MySQL Performance Schema
in Action

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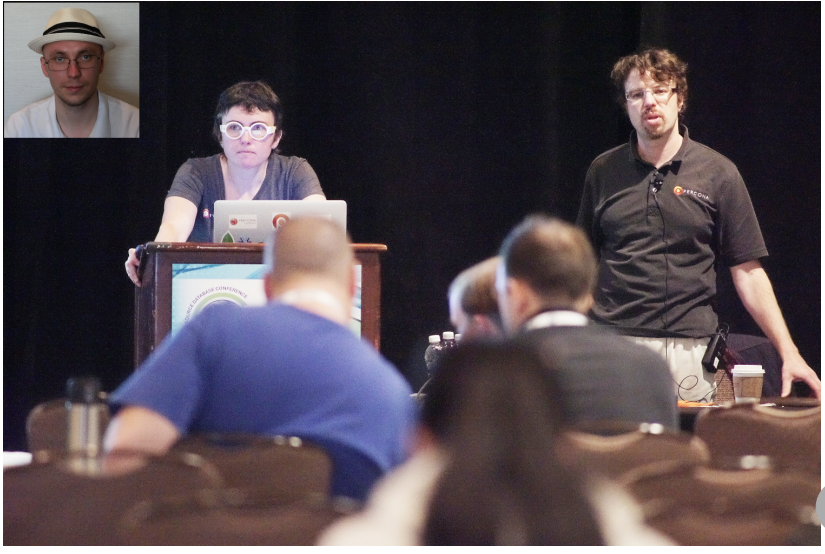
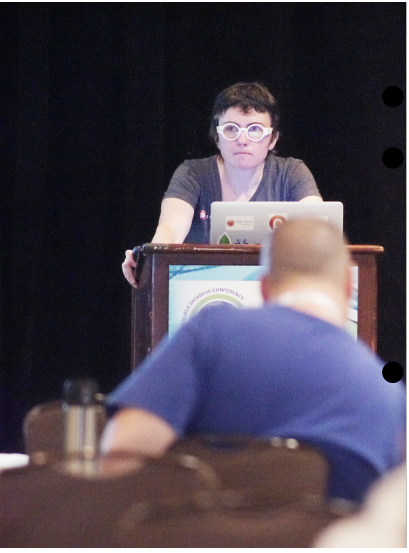
Who We Are



Who We Are: Sveta Smirnova



- MySQL Support engineer
- Author of
  - MySQL Troubleshooting
  - JSON UDF functions
  - `FILTER` clause for MySQL
- Speaker
  - Percona Live, OOW, Fosdem, DevConf, HighLoad...

Who We Are: Alexander Rubin

- Director of data architecture
  - VirtualHealth (medical startup)
- With MySQL for $>$ 12 years
- Speaker
  - Percona Live, OOW, HighLoad...

Who We Are: Nickolay Ihalainen

- Senior Support Engineer
- In Percona for 7+ years
- DBA Expert in
  - MySQL
  - MongoDB
  - PostgreSQL

Internal Diagnostic in MySQL

Old Style

- `INFORMATION_SCHEMA`
- `SHOW` commands
  - Metadata
  - Storage engine extentions
    - Runtime
    - Can be anything

Old Style

- `INFORMATION_SCHEMA`
- `SHOW` commands
- Status variables
  - Runtime

Old Style

- INFORMATION_SCHEMA
- SHOW commands
- Status variables
- Administration statements
  - ANALYZE
  - EXPLAIN
  - CHECK

Old Style

- `INFORMATION_SCHEMA`
- `SHOW` commands
- Status variables
- Administration statements
- No or limited information on
  - Performance
  - Internal server operations

Performance Schema

- Introduced in version 5.5

Performance Schema

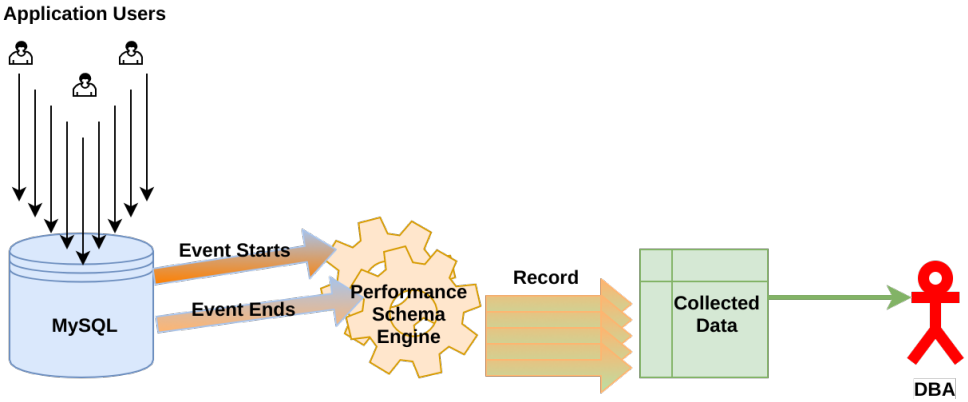
- Introduced in version 5.5
- Runtime performances statistics

Performance Schema

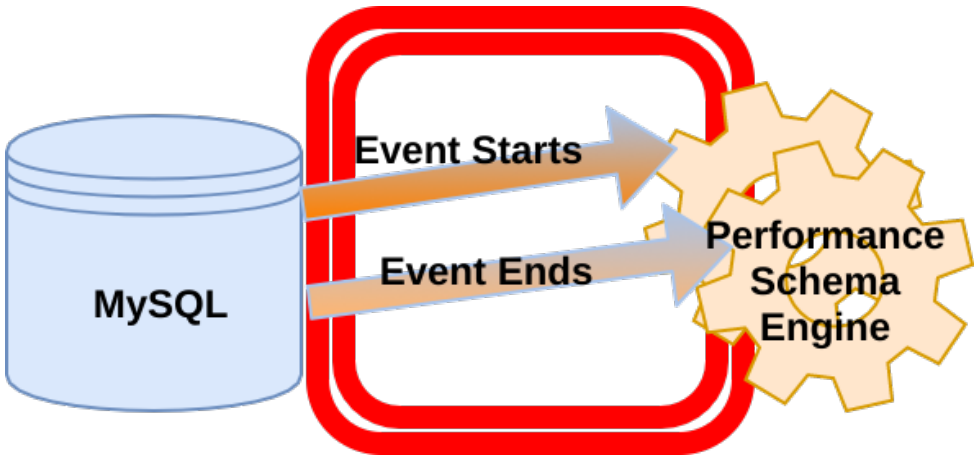
- Introduced in version 5.5
- Runtime performances statistics
- Wraps the diagnosed code

```
locker = PSI_RWLOCK_CALL(start_rwlock_wrwait)(
    &state, lock->pfs_psi, PSI_RWLOCK_TRYEXCLUSIVELOCK,
    file_name, static_cast<uint>(line));

ret = rw_lock_x_lock_func_nowait(lock, file_name, line);

if (locker != NULL)
    PSI_RWLOCK_CALL(end_rwlock_wrwait)(
    locker, static_cast<int>(ret));
```

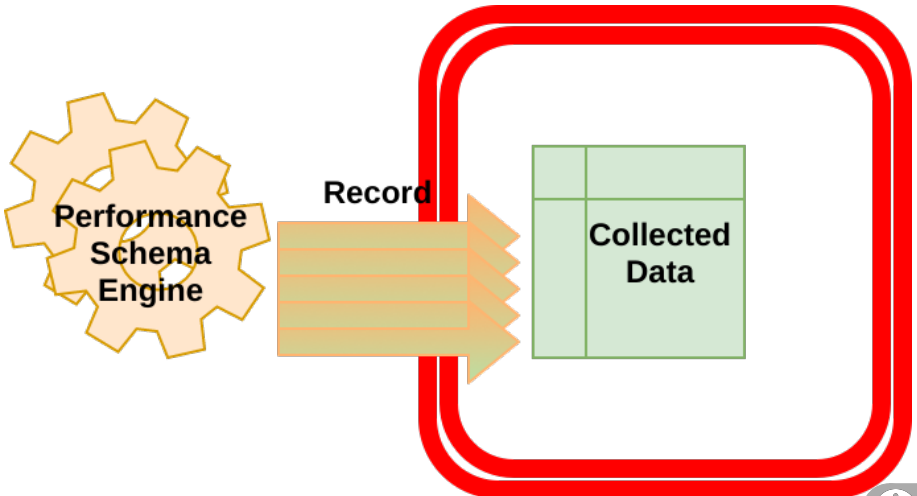
How Does Performance Schema Works?



