MySQL 8.0-dev 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
- Pending issues..
- Progress in MySQL 8.0-dev & Benchmark results..
- Q & A

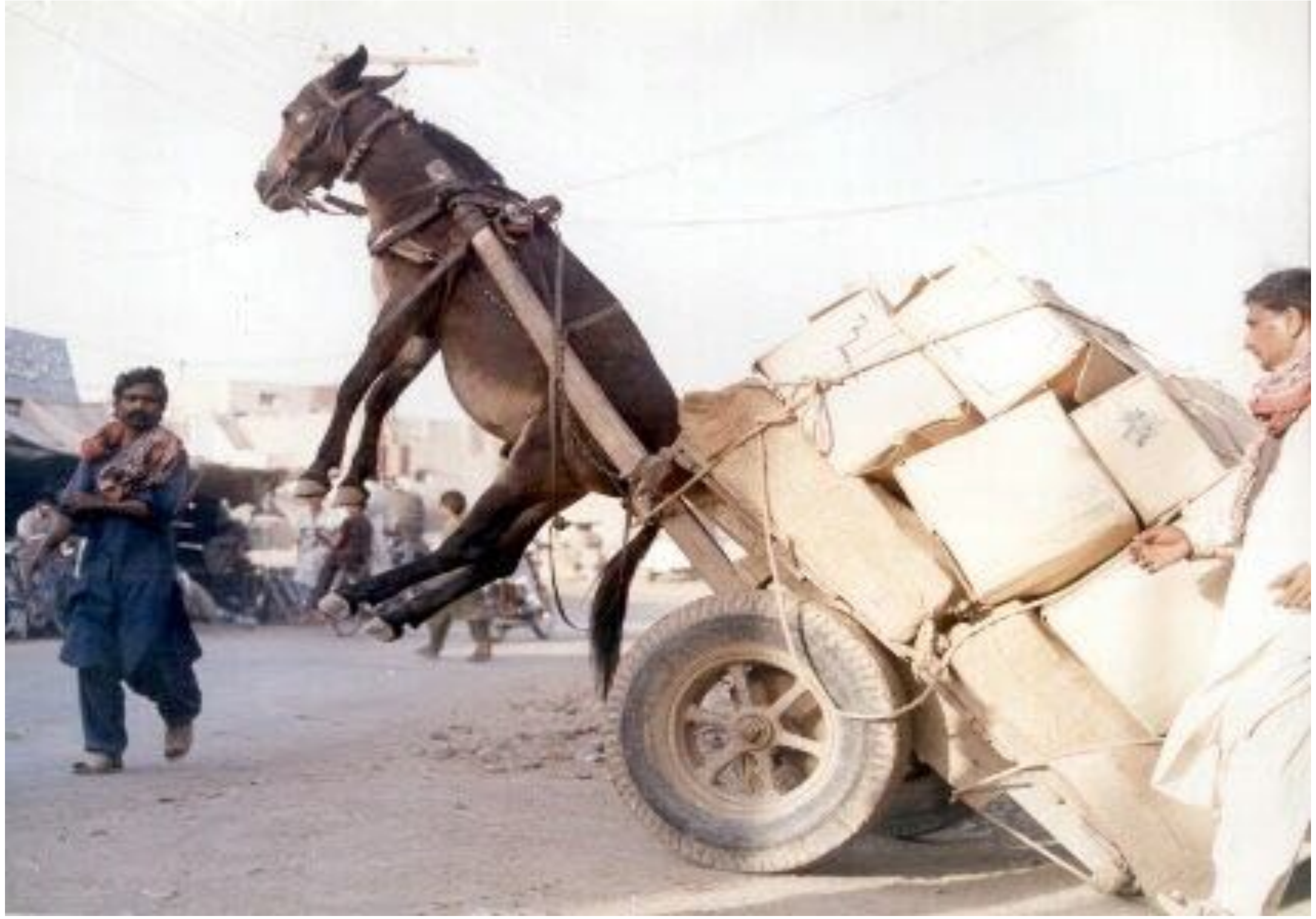
Why MySQL Performance ?...

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 !!! ;-)

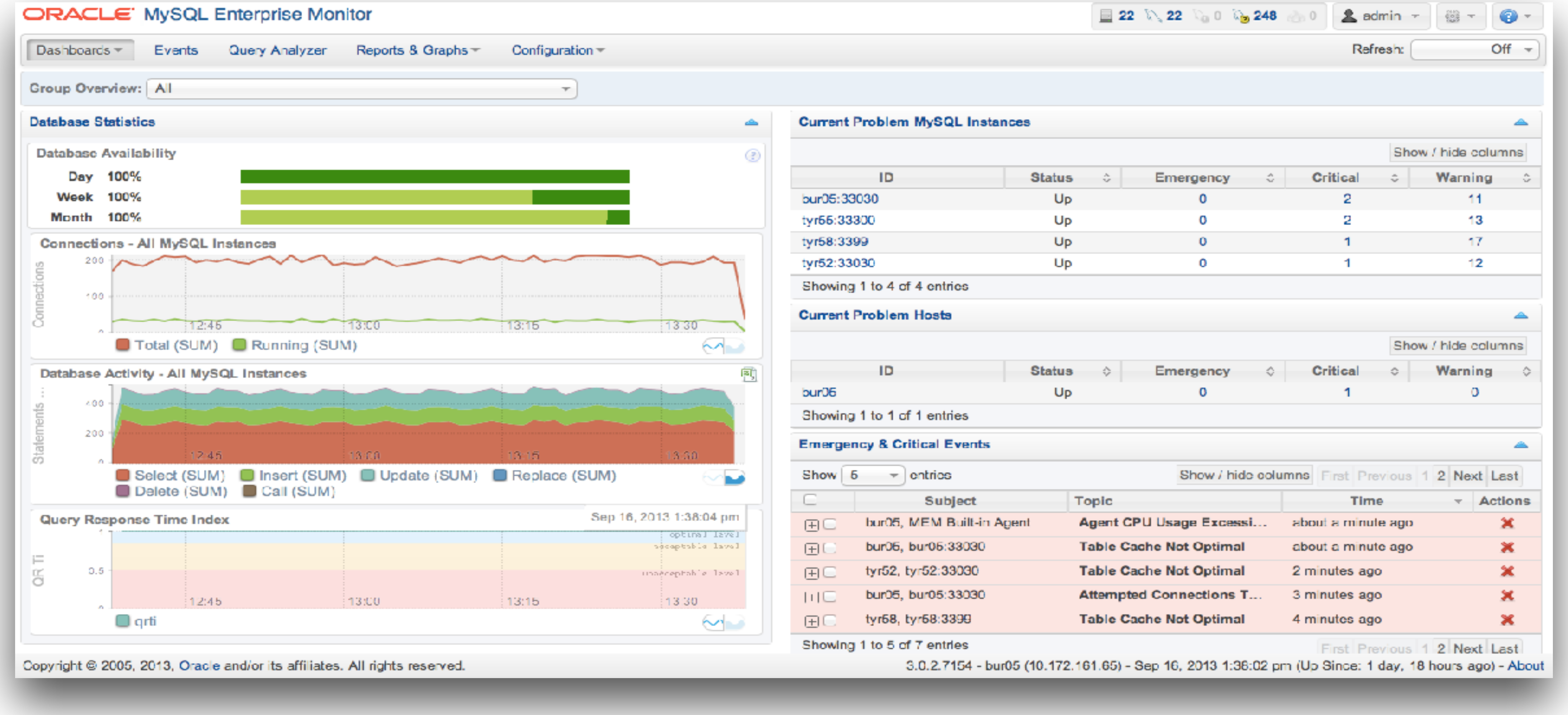
THE MAIN
SLIDE! ;-))

#2 - Monitoring is THE MUST !

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

MySQL Enterprise Monitor (MEM)

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



Database Statistics

Database Availability

Day	100%	
Week	100%	
Month	100%	

Current Problem MySQL Instances

Show / hide columns

ID	Status	Emergency	Critical	Warning
bur05:33030	Up	0	2	11
tyr55:33300	Up	0	2	13
tyr58:3399	Up	0	1	17
tyr52:33030	Up	0	1	12

Showing 1 to 4 of 4 entries

Current Problem Hosts

Show / hide columns

ID	Status	Emergency	Critical	Warning
bur05	Up	0	1	0

Showing 1 to 1 of 1 entries

Emergency & Critical Events

Show 5 entries Show / hide columns First Previous 1 2 Next Last

□	Subject	Topic	Time	Actions
⊞ □	bur05, MEM Built-in Agent	Agent CPU Usage Excessi...	about a minute ago	✗
⊞ □	bur05, bur05:33030	Table Cache Not Optimal	about a minute ago	✗
⊞ □	tyr52, tyr52:33030	Table Cache Not Optimal	2 minutes ago	✗
⊞ □	bur05, bur05:33030	Attempted Connections T...	3 minutes ago	✗
⊞ □	tyr58, tyr58:3399	Table Cache Not Optimal	4 minutes ago	✗

Showing 1 to 5 of 7 entries First Previous 1 2 Next Last

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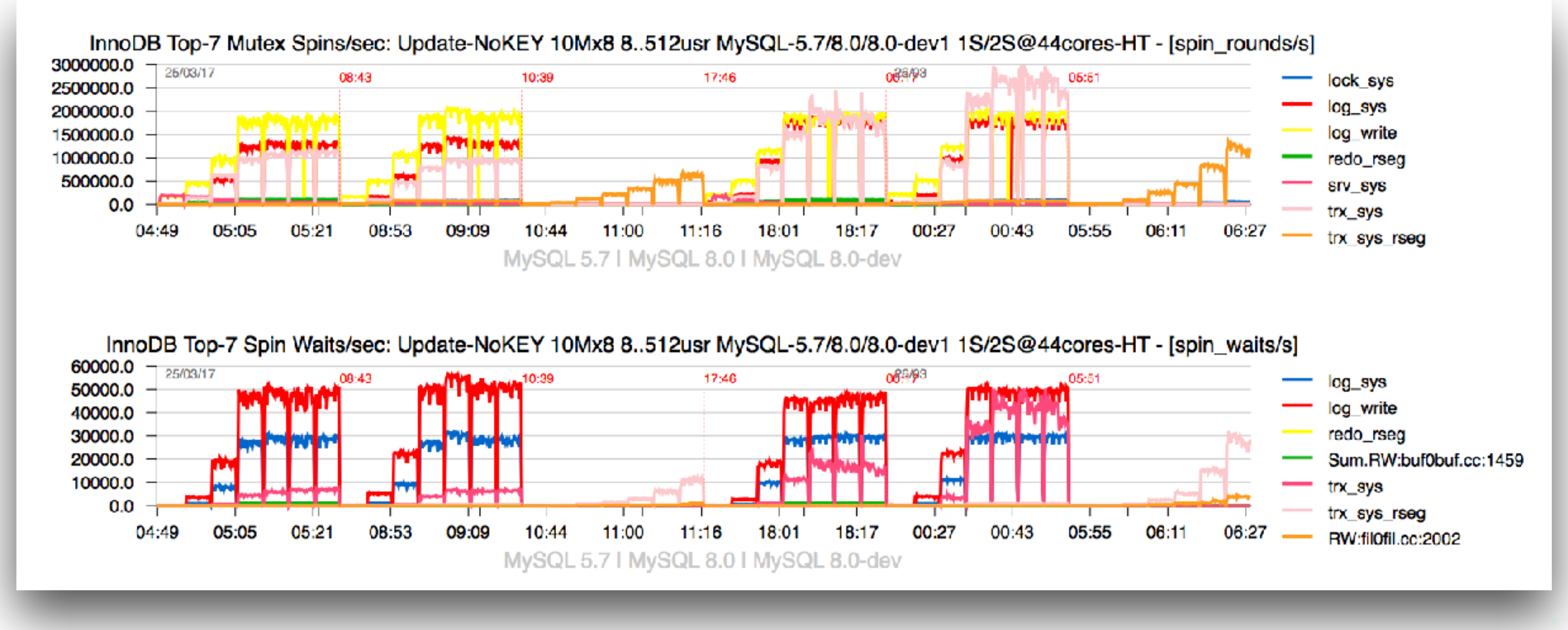
3.0.2.7154 - bur05 (10.172.161.65) - Sep 16, 2013 1:36:02 pm (Up Since: 1 day, 18 hours ago) - About

Other Monitoring Tools

- Cacti, Zabbix, Nagios, Solarwinds, VividCortex, PMM, etc…..
- ***dim_STAT***
  - yes, I'm using mine, 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 ;-))

Common Sources of MySQL Performance Problems..

