Troubleshooting MySQL Performance

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About Percona

- Performance Consulting Experts
- Free software: extended versions of MySQL and MongoDB (Percona Server), technical support, consulting, remote DBA (managed services)
- Since 2006, headquarters are in USA
- Distributed company with more than 100 employees in 30 countries
- 3000+ customers, including Cisco and Alcatel Lucent

Percona customers

- Data retrieved from free sources

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- MySQL Server overview

- Single statement performance

- Internal concurrency issues

- Environment

MySQL Server overview

MySQL architecture

Connectors: C, JDBC, ODBC, Python, ...

Connection Pool: Authentication, Caches

SQL interface

Parser

Optimizer

Caches and Buffers:
Global
Engine-specific

Storage engines: InnoDB, TokuDB, ...

File system: Data, Index, logs, other files

- Base
  - Layout
  - Log files
- Connectors
- Optimizer
- Cache and buffers
- Storage engines
- Management

Important server parts

- Optimizer

- Storage engine

  - Study tools which offers your engine

- Variables

Troubleshooting instruments

- Log files

- Information Schema

  - SHOW commands

- Performance Schema

- Storage engine instruments

Troubleshooting instruments

- Log files

    - Error
    - Slow query
    - General query
    - Audit plugins
    - Your application
    - Operating system

Troubleshooting instruments

- Information Schema

  - Contains metadata information

    - Tables

    - Indexes

    - Other

  - Allows to create plugins

    - InnoDB plugins

Troubleshooting instruments

- Performance Schema
    - Monitors interval operations
        - Statements
        - Stages
        - Locks
        - Memory
        - Variables
        - Replication
        - IO
        - Mutexes and waits

Troubleshooting instruments

- Storage engine instruments

    - SHOW ENGINE ... STATUS

    - engine_* variables
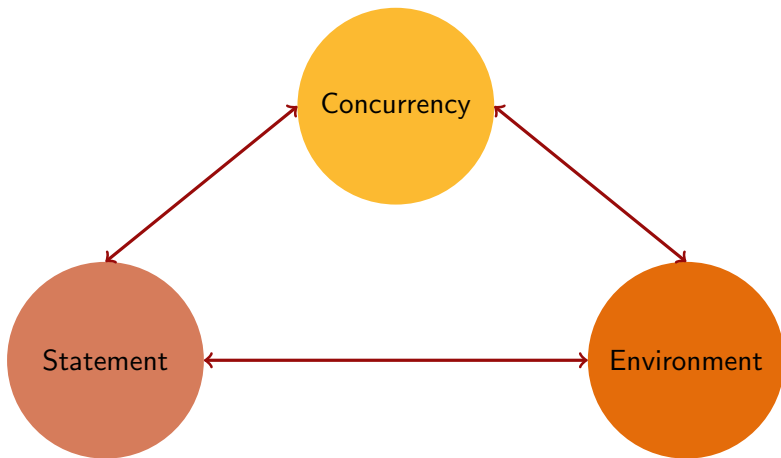
    - Engine-specific tools

Monitoring solutions

- Command-line
  - Percona Toolkit
  - MySQL Utilities
- With GUI
  - MySQL Enterprise Monitor (MEM)
  - MEM plugin for Oracle Enterprise Manager
  - VividCortex
  - Many others

What can affect performance?

- Query processing
  - Optimization
  - Execution

- Concurrency

- Environment
  - Parallel processes
  - Hardware

Troubleshooting workflow
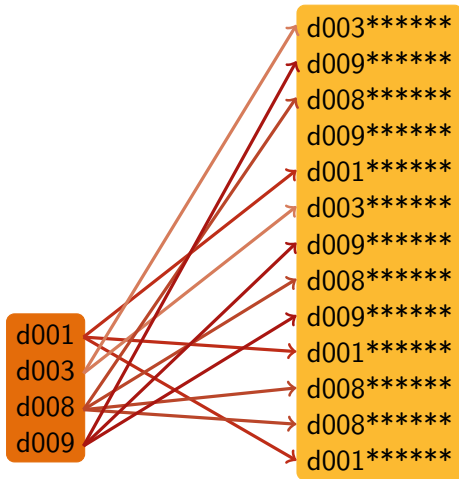
Single statement performance

Where to find slow statement?

