MySQL

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MySQL Performance: Benchmarks & 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

- Benchmarks & Benchmarks..
- HOWTO
- Q & A

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

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USE YOUR BRAIN !!! ;-)

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

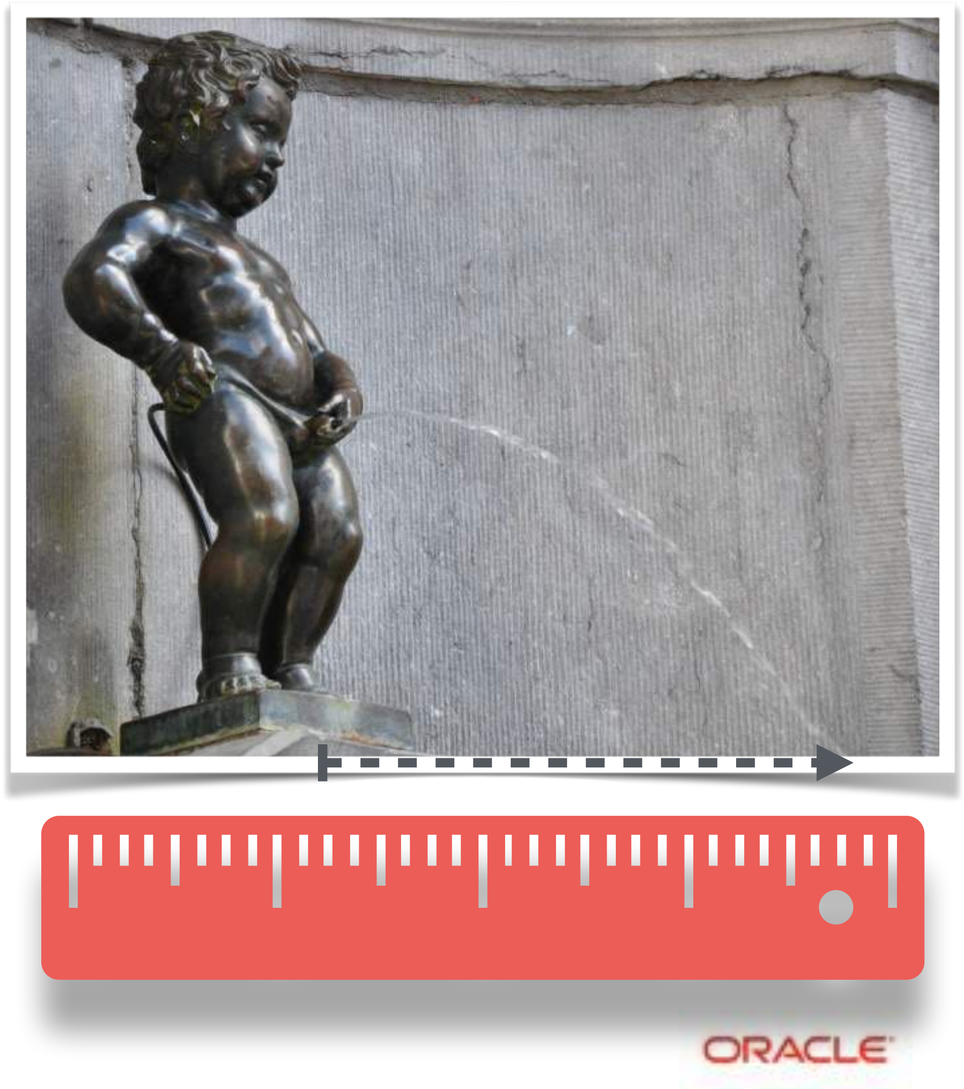
USE YOUR BRAIN !!! ;-)

#2 - Monitoring is THE MUST !

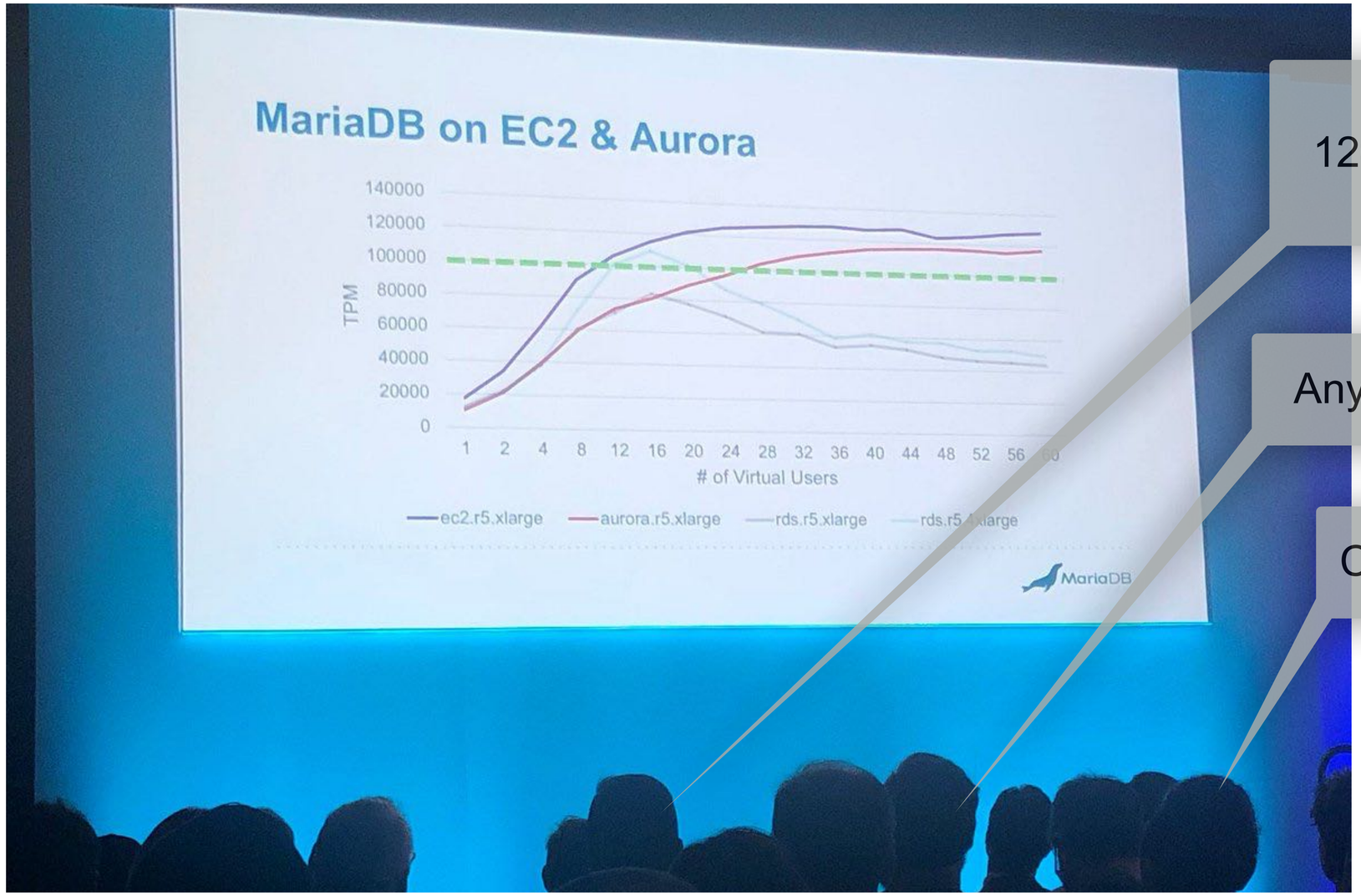
even **don’t** start to **touch** anything
without monitoring.. ;-)

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 ;-))



Indeed, There Are Some Bad Examples..



