MySQL

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MySQL 5.7 Performance: Scalability & Benchmarks

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Are you Dimitri?.. ;-)

- Yes, it's me :-)
- Hello from Paris! ;-)
- Passionated by Systems and Databases Performance
- Previous 15 years @Sun Benchmark Center
- Started working on MySQL Performance since v3.23
- But during all that time just for “fun” only ;-)
- Since 2011 “officially” @MySQL Performance full time now
- http://dimitrik.free.fr/blog / @dimitrik_fr

Agenda

- Overview of MySQL Performance
- Performance improvements in MySQL 5.7 & Benchmark results
- Pending issues..
- Q & A
- As well may be not exactly in the proposed order ;-)

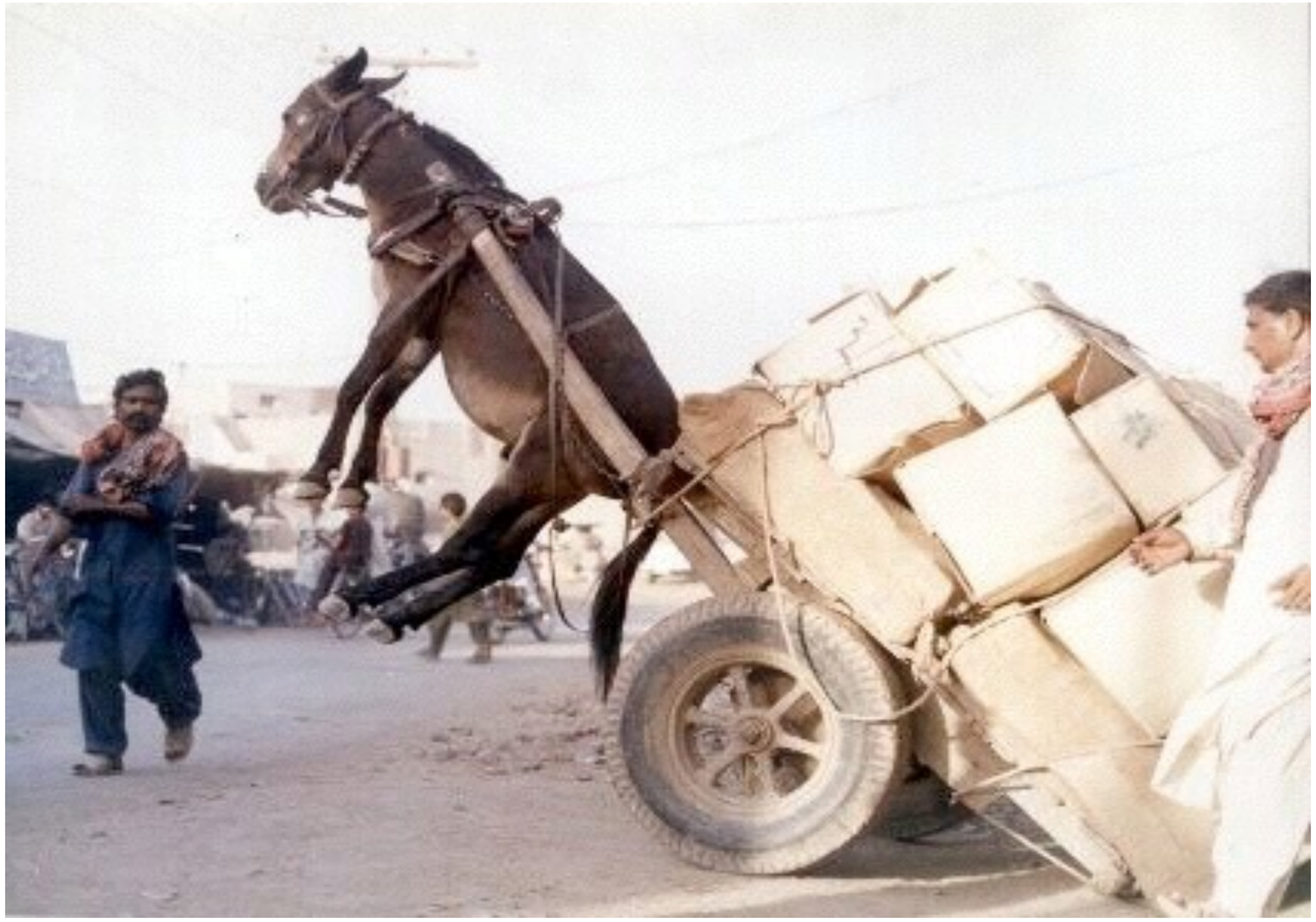
Why MySQL Performance ?...

Why MySQL Performance ?..

- Any solution may look “good enough”...

Why MySQL Performance ?..

- Until it did not reach its limit..



Why MySQL Performance ?..

- And even improved solution may not resist to increasing load..

Why MySQL Performance ?..

- And reach a similar limit..

Why MySQL Performance ?..

- Analyzing your workload performance and testing your limits may help you to understand ahead the resistance of your solution to incoming potential problems ;-)

Why MySQL Performance ?..

- However :
  - Even a very powerful solution but leaved in wrong hands may still be easily broken!... :-)

The MySQL Performance Best Practice #1 is... ???..

The MySQL Performance Best Practice #1 is... ???..

USE YOUR BRAIN !!!... ;-)

The MySQL Performance Best Practice #1 is... ???..

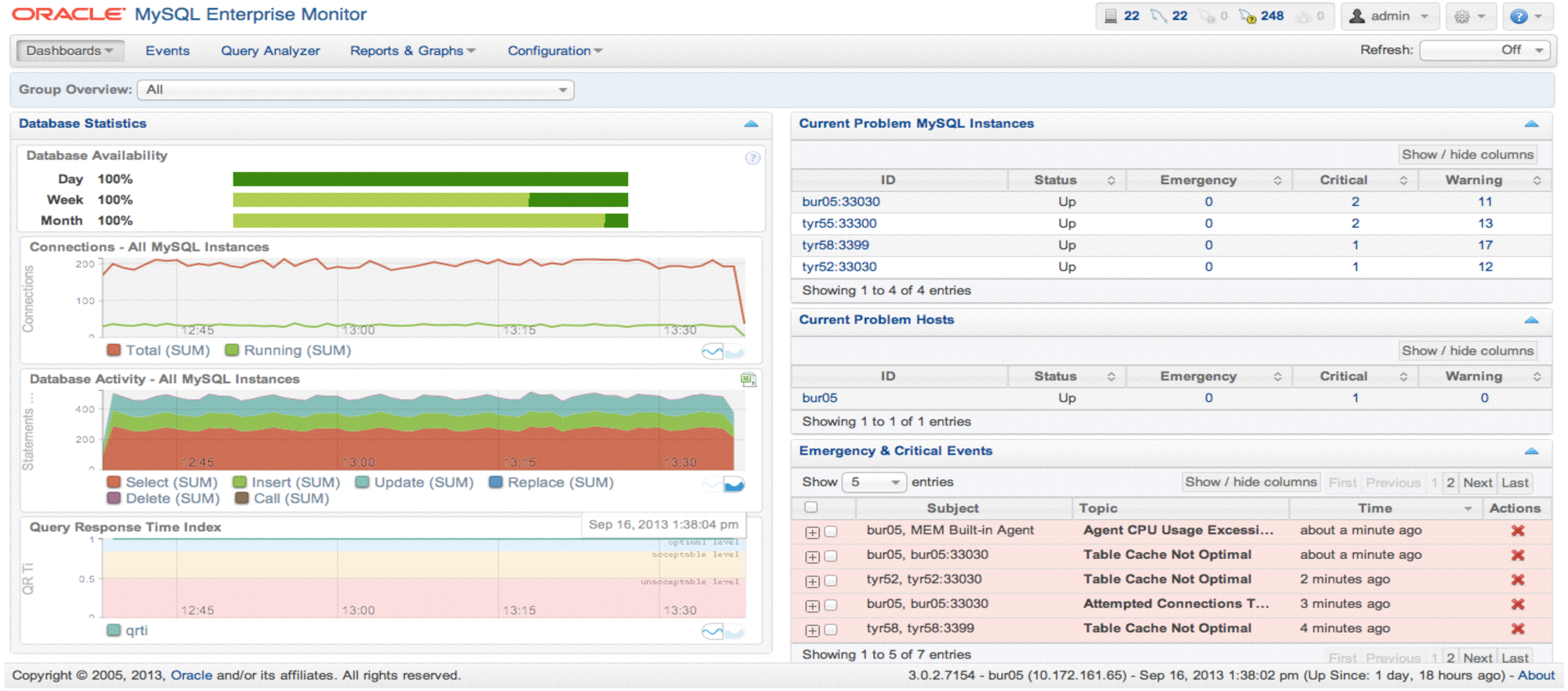
USE YOUR BRAIN !!!... ;-)

#2 - Monitoring is THE MUST !

even don’t start to touch anything
without monitoring.. ;-)

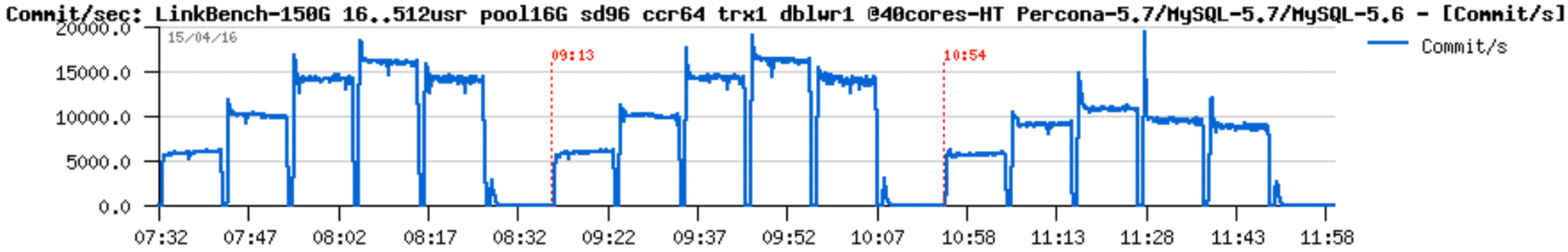
MySQL Enterprise Monitor

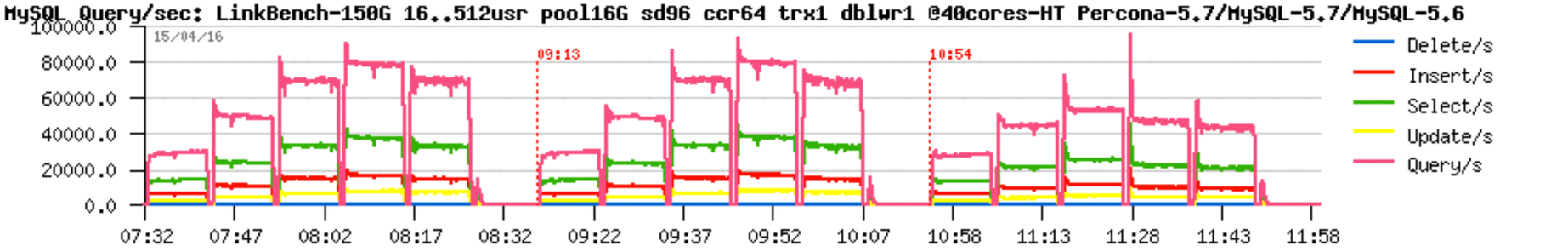
- Fantastic tool!
  - Did you already try it?.. Did you see it live?..



Other Monitoring Tools

- Cacti, Zabbix, Nagios, Solarwinds, etc…..
- *dim_STAT*
  - well, I'm using this one, sorry ;-)
  - all graphs within presentation were made with it
  - details are in the end of presentation..





A Word about Monitoring…

- **always** validate the impact of your Monitoring on your Production ;-)
- taking 1sec measurements is fine, except :
  - if it's eating 100% CPU time on one or more CPU cores..
  - reducing your network traffic / latency..
  - eats your RAM, etc.
- avoid to be too much intrusive on MySQL/InnoDB internals..
  - you may easily create an additional overhead
  - as well you may add artificial locks on your workflow
    - for ex: run in loop "show processlist", etc..
- well, nothing is coming for free, so **think** about what you're doing !
- (#1 best practice once again ;-))

The following materials are about…

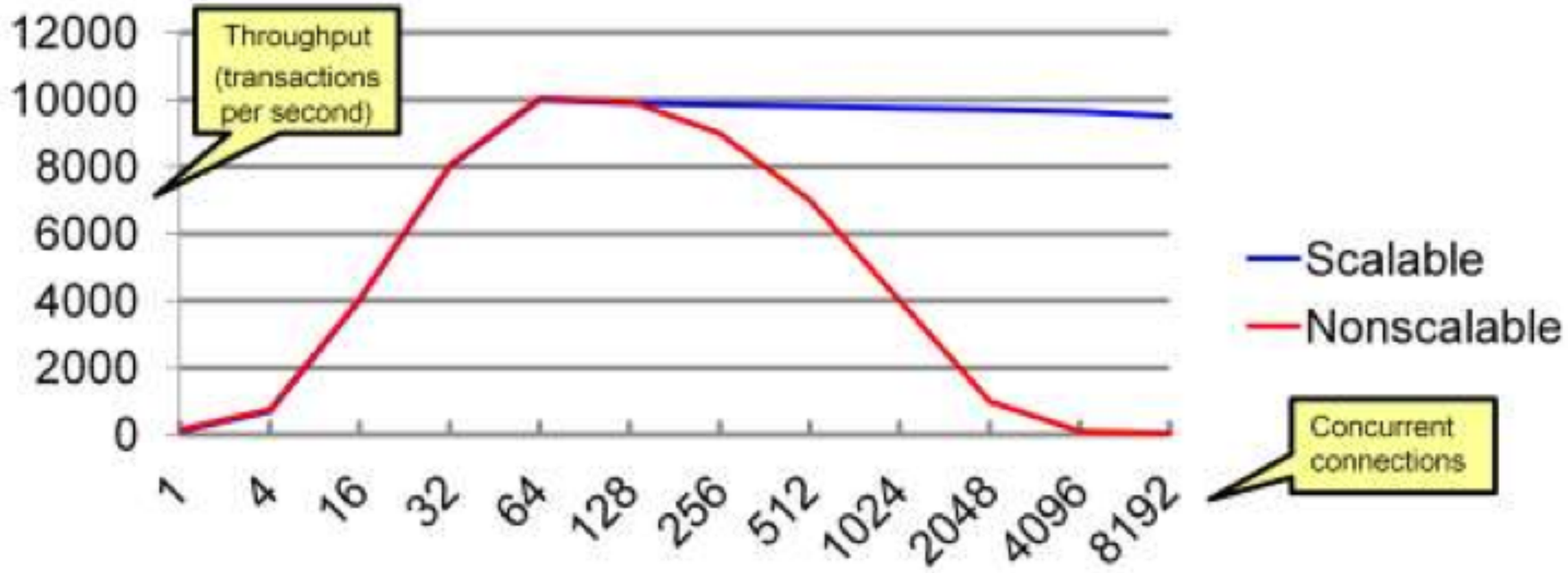
- Single MySQL Instance Performance & Scalability
  - single HW host
  - no replication
  - just to understand how far MySQL Server may scale..
  - what are the limits
  - what to care about ahead
  - which situations are absolutely to avoid.
- NOTE:
  - this talk is mainly focused on **benchmark results** as for Apr.2016
  - all details about related tuning are tomorrow

Why Scalability ?..

- CPU Speed : no more "free lunches" ;-)
  - will x2 times faster CPU increase your performance by x2 ?..
- CPU cores : more and more over year-to-year..
  - Intel 2CPU : 8cores-HT
  - Intel 2CPU : 12cores-HT
  - Intel 2CPU : 16cores-HT
  - Intel 2CPU : 20cores-HT
  - Intel 2CPU : 36cores-HT (2015)
  - intel 2CPU : 44cores-HT (March 2016)..
  - …
- Scalability In Few Words :
  - your software is able to deliver a **higher** throughput if more HW resources are available..
  - (then, scaling it well or not is another story ;-))

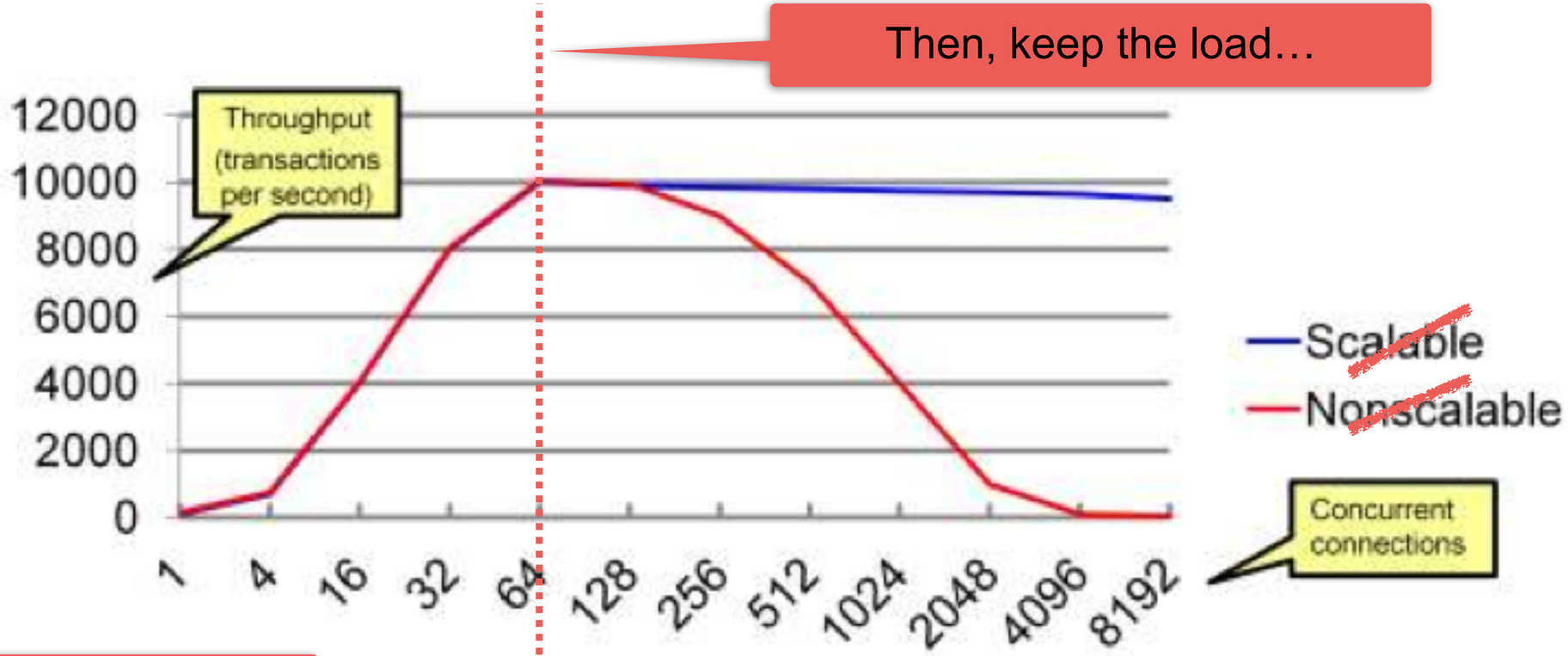
A B-shit Slide…

- Odd interpretation of Scalability…



A B-shit Slide… (2)

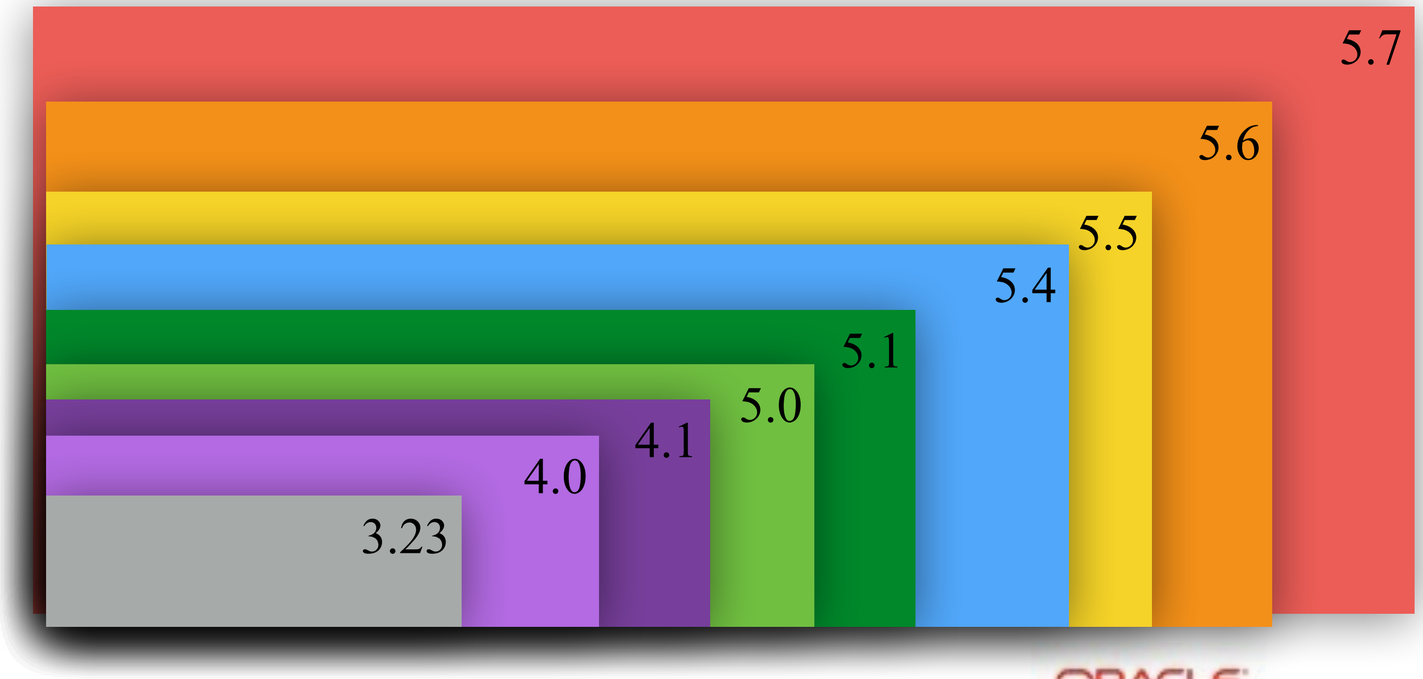
- Odd interpretation of Scalability…



Both are scaling up to 64 connections,
but only one is able to keep a higher load..

MySQL Performance Evolution

- From version-to-version :
  - 3.23 => 4.0 => 4.1 => 5.0 => 5.1 => 5.4 => 5.5 => 5.6 => 5.7 …
  - more features => longer code path.. (see: “What is new in MySQL 5.7” by Geir, Morgan,..)
  - MySQL/InnoDB code is very sensible to CPU cache(s)..
  - single user / low load => going slower..
- Looking back :
  - Drizzle !
  - do you know Drizzle ?
  - do you use Drizzle ?
  - do you run your production on ?



MySQL Performance Evolution

- From
  - 3.23
  - more
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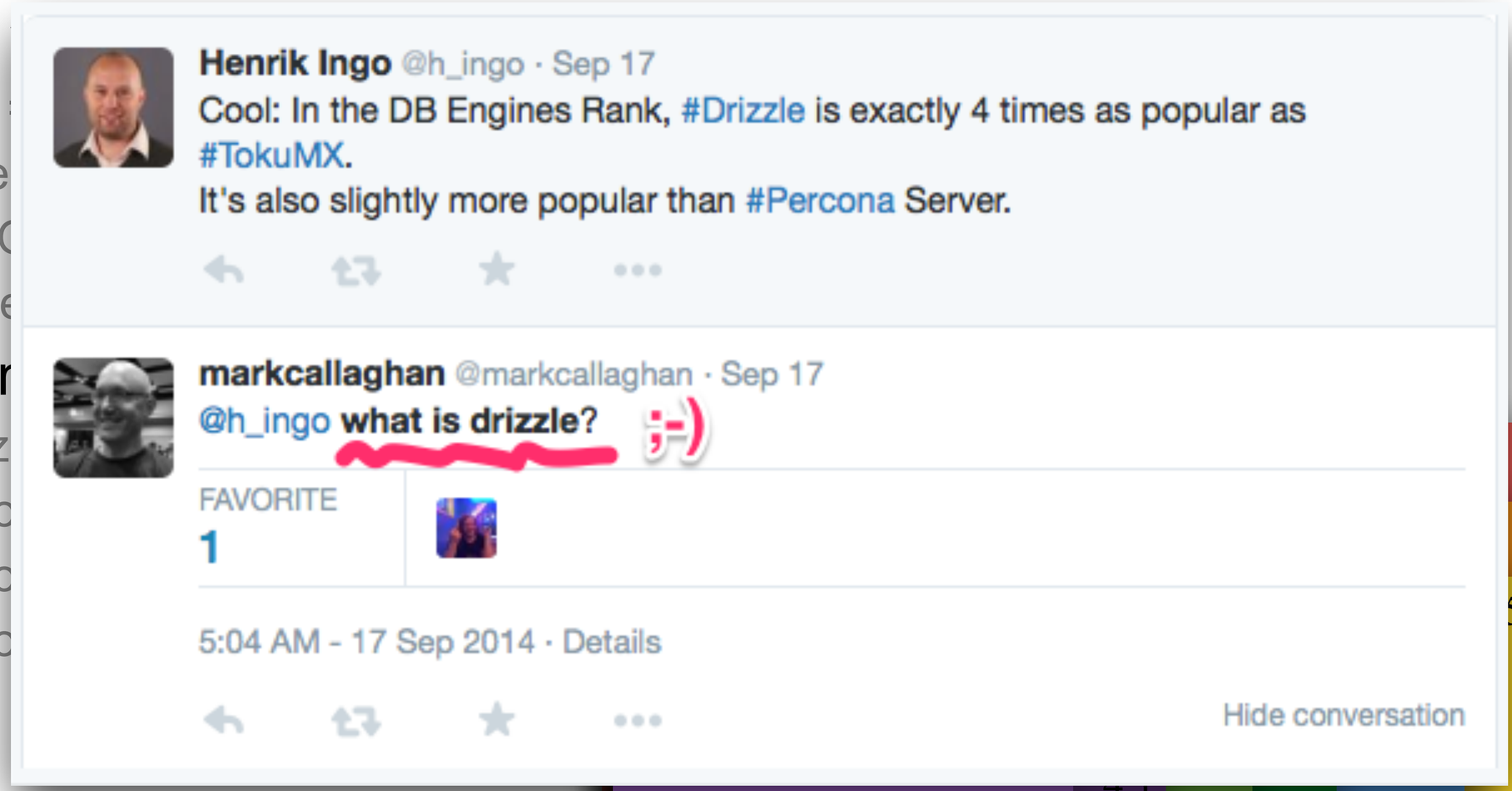
r, Morgan,..)



Performance Investigation Efforts (relative)

- report a problem..
- point on the source of the problem..
- suggest what should be fixed..
- suggest **how** it should be fixed…
- **implement** the final fix…

“Don’t Trust Benchmarks !!!” ;-)

- You were told this already, right ?
- Well, generally it’s true..
- But my own you can trust ;-))
  - (kidding ;-))
- Seriously :
  - #1 you should not base your conclusions on a single benchmark result
  - #2 to be able to evaluate the result you’re seeing, you first have to understand the benchmark workload and its impact on database engine..
- Usually the obtained numbers itself are less important comparing to what is behind the numbers ;-))
  - some “industrial” benchmarks may not spell at al to a final user..
  - MySQL Performance is not yet there ;-))
  - **most MySQL Benchmarks today are rather focused on problem resolving !**

Benchmarking & Tuning : Why & What ?

- Why Benchmarks ?..
  - the last thing you should do is to validate your tuning tweaks on live production ;-)
  - rather take a time to create a test case to reproduce the problem
  - then test the fix on “dev” (or “benchmark”) server(s)..
- The best Benchmark Workload for you ?
  - the Benchmark reproducing your own production conditions !
  - the collection of your production test cases may quickly become your own Benchmark Suite to validate any tuning or HW changes impact..
- If you don’t have :
  - adopt “standard” / existing benchmark workload
  - test your tuning, your HW, your database Engine
  - try to adapt the workload conditions to be more close to your production
  - etc..

Test Workload

- Before to jump into something complex...
  - Be sure first you're comfortable with “basic” operations!
  - Single table? Many tables?
  - Short queries? Long queries?
- Remember: any complex load in fact is just a mix of simple operations..
  - So, try to split problems..
  - Start from as simple as possible..
  - And then increase complexity progressively..
- NB : **any** test case is important !!!
  - Consider the case rather reject it with “I’m sure you’re doing something wrong..” ;-))

“Generic” Test Workloads @MySQL

- Sysbench <= “Entry Ticket”
  - OLTP, RO/RW, N-tables, lots test workload load options, deadlocks
- DBT2 / TPCC-like
  - OLTP, RW, very complex, growing db, no options, deadlocks
  - In fact using mostly only 2 tables! (thanks Performance Schema ;-))
- dbSTRESS
  - OLTP, RO/RW, several tables, one most hot, configurable, no deadlocks
- iiBench
  - pure INSERT (time series) + SELECT
- LinkBench (Facebook)
  - OLTP, RW, very intensive, IO-hungry..
- DBT3
  - DWH, RO, complex heavy query, loved by Optimizer Team ;-)

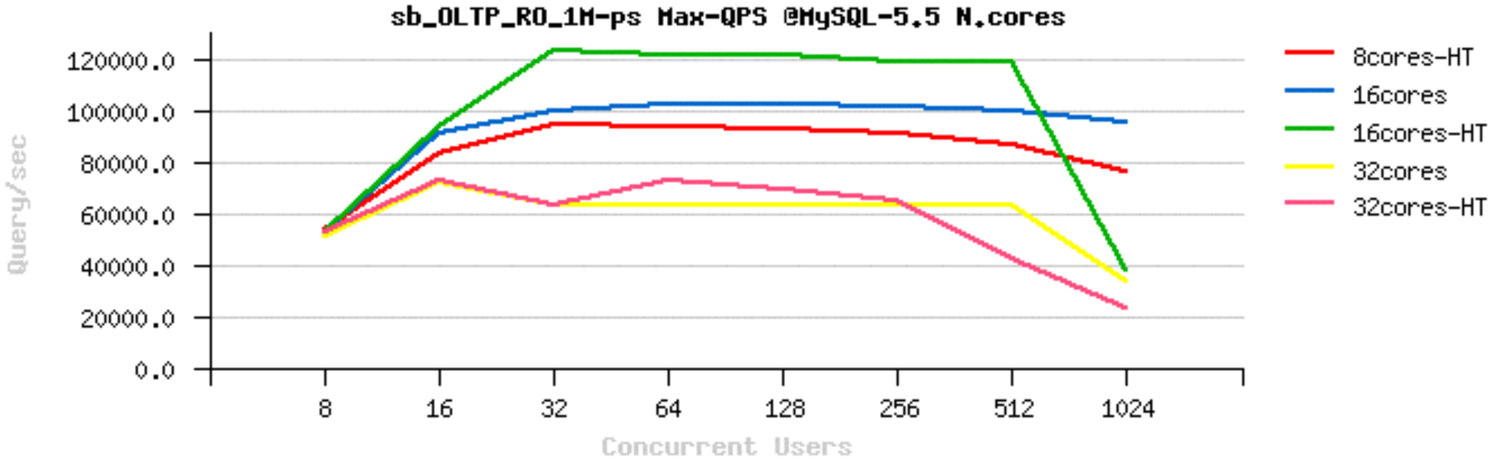
Testing Workloads: from a more Simple to more Complex

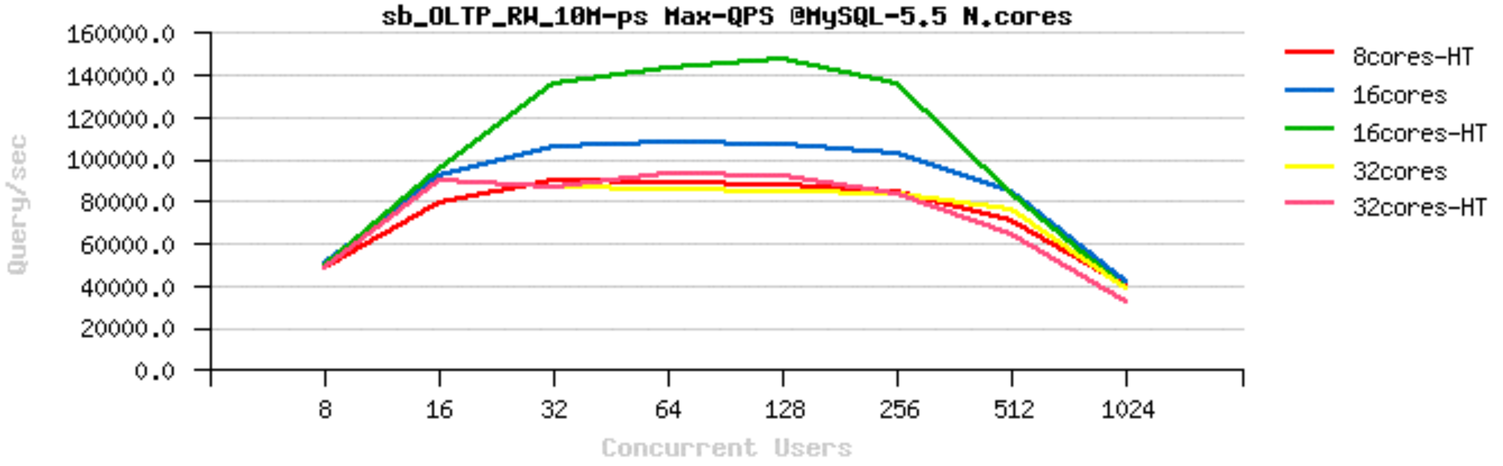
- Read-Only (RO) :
  - Nothing more simple when comparing DB Engines, HW configs, etc..
  - RO In-Memory : data set fit in memory / BP / cache
  - RO IO-bound : data set out-passing a given memory / BP / cache
- Read+Write (RW) :
  - I/O is **ALWAYS** present ! - storage performance matters a lot !
  - may be considered as always IO-bound ;-)
  - RW In-Memory : same as RO, data set fit in memory, but :
    - small data set => small writes
    - big dataset => big writes ;-)
  - RW IO-bound : data set out-passing a memory
    - means there will be (a lot of?) reads !
- NOTE : Random Read (RR) operation is the main IO-bound killer !!!

Why so much attention to RO Performance in MySQL 5.7 ?..

From where we're coming with MySQL 5.7 ?..

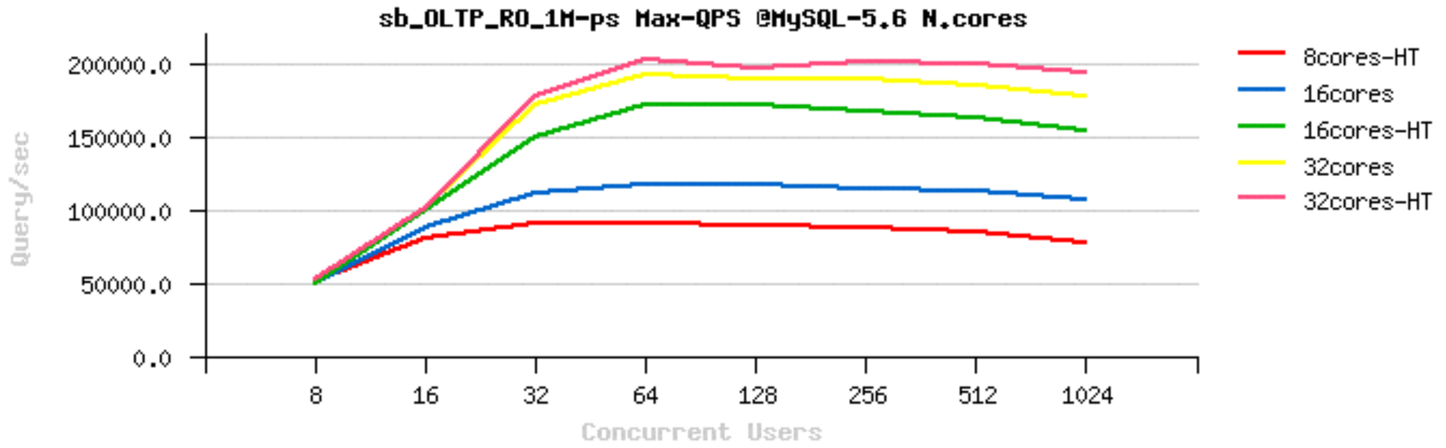
- MySQL 5.5 : RO & RW
  - QPS Max on 16cores
  - worse on 32cores
  - Note: RW out-pass RO!

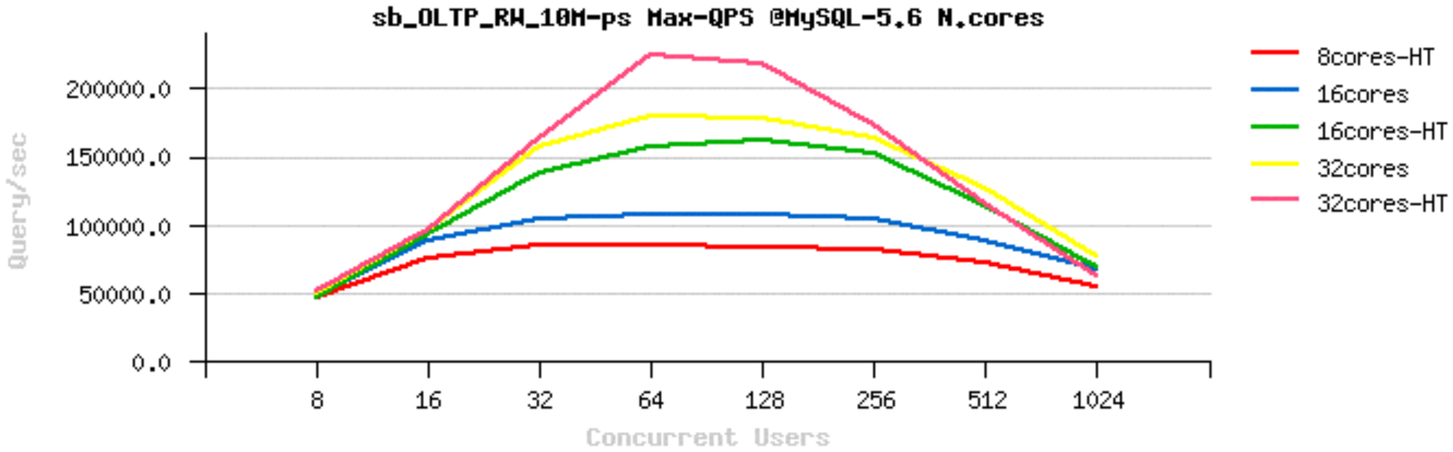




From where we're coming with MySQL 5.7 ?..

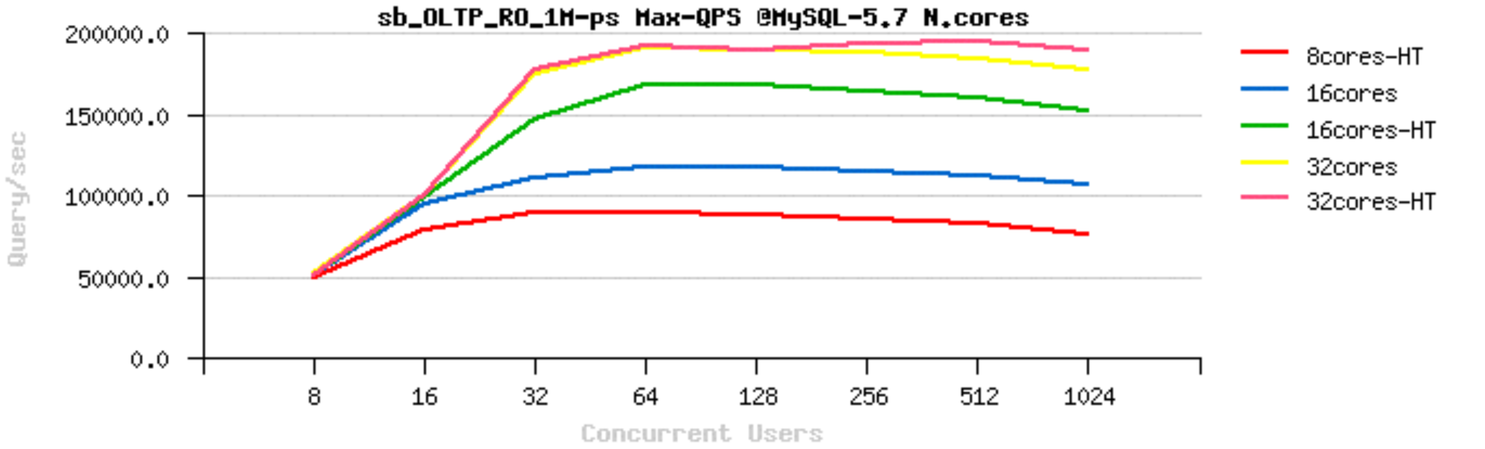
- MySQL 5.6 : RO & RW
  - not lower on 32cores!! ;-)
  - RW out-pass RO !!..??

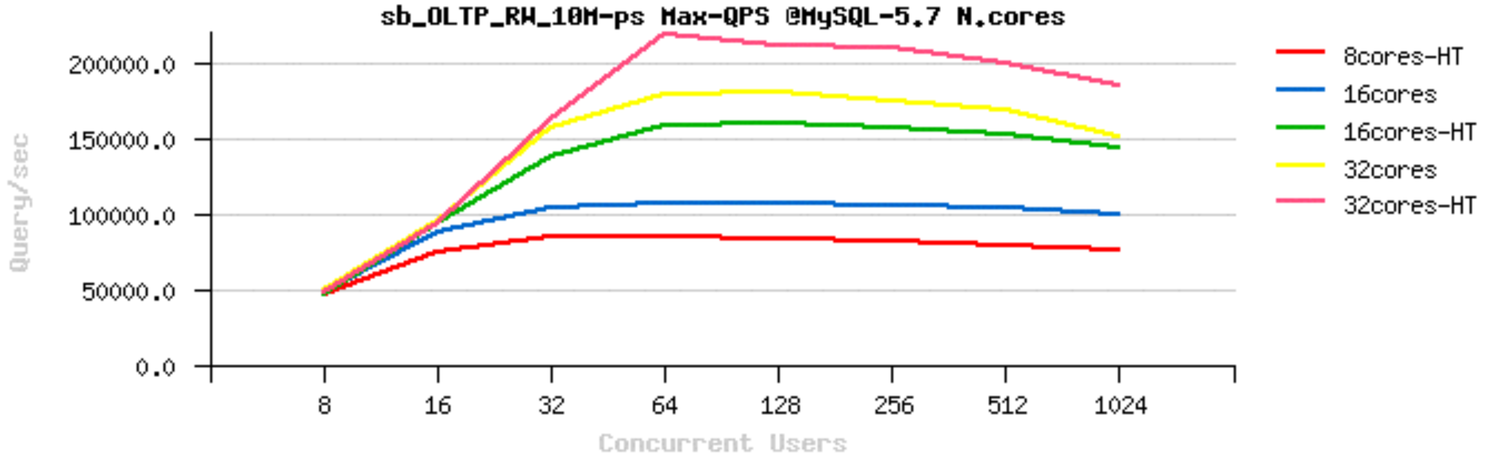




From where we're coming with MySQL 5.7 ?..

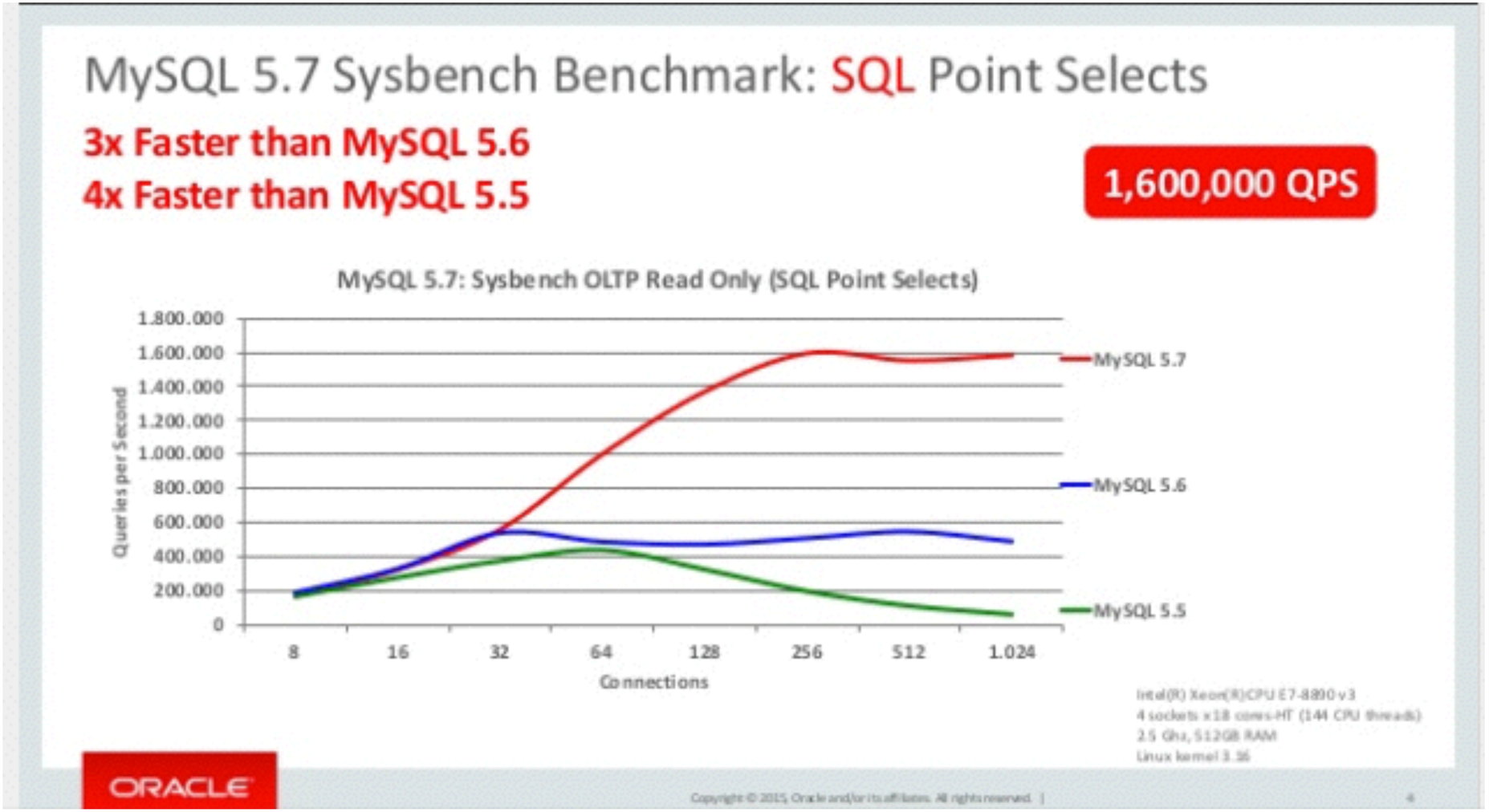
- MySQL 5.7.1 : RO & RW
  - more stable than 5.6
  - **RW** out-pass RO !!..





MySQL 5.7 : 1.6M QPS

- What is behind this number ?..



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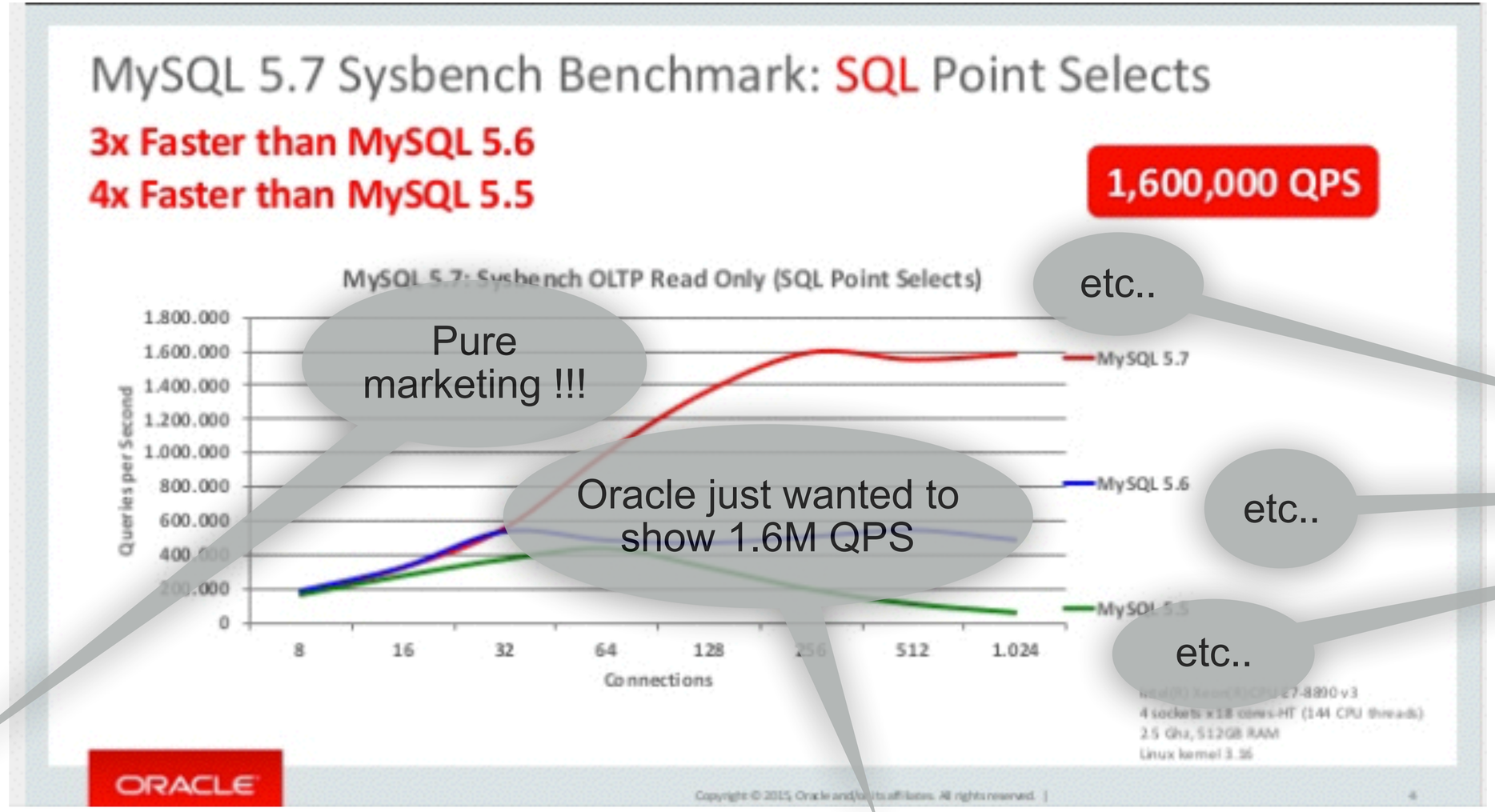
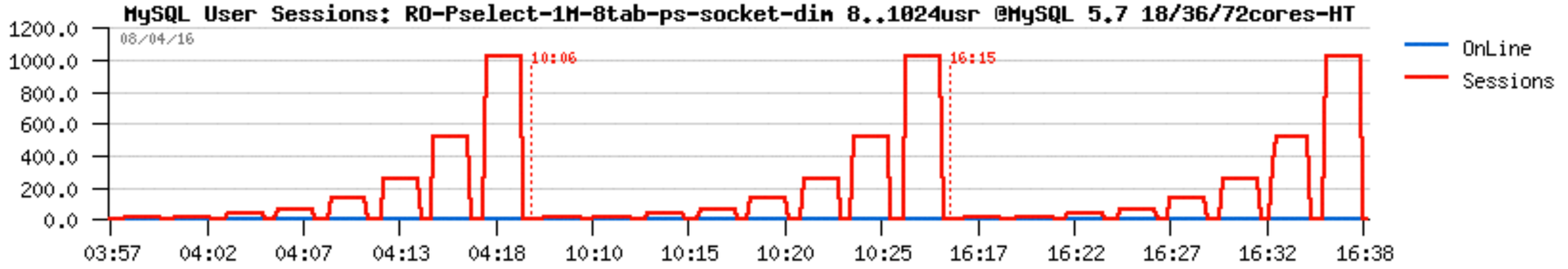


Marketing ?..

- Why you did not hear then about **1.8M QPS** ?.. ;-))
  - same 72cores-HT server, same MySQL 5.7
  - we are not running after numbers ;-)
  - numbers are just reflecting what is behind..

1.8M QPS



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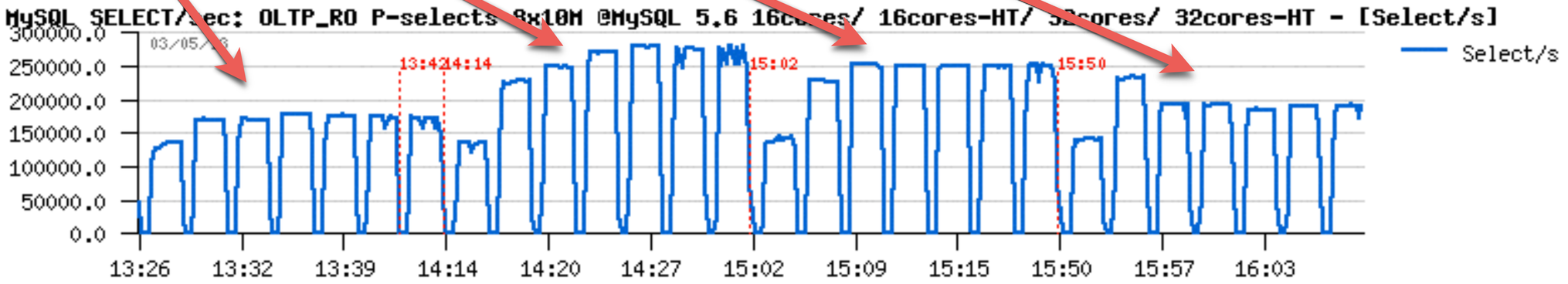
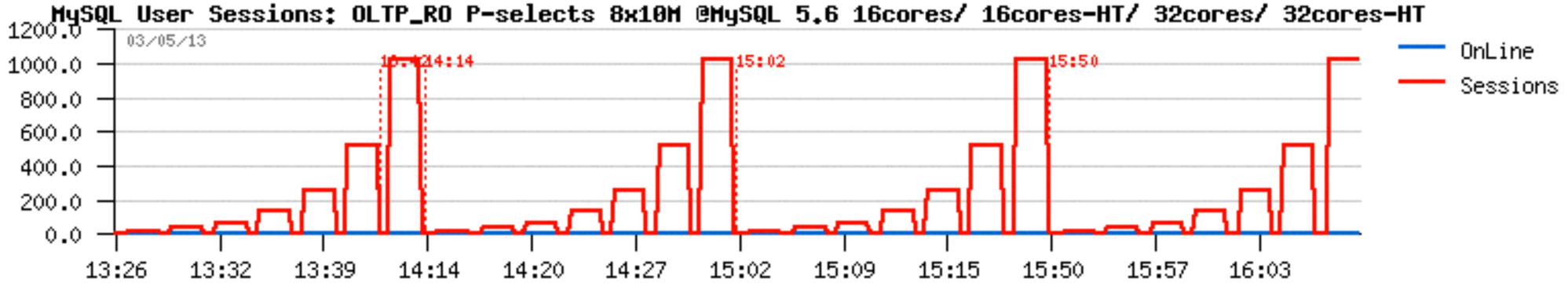
Behind the numbers...

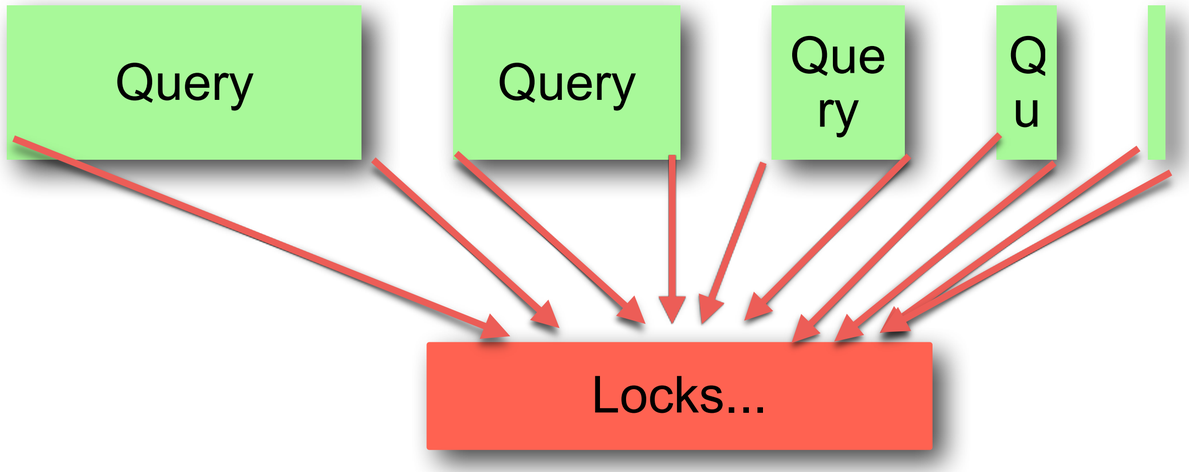
- MySQL 5.6, RO Point-Select Performance
  - 16cores, 16cores-HT, 32cores, 32cores-HT

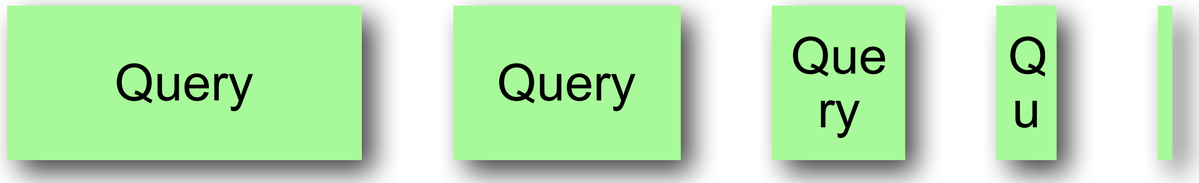




Behind the numbers...

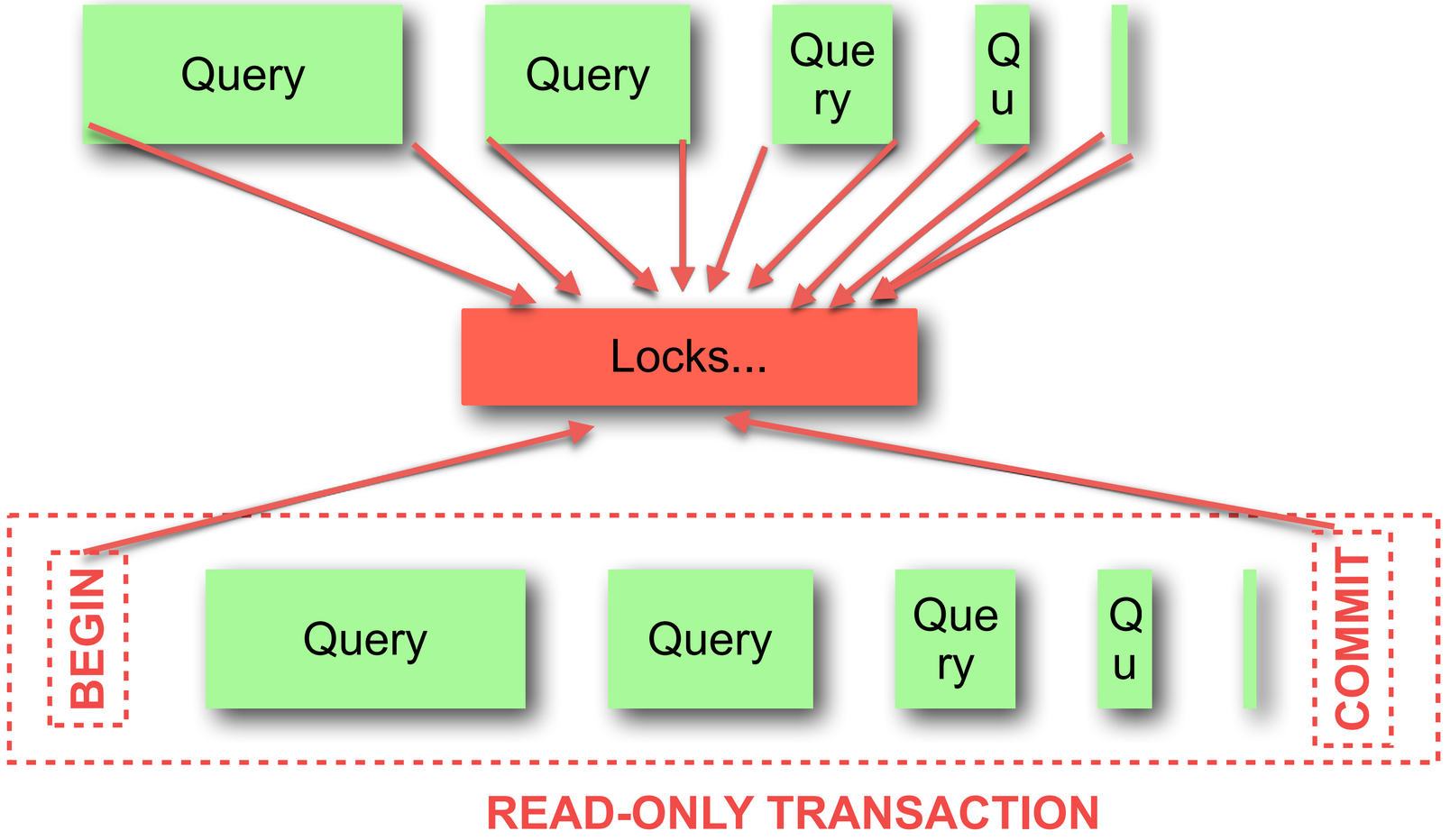
- Why ?..





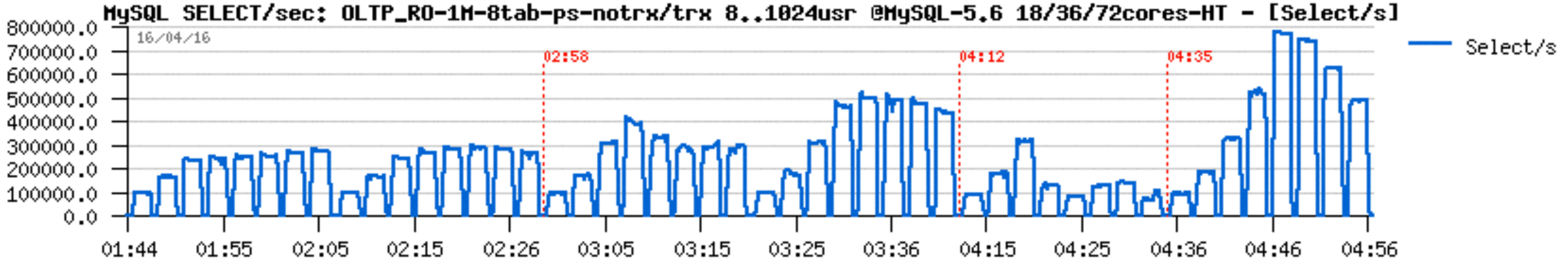
Behind the numbers...

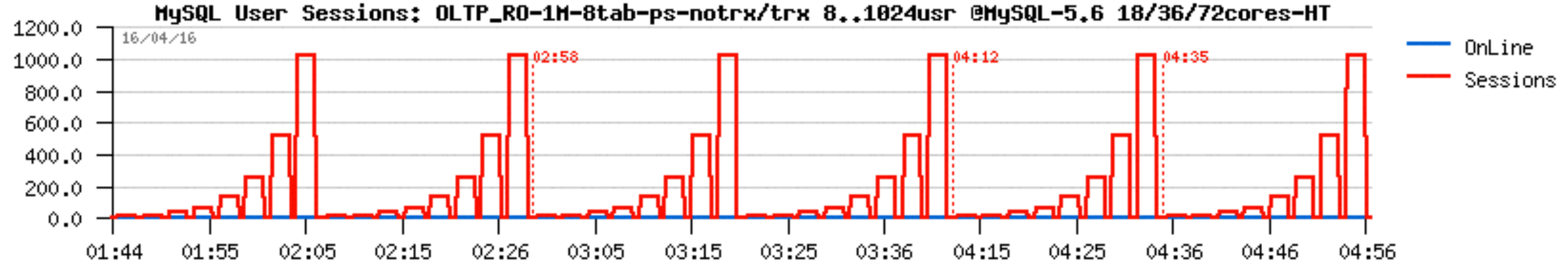
- MySQL 5.6 : Read-Only Transactions "workaround" :



Behind the numbers...

- MySQL 5.6, OLTP_RO-1Mx8-tables, 72cores-HT
  - OLTP_RO : [x14 SELECT Queries]
  - without / with transaction enclosure, 18/36/72cores-HT





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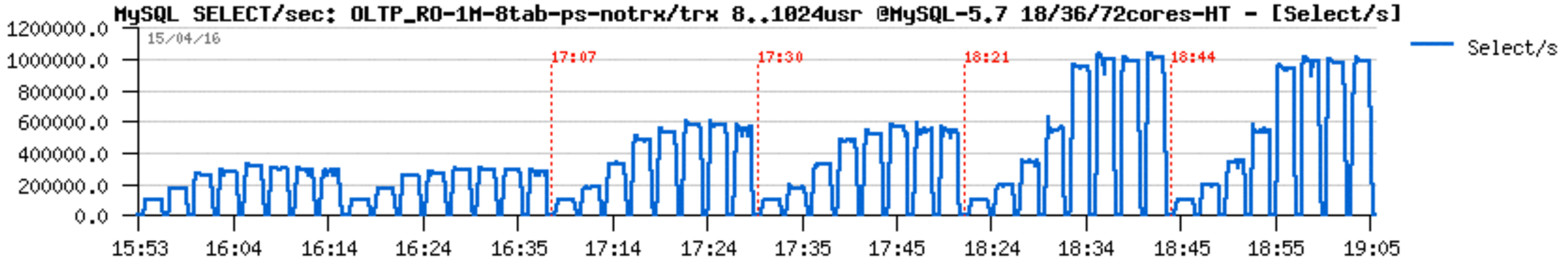
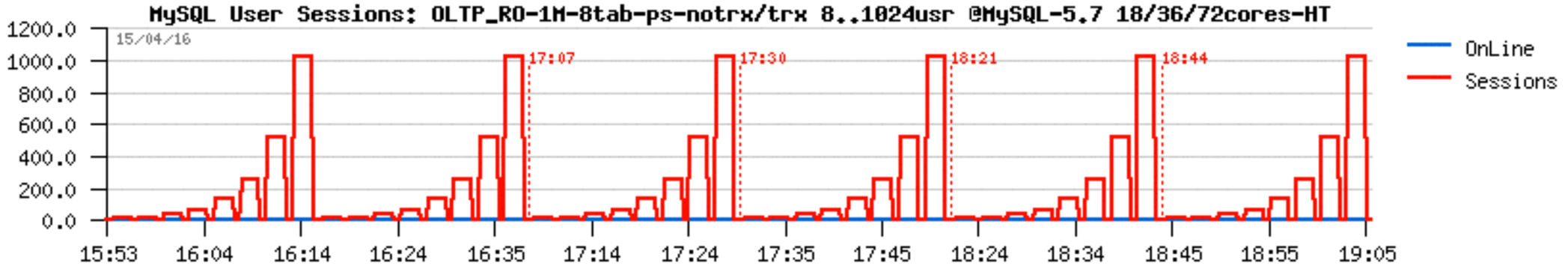


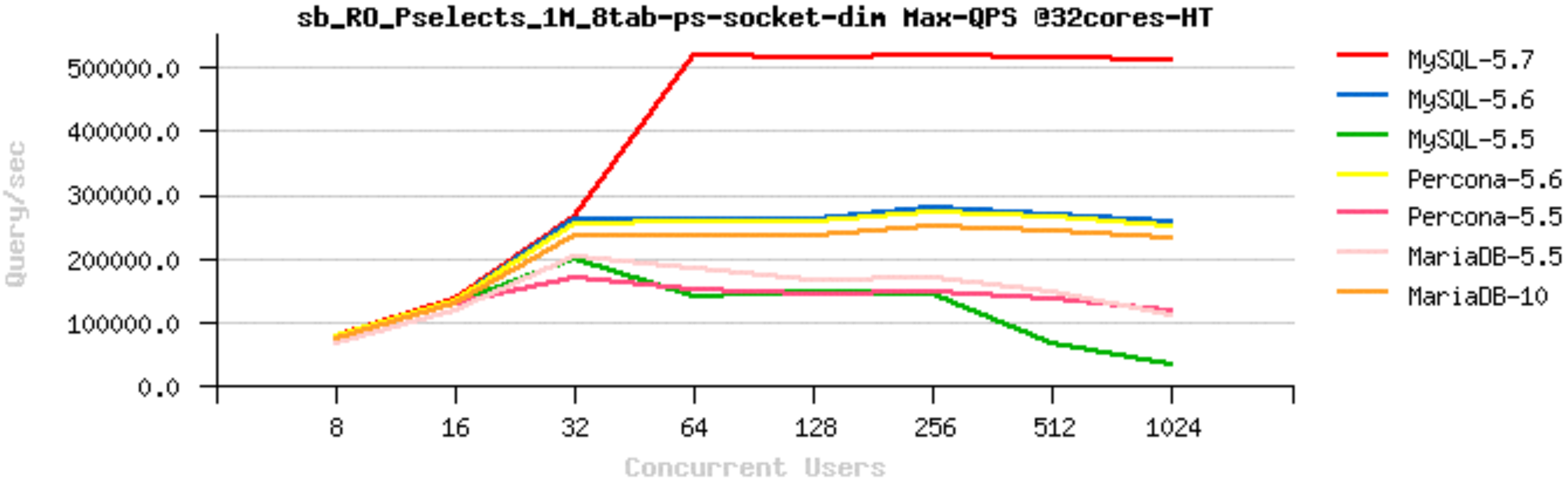


Behind the numbers...

- Up to you to decide what is less or more significant for you..
- If for ex. [x1000(!) Point-Select Queries] in transaction is OK
  - as was done by MariaDB to show their 1M QPS result..
  - hm.. and nobody called this Marketing ?..

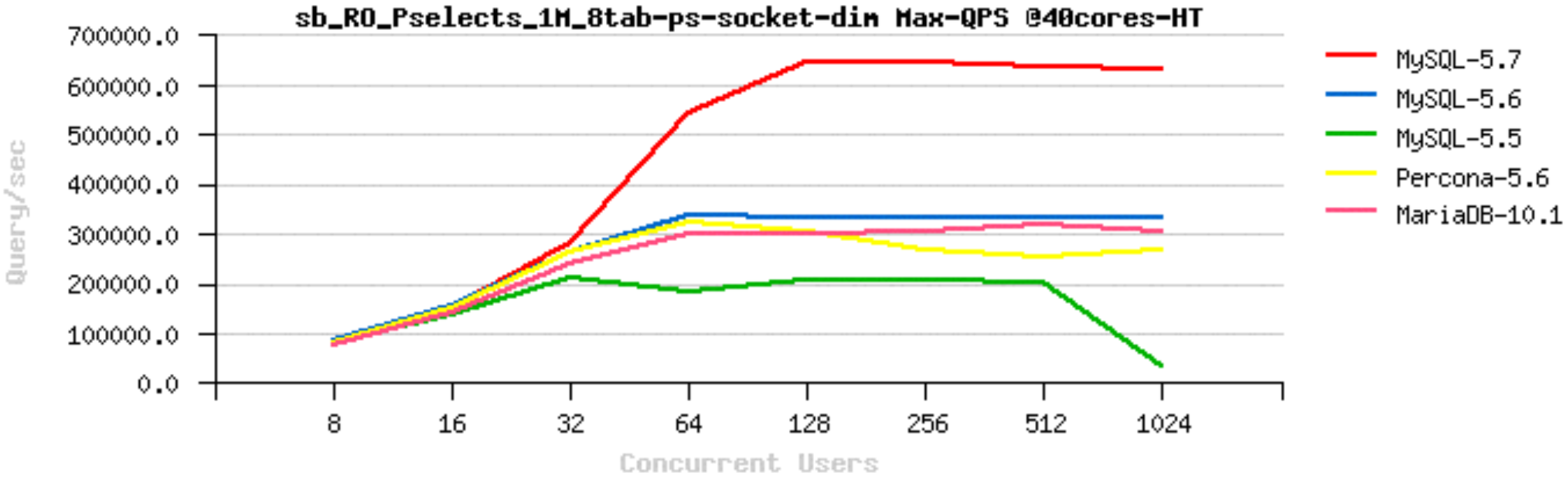
RO In-Memory @MySQL 5.7

- **500K QPS** Sysbench Point-Selects 8-tab :
  - 32cores-HT



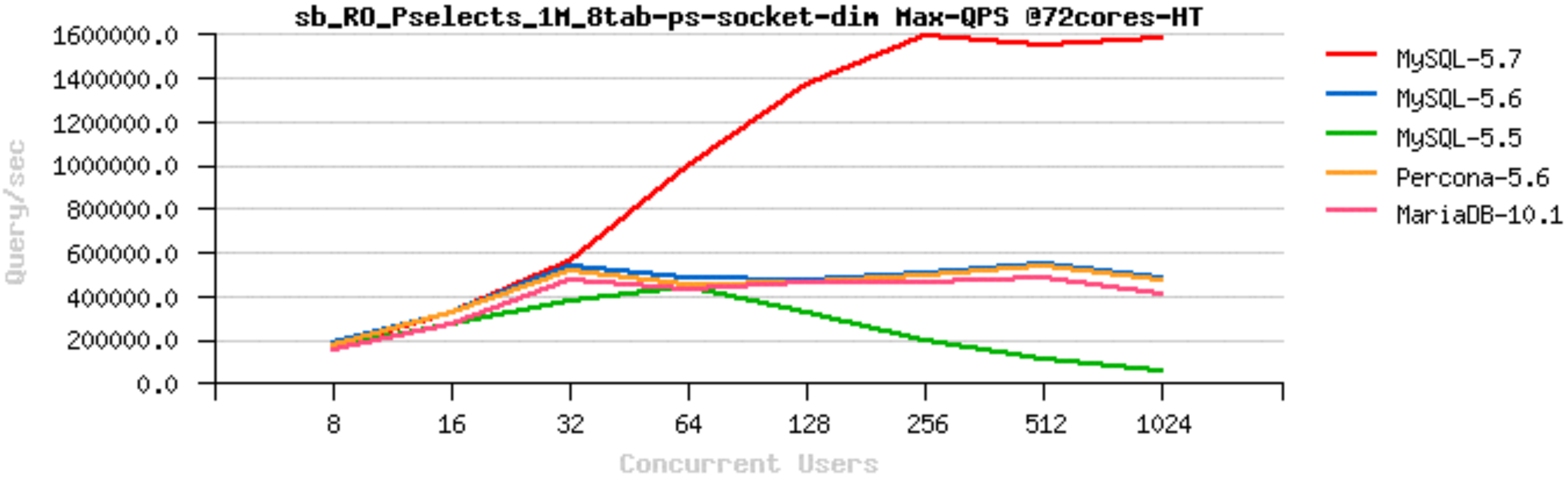
RO In-Memory @MySQL 5.7

- **645K QPS** Sysbench Point-Selects 8-tab :
  - 40cores-HT



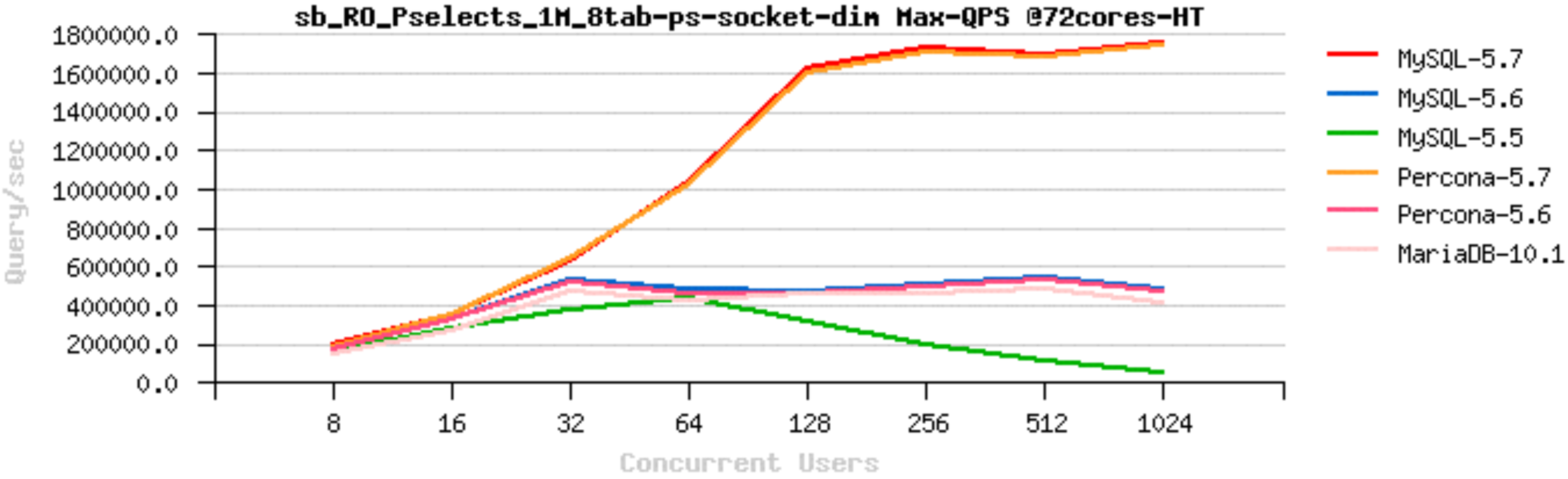
RO Point-Selects @MySQL 5.7 (Oct.2015)

- **1.6M (!!) QPS** Sysbench Point-Selects 8-tab :
  - 72cores-HT



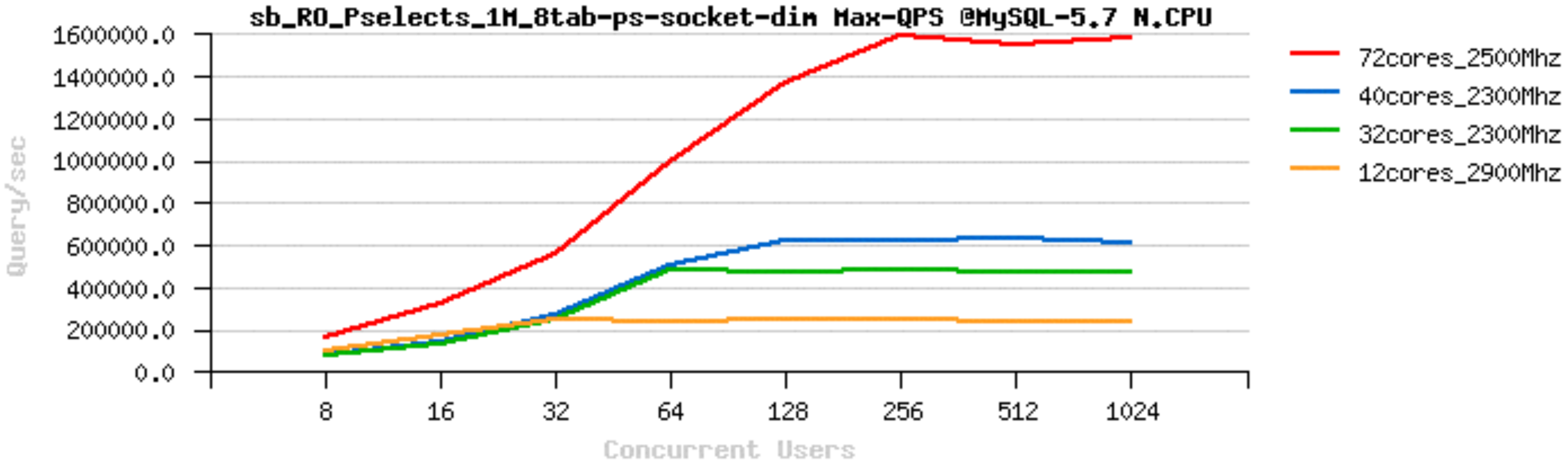
RO Point-Selects @MySQL 5.7 (Apr.2016)

- **1.8M QPS** Sysbench Point-Selects 8-tab, 72cores-HT :
  - or even more, if you really run after numbers.. ;-))



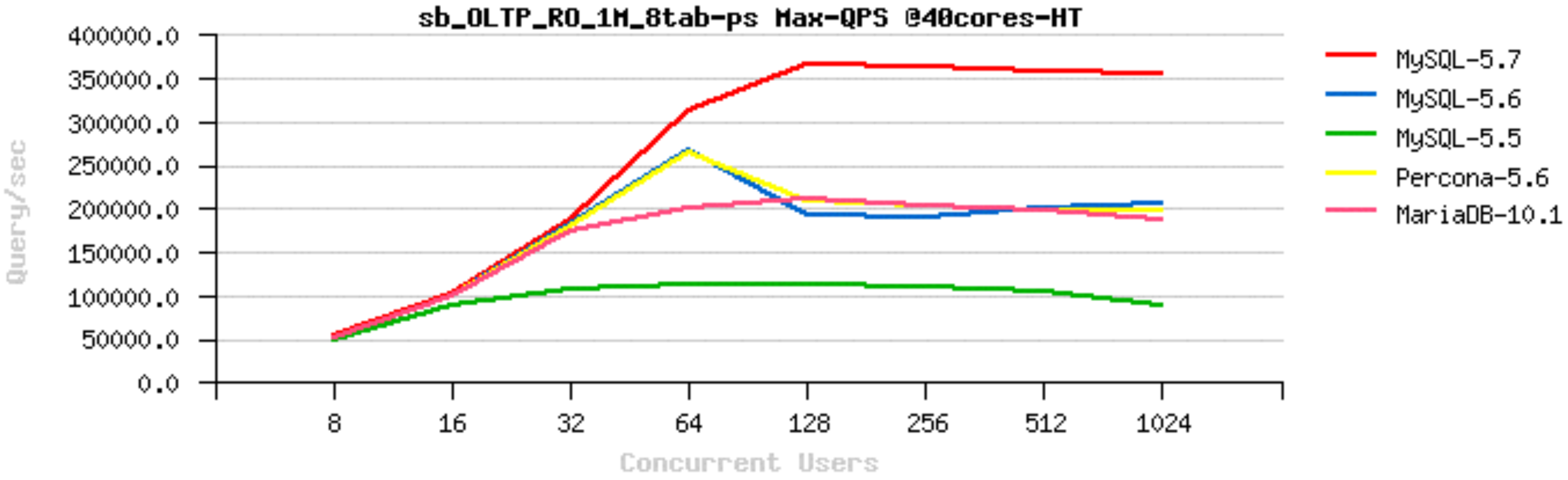
RO Point-Selects @MySQL 5.7

- Sysbench Point-Selects 8-tab => HW Progress :
  - new Intel CPU chips rock! (on 72cores-HT server here)



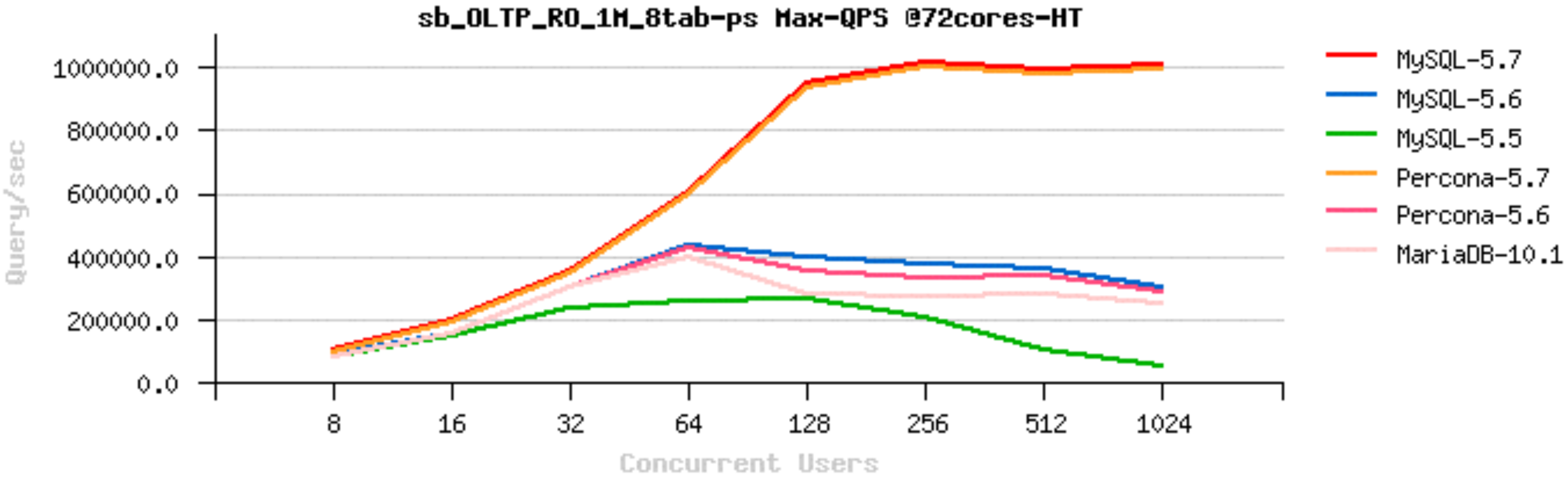
OLTP_RO : 8-tables

- Sysbench OLTP_RO 1Mx8-tables
  - 40cores-HT



OLTP_RO : 8-tables

- Sysbench OLTP_RO 1Mx8-tables - **~1M (!!) QPS**
  - 72cores-HT



Read-Only Scalability @MySQL / InnoDB

- Depends on a workload..
  - sometimes the limit is only within your memcpy() rate ;-)
- But really started to scale only since MySQL 5.7
  - due improved TRX list management, MDL, THR_lock, etc..
  - scaling up to 72 CPU cores-HT for sure, reported on more cores too..
  - Note : code path is growing with new features! (small HW may regress)
- IO-bound :
  - could be limited by storage (if you're not using a fast flash)
  - or by internal contentions (InnoDB file_sys mutex)
- Limitations
  - **there are still some limitations "by design"** (AHI, block lock, file_sys, etc..)
  - all in TODO to be fixed, but some are really needing a deep redesign..

Read+Write (RW) Workloads Scalability @MySQL 5.7

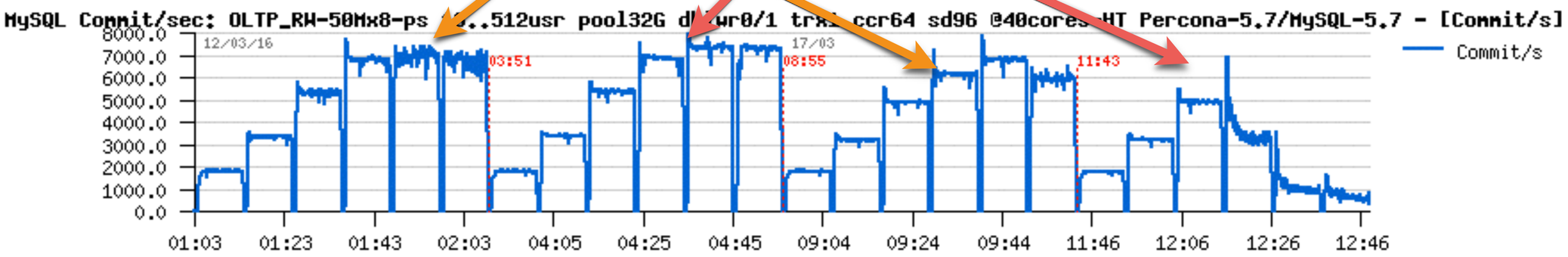
- Huge progress is already here too!
  - improved index locking
  - reduced lock_sys mutex contention
  - parallel flushing + improved flushing design
  - much better observability of internals
  - etc..
- However, not yet as good as Read-Only..
  - Performance continues to increase with more CPU cores
  - But on move from 16 to 32cores-HT you may gain only 50% better
  - Better performance on a faster storage as well
  - **On OLTP_RW can use a full power of fast flash for today!**
  - **More work in progress ;-)**
  - Internal contentions & Design limitations are the main issues here..
  - still many things are in pipe & prototype..

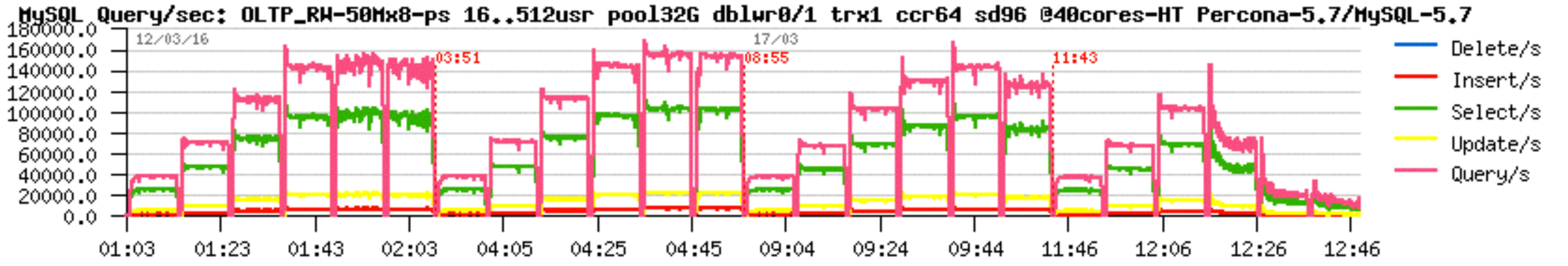
Read+Write Performance @MySQL / InnoDB

- Transactional processing
  - your CPU-bound transactional processing defines your Max possible TPS
  - with a bigger volume / more IO / etc. => Max TPS will not increase ;-)
- Pending issues :
  - same as RO + REDO (log_sys), locks (lock_sys), TRX (trx_sys), AHI=off, etc..
  - Purge lagging, more improved Adaptive Flushing
- Data Safety
  - binlog : overhead + bottleneck (be sure you have binlog group commit)
  - InnoDB checksums : overhead (reasonable since crc32 is used)
  - innodb_flush_log_at_trx_commit = 1 : overhead + bottleneck
  - **InnoDB double write buffer : KILLER ! overhead + huge bottleneck..**
    - need a fix since a so long time.. => / re-design / etc. in urgency ;-)
    - Fusion-io atomic writes is one of (**true** support in MySQL 5.7)
    - a true re-design is still preferable ;-)

InnoDB Double-Write (DBLWR)

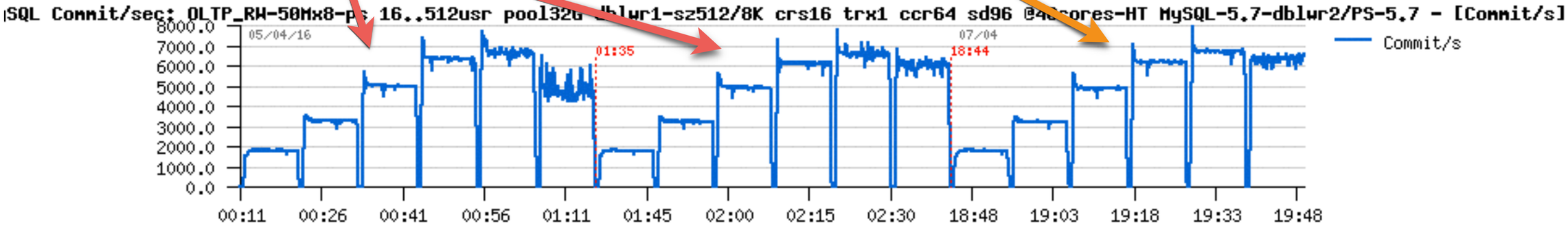
- OLTP_RW 50M x8-tables (120G dataset)
  - BP=32G, trx=1, dblwr=0/1, checksum=crc32, Flash “Nytro” Seagate-XP6500
  - Percona-5.7 / MySQL-5.7 (Jan.2016)

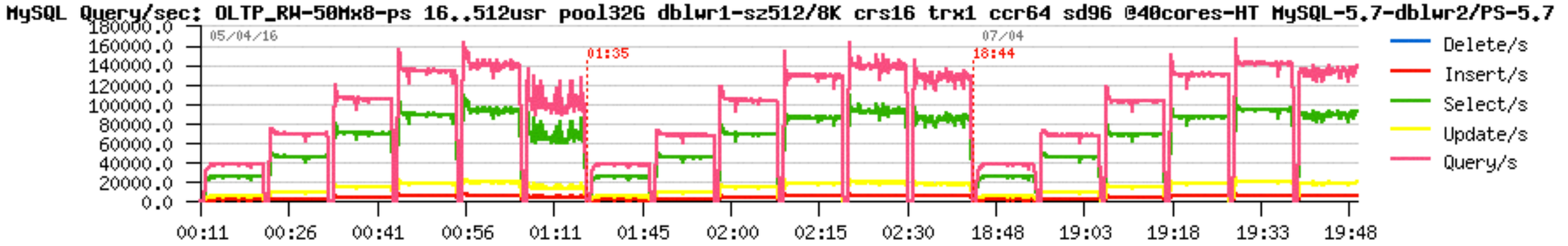




InnoDB Double-Write (DBLWR)

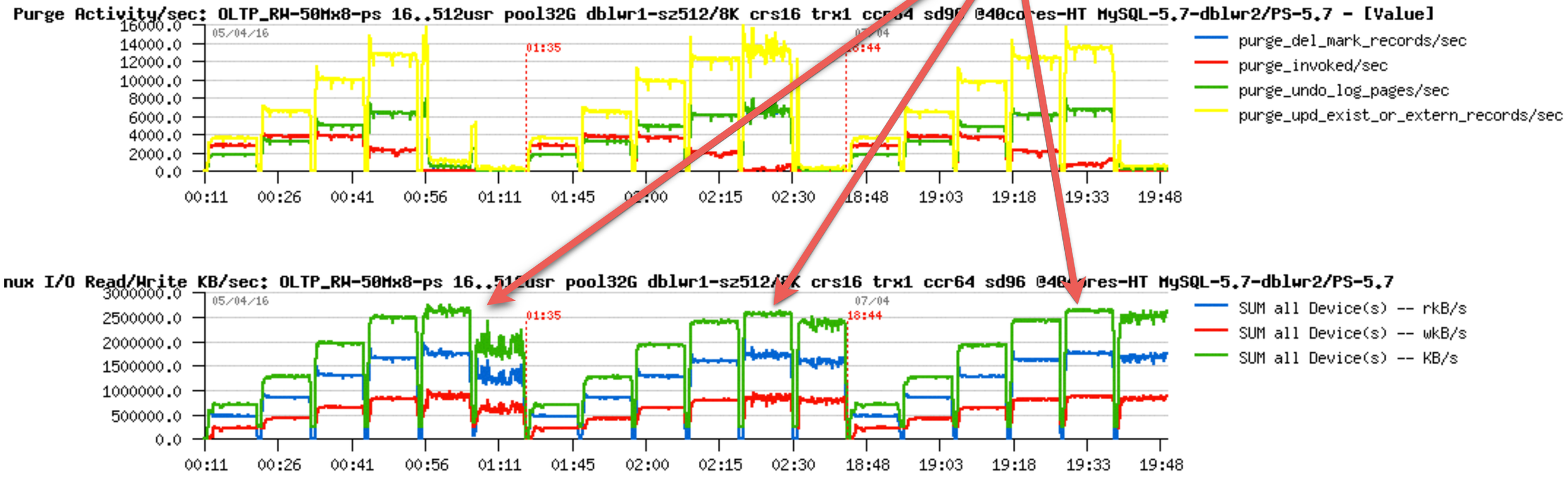
- OLTP_RW 50M x8-tables (120G dataset)
  - BP=32G, trx=1, dblwr=1, checksum=crc32, Flash “Nytro” Seagate-XP6500
  - MySQL-5.7-dblwr (work-in-progress) / Percona-5.7





InnoDB Double-Write (DBLWR) - Side Note..

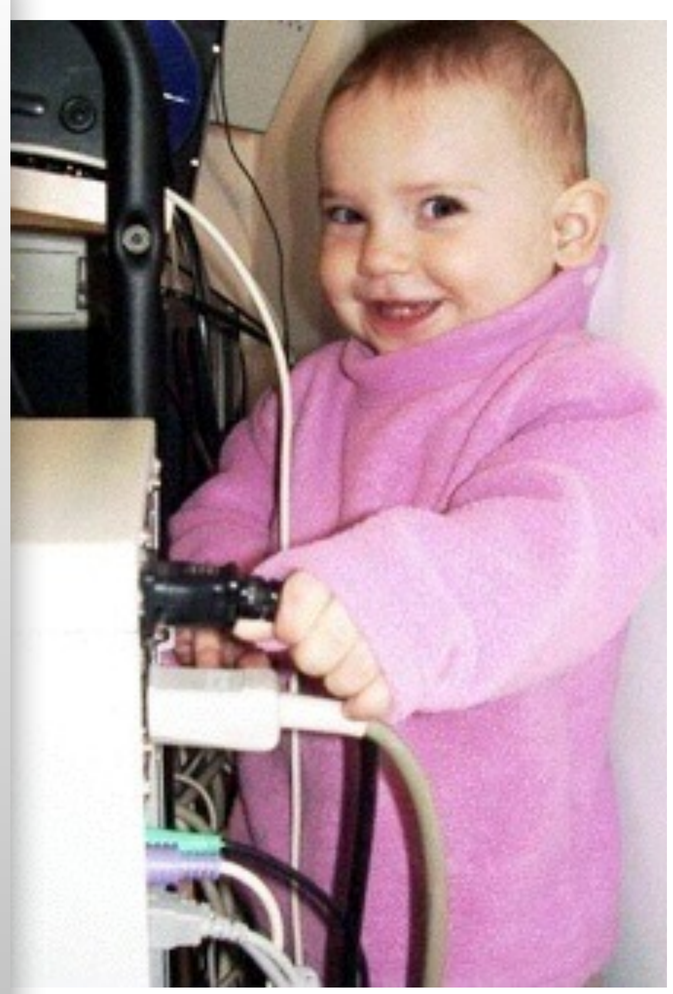
- OLTP_RW 50M x8-tables (120G dataset)
  - Purge lagging can be a very serious issue..
  - 5.7 with Flash “Nytro” Seagate-XP6500 => **over 2500 MB/sec** (16K InnoDB pages)



RW related starter configuration settings

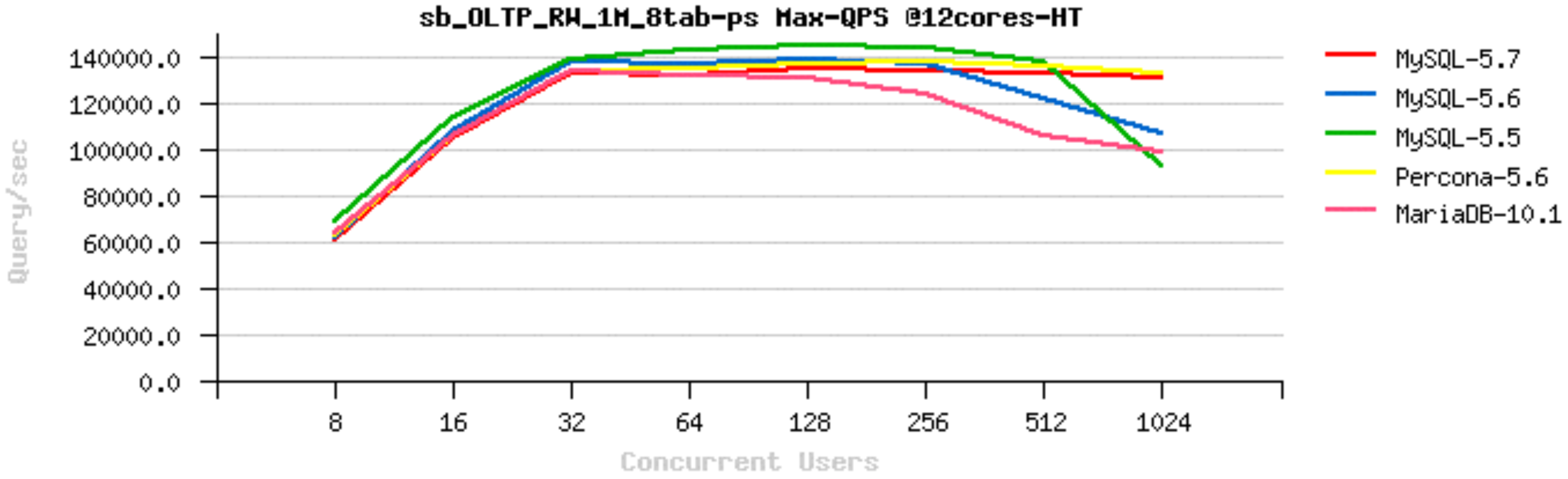
- my.conf :

```
innodb_file_per_table
innodb_log_file_size=1024M
innodb_log_files_in_group=3 / 12 / ...
innodb_checksum_algorithm= none / crc32
innodb_doublewrite= 0 / 1
innodb_flush_log_at_trx_commit= 2 / 1
innodb_flush_method=O_DIRECT_NO_FSYNC
innodb_use_native_aio=1
innodb_adaptive_hash_index=0

innodb_adaptive_flushing = 1
innodb_flush_neighbors = 0
innodb_read_io_threads = 16
innodb_write_io_threads = 16
innodb_io_capacity=15000
innodb_max_dirty_pages_pct=90
innodb_max_dirty_pages_pct_lwm=10
innodb_lru_scan_depth=4000
innodb_page_cleaners=4

innodb_purge_threads=4
innodb_max_purge_lag_delay=30000000
innodb_max_purge_lag= 0 / 1000000

binlog ??
```



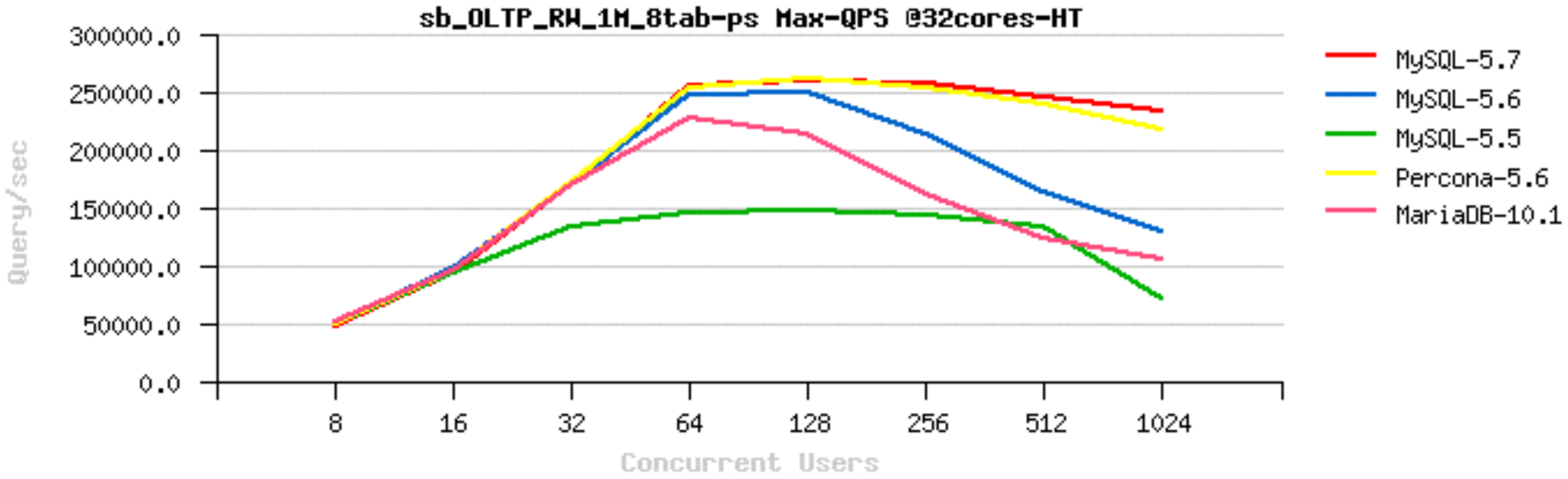
OLTP_RW : 8-tables

- Sysbench OLTP_RW 1Mx8-tables
  - 12cores-HT
  - and the winner is: MySQL 5.5 !! ;-))



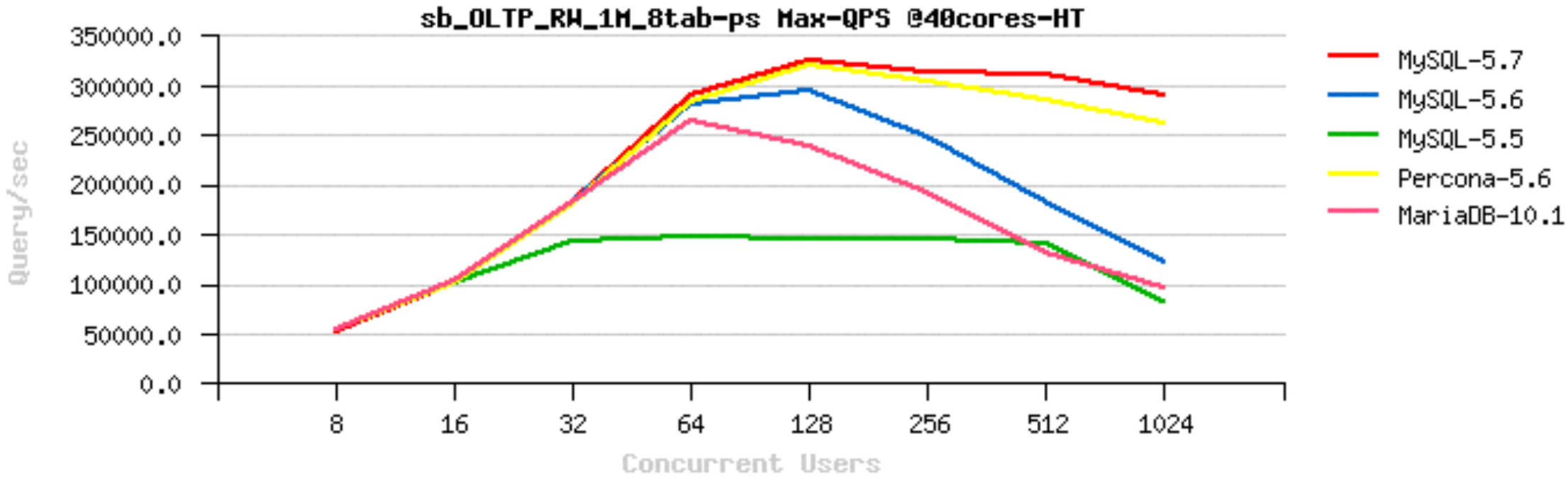
OLTP_RW : 8-tables

- Sysbench OLTP_RW 1Mx8-tables
  - 32cores-HT
  - and the winner is: rather MySQL 5.7 !! ;-))



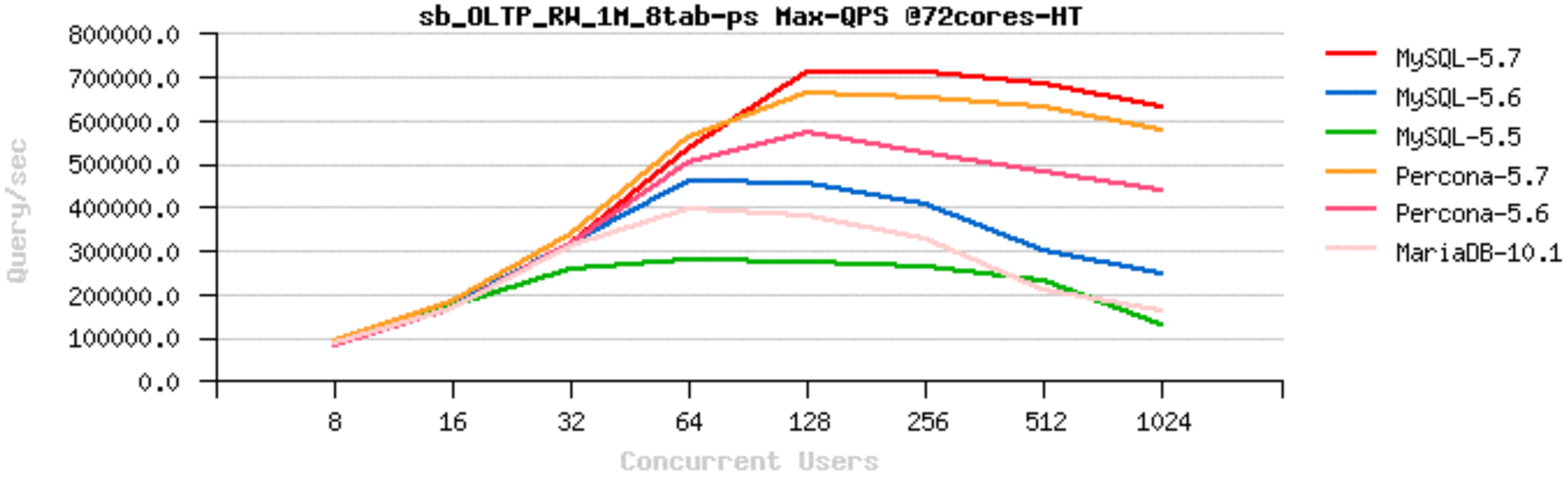
OLTP_RW : 8-tables

- Sysbench OLTP_RW 1Mx8-tables
  - 40cores-HT
  - and the winner is: rather MySQL 5.7 !! (or Percona-5.7 ;-))



OLTP_RW : 8-tables

- Sysbench OLTP_RW 1Mx8-tables
  - 72cores-HT
  - and the winner is: MySQL 5.7 !! (or Percona-5.7 + patch ;-))

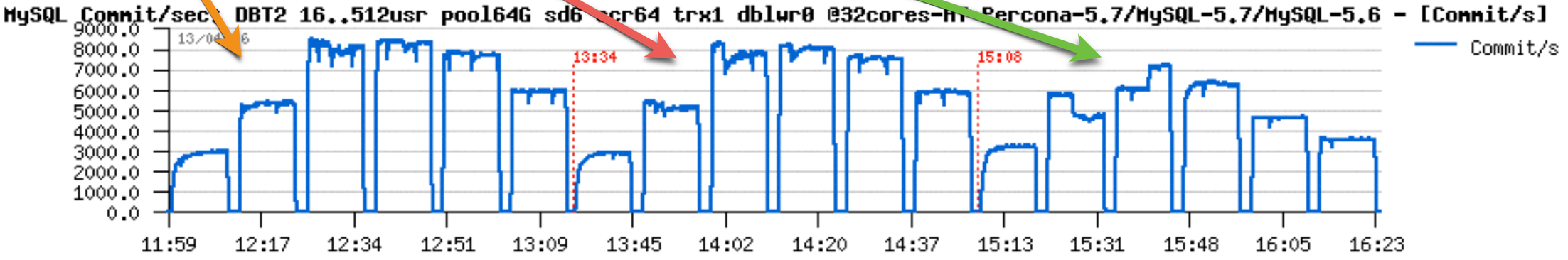


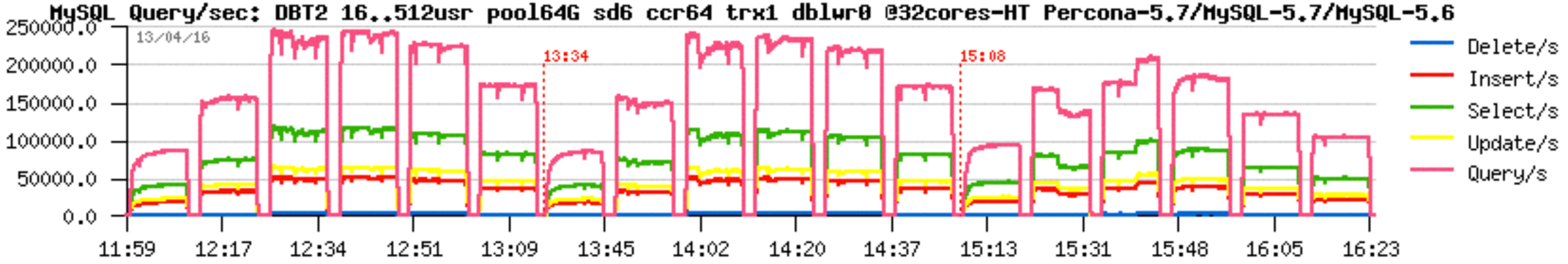
DBT2 (TPC-C) Benchmark

- Tested workload: DBT2 W500 or W512
  - (single database 8 databases of W64 size each)
  - **concurrent users: 16, 32, .. 512**
- Engines: Percona-5.7, MySQL-5.7-dblwr, MySQL-5.6
- Configurations:
  - 64G BP size (REDO-driven flushing), and 16G (LRU-bound flushing)
- Safe options:
  - trx_commit = 1 dblwr=0
  - trx_commit = 1 dblwr=1
- Tuning:
  - spin_delay = 6 / 96
  - innodb thread concurrency = 64
  - redo = 32G

DBT2 W500, 32cores-HT

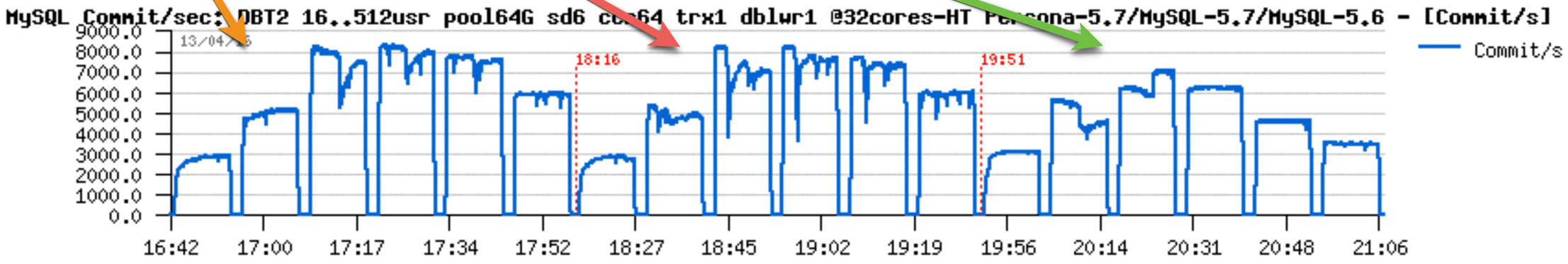
- 64G pool, trx=1, dblwr=0
  - Percona-5.7 / MySQL-5.7 / MySQL-5.6

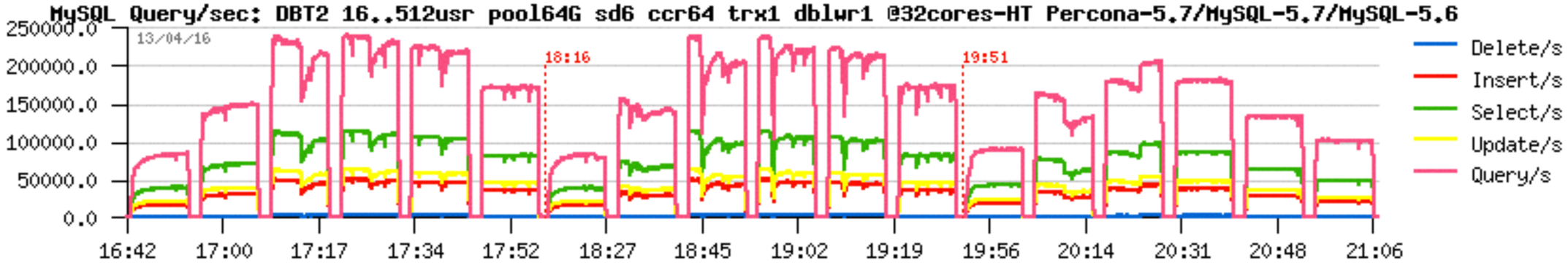




DBT2 W500, 32cores-HT

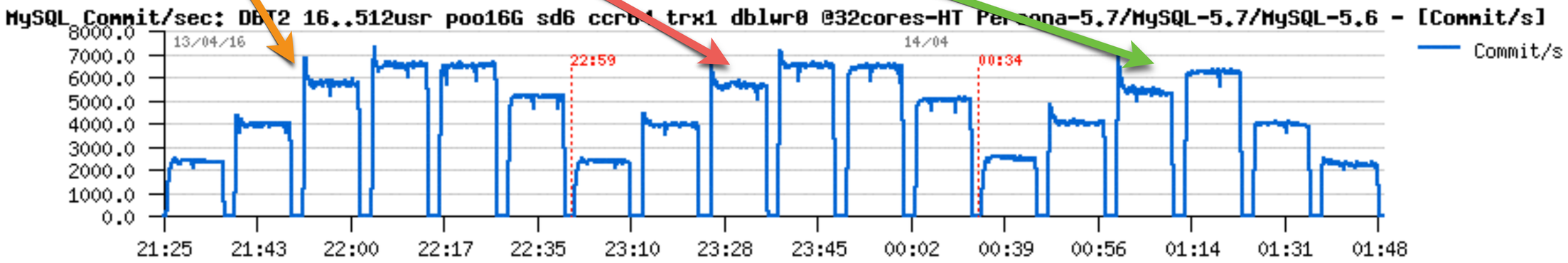
- 64G pool, trx=1, dblwr=1
  - Percona-5.7 / MySQL-5.7 / MySQL-5.6

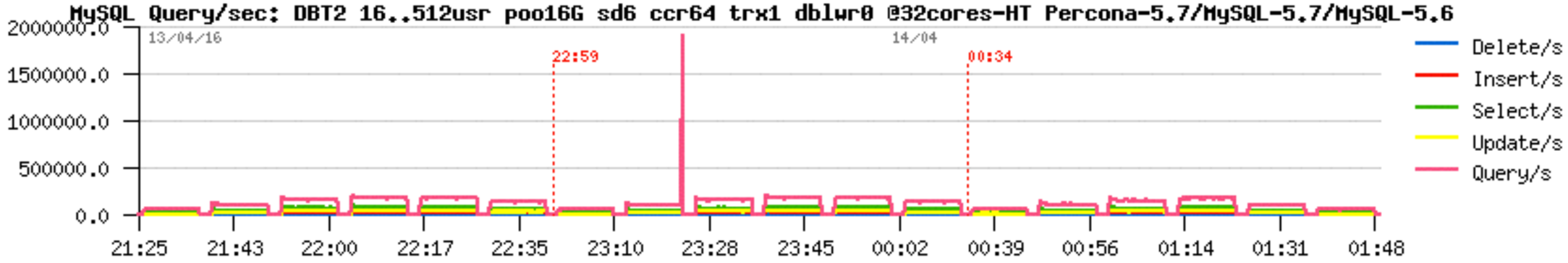




DBT2 W500, 32cores-HT

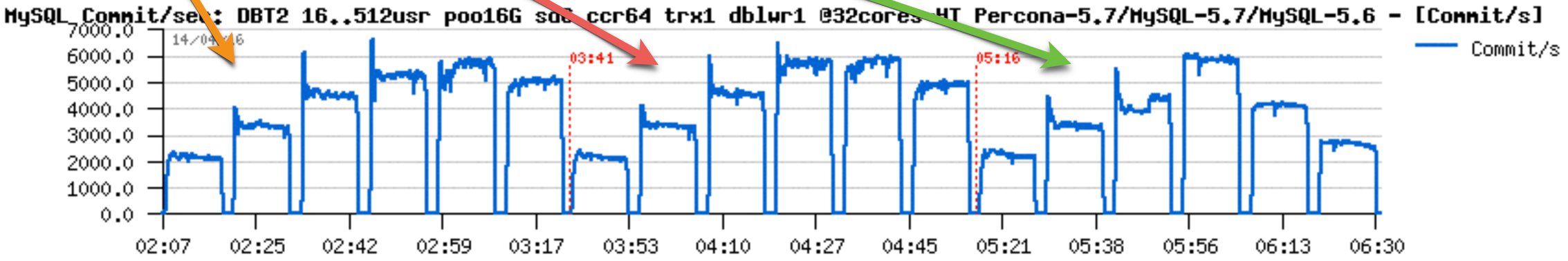
- 16G pool, trx=1, dblwr=0
  - Percona-5.7 / MySQL-5.7 / MySQL-5.6

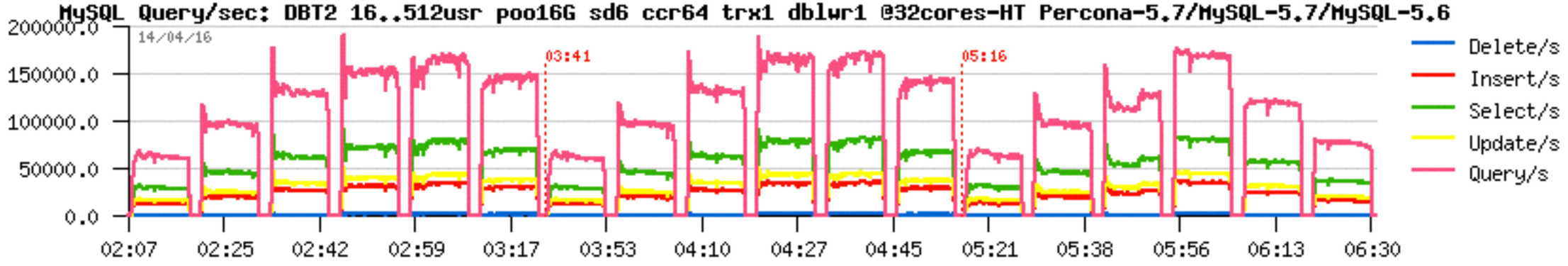




DBT2 W500, 32cores-HT

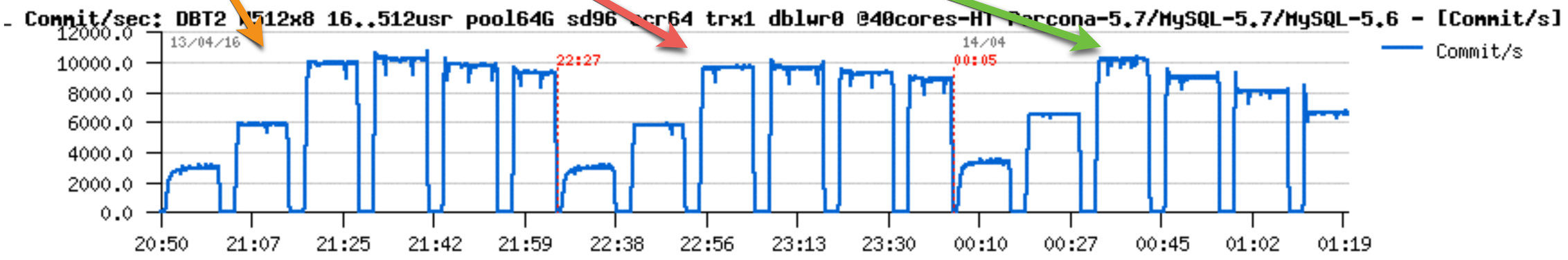
- 16G pool, trx=1, dblwr=1
  - Percona-5.7 / MySQL-5.7 / MySQL-5.6

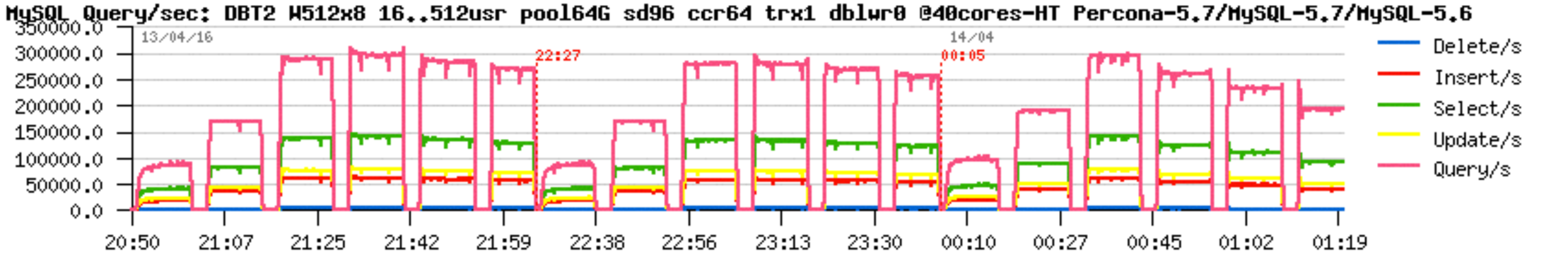




DBT2 W500, 40cores-HT

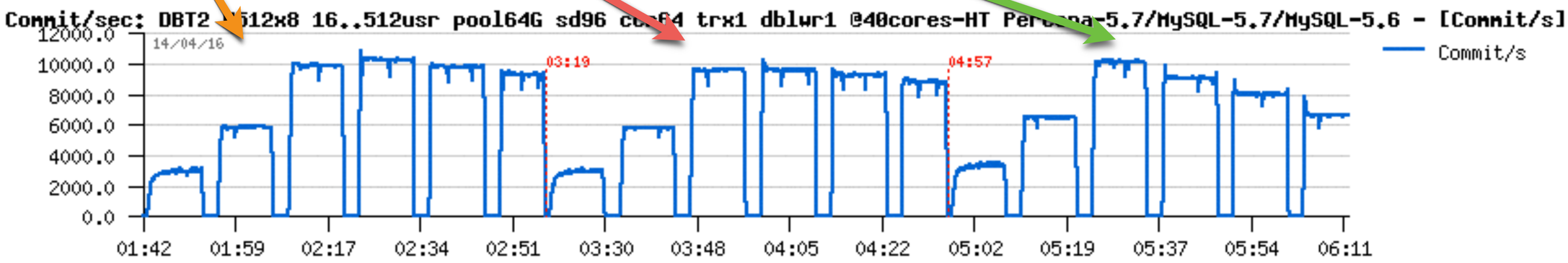
- 64G pool, trx=1, dblwr=0
  - Percona-5.7 / MySQL-5.7 / MySQL-5.6

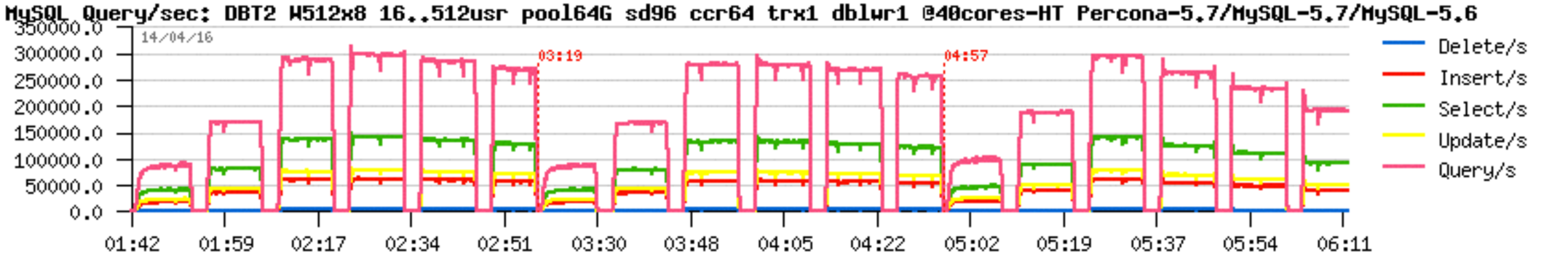




DBT2 W500, 40cores-HT

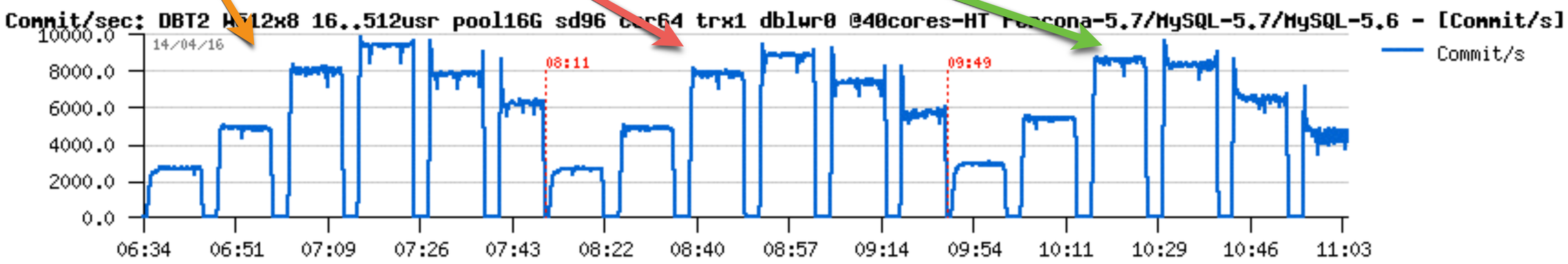
- 64G pool, trx=1, dblwr=1
  - Percona-5.7 / MySQL-5.7 / MySQL-5.6

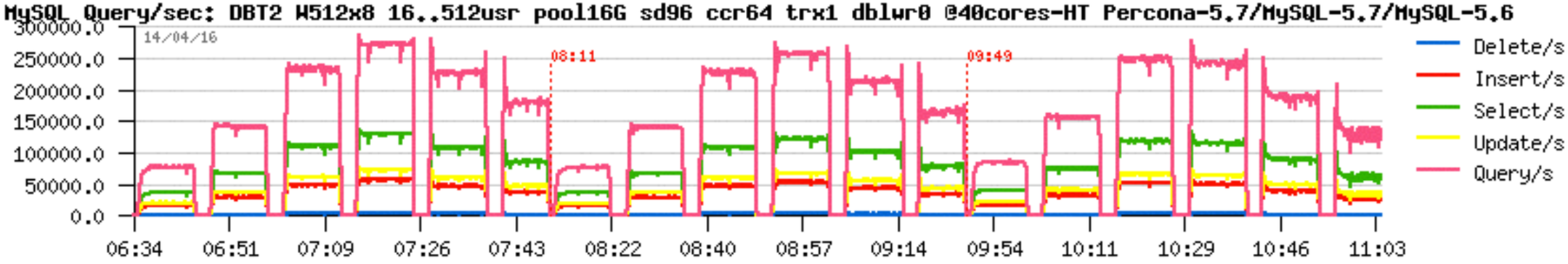




DBT2 W500, 40cores-HT

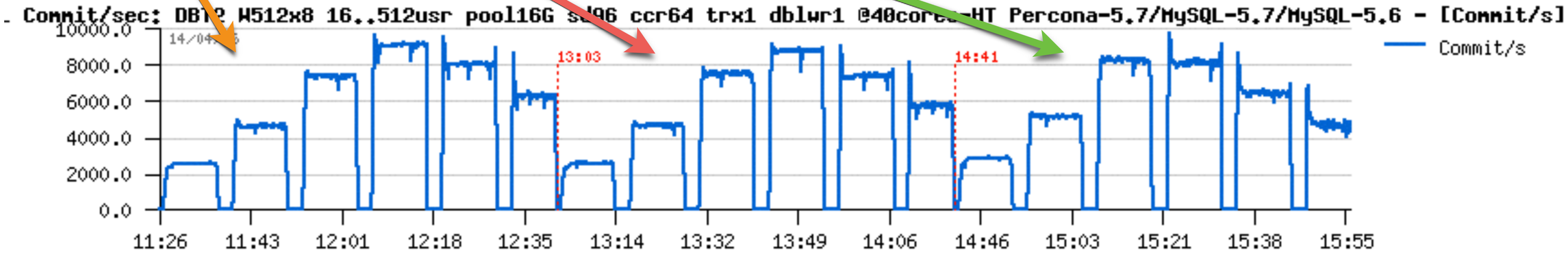
- 16G pool, trx=1, dblwr=0
  - Percona-5.7 / MySQL-5.7 / MySQL-5.6

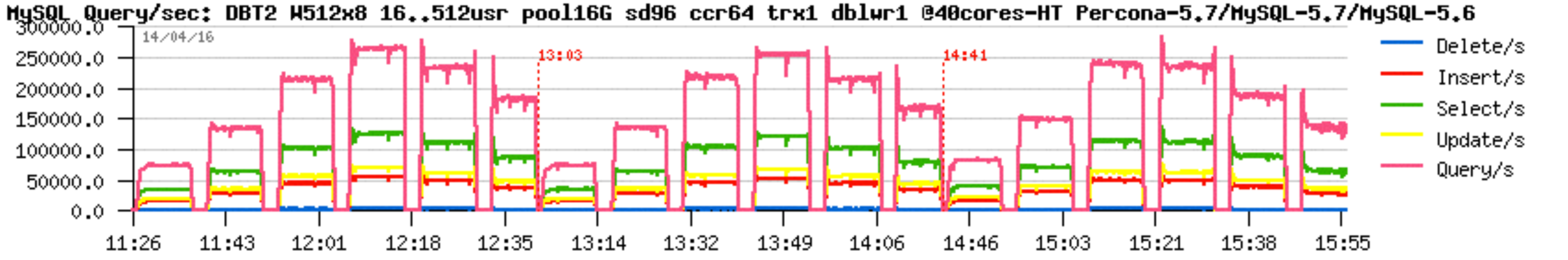




DBT2 W500, 40cores-HT

- 16G pool, trx=1, dblwr=1
  - Percona-5.7 / MySQL-5.7 / MySQL-5.6



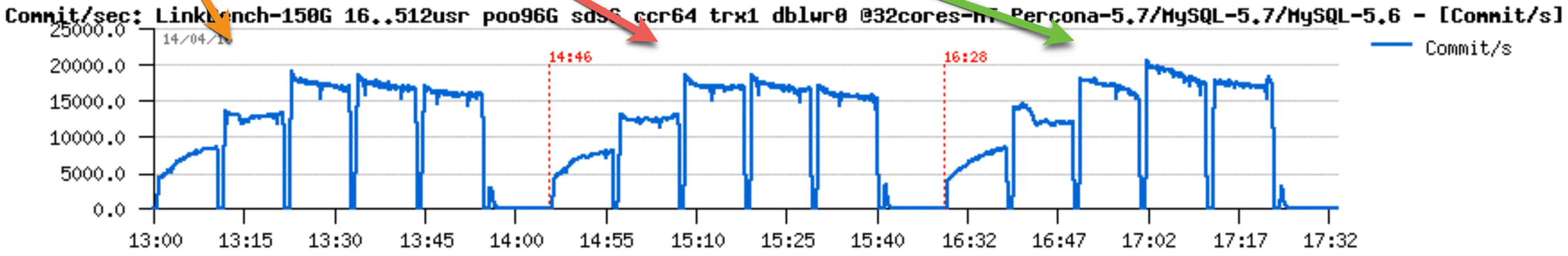


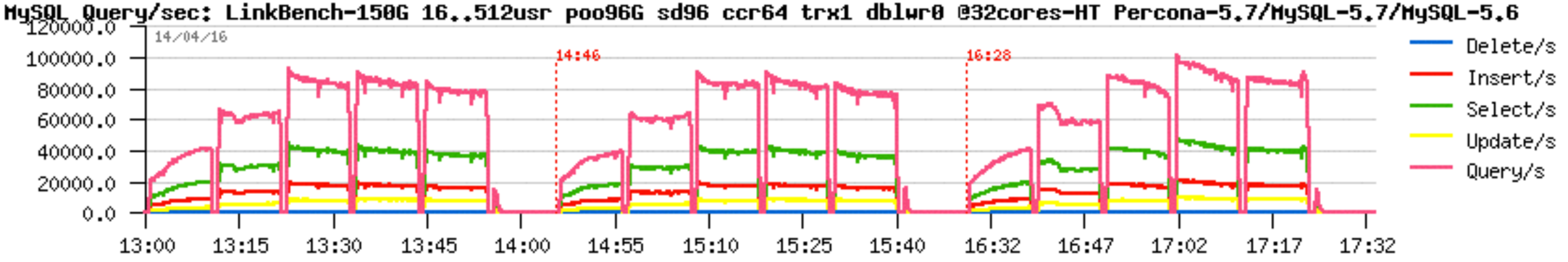
LinkBench Benchmark

- Tested workload:
  - 150M data (~200G data)
  - **concurrent users: 16, 32, .. 512**
- Engines: Percona-5.7, MySQL-5.7-dblwr, MySQL-5.6
- Configurations:
  - 96/128G BP size (REDO-driven flushing), and 16G (LRU-bound flushing)
- Safe options:
  - trx_commit = 1 dblwr=0
  - trx_commit = 1 dblwr=1
- Tuning:
  - spin_delay = 6 / 96
  - innodb thread concurrency = 64
  - redo = 32G

LinkBench-150M, 32cores-HT

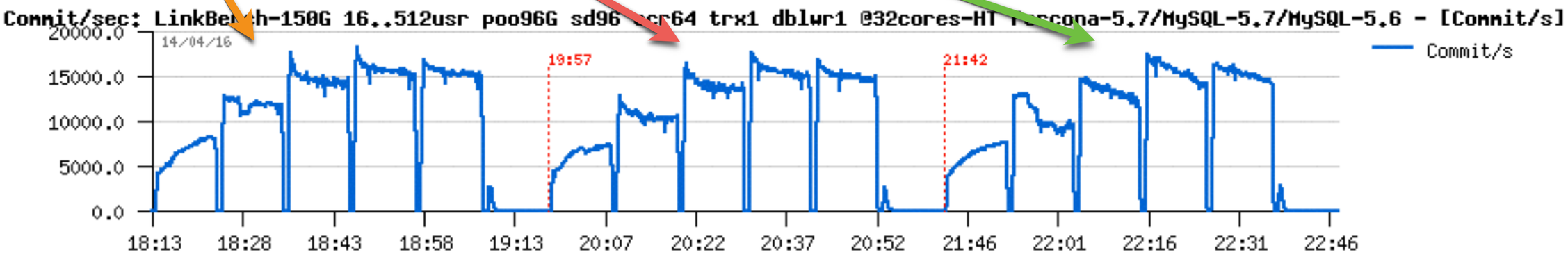
- 96G pool, trx=1, dblwr=0
  - Percona-5.7 / MySQL-5.7 / MySQL-5.6

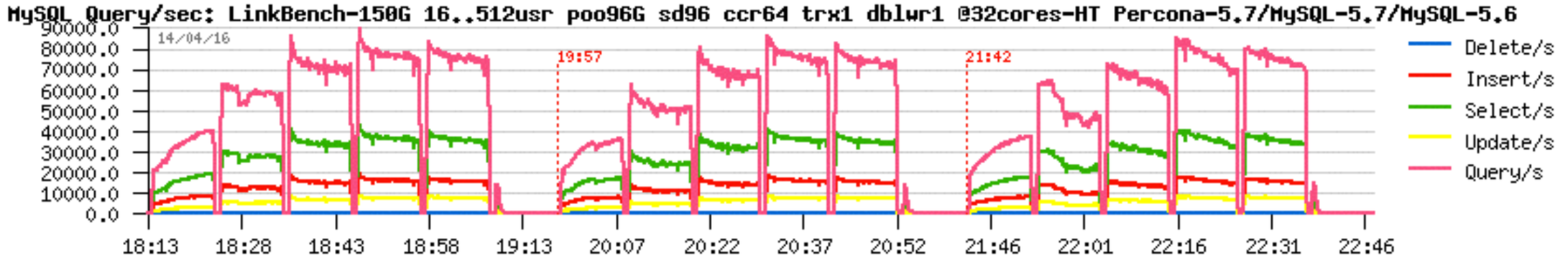




LinkBench-150M, 32cores-HT

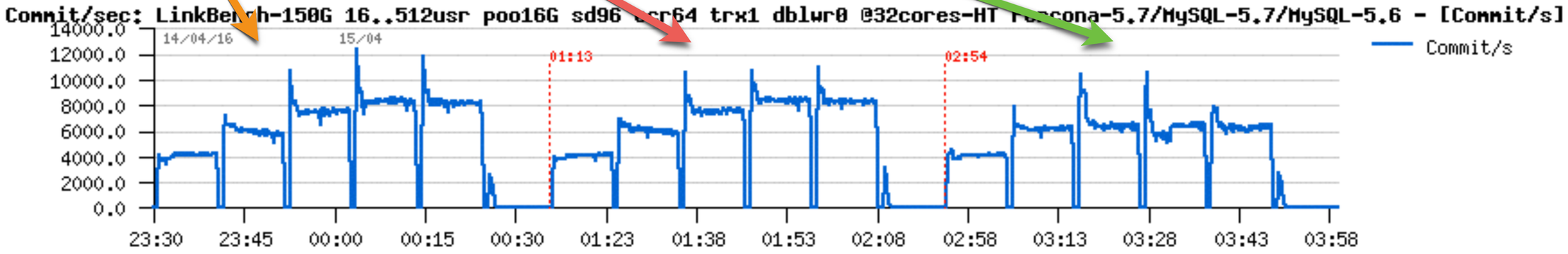
- 96G pool, trx=1, dblwr=1
  - Percona-5.7 / MySQL-5.7 / MySQL-5.6

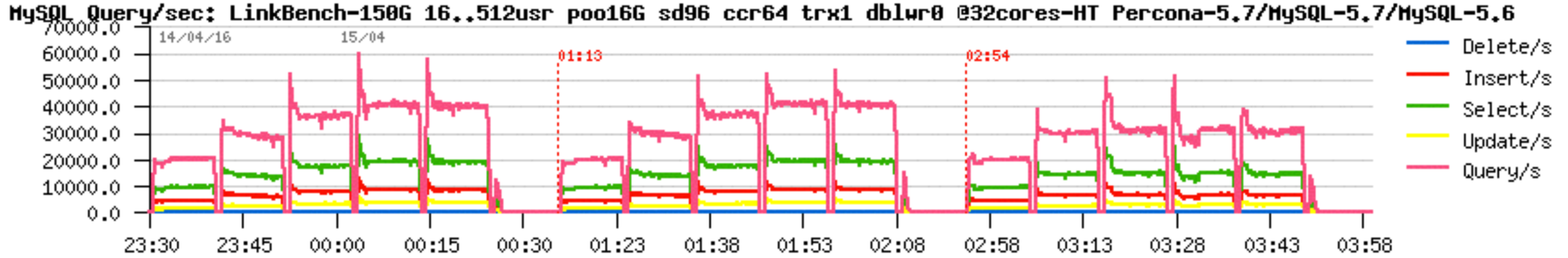




LinkBench-150M, 32cores-HT

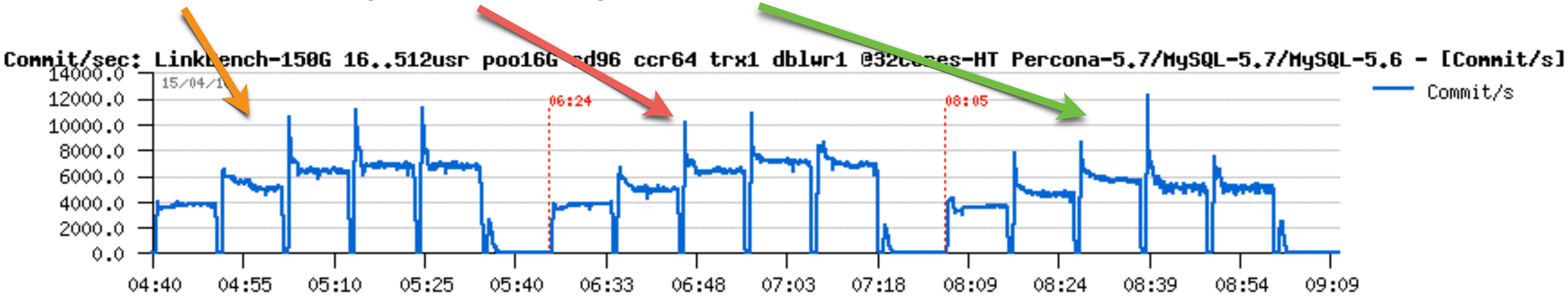
- 16G pool, trx=1, dblwr=0
  - Percona-5.7 / MySQL-5.7 / MySQL-5.6

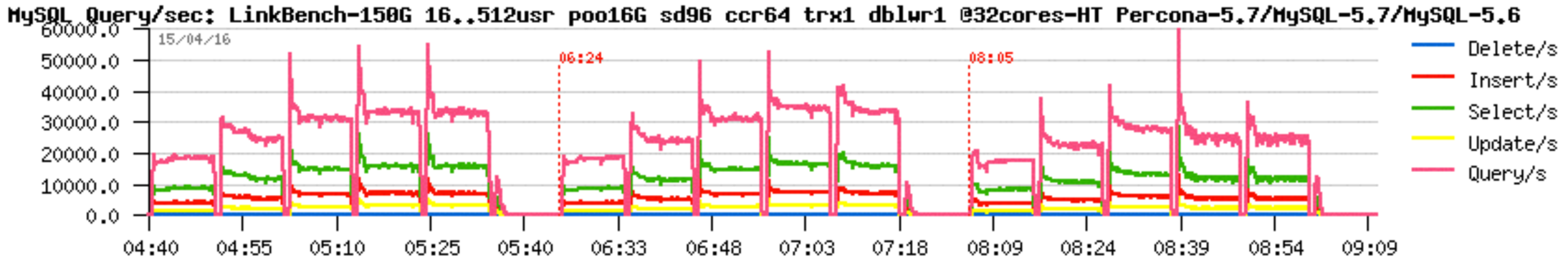




LinkBench-150M, 32cores-HT

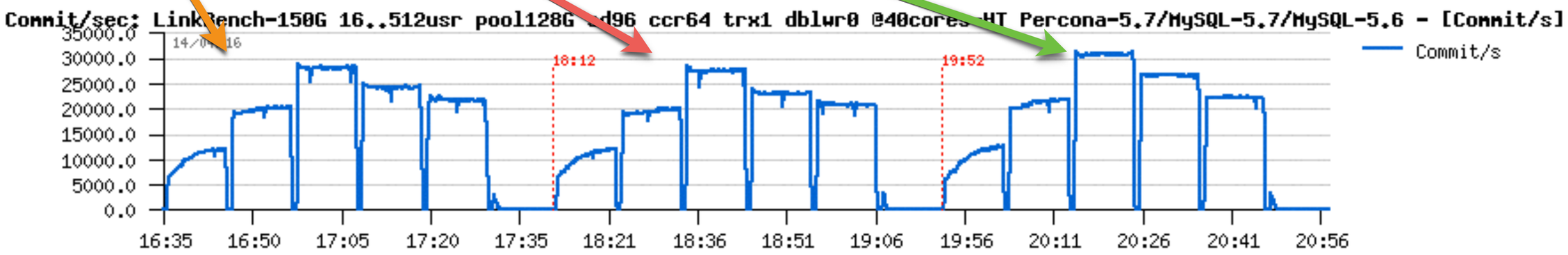
- 16G pool, trx=1, dblwr=1
  - Percona-5.7 / MySQL-5.7 / MySQL-5.6

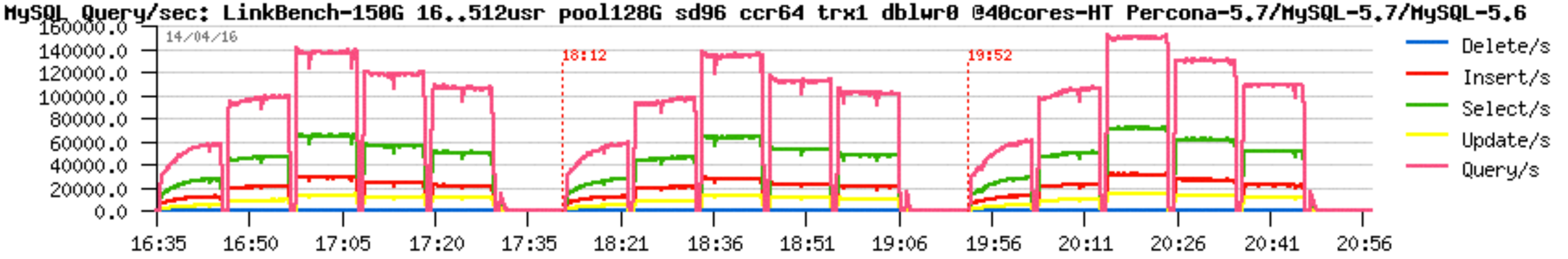




LinkBench-150M, 40cores-HT

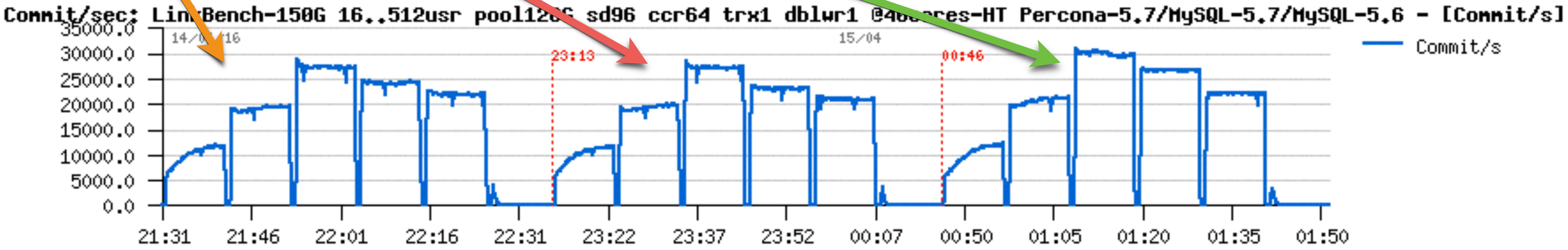
- 128G pool, trx=1, dblwr=0
  - Percona-5.7 / MySQL-5.7 / MySQL-5.6

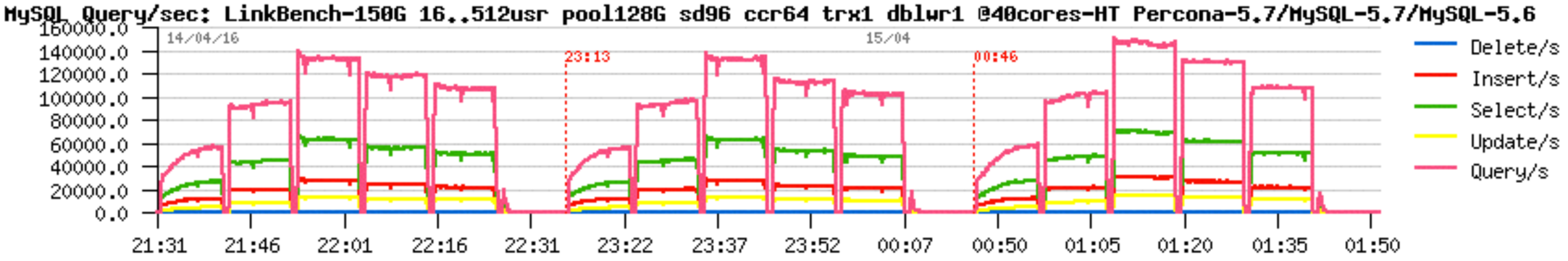




LinkBench-150M, 40cores-HT

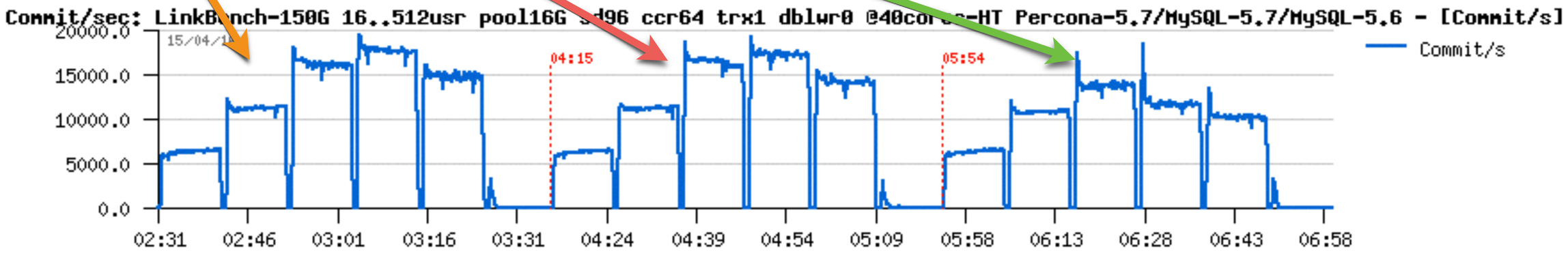
- 128G pool, trx=1, dblwr=1
  - Percona-5.7 / MySQL-5.7 / MySQL-5.6

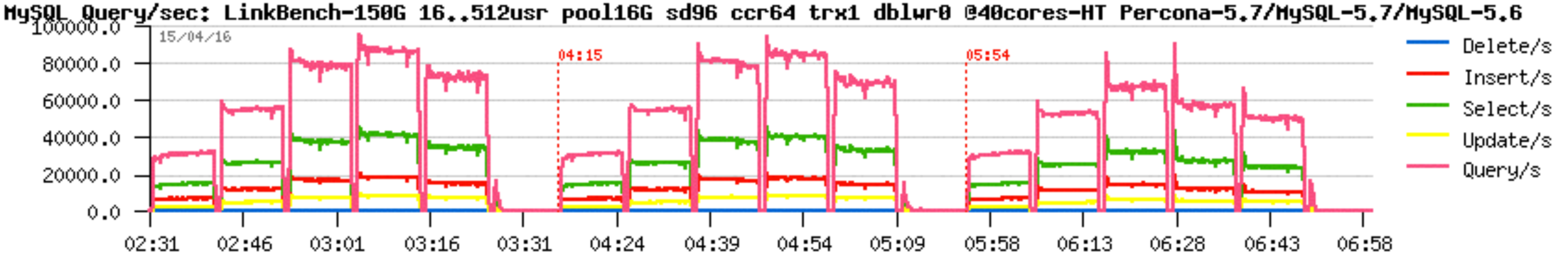




LinkBench-150M, 40cores-HT

- 16G pool, trx=1, dblwr=0
  - Percona-5.7 / MySQL-5.7 / MySQL-5.6

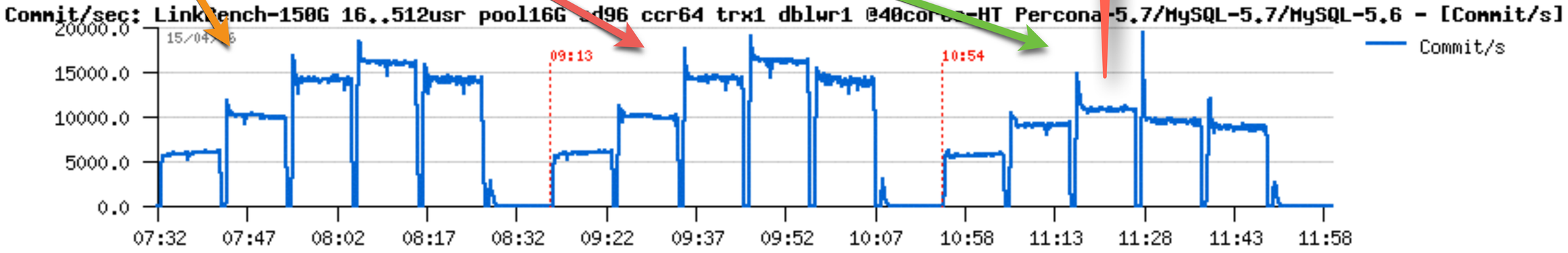


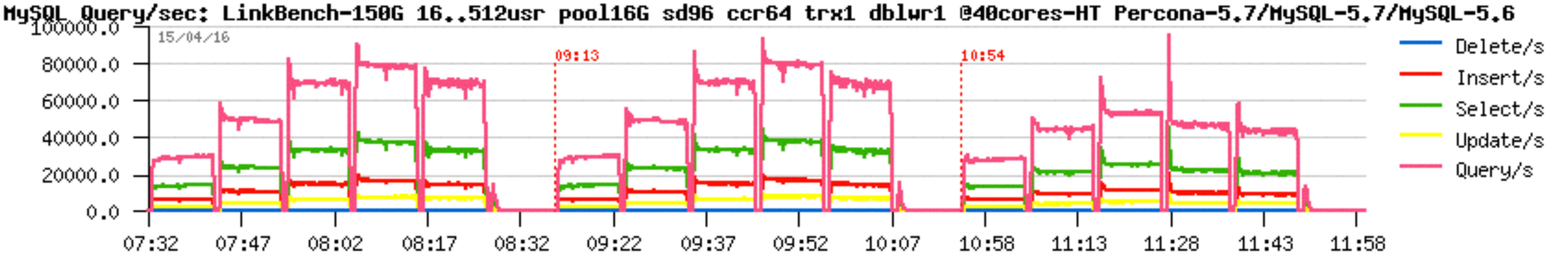


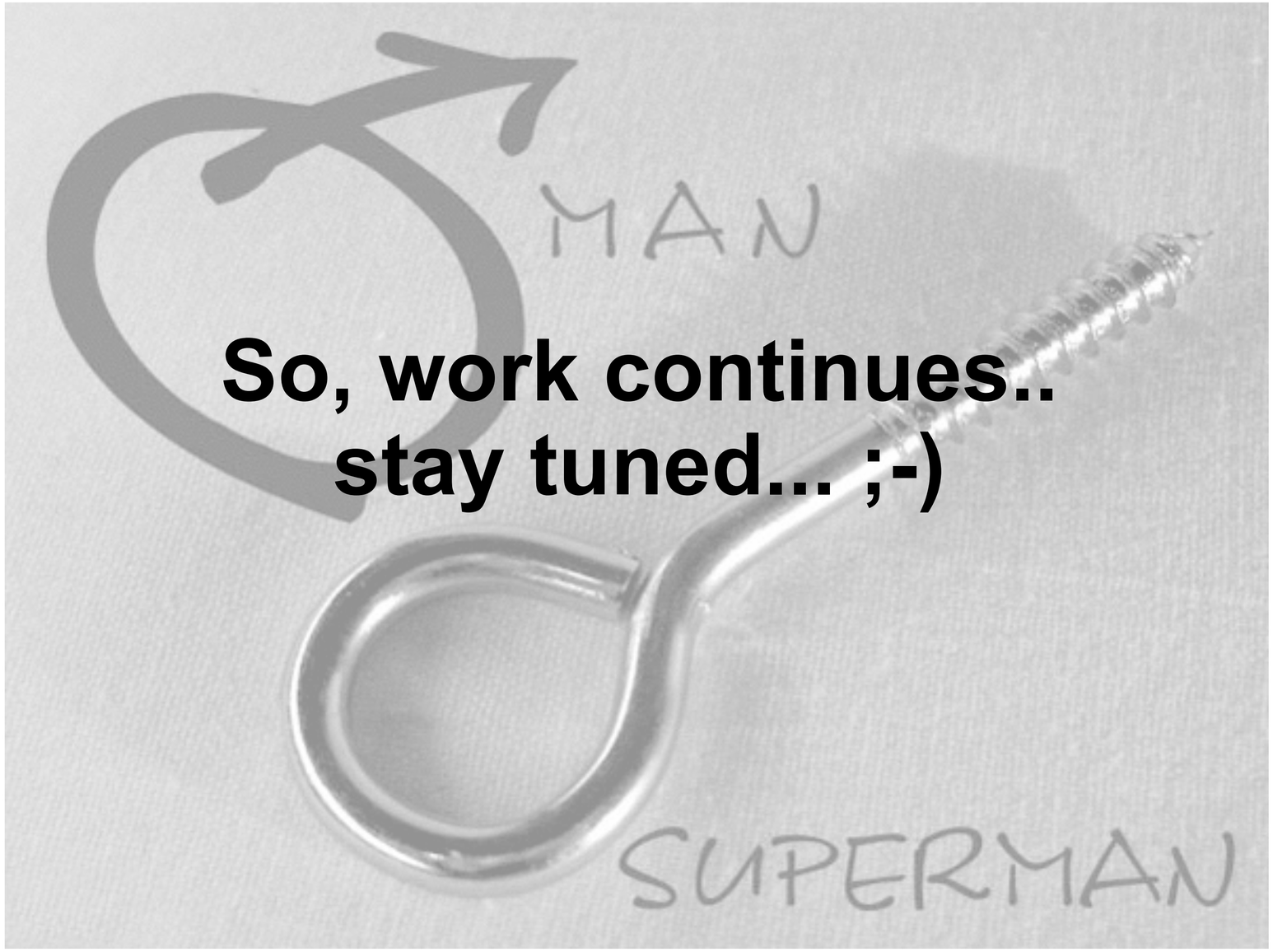
LinkBench-150M, 40cores-HT

- 16G pool, trx=1, dblwr=1
  - Percona-5.7 / MySQL-5.7 / MySQL-5.6

Please, upgrade me to 5.7 !!! ;-)






MAN
So, work continues..
stay tuned... ;-)
SUPERMAN

One more thing ;-)

- All graphs are built with dim_STAT (http://dimitrik.free.fr)
  - All System load stats (CPU, I/O, Network, RAM, Processes,...)
  - Manly for Linux, Solaris, OSX (and any other UNIX too :-)
  - Add-Ons for MySQL, Oracle RDBMS, PostgreSQL, Java, etc.
  - MySQL Add-Ons:
    - mysqlSTAT : all available data from “show status”
    - mysqlLOAD : compact data, multi-host monitoring oriented
    - mysqlWAITS : top wait events from Performance SCHEMA
    - InnodbSTAT : most important data from “show innodb status”
    - innodbMUTEX : monitoring InnoDB mutex waits
    - innodbMETRICS : all counters from the METRICS table
    - And any other you want to add! :-)
- Links
  - http://dimitrik.free.fr - dim_STAT, dbSTRESS, Benchmark Reports, etc.
  - http://dimitrik.free.fr/blog - Articles about MySQL Performance, etc.