- “Fixable” ones ;-)
  - DB Schema/ Indexes/ SQL query/ Optimizer plan/ Apps code/ etc. etc..
  - odd tuning/ wrong config setup/
  - e.g. generally can be fixed by => RTFM ! ;-)
- “By design” ones..
  - known ?..
  - workaround ?..
  - can be ever fixed ?..
  - heh…
  - work in progress.. <= and here is where we come ;-))

My main topic ;-)

Why Benchmarks ?

- Common perception of benchmarks is often odd..
  - “not matching real world”…
  - “pure Marketing”..
  - “pure BenchMarketing”..
  - etc. etc. etc..
- well..
  - “it depends..” ©
  - get your own opinion by understanding of the tested workloads !
  - e.g. remind Best Practice #1 ;-))

Benchmarks & MySQL

- Every test workload is pointing to a problem to resolve !
  - evaluate & understand the problem(s)
  - fix it
  - or propose a workaround
  - evaluate & confirm the fix / workaround
  - keep running in QA to discover any potential regression ON TIME !..

- As well :
  - kind of “reference” of what to expect
  - evaluate any new HW, systems, etc..

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Example: iiBench (INSERT Benchmark)

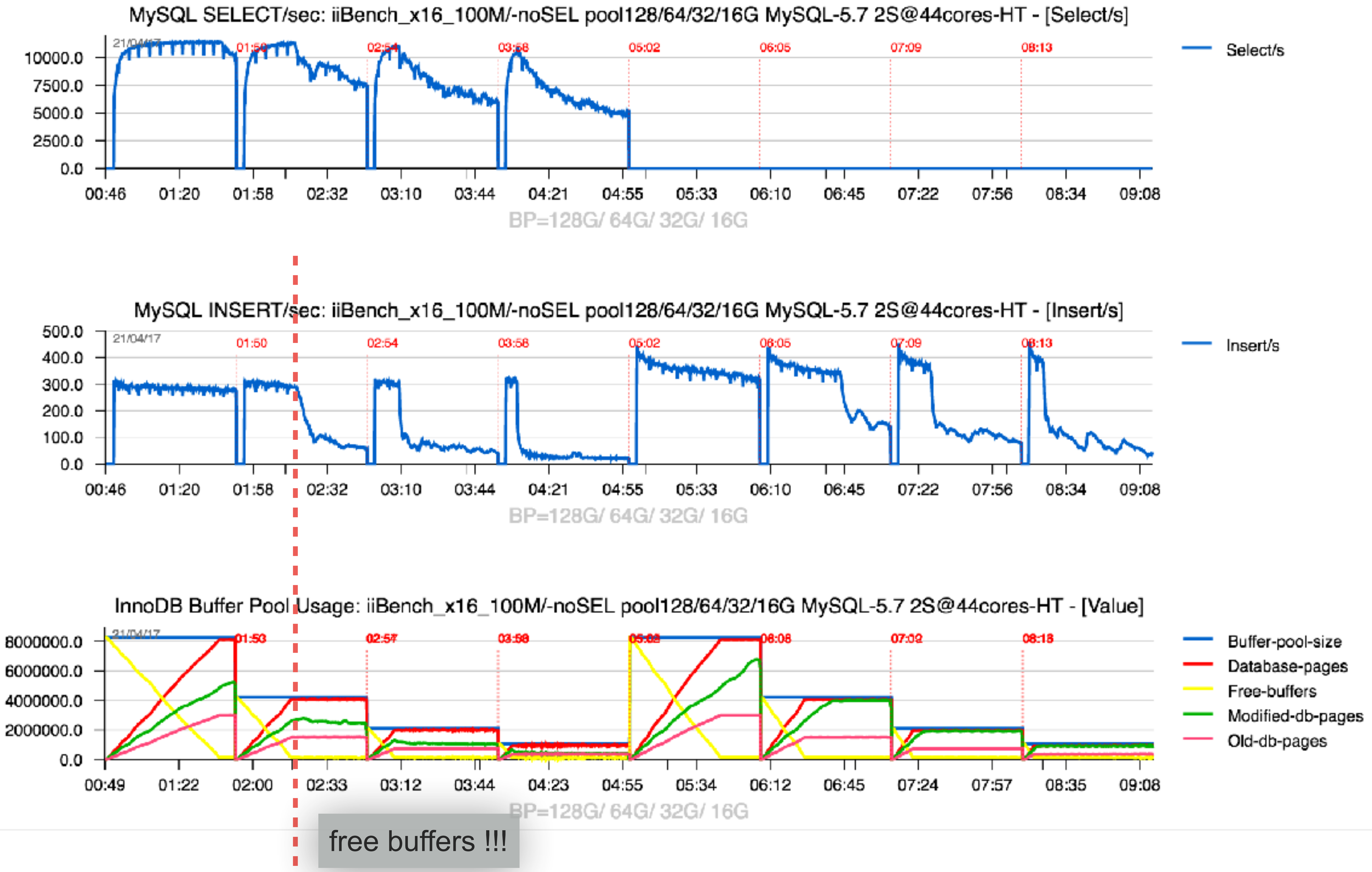
- Main claim :
  - InnoDB is xN times slower vs Write-oriented Engine XXX
  - so, use XXX, as it’s better

- Test Scenario :
  - x16 parallel iiBench processes running together during 1H
  - each process is using its own table
  - one test with SELECTs, another without..

- Key point :
  - during INSERT activity, B-Tree index in InnoDB growing quickly
  - as soon as index pages have no more place in BP and re-read from storage, performance is going down..
  - e.g. “by design” problem ;-))

iiBench 100M x16 : BP= 128G/ 64G/ 32G/ 16G

- Observations :
  - until B-Tree remains in BP => 300K INSERT/sec.. (and if not, QPS drop)

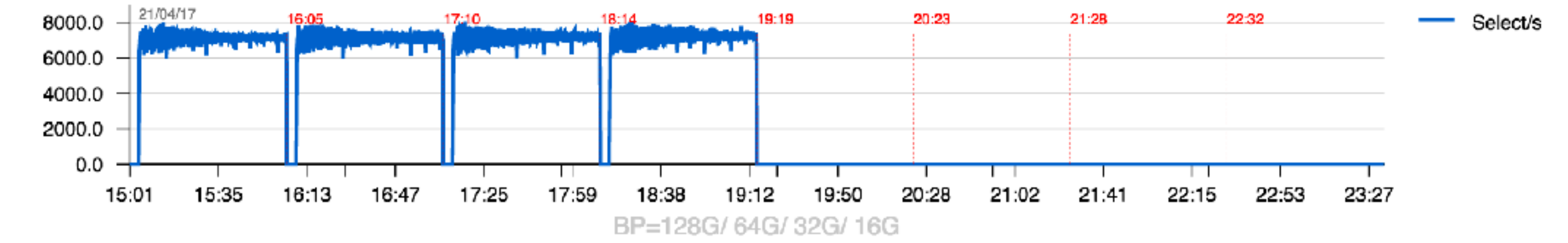


free buffers !!!

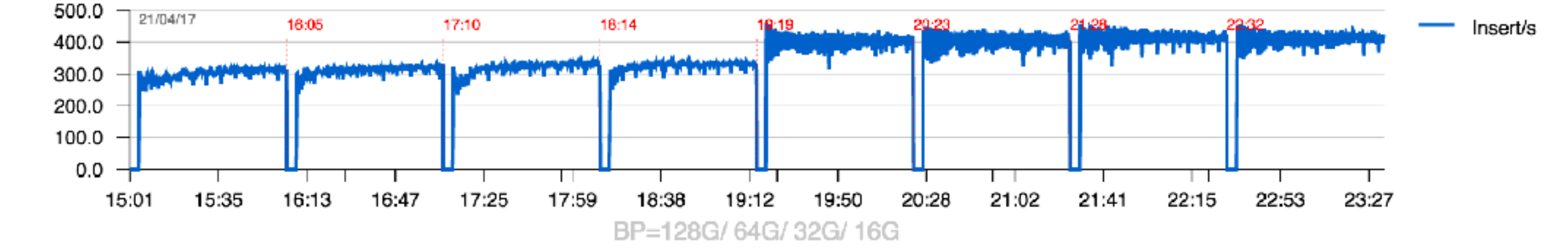
iiBench 100M x16 & 1M-parts : BP= 128G/ 64G/ 32G/ 16G

- Observations :
  - workaround : using partitions for table splits index B-Tree

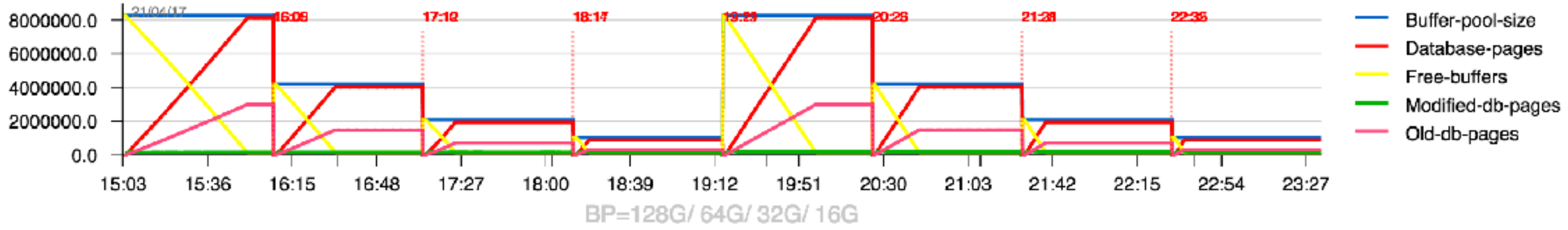
MySQL SELECT/sec: iiBench_x16_100M-1Mpart/-noSEL pool128/64/32/16G MySQL-5.7 2S@44cores-HT - [Select/s]



MySQL INSERT/sec: iiBench_x16_100M-1Mpart/-noSEL pool128/64/32/16G MySQL-5.7 2S@44cores-HT - [Insert/s]



InnoDB Buffer Pool Usage: iiBench_x16_100M-1Mpart/-noSEL pool128/64/32/16G MySQL-5.7 2S@44cores-HT - [Value]



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.." ;-))
  - And even if you were doing something wrong, try to understand its impact..
  - (Best Practice #1 once again ;-))

“Generic” Test Workloads @MySQL

- Sysbench - #1
  - “Entry Ticket” Workloads, looks simple, but still the most complete test kit !
  - OLTP, RO/RW, points on RO and RW issues
- DBT2 / TPCC-like
  - OLTP, RW, pretty complex, growing db, no options, deadlocks
  - in reality using mostly 2 tables only! (thanks Performance Schema ;-))
- DBT3
  - DWH, RO, complex heavy queries, loved by Optimizer Team ;-)
- dbSTRESS
  - OLTP, RO/RW, several tables, points on RW and Sec.IDX issues
- iiBench
  - pure INSERT bombarding + optionally SELECTs, points on B-Tree issues
- LinkBench (Facebook)
  - OLTP, RW, looks intensive and IO-hungry

Why Sysbench is #1 ?..