Hmm..
120K TPM = only **2K TPS**
why so slow ???

Any more **details** ???

Can I **reproduce** ???

- image credits : https://twitter.com/bytebot/status/1100410544480124928

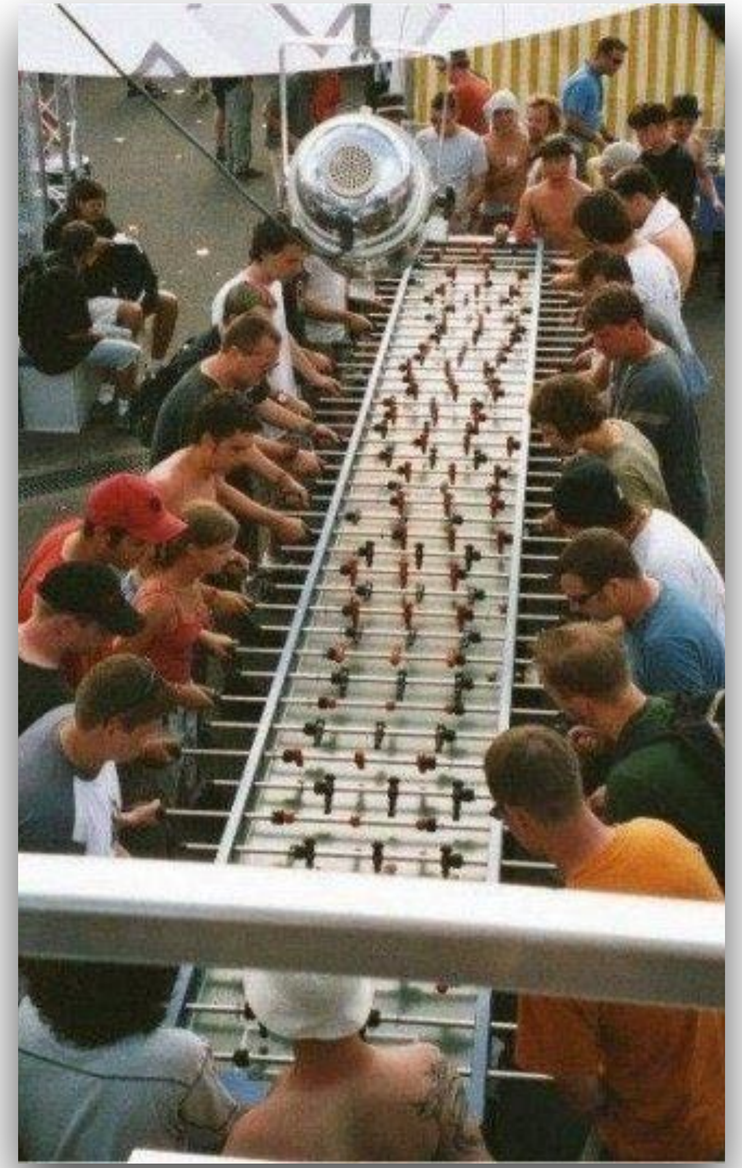
Benchmarks & MySQL

- Every test workload is pointing to a problem to resolve !
  - evaluate & understand the problem(s)
  - then try to 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..

The Best Test Workload

- For You :
  - workload simulating your Production !
  - JMetter (free)
  - LoadRunner ($$)
  - etc.
- otherwise :
  - use “generic” test workloads
  - change / adapt / extend..
  - **share** with us ! ;-))



Test Workload

- Before to jump into something complex...
  - Be sure first you're comfortable with “basic” operations!
- 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..

Understand what you're testing !!!

- Recently many vendors started to propose their Test Workloads
- Example by DigitalOcean :
  - 1) deploy "employee" database set
  - 2) run "mysqlslap" with 5 SQL queries and "--concurrency=50"
  - ref: https://www.digitalocean.com/community/tutorials/how-to-measure-mysql-query-performance-with-mysqlslap

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- Now, what exactly this test is doing ?
  - all 5 SQL queries => SELECT * from table;
  - e.g. 5 full scans of 5 tables concurrently executed by 50 users

- Does it represent your Production Workload ???
  - (e.g. mind "Best practice #1")

Popular “Generic” Test Workloads @MySQL

- Sysbench - #1
  - The “Entry Ticket” Workloads - looks simple, but still the most complete test kit !
  - OLTP, RO/RW, points on various RO and RW issues
- TPC-C :
  - DBT-2 / TPCC-like / HammerDB / Sysbench-TPCC
- TPC-H / DBT-3
  - 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
  - FB workload

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 ! ;-)
  - => becomes a true **dev platform** for workload scenarios !

Your Own Test Scenario With Sysbench ?

- “Just do it!”

```
function thread_init()
  drv = sysbench.sql.driver()
  con = drv:connect()
end

function thread_done()
  con:disconnect()
end

function event()
  local id = sysbench.rand.default( 1, 1000000 )
  con:query( "select * from table1 where id = " .. id )
end
```

Using Sysbench ? => Mind The Details !!!

- Random (rand-type=…) Access :
  - special / uniform / pareto / gaussian / zipfian
  - for more details see: https://github.com/akopytov/sysbench/issues/329
  - how impacts on MySQL workloads ? => see in next slides..
- Note : by default “historically” => special (!!!)
  - **special** = mostly accessing only 1% of your data !!
  - e.g. 2GB or 2TB of data = nearly the same result with 32GB Buffer Pool

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- Victims :
  - **PostgreSQL** : https://www.ongres.com/blog/benchmarking-do-it-with-transparency/
  - **ScaleGrid** : https://scalegrid.io/blog/how-to-improve-mysql-aws-performance-2x-over-amazon-rds-at-the-same-cost/

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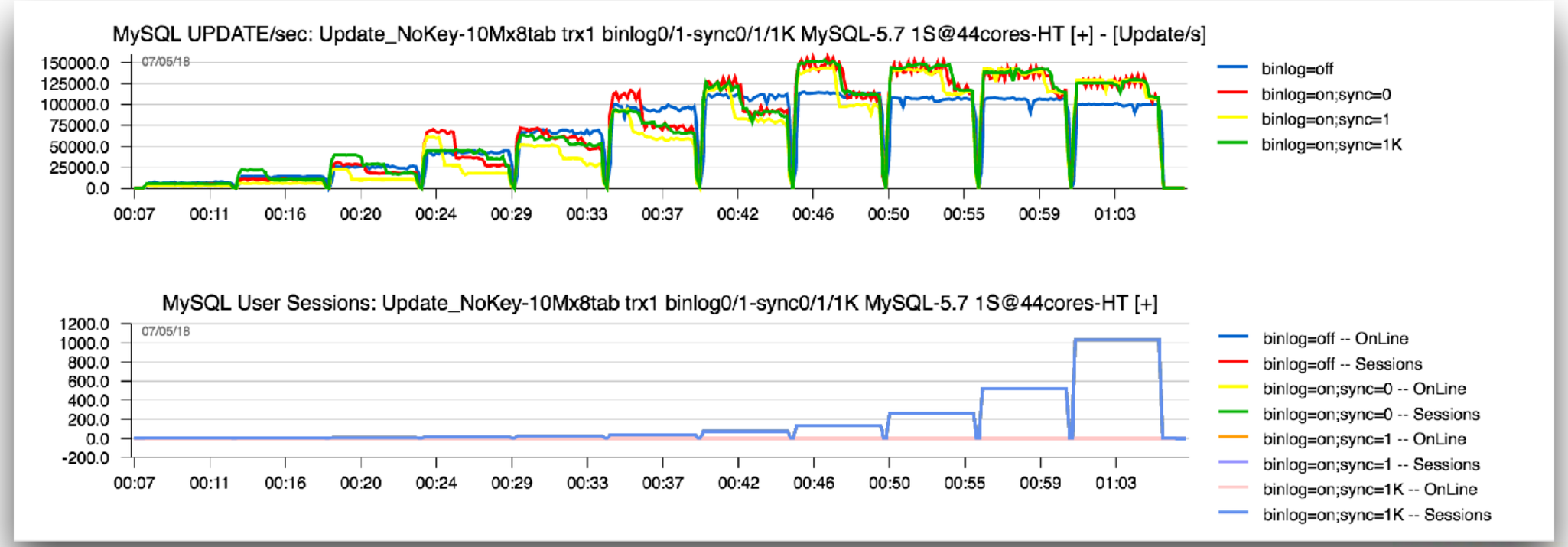
- But :
  - At least they **published** all the **details**, so the confusion in results could be explained, and error found..

