About the presenter

- Joined Pythian team in January 2015
- Worked with MySQL since 2008 (5.0) in both DBA and DBD roles
- Originally worked as SQL Server DBA
- Is originally from Detroit, but currently lives in the Greater Toronto Area.
- Social media
  - Twitter = @PeterTheDBA
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20 Years in Business

400+ Pythian Experts in 35 Countries

350+ Current Clients Globally
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MyRocks: Bird’s eye view

- Direct storage access to RocksDB
  - [Facebook project for MySQL Community 5.6](#)
  - Initially released May 2012
  - Based on LevelDB
- Log Structured Merge Key Value Store
- [Available in Percona Server 5.7 and MariaDB 10.3 (Beta)](#)
MyRocks: Why is this important?

- Percona announces in December 2018 Percona Server would deprecate the TokuDB engine and recommended use of MyRocks
- RocksDB has been at the center of emerging technologies
  - PingCAP / TiDB
  - CockroachDB
- RocksDB being made available as a storage engine for Cassandra
Basis of presentation

- Information was very difficult to find online, conducted my own research
- Converted my notes into a 7-part blog series on internals, focusing on
  - Data writing into memory
  - Flushing to disk
  - Compaction
  - Compression & Bloom Filters
  - Data Reads
  - Replication
  - Use case considerations

Focused on exposing mechanics by looking as system server and status variables, column family options, information_schema tables, and some performance schema instruments.
Basis of presentation

● What we’re covering today
● Mechanics at a high level: data in, data out
  ● Data writing into memory / Flushing to disk
  ● Compaction
  ● Compression & Bloom Filters
  ● Data Reads
● Crucial variables and metrics for each section listed above
● Use Case Considerations
● Q&A, time permitting

This is only going to cover the basics. Please see the blog series for full details.
MyRocks: Row -> Key Value

- **Key**
  - Internal Index ID
  - Explicitly defined primary key
- **Value**
  - Non-primary key columns

Handy Link: [MyRocks record format](http://myrocks.com)
MyRocks: Column Families

Multiple tables and secondary indexes can belong to the same column family.

```
CREATE TABLE `t1` (
  `c1` int(10) unsigned NOT NULL AUTO_INCREMENT,
  `c2` char(255) NOT NULL,
  PRIMARY KEY (`c1`) COMMENT 'cf_t1'
) ENGINE=ROCKSDB DEFAULT CHARSET=latin1
```

Recommendation from Facebook team is not to create more than 20 column families.
MyRocks: CF Configuration Considerations

MySQL Configuration Scope

- Global
- Session

MyRocks Configuration Scope

- Global
- Session
- Column Family Option
  - Typically configured with variable rocksdb_default_cf_options

Important distinction when you can have multiple column families each with their own memory caches.
MyRocks: Data Format objective

Create a series of data files that each store a non-overlapping range of keys, making for a faster lookup.
Initial data writing: Start Writing to Memtable
Initial data writing: Memtable is full!
Initial data writing
Initial data writing: Important variables / options

- CF_OPTION write_buffer_size

This is the size of each memtable.

Active tables and immutable memtables are the same size.

**Default:** 64 Mb
Initial data writing: Important variables / options

- **CF_OPTION min_write_buffer_number_to_merge**

How many immutable memtables should be created before that first flush to disk will occur.

Impacts flushing rate, flushing size, and also how much memory will be consumed.

**Default:** 1

Currently this option doesn’t appear to change anything. I have opened up a bug with Percona in regard to this. Bug [PS-5437](https://example.com/ps-5437)
Initial data writing: Important variables / options

- Rocksdb_db_write_buffer_size

  Maximum amount of memory that can be consumed by active memtables across all column families

  **Default:** 0 (no limit)

  Highly recommended to set this to a non-zero value.
Initial data writing: Important variables / options

- Rocksdb_max_total_wal_size

  Maximum amount of disk space that can be consumed by active write ahead logs across all column families

  **Default:** 0 (no limit)

  Highly recommended to leave this at 0. Hitting the limit will force a flush of all memtables so that a new WAL can be created.
Initial data writing: Associated Metrics

- System status variables (show global status output)
  - Rocksdb_memtable_total
    - Current amount of memory currently being consumed by memtables
  - Rocksdb_stall_memtable_limit_slowdowns / stops
    - Number of times MyRocks has has to stop or throttle writes due to hitting the maximum number of allowable memtables

- information_schema.ROCKSDB_CFSTATS table
  - CUR_SIZE_ACTIVE_MEM_TABLE
    - The current size of all active memtables per column family
  - NUM_ENTRIES_ACTIVE_MEM_TABLE
    - The number of record changes in the active memtables per column family
  - NUM_ENTRIES_IMM_MEM_TABLES
    - The number of record changes in the immutable memtable(s) per column family
What happens after the initial flush? Compaction!
Compaction
Compaction

L0

SST File
Records: 100 - 250

SST File
Records: 0 - 150

Selects

Compaction

L1

SST File
Records: 0 - 100

SST File
Records: 101 - 200

SST File
Records: 201 - 300
Compaction
Compaction

L0

SST File Records: 100 - 250
SST File Records: 0 - 150

Deletes

L1

SST File Records: 0 - 100
SST File Records: 101 - 200
SST File Records: 0 - 200
SST File Records: 201 - 300

Deletes

Compaction
Compaction

L0
SST File Records: 100 - 250

L1
SST File Records: 0 - 200
SST File Records: 201 - 300
Compaction
Compaction: Important variables / options

- CF_OPTION Level0_file_num_compaction_trigger

  The maximum number of files in L0 before compaction to L1 is triggered

  **Default:** 4 (256Mb max)
Compaction: Important variables / options

- CF_OPTION Max_bytes_for_level_base

The maximum number of bytes in L1 before compaction to L2 is triggered

**Default:** 268435456 (256Mb)
Compaction: Important variables / options

- CF_OPTION Max_bytes_for_level_multiplier

Make N compaction layer X times larger than N-1

Default: 10

L2: 2.5 Gig
L3: 25 Gig
L4: 250 Gig
L5: 2.44 Tb
L6: 24.41 Tb
Compaction: Important variables / options

- CF OPTION Num_levels

Maximum number of compaction layers

**Default:** 7 (L0 - L6)
Compaction: Important variables / options

- CF_OPTIONS Target_file_size_base & Target_file_size_multiplier

This sets the size of the files at each layer of compaction

L0 = Size of deduplicated memtables

L1 = Size of Target_file_size_base

L2+ = Size of N-1 layer multiplied by Target_file_size_multiplier

Default: 64Mb / 1 (respectively). All files will be 64Mb
Compaction: Important variables / options

- **Rocksdb_max_background_jobs**

  Number of threads can be used for table flushing and compaction

  Used to be separate variables

  **Default:** 2

  I would recommend increasing given the intended multithreaded approach to compaction in RocksDB
Compaction: Important variables / options

- Rocksdb_max_subcompactions

Number of ‘subthreads’ used to support each compaction thread

**Default:** 1

Given the single threaded nature of L0 -> L1 compaction, I would recommend increasing this variable.
Compaction: Associated Metrics

● System status variables (show global status output)
  ● Rocksdb_stall_l0_file_count_limit_slowdowns / stop
    ■ Number of times MyRocks has has to stop or throttle writes due to L0 being close to full since last MySQL restart
    ■ Check out [this wiki entry on write stalling](https://example.com) for a lot more info

● information_schema.ROCKSDB_CFSTATS table
  ● COMPACTION_PENDING
    ■ Shows the current number of pending compaction requests

● Additional information_schema tables
  ● ROCKSDB_COMPACTION_STATS
  ● ROCKSDB_DDL
  ● ROCKSDB_INDEX_FILE_MAP
We’ve got several copies of our data… how do we manage this effectively?

- Compression
- Bloom filters
Bloom Filters

- Space efficient data structure used to assist with the determination of set membership
Bloom Filters: Important variables / options

- **CF_OPTION Block_based_table_factory: Filter_policy**

  Enables bloom filtering

  **Default:** NULL (disabled)

  Has a strange configuration requirement

  ```
  rocksdb_default_cf_options=block_based_table_factory={filter_policy=
  bloomfilter:10:false}
  ```
Bloom Filter: Associated Metrics

- System status variables (show global status output)
  - Rocksdb_bloom_filter_useful
    - Number of times a bloom filter resulted in the avoidance of a data read
Compression

- Can use multiple forms of compression
  - kZSTD
  - kXpressCompression
  - kLZ4HCCompression
  - kLZ4Compression
  - kBZip2Compression
  - kZlibCompression
  - kSnappyCompression
## Compression

```
[root@centos7-1 .rocksdb]# cat ./LOG | grep -A 10 "Compression algorithms supported"
2019/03/01-09:28:38.437724 7ff6cfd44880 Compression algorithms supported:
2019/03/01-09:28:38.437727 7ff6cfd44880 kzZSTDNotFinalCompression supported: 1
2019/03/01-09:28:38.439318 7ff6cfd44880 kZSTD supported: 1
2019/03/01-09:28:38.439324 7ff6cfd44880 kXpressCompression supported: 0
2019/03/01-09:28:38.439326 7ff6cfd44880 kLZ4HCCompression supported: 1
2019/03/01-09:28:38.439327 7ff6cfd44880 kLZ4Compression supported: 1
2019/03/01-09:28:38.439329 7ff6cfd44880 kBZip2Compression supported: 0
2019/03/01-09:28:38.439330 7ff6cfd44880 kZlibCompression supported: 1
2019/03/01-09:28:38.439332 7ff6cfd44880 kSnappyCompression supported: 0
2019/03/01-09:28:38.439339 7ff6cfd44880 Fast CRC32 supported: Supported on x86
```
Compresses
- 3 - 4x better than InnoDB uncompressed
- 2x better than InnoDB compressed

Can be applied...
- Per column family
- Per compaction level

Recommended configuration
- No compression at L0 & L1 so there is as little overhead with initial flushes and first compaction. Remember, L0 -> L1 compaction is single threaded
- Moderate compression for >= L2, kLZ4
- High compression for bottom most compaction layer L6, kZSTD
Compression: Important variables / options

- CF_OPTION Compression
- CF_OPTION Bottommost_compression
- CF_OPTION Compression_per_level

Allow for compressing at various levels of compaction

Default: NULL (disabled)

--options
compression=kLZ4Compression;
bottommost_compression=kZSTD;
compression_per_level=kNoCompression:kNoCompression:kLZ4Compression:kLZ4
Compression:kLZ4Compression:kLZ4Compression:kZSTD;
Compression: A word from your speaker
Data Reading

Read Process → Found in Block Cache? → Read From → Block Cache → Storage Engine Result Data

No → Immutable Memtable(s) → Found in Memtables?

No → Persistant Data Storage (Table Data) → Load Into

No → Load Into
Data Reading

Read Process
Read ID: 200

Reads

L0

SST File
Records:
100 - 250

SST File
Records:
0 - 150
Data Reading
Data Reading
Data Reads: Important variables / options

- Rocksdb_block_cache_size

Primary data cache for reads

**Default:** 512Mb

Recommended to be 60 - 75% of available system physical memory

Can be disabled temporarily using Rocksdb_skip_fill_cache dynamically
Data Reads: Important variables / options

- Rocksdb_sim_cache_size

Provides hit / miss ratio if the block cache was the size of Rocksdb_sim_cache_size. Only costs 2% of the designated value.

**Default:** 0 (disabled)

Ever wondered how much larger your read cache would have to be if you wanted a better hit rate? Ever get a constant 99.9% hit rate and wonder how much memory could be used for another part of the database engine?

Disadvantage: Non-dynamic variable
Data Read: Associated Metrics

● System status variables (show global status output)
   ● Rocksdb_block_cache_data_hit / Rocksdb_block_cache_data_miss
     ■ Block cache hit ratio
   ● Rocksdb_get_hit_l0 / Rocksdb_get_hit_l1 / Rocksdb_get_hit_l2_and_up
     ■ Hit rate of various compaction layers. Are you hitting frequently updated data?
   ● Rocksdb_bytes_read / Rocksdb_block_cache_bytes_read
     ■ How much data did I have to pull from disk?

● SHOW ENGINE ROCKSDB STATUS
   ● Rocksdb.sim.block.cache.hit
   ● Rocksdb.sim.block.cache.miss
MyRocks Use Case Considerations

Ok, I know how it works, but is it right for me? 😐
MyRocks Use Case Considerations: Advantages

- **Compression**
  - Can be configured all the way down to the compaction layer for each column family
  - Can use more or less aggressive compression, you’re not stuck with a single compression algorithm
  - Remember that there is more to a storage engine than just how well it compresses!
MyRocks Use Case Considerations: Advantages

- Write Optimized
  - Compaction = Deferred write amplification

MyRocks: Get the data in the system initially as fast as possible and then organize it later

vs

InnoDB: Organize the data on entry to evenly optimize for read requests
MyRocks Use Case Considerations: Advantages

- Better performance when working with active data sets that are larger than the amount of available system memory

Image Credit: Percona / Vadim Tkachenko
MyRocks Use Case Considerations: Advantages

- Backups

Percona xtrabackup supports MyRocks AND InnoDB in its 8.0.6 release
MyRocks Use Case Considerations: Disadvantages

- Range Lookups
  - Bloom filters are oriented for point lookup
  - Prefix bloom filters are available
  - RocksDB does have better scanning capabilities. Read more about it in [this blog post](https://example.com) on why CockroachDB selected RocksDB to be their underlying storage engine.
MyRocks Use Case Considerations: Disadvantages

- Reduced MySQL functionality
  - No Online DDL
  - No Foreign Keys
  - No Transportable Tablespaces
  - No Select for update when using repeatable read isolation level
MyRocks Use Case Considerations: When to use it?

- A large OLTP dataset where your active data set doesn’t fit into memory
- Write intensive workloads
- High concurrency reads that don’t filter on range
Conclusion

- What we’re covering today
- Mechanics at a high level: data in, data out
  - Data writing into memory / Flushing to disk
  - Compaction
  - Compression & Bloom Filters
  - Data Reads
- Crucial variables and metrics for each section listed above
- Use Case Considerations
Questions?
Thank You

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