ORACLE DevLive | Level Up | MySQL Summit

Top 10 tips for MySQL Performance Tuning

Configuration, best practices and tracking the ugly duckling

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Agenda

Top Ten Tips
Agenda

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2. Speeding up import

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4. Indexes
5. Parallel Index Creation

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6. The right config for the workload

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7. Consumption
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All about queries

9. Workload
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Importing Data
at speed of light !

Importing Data

For logical dumps, MySQL Shell Dump & Load Utility should be preferred over the old and single threaded mysqldump !

MySQL Shell Dump & Load can dump a full instance, one or multiple schemas or tables. You can also add a where clause.

This tool dumps and load the data in parallel !

The data can be stored on filesystem, OCI Object Storage, S3 and Azure Blob Storage.

```
JS > util.dumpInstance("/opt/dump/", {threads: 32})
```

Importing Data (2)

The dump can be imported into MySQL using util.loadDump().
loadDump() is the method used to load dumps created by:

- util.dumpInstance()
- util.dumpSchemas()
- util.dumpTables()

```
JS > util.loadDump("/opt/dump/", {threads: 32})
```


Importing Data – High Speed

We can speed up the process even more ! During an initial load, & the durability is not a problem, if there is a crash, the process can be restarted. Therefore, if the durability is not important, we can reduce it to speed up the loading even more.

We can disable binary logs, disable redo logs and tune InnoDB by altering a few settings.

Pay attention that disabling and enabling binary logs require a restart of MySQL.

```
start mysqld with --disable-log-bin

MySQL > ALTER INSTANCE DISABLE INNODB REDO_LOG;
MySQL > set global innodb_extend_and_initialize=OFF;
MySQL > set global innodb_max_dirty_pages_pct=10;
MySQL > set global innodb_max_dirty_pages_pct_lwm=10;
```

Importing Data – High Speed (2)

We can speed up the process even more ! During an initial load, the durability is not a problem, if there is a crash, the process can be restarted. Therefore, if the durability is not important, we can reduce it to speed up the loading even more.

We can disable binary logs, disable redo logs and tune some InnoDB settings.

Pay attention that disabling and enabling binary logs require a restart of MySQL.

```
2802 chunks (194.70M rows, 64.75 GB) for 1 tables in 1 schemas
were loaded in 4 min 51 sec (avg throughput 222.51 MB/s)
```

```
MySQL > ALTER INSTANCE DISABLE INNODB REDO_LOG;
MySQL > set global innodb_extend_and_initialize=OFF;
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```

Schema Design

primary keys
indexes, not too little, not too much

Primary Keys

For InnoDB, a Primary Key is required and a good one is even better !

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Some theory

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Some theory

InnoDB stores data in table spaces. The records are stored and sorted using the clustered index (PK).

All secondary indexes also contain the primary key as the right-most column in the index (even if this is not exposed). That means when a secondary index is used to retrieve a record, two indexes are used: first the secondary one pointing to the primary key that will be used to finally retrieve the record.

InnoDB Primary Key (2)

The primary key impact how the values are inserted and the size of the secondary indexes.

A non sequential PK can lead to many random IOPS.

InnoDB Primary Key (2)

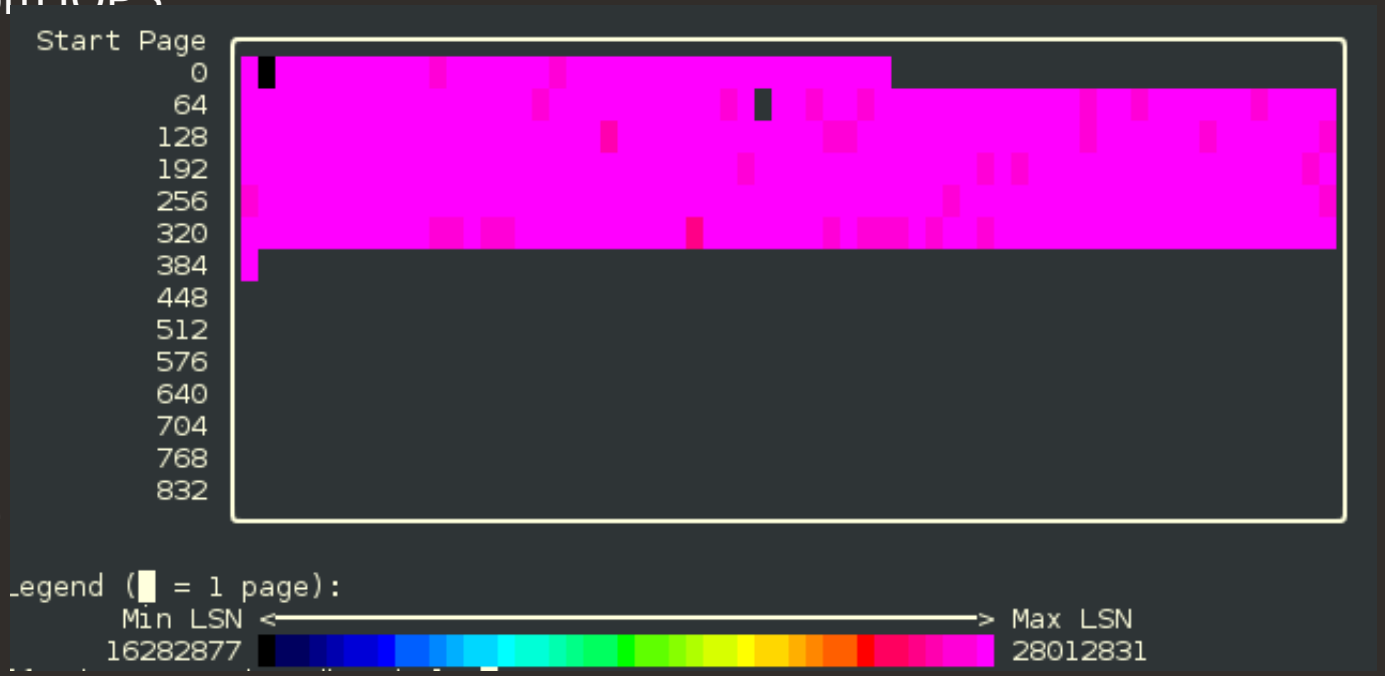
The primary key impact how the values are inserted and the size of the secondary indexes.

A non sequential PK can lead to many random IOPS

Also, it's more and more common to use application that generates complete random primary keys

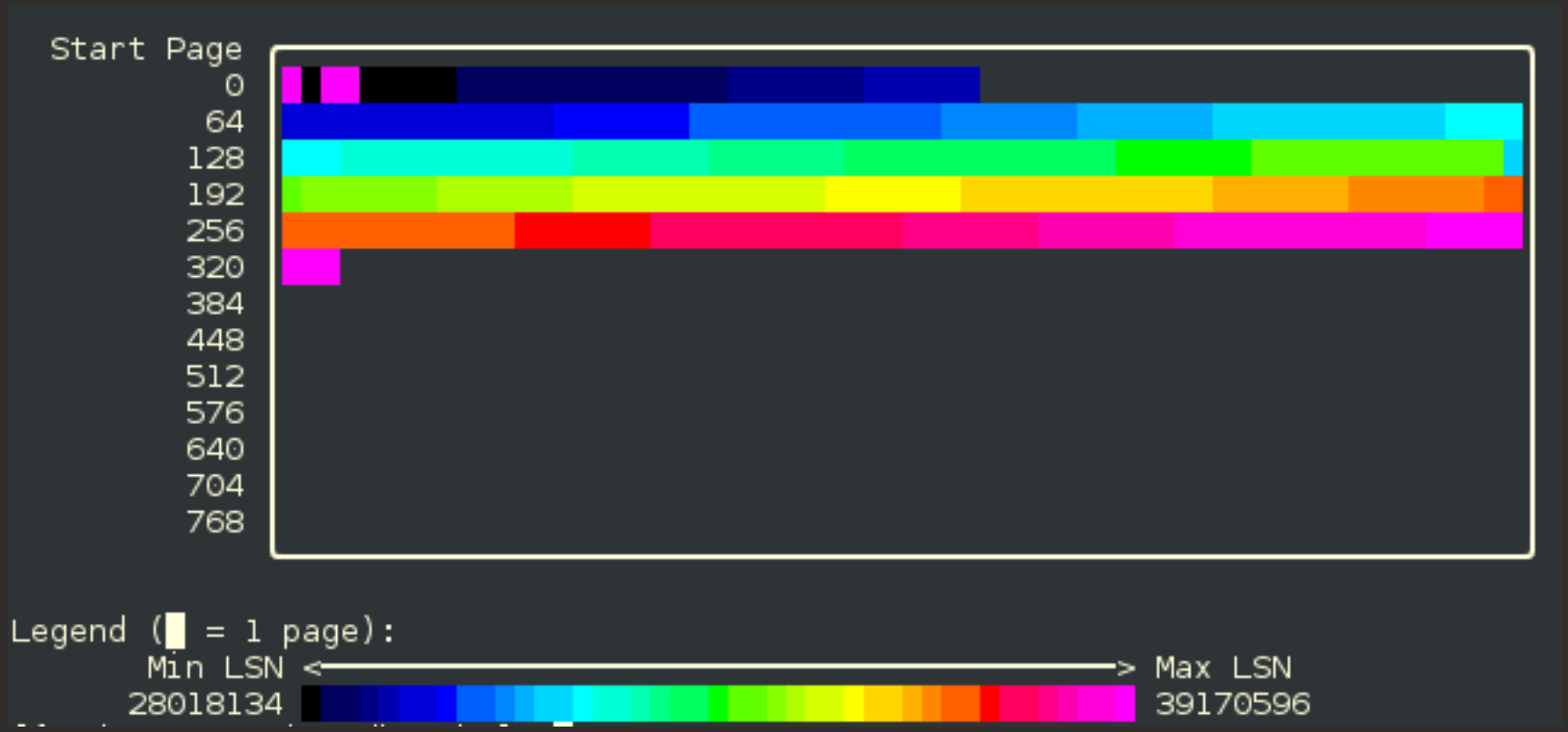
...that means if the Primary Key is not sequential,

InnoDB will have to heavily re-balance all the pages on inserts.



InnoDB Primary Key (3)

If we compare the same load (inserts) when using an auto_increment integer as Primary Key, we can see that only the latest pages are recently touched:



Generated with https://github.com/jeremycole/innodb_ruby from @jeremycole

InnoDB Primary Key ? No Key !

Another common mistake when using InnoDB is to not define any Primary Key.

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Another common mistake when using InnoDB is to not define any Primary Key.

When no primary key is defined, the first unique not null key is used.

And if none is available, InnoDB will create an hidden primary key (6 bytes).

InnoDB Primary Key ? No Key !

Another common mistake when using InnoDB is to not define any Primary Key.

When no primary key is defined, the first unique not null key is used.

And if none is available, InnoDB will create an hidden primary key (6 bytes).

The problem with such key is that you don't have any control of it and worse, this value is global to all tables without primary keys and can be a contention problem if you perform multiple simultaneous writes on such tables (**dict_sys->mutex**).

And if you plan for High Availability, tables without Primary Key are **not supported** !

InnoDB Primary Key ? No Key ! (2)

To identify those tables, run the following SQL statement, which is to lookup for GEN_CLUST_INDEX:

```
SELECT i.TABLE_ID,
      t.NAME
FROM INFORMATION_SCHEMA.INNODB_INDEXES i
JOIN
    INFORMATION_SCHEMA.INNODB_TABLES t ON (i.TABLE_ID = t.TABLE_ID)
WHERE
   i.NAME='GEN_CLUST_INDEX';
```

see https://elephantdolphin.blogspot.com/2021/08/finding-your-hidden-innodb-primary.html

InnoDB Primary Key ? No Key ! (2)

```
+----------+-------------------------+
| TABLE_ID | NAME                    |
+----------+-------------------------+
| 1198     | slack/some_table        |
| 1472     | test/default_test       |
| 1492     | test/t1                 |
| 2018     | world/orders            |
| 2019     | world/sales             |
| 2459     | dbt3/time_statistics    |
+----------+-------------------------+
```

InnoDB GIPK mode

Since MySQL 8.0.30, MySQL supports generated invisible primary keys when running in GIPK mode !

GIPK mode is controlled by the sql_generate_invisible_primary_key server system variable.

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GIPK mode is controlled by the sql_generate_invisible_primary_key server system variable.

When MySQL is running in GIPK mode, a primary key is added to a table by the server, the column and key name is always **my_row_id**.

InnoDB Primary Key ? No Key ! (2)

```
MySQL > SELECT @@sql_generate_invisible_primary_key;
+-----------------------------------------+
| @@sql_generate_invisible_primary_key |
+-----------------------------------------+
| 1 |
+-----------------------------------------+
MySQL > CREATE TABLE devlive (name varchar(20), beers int unsigned);
MySQL > INSERT INTO devlive VALUES ('kenny', 0), ('lefred',1);
MySQL > SELECT * FROM devlive;
+--------+-------+
| name   | beers |
+--------+-------+
| kenny  | 0     |
| lefred | 1     |
+--------+------+
```

InnoDB Primary Key ? No Key ! (2)