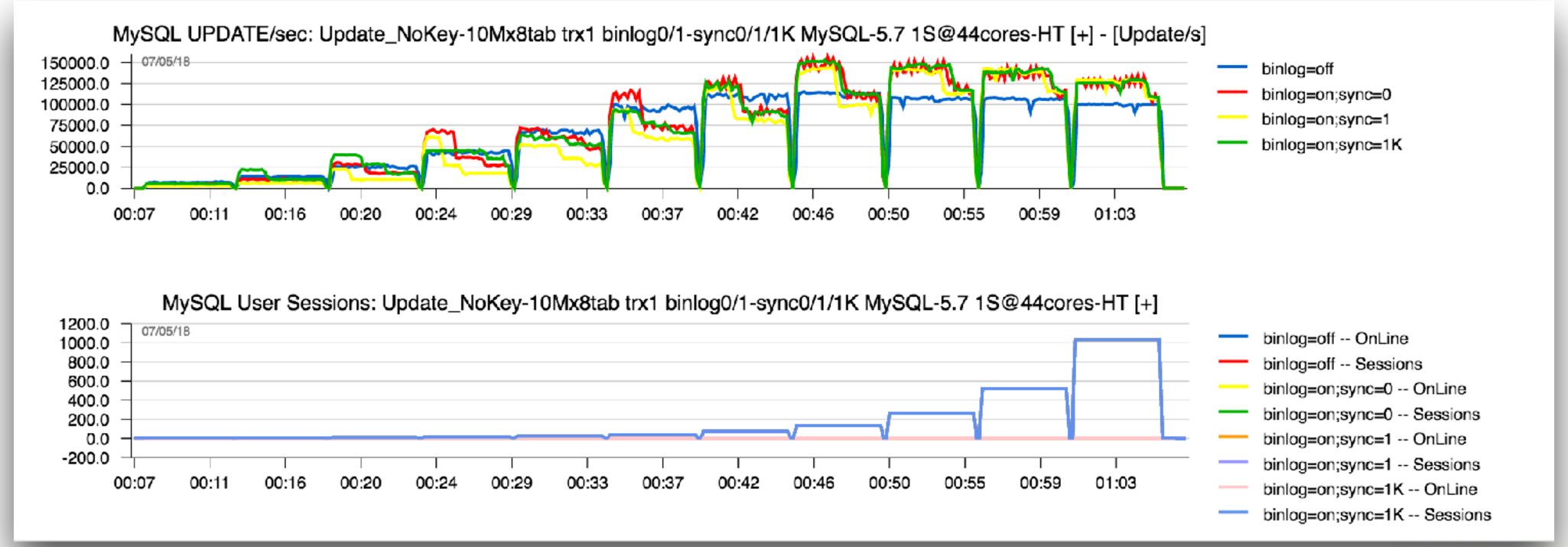
Using Sysbench ? => More About Random

- Observation :
  - Enabling Binlog improves performance ?? — Really ?? WTF ??
  - Or maybe there is a bug, and Binlog disabling REDO log ??..
  - Or maybe we hit some “short CPU boost” frequency feature ??
  - Or .. ??



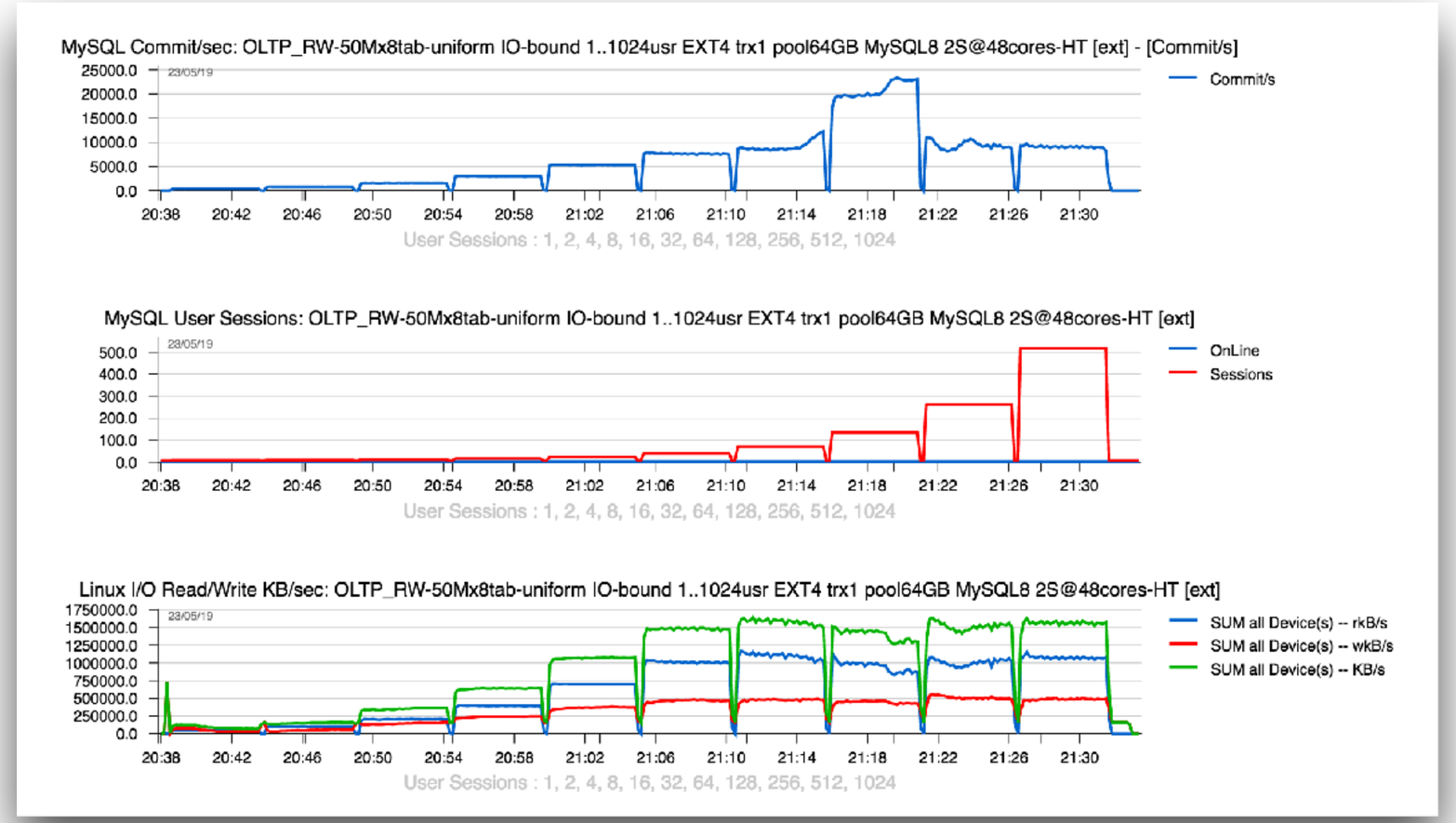
Using Sysbench ? => More About Random

- Explanation :
  - **rand-seed**=N : 0 = current time, not 0 = your choice (helps to debug)
  - here: rand-seed=**1** ; so on every new load level the same “random” values used
  - so, UPDATE with the same value = NO CHANGE ! => of course it goes faster ;-))
  - why only with Binlog ? => Good Question !!! ;-)) (but who cares?? — just use ZERO !!)



