MySQL

ORACLE

MySQL 8.0 Performance: InnoDB Re-Design

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MySQL Performance Architect @Oracle

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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

- To tell you in 15min where we’re & where we’re going ;-))
- Q & A

Common Sources of MySQL Performance Problems..

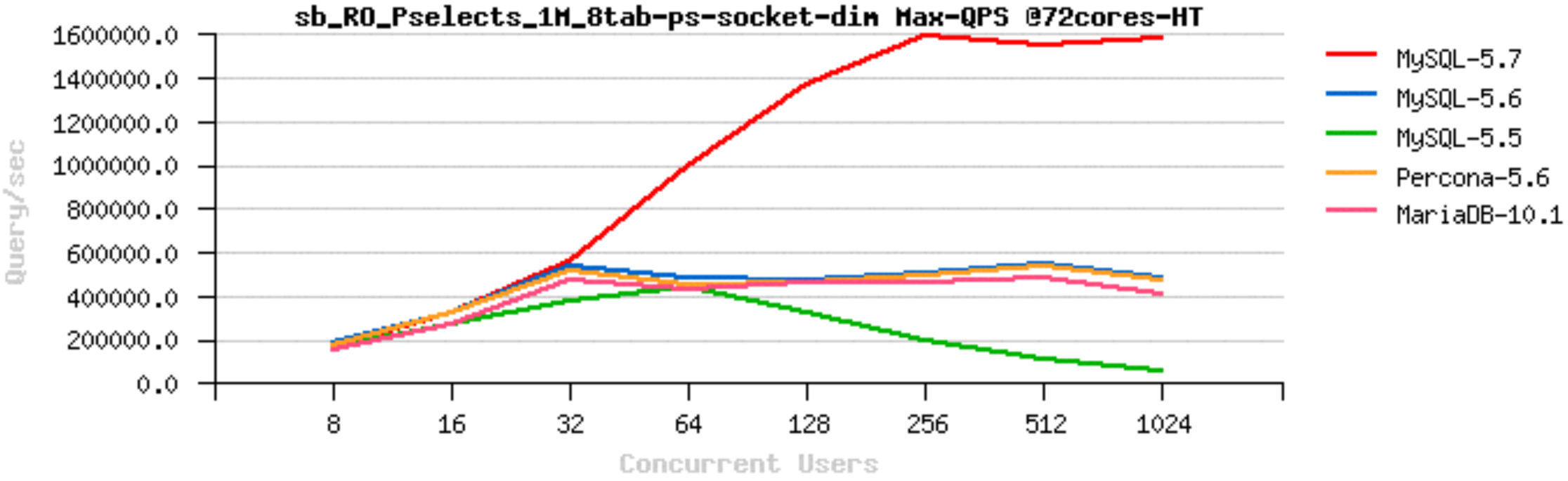
- “Fixable” ones ;-)
  - DB Schema/ Indexes/ SQL query/ Optimizer plan/ Apps code/ etc. etc..
  - odd tuning/ wrong config setup/
  - e.g. generally can be fixed by => RTFM ! ;-)
- “By design” ones..
  - known ?..
  - workaround ?..
  - can be ever fixed ?..
  - heh…
  - work in progress.. <= and here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

MySQL Scalability milestones

- MySQL 5.5
  - delivered “already known” solutions (except BP instances and few other)..
- MySQL 5.6
  - first fundamental changes (kernel_mutex split, G5 patch, RO transactions, etc..)
  - but : RW workloads are faster than RO ! ;-))
- MySQL 5.7
  - finally fully unlocked Read-Only, no more contentions on the “Server” layer, etc..
  - so RO is faster than RW ! ;-))
- MySQL 8.0
  - main focus is on efficiency : do more on the same HW ;-))
  - work in progress..

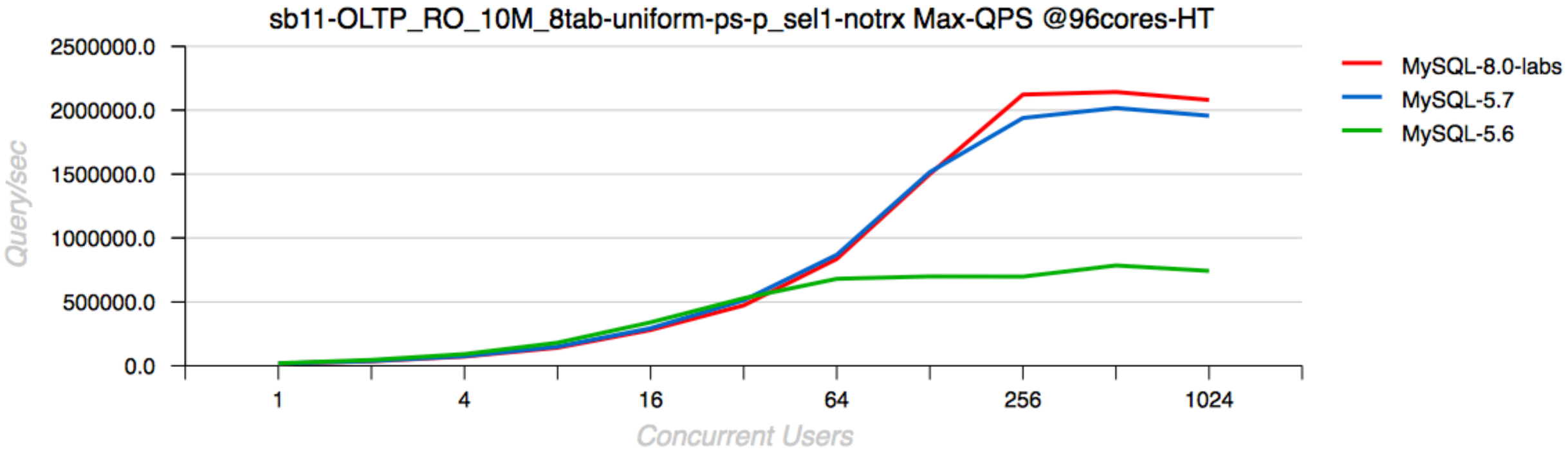
RO Point-Selects @MySQL 5.7 (Oct.2015)

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



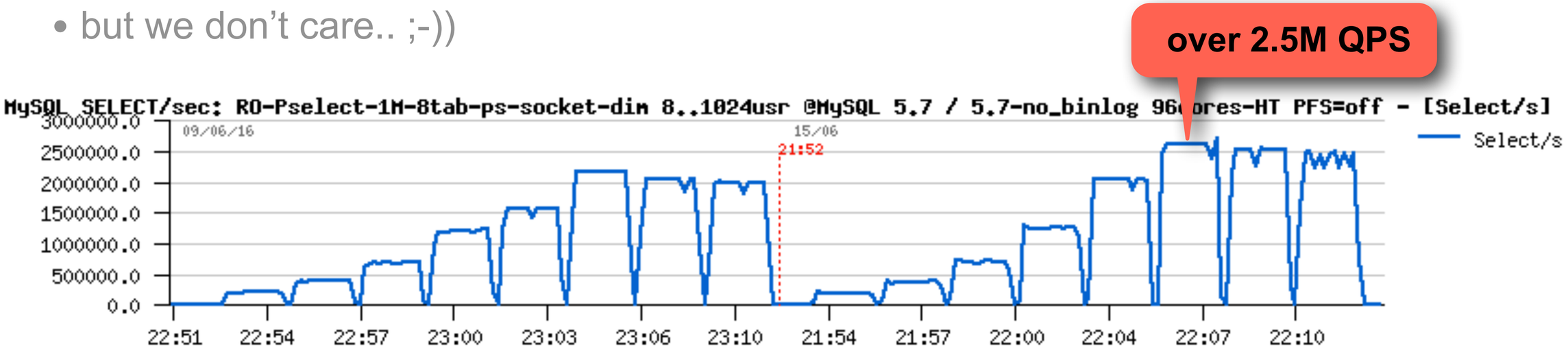
RO Point-Selects @MySQL 8.0 (Sep.2017)

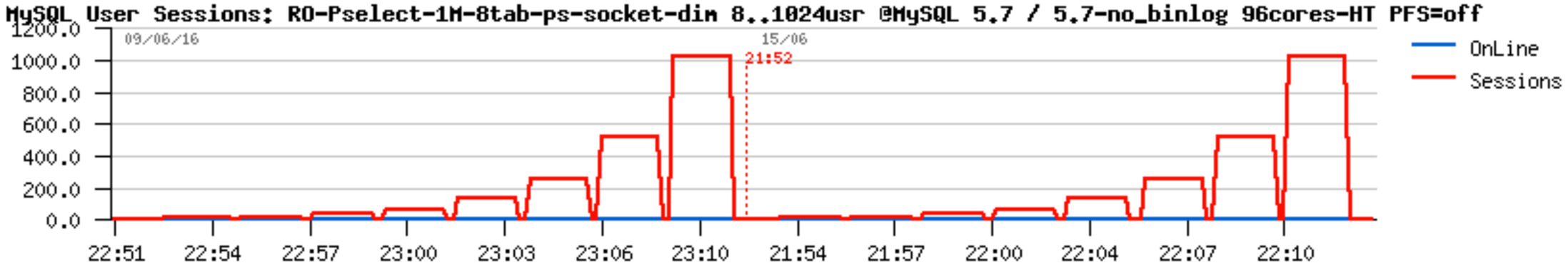
- **2.1M (!!) QPS** Sysbench Point-Selects 8-tab :
  - 96cores-HT Broadwell



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.. ;-))





Pending Scalability Issues after MySQL 5.7 GA..