```
MySQL > SHOW CREATE TABLE devlive\G
*************************** 1. row ***************************
Table: devlive
Create Table: CREATE TABLE `devlive` (
`my_row_id` bigint unsigned NOT NULL AUTO_INCREMENT /*!80023 INVISIBLE */,
`name` varchar(20) DEFAULT NULL,
`beers` int unsigned DEFAULT NULL,
PRIMARY KEY (`my_row_id`)
) ENGINE=InnoDB AUTO_INCREMENT=3 DEFAULT CHARSET=utf8mb4
COLLATE=utf8mb4_0900_ai_ci
```

InnoDB Primary Key ? No Key ! (2)

```
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`my_row_id` bigint unsigned NOT NULL AUTO_INCREMENT /*!80023 INVISIBLE */,
`name` varchar(20) DEFAULT NULL,
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PRIMARY KEY (`my_row_id`)
) ENGINE=InnoDB AUTO_INCREMENT=3 DEFAULT CHARSET=utf8mb4
COLLATE=utf8mb4_0900_ai_ci
```

```
MySQL > SELECT *, my_row_id FROM devlive;
+--------+-------+-----------+
| name   | beers | my_row_id |
+--------+-------+-----------+
| kenny  | 0     | 1         |
| lefred | 1     | 2         |
+--------+-------+-----------+
```

InnoDB GIPK mode - example (3)

It's also possible to hide it completely (for some legacy application that could rely on informantion_schema and SHOW CREATE TABLE):

```
MySQL > SET show_gipk_in_create_table_and_information_schema = 0;
MySQL > SHOW CREATE TABLE devlive\G
*************************** 1. row ***************************
Table: devlive
Create Table: CREATE TABLE `devlive` (
`name` varchar(20) DEFAULT NULL,
`beers` int unsigned DEFAULT NULL
) ENGINE=InnoDB DEFAULT CHARSET=utf8mb4 COLLATE=utf8mb4_0900_ai_ci
```

Indexes, not too little, not too much - unused indexes

Having to maintain indexes that are not used can be costly and increase unnecessary iops.
Using sys Schema and innodb_index_stats it's possible to identify those unused indexes:

```
select database_name, table_name, t1.index_name,
format_bytes(stat_value * @@innodb_page_size) size
from mysql.innodb_index_stats t1
join sys.schema_unused_indexes t2 on
object_schema=database_name
and object_name=table_name and
t2.index_name=t1.index_name
where stat_name='size' order by stat_value desc;
```

Indexes, not too little, not too much - unused indexes

```
select database_name, table_name, t1.index_name,
format_bytes(stat_value * @@innodb_page_size) size
from mysql.innodb_index_stats t1
join sys.schema_unused_indexes t2 on object_schema=database_name
and object_name=table_name and t2.index_name=t1.index_name
where stat_name='size' and database_name="employees" order by stat_value
desc;
```

Drop Unused

```
+---------------+--------------+-----------------------+-----------+
| database_name | table_name   | index_name            | size      |
+---------------+--------------+-----------------------+-----------+
| employees     | employees    | hash_bin_names2       | 9.52 MiB  |
| employees     | employees    | month_year_hire_idx   | 6.52 MiB  |
| employees     | dept_emp     | dept_no               | 5.52 MiB  |
| employees     | dept_manager | dept_no               | 16.00 KiB |
+---------------+--------------+-----------------------+-----------+
4 rows in set (0.0252 sec)
```

Indexes, not too little, not too much - unused indexes

And this is the same behaviour for duplicate indexes.

There is no reason to keep maintaining them:

```
select t2.*, format_bytes(stat_value * @@innodb_page_size) size
from mysql.innodb_index_stats t1
join sys.schema_redundant_indexes t2
on table_schema=database_name and t2.table_name=t1.table_name
and t2.redundant_index_name=t1.index_name
where stat_name='size' order by stat_value desc\G
```

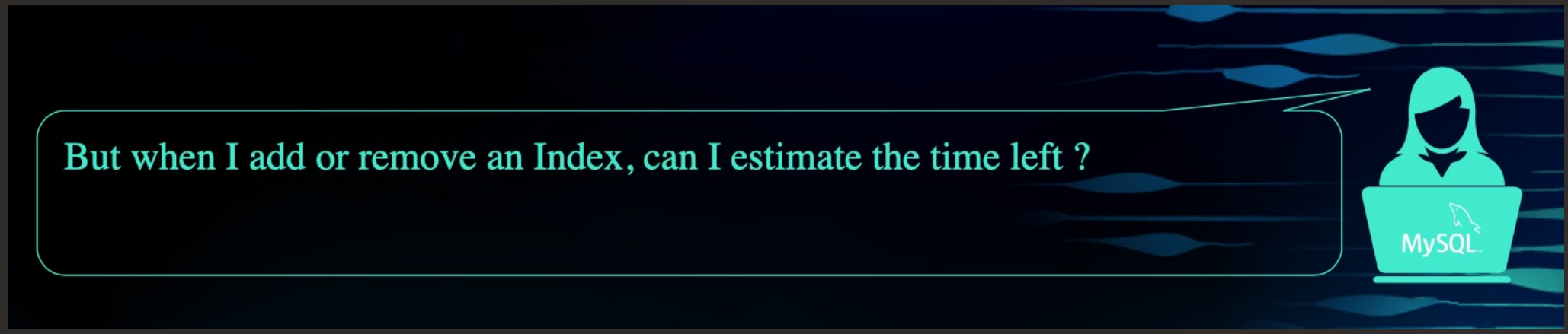
Duplicate Indexes

```
*************************** 1. row ***************************
table_schema: world
table_name: city
redundant_index_name: part_of_name
redundant_index_columns: Name
redundant_index_non_unique: 1
dominant_index_name: name_idx
dominant_index_columns: Name
dominant_index_non_unique: 1
subpart_exists: 1
sql_drop_index: ALTER TABLE `world`.`city` DROP INDEX `part_of_name`
size: 112.00 KiB
*************************** 2. row ***************************
table_schema: world
table_name: countrylanguage
redundant_index_name: CountryCode
redundant_index_columns: CountryCode
redundant_index_non_unique: 1
dominant_index_name: PRIMARY
dominant_index_columns: CountryCode,Language
dominant_index_non_unique: 0
subpart_exists: 0
sql_drop_index: ALTER TABLE `world`.`countrylanguage` DROP INDEX `CountryCode`
size: 64.00 KiB
2 rows in set (0.0330 sec)
```

Don't forget !

Do not take recommendations at face value, check before deleting an index.

Do not delete an index immediately, but first set it as INVISIBLE for some time. Once in a while this index might be used, like for a monthly report.



Monitoring an ALTER statements progress

```
select stmt.thread_id, stmt.sql_text, stage.event_name as state,
stage.work_completed, stage.work_estimated,
lpad(concat(round(100*stage.work_completed/stage.work_estimated, 2),"%"),10," ")
as completed_at,
lpad(format_pico_time(stmt.timer_wait), 10, " ") as started_ago,
lpad(format_pico_time(stmt.timer_wait/round(100*stage.work_completed/stage.work_estimated,2)*10
0),
10, " ") as estimated_full_time,
lpad(format_pico_time((stmt.timer_wait/round(100*stage.work_completed/stage.work_estimated,2)*1
00)
-stmt.timer_wait), 10, " ") as estimated_remaining_time,
current_allocated memory
from performance_schema.events_statements_current stmt
inner join sys.memory_by_thread_by_current_bytes mt
on mt.thread_id = stmt.thread_id
inner join performance_schema.events_stages_current stage
on stage.thread_id = stmt.thread_id\G
```

Monitoring an ALTER statements progress

For example

```
SQL > select stmt.thread_id, stmt.sql_text, stage.event_name as state,
                    stage.work_completed, stage.work_estimated,
                    lpad(concat(round(100*stage.work_completed/stage.work_estimated, 2),"%"),10," ")
                    as completed_at,
                    lpad(format_pico_time(stmt.timer_wait), 10, " ") as started_ago,
                    lpad(format_pico_time(stmt.timer_wait/round(100*stage.work_completed/stage.work_estimated,2)*100),
                         10, " ") as estimated_full_time,
                    lpad(format_pico_time((stmt.timer_wait/round(100*stage.work_completed/stage.work_estimated,2)*100)
                         -stmt.timer_wait), 10, " ") as estimated_remaining_time,
                    current_allocated memory
               from performance_schema.events_statements_current stmt
               inner join sys.memory_by_thread_by_current_bytes mt
                       on mt.thread_id = stmt.thread_id
               inner join performance_schema.events_stages_current stage
                       on stage.thread_id = stmt.thread_id\G
*************************** 1. row ***************************
               thread_id: 5169
                sql_text: alter table temperature_history add index time_idx(time_stamp)
                   state: stage/innodb/alter table (read PK and internal sort)
          work_completed: 607064
          work_estimated: 1303965
            completed_at:     46.56%
             started_ago:   4.30 min
     estimated_full_time:   9.24 min
estimated_remaining_time:   4.94 min
                  memory: 3.78 MiB
```

Missing indexes

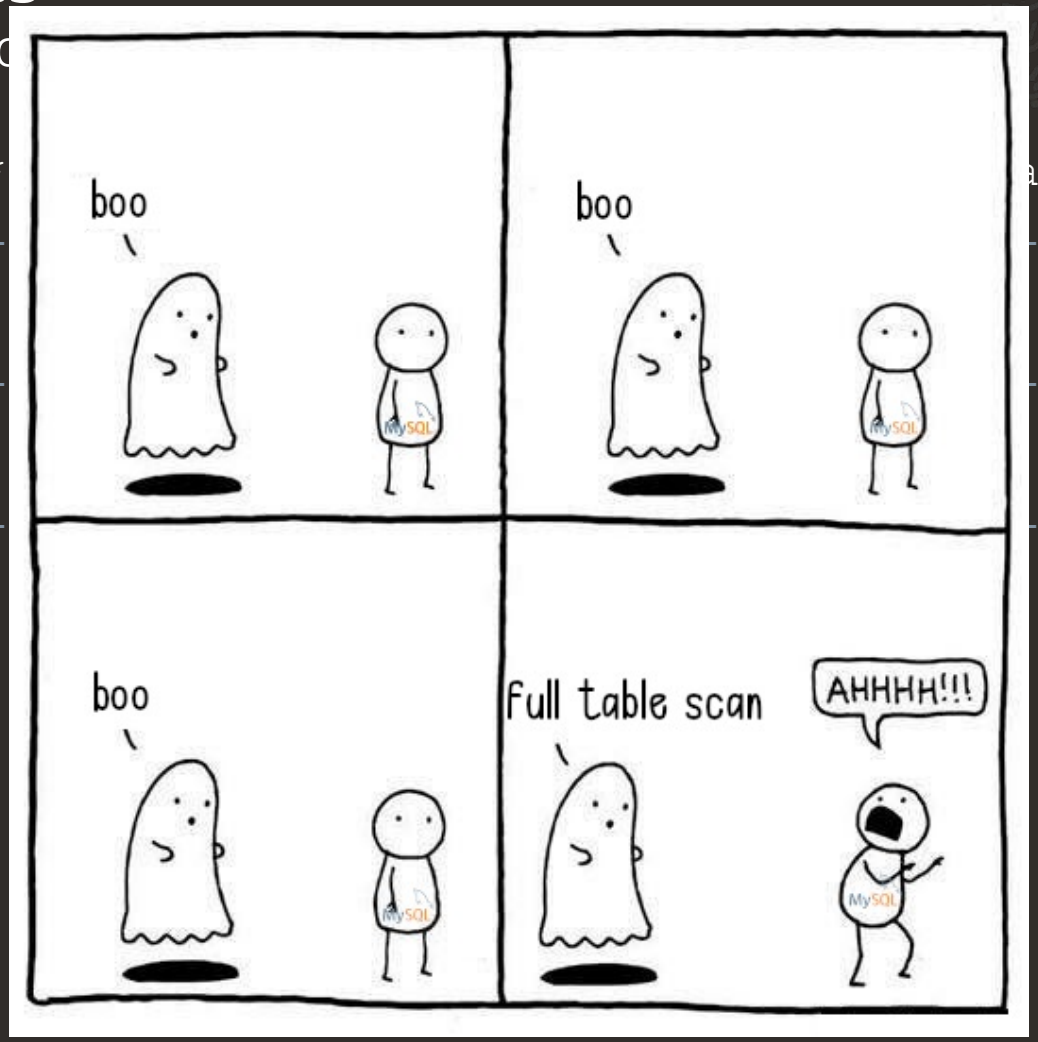
We also need to find which indexes might be missing:

```
MySQL > select * from sys.schema_tables_with_full_table_scans;
+---------------+-------------+--------------------+-------------+
| object_schema | object_name | rows_full_scanned  | latency     |
+---------------+-------------+--------------------+-------------+
| students      | Customers   | 12210858800        | 41.28 min   |
+---------------+-------------+--------------------+-------------+
```

Missing indexes

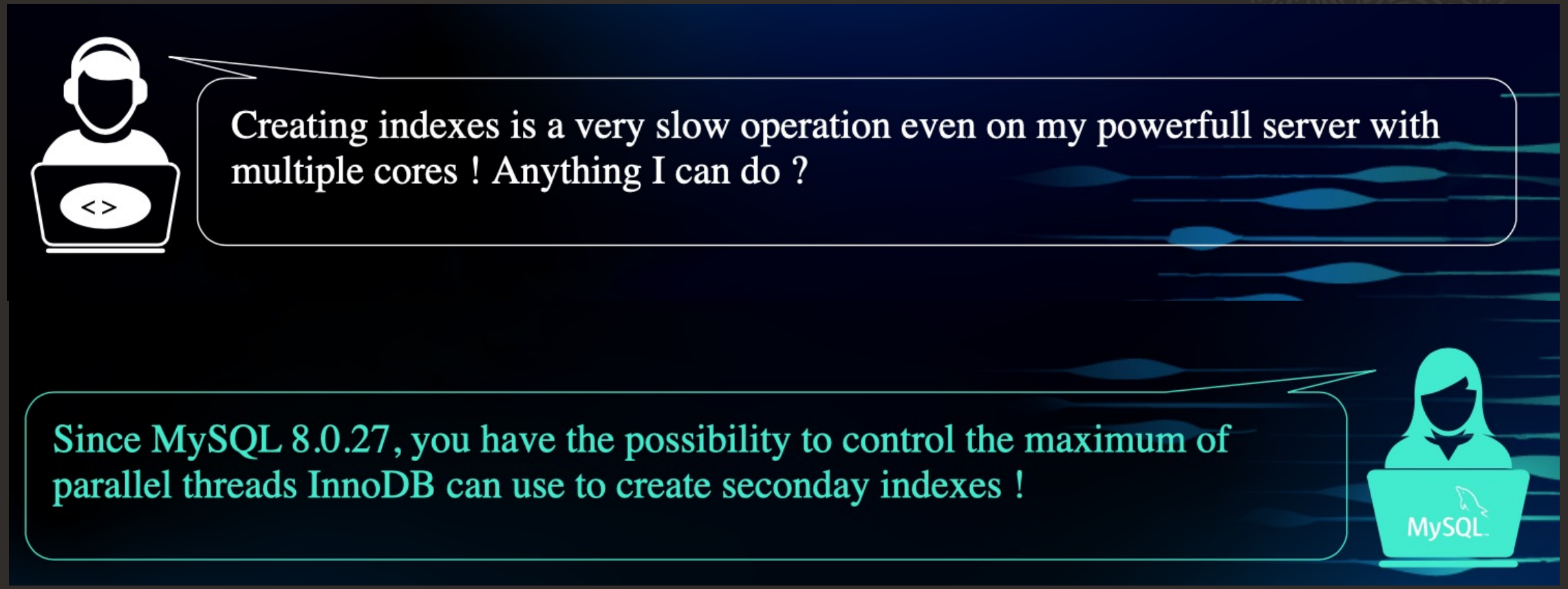
We also need to find

```
MySQL > select *                                                    able_scans;
+--------------                                                    ------------+------------+
| object_schema                                                     latency                  |
+--------------                                                    ------------+------------+
| students                                                          41.28 min                |
+--------------                                                    ------------+------------+
```



```
MySQL > select * from sys.statements_with_full_table_scans where db='students' and query like '%customers%'\G
*************************** 1. row ***************************
query: SELECT * FROM `Customers` WHERE `age` > ?
db: students
exec_count: 140
total_latency: 17.97s
no_index_used_count: 137
no_good_index_used_count: 0
no_index_used_pct: 100
rows_sent: 87220420
rows_examined: 12210858800
rows_sent_avg: 623003
rows_examined_avg: 2505942
first_seen: 23-01-27 14:34:12.66877
last_seen: 2023-02-23 17:44:47.738911
digest: 4396a7fc5d8f2cdc157b04bbd0543facaeaa5d4bb0ab02734b101ab5018a9b18
```

Index Creation is slow



Parallel Index Creation

The amount of parallel threads used by InnoDB is controlled by innodb_ddl_threads.

This new variable is coupled with another new variable: innodb_ddl_buffer_size.

If you have fast storage and multiple CPU cores,
tuning these variables can speed up secondary index creation.

Parallel Index Creation - example

```
MySQL > alter table booking
add index idx_2(flight_id, seat, passenger_id);
Query OK, 0 rows affected (9 min 0.6838 sec)
```


Parallel Index Creation - example

```
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add index idx_2(flight_id, seat, passenger_id);
Query OK, 0 rows affected (9 min 0.6838 sec)
```

The default settings are:

```
innodb_ddl_threads = 4
innodb_ddl_buffer_size = 1048576
innodb_parallel_read_threads = 4
```


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Query OK, 0 rows affected (9 min 0.6838 sec)
```

The default settings are:

```
innodb_ddl_threads = 4
innodb_ddl_buffer_size = 1048576
innodb_parallel_read_threads = 4
```

The **innodb_ddl_buffer_size** is shared between all **innodb_ddl_threads** defined.
If you increase the amount of threads, we recommend that you also increase the buffer size.

Parallel Index Creation - example (2)

To find the best values for these variables, let's have a look at the amount of CPU cores:

```
MySQL > select count from information_schema.INNODB_METRICS
where name = 'cpu_n';
+-------+
| count |
+-------+
| 16    |
+-------+
```

So we have **16 cores** to share.

As this machine has plenty of memory, we can allocate 1GB for the InnoDB DDL buffer.

Parallel Index Creation - example (3)

```
MySQL > SET innodb_ddl_threads = 8;
MySQL > SET innodb_parallel_read_threads = 8;
MySQL > SET innodb_ddl_buffer_size = 1048576000;
```

Parallel Index Creation - example (3)

```
MySQL > SET innodb_ddl_threads = 8;
MySQL > SET innodb_parallel_read_threads = 8;
MySQL > SET innodb_ddl_buffer_size = 1048576000;
```

We can now retry the same index creation as previously:

```
MySQL > alter table booking add index idx_2(flight_id, seat, passenger_id);
Query OK, 0 rows affected (2 min 43.1862 sec)
```


Parallel Index Creation - example (4)

Best to run tests to define the optimal settings for your database, your hardware and data.

For example, here we got the best result setting the buffer size to 2GB
and both ddl threads and parallel read threads to 4.

It took 2 min 43 sec, much better than the initial 9 minutes !

For more information, go to
https://lefred.be/content/mysql-8-0-innodb-parallel-threads-for-online-ddl-operations/

Configuration
when MySQL is configured to match the workload

The secret #1 is the size of InnoDB Buffer Pool

It's important to have the working set in memory.

The size of the InnoDB Buffer Pool is important:

```
MySQL > SELECT format_bytes(@@innodb_buffer_pool_size) BufferPoolSize,
FORMAT(A.num * 100.0 / B.num,2) BufferPoolFullPct,
FORMAT(C.num * 100.0 / D.num,2) BufferPollDirtyPct
FROM
(SELECT variable_value num FROM performance_schema.global_status
WHERE variable_name = 'Innodb_buffer_pool_pages_data') A,
(SELECT variable_value num FROM performance_schema.global_status
WHERE variable_name = 'Innodb_buffer_pool_pages_total') B,
(SELECT variable_value num FROM performance_schema.global_status
WHERE variable_name='Innodb_buffer_pool_pages_dirty') C,
(SELECT variable_value num FROM performance_schema.global_status
WHERE variable_name='Innodb_buffer_pool_pages_total') D;
```

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FROM
(SELECT vari
WHERE varia
(SELECT vari
WHERE variable_name = 'Innodb_buffer_pool_pages_total') B,
(SELECT variable_value num FROM performance_schema.global_status
WHERE variable_name='Innodb_buffer_pool_pages_dirty') C,
(SELECT variable_value num FROM performance_schema.global_status
WHERE variable_name='Innodb_buffer_pool_pages_total') D;
```

```
+----------------+--------------------+---------------------+
| BufferPoolSize | BufferPoolFullPct | BufferPollDirtyPct |
+----------------+--------------------+---------------------+
| 128.00 MiB     | 87.12              | 0.36                |
+----------------+--------------------+---------------------+
1 row in set (0.0012 sec)
```

The secret #1 is the size of InnoDB Buffer Pool (2)

We can also verify the Ratio of pages requested and read from disk:

```
MySQL > SELECT FORMAT(A.num * 100 / B.num,2) DiskReadRatioPct
FROM
(SELECT variable_value num FROM performance_schema.global_status
WHERE variable_name = 'Innodb_buffer_pool_reads') A,
(SELECT variable_value num FROM performance_schema.global_status
WHERE variable_name = 'Innodb_buffer_pool_read_requests') B;
+-----------------+
| DiskReadRatioPct |
+-----------------+
| 3.53             |
+-----------------+
```

Secret #2: InnoDB Redo Log

Too big or too small can affect perform

It's not recommended to oversize the Redo Log Capacity.

Redo Log files consume disk space and increases the recovery time in case of a restart (innodb_fast_shutdown=1) or a sudden crash.

And it also slows down shutdown when innodb_fast_shutdown=0.

Secret #2: InnoDB Redo Log - Recommendations

During peak traffic time, you can get an estimation of the required amount for the Redo Log Capacity by running the query below (all in one single line):

```
MySQL > SELECT VARIABLE_VALUE from performance_schema.global_status
WHERE VARIABLE_NAME='Innodb_redo_log_current_lsn' INTO @a;SELECT sleep(60)
INTO @garb ;SELECT VARIABLE_VALUE FROM performance_schema.global_status
WHERE VARIABLE_NAME='Innodb_redo_log_current_lsn' INTO @b;select
format_bytes(abs(@a - @b)) per_min, format_bytes(abs(@a - @b)*60) per_hour;
+-----------+----------+
| per_min   | per_hour |
+-----------+----------+
| 21.18 MiB | 1.24 GiB |
+-----------+----------+
```

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INTO @garb ;SELECT VARIABLE_VALUE FROM performance_schema.global_status
WHERE
format_
+--------
| per_min | per_hour |
+-----------+----------+
| 21.18 MiB | 1.24 GiB |
+-----------+----------+
```

```
MySQL > SET persist innodb_redo_log_capacity=1.24*1024*1024*1024;
```

Optimal InnoDB Configuration to start

On a dedicated MySQL Server,
the best is to let InnoDB decide the size of the Buffer Pool and the Redo Log Capacity.

In my.cnf:
innodb_dedicated_server=1

See https://dev.mysql.com/doc/refman/8.0/en/innodb-dedicated-server.html

Memory Consumption

How much memory and how to limit it

Memory - InnoDB

The secret is to always run a production server with a warm Buffer Pool.

If you need to restart MySQL for any reason (maintenance, updgrade, crash), it's recommended to dump the content of the InnoDB Buffer Pool to disk and load it at startup:

```
innodb_buffer_pool_dump_at_shutdown=1
innodb_buffer_pool_load_at_startup=1
```


Memory - InnoDB (2)

We can get the InnoDB Buffer Pool memory allocation usage with the following query:

```
MySQL > SELECT * FROM sys.memory_global_by_current_bytes
WHERE event_name LIKE 'memory/innodb/buf_buf_pool'\G
*************************** 1. row ***************************
event_name: memory/innodb/buf_buf_pool
current_count: 1
current_alloc: 130.88 MiB
current_avg_alloc: 130.88 MiB
high_count: 1
high_alloc: 130.88 MiB
high_avg_alloc: 130.88 MiB
1 row in set (0.0010 sec)
```


Memory - MySQL

From Performance_Schema (and sys) we can get information about the Memory consumption of MySQL, this instrumentation has been extended in MySQL 8.0:

```
SELECT * FROM sys.memory_global_total;
```

And you can have details related to the code area:

```
SELECT SUBSTRING_INDEX(event_name,'/',2) AS code_area,
format_bytes(SUM(current_alloc)) AS current_alloc
FROM sys.x$memory_global_by_current_bytes
GROUP BY SUBSTRING_INDEX(event_name,'/',2)
ORDER BY SUM(current_alloc) DESC;
```


```
+-----------------+
| total_allocated |
+-----------------+
| 4.28 GiB |
+-----------------+
```

code_area	current_alloc
memory/innodb	2.30 GiB
memory/group_rpl	1024.00 MiB.
memory/performance_schema	916.88 MiB
memory/sql	75.80 MiB
memory/mysys	9.13 MiB
memory/temptable	3.00 MiB
memory/mysqlx	22.42 KiB
memory/vio	3.16 KiB

Memory - Connections Tracking and Limiting

To avoid bad surprises (like swapping), it's possible to track and limit the memory consumption of the connections.

To enable it you need to set global_connection_memory_tracking to 1:

```
MySQL > SET global global_connection_memory_tracking=1;
```


Memory - Connections Tracking and Limiting

To avoid bad surprises (like swapping), it's possible to track and limit the memory consumption of the connections.

To enable it you need to set global_connection_memory_tracking to 1:

```
MySQL > SET global global_connection_memory_tracking=1;
```

You can limit the connection memory limit:

```
MySQL > SET <GLOBAL/SESSION> connection_memory_limit=2200000;
MySQL > SET GLOBAL global_connection_memory_limit=536870912000;
```


Memory - Connections Tracking and Limiting (2)

To know the Global Connection Consumption Memory:

```
MySQL > SELECT format_bytes(variable_value) global_connection_memory
FROM performance_schema.global_status
WHERE variable_name='Global_connection_memory';
+---------------------------+
| global_connection_memory |
+---------------------------+
| 16.22 MiB                 |
+---------------------------+
```


Memory - Connections Tracking and Limiting (3)

If the limit it reached, the user will be disconnected with the following error:

ERROR: 4081 (HY000): Connection closed. Global connection memory limit 16777216 bytes exceeded. Consumed 16949968 bytes.

This limitation doesn't appy to users with CONNECTION_ADMIN privilege.

Memory: better allocation = better performance !

To have better performance choosing the right memory allocator (Linux) is important !

The default memory allocator in Linux distribution (glibc-malloc) doesn't perform well in high concurrency environments and should be avoided !

Fortunately we have 2 other choices:

- jemalloc (good for perf, but less RAM management efficiency)
- tcmalloc (recommended choice)

Memory: better allocation = better performance ! (2)

Install tcmalloc:

```
$ sudo yum -y install gperftools-libs
```

And in systemd service file you need to add:

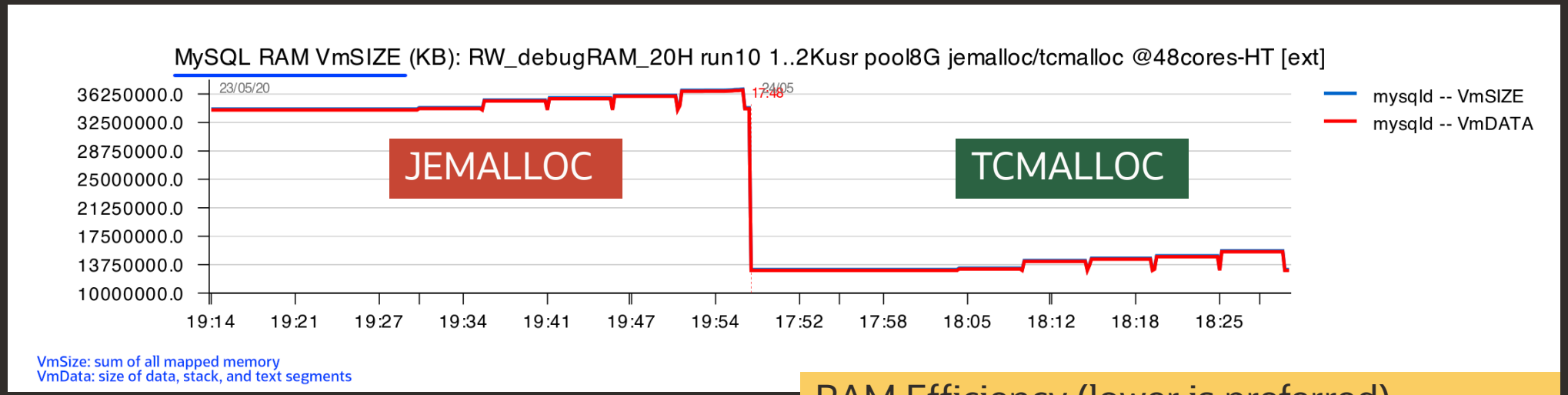
```
$ sudo EDITOR=vi systemctl edit mysqld
[Service]
Environment="LD_PRELOAD=/usr/lib64/libtcmalloc_minimal.so.4"
```


Memory: better allocation = better performance ! (3)

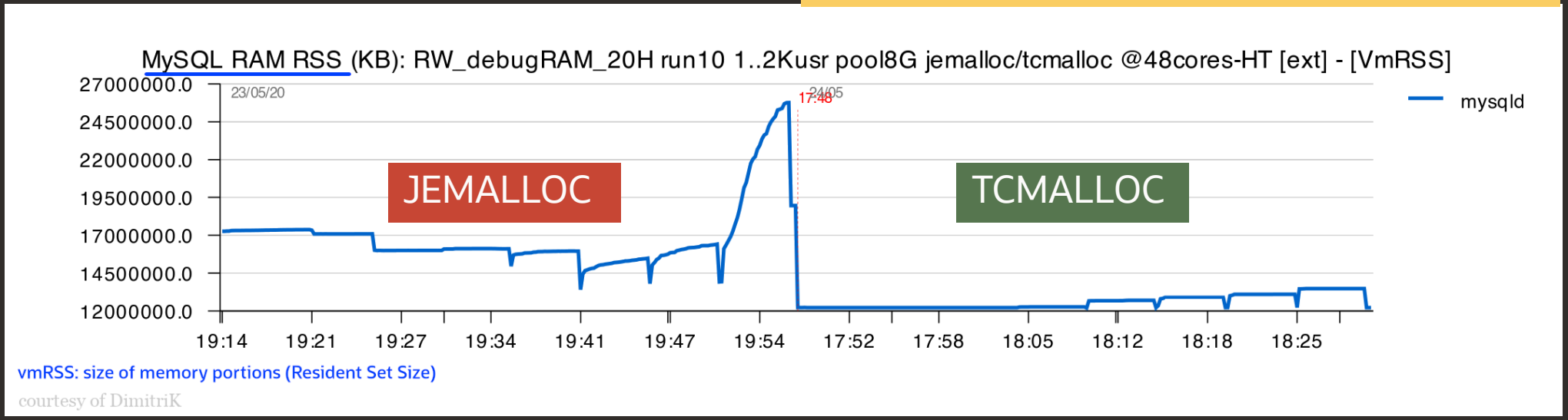
Reload the service and restart MySQL:
Memory Allocator: jemalloc vs tcmalloc:

```
$ sudo systemctl daemon-reload
$ sudo systemctl restart mysqld
```


Memory Allocator: jemalloc vs tcmalloc:



RAM Efficiency (lower is preferred)



courtesy of DimitriK

All about queries

everything you need to know about your queries

Know your workload !

It's important to know what type of workload your database is performing.
Most of the time, people are surprised with the result !

```
MySQL > SELECT SUM(count_read) `tot reads`,
CONCAT(ROUND((SUM(count_read)/SUM(count_star))*100, 2),"%") `reads`,
SUM(count_write) `tot writes`,
CONCAT(ROUND((SUM(count_write)/sum(count_star))*100, 2),"%") `writes`
FROM performance_schema.table_io_waits_summary_by_table
WHERE count_star > 0 ;
+-----------+--------+-------------+--------+
| tot reads | reads  | tot writes | writes |
+-----------+--------+-------------+--------+
| 16676217  | 99.11% | 149104     | 0.89%  |
+--------------+----------+---------------+-----------+
```

Know your workload ! (2)

```
MySQL > SELECT object_schema,
CONCAT(ROUND((SUM(count_read)/SUM(count_star))*100, 2),"%") `reads`,
CONCAT(ROUND((SUM(count_write)/SUM(count_star))*100, 2),"%") `writes`
FROM performance_schema.table_io_waits_summary_by_table
WHERE count_star > 0 GROUP BY object_schema;
+----------------------------+---------+---------+
| object_schema              | reads   | writes  |
+----------------------------+---------+---------+
| sys                        | 100.00% | 0.00%.  |
| mydb                       | 100.00% | 0.00%   |
| test                       | 100.00% | 0.00%   |
| docstore                   | 100.00% | 0.00%   |
| sbtest                     | 99.09%  | 0.91%   |
+----------------------------+---------+---------+
```


Know your workload ! (3)

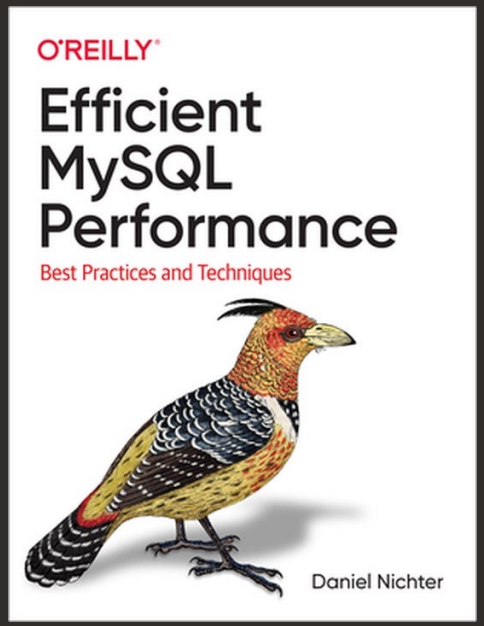
And we can check the statistics per table:

```
MySQL > SELECT object_schema, object_name,
CONCAT(ROUND((count_read/count_star)*100, 2),"%") `reads`,
CONCAT(ROUND((count_write/count_star)*100, 2),"%") `writes`
FROM performance_schema.table_io_waits_summary_by_table
WHERE count_star > 0 and object_schema='sbtest' ;
+---------------+-------------+--------+--------+
| object_schema | object_name | reads  | writes |
+---------------+-------------+--------+--------+
| sbtest        | sbtest1     | 99.67% | 0.33%  |
| sbtest        | sbtest2     | 97.71% | 2.29%  |
| sbtest        | sbtest3     | 97.71% | 2.29%  |
| sbtest        | sbtest4     | 97.73% | 2.27%  |
+-------------------+-----------------+-----------+----------+
```

Query Response time

Query response time is the only metric anyone truly cares about [...]
because query response time is the only metric we experience.
When a query takes 7.5 seconds to execute, we experience 7.5 seconds of impatience.

That same query might examine a million rows,
but we don't experience a million rows examined. Our time is precious.(*)



Daniel Nichter, Efficient MySQL Performance
- Best Practices and Techniques, O'Reilly, 2021

Finding the Ugly Duckling

We can define bad queries in two different categories:

- Queries called too often
- Queries that are too slow
  - Full table scan
  - Use filesort
  - Use temporary tables

If there could be only one?

If you should optimize only one query, the best candidate should be the query that consumes the most of the execution time (seen as latency in PFS, aka *"response time"*).

sys Schema contains all the necessary info to find that Ugly Duckling:

```
SELECT schema_name, format_pico_time(total_latency) tot_lat,
exec_count, format_pico_time(total_latency/exec_count) latency_per_call,
query_sample_text
FROM sys.x$statements_with_runtimes_in_95th_percentile AS t1
JOIN performance_schema.events_statements_summary_by_digest AS t2
ON t2.digest=t1.digest
WHERE schema_name NOT in ('performance_schema', 'sys')
ORDER BY (total_latency/exec_count) desc LIMIT 1\G
```

If there could be only one? And we have the biggest loser.

```
*************************** 1. row ***************************
schema_name: piday
tot_lat: 4.29 h
exec_count: 5
latency_per_call: 51.51 min
query_sample_text: select a.device_id, max(a.value) as `max temp`,
min(a.value) as `min temp`, avg(a.value) as `avg temp`,
max(b.value) as `max humidity`, min(b.value) as `min humidity`,
avg(b.value) as `avg humidity`
from temperature_history a
join humidity_history b on b.device_id=a.device_id
where date(a.time_stamp) = date(now())
and date(b.time_stamp)=date(now()) group by device_id
```


More info about Queries

Sys Schema contains all the required information in these tables :

- statements_with_full_table_scans
- statements_with_runtimes_in_95th_percentile
- statements_with_sorting
- statements_with_temp_tables

And since MySQL 8.0 you can join the
table **performance_schema.events_statements_summary_by_digest** to have a sample you can use.

Compare you QEP over time

Today's reality may not be tomorrow's.

SO - save the Query Execution Plan (EXPLAIN) of your queries and compare them over time, upgrades, ...

```
JS> qep-get ()
Enter the query (end it with ';*): select emp_no, first_name, last_name,
> hire_ date
> from employees
> where last _name like 'de%' limit 10;
The cost of the query is 30170.15
Do you want to have EXPLAIN output? (y/N) n
Do you want to have EXPLAIN in JSON format output? (Y/N) n
Do you want to have EXPLAIN in TREE format output? (y/N) y
    •> Limit: 10 row(s) (cost=30170.15 rows=10)
        •> Filter: (employees. Last _name like 'de%*) (cost=30170.15 rows=33261)
            •> Table scan on employees (cost=30170.15 rows=299379)
Do you want to have EXPLAIN ANALYZE output? (y/N) n
The schema 'ba' is missing, do you wanna create it? (y/N) y
Do you want to save the QEP? (y/N) y
```

Compare you QEP over time (2)

```
MySQL  130.61.46.6:6448+  employees  2022-03-17 14:00:57
JS \sql alter table employees alter index lastname_idx visible;
Query OK, 0 rows affected (0.0336 sec)

Records: 0  Duplicates: 0  Warnings: 0
MySQL  130.61.46.6:6448+  employees  2022-03-17 14:01:02
JS qep.get()
Enter the query (end it with ';'): select emp_no, first_name, last_name,
>        hire_date
>   from employees
>  where last_name like 'de%' limit 10;
The cost of the query is 2280.86
Do you want to have EXPLAIN output? (y/N)
Do you want to have EXPLAIN in JSON format output? (y/N)
Do you want to have EXPLAIN in TREE format output? (y/N)
Do you want to have EXPLAIN ANALYZE output? (y/N)
The last QEP saved for this query on 2022-03-17 13:00:57 had a cost of 30170.2
Do you want to compare with a previous QEP? (y/N) y
+-----+---------------------+-------------+--------------------+
| Num | Timestamp           |  Query Cost |            Version |
+-----+---------------------+-------------+--------------------+
|   1 | 2022-03-17 13:00:57 |     30170.2 |    8.0.28-u1-cloud |
+-----+---------------------+-------------+--------------------+
With which previous QEP do you want to compare? (1) 1
CURRENT:
--------
-> Limit: 10 row(s)  (cost=2280.86 rows=10)
    -> Filter: (employees.last_name like 'de%')  (cost=2280.86 rows=5068)
        -> Index range scan on employees using lastname_idx over ('de' <= last_n

PREVIOUS:
---------
-> Limit: 10 row(s)  (cost=30170.15 rows=10)
    -> Filter: (employees.last_name like 'de%')  (cost=30170.15 rows=33261)
        -> Table scan on employees  (cost=30170.15 rows=299379)
```

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