Don’t Look Only On Numbers !!!

- **IO-bound** Workload
  - but x2 times higher TPS on 128 users load level !! => “False Positive”
  - use Best Practice #2 (Monitoring) and then #1 ! ;-))



The 4 Main Sysbench “entry-ticket” Workloads

- OLTP_RO-point_select
  - the most aggressive, most simple (PK lookup), scaling well since MySQL 5.7
  - start with this to test your HW scalability, compare your results
  - meet any trouble ? => makes no sense to go any further.. (fix it first ;-))
- OLTP_RO (mixed RO)
  - more various RO operations (ranges, order by, distinct (group by), + 10 point-selects)
- OLTP_RW (mixed RO + writes)
  - mix of all, good enough “generic” OLTP
- OLTP_RW-update_no_index (aka Update_NoKEY)
  - bombarding with in-place UPDATE(s) => good for testing write bottlenecks
- Note:
  - our writes are NOT scaling (yet)

Minimal “Test Kit” Scenarios

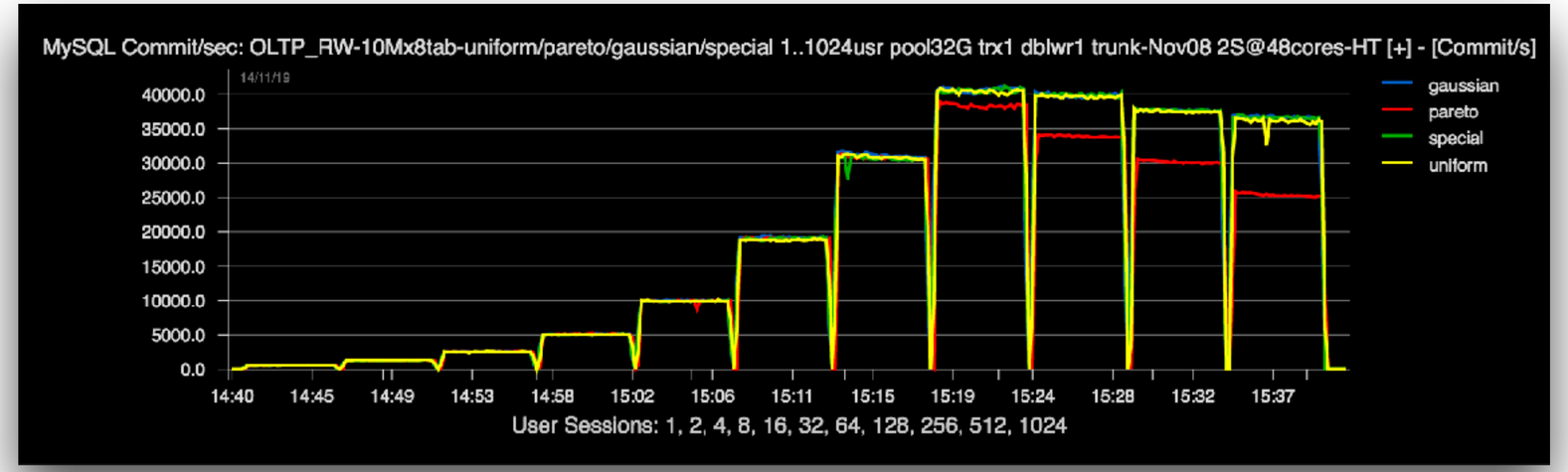
- Data Volume and Number of Tables :
  - 1 table : to simulate one “hot table” in your app/production
  - 8 tables : splits “hot table” issue(s) by 8 and let you see if it helps or you hit something else
- Data / Memory Ratio :
  - all in-memory
  - 1/2 of data can feet memory
  - 1/4 of data can feet memory
- Other :
  - random : uniform / pareto
  - prepared statements : ON / OFF

Minimal “Test Kit” Scenarios : Example

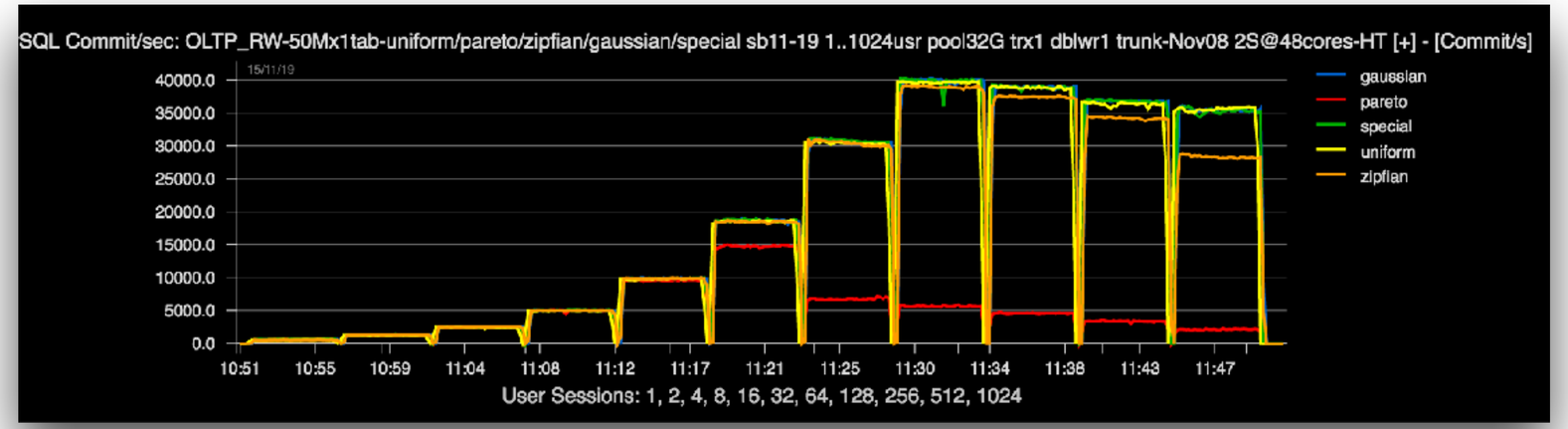
- Data Volume and Number of Tables :
  - 1 table : 400M rows (~120GB) - 400Mx1tab
  - 8 tables : 50M rows per table (same 400M in total) - 50Mx8tab
- Data / Memory Ratio :
  - all in-memory : BP = 128G
  - 1/2 of data can feet memory : BP = 64G
  - 1/4 of data can feet memory : BP = 32G
- Other :
  - random : uniform / pareto / special / gaussian / zipfian
  - prepared statements : ON
  - trx_commit=1, dblwr=1, checksum=1, PFS=on, UTF8, etc.