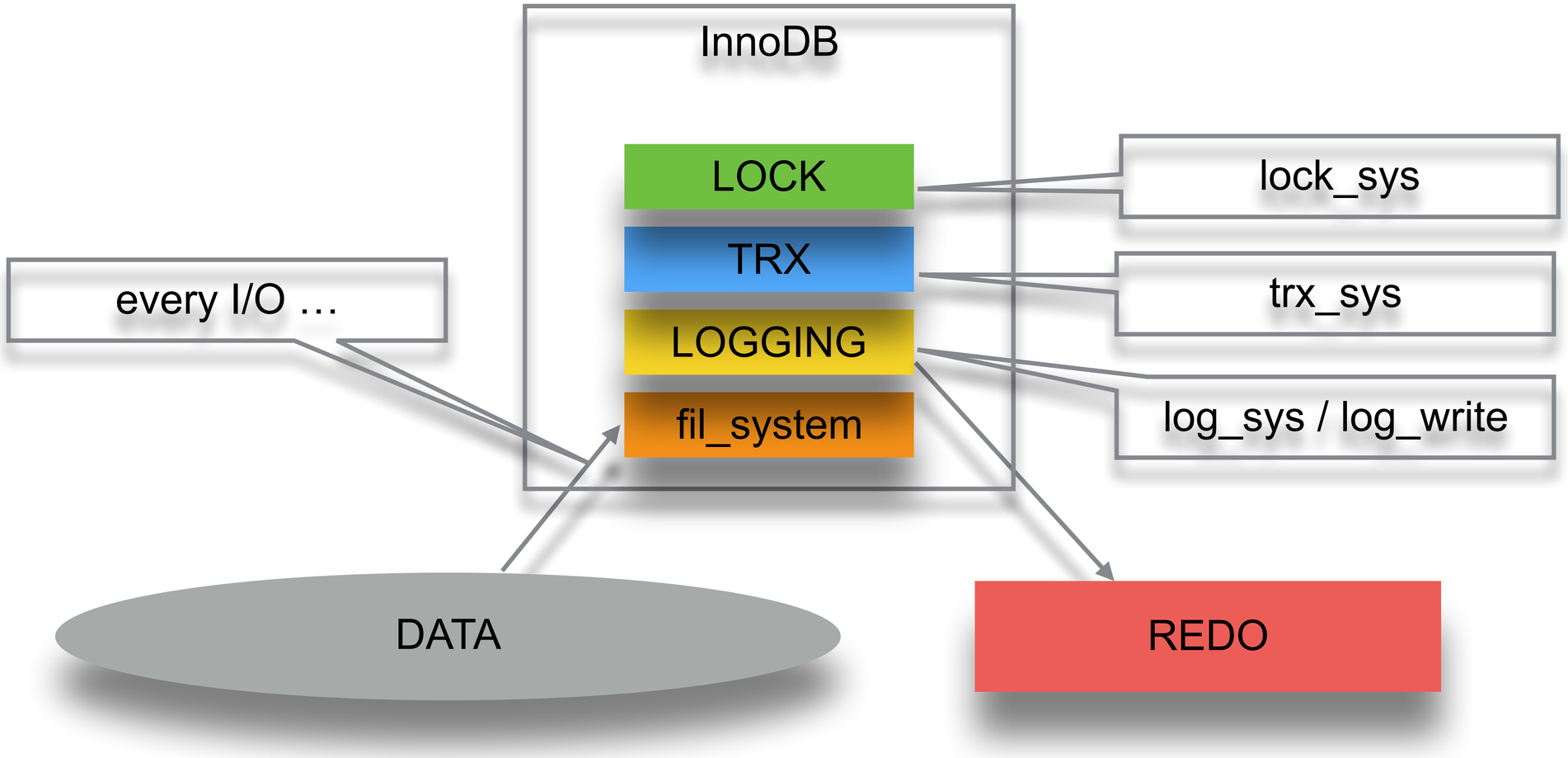
- RO :
  - Block Locks
  - Lookups via Sec.IDX
  - UTF8
- RW :
  - Double Write..
  - REDO log related bottlenecks
  - TRX management contentions
  - LOCK management..
  - RR / RC isolation..
  - UPDATE Performance..
  - INSERT Performance..
  - Purge lagging..

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.. + **CATS** since 8.0.3
  - 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..

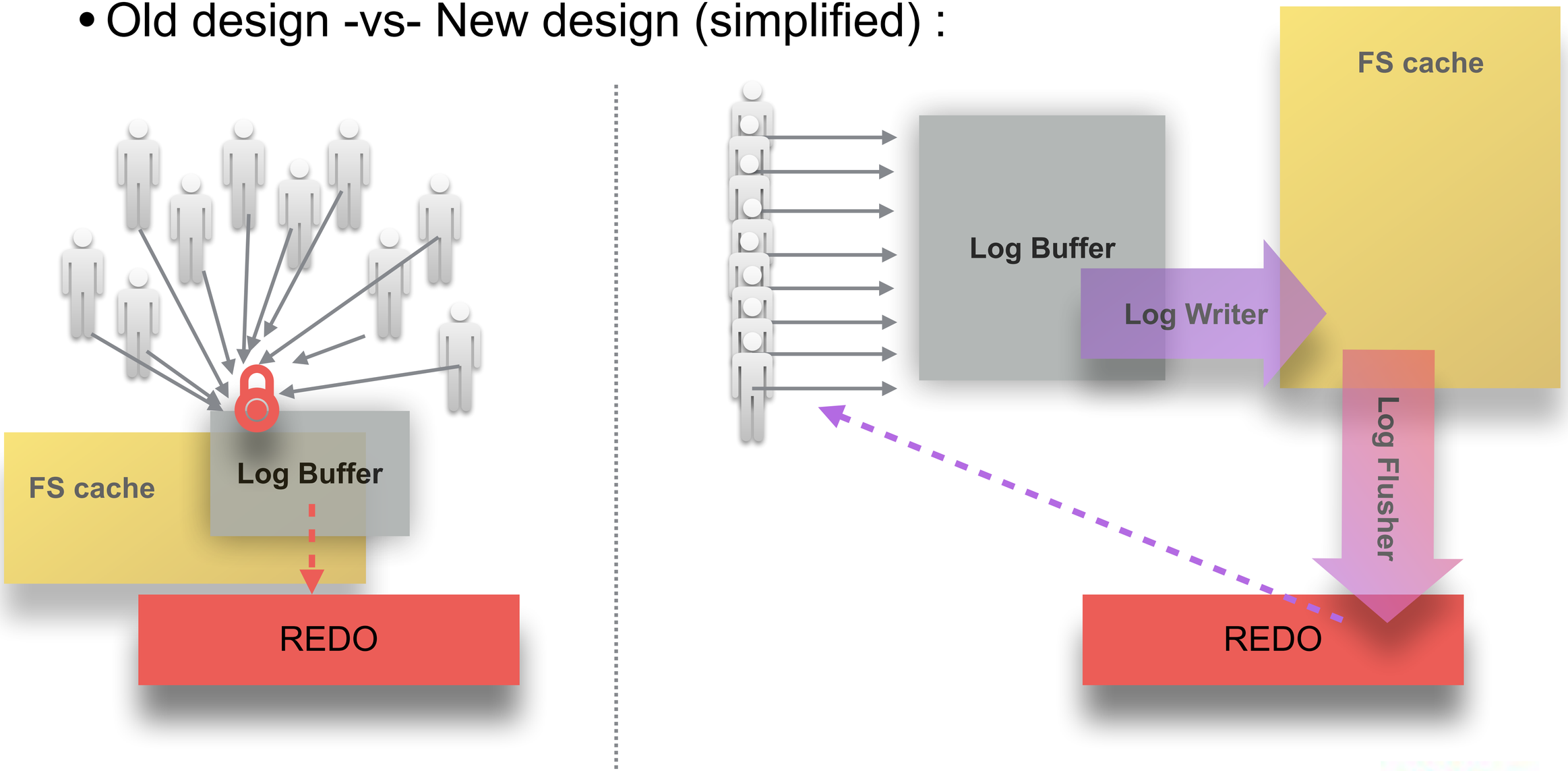


MySQL 8.0 : Re-Designed REDO

- 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..

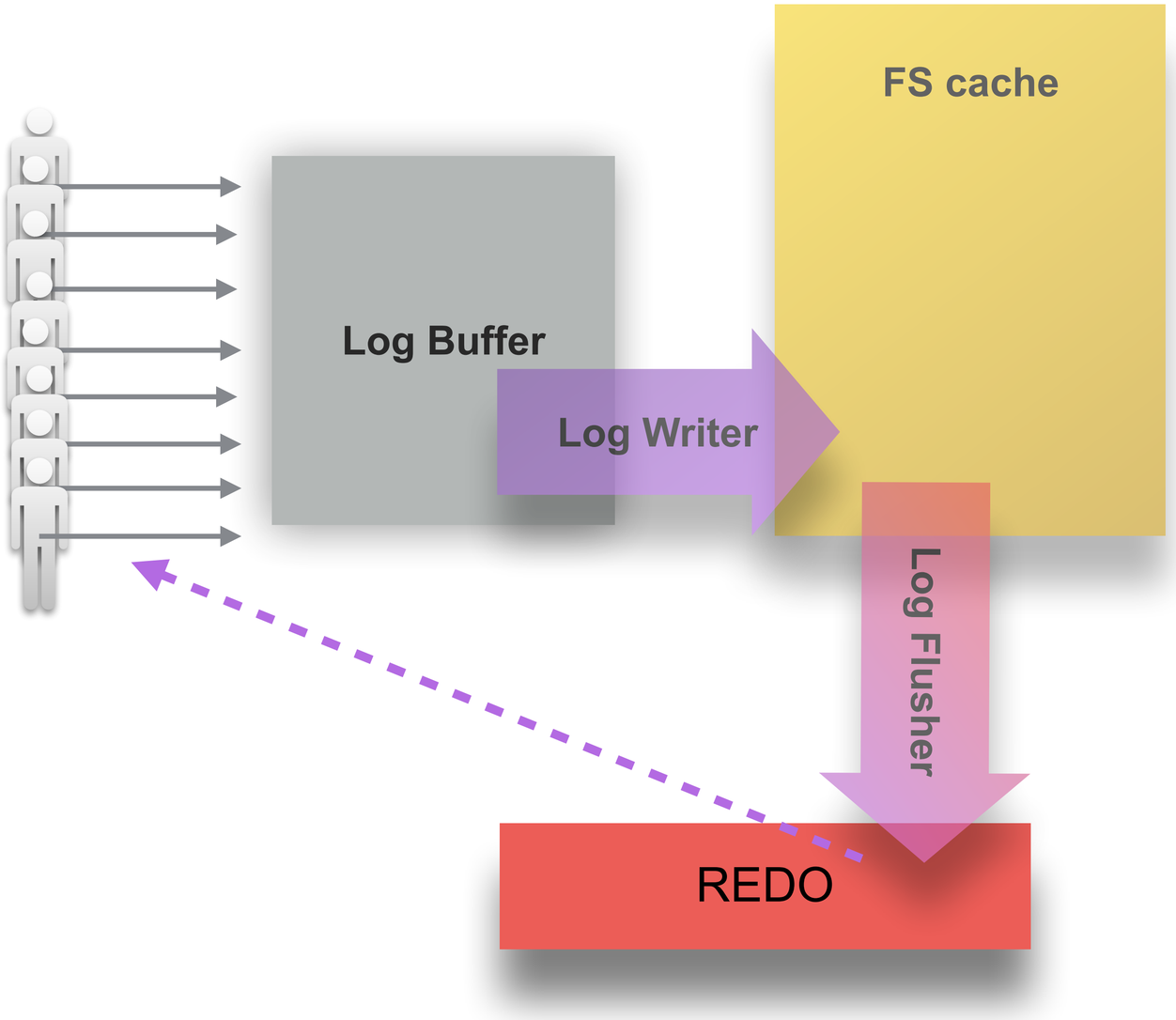
MySQL 8.0 : Re-Designed REDO

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



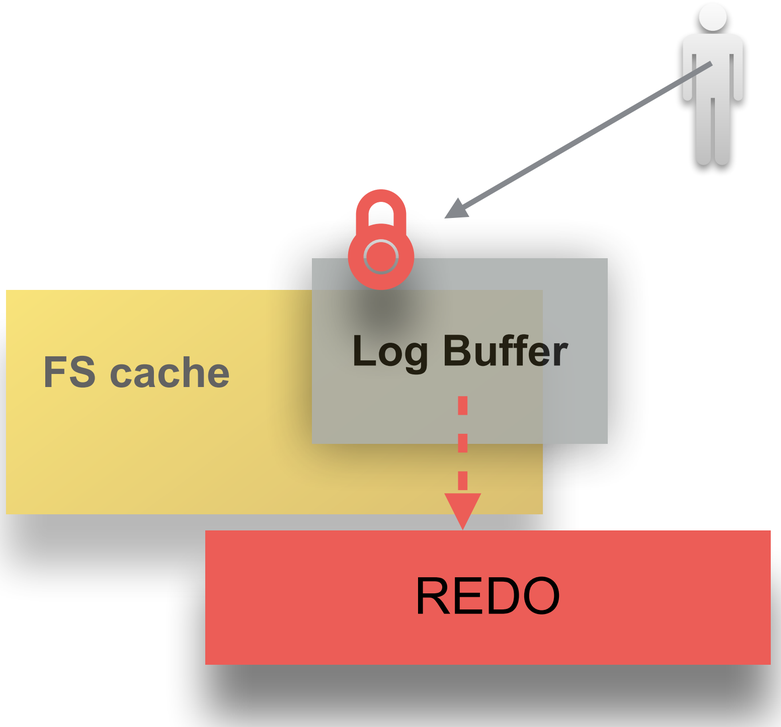
MySQL 8.0 : Re-Designed REDO

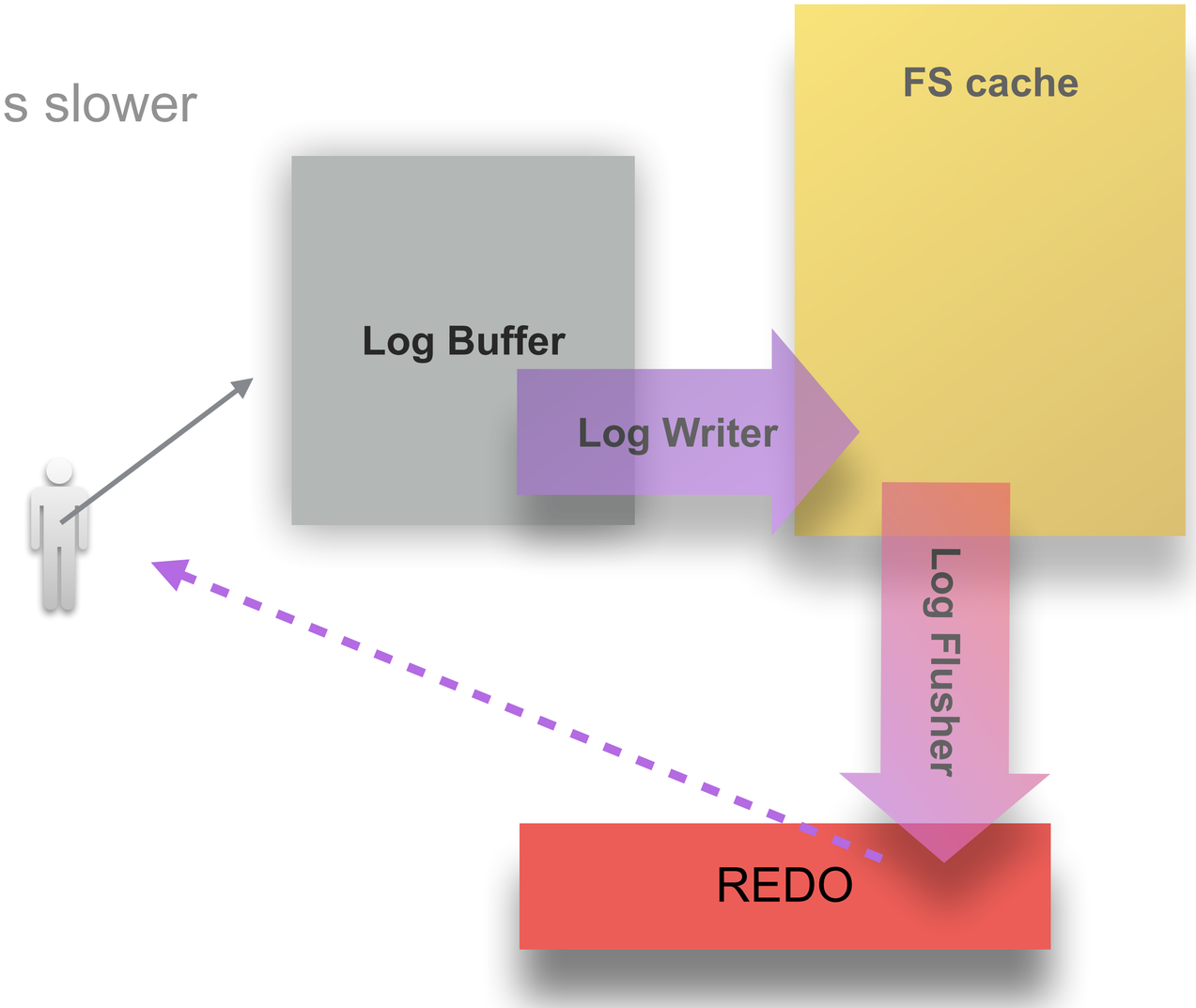
- New REDO design :
  - users are not fighting anymore !
  - self-driven processing..
  - self-driven by fsync() capacity
- Instrumented !
  - spins / waits
  - writer / flusher rates
  - max / avg flush times
  - etc..
- Configuration :
  - **mostly all dynamic !!!**
  - so you can play with it on-line ;-))



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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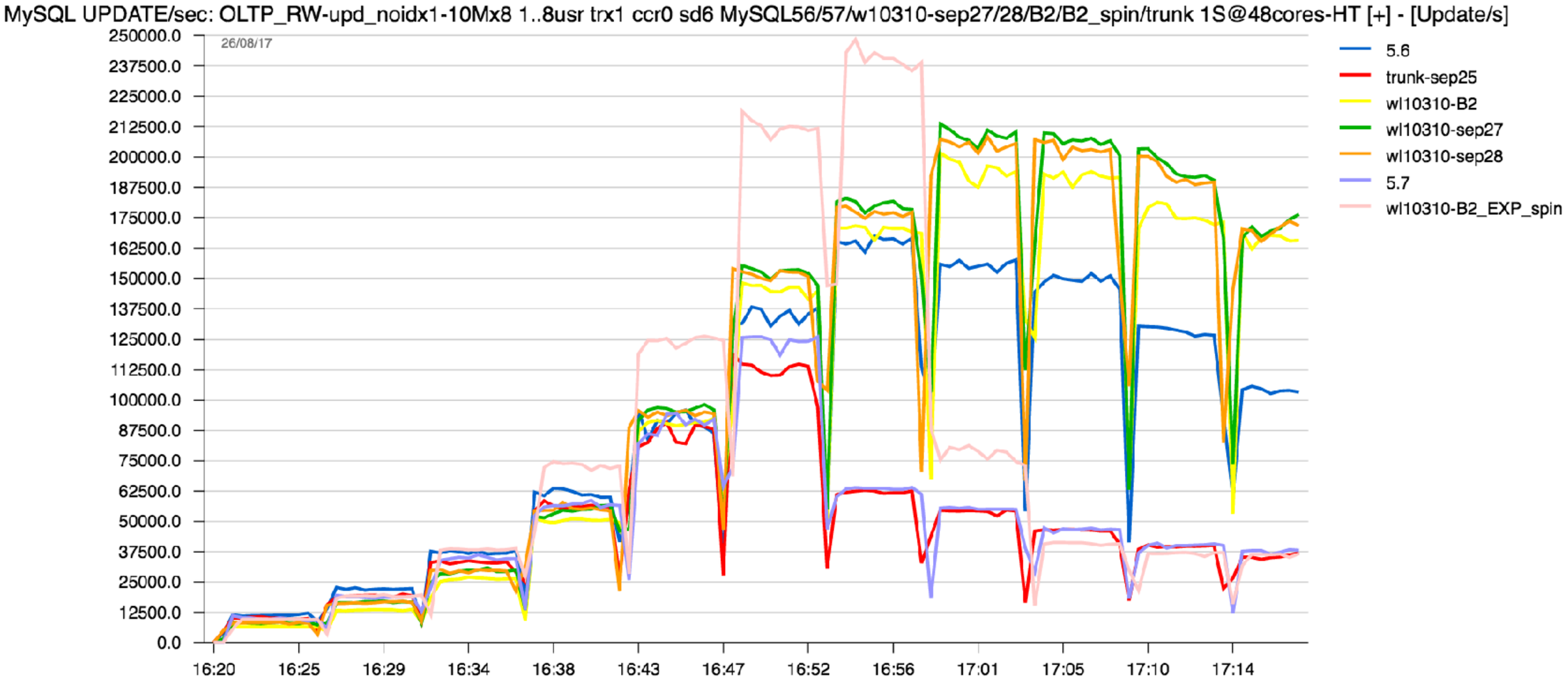

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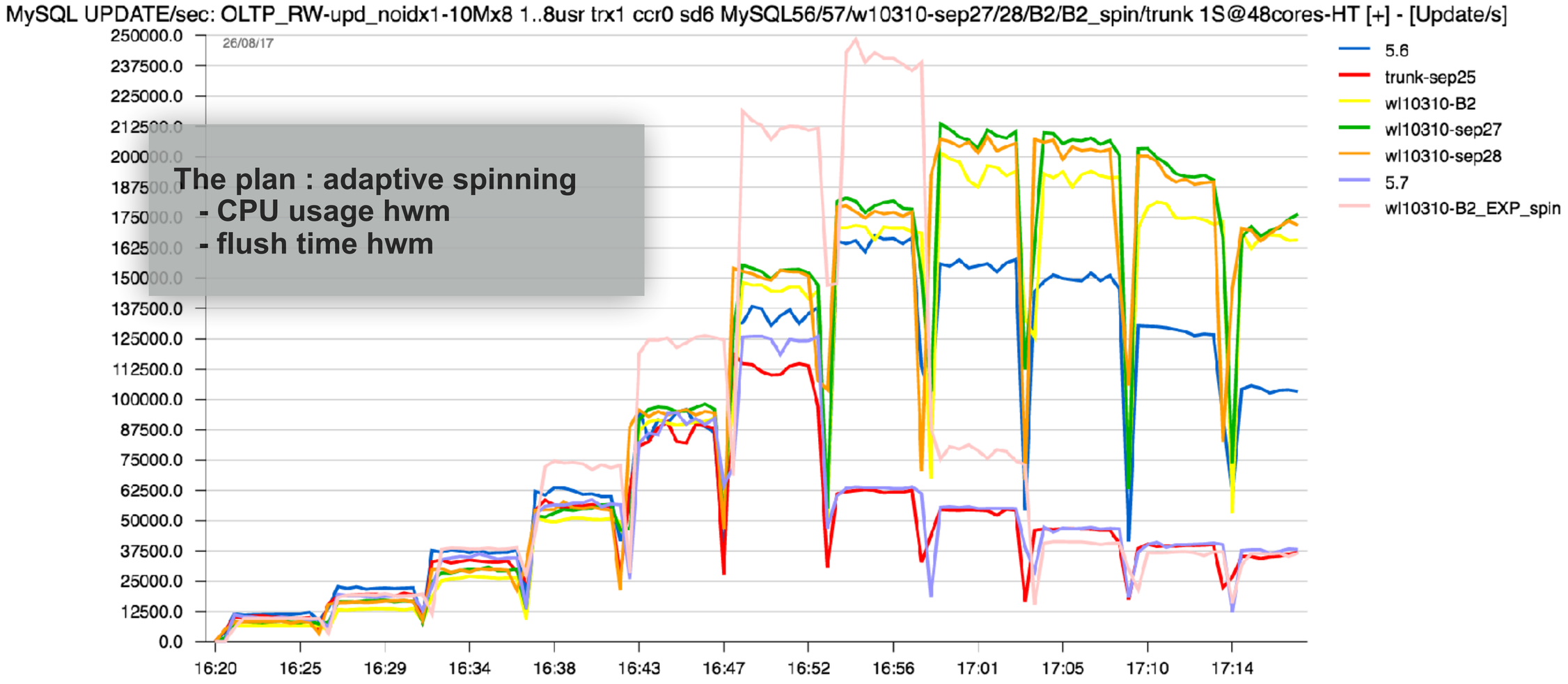
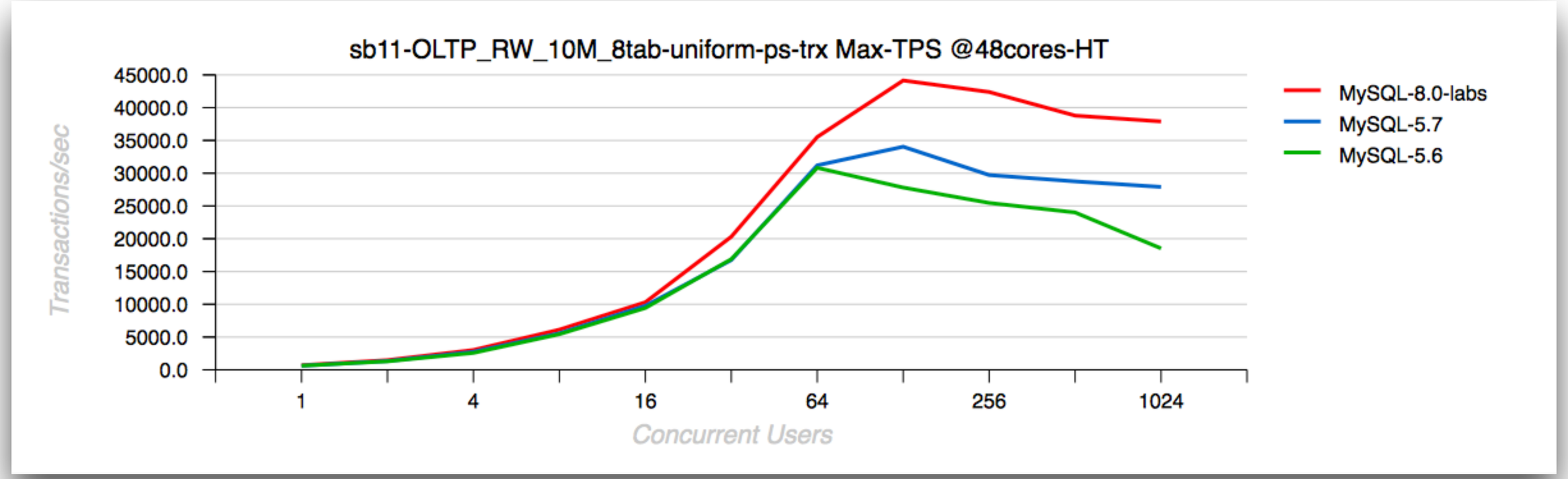


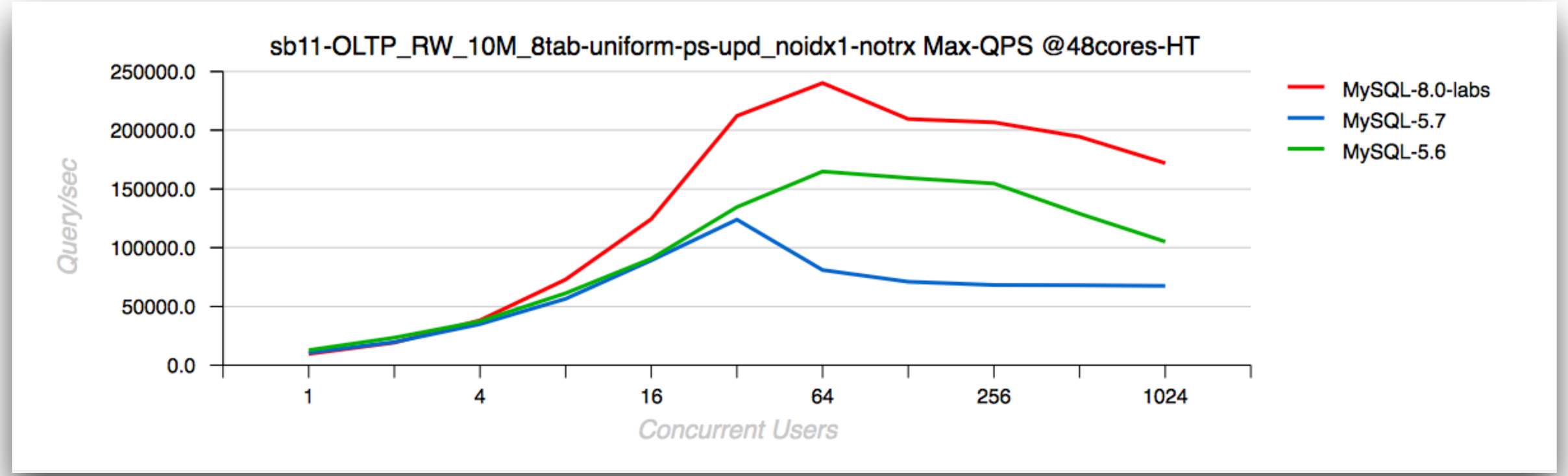
MySQL 8.0-labs Performance

- 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 !! ;-))

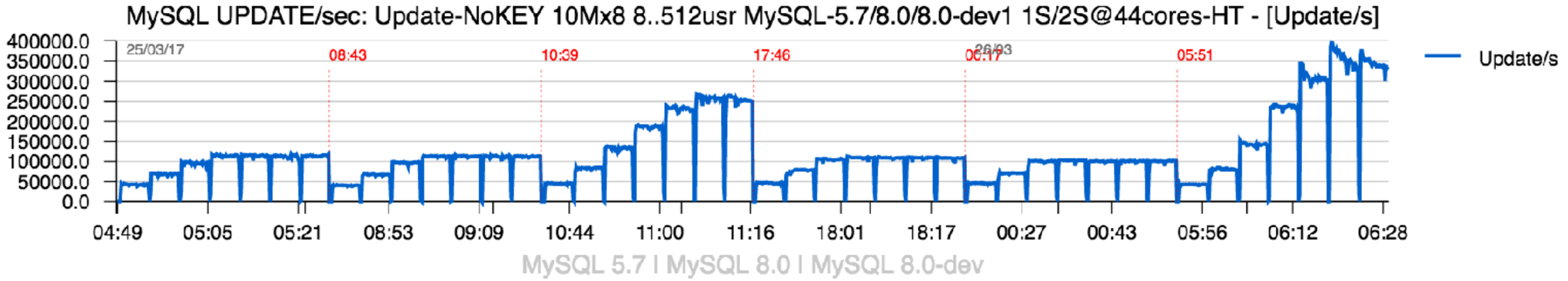


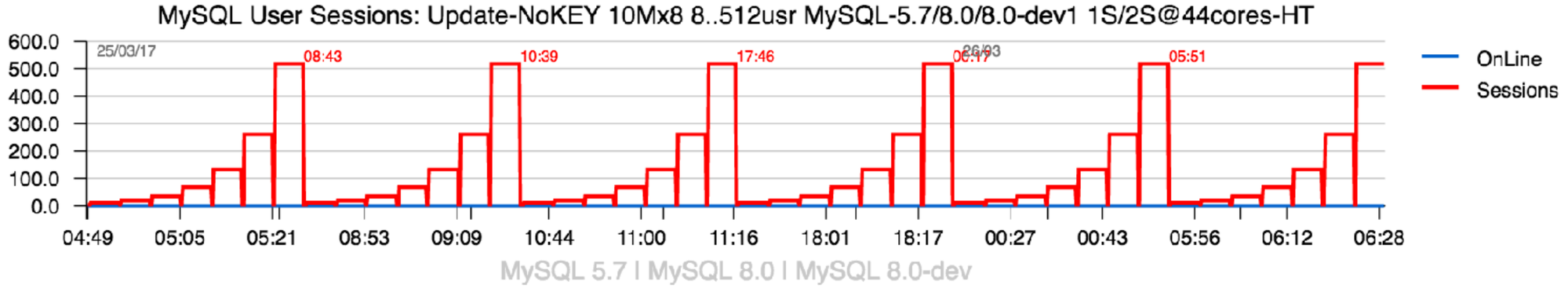
MySQL 8.0 Writes Scalability

- 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 ;-))

MySQL-dev preview : Sysbench Update-NoKEY 10Mx8-tables

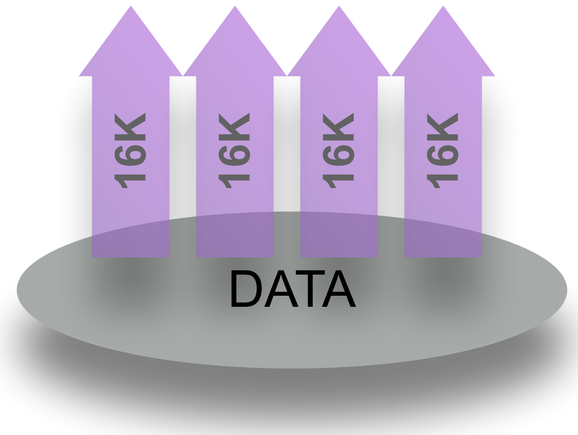
- Observations :
  - MySQL-dev : **x2** times better on 1 CPU socket, **x3** times on 2 CPU !!!
  - NOTE : the gain becomes visible already since **4usr** load level !!!





IO-bound Workloads : The 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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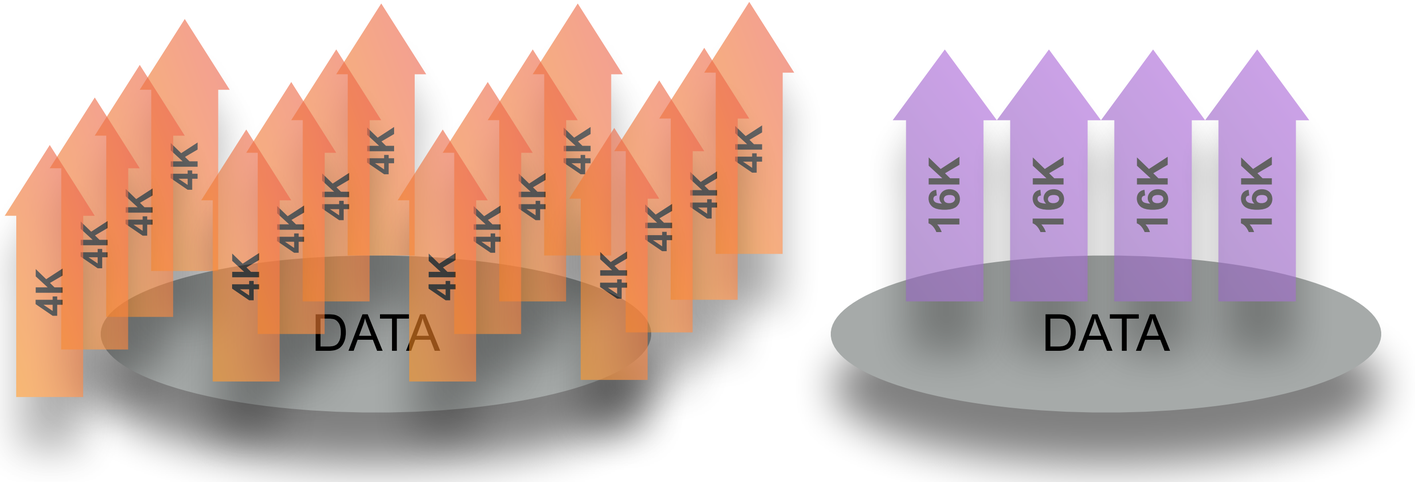
  - **Compression** ? => x4 times more IO reads !!!



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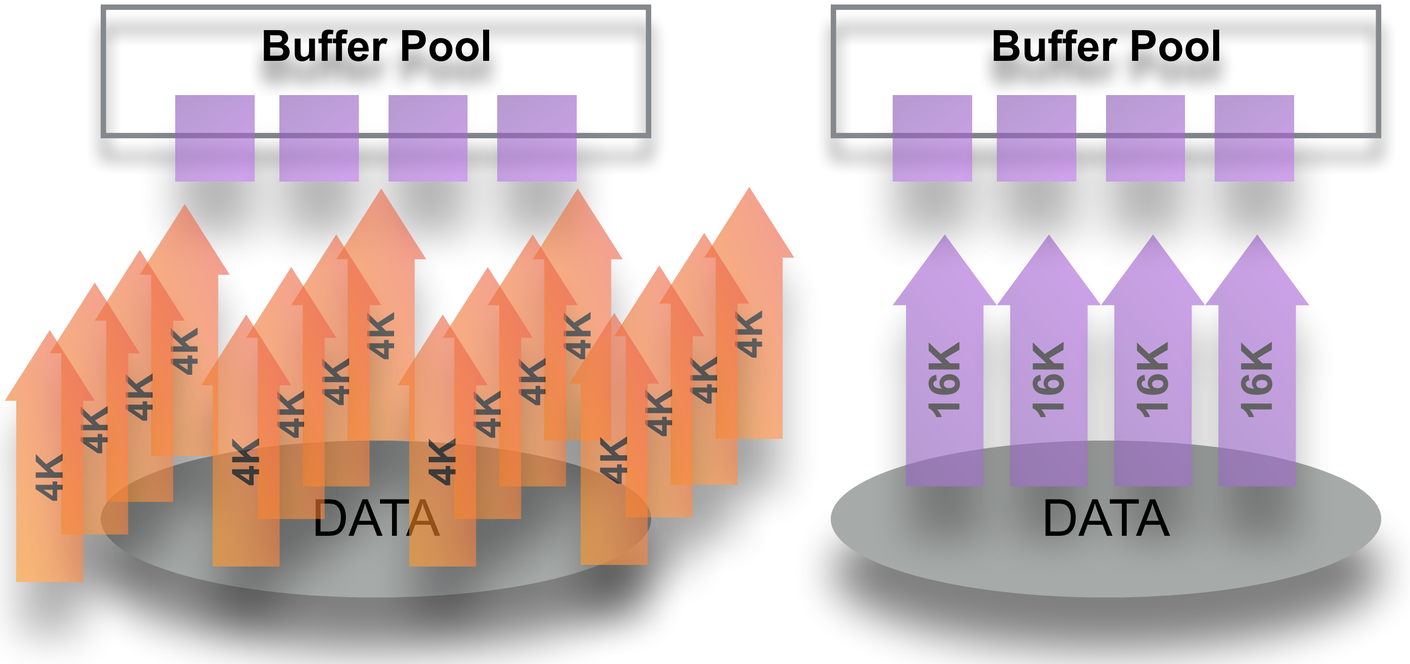

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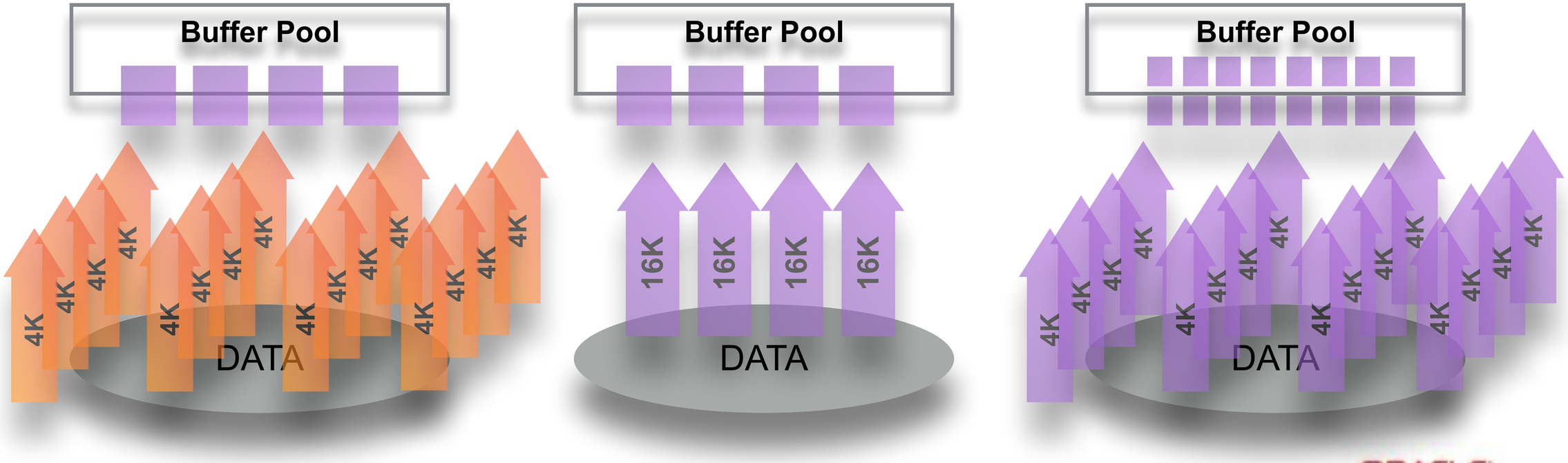
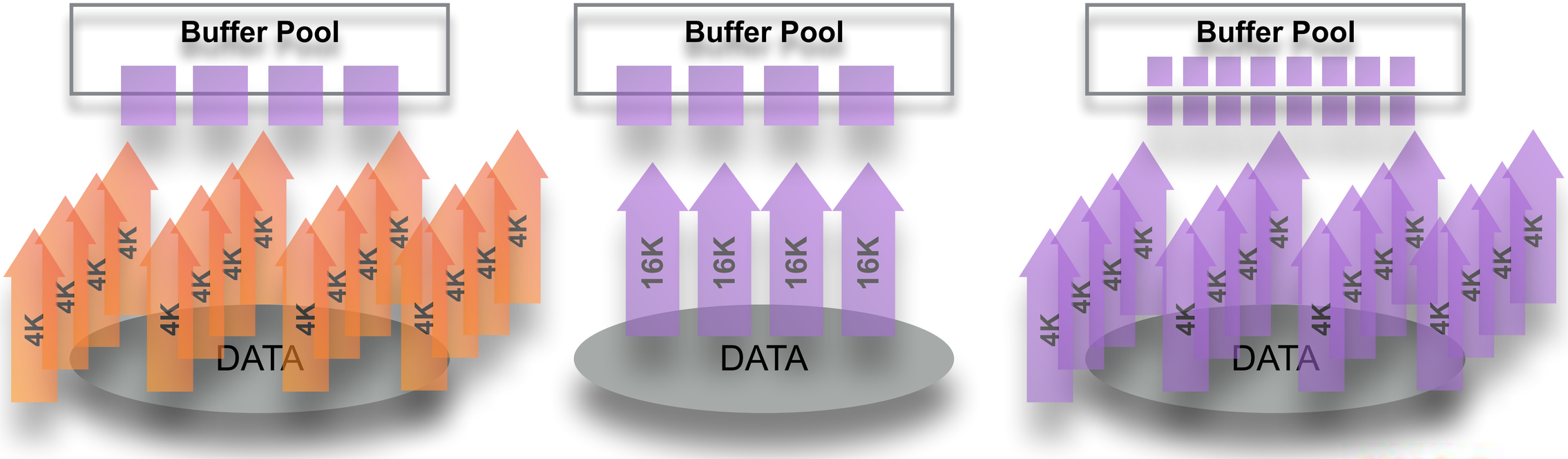
  - => driven by IO read **Operations/sec** …
  - Compression ? => x4 times more IO reads !!! => and QPS ?.. **and what about 4K page ?**



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

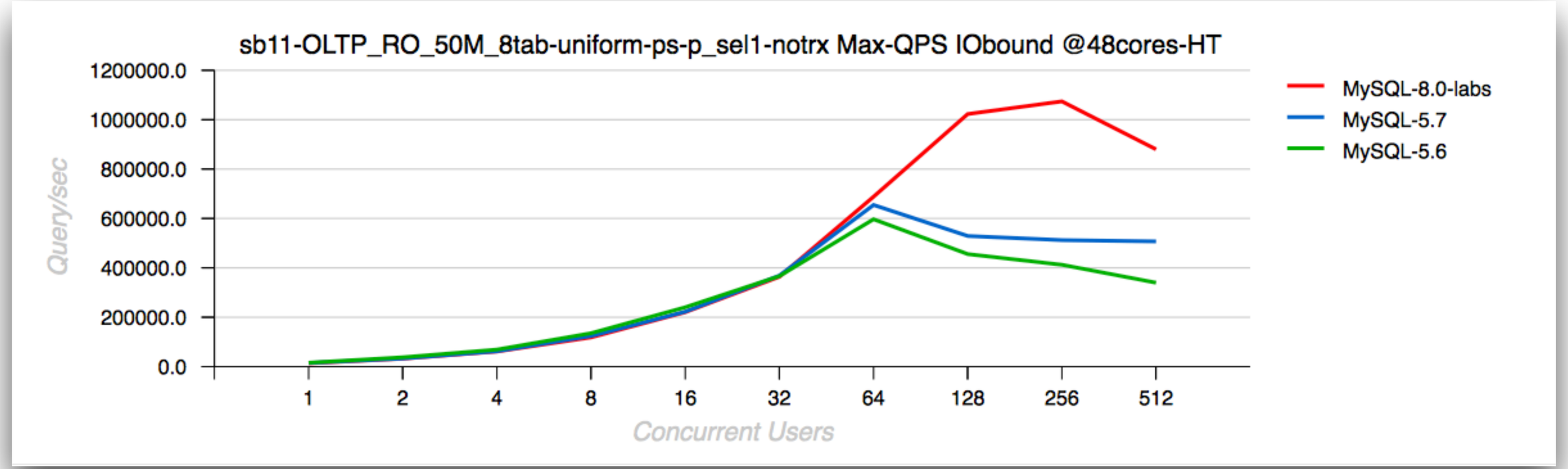
- Intel Optane drive :
  - IO read latency : 0,01ms (!!!)
  - 1 single process doing 16KB IO reads : ~65K reads/sec, 1000 MB/sec
  - however, the max throughput : 2000 MB/sec only (fix in progress by Intel)

- 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 ?..

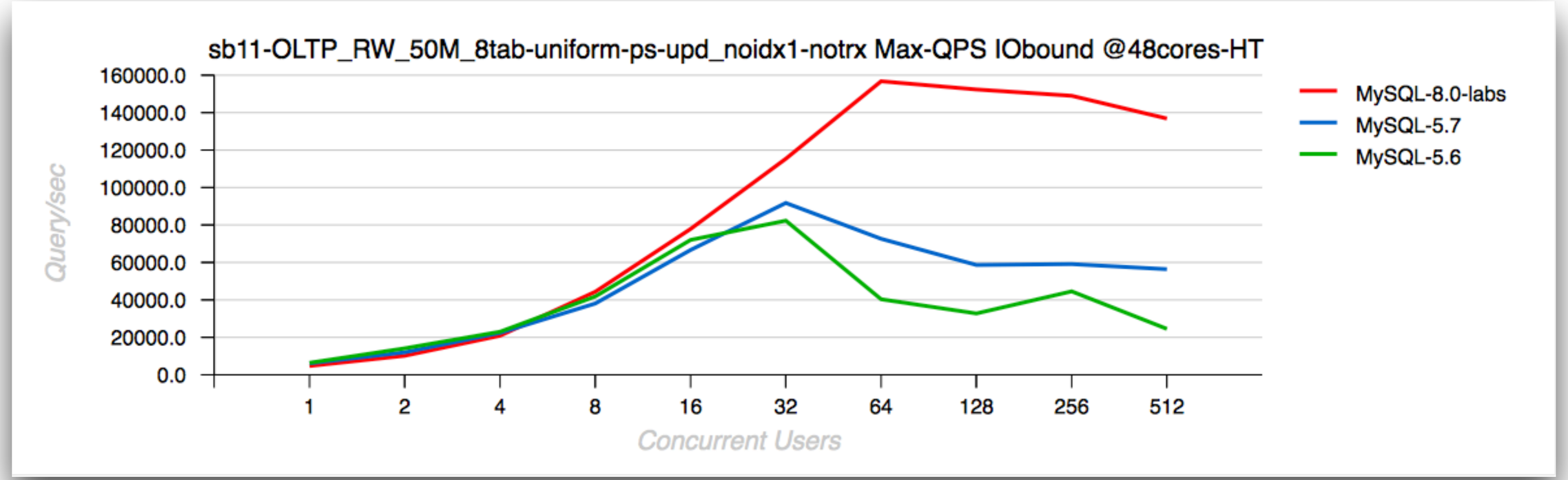
MySQL 8.0-labs Performance

- 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 !!!



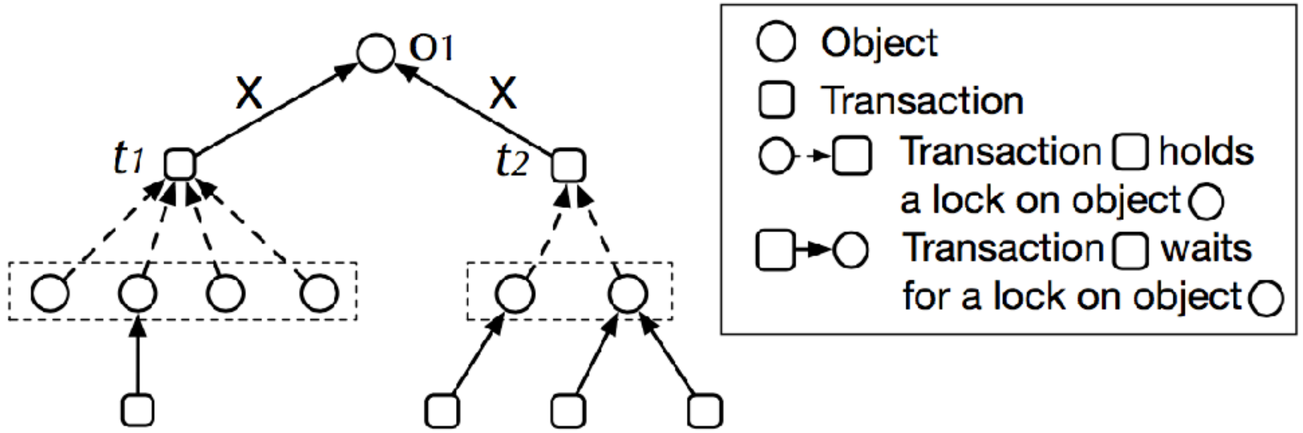
MySQL 8.0-labs Performance

- 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 !!!



MySQL 8.0 : InnoDB CATS (VATS)

- CATS : Contention-Aware Transactions Scheduling
  - invention : University of Michigan
  - adopted and integrated by InnoDB Team, available since MySQL 8.0.3
- Idea :
  - not all transactions are equal
  - FIFO could be not optimal..
  - unblock the most blocking transaction first



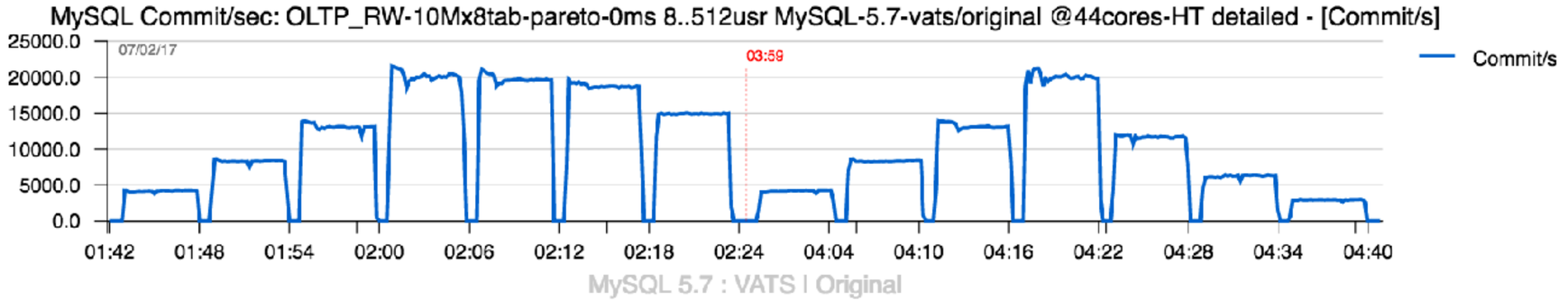
see :
- https://mysqlserverteam.com/contention-aware-transaction-scheduling-arriving-in-innodb-to-boost-performance/
- http://www.vldb.org/pvldb/vol11/p648-tian.pdf

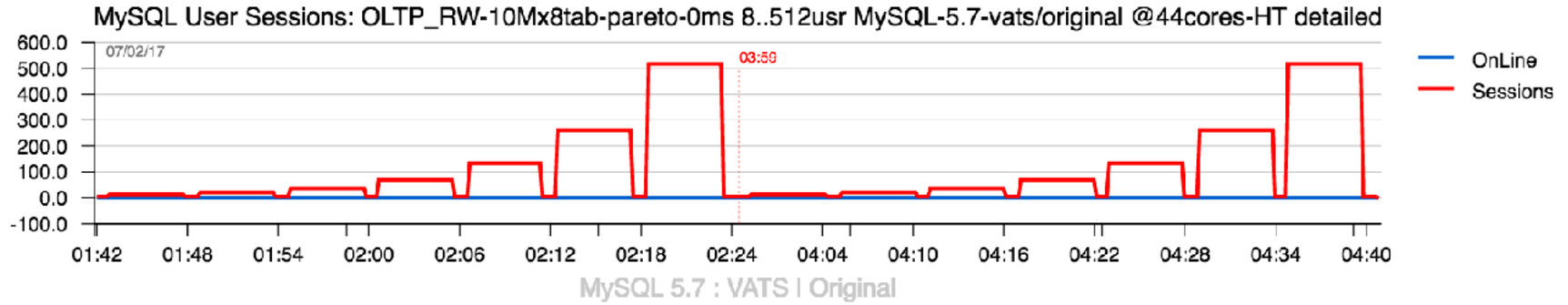
MySQL 8.0 : InnoDB CATS (VATS)

- CATS : Contention-Aware Transactions Scheduling
  - invention : University of Michigan
  - adopted and integrated by InnoDB Team, available since MySQL 8.0.3
- Kind of a detective story ;-))
  - claim : huge performance improvement
  - initial probe tests of patched code on all test workloads we have around : **zero** gain..
  - long investigation and deep discussions with authors to understand what kind of problems they're expecting to solve.. (they are not kidding, right ? ;-))
  - finally able to build a test scenario showing a visible gain ! - **Yes !** ;-))
  - Sunny analyzing the patch => several serious bugs..
  - loop : bug fix => remastering => retesting => goto begin..
  - finally stable ! => but brings regression on "normal" workloads..
  - solution ? => auto-tuned detection on switching to FIFO or CATS

MySQL 8.0 : InnoDB CATS (VATS)

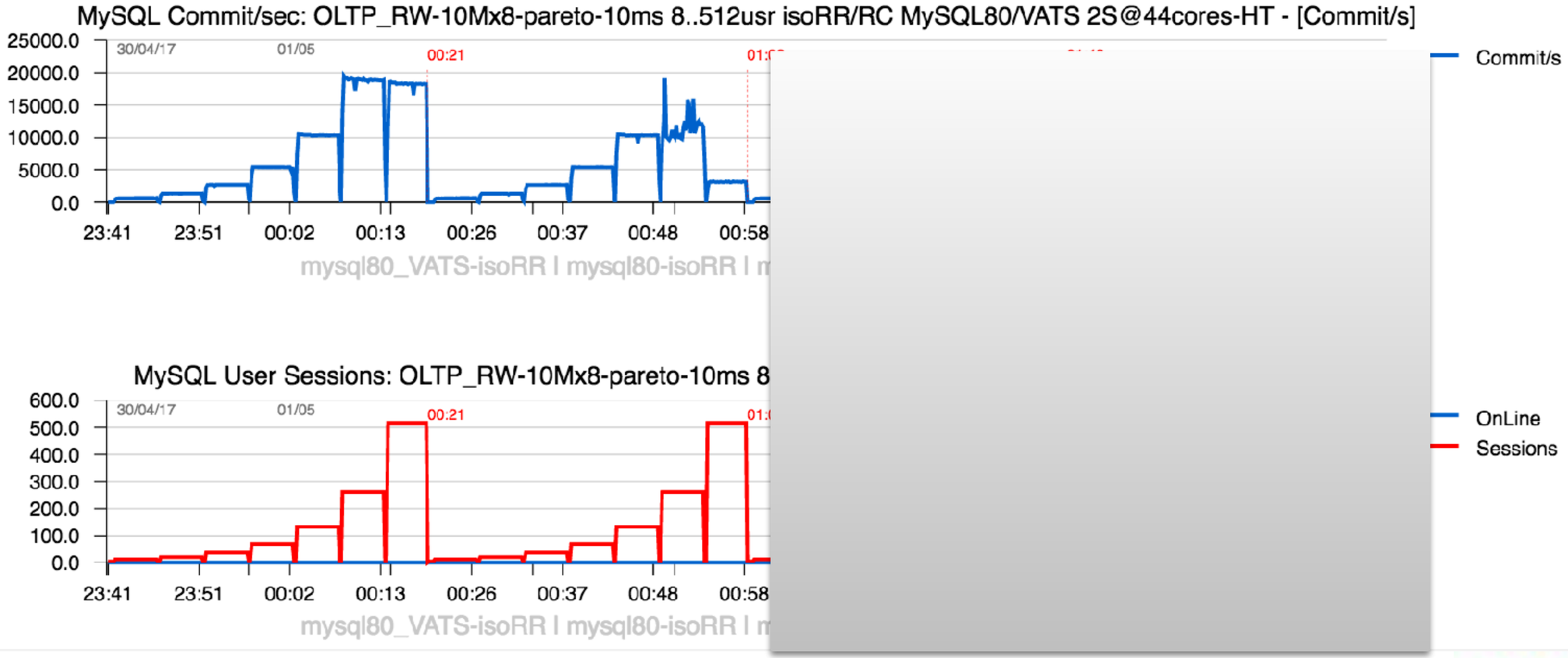
- CATS : Contention-Aware Transactions Scheduling
  - where it helps ? — workloads hitting row lock contentions
  - how to recognize ? — monitor your “show engine innodb mutex” !!





MySQL 8.0 : InnoDB CATS (VATS)

- CATS : Contention-Aware Transactions Scheduling
  - so, look in depth, understand your workload..
  - ex: RR -vs- RC transaction isolation on the same workload :



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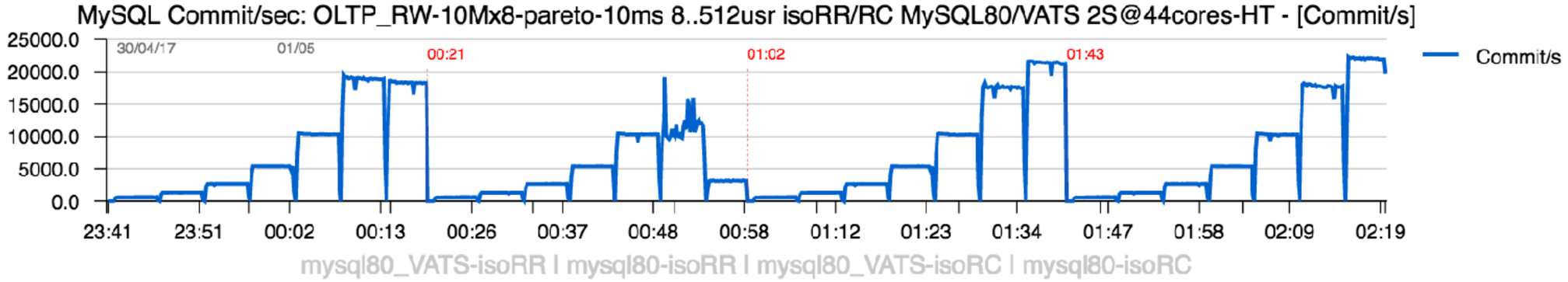

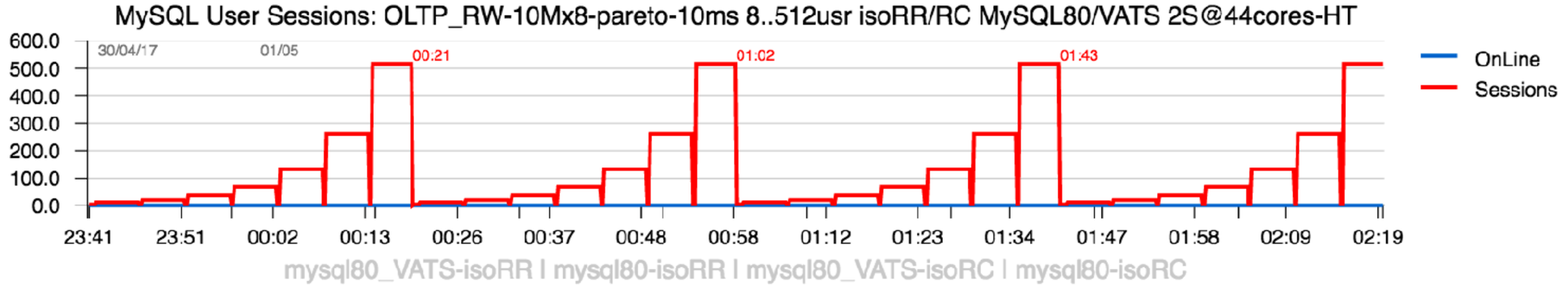

Hope you’re seeing much more clear now ;-)

- Call To Action :
  - 2) download 8.0-labs / 8.0-rc
  - 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.