- While designing application
- In slow query log
- In Performance Schema

```
mysql> select sql_text, (timer_end - timer_start)/1000000000 as time \
    -> from events_statements_history_long \
    -> where (timer_end - timer_start) > 4*10000000000 \
    -> and event_name='statement/sql/select' and current_schema='employees'\G
*************************** 1. row ***************************
sql_text: select * from titles
    time: 1929.8997
*************************** 2. row ***************************
sql_text: select count(*) from titles join employees using (emp_no)
         where title='Senior Engineer'
    time: 4493.3863
2 rows in set (0.01 sec)
```

MySQL Indexes

- B-Tree (Mostly)
- Fractal Tree
- R-Tree (Spatial)
- Hash (Memory SE)
- Engine-dependent

d001
d003
d008
d009

d003******
d009******
d008******
d009******
d001******
d003******
d009******
d008******
d009******
d001******
d008******
d008******
d001******

More in Performance Schema

- 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
- Views in sys schema

More in Performance Schema

- 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

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 (in Support)

Stages shortcuts

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

How to fix? Optimize!

- EXPLAIN EXTENDED
  - Should be followed by SHOW WARNINGS

- EXPLAIN PARTITIONS

- EXPLAIN FORMAT=JSON

- Status variables 'Handler_%'

- INFORMATION_SCHEMA.TRACE

EXPLAIN in MySQL

```
mysql> EXPLAIN EXTENDED SELECT user, host FROM mysql.user\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: user
         type: index
possible_keys: NULL
          key: PRIMARY
      key_len: 228
          ref: NULL
         rows: 4
     filtered: 100.00
        Extra: Using index
1 row in set, 1 warning (0.00 sec)
mysql> SHOW WARNINGS\G
******* 1. row *******
  Level: Note
   Code: 1003
Message: /* select#1 */ select `mysql`.`user`.`User` AS `user`,
`mysql`.`user`.`Host` AS `host` from `mysql`.`user`
```

EXPLAIN in details

```
mysql> explain extended select * from t1 join t2 where...
+----+-------------+-------+-------+***
| id | select_type | table | type  |***
+----+-------------+-------+-------+***
| 1  | SIMPLE      | t1    | ref   |***
| 1  | SIMPLE      | t2    | index |***
+----+-------------+-------+-------+***
2 rows in set, 1 warning (0.00 sec)
```

system
const
eq_ref
ref
fulltext
ref_or_null
index_merge
unique_subquery
index_subquery
range
index
ALL

SIMPLE;PRIMARY;UNION;DEPENDENT UNION;UNION RESULT;
SUBQUERY;DEPENDENT SUBQUERY;DERIVED;MATERIALIZED

EXPLAIN in details: keys

Keys, which can be used for resolving the query

Actual length of the key (Important for multiple-column keys)

```
mysql> explain extended select * from t1 join t2 where t1.int_key=1;
***+----------------+----------+---------+--------+***
***| possible_keys  | key      | key_len | ref    |***
***+----------------+----------+---------+--------+***
***| int_key,ik     | int_key  | 5       | const  |***
***| NULL           | pk       | 9       | NULL   |***
***+----------------+----------+---------+--------+***
2 rows in set, 1 warning (0.00 sec)
```

Constant
Numeric in our case

Index used
to resolve rows

Which columns were compared with the index

Only one key was actually used

EXPLAIN in details: rows

% of rows filtered

Number of rows accessed

Additional information: how query is resolved

Using filesort
Using temporary
etc.

```
mysql> explain extended select * from t1 join t2 where t1.int_key=1;
***+-------+----------+-------------------------------------------------+
***| rows  | filtered | Extra                                           |
***+-------+----------+-------------------------------------------------+
***|    4  |  100.00  | NULL                                            |
***|    6  |  100.00  | Using index; Using join buffer (Block Nested Loop) |
***+-------+----------+-------------------------------------------------+
2 rows in set, 1 warning (0.00 sec)
```

4X6
=
24

All rows used

EXPLAIN FORMAT=JSON

- Gives more information than regular EXPLAIN
  - Real execution path of the query
  - Pushed conditions
  - Query cost
  - Temporary table and index creation are more precise
  - Reflects execution order of "group by" and "order by" operations
  - Displays table materializations

EXPLAIN FORMAT=JSON

```
mysql> EXPLAIN FORMAT=JSON SELECT user, host FROM mysql.user\G
*************************** 1. row ***************************
EXPLAIN: {
    "query_block": {
        "select_id": 1,
        "table": {
            "table_name": "user",
            "access_type": "index",
            "key": "PRIMARY",
            "used_key_parts": [
              "Host",
              "User"
            ],
            "key_length": "228",
            "rows": 8,
            "filtered": 100,
            "using_index": true
        }
    }
}
```