Sysbench OLTP_RW

- In-Memory, 8 tables :

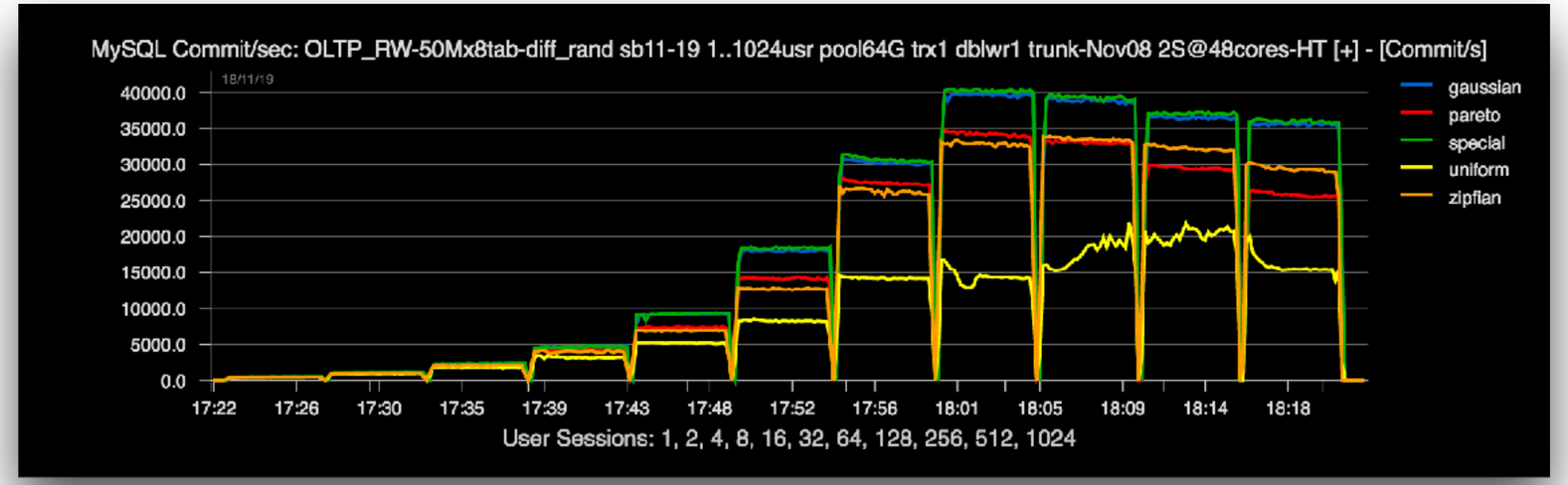


- In-Memory, 1 table :

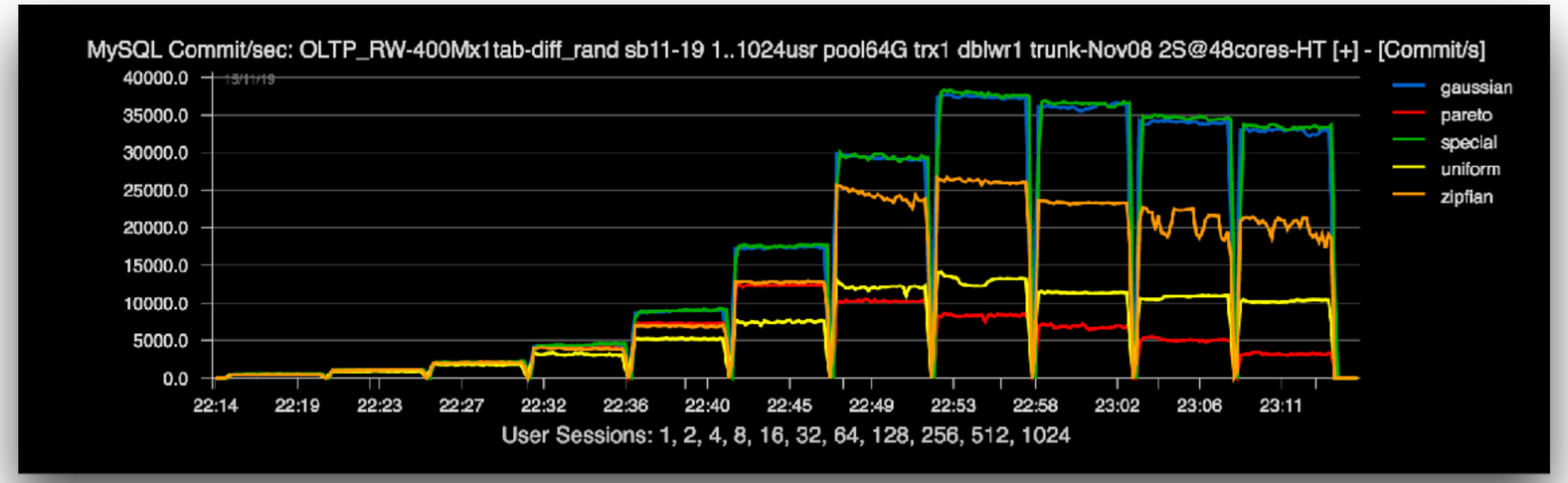


Sysbench OLTP_RW

- 1/2 Memory, 8 tables :

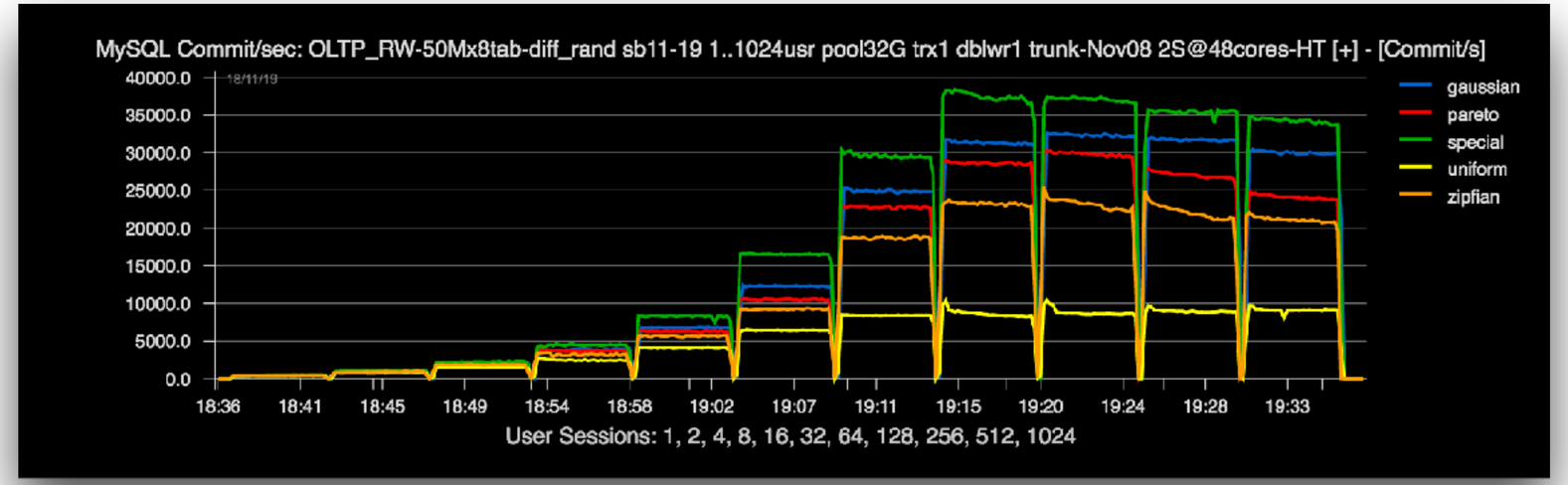


- 1/2 Memory, 1 table :