- Historically :
  - the most simple to install, to use, most lightweight
  - why entry ticket : covers most important “key workload cases” in MySQL performance

- New Sysbench :
  - https://github.com/akopytov/sysbench
  - have fixed all past issues
  - high flexibility for any test scenario with LUA scripts
  - integrated LUA JIT => high execution speed + lightweight !
  - more various test scenarios are expected to come
  - excellent opportunity to write your own test cases !
  - move and use it now ! ;-)

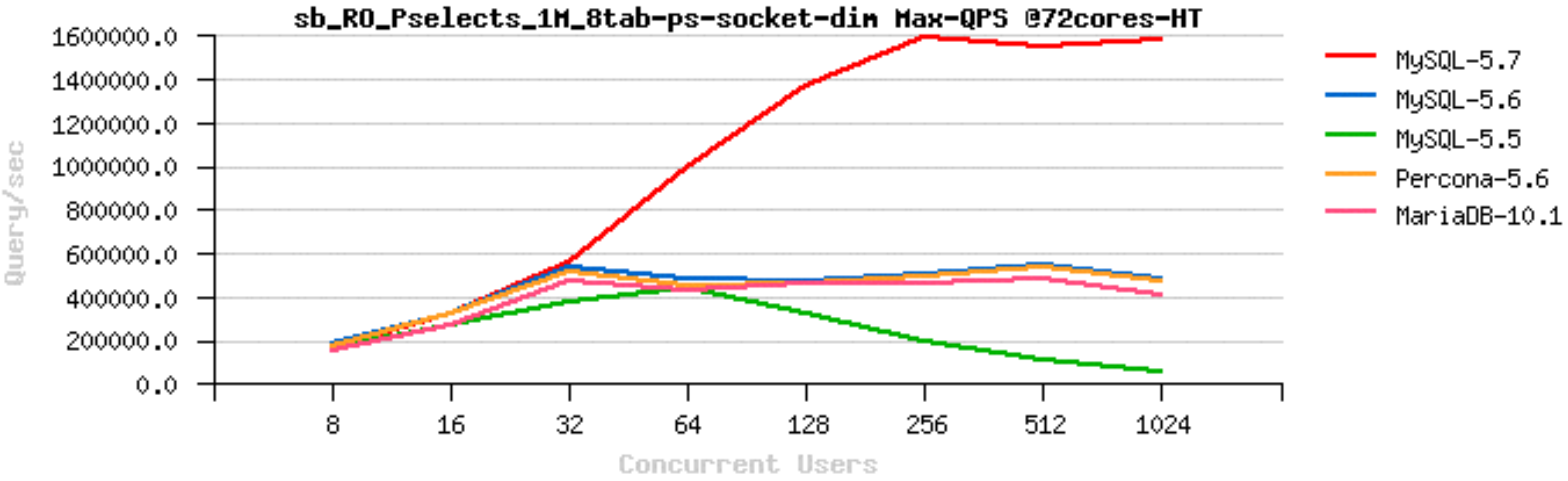
Historically main target : In-Memory Workloads

- What do you mean here ?..
  - have enough RAM for BP to keep all the data (or the "active data-set”) cached
  - e.g. => no I/O reads
  - e.g. => because the disks are so slow, keep as much as you can in RAM
  - historically => part of “best practice” to any RDBMS :
    - I/O reads most impacting
    - I/O writes => many solutions to speed-up

- Historical problems :
  - low load / high load
  - scalability

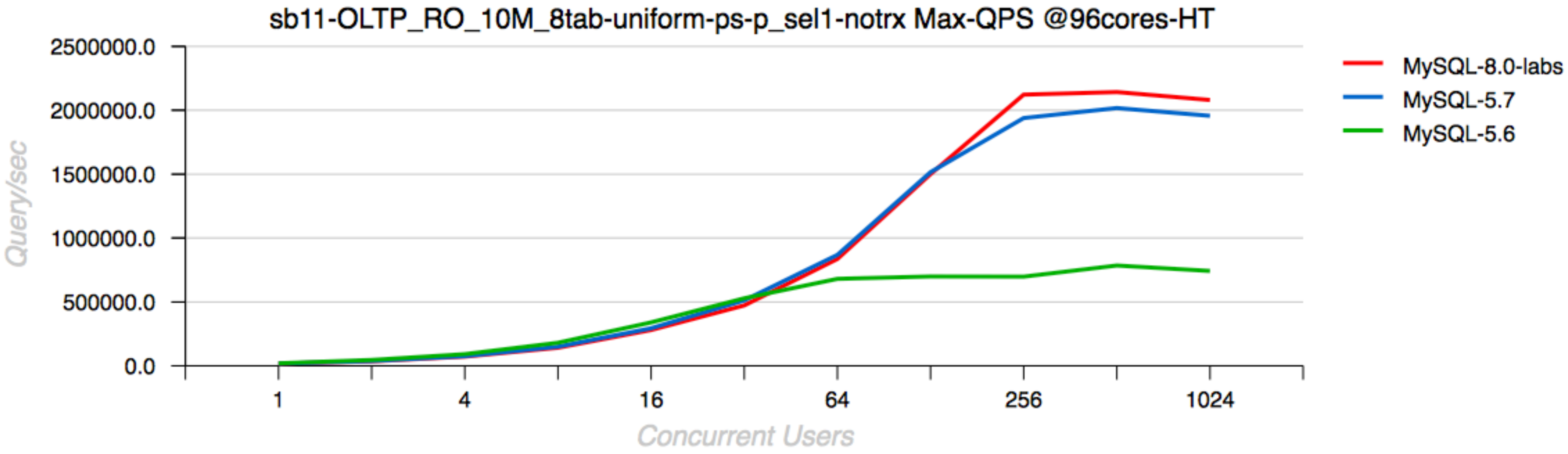
RO Point-Selects @MySQL 5.7 (Oct.2015)

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



RO Point-Selects @MySQL 8.0 (Sep.2017)

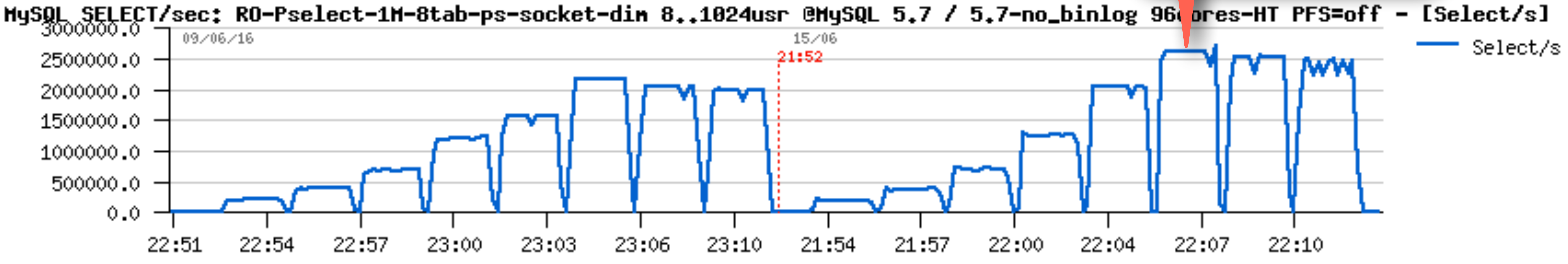
- **2.1M (!!) QPS** Sysbench Point-Selects 8-tab :
  - 96cores-HT Broadwell

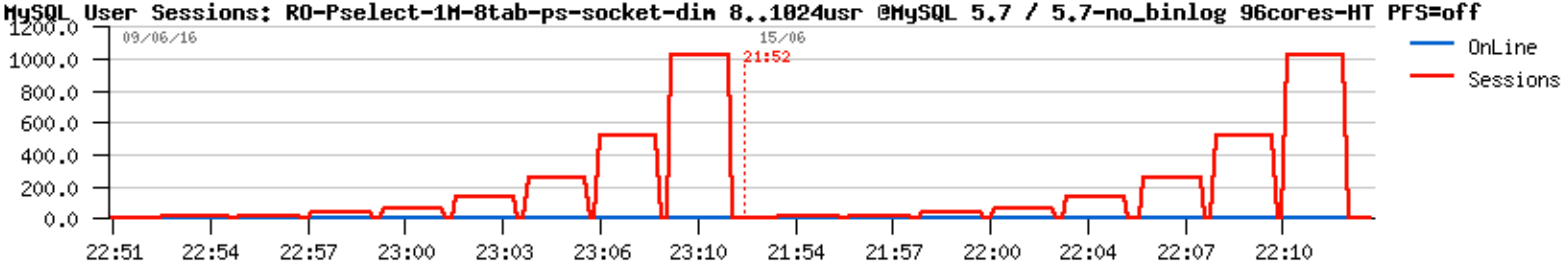


Potential RO Point-Selects @MySQL 5.7 (Jun.2016)

- Potential **2.5M (!!) QPS** Sysbench Point-Selects 8-tab, 96cores-HT :
  - but we don’t care.. ;-))

over 2.5M QPS


MySQL SELECT/sec: RO-Pselect-1M-8tab-ps-socket-dim 8..1024usr @MySQL 5.7 / 5.7-no_binlog 96cores-HT PFS=off - [Select/s]


MySQL User Sessions: RO-Pselect-1M-8tab-ps-socket-dim 8..1024usr @MySQL 5.7 / 5.7-no_binlog 96cores-HT PFS=off

Pending Scalability Issues after MySQL 5.7 GA..

- RO :
  - Block Locks
  - Lookups via Sec.IDX
  - UTF8

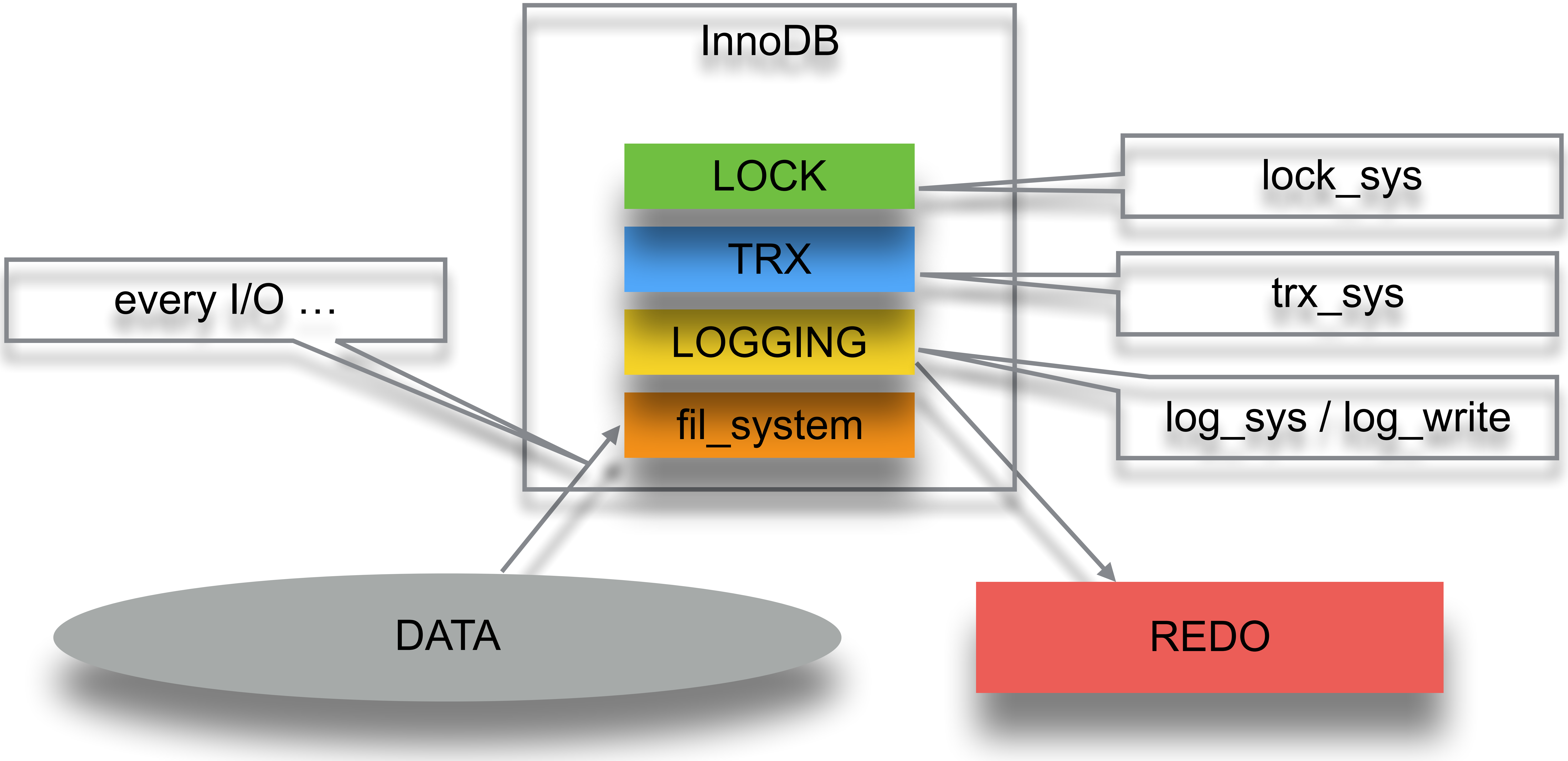
- RW :
  - Double Write..
  - REDO log related bottlenecks
  - TRX management contentions
  - LOCK management..
  - RR / RC isolation..
  - UPDATE Performance..
  - INSERT Performance..
  - Purge lagging..

Pending Scalability Issues after MySQL 5.7 GA..

- RO :
  - Block Locks <= workaround : ProxySQL Query Cache
  - Lookups via Sec.IDX <= possible workaround : use PK, AHI
  - UTF8 <= **use 8.0** ;-)

- RW :
  - Double Write.. <= **expected in 8.0**
  - REDO log related bottlenecks <= **new REDO 8.0-labs**
  - TRX management contentions <= work-in-progress, prototyped..
  - LOCK management.. <= work-in-progress, prototyped..
  - RR / RC isolation.. <= work-in-progress, prototyped..
  - UPDATE Performance.. <= **8.0-labs, more to come**
  - INSERT Performance.. <= possible workaround : use partitions
  - Purge lagging.. <= not yet solved, but you can truncate UNDO

MySQL-dev : New Design for InnoDB Fundamentals..



InnoDB

LOCK

TRX

LOGGING

fil_system

lock_sys

trx_sys

log_sys / log_write

every I/O …

DATA

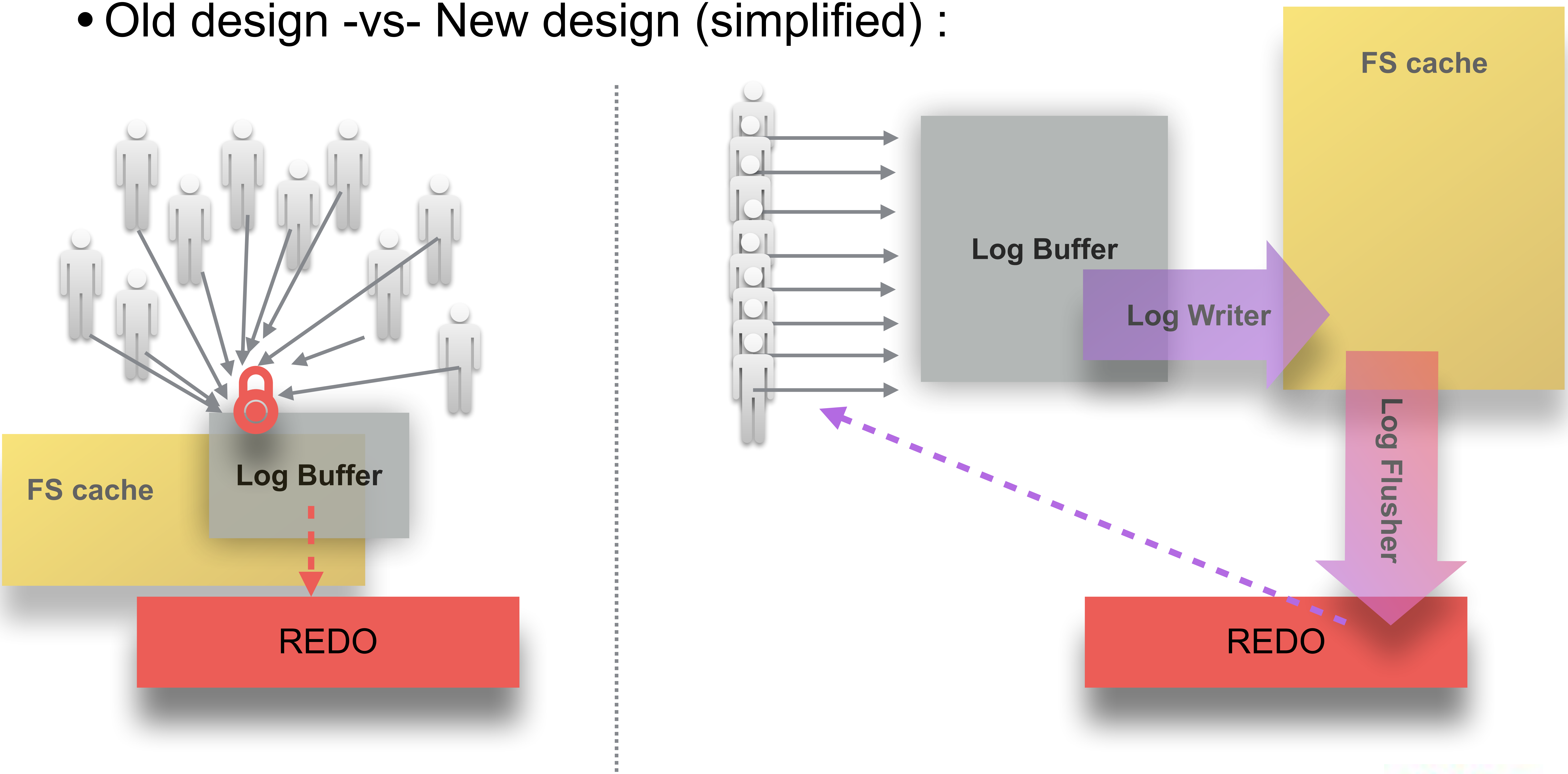
REDO

MySQL 8.0 : Re-Designed REDO

- InnoDB REDO writes :
  - FS cache buffered write() + fsync()
  - innodb_flush_log_at_trx_commit = 1 / 2 / 0
    - = 1 : fsync() on every COMMIT
    - = 2 : do write() on every COMMIT, but fsync() once per second
    - = 0 : do write() once per second, and fsync() once per second
  - historical supposition : the biggest impact is coming from fsync()
    - => group commit, etc.
  - **2015** : Sunny's probe patch is showing trx_commit=1 is faster than trx_commit=2
  - so, what is odd with REDO then ?..
    - user threads fight !
    - with faster storage fsync() becomes much less important -vs- internal contentions..

MySQL 8.0 : Re-Designed REDO

- Old design -vs- New design (simplified) :

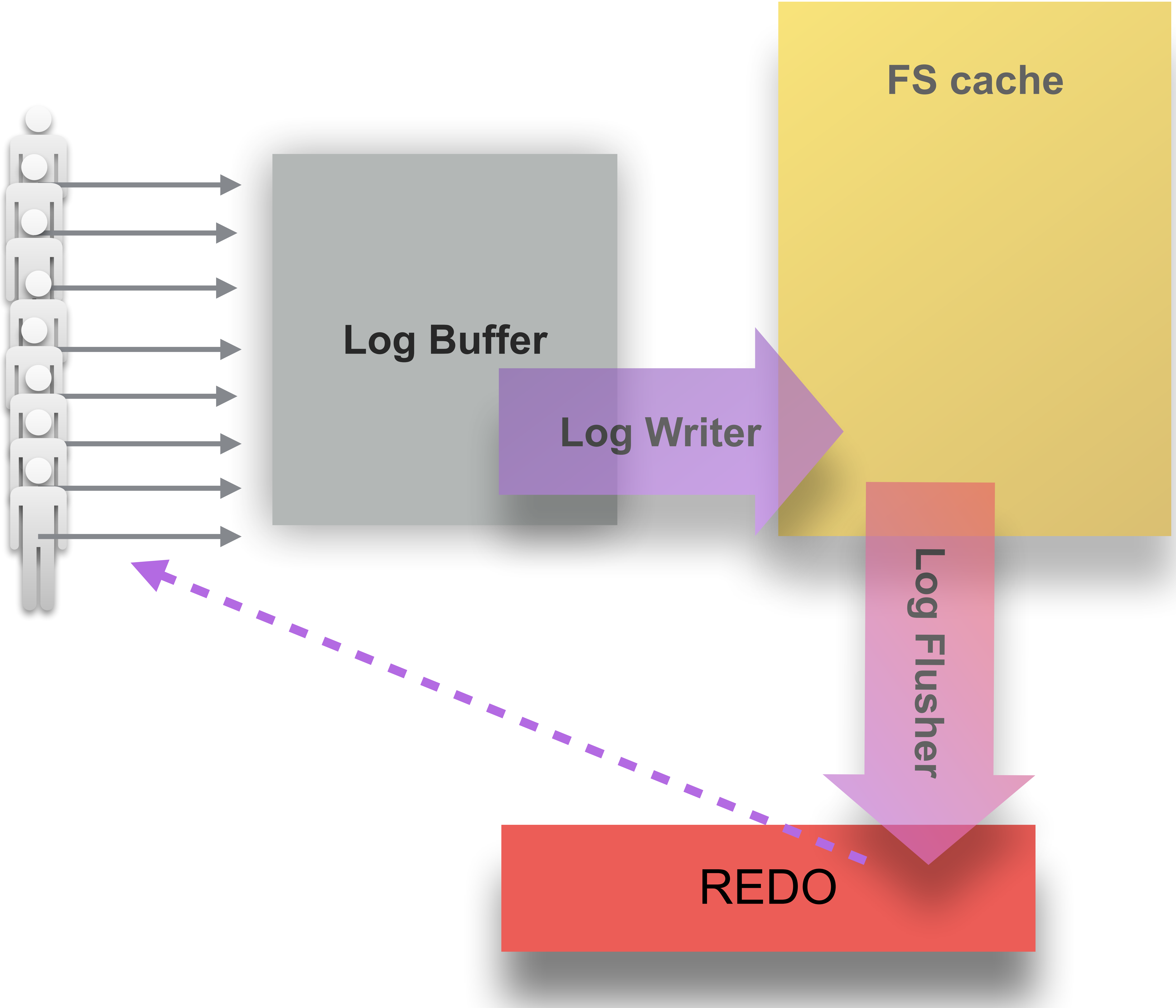


MySQL 8.0 : Re-Designed REDO

- New REDO design :
  - users are not fighting anymore !
  - self-driven processing..
  - self-driven by fsync() capacity

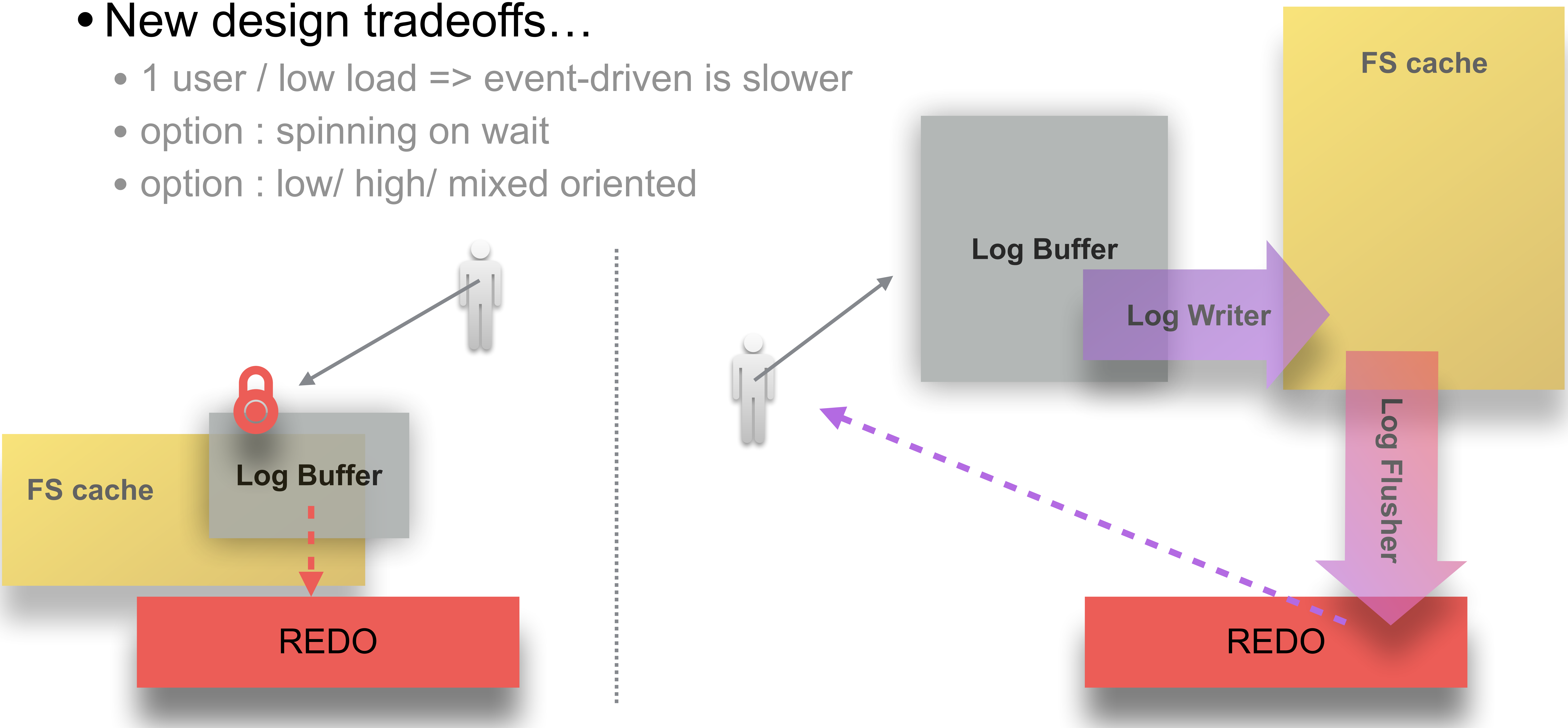
- Instrumented !
  - spins / waits
  - writer / flusher rates
  - max / avg flush times
  - etc..

- Configuration :
  - **mostly all dynamic !!!**
  - so you can play with it on-line ;-))



MySQL 8.0 : Re-Designed REDO

- New design tradeoffs…
  - 1 user / low load => event-driven is slower
  - option : spinning on wait
  - option : low/ high/ mixed oriented



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MySQL 8.0 : Re-Designed REDO

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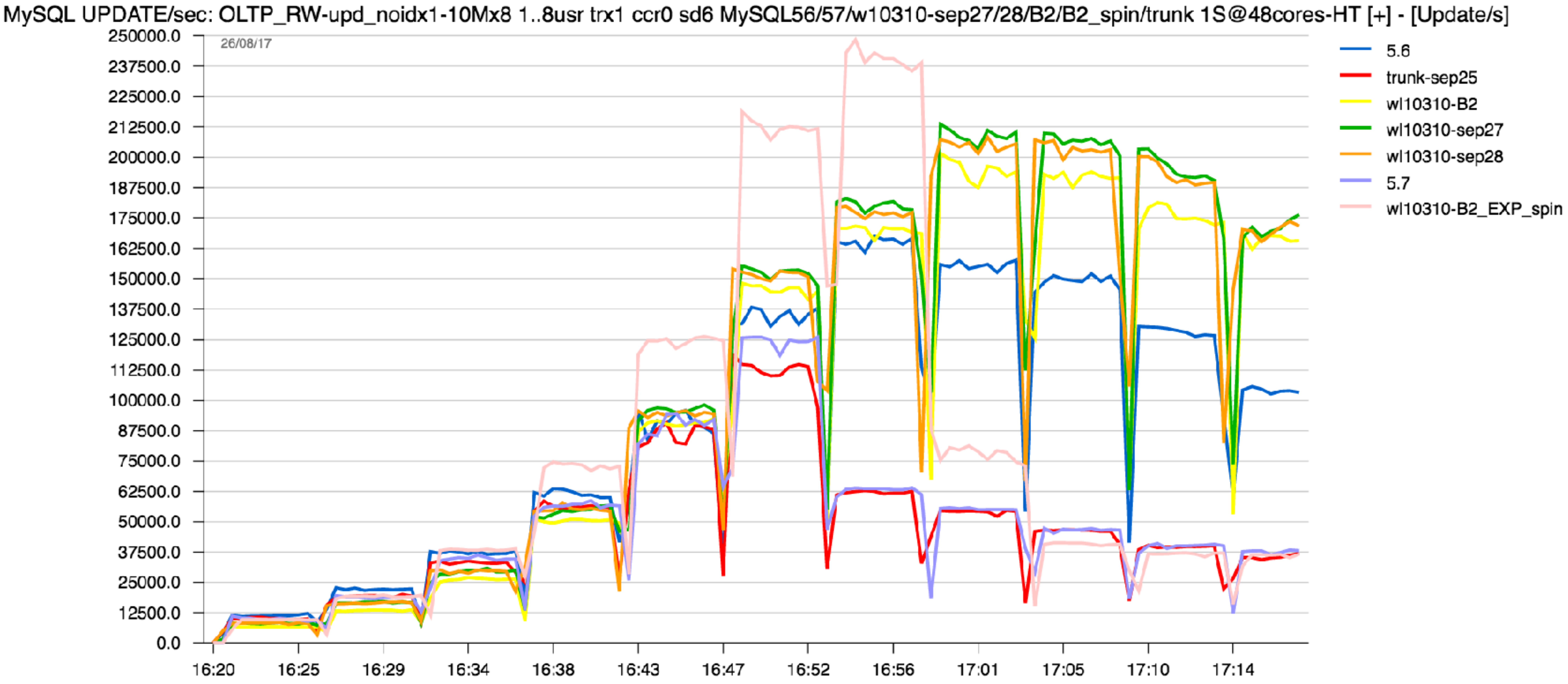
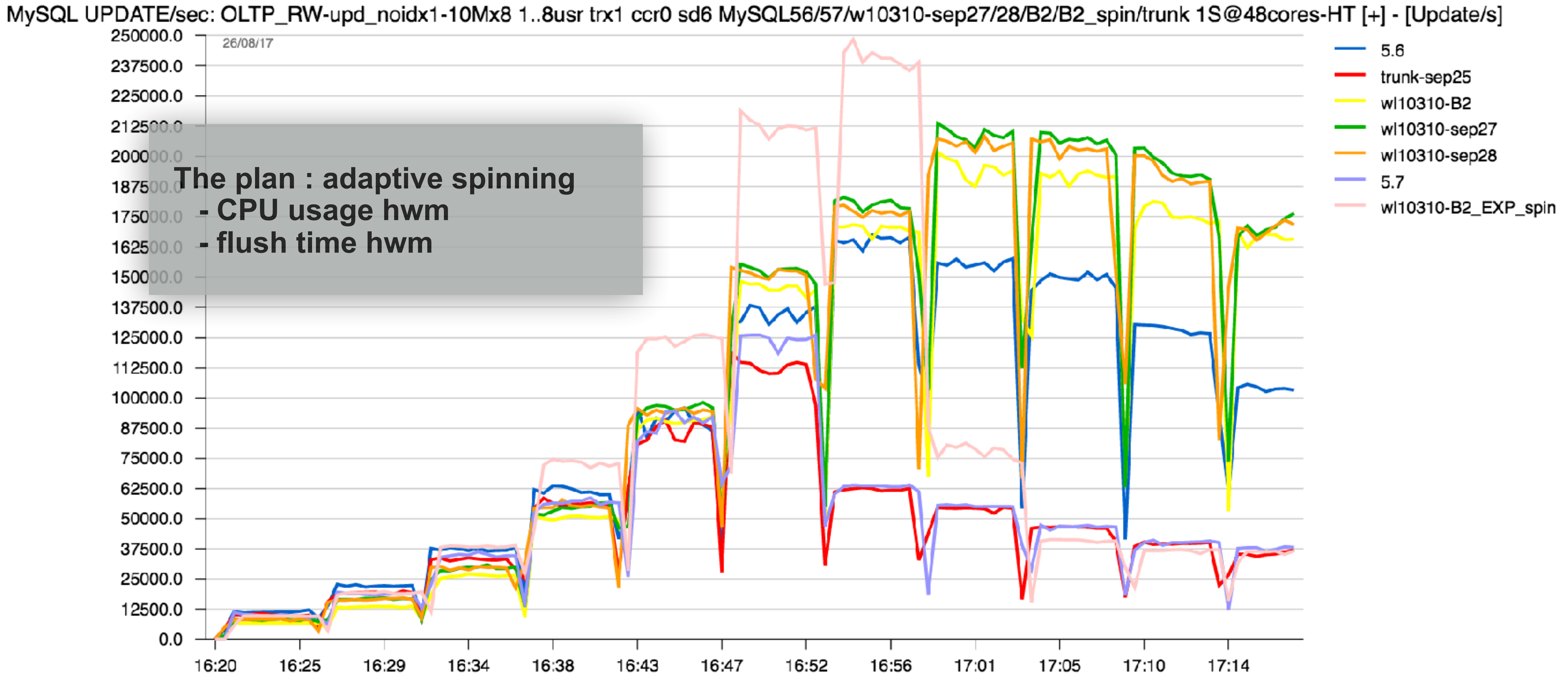


MySQL 8.0 : Re-Designed REDO

- New design tradeoffs…

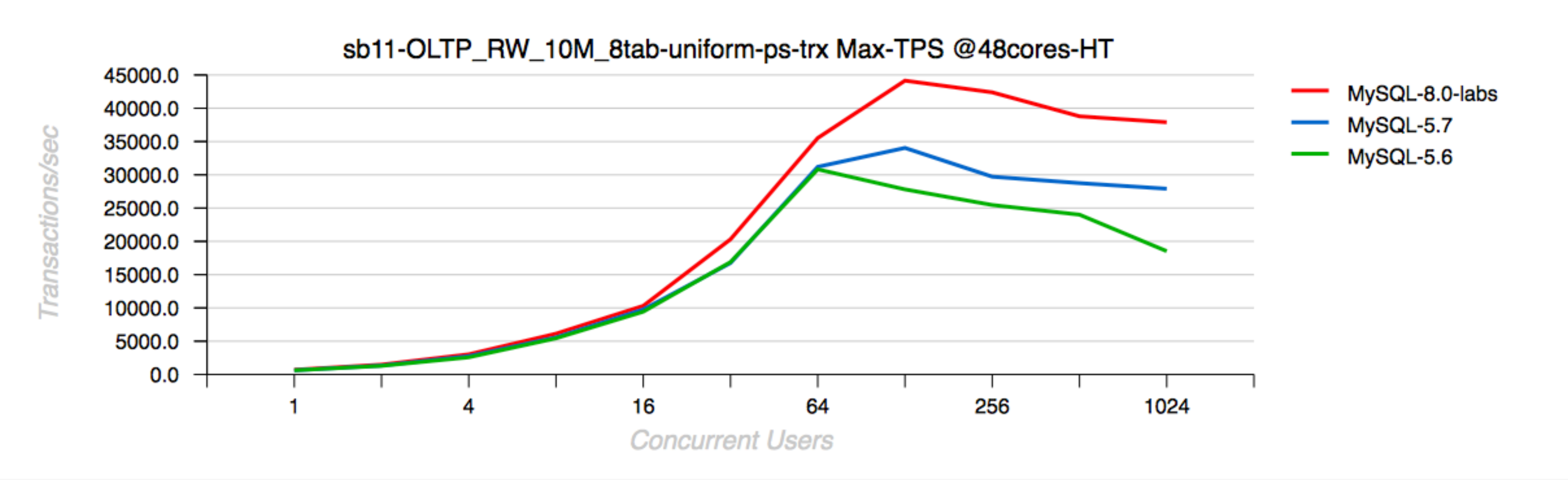


MySQL UPDATE/sec: OLTP_RW-upd_noidx1-10Mx8 1..8usr trx1 ccr0 sd6 MySQL56/57/w10310-sep27/28/B2/B2_spin/trunk 1S@48cores-HT [+] - [Update/s]

The plan : adaptive spinning
- CPU usage hwm
- flush time hwm

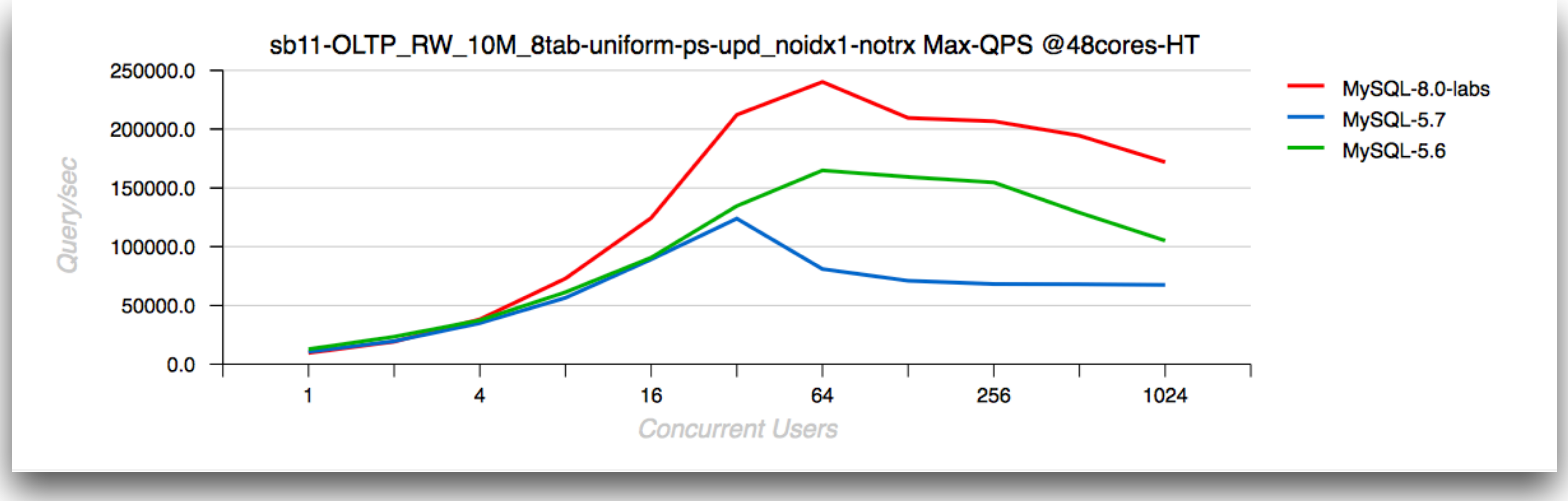
MySQL 8.0-labs Performance

- Sysbench OLTP_RW 10Mx8tab, trx_commit=1, 48cores-HT (Skylake)
  - 30% gain vs MySQL 5.7
  - 50% gain vs MySQL 5.6



MySQL 8.0-labs Performance

- Sysbench Updates-Nokey 10Mx8tab, trx_commit=1, 48cores-HT (Skylake)
  - 100% gain vs MySQL 5.7
  - 50% gain vs MySQL 5.6 (and yes, 5.7 is bad here.. => fixed !! ;-))

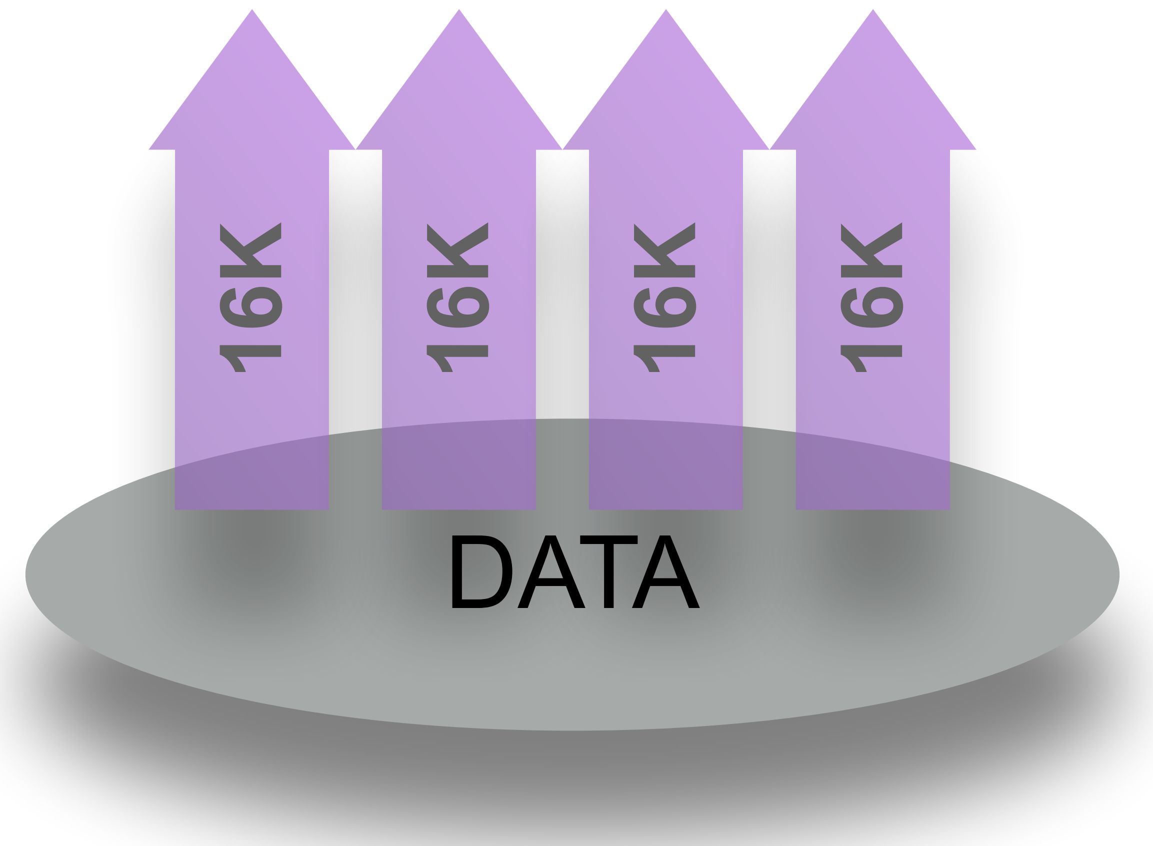


MySQL 8.0 Writes Scalability

- IMPORTANT :
  - MySQL 8.0 overall WRITE performance is way better comparing to all we have before !
  - but : we're NOT scaling yet..
- Going from 1S => 2S (CPU Sockets) :
  - OLTP_RW : somewhat 50% better TPS only, and it's due RO scaling..
  - Update-NoKEY : just worse TPS..
- Why ?
  - 1) next-level bottlenecks (TRX / LOCK Management)
  - 2) + something else (yet to discover)..
  - so, still a lot of work ahead ;-))

IO-bound Workloads : Game Changer..

- IO reads :
  - game changer : **FLASH** => goes faster / cheaper / more stable / living longer / etc..
  - e.g. no more “seek time” cost, the main IO limit : device throughput
  - supposing your max throughput is XXX MB/sec, what is the max IO-bound QPS possible ?
  - => driven by IO read **Operations/sec** …



IO-bound Workloads : more in depth..

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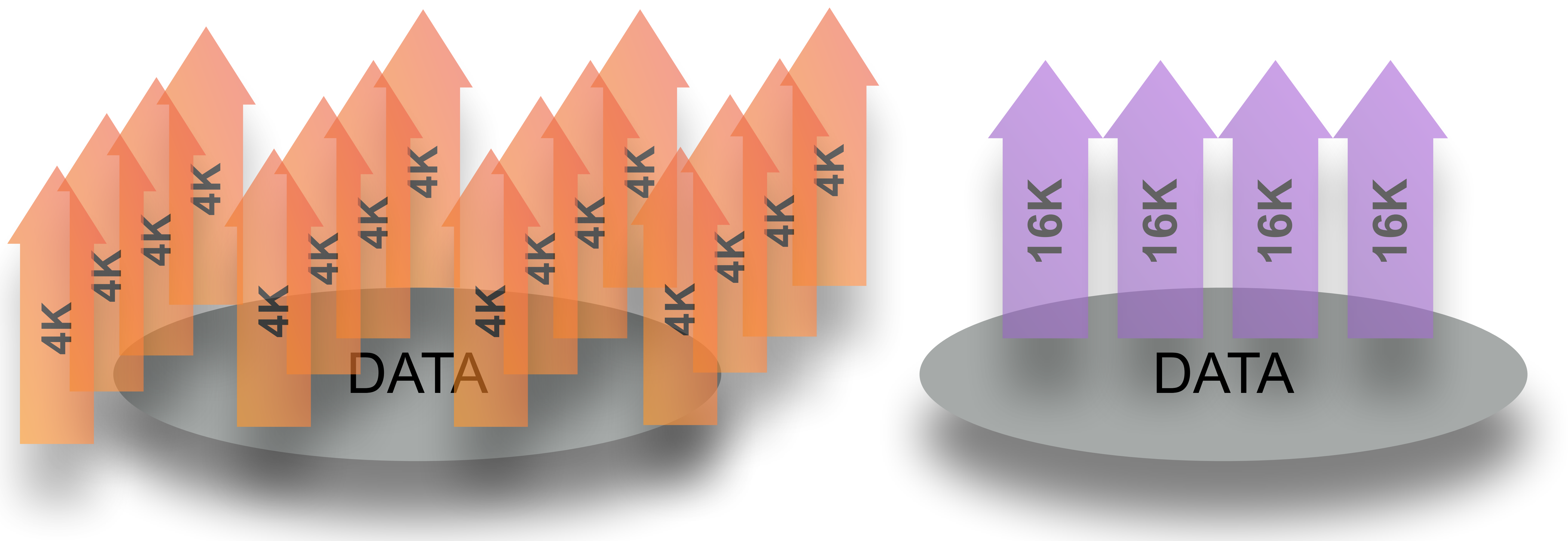
  - Compression ? => x4 times more IO reads !!!



IO-bound Workloads : more in depth..

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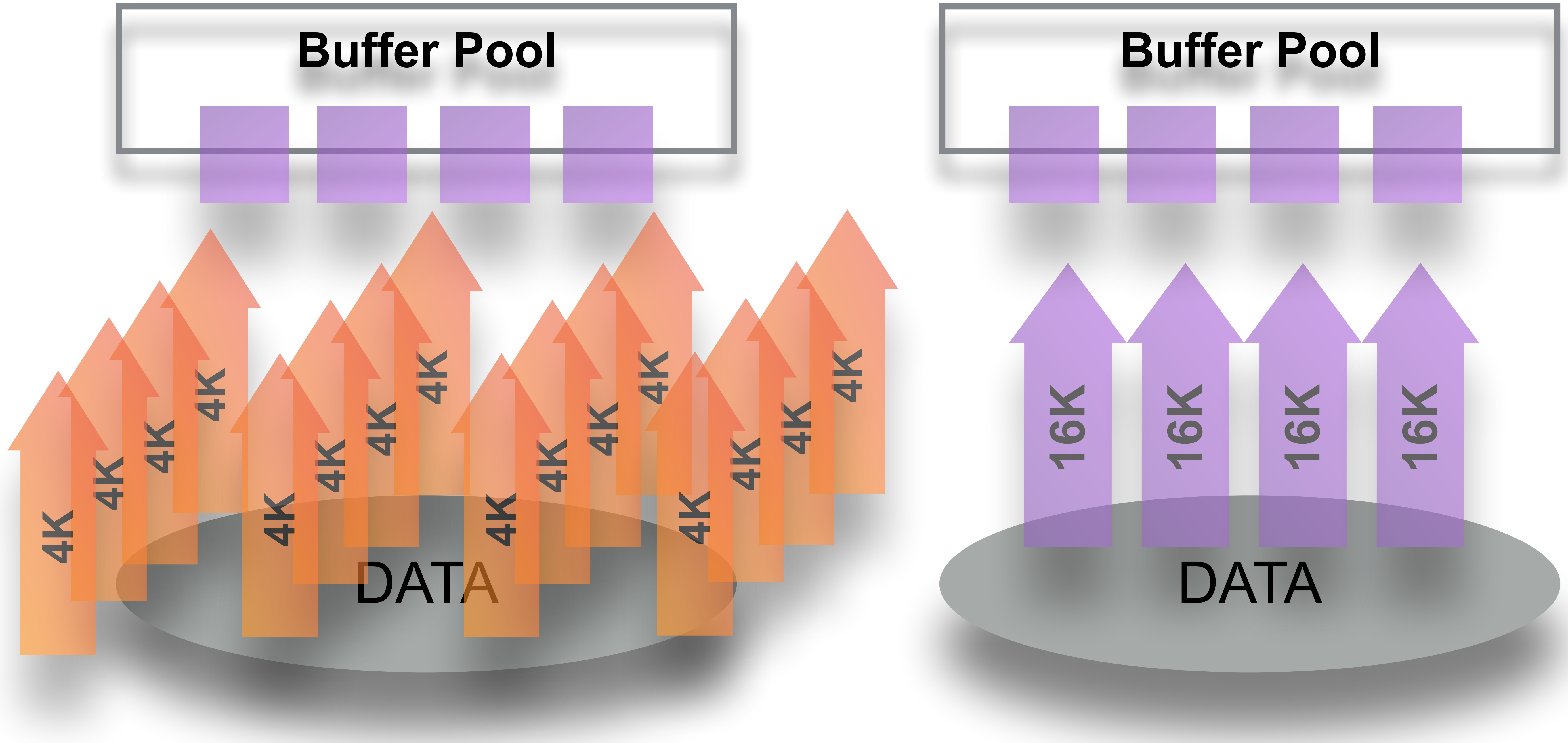
  - Compression ? => x4 times more IO reads !!! => **and QPS** ?..



IO-bound Workloads : more in depth..

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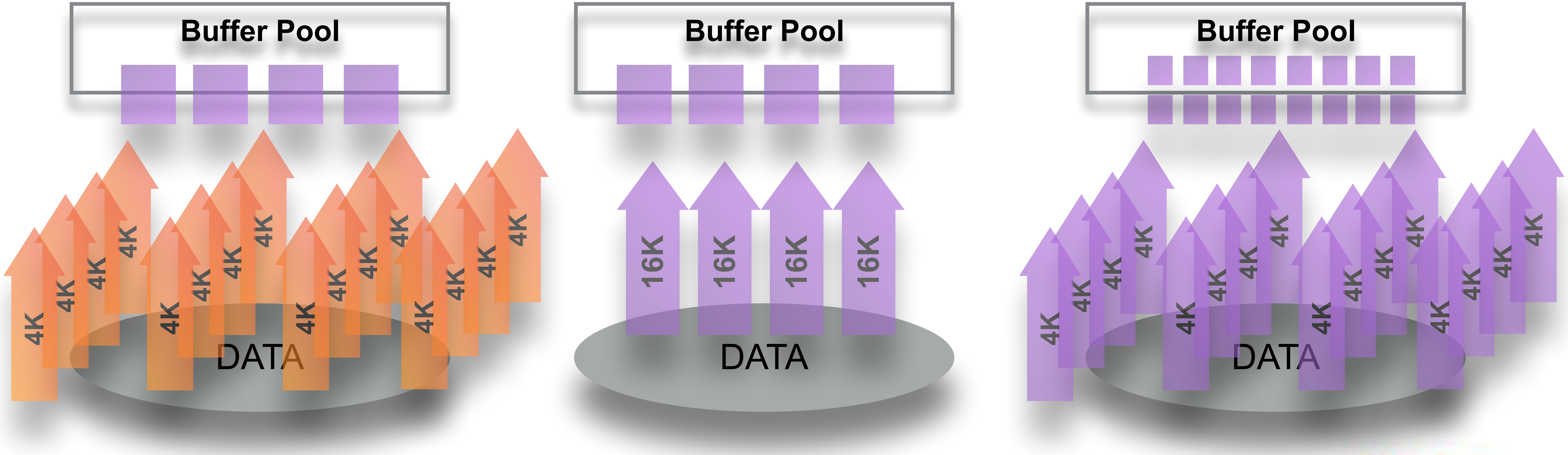
  - => driven by IO read **Operations/sec** …
  - Compression ? => x4 times more IO reads !!! => and QPS ?.. **and what about 4K page ?**



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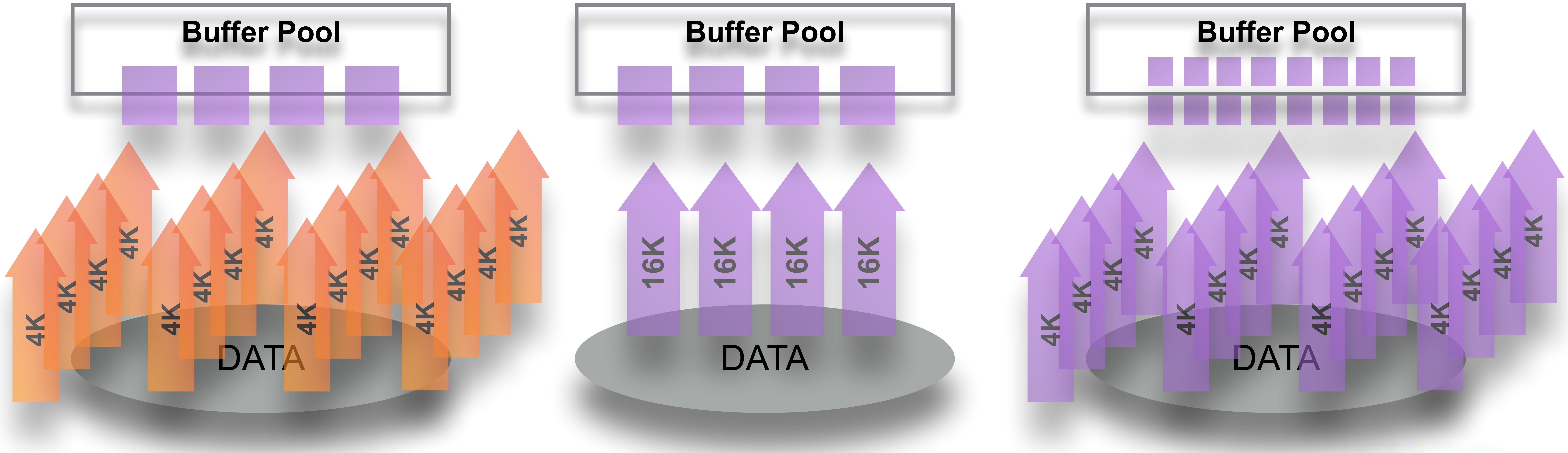
IO-bound Workloads : more in depth..

- IO reads :
  - so, with fast FLASH + 4K page size => x4 times better RO performance vs default 16K ?
  - potentially YES ;-))
  - but.. => historically : **fil_system** global mutex lock on **every IO operation !!!**
  - good news : **fixed with 8.0 ! ;-))**



IO-bound Workloads : Test Case

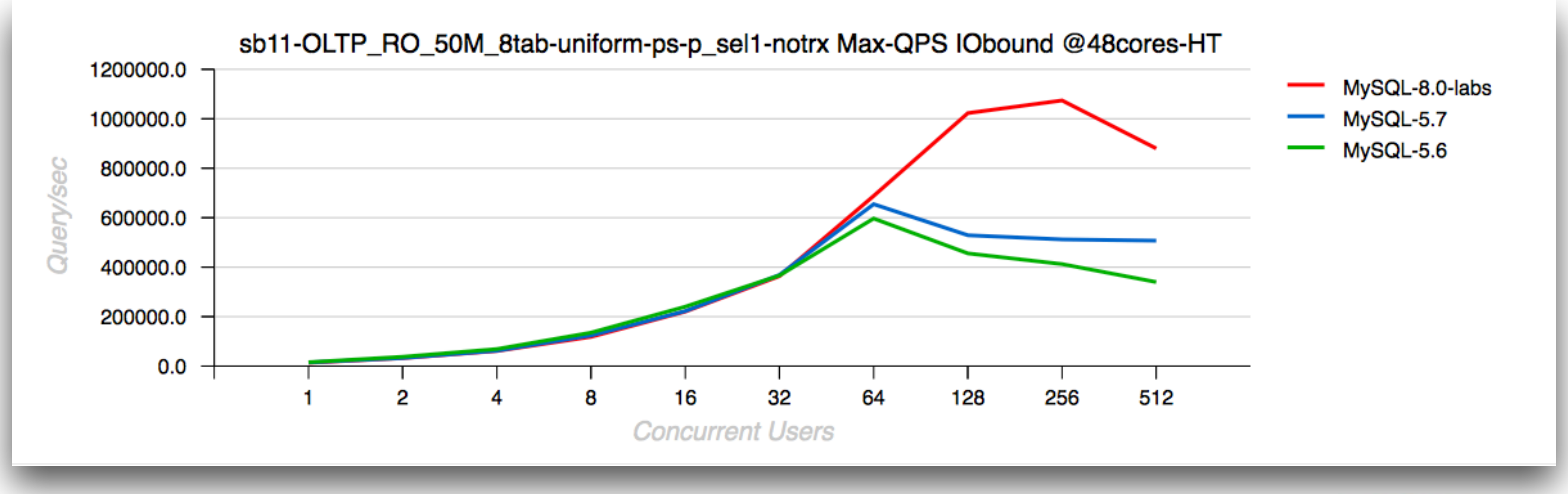
- Intel Optane drive :
  - IO read latency : 0,01ms (!!!)
  - 1 single process doing 16KB IO reads : ~65K reads/sec, 1000 MB/sec
  - however, the max throughput : 2000 MB/sec only (fix in progress by Intel)

- with x2 drives :
  - over 4000 MB/sec throughput
    - 16K page : ~260K IO reads/s
    - 8K page : over 500K IO reads/s
    - 4K page : **over 1M IO reads/s**

  - can MySQL get a profit of such an IO power ?..

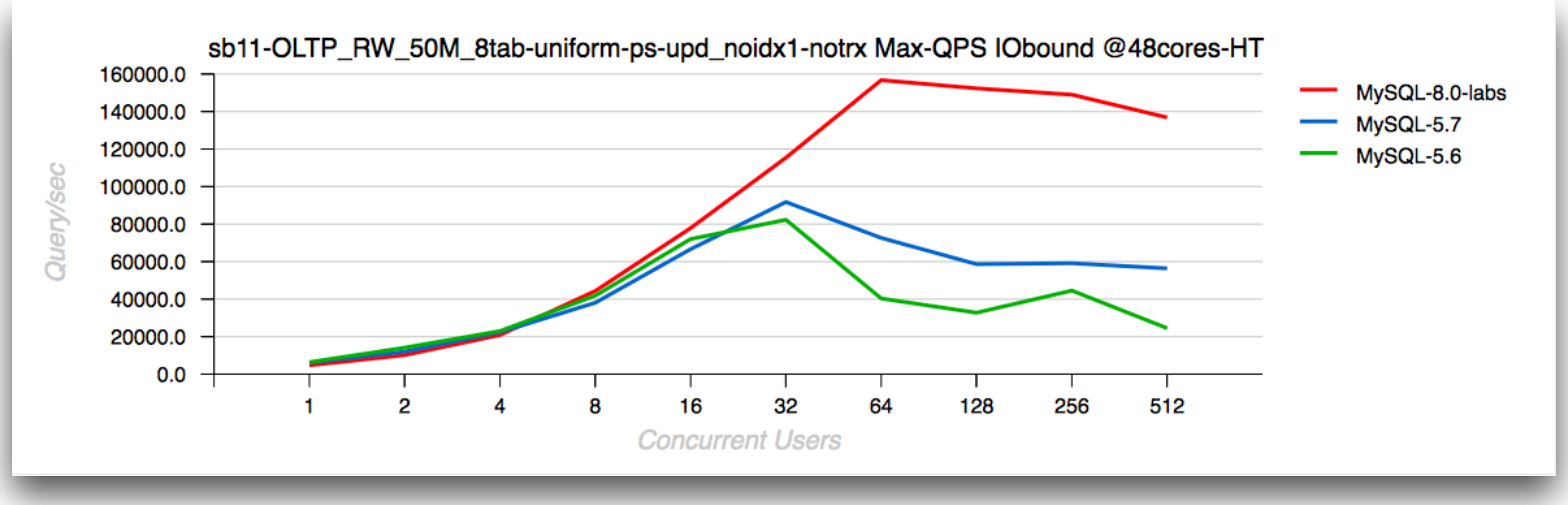
MySQL 8.0-labs Performance

- IO-bound Sysbench OLTP_RO Point-Selects
  - 50M x 8-tables, 48cores-HT, x2 Optane drives
  - NOTE : storage saturated & 100% CPU (new face of IO-bound ? ;-))
  - over **1M IO-bound QPS** with MySQL 8.0-labs !!!



MySQL 8.0-labs Performance

- IO-bound Sysbench OLTP_RW Update-NoKEY
  - 50M x 8-tables, 48cores-HT, x2 Optane drives
  - over **160K IO-bound QPS** with MySQL 8.0-labs !!!



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MySQL Resource Groups

- What :
  - starting codebase for our future Resource Management solutions
  - flexible and proper thread / query isolation
  - dynamic, integrated, fun ! ;-))

- Why :
  - protect background threads, provide them optimal conditions for processing
  - run batches on low priority, OLTP on higher (and opposite on night)
  - isolate DDL orders from other activity
  - allow to move long running queries to low priority / isolate (live !! ;-))
  - apply particular execution conditions for any SQL query via Optimizer Hint
    - => Query Rewrite, ProxySQL, etc..
  - automatically assign RG to users / databases / workloads via ProxySQL
  - potential workaround for many CPU cache related issues
  - **huge opportunity to all kind of new tools !!!**

MySQL Resource Groups

- Implementation Details :
  - currently : USER and SYSTEM groups
  - attributes : CPU (vcpu) affinity & thread priority
  - **thread priority** :
    - SYSTEM : [-19, 0] normal or **higher**
    - USER : [0, 20] normal or **lower**

- Admin :
  - permissions : none / can use / can use + admin
  - mysql> create RESOURCE GROUP RG10 type=user vcpu=0-9,40-49 thread_priority=0 ;
  - mysql> alter … ; drop … ; (also DISABLE / ENABLE / etc..)

- Using : only by name !
  - mysql> SET RESOURCE GROUP name ; (also for any THREAD ID)
  - SELECT /*+ RESOURCE_GROUP(name) */ … ; (query hint)

MySQL Resource Groups in Action

- Test case :
  - 40cores-HT 4S (Broadwell) server, OL7
  - 32 concurrent users are running SELECTs (Sysbench OLTP_RO)
  - other users are coming with UPDATEs (Sysbench Update-NoKEY)
    - 16 users, then 32, 64, 128, 256, 512
  - **Problem :** each workload is running well alone, but NOT together (yet)..
  - **Workaround :**
    - UPDATEs are not scaling and mixed with SELECTs creating yet more contentions
    - let's limit UPDATE queries to 10cores-HT only
    - mysql> create RESOURCE GROUP RG10 type=user vcpu=0-9,40-49 thread_priority=0 ;
    - and add a hint to UPDATE queries :
      UPDATE /*+ RESOURCE_GROUP(RG10) */ … ;

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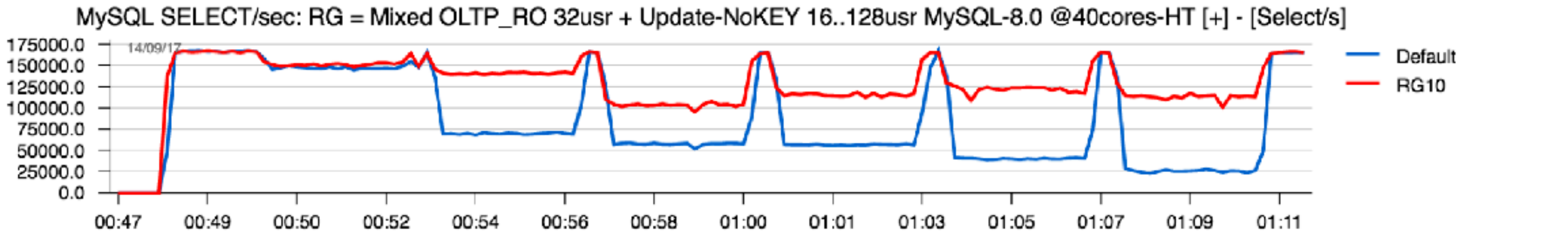
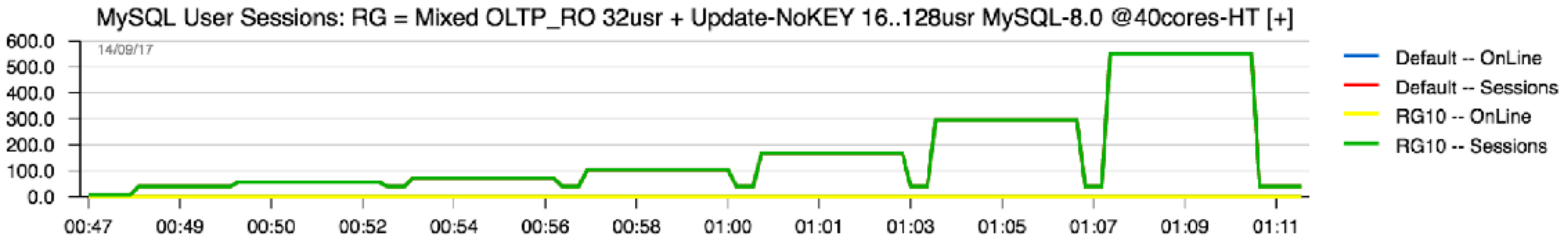
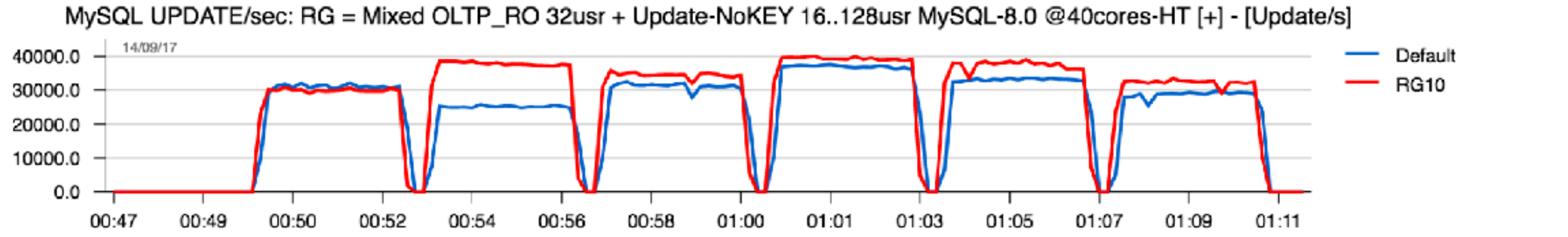

MySQL SELECT/sec: RG = Mixed OLTP_RO 32usr + Update-NoKEY 16..128usr MySQL-8.0 @40cores-HT [+] - [Select/s]


MySQL User Sessions: RG = Mixed OLTP_RO 32usr + Update-NoKEY 16..128usr MySQL-8.0 @40cores-HT [+]


MySQL UPDATE/sec: RG = Mixed OLTP_RO 32usr + Update-NoKEY 16..128usr MySQL-8.0 @40cores-HT [+] - [Update/s]

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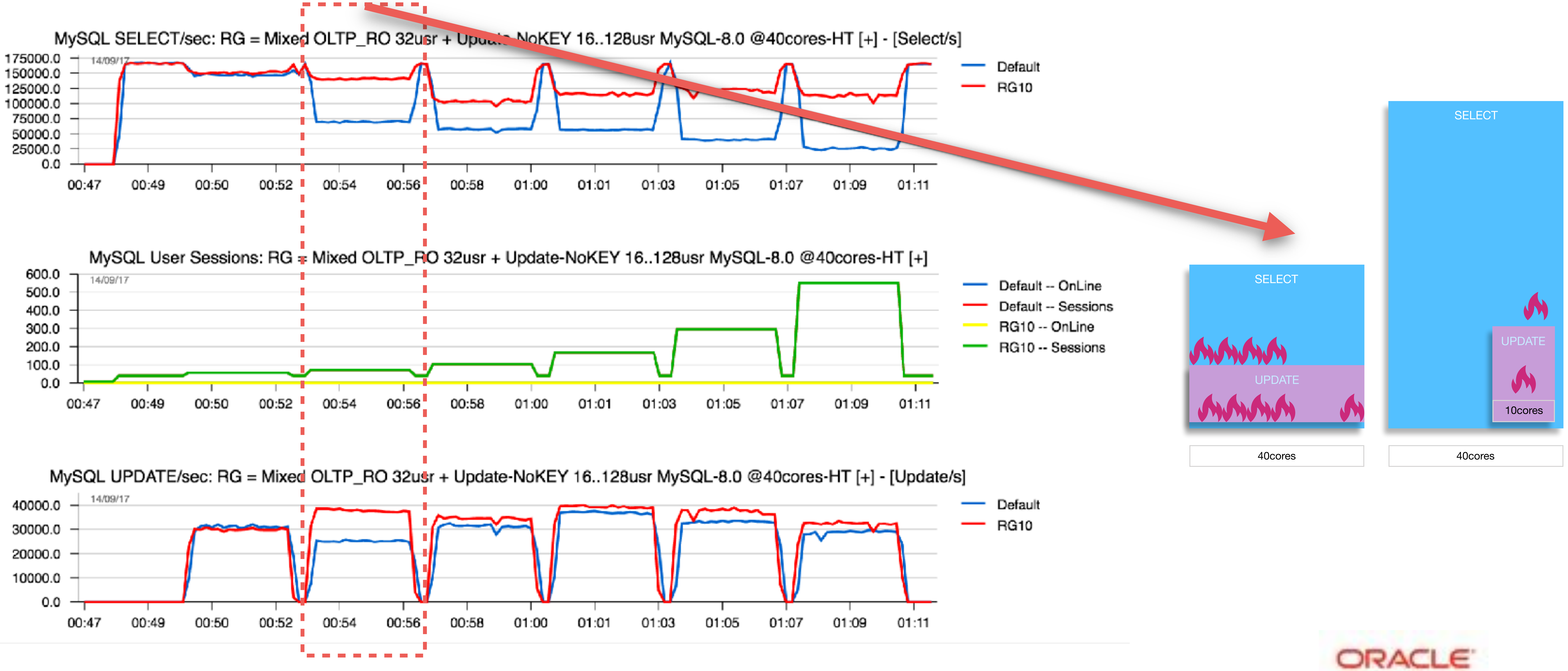

TL;DR

- MySQL 8.0 :
  - huge amount of new features !!!

- MySQL 8.0 Performance & Scalability :
  - new REDO design
  - better IO-bound scalability
  - Resource Groups : a completely new angle in MySQL Workloads Tuning
  - yet more work in progress..

Hope you're seeing much more clear now ;-)

- Call To Action :
  - 2) download 8.0-rc / 8.0-labs
  - 3) test it in your own workloads
  - 4) send us feedback !!!

    …
  - 1) have fun ! ;-))

One more thing ;-)

- All graphs are built with dim_STAT (http://dimitrik.free.fr)
  - All System load stats (CPU, I/O, Network, RAM, Processes,...)
    - Mainly for Linux, Solaris, OSX (and any other UNIX too :-)
    - Add-Ons for MySQL, Oracle RDBMS, PostgreSQL, Java, etc.
    - Linux : PerfSTAT ("perf" based), mysqlSTACK (quickstack based)
  - 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.