugar
id=5006
type=Chocolate with Sprinkles
type=Chocolate
type=with
type=Sprinkles
id=5003
type=Chocolate
id=5004
type=Maple
1 row in set (0.00 sec)
```

Note substring indexing

Indexing the flattened JSON

- Keys are now attached to our values in an easily searchable way.
- Index it with a FULLTEXT index to make it searchable.

- Problem:
- MySQL will split words on the equal sign. We don't want this as it removes the locality of the keyword and the value.

- To fix use custom character set as described in the manual. You just have to change two text files, no need to recompile the server or anything, so it is pretty easy.

Add a fulltext materialzed view index

```
mysql> call flexviews.create('demo','json_idx','INCREMENTAL');
Query OK, 0 rows affected (0.00 sec)

mysql> set @mvid:=last_insert_id();
Query OK, 0 rows affected (0.00 sec)

mysql> call flexviews.create_mvlog('demo','json4');
Query OK, 1 row affected (0.03 sec)

mysql> call flexviews.add_table(@mvid, 'demo','json4','j',null);
Query OK, 1 row affected (0.00 sec)

mysql> call flexviews.add_expr(@mvid, 'COLUMN','rapid_flatten_json(doc)', 'flat');
Query OK, 1 row affected (0.01 sec)

mysql> call flexviews.add_expr(@mvid,'COLUMN','id','id');
Query OK, 1 row affected (0.00 sec)

mysql> call flexviews.enable(@mvid);
Query OK, 2 rows affected (14.62 sec)

mysql> alter table json_idx modify flat longtext collate latin1_kvpair_ci, add fulltext(flat);
Query OK, 18801 rows affected (36.08 sec)
Records: 18801  Duplicates: 0  Warnings: 0
```

Using the index

```
-- index only query
mysql> select count(*)
-> from json_idx
-> where match(flat) against
('last_name=Vembu');
+-----------+
| count(*)  |
+-----------+
|         3 |
+-----------+
1 row in set (0.00 sec)
```

More complex usage

```
mysql> select sum(jsum(json_extract_all(doc,'id')))
-> from json_idx join json4 using(id)
-> where match(json_idx.flat) against ('last_name=Vembu');
+-----------------------------------------+
| sum(jsum(json_extract_all(doc,'id'))) |
+-----------------------------------------+
|                              14325.00000 |
+-----------------------------------------+
1 row in set (0.00 sec)
```