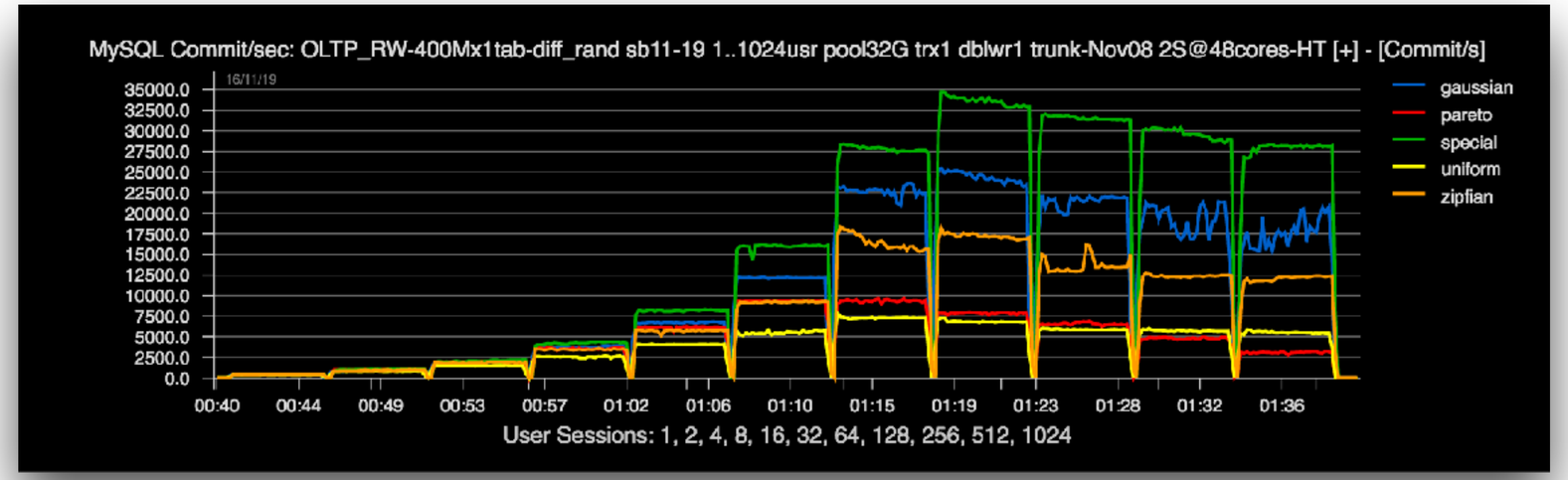


Sysbench OLTP_RW

- 1/4 Memory, 8 tables :



- 1/4 Memory, 1 table :



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To Avoid Confusions : Benchmark Kit

- In The Box :
  - pre-generated scripts for all workloads
  - script name = test & options
  - all Sysbench tests
  - (but without “special” ;-))
  - includes TPCC
  - includes dbSTRESS
  - coming after FOSDEM ;-))

```
cd /BMK

# prepare data
bash ./sb_exec/sb11-Prepare_50M_8tab-InnoDB.sh 32

# run OLTP_RW for 5min each load level..
for rnd in uniform pareto
do
  for users in 1 2 4 8 16 32 64 128 256 512 1024
  do
    bash ./sb_exec/sb11-OLTP_RW_50M_8tab-$rnd-ps-trx.sh $users 300
    sleep 15
  done
  sleep 60
done
```

Yet More Things To Keep In Mind..

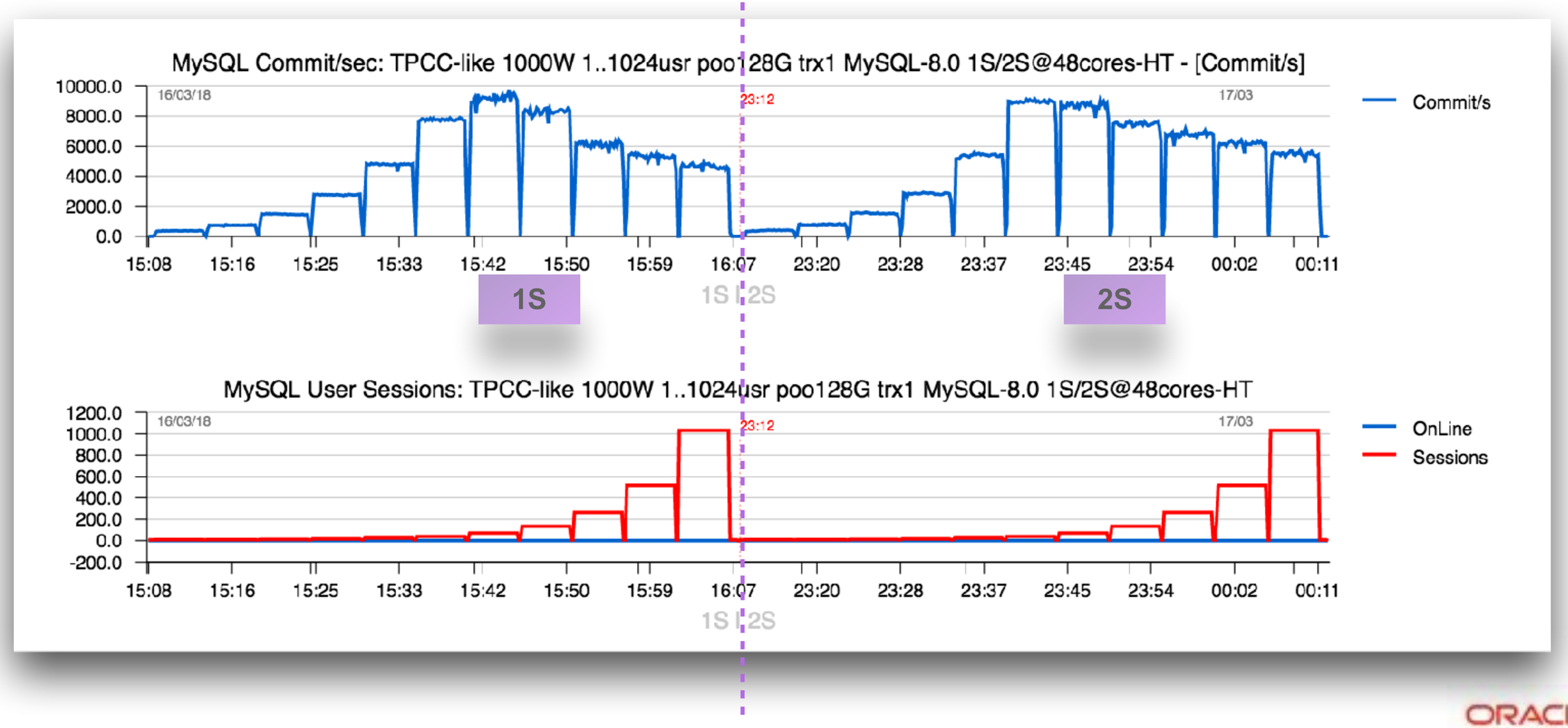
- Configurations :
  - jemalloc-5.2.1 => the MUST
  - same storage / diff drives
  - flash : (yes, please, LOVE your DATA !!) — *but mind latency driven, more drives != better perf*
  - EXT4 / XFS ?? — *massive EXT4 regression in the latest kernels..*
  - O_DIRECT !!!
  - dblwr = 1/0 (note: 1 by default)
  - Binlog = 1/0 (note: 1 by default)
  - trx_commit = N (note: 1 by default)
  - REDO size
  - IO capacity / capacity_max
  - flushing neighbors = OFF
  - UNIX socket / IP port (localhost) / xNET
  - ssl = 0/1 (note: 1 by default)
  - UTF8 -vs- latin1 (note: UTF8 by default)
  - UNDO auto-truncate (note: 1 by default)
  - MySQL 8.0 Resource Groups: you can split your activity..