Instruments: Get the Data



Consumers: Store the Data



Performance Schema Limitations

- Must be supported by the component
- Collects data only after they are enabled
- Never frees allocated memory

sys Schema

- **Views** on Performance Schema tables
- Stored routines

sys Schema

- **Views** on Performance Schema tables
- Stored routines
- Easier configuration
- Shortcuts to typical use cases

sys Schema

- **Views** on Performance Schema tables
- Stored routines
- Easier configuration
- Shortcuts to typical use cases
- **5.7+:** Installed by default
- Before: `github.com/mysql/mysql-sys`

What will We Discuss Today?

- Statements
- Locks
- Memory Usage
- Replication
- Variables
- Errors

Configuration

What is Inside?

5.6

- 52 tabless
  589 Percona Server
- 31 variables

5.7

- 87 tables
- 1029 instrs
  1067 Percona Server
- 42 variables

8.0

- 103 tables
- 1236 instrs
  1255 Percona Server
- 44 variables

Performance Schema Defaults

- Defaults
  - ON

5.7: Only global, thread, statements and transactions instrumentation

8.0: Memory and MDL

Performance Schema Defaults

- Defaults
  - ON

5.7: Only global, thread, statements and transactions instrumentation

8.0: Memory and MDL

- All other instruments/consumers disabled

Prepare

- We will turn required instrumentation ON for each exercise separately

Prepare

- We will turn required instrumentation ON for each exercise separately
- We will use pattern

```
update performance_schema.setup_consumers set enabled='yes'
where name like 'OUR_REQUIREMENT_%';

update performance_schema.setup_instruments set enabled='yes', timed='yes'
where name like 'OUR_REQUIREMENT_%';
```

Prepare

- We will turn required instrumentation ON for each exercise separately
- Or easier

```
call sys.ps_setup_enable_consumer(YOUR_CONSUMER);

call sys.ps_setup_enable_instrument(YOUR_INSTRUMENT);
```

Prepare

- We will turn required instrumentation ON for each exercise separately
- **Be careful!**
  - They are memory and CPU intensive
  - Do not turn them all ON until needed

5.6+: Statements Instrumentation

Statements: configuration

- Instruments
- $>$ 500

```
mysql> select name from setup_instruments where name like 'statement%';
+----------------------------------------------+
| name                                         |
+----------------------------------------------+
| statement/sql/select                         |
| statement/sql/create_table                   |
| statement/sql/create_index                   |
| statement/sql/alter_table                    |
| statement/sql/update                         |
| statement/sql/insert                         |
| statement/sql/insert_select                  |
...
```

  - Enable those you want to examine

Statements: configuration

- Instruments
- $>$ 500
- Consumers

```
mysql> select name from setup_consumers where name like '%statement%';
+--------------------------------+
| name                           |
+--------------------------------+
| events_statements_current      | -- Current statements
| events_statements_history      | -- Last 10 statements
| events_statements_history_long | -- Last 1K statements
| statements_digest              | -- Digests
+--------------------------------+
4 rows in set (0.00 sec)
```

What Can We Discover?

- Why statements are slow?
  - Examine more rows than return/change
  - Use disk instead of memory
  - Full table scan instead of index
  - **This is not full list!**

What Can We Discover?

- Why statements are slow?
- Performance Schema has
  - Per-query statistics
  - Most evolving stages

Why Statements are Slow?

- `events_statements_*` and `prepared_statements_instances` tables
  - Important field names
    - `CREATED_TMP_DISK_TABLES`
    - `CREATED_TMP_TABLES`
    - `SELECT_FULL_JOIN`
    - `SELECT_RANGE_CHECK`
    - `SELECT_SCAN`
    - `SORT_MERGE_PASSES`
    - `SORT_SCAN`

Why Statements are Slow?

- `events_statements_*` and `prepared_statements_instances` tables
- Views in `sys` schema
  - Important view names
    - `statement_analysis`
    - `statements_with_full_table_scans`
    - `statements_with_runtimes_in_95th_percentile`
    - `statements_with_sorting`
    - `statements_with_temp_tables`
    - `statements_with_errors_or_warnings`

Why Statements are Slow?

- `events_statements_*` and `prepared_statements_instances` tables
- Views in `sys` schema
- Digest tables
  - Combined statistics
    - `events_statements_summary_by_account_by_event_name`
    - `events_statements_summary_by_host_by_event_name`
    - `events_statements_summary_by_thread_by_event_name`
    - `events_statements_summary_by_user_by_event_name`
    - `events_statements_summary_global_by_event_name`
    - **5.7+:** `events_statements_summary_by_program`

Why Statements are Slow?

- `events_statements_*` and `prepared_statements_instances` tables
- Views in `sys` schema
- Digest tables
  - Histogram Summary
    - `events_statements_histogram_by_digest`
    - `events_statements_histogram_global`
    - **Do NOT mix with Optimizer histograms!**

Why Statements are Slow?

- `events_statements_*` and `prepared_statements_instances` tables
- Views in `sys` schema
- Digest tables
  - `events_statements_summary_by_digest`
    - SCHEMA_NAME
    - DIGEST
    - DIGEST_TEXT
    - **8.0+:** QUERY_SAMPLE_TEXT

Which Queries Do Not Use Indexes?

```
mysql> SELECT THREAD_ID TID, SUBSTR(SQL_TEXT, 1, 50) SQL_TEXT, ROWS_SENT RS,
    -> ROWS_EXAMINED RE,CREATED_TMP_TABLES,NO_INDEX_USED,NO_GOOD_INDEX_USED
    -> FROM performance_schema.events_statements_history
    -> WHERE NO_INDEX_USED=1 OR NO_GOOD_INDEX_USED=1\G
*********************** 1. row ***********************
               TID: 10124
          SQL_TEXT: select emp_no, first_name, last_name from employee
                RS: 97750
                RE: 397774
CREATED_TMP_TABLES: 0
     NO_INDEX_USED: 1
NO_GOOD_INDEX_USED: 0
...
```

Take it Easy: Index Usage with sys Schema

```
mysql> SELECT query, total_latency, no_index_used_count, rows_sent,
    -> rows_examined
    -> FROM sys.statements_with_full_table_scans
    -> WHERE db='employees' AND query NOT LIKE '%performance_schema%'\G
*********************** 1. row ***********************
             query: SELECT COUNT ( `emp_no` ) FROM ...  `emp_no` )
                    WHERE `title` = ?
      total_latency: 805.37 ms
no_index_used_count: 1
          rows_sent: 1
      rows_examined: 397774
...
```

Take it Easy: with Digest Tables

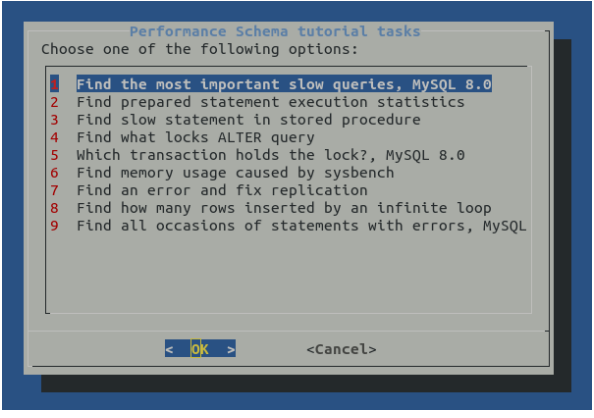
```
mysql> select DIGEST, DIGEST_TEXT, COUNT_STAR, SUM_CREATED_TMP_DISK_TABLES,
    -> SUM_SELECT_FULL_JOIN, SUM_SELECT_RANGE , SUM_SELECT_SCAN , SUM_NO_INDEX_USED
    -> SUM_ROWS_SENT, SUM_ROWS_EXAMINED
    -> from events_statements_summary_by_digest where SUM_NO_INDEX_USED > 0\G
*************************** 1. row ***************************
                    DIGEST: 3884185b07312b354c4918f2368d8fe2c431aeb8e39bf8ff5c3dcc
                DIGEST_TEXT: SELECT `c` FROM `sbtest1` WHERE `id` BETWEEN ? AND ?
                 COUNT_STAR: 1501791
SUM_CREATED_TMP_DISK_TABLES: 0
       SUM_SELECT_FULL_JOIN: 0
           SUM_SELECT_RANGE: 1501840
            SUM_SELECT_SCAN: 4
          SUM_NO_INDEX_USED: 4
              SUM_ROWS_SENT: 150872400
          SUM_ROWS_EXAMINED: 152872000
...
```

Statements: practice

- Login into EC2 instance
  - Login: see your card
  - Password: see your card

Statements: practice

- Start the task



Statements: practice

- Inside MySQL client

```
CALL help_task()\G
CALL help_solve()\G
```

- We need to find slowest queries:
  - With largest response time
  - With large scanned rows number
  - Not using indexes
  - Creating temporary tables

Statements Deep Dive

- `events_stages_*` tables

Statements Deep Dive

- `events_stages_*` tables
- Same information as in table `INFORMATION_SCHEMA.PROCESSLIST` or `SHOW PROCESSLIST` output
  - `init`
  - `executing`
  - `Opening tables`

Statements Deep Dive

- `events_stages_*` tables
- Same information as in table `INFORMATION_SCHEMA.PROCESSLIST` or `SHOW PROCESSLIST` output
  - `init`
  - `executing`
  - `Opening tables`
- Replacement for `SHOW PROFILE`

Statements Deep Dive

- `events_stages_*` tables
- Same information as in table `INFORMATION_SCHEMA.PROCESSLIST` or `SHOW PROCESSLIST` output
  - `init`
  - `executing`
  - `Opening tables`
- Replacement for `SHOW PROFILE`
- Only server-level
  - **No storage engine information!**

Stages: configuration

- Instruments

```
mysql> select name from setup_instruments where name like 'stage%';
+----------------------------------------------------+
| name                                               |
+----------------------------------------------------+
| stage/sql/After create                             |
| stage/sql/allocating local table                   |
| stage/sql/preparing for alter table                |
| stage/sql/altering table                           |
| stage/sql/committing alter table to storage engine |
| stage/sql/Changing master                          |
| stage/sql/Checking master version                  |
...
```

  - Enable those you want to examine

Stages: configuration

- Instruments
- Consumers

```
mysql> select name from setup_consumers where name like '%stage%';
+----------------------------+
| name                       |
+----------------------------+
| events_stages_current      | -- Current stages
| events_stages_history      | -- Last 10 stages
| events_stages_history_long | -- Last 1K stages
+----------------------------+
3 rows in set (0.00 sec)
```

Stages Shortcuts

- Everything, related to temporary tables
  - `EVENT_NAME LIKE 'stage/sql/%tmp%'`
- Everything, related to locks
  - `EVENT_NAME LIKE 'stage/sql/%lock%'`
- Everything in state "`Waiting for`"
  - `EVENT_NAME LIKE 'stage/%/Waiting for%'`
- Frequently met issues

Stages Shortcuts

- Everything, related to temporary tables
- Everything, related to locks
- Everything in state "`Waiting for`"
- Frequently met issues
  - `EVENT_NAME='stage/sql/freeing items'`
  - `EVENT_NAME='stage/sql/Sending data'`
  - `EVENT_NAME='stage/sql/cleaning up'`
  - `EVENT_NAME='stage/sql/closing tables'`
  - `EVENT_NAME='stage/sql/end'`

Stages Example: Which Run Critically Long?

```
mysql> SELECT eshl.event_name, sql_text, eshl.timer_wait/1000000000000 w_s
    -> FROM performance_schema.events_stages_history_long eshl
    -> JOIN performance_schema.events_statements_history_long esthl
    -> ON (eshl.nesting_event_id = esthl.event_id)
    -> WHERE eshl.timer_wait > 1*10000000000\G
*************************** 1. row ***************************
event_name: stage/sql/Sending data
  sql_text: SELECT COUNT(emp_no) FROM employees JOIN salaries USING(emp_no)
            WHERE hire_date=from_date
       w_s: 0.8170
1 row in set (0.00 sec)
```

5.7+: Prepared Statements

Table prepared_statements_instances

- Contains current prepared statements

Table prepared_statements_instances

- Contains current prepared statements
- Statistics by
  - Which thread owns the statement
  - How many times executed
  - Optimizer statistics, similar to `events_statements_*`

Prepared Statements: configuration

- Instruments

```
statement/sql/prepare_sql
statement/sql/execute_sql
statement/com/Prepare
statement/com/Execute
```

Prepared Statements: configuration

- Instruments
- Consumers
  - `prepared_statements_instances`

Prepared Statements: configuration

- Instruments
- Consumers
- Size

```
mysql> select @@performance_schema_max_prepared_statements_instances\G
*************************** 1. row ***************************
@@performance_schema_max_prepared_statements_instances: -1
1 row in set (0.00 sec)
```

Example: Prepared Statement

```
mysql1> prepare stmt from 'select count(*) from employees where hire_date > ?';
Query OK, 0 rows affected (0.00 sec)
Statement prepared
mysql1> set @hd='1995-01-01';
Query OK, 0 rows affected (0.00 sec)
mysql1> execute stmt using @hd;
+----------+
| count(*) |
+----------+
|    34004 |
+----------+
1 row in set (1.44 sec)
```

Example: Prepared Statement

```
mysql1> prepare stmt from 'select count(*) from employees where hire_date > ?';
Query OK, 0 rows affected (0.00 sec)
Statement prepared
mysql1> set @hd='1995-01-01';
Query OK, 0 rows affected (0.00 sec)
mysql1> execute stmt using @hd;
+----------+
| count(*) |
+----------+
|    34004 |
+----------+
1 row in set (1.44 sec)
```

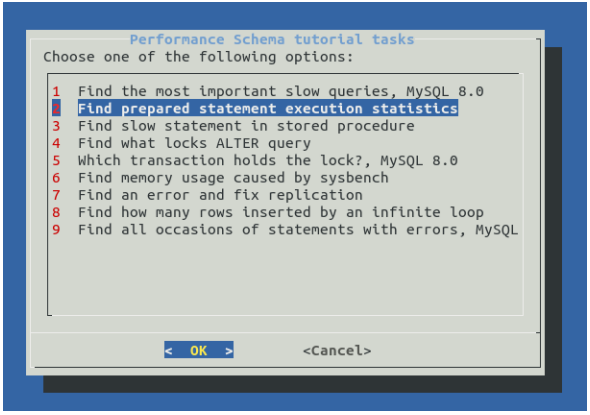
- Try `EXECUTE` with different values

Example: diagnosis

```
mysql2> select statement_name, sql_text, owner_thread_id, count_reprepare,
     -> count_execute, sum_timer_execute from prepared_statements_instances\G
*************************** 1. row ***************************
   statement_name: stmt
         sql_text: select count(*) from employees where hire_date > ?
  owner_thread_id: 22
  count_reprepare: 0
    count_execute: 3
sum_timer_execute: 4156561368000
1 row in set (0.00 sec)

mysql1> drop prepare stmt;
Query OK, 0 rows affected (0.00 sec)

mysql2> select * from prepared_statements_instances\G
Empty set (0.00 sec)
```

Prepared Statements: practice

- Start the task



Prepared Statements: practice

- Inside MySQL client

```
CALL help_task()\G
CALL help_solve()\G
```

- We need to find out how effective is the prepared statement

5.7+: Stored Routines

New Instruments

```
mysql> select * from setup_instruments where name like 'statement/sp%';
+-------------------------------+---------+-------+
| NAME                          | ENABLED | TIMED |
+-------------------------------+---------+-------+ ...
| statement/sp/stmt             | YES     | YES   | | statement/sp/hreturn       |
| statement/sp/set              | YES     | YES   | | statement/sp/cpush         |
| statement/sp/set_trigger_field | YES     | YES   | | statement/sp/cpop          |
| statement/sp/jump             | YES     | YES   | | statement/sp/copen         |
| statement/sp/jump_if_not      | YES     | YES   | | statement/sp/cclose        |
| statement/sp/freturn          | YES     | YES   | | statement/sp/cfetch        |
| statement/sp/hpush_jump       | YES     | YES   | | statement/sp/error         |
| statement/sp/hpop             | YES     | YES   | | statement/sp/set_case_expr |
...                                                +--------------------------+
16 rows in set (0.00 sec)
```

Stored Routines Instrumentation

- What happens inside the routine

Stored Routines Instrumentation

- What happens inside the routine
- Queries, called from the routine
  - `statement/sp/stmt`

Stored Routines: example

- We will use this procedure

```
CREATE DEFINER=‘root‘@‘localhost‘ PROCEDURE ‘sp_test‘(val int)
BEGIN
  DECLARE CONTINUE HANDLER FOR 1364, 1048, 1366
  BEGIN
    INSERT IGNORE INTO t1 VALUES(’Some string’);
    GET STACKED DIAGNOSTICS CONDITION 1 @stacked_state = RETURNED_SQLSTATE;
    GET STACKED DIAGNOSTICS CONDITION 1 @stacked_msg = MESSAGE_TEXT;
  END;
INSERT INTO t1 VALUES(val);
END
```

Stored Routines: example

- We will use this procedure

```
CREATE DEFINER=‘root‘@‘localhost‘ PROCEDURE ‘sp_test‘(val int)
BEGIN
  DECLARE CONTINUE HANDLER FOR 1364, 1048, 1366
  BEGIN
    INSERT IGNORE INTO t1 VALUES(’Some string’);
    GET STACKED DIAGNOSTICS CONDITION 1 @stacked_state = RETURNED_SQLSTATE;
    GET STACKED DIAGNOSTICS CONDITION 1 @stacked_msg = MESSAGE_TEXT;
  END;
INSERT INTO t1 VALUES(val);
END
```

- **When HANDLER called?**

Correct Value

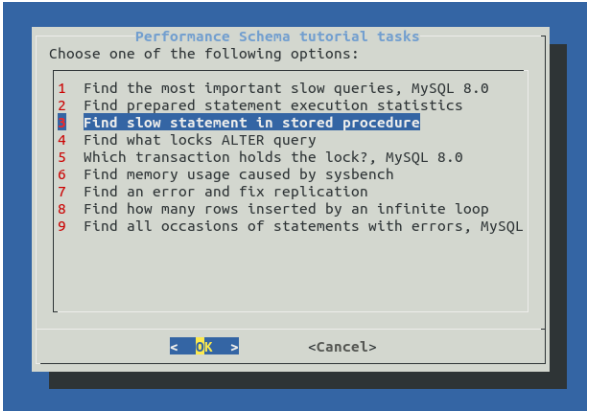
```
mysql> call sp_test(1);
Query OK, 1 row affected (0.07 sec)

mysql> select thread_id, event_name, sql_text from events_statements_history
    -> where event_name like 'statement/sp%';
+-----------+-------------------------+---------------------------+
| thread_id | event_name              | sql_text                  |
+-----------+-------------------------+---------------------------+
|        24 | statement/sp/hpush_jump | NULL                      |
|        24 | statement/sp/stmt       | INSERT INTO t1 VALUES(val) |
|        24 | statement/sp/hpop       | NULL                      |
+-----------+-------------------------+---------------------------+
3 rows in set (0.00 sec)
```

HANDLER call

```
mysql> call sp_test(NULL);
Query OK, 1 row affected (0.07 sec)

mysql> select thread_id, event_name, sql_text from events_statements_history
    -> where event_name like 'statement/sp%';
+-----------+-------------------------+-----------------------------------------+
| thread_id | event_name              | sql_text                                |
+-----------+-------------------------+-----------------------------------------+
|        24 | statement/sp/hpush_jump | NULL                                    |
|        24 | statement/sp/stmt       | INSERT INTO t1 VALUES(val)              |
|        24 | statement/sp/stmt       | INSERT IGNORE INTO t1 VALUES('Some str... |
|        24 | statement/sp/stmt       | GET STACKED DIAGNOSTICS CONDITION 1 @s... |
|        24 | statement/sp/stmt       | GET STACKED DIAGNOSTICS CONDITION 1 @s... |
|        24 | statement/sp/hreturn    | NULL                                    |
|        24 | statement/sp/hpop       | NULL                                    |
+-----------+-------------------------+-----------------------------------------+
7 rows in set (0.00 sec)
```

Stored Routines: practice

- Start the task



Stored Routines: practice

- Inside MySQL client

```
CALL help_task()\G
CALL help_solve()\G
CALL task_prepare();
```

- We need to find out why procedure takes different time each run
- For better output set pager to less:

```
mysql> \P less
```

5.7+: Locks Diagnostic

5.7+: MDL

- Table `METADATA_LOCKS`

5.7+: MDL

- Table `METADATA_LOCKS`
- Which thread is waiting for a lock

5.7+: MDL

- Table `METADATA_LOCKS`
- Which thread is waiting for a lock
- Which thread holds the lock

5.7+: MDL

- Table `METADATA_LOCKS`
- Which thread is waiting for a lock
- Which thread holds the lock
- Not only for tables:

  `GLOBAL, SCHEMA, TABLE, FUNCTION, PROCEDURE, EVENT, COMMIT, USER LEVEL LOCK, TABLESPACE`

MDL: configuration

- Instruments
  - `wait/lock/metadata/sql/mdl`

MDL: configuration

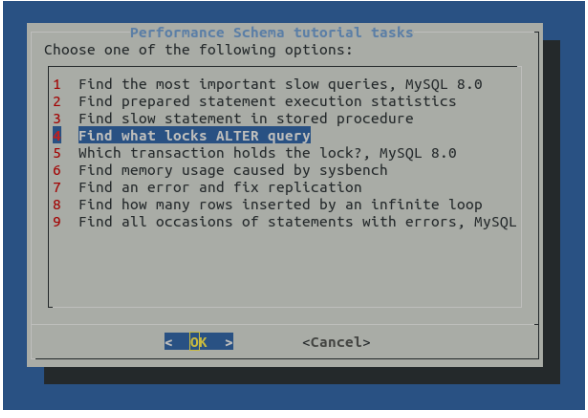
- Instruments
- Consumers
  - METADATA_LOCKS

METADATA_LOCKS: example

```
mysql> select processlist_id, object_type, lock_type, lock_status, source
    -> from metadata_locks join threads on (owner_thread_id=thread_id)
    -> where object_schema='employees' and object_name='titles'\G
*************************** 1. row ***************************
processlist_id: 4
   object_type: TABLE
     lock_type: EXCLUSIVE
   lock_status: PENDING -- waits
        source: mdl.cc:3263
*************************** 2. row ***************************
processlist_id: 5
   object_type: TABLE
     lock_type: SHARED_READ
   lock_status: GRANTED -- holds
        source: sql_parse.cc:5707
```

MDL: practice

- Start the task



MDL: practice

- Inside MySQL client

```
CALL help_task()\G
CALL help_solve()\G
CALL task_prepare();
```

- We need to find out what prevents `ALTER` from finishing

8.0.+: Data Locks

- Information about locks, held by engine

8.0.+: Data Locks

- Information about locks, held by engine
- Only for engines with own locking models

8.0.+: Data Locks

- Information about locks, held by engine
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- Currently only **InnoDB**

8.0.+: Data Locks

- Information about locks, held by engine
- Only for engines with own locking models
- Currently only **InnoDB**
- Replacement for `I_S` tables
  - `INNODB_LOCKS`
  - `INNODB_LOCK_WAITS`

Data Locks: configuration

Unlike most Performance Schema data collection, there are no instruments for controlling whether data lock information is collected or system variables for controlling data lock table sizes. The Performance Schema collects information that is already available in the server, so there is no memory or CPU overhead to generate this information or need for parameters that control its collection.

https://dev.mysql.com/doc/refman/8.0/en/data-locks-table.html

Table DATA_LOCKS

- Which lock is held

```
*************************** 4. row ***************************
               ENGINE: INNODB
       ENGINE_LOCK_ID: 2408:0:393:2
ENGINE_TRANSACTION_ID: 2408
            THREAD_ID: 34
        OBJECT_SCHEMA: test
          OBJECT_NAME: t
           INDEX_NAME: PRIMARY
            LOCK_TYPE: RECORD
            LOCK_MODE: X
          LOCK_STATUS: GRANTED
            LOCK_DATA: 12345
```

Table DATA_LOCKS

- Which lock is held
- Which lock is requested

```
*************************** 2. row ***************************
               ENGINE: INNODB
      ENGINE_LOCK_ID: 2409:0:393:2
ENGINE_TRANSACTION_ID: 2409
            THREAD_ID: 36
        OBJECT_SCHEMA: test
          OBJECT_NAME: t
           INDEX_NAME: PRIMARY
            LOCK_TYPE: RECORD
            LOCK_MODE: X
          LOCK_STATUS: WAITING
            LOCK_DATA: 12345
```

Table DATA_LOCKS

- Which lock is held
- Which lock is requested
- Both record-level and table level

```
p_s> select * from data_locks\G
*************************** 1. row ***************************
...
            LOCK_TYPE: TABLE
            LOCK_MODE: IX
          LOCK_STATUS: GRANTED
            LOCK_DATA: NULL
*************************** 2. row ***************************
...
            LOCK_TYPE: RECORD
```

Table DATA_LOCK_WAITS

- Maps lock waits with granted locks

Table DATA_LOCK_WAITS

- Maps lock waits with granted locks
- Only granted blocking other transactions

```
p_s> select ENGINE, ... from data_lock_waits\G
*************************** 1. row ***************************
                           ENGINE: INNODB
       REQUESTING_ENGINE_LOCK_ID: 2409:0:393:2
REQUESTING_ENGINE_TRANSACTION_ID: 2409
            REQUESTING_THREAD_ID: 36
         BLOCKING_ENGINE_LOCK_ID: 2408:0:393:2
  BLOCKING_ENGINE_TRANSACTION_ID: 2408
              BLOCKING_THREAD_ID: 34
1 row in set (0,01 sec)
```

New Information

- Partition
- Subpartition
- Lock data
- Requesting and blocking thread id

In sys Schema

- View `innodb_lock_waits`

In sys Schema

- View `innodb_lock_waits`
- Takes additional information from `INFORMATION_SCHEMA.INNODB_TRX`

In sys Schema

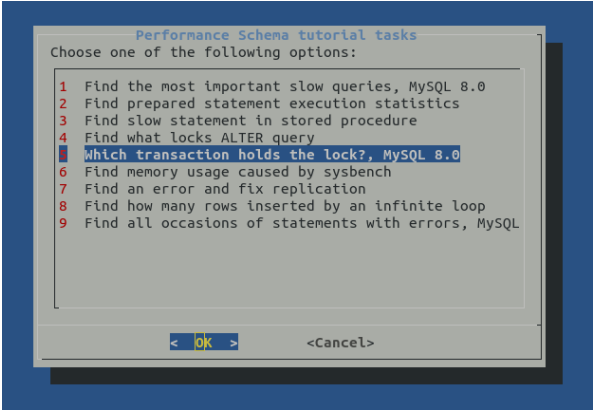
- View `innodb_lock_waits`

```
sys> select locked_table, ...
   -> from innodb_lock_waits\G
*************************** 1. row ***************************
                locked_table: `test`.`t`          blocking_pid: 4
                locked_index: PRIMARY           blocking_query: NULL
                 locked_type: RECORD  blocking_trx_rows_locked: 1
     waiting_trx_rows_locked: 1     blocking_trx_rows_modified: 1
   waiting_trx_rows_modified: 0        sql_kill_blocking_query: KILL QUERY 4
                 waiting_pid: 6   sql_kill_blocking_connection: KILL 4

               waiting_query: UPDATE t SET f='bar' WHERE id=12345
```

Data Locks: Practice

- Start the task



Data Locks: Practice

- Inside MySQL client

```
CALL help_task()\G
CALL help_solve()\G
```

- We need to find
  - Which transaction holds the lock
  - What is the missed statement
  - Which row is locked
  - Which partition is locked

5.7+: Memory Usage

Memory: configuration

- Instruments

```
mysql> select name from setup_instruments where name like 'memory%';
+----------------------------------------------------+
| name                                               |
+----------------------------------------------------+
...
| memory/sql/Gtid_state::group_commit_sidno_locks     |
| memory/sql/Mutex_cond_array::Mutex_cond            |
| memory/sql/TABLE_RULE_ENT                          |
| memory/sql/Rpl_info_table                          |
| memory/sql/Rpl_info_file::buffer                   |
| memory/sql/db_worker_hash_entry                    |
| memory/sql/rpl_slave::check_temp_dir               |
| memory/sql/rpl_slave::command_buffer               |
| memory/sql/binlog_ver_1_event                      |
| memory/sql/SLAVE_INFO                              |
```

Memory: configuration

- Instruments
- Consumers
  - Digest tables in Performance Schema
  - Views in sys schema

Memory Diagnostic

- Memory, used by internal `mysqld` structures

Memory Diagnostic

- Memory, used by internal `mysqld` structures
- Aggregated by
  - Global
  - Thread
  - Account
  - Host
  - User

Memory Diagnostic

- Memory, used by internal `mysqld` structures
- Aggregated by
  - Global
  - Thread
  - Account
  - Host
  - User
- Nice views in `sys` schema

Memory Usage by Thread

```
mysql> select thread_id tid, user, current_allocated ca, total_allocated
    -> from sys.memory_by_thread_by_current_bytes;
+-----+-------------------------+------------+-----------------+
| tid | user                    |         ca | total_allocated |
+-----+-------------------------+------------+-----------------+
|   1 | sql/main                | 2.53 GiB   | 2.69 GiB        |
| 150 | root@127.0.0.1          | 4.06 MiB   | 32.17 MiB       |
| 146 | sql/slave_sql           | 1.31 MiB   | 1.44 MiB        |
| 145 | sql/slave_io            | 1.08 MiB   | 2.79 MiB        |
...
|  60 | innodb/io_read_thread   | 0 bytes    | 384 bytes       |
| 139 | innodb/srv_purge_thread | -328 bytes | 754.21 KiB      |
|  69 | innodb/io_write_thread  | -1008 bytes| 34.28 KiB       |
|  68 | innodb/io_write_thread  | -1440 bytes| 298.05 KiB      |
|  74 | innodb/io_write_thread  | -1656 bytes| 103.55 KiB      |
|   4 | innodb/io_log_thread    | -2880 bytes| 132.38 KiB      |
|  72 | innodb/io_write_thread  | -7632 bytes| 1.10 MiB        |
```

Threads Statistics

```
mysql> select * from sys.memory_by_thread_by_current_bytes
    -> order by current_allocated desc\G
*************************** 1. row ***************************
         thread_id: 152
              user: lj@127.0.0.1
 current_count_used: 325
  current_allocated: 36.00 GiB
  current_avg_alloc: 113.43 MiB
  current_max_alloc: 36.00 GiB
    total_allocated: 37.95 GiB
...
```

- Find threads, eating memory, in a second!

RAW Performance Schema tables

- memory_summary_by_account_by_event_name
- memory_summary_by_host_by_event_name
- memory_summary_by_thread_by_event_name
- memory_summary_by_user_by_event_name
- memory_summary_global_by_event_name

RAW Performance Schema tables

- `memory_summary_by_account_by_event_name`
- `memory_summary_by_host_by_event_name`
- `memory_summary_by_thread_by_event_name`
- `memory_summary_by_user_by_event_name`
- `memory_summary_global_by_event_name`
- **You must enable memory instrumentation!**

RAW Performance Schema tables

- `memory_summary_by_account_by_event_name`
- `memory_summary_by_host_by_event_name`
- `memory_summary_by_thread_by_event_name`
- `memory_summary_by_user_by_event_name`
- `memory_summary_global_by_event_name`
- **You must enable memory instrumentation!**
- `sys` schema includes user name

Users in sys.memory_* tables

- `NAME@HOST` - regular user

Users in sys.memory_* tables

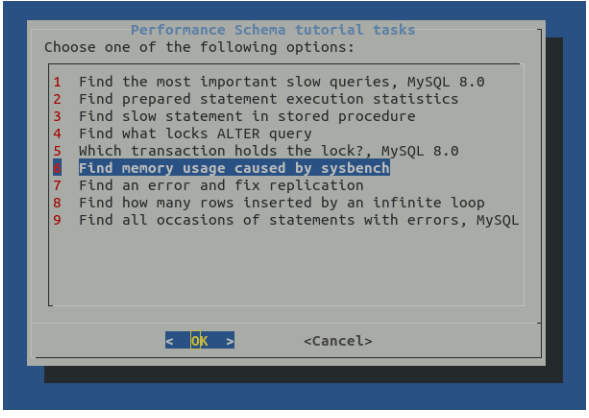
- `NAME@HOST` - regular user
- System users
  - `sql/main`
  - `innodb/*`
  - ...

Users in sys.memory_* tables

- `NAME@HOST` - regular user
- System users
  - `sql/main`
  - `innodb/*`
  - ...
- Data comes from table `THREADS`

Memory Usage: practice

- Start the task



Memory Usage: practice

- Inside MySQL client

```
CALL help_task()\G
CALL help_solve()\G
CALL task_prepare();
```

- We need to find out how much memory uses SysBench load, running in parallel
- To identify how much RAM used by whole server run

```
select * from sys.memory_global_total;
```

5.7+: Replication

Major Improvements

- Data from `SHOW SLAVE STATUS` available in `replication_*` tables

Major Improvements

- Data from `SHOW SLAVE STATUS` available in `replication_*` tables
- Support of Replication Channels (Multi-master slave)

Major Improvements

- Data from `SHOW SLAVE STATUS` available in `replication_*` tables
- Support of Replication Channels (Multi-master slave)
- More instruments for GTID

SLAVE STATUS

- No need to parse `SHOW` output

SLAVE STATUS

- No need to parse `SHOW` output
- Configuration
  - `replication_connection_configuration`
  - `replication_applier_configuration`

SLAVE STATUS

- No need to parse `SHOW` output
- Configuration
- IO thread
  - `replication_connection_status`

SLAVE STATUS

- No need to parse `SHOW` output
- Configuration
- IO thread
- SQL thread
  - `replication_applier_status`
  - `replication_applier_status_by_coordinator` - **MTS only**
  - `replication_applier_status_by_worker`
  - `replication_applier_global_filters`
  - `replication_applier_filters`

SLAVE STATUS

- No need to parse `SHOW` output
- Configuration
- IO thread
- SQL thread
- Group replication
  - `replication_group_members`
  - `replication_group_member_stats`

SLAVE STATUS

- Configuration

```
mysql> select * from replication_connection_configuration
    -> join replication_applier_configuration using(channel_name)\G
*************************** 1. row ***************************
             CHANNEL_NAME:
                     HOST: 127.0.0.1
                     PORT: 13000
                     USER: root
        NETWORK_INTERFACE:
            AUTO_POSITION: 1
              SSL_ALLOWED: NO
              SSL_CA_FILE:
...
             CHANNEL_NAME:
            DESIRED_DELAY: 0
```

SLAVE STATUS

- State of IO Thread

```
mysql> select * from replication_connection_status\G
*************************** 1. row ***************************
             CHANNEL_NAME:
               GROUP_NAME:
              SOURCE_UUID: d0753e78-14ec-11e5-b3fb-28b2bd7442fd
                THREAD_ID: 21
            SERVICE_STATE: ON
COUNT_RECEIVED_HEARTBEATS: 17
 LAST_HEARTBEAT_TIMESTAMP: 2015-06-17 15:49:08
 RECEIVED_TRANSACTION_SET:
        LAST_ERROR_NUMBER: 0
       LAST_ERROR_MESSAGE:
     LAST_ERROR_TIMESTAMP: 0000-00-00 00:00:00
1 row in set (0.00 sec)
```

Performance Schema: State of SQL Thread

- Coordinator thread for multiple workers

```
mysql> select * from replication_applier_status join
    -> replication_applier_status_by_coordinator using(channel_name)\G
*************************** 1. row ***************************
              CHANNEL_NAME:
             SERVICE_STATE: ON
           REMAINING_DELAY: NULL
COUNT_TRANSACTIONS_RETRIES: 0
                 THREAD_ID: 76
             SERVICE_STATE: ON
         LAST_ERROR_NUMBER: 0
        LAST_ERROR_MESSAGE:
      LAST_ERROR_TIMESTAMP: 0000-00-00 00:00:00.000000
LAST_PROCESSED_TRANSACTION: c634ce2d-cbb3-11e8-9532-0242cedce297:6
LAST_PROCESSED_TRANSACTION_ORIGINAL_COMMIT_TIMESTAMP: 2018-10-09
...
```

Performance Schema: State of SQL Thread

- Coordinator thread for multiple workers
- Multi-source slave

```
mysql> select * from replication_applier_status join
    -> replication_applier_status_by_worker using(channel_name)\G
*************************** 1. row ***************************
             CHANNEL_NAME: master-01
           SERVICE_STATE: ON
         REMAINING_DELAY: NULL
...
LAST_APPLIED_TRANSACTION: c634ce2d-cbb3-11e8-9532-0242cedce297:7
LAST_APPLIED_TRANSACTION_ORIGINAL_COMMIT_TIMESTAMP: 2018-10-09 15:12:56.285995
...
```

Performance Schema: State of SQL Thread

- Coordinator thread for multiple workers
- Multi-source slave

```
*************************** 2. row ***************************
             CHANNEL_NAME: m-03
           SERVICE_STATE: OFF
...
       LAST_ERROR_NUMBER: 1050
      LAST_ERROR_MESSAGE: Worker 1 failed executing transaction ...
    LAST_ERROR_TIMESTAMP: 2018-10-09 15:15:14.306672
LAST_APPLIED_TRANSACTION: c63ae70c-cbb3-11e8-b634-0242cedce297:2
...
LAST_APPLIED_TRANSACTION_END_APPLY_TIMESTAMP: 2018-10-09 15:13:33.770744
    APPLYING_TRANSACTION: c63ae70c-cbb3-11e8-b634-0242cedce297:3
...
```

Performance Schema: State of SQL Thread

- Coordinator thread for multiple workers
- Multi-source slave
- Transient Errors

```
mysql> select * from replication_applier_status_by_worker \G
*************************** 1. row ***************************
...
                                     LAST_ERROR_NUMBER: 0
...
                 LAST_APPLIED_TRANSACTION_RETRIES_COUNT: 1
   LAST_APPLIED_TRANSACTION_LAST_TRANSIENT_ERROR_NUMBER: 1205
  LAST_APPLIED_TRANSACTION_LAST_TRANSIENT_ERROR_MESSAGE:
  Lock wait timeout exceeded; try restarting transaction
LAST_APPLIED_TRANSACTION_LAST_TRANSIENT_ERROR_TIMESTAMP:
                              2019-05-22 01:28:57.704802
```

GTID Diagnostics

- `RECEIVED_TRANSACTION_SET`
  in table `replication_connection_status`

GTID Diagnostics

- RECEIVED_TRANSACTION_SET
  in table replication_connection_status
- LAST_SEEN_TRANSACTION
  in replication_applier_status_by_worker

GTID: All in One Place

- Single-threaded slave

```
mysql> select cs.CHANNEL_NAME, cs.SOURCE_UUID, cs.RECEIVED_TRANSACTION_SET,
    -> asw.LAST_APPLIED_TRANSACTION, aps.SERVICE_STATE
    -> from replication_connection_status cs
    -> join replication_applier_status_by_worker
    -> asw using(channel_name) join replication_applier_status aps
    -> using(channel_name) \G
*************************** 1. row ***************************
            CHANNEL_NAME:
             SOURCE_UUID: 9038967d-7164-11e6-8c88-30b5c2208a0f
RECEIVED_TRANSACTION_SET: 9038967d-7164-11e6-8c88-30b5c2208a0f:1-2
LAST_APPLIED_TRANSACTION: 9038967d-7164-11e6-8c88-30b5c2208a0f:2
           SERVICE_STATE: ON
1 row in set (0,00 sec)
```

GTID: All in One Place

- Single-threaded slave
- Multi-threaded

```
*************************** 1. row ***************************
               THREAD_ID: 30
          SERVICE_STATE: ON
RECEIVED_TRANSACTION_SET: 9038967d-7164-11e6-8c88-30b5c2208a0f:1-3
LAST_APPLIED_TRANSACTION:
   ...
*************************** 8. row ***************************
               THREAD_ID: 37
          SERVICE_STATE: ON
RECEIVED_TRANSACTION_SET: 9038967d-7164-11e6-8c88-30b5c2208a0f:1-3
LAST_APPLIED_TRANSACTION: 9038967d-7164-11e6-8c88-30b5c2208a0f:3
8 rows in set (0,00 sec)
```

Replication Filters

- Global

```
mysql> select * from replication_applier_global_filters\G
*************************** 1. row ***************************
  FILTER_NAME: REPLICATE_IGNORE_TABLE
  FILTER_RULE: test.test
CONFIGURED_BY: CHANGE_REPLICATION_FILTER
 ACTIVE_SINCE: 2018-10-09 16:54:45.733490
1 row in set (0.00 sec)
```

Replication Filters

- Global
- Worker's

```
mysql> select * from replication_applier_filters\G
*************************** 1. row ***************************
 CHANNEL_NAME: m-01
  FILTER_NAME: REPLICATE_IGNORE_TABLE
  FILTER_RULE: test.test
CONFIGURED_BY: CHANGE_REPLICATION_FILTER
 ACTIVE_SINCE: 2018-10-09 16:54:45.733490
      COUNTER: 0
*************************** 2. row ***************************
 CHANNEL_NAME: m-03
  FILTER_NAME: REPLICATE_IGNORE_TABLE
  FILTER_RULE: test.t1
  ...
```

Group Replication

- replication_group_members

```
mysql> SELECT * FROM performance_schema.replication_group_members\G
*************************** 1. row ***************************
  CHANNEL_NAME: group_replication_applier
     MEMBER_ID: c26fc705-cbcc-11e8-b5b8-0242cedce297
   MEMBER_HOST: delly
   MEMBER_PORT: 24801
  MEMBER_STATE: ONLINE
   MEMBER_ROLE: PRIMARY
MEMBER_VERSION: 8.0.12
...
```

Group Replication

- replication_group_members

```
*************************** 2. row ***************************
  CHANNEL_NAME: group_replication_applier
     MEMBER_ID: f3d2feda-cbcc-11e8-9eb9-0242cedce297
   MEMBER_HOST: delly
   MEMBER_PORT: 24802
  MEMBER_STATE: RECOVERING
   MEMBER_ROLE: PRIMARY
MEMBER_VERSION: 8.0.12
2 rows in set (0.00 sec)
```

Group Replication

- replication_group_members
- replication_group_member_stats

```
mysql> SELECT * FROM performance_schema.replication_group_member_stats\G
*************************** 1. row ***************************
                       CHANNEL_NAME: group_replication_applier
                            VIEW_ID: 15390963914656312:3
                          MEMBER_ID: 1dfa4dee-cbcd-11e8-bad1-0242cedce297
        COUNT_TRANSACTIONS_IN_QUEUE: 0
         COUNT_TRANSACTIONS_CHECKED: 1
           COUNT_CONFLICTS_DETECTED: 0
COUNT_TRANSACTIONS_ROWS_VALIDATING: 8
...
```

More Diagnostic

- Tables in mysql schema
  - `slave_master_info`
  - `slave_relay_log_info`
  - `slave_worker_info`
  - **Join with Performance Schema tables**

More Diagnostic

- Tables in mysql schema
  - `slave_master_info`
  - `slave_relay_log_info`
  - `slave_worker_info`
  - **Join with Performance Schema tables**
- New instruments
  - `memory`
  - `wait`
  - `stage`

Table log_status

- Not only replication

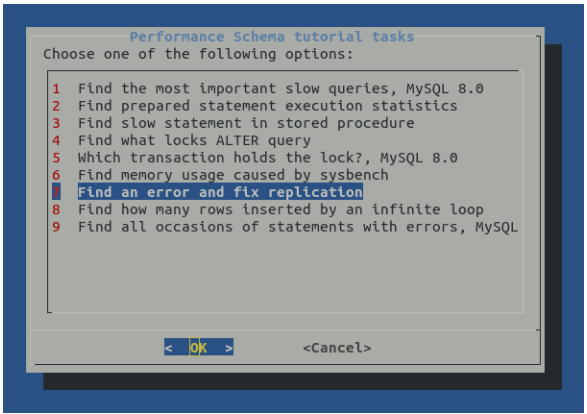
```
mysql> select * from log_status\G
*************************** 1. row ***************************
    SERVER_UUID: c634ce2c-cbb3-11e8-8900-0242cedce297
          LOCAL: {"gtid_executed": "c634ce2d-cbb3-11e8-9532-0242cedce297:1-2",
                  "binary_log_file": "binlog.000001",
                  "binary_log_position": 620}
    REPLICATION: {"channels": [{"channel_name": "",
                  "relay_log_file": "delly-relay-bin.000002",
                  "relay_log_position": 819,
                  "relay_master_log_file": "binlog.000001",
                  "exec_master_log_position": 611}]}
STORAGE_ENGINES: {"InnoDB": {"LSN": 19177930, "LSN_checkpoint": 19177930}}
1 row in set (0.01 sec)
```

Table log_status

- Not only replication
- InnoDB and MyRocks

Replication: practice

- Start the task



Replication: practice

- Inside MySQL client

```
CALL help_task()\G
CALL help_solve()\G
```

- To open another terminal: `Ctrl+b,c`
- Connection commands **in another terminal**
  - Master: `m`
  - Slave: `s1`
- We need to find out why replication is broken and fix it

5.7+: Variables

Variables Instrumentation

- Variables
  - `global_variables`
  - `session_variables`
  - `user_variables_by_thread`
  - `variables_by_thread`

Variables Instrumentation

- Variables
- Status variables
  - `global_status`
  - `session_status`
  - `status_by_[account|host|thread|user]`

Variables Instrumentation

- Variables
- Status variables
- `show_compatibility_56 = 0`

Global and Session Variables

- Same information which is in
  - `SHOW [GLOBAL] STATUS`
  - `I_S.GLOBAL_VARIABLES`
    - Deprecated in 5.7
    - Removed in 8.0.1
  - `I_S.SESSION_VARIABLES`
    - Deprecated in 5.7
    - Removed in 8.0.1

Global and Session Variables

- Same information which is in
  - `SHOW [GLOBAL] STATUS`
  - `I_S.GLOBAL_VARIABLES`
    - Deprecated in 5.7
    - Removed in 8.0.1
  - `I_S.SESSION_VARIABLES`
    - Deprecated in 5.7
    - Removed in 8.0.1
- Helps to watch session variables changes

Status Variables

- Same information which is in
  - `SHOW [GLOBAL] STATUS`
  - `I_S.GLOBAL_STATUS`
    - Deprecated in 5.7
    - Removed in 8.0.1
  - `I_S.SESSION_STATUS`
    - Deprecated in 5.7
    - Removed in 8.0.1

Status Variables

```
mysql> SELECT ss.variable_name, ss.variable_value FROM session_status ss
    -> LEFT JOIN global_status gs USING(variable_name)
    -> WHERE ss.variable_value != gs.variable_value OR gs.variable_value IS NULL;
+---------------------------+----------------+
| variable_name             | variable_value |
+---------------------------+----------------+
| Bytes_sent                | 197774         |
| Handler_commit            | 0              |
| Handler_external_lock     | 44             |
| Handler_read_first        | 3              |
| Handler_read_key          | 523            |
| Handler_read_next         | 0              |
| Handler_read_rnd_next     | 7241           |
| Opened_table_definitions  | 0              |
...
```

Possible to Group

- variables_by_thread
- status_by_
  - account
  - host
  - thread
  - user

Possible to Group

- variables_by_thread

```
mysql> select * from variables_by_thread where variable_name='tx_isolation';
+-----------+---------------+-----------------+
| THREAD_ID | VARIABLE_NAME | VARIABLE_VALUE  |
+-----------+---------------+-----------------+
|        71 | tx_isolation  | REPEATABLE-READ |
|        83 | tx_isolation  | REPEATABLE-READ |
|        84 | tx_isolation  | SERIALIZABLE    |
+-----------+---------------+-----------------+
3 rows in set, 3 warnings (0.00 sec)
```

Possible to Group

- variables_by_thread
- status_by_

```
mysql> select * from status_by_thread where variable_name='Handler_write';
+-----------+---------------+----------------+
| THREAD_ID | VARIABLE_NAME | VARIABLE_VALUE |
+-----------+---------------+----------------+
|        71 | Handler_write | 94             |
|        83 | Handler_write | 477            | -- Most writes
|        84 | Handler_write | 101            |
+-----------+---------------+----------------+
3 rows in set (0.00 sec)
```

User Variables

- Grouped by connection
- Sometimes can help to find tricky bugs with persistent connections

```
mysql> select * from user_variables_by_thread;
+-----------+---------------+----------------+
| THREAD_ID | VARIABLE_NAME | VARIABLE_VALUE |
+-----------+---------------+----------------+
|        71 | baz           | boo            |
|        84 | foo           | bar            |
+-----------+---------------+----------------+
2 rows in set (0.00 sec)
```

8.0+: Variables Info

- VARIABLES_INFO
  - Source of variable
    - COMPILED
    - EXPLICIT
    - COMMAND_LINE
    - DYNAMIC
  - Path of option file if specified
  - Minimum and maximum values

8.0+: Variables Info

- VARIABLES_INFO

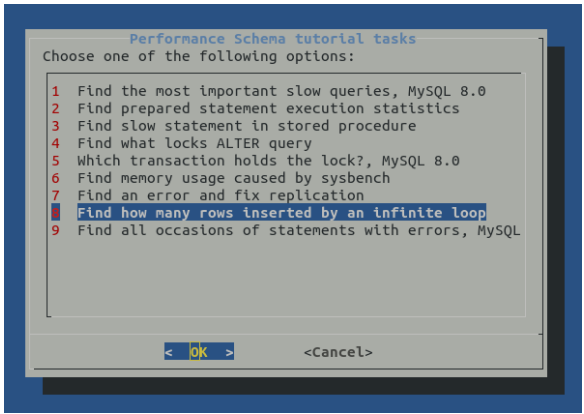
```
mysql> select * from variables_info where set_user is not null\G
*************************** 1. row ***************************
  VARIABLE_NAME: innodb_file_per_table
VARIABLE_SOURCE: DYNAMIC
  VARIABLE_PATH:
      MIN_VALUE: 0
      MAX_VALUE: 0
       SET_TIME: 2018-10-09 22:17:34.638459
       SET_USER: root
       SET_HOST: localhost
*************************** 2. row ***************************
  VARIABLE_NAME: max_allowed_packet
VARIABLE_SOURCE: DYNAMIC
  VARIABLE_PATH:
      ...
```

8.0+: Variables Info

- VARIABLES_INFO
  - Source of variable
    - COMPILED
    - EXPLICIT
    - COMMAND_LINE
    - DYNAMIC
  - Path of option file if specified
  - Minimum and maximum values
- **No variable values in this table!**

Variables: practice

- Start the task



Variables: practice

- Inside MySQL client

```
CALL help_task()\G
CALL help_solve()\G
CALL task_prepare();
```

- We need to watch progress of `INSERT` command, running by stored routine.
- Note what there is parallel load, caused by SysBench. We are not interested in its statistics.

8.0+: Errors Summary

Errors Summary Tables

- Traditionally aggregated
  - `events_errors_summary_by_account_by_error`
  - `events_errors_summary_by_host_by_error`
  - `events_errors_summary_by_thread_by_error`
  - `events_errors_summary_by_user_by_error`
  - `events_errors_summary_global_by_error`

Errors Summary Tables

- Traditionally aggregated
- All tables have similar structure

```
mysql> DESC events_errors_summary_global_by_error;
+-------------------+---------------------+------+-----+---------------------+
| Field             | Type                | Null | Key | Default             |
+-------------------+---------------------+------+-----+---------------------+
| ERROR_NUMBER      | int(11)             | YES  | UNI | NULL                |
| ERROR_NAME        | varchar(64)         | YES  |     | NULL                |
| SQL_STATE         | varchar(5)          | YES  |     | NULL                |
| SUM_ERROR_RAISED  | bigint(20) unsigned | NO   |     | NULL                |
| SUM_ERROR_HANDLED | bigint(20) unsigned | NO   |     | NULL                |
| FIRST_SEEN        | timestamp           | YES  |     | 0000-00-00 00:00:00 |
| LAST_SEEN         | timestamp           | YES  |     | 0000-00-00 00:00:00 |
+-------------------+---------------------+------+-----+---------------------+
7 rows in set (0,03 sec)
```

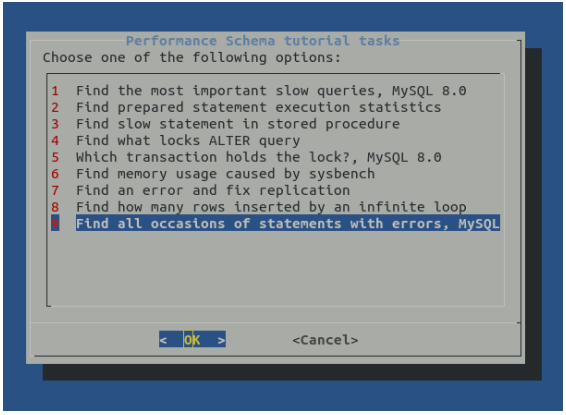
Errors Summary: Which Accounts Raise More Errors?

```
mysql> select * from events_errors_summary_by_account_by_error
    -> where SUM_ERROR_RAISED > 100\G
```

```
*************** 1. row *************** *************** 2. row ***************
            USER: root                              USER: root
            HOST: localhost                         HOST: localhost
    ERROR_NUMBER: 1213                      ERROR_NUMBER: 1287
      ERROR_NAME: ER_LOCK_DEADLOCK            ERROR_NAME: ER_WARN_DEPRECATED_SYNTAX
       SQL_STATE: 40001                        SQL_STATE: HY000
 SUM_ERROR_RAISED: 221                   SUM_ERROR_RAISED: 279
SUM_ERROR_HANDLED: 0                    SUM_ERROR_HANDLED: 0
      FIRST_SEEN: 2016-09-28 01:45:09         FIRST_SEEN: 2016-09-27 23:59:49
       LAST_SEEN: 2016-09-28 01:47:02          LAST_SEEN: 2016-09-28 01:47:05
```

Errors Summary: practice

- Start the task



Errors Summary: practice

- Inside MySQL client

```
CALL help_task()\G
CALL help_solve()\G
```

- We need to find all occasions of statements with errors
  - Get the list all accounts which raised errors
  - Get the top 3 error types globally

Practice: Download Code

github.com/svetasmirnova/performance_schema_tutorial

More information

 Blog of MySQL developers team

 Mark Leith: author of `sys` schema

 Official reference manual

 Webinar ”Performance Schema for MySQL Troubleshooting”

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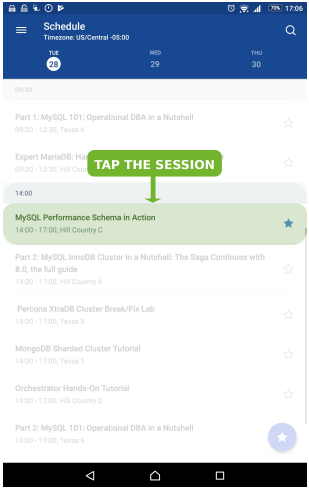

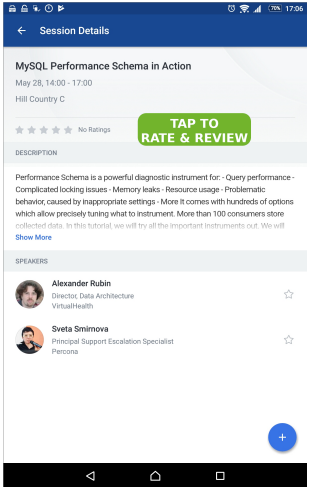

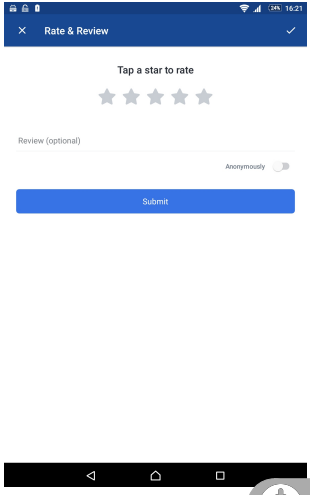

Thank you!

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