EXPLAIN PARTITIONS

```
mysql> explain partitions select count(*) \
    -> from employees_part where hire_date > '1991-01-01'\G
*********************** 1. row ***********************
           id: 1
  select_type: SIMPLE
        table: employees_part
   partitions: p1,p2
         type: index
possible_keys: NULL
          key: PRIMARY
      key_len: 7
          ref: NULL
         rows: 135214
Extra: Using where; Using index
```

When EXPLAIN lies: Handler_%

```
mysql> flush status;
Query OK, 0 rows affected (0.00 sec)
mysql> select titles.* from titles join employees using (emp_no) \
    -> where title='Senior Engineer' and to_date='9999-01-01' \
    -> order by from_date limit 10;
+--------+-----------------+------------+------------+
| emp_no | title           | from_date  | to_date    |
+--------+-----------------+------------+------------+
| 235233 | Senior Engineer | 1985-02-01 | 9999-01-01 |
...
mysql> SHOW STATUS LIKE 'Handler_read_%';
+----------------------------+--------+
| Variable_name              | Value  |
+----------------------------+--------+
| Handler_read_first         | 1      |
| Handler_read_key           | 11     |
...
| Handler_read_rnd_next      | 443309 |
+----------------------------+--------+
7 rows in set (0.00 sec)
```

I_S.OPTIMIZER_TRACE

- Debug trace of optimizer
- Prints
  - join_preparation
  - join_optimization
    - considered_execution_plans
    - refine_plan
    - More
  - join_execution

I_S.OPTIMIZER_TRACE example

```
mysql>  SET optimizer_trace="enabled=on";
Query OK, 0 rows affected (0.00 sec)

mysql> select titles.* from titles join employees using (emp_no) \
    -> where title='Senior Engineer' and to_date='9999-01-01' \
    -> order by from_date limit 10\G
*************************** 1. row ***************************
   emp_no: 235233
    title: Senior Engineer
from_date: 1985-02-01
  to_date: 9999-01-01
...
```

I_S.OPTIMIZER_TRACE example cont.

```
mysql> SELECT * FROM INFORMATION_SCHEMA.OPTIMIZER_TRACE\G
*************************** 1. row ***************************
QUERY: select titles.* from titles join employees using (emp_no) where ...
TRACE: {
    "steps": [
    {
        "join_preparation": {
            "select#": 1,
            "steps": [
            {
                "expanded_query":
...
{
    "join_optimization": {
        "select#": 1,
        "steps": [
        {
            "condition_processing": {
...
```

I_S.OPTIMIZER_TRACE example cont.

```
"considered_execution_plans": [
{
    "plan_prefix": [
    ],
    "table": "`employees`",
    "best_access_path": {
        "considered_access_paths": [
        {
            "access_type": "ref",
            "index": "PRIMARY",
            "usable": false,
            "chosen": false
        },
        {
            "rows_to_scan": 269763,
            "access_type": "scan",
            "resulting_rows": 269763,
            "cost": 54754,
            "chosen": true
        }
...
```

I_S.OPTIMIZER_TRACE example cont.

```
    "condition_filtering_pct": 100,
    "rows_for_plan": 269763,
    "cost_for_plan": 54754,
...
"rest_of_plan": [
{
    "plan_prefix": [
    "'titles'"
    ],
    "table": "'employees'",
    "best_access_path": {
    "considered_access_paths": [
        {
            "access_type": "eq_ref",
            "index": "PRIMARY",
            "rows": 1,
            "cost": 5222.9,
            "chosen": true,
            "cause": "clustered_pk_chosen_by_heuristics"
            },
```

I_S.OPTIMIZER_TRACE example cont.

```
            {
                "access_type": "scan",
                "chosen": false,
                "cause": "covering_index_better_than_full_scan"
            }
        ]
    },
    "condition_filtering_pct": 100,
    "rows_for_plan": 4352.4,
    "cost_for_plan": 93459,
    "chosen": true
...
```

Internal
concurrency issues

Common concurrency issues

- Query or transaction waits a lock, held by another one
- Fight for system resources
- Symptoms
  - Many processes are waiting
  - You see query in the slow log, but it runs fast if single-thread environment
  - Query execution time varies

Lock types and transactions

- Lock types
- Levels
  - MDL
  - Table-level
  - Row-level
- What do they lock
  - Read locks
    - Block writes
  - Write locks
    - Block reads and writes

- Transactions
  - Server-level
    - MDL locks
    - Table locks
  - Engine-level
    - Table locks
    - Row locks
  - AUTOCOMMIT
    - supported

Locks diagnostic

- SHOW [FULL] PROCESSLIST
- SHOW ENGINE INNODB STATUS
- INFORMATION SCHEMA
  - PROCESSLIST
  - InnoDB tables
- Performance Schema
  - METADATA_LOCKS
  - TABLE_HANDLES
  - EVENTS_TRANSACTIONS_*
    - Both server-level and engine-level
    - Contain GTID information

Locks diagnostic

- SHOW [FULL] PROCESSLIST
- For any kind of locks

```
mysql> select id, state, info from information_schema.processlist\G
******************** 1. row ********************
    id: 5
state:
 info: NULL
******************** 2. row ********************
    id: 4
state: Waiting for table metadata lock
 info: alter table titles add column f1 int
******************** 3. row ********************
    id: 2
state: executing
 info: select id, state, info from information_schema.processlist
```

Locks diagnostic

- Performance Schema
- Metadata locks

```
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
```

Locks diagnostic

- Performance Schema
- Table locks

```
mysql2> select * from table_handles\G
*************************** 1. row ***************************
          OBJECT_TYPE: TABLE
        OBJECT_SCHEMA: employees
          OBJECT_NAME: employees
OBJECT_INSTANCE_BEGIN: 140544885988272
      OWNER_THREAD_ID: 23
       OWNER_EVENT_ID: 818320
        INTERNAL_LOCK: NULL
        EXTERNAL_LOCK: READ EXTERNAL -- Table lock!
1 row in set (0.00 sec)
```

Locks diagnostic

- Performance Schema
- Transactions

```
mysql> select thread_id, processlist_id, access_mode, gtid \
    -> from events_transactions_current join threads using(thread_id) \
    -> where state = 'active'\G
*************************** 1. row ***************************
      thread_id: 25
 processlist_id: 2
    access_mode: READ WRITE
           gtid: AUTOMATIC
*************************** 2. row ***************************
      thread_id: 28
 processlist_id: 5
    access_mode: READ WRITE
           gtid: 07aff4c6-87e7-11e5-9a51-30b5c2208a0f:202
2 rows in set (0.00 sec)
```

InnoDB Monitors

- SHOW ENGINE INNODB STATUS

- Permanent output

  - innodb_status_output

  - innodb_status_output_locks

  - innodb-status-file - Deleted on normal shutdown!

InnoDB Monitors

- SHOW ENGINE INNODB STATUS

```
-------------
TRANSACTIONS
-------------
Trx id counter 0 26243837
Purge done for trx's n:o < 0 26243834 undo n:o < 0 0
History list length 2
LIST OF TRANSACTIONS FOR EACH SESSION:
---TRANSACTION 0 26243836, ACTIVE 4 sec, OS thread id 101514240 starting index
mysql tables in use 1, locked 1
LOCK WAIT 2 lock struct(s), heap size 320, 1 row lock(s)
MySQL thread id 4485, query id 25022137 localhost root Updating
update t set a=36 where a=6
```

Other InnoDB diagnostic

- INFORMATION_SCHEMA

    - INNODB_TRX
    - INNODB_LOCKS
    - INNODB_LOCK_WAITS
    - INNODB_METRICS
        - Options innodb_monitor_*

- Option innodb_print_all_deadlocks

Other InnoDB diagnostic

- INFORMATION_SCHEMA
- ```
mysql> SELECT TRX_ID, TRX_REQUESTED_LOCK_ID, BLOCKING_TRX_ID, \
    -> BLOCKING_LOCK_ID, TRX_QUERY \
    -> FROM INNODB_TRX JOIN INNODB_LOCK_WAITS ON \
    -> (INNODB_TRX.TRX_ID=INNODB_LOCK_WAITS.REQUESTING_TRX_ID) \
    -> WHERE TRX_STATE = 'LOCK WAIT'\G
*************************** 1. row ***************************
              TRX_ID: 2318
TRX_REQUESTED_LOCK_ID: 2318:28:5:2
     BLOCKING_TRX_ID: 2316
    BLOCKING_LOCK_ID: 2316:28:5:2
           TRX_QUERY: update titles set title='Principal Engineer'
                      where title='Senior Engineer'
1 row in set (0.00 sec)

mysql> select TRX_ID, trx_mysql_thread_id from INNODB_TRX WHERE TRX_ID=2316\G
*************************** 1. row ***************************
              TRX_ID: 2316
trx_mysql_thread_id: 2
1 row in set (0.00 sec)
```

# Locks diagnostic summary

- Table-level
  - PROCESSLIST: "Waiting for table lock"
  - P_S.TABLE_HANDLES
- Row-level
  - InnoDB monitors
    - SHOW ENGINE INNODB STATUS
  - Tables in INFORMATION_SCHEMA
  - P_S.EVENTS_TRANSACTIONS
  - Option –innodb_print_all_deadlocks
- MDL
  - PROCESSLIST
    - "Waiting for metadata lock"
  - P_S.METADATA_LOCKS

# Environment

# Memory usage

- What uses memory in MySQL

    - Buffers

    - Temporary tables

    - Internal structures - out of user control!

    - OS did not show memory as freed yet?

# Memory diagnostic before 5.7

- free

- top

- vmstat

- Investigation

- There was no way to know how exactly memory was allocated

# Memory diagnostic before 5.7

- free

```
$free
total       used      free     shared    buffers     cached
Mem:    16149184  6223916   9925268    317536       1048    3655160
-/+ buffers/cache:  2567708  13581476
Swap:    2110460        0   2110460
```

- top

- vmstat

- Investigation

Memory diagnostic before 5.7

- free
- top

```
$top
Tasks: 295 total,   3 running, 292 sleeping,   0 stopped,   0 zombie
%Cpu(s):  3.0 us,  0.8 sy,  0.1 ni, 95.4 id,  0.8 wa,  0.0 hi,  0.0 si,  0.0 s
KiB Mem: 16149184 total, 6231688 used, 9917496 free,    1048 buffers
KiB Swap: 2110460 total,       0 used, 2110460 free. 3670752 cached Mem

PID USER      PR  NI    VIRT    RES    SHR S %CPU %MEM    TIME+ COMMAND
1914 mysql    20   0    670m    95m   1296 S  0.7  1.2  2:42.14 mysqld
```

- vmstat
- Investigation

Memory diagnostic before 5.7

- free
- top
- vmstat

```
$vmstat -t 5 3
procs ---------------------memory--------------------- ------swap---- ------
 r  b   swpd    free   buff   cache   si   so    bi    bo   in   cs us sy id wa..
 2  0      0 9923160   1048 3662724    0    0   168    86  167  674  3  1 87...
 0  0      0 9923252   1048 3662904    0    0    30   122 1168 5264  3  1 96...
 0  0      0 9922864   1048 3663120    0    0    25   128 1191 5342  2  1 96...
```

- Investigation

Memory diagnostic before 5.7

- free
- top
- vmstat
- Investigation
  - Total size of buffers
  - Number of temporary tables
  - Number of parallel connections

Memory diagnostic in 5.7

```
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        |
+-----+-------------------------+-------------+-----------------+
145 rows in set (2.65 sec)
```

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
...
```

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

- sys schema also includes information about user name

Users in sys.memory_* tables

- NAME@HOST - regular user

- System users

  - sql/main

  - innodb/*

  - ...

- Data comes from table THREADS

Memory usage: how to fix?

- mysqld uses to low memory
  - Buffers are not tuned for performance
  - Operating system limits resources
- mysqld uses too much memory
  - Buffers are too large
    - General use buffers: allocated once for whole server
    - Connection buffers: allocated for every connection
    - Task buffers: allocated for the particular task
    - Prioritize!
  - Allocations, which cannot be controlled
    - Watch
    - Find workaround
    - Implement

Disk diagnostics

- df
- iostat
- ls -l /proc/{PID_OF_MYSQLD}/fd
- InnoDB status
- performance_schema.table_io_waits_%
- sys.io_%

Disk diagnostics

- df

```
Filesystem      1K-blocks      Used  Available  Use%  Mounted on
/dev/sda6       41944064  28429816   11433384   72%  /
devtmpfs         8067632         0    8067632    0%  /dev
tmpfs            8074592     41300    8033292    1%  /dev/shm
tmpfs            8074592      2376    8072216    1%  /run
tmpfs            8074592         0    8074592    0%  /sys/fs/cgroup
/dev/sda6       41944064  28429816   11433384   72%  /.snapshots
/dev/sda6       41944064  28429816   11433384   72%  /var/tmp
/dev/sda6       41944064  28429816   11433384   72%  /var/spool
/dev/sda6       41944064  28429816   11433384   72%  /var/opt
/dev/sda6       41944064  28429816   11433384   72%  /var/log
/dev/sda6       41944064  28429816   11433384   72%  /var/lib/pgsql
/dev/sda6       41944064  28429816   11433384   72%  /var/lib/named
/dev/sda6       41944064  28429816   11433384   72%  /var/lib/mailman
/dev/sda6       41944064  28429816   11433384   72%  /var/crash
/dev/sda6       41944064  28429816   11433384   72%  /usr/local
/dev/sda6       41944064  28429816   11433384   72%  /tmp
...
```

Disk diagnostics

- iostat

```
sveta@thinkie:~/src/test-db/employees_db> iostat -x
Linux 3.16.7-92-desktop (thinkie)   11/11/2015   _x86_64_   (8 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
          14.47    1.77    2.54    0.94    0.00   80.28

Device: rrqm/s  wrqm/s    r/s     w/s    rkB/s    wkB/s avgrq-sz avgqu-sz ...
sda       0.28    0.70    4.66   21.59    93.69   346.10    33.51     4.14 ...
sdb       0.00    0.00    0.00    0.00     0.02     0.00    15.69     0.00 ...
```

www.percona.com

Disk diagnostics

- ls -l /proc/{PID_OF_MYSQLD}/fd

```
sveta@thinkie:~/src/test-db/employees_db> ls -l /proc/26676/fd
total 0
lrwx------ 1 sveta users 64 Nov 11 15:11 0 -> /dev/pts/1
l-wx------ 1 sveta users 64 Nov 11 15:11 1 -> /log/mysqld.1.err
lrwx------ 1 sveta users 64 Nov 11 15:11 10 -> /data/ib_logfile1
lrwx------ 1 sveta users 64 Nov 11 15:11 11 -> /data/ibtmp1
lrwx------ 1 sveta users 64 Nov 11 15:11 12 -> /tmp/mysqld.1/ibx2zTxG (deleted
...
lrwx------ 1 sveta users 64 Nov 11 15:11 27 -> /data/sys/sys_config.ibd
l-wx------ 1 sveta users 64 Nov 11 15:11 28 -> /data/master-bin.000002
lrwx------ 1 sveta users 64 Nov 11 15:11 29 -> socket:[1245731]
lrwx------ 1 sveta users 64 Nov 11 15:11 3 -> /data/master-bin.index
...
lrwx------ 1 sveta users 64 Nov 11 15:11 5 -> /tmp/mysqld.1/ibT4odfr (deleted)
lrwx------ 1 sveta users 64 Nov 11 15:11 6 -> /tmp/mysqld.1/ibJoMdZu (deleted)
lrwx------ 1 sveta users 64 Nov 11 15:11 7 -> /tmp/mysqld.1/ibvUBeJy (deleted)
lrwx------ 1 sveta users 64 Nov 11 15:11 8 -> /tmp/mysqld.1/ibP6JxvC (deleted)
lrwx------ 1 sveta users 64 Nov 11 15:11 9 -> /data/ib_logfile0
```

Disk diagnostics

- InnoDB status

```
mysql> show engine innodb status\G
...
--------
FILE I/O
--------
I/O thread 0 state: waiting for i/o request (insert buffer thread)
I/O thread 1 state: waiting for i/o request (log thread)
I/O thread 2 state: waiting for i/o request (read thread)
I/O thread 3 state: waiting for i/o request (read thread)
I/O thread 4 state: waiting for i/o request (write thread)
I/O thread 5 state: waiting for i/o request (write thread)
Pending normal aio reads: [0, 0] , aio writes: [0, 0] ,
ibuf aio reads:, log i/o's:, sync i/o's:
Pending flushes (fsync) log: 0; buffer pool: 0
11468 OS file reads, 102 OS file writes, 17 OS fsyncs
11.80 reads/s, 16384 avg bytes/read, 0.00 writes/s, 0.00 fsyncs/s
...
```

Disk diagnostics

- InnoDB status

```
-------------
ROW OPERATIONS
-------------
0 queries inside InnoDB, 0 queries in queue
0 read views open inside InnoDB
Process ID=26676, Main thread ID=140424906065664, state: sleeping
Number of rows inserted 19, updated 0, deleted 0, read 5843307
0.00 inserts/s, 0.00 updates/s, 0.00 deletes/s, 1584.23 reads/s
```

Disk diagnostics

```
mysql> select OBJECT_SCHEMA, OBJECT_NAME, INDEX_NAME \
    -> from table_io_waits_summary_by_index_usage where COUNT_STAR=0;
+---------------+--------------+------------+
| OBJECT_SCHEMA | OBJECT_NAME  | INDEX_NAME |
+---------------+--------------+------------+
| employees     | departments  | PRIMARY    |
| employees     | departments  | dept_name  |
| employees     | dept_emp     | PRIMARY    |
| employees     | dept_emp     | emp_no     |
| employees     | dept_emp     | dept_no    |
| employees     | dept_manager | PRIMARY    |
| employees     | dept_manager | emp_no     |
| employees     | dept_manager | dept_no    |
| employees     | salaries     | PRIMARY    |
| employees     | salaries     | emp_no     |
| sys           | sys_config   | PRIMARY    |
+---------------+--------------+------------+
11 rows in set (0.00 sec)
```

Disk diagnostics

- sys.io_%

```
mysql> select event_name, count_read, total_read, total_requested \
    -> from io_global_by_wait_by_bytes;
+------------------------+------------+------------+-----------------+
| event_name             | count_read | total_read | total_requested |
+------------------------+------------+------------+-----------------+
| innodb/innodb_data_file|      17349 | 274.36 MiB | 289.22 MiB      |
| sql/binlog             |      16696 | 130.42 MiB | 130.42 MiB      |
| sql/io_cache           |       1556 | 37.61 MiB  | 100.49 MiB      |
| sql/FRM                |       1137 | 626.03 KiB | 626.03 KiB      |
| innodb/innodb_log_file |          8 | 132.50 KiB | 141.50 KiB      |
| sql/ERRMSG             |          3 | 72.23 KiB  | 72.23 KiB       |
| sql/query_log          |          0 | 0 bytes    | 44.02 KiB       |
| myisam/dfile           |         20 | 21.99 KiB  | 21.99 KiB       |
| mysys/charset          |          1 | 18.27 KiB  | 18.27 KiB       |
| myisam/kfile           |         24 | 6.62 KiB   | 6.62 KiB        |
| sql/file_parser        |          3 | 2.11 KiB   | 2.11 KiB        |
| sql/slow_log           |          0 | 0 bytes    | 1.64 KiB        |
| mysys/cnf              |          3 | 56 bytes   | 56 bytes        |
...
```

Disk diagnostics

- sys.io_%
- Other useful views
  - host_summary_by_file_io
  - host_summary_by_file_io_type
  - io_by_thread_by_latency
  - io_global_by_file_by_bytes - Per-file
  - io_global_by_file_by_latency
  - io_global_by_wait_by_bytes
  - io_global_by_wait_by_latency
  - latest_file_io - Latest IO operations
  - user_summary_by_file_io
  - user_summary_by_file_io_type

How to fix IO issues

- Optimize queries

- InnoDB options, affecting writes

- Binary log

How to fix IO issues

- Optimize queries
- InnoDB options, affecting writes
    - innodb_adaptive_flushing
    - innodb_doublewrite
    - innodb_flush_log_at_trx_commit
    - innodb_flush_method - Test!
    - innodb_io_capacity - Follow docs
    - innodb_max_dirty_pages_pct

How to fix IO issues

- Optimize queries
- Binary log
  - Formats
    - ROW
    - STATEMENT
    - MIXED
  - binlog_row_image
  - sync_binlog

CPU diagnostics

- top

- iostat

- ps

CPU diagnostics

- top

```
Tasks: 298 total,   2 running, 296 sleeping,   0 stopped,   0 zombie
%Cpu(s): 15.2 us,  2.7 sy,  1.8 ni, 79.4 id,  0.9 wa,  0.0 hi, 0.0 si, 0.0 st
KiB Mem:  16149184 total, 15075560 used,  1073624 free,     1596 buffers
KiB Swap: 2110460 total,      8252 used,  2102208 free.  9994956 cached Mem

  PID USER      PR  NI    VIRT    RES    SHR S  %CPU %MEM     TIME+ COMMAND
26676 sveta     20   0 1963204 155108  23300 S 100.0 0.960   0:43.73 mysqld
10365 sveta     20   0 3601524 1.555g 108488 S 25.00 10.10 224:21.91 firefox
29915 sveta     20   0   15476   2612   2120 R 12.50 0.016   0:00.02 top
...
```

CPU diagnostics

- iostat

```
sveta@thinkie:~/src/test-db/employees_db> iostat -x
Linux 3.16.7-92-desktop (thinkie)    11/11/2015    _x86_64_    (8 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
          14.47    1.77    2.54    0.94    0.00   80.28

Device: rrqm/s  wrqm/s    r/s     w/s    rkB/s    wkB/s avgrq-sz avgqu-sz ...
sda       0.28    0.70    4.66   21.59    93.69   346.10    33.51     4.14 ...
sdb       0.00    0.00    0.00    0.00     0.02     0.00    15.69     0.00 ...
```

CPU diagnostics

- ps

```
sveta@thinkie> ps -eo pid,user,comm,pcpu,pmem,vsz | grep mysqld
26676 sveta    mysqld              1.4  0.9 1963204
26678 sveta    mysqld              0.0  0.7 1765772
```

CPU: problem solving

- Low load
  - Is your mysqld really active?
  - Check OS limits
    - ulimit
    - User options
    - Global options
  - Increase concurrency-related options
    - innodb_thread_concurrency
    - innodb_read_io_threads
    - innodb_write_io_threads
    - Max (2 X (number of CPU cores))!
- High load
  - Move job to memory: increase buffers
  - Tune queries

Network: what is worth attention?

- Stability
- Bandwidth
- Speed
  - RTT

```
sveta@thinkie> ping www.percona.com -c 2
PING www.percona.com (74.121.199.234) 56(84) bytes of data.
64 bytes from www.percona.com (74.121.199.234): icmp_seq=1 ttl=54 time=18
64 bytes from www.percona.com (74.121.199.234): icmp_seq=2 ttl=54 time=18

--- www.percona.com ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 181.380/181.685/181.991/0.524 ms
```

Network:diagnostics

- –log-warnings=2

- Send huge file (1G or larger)

- tcpdump

- P_S.accounts, hosts, users

- P_S.host_cache

Network:diagnostics

- tcpdump

```
$tcpdump -i en1 host master.mysql.com and port 33051
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on en1, link-type EN10MB (Ethernet), capture size 96 bytes
22:28:12.195270 IP master.mysql.com.33051 > apple.60344: P
1752426772:1752426864(92) ack 1474226199 win 91 <nop,nop,timestamp 1939999898
649946687>
22:28:12.195317 IP apple.60344 > master.mysql.com.33051: . ack 92 win 65535
<nop,nop,timestamp 649946998 1939999898>
^C
2 packets captured
37 packets received by filter
0 packets dropped by kernel
```

Network:diagnostics

- P_S.accounts, hosts, users

```
mysql> select user, host, current_connections as cur, \
    -> total_connections as total from accounts;
+------+-----------+-----+-------+
| user | host      | cur | total |
+------+-----------+-----+-------+
| foo  | localhost | 0   | 3     |
| root | localhost | 1   | 3     |
| NULL | NULL      | 14  | 17    |
+------+-----------+-----+-------+
3 rows in set (0.01 sec)
```

Network:diagnostics

- P_S.host_cache

```
mysql> select IP, HOST, HOST_VALIDATED, SUM_CONNECT_ERRORS, \
    -> COUNT_NAMEINFO_PERMANENT_ERRORS,  COUNT_PROXY_USER_ERRORS, \
    -> COUNT_DEFAULT_DATABASE_ERRORS, FIRST_SEEN, LAST_SEEN from host_cache\G
*********************** 1. row ***********************
                             IP: 10.159.169.27
                           HOST: foo.bar.com
                 HOST_VALIDATED: YES
             SUM_CONNECT_ERRORS: 1
COUNT_NAMEINFO_PERMANENT_ERRORS: 0
        COUNT_PROXY_USER_ERRORS: 0
  COUNT_DEFAULT_DATABASE_ERRORS: 1
                     FIRST_SEEN: 2014-06-10 20:29:45
                      LAST_SEEN: 2015-11-11 15:32:44
```

More information

Further reading

- MySQL Troubleshooting book
- High Performance MySQL book
- Planet MySQL
- MySQL User Reference Manual
- Bug trackers
    - http://bugs.mysql.com
    - https://bugs.launchpad.net/percona-server/

Current Percona vacancies

www.percona.com/about-percona/careers

Place for your questions

???

Thank you!

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