TPCC Workloads

- DBT2
  - old stuff (but still loved by some ones (definitively not me ;-)))
- TPCC-like
  - more simple to use, but “hard-coded” ;-))
- HammerDB
  - fully based on Stored Procedures
- Sysbench TPCC
  - ported to Sysbench from TPCC-like by Percona
  - totally flexible (LUA scripts)
  - easily hackable
  - can use more than 1 TPCC “instance”

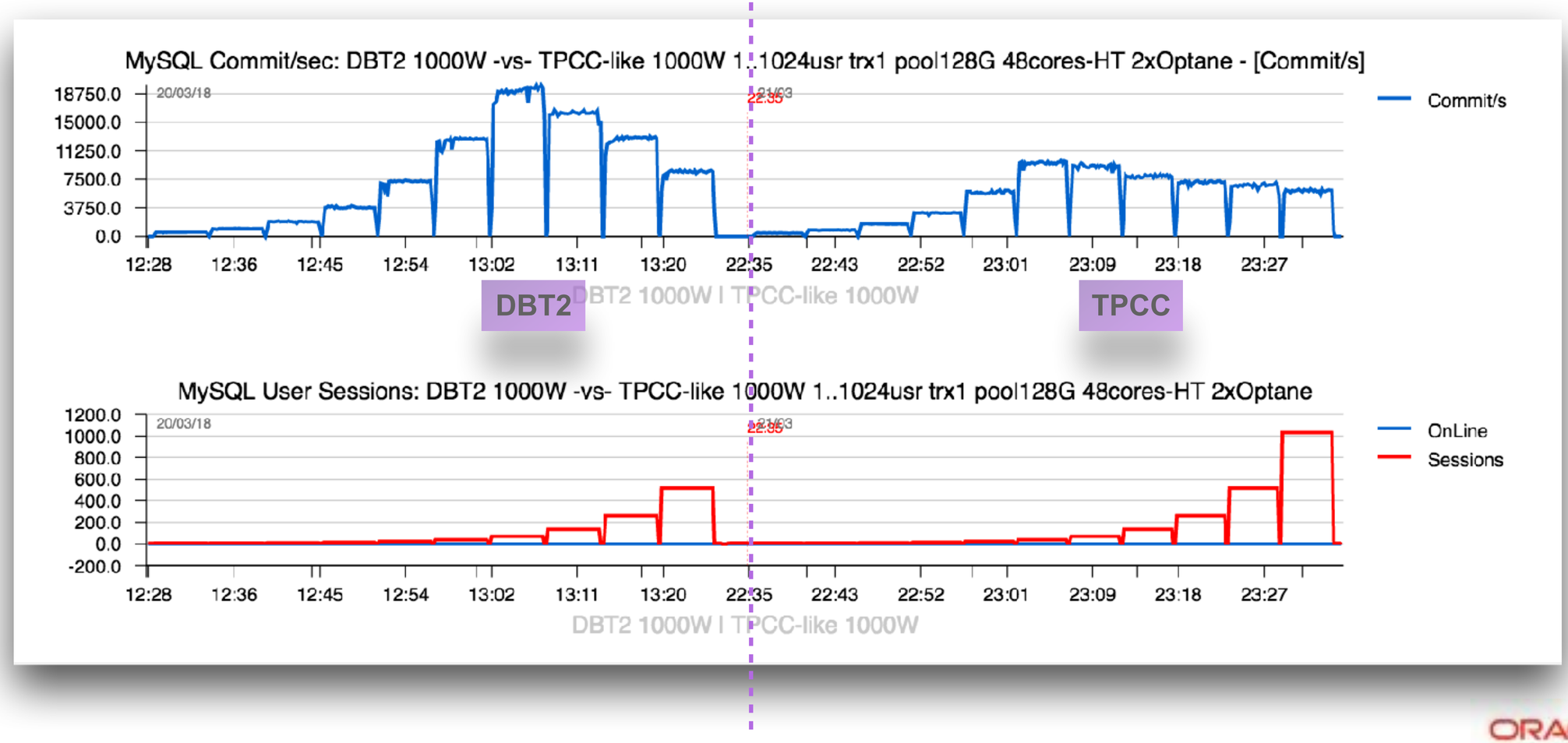
TPCC “mystery” : 1000W Workload @Sysbench-TPCC

- MySQL 8.0 :
  - small or no gain between 1S -vs- 2S
  - scalability is totally blocked by “index RW-lock” contention..



TPCC “mystery” : DBT2 -vs- Sysbench-TPCC (Apr.2018)

- BP = 128GB : in-memory
  - nearly the same workloads, but different “execution profile”
  - no index RW-lock contention in DBT2.. => **to investigate**



TPCC “mystery” : Investigation

- Motivation
  - even if we could not “fix” index RW-lock contention in InnoDB on TPCC…
  - …but we can find a “workaround” on how to avoid it => **already a huge gain !!!**

TPCC “mystery” : Investigation

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- 1) Ranger (ex-MySQL, now Percona, DBT2 lover in the past ;-))
  - => who changed the DBT2 schema ???
  - => as the result : 1/2 transactions are rejected on INSERT of NULL value !!!
  - => at least it became clear why in my case DBT2 was doing better ;-))

Anything could we do with INDEX lock contention ???

TPCC “mystery” : Investigation

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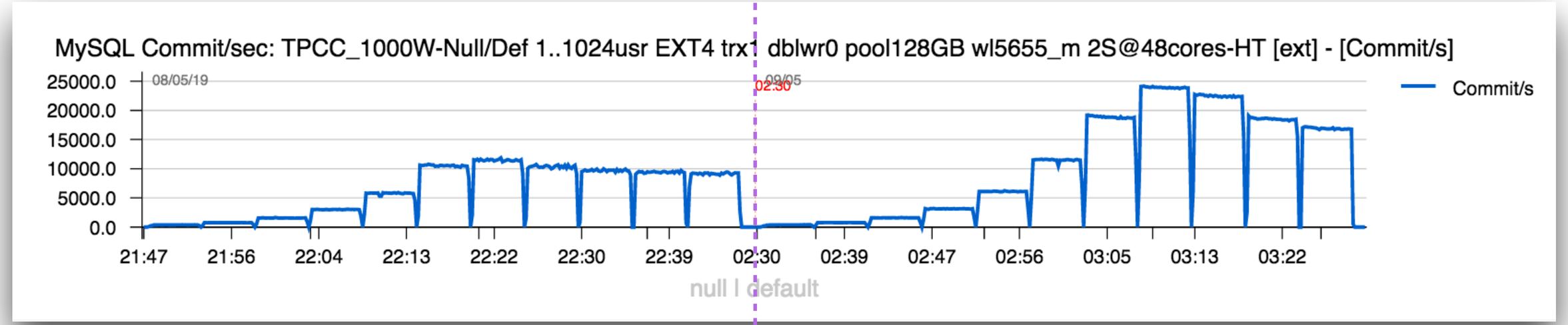
  - => at least it became clear why in my case DBT2 was doing better ;-))
- 2) Yasufumi (ex-Percona, ex-MySQL, now MySQL again, TPCC lover ;-))
  - why INDEX lock ? => excessive page split !
  - why page split ? => …
  - TPCC : … INSERT val=NULL
  - TPCC: … UPDATE val=DATE
  - NULL => DATE => no space in page => page split !!! ;-))

TPCC “mystery” : Solution

- Workaround :
  - instead of NULL use DEFAULT (and assign an “good size” value to DEFAULT)
  - then : INSERT values(…, DEFAULT, …) /* instead of NULL */
  - then : UPDATE … var = DEFAULT … /* instead of NULL */
  - then : SELECT … WHERE var != DEFAULT /* instead of NULL */
  - and so on.. => no more page split (or very minimal)
- Final solution :
  - work in progress..

TPCC “mystery” : test results

- Sysbench-TPCC 1000W
  - NULL -vs- DEFAULT

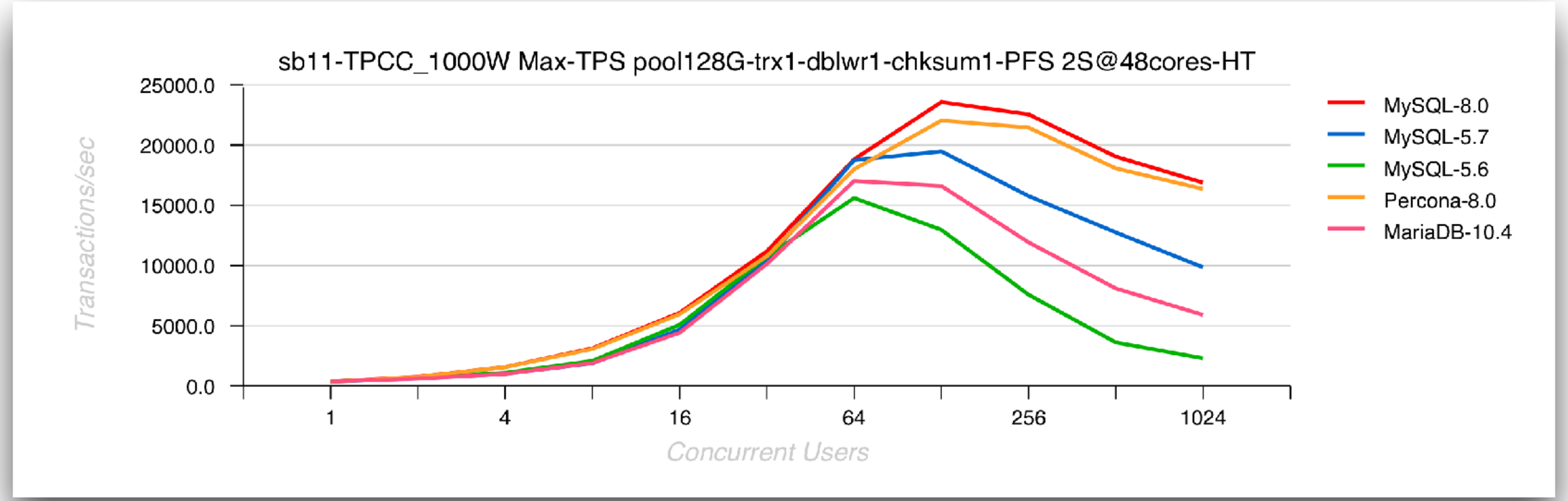


NULL

DEFAULT

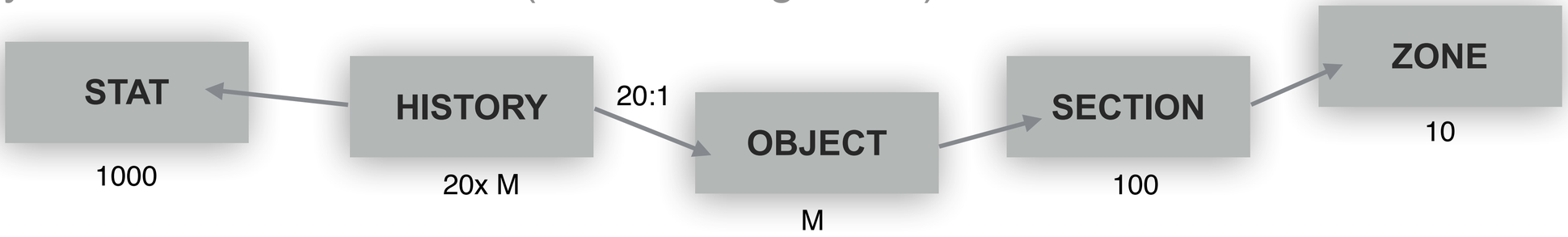
TPCC “mystery” : test results (Sep.2019)

- Sysbench-TPCC 1000W, using DEFAULT
  - **in-memory** (pool=128G)
  - 2S Intel Cascade Lake 48cores-HT & 2xOptane NVMe :



dbSTRESS Workload

- Developed & Maintained by me ;-))
  - fully ported to Sysbench, but not yet published (in progress)
  - can be executed as x1 dataset or xN datasets (similar to xN db, except it's the same db)
  - inspired by real customer workload (stock management)
  - schema :

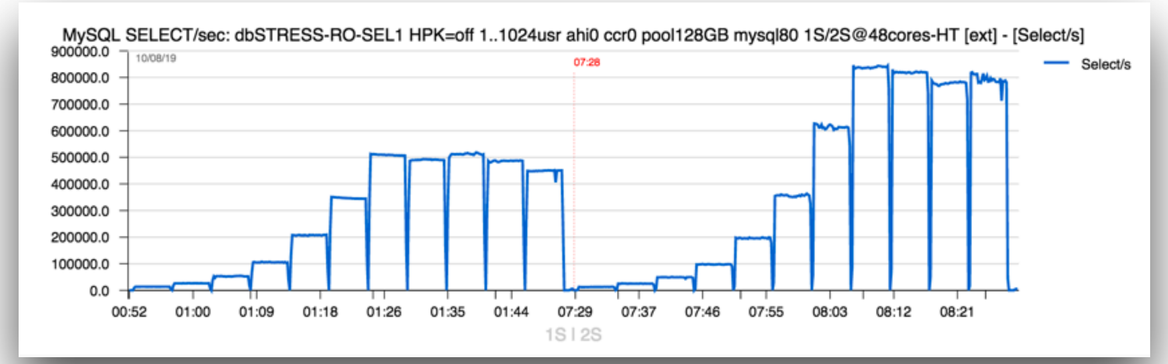


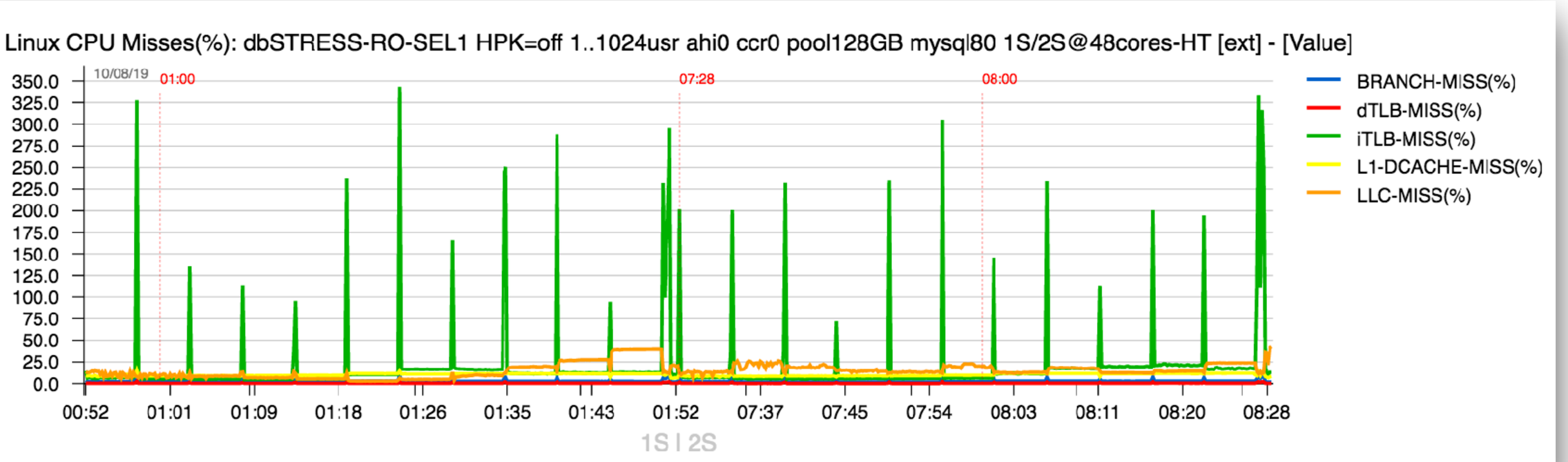
  - queries :
    - SEL1 : join of 3 tables by OBJECT REF (OBJECT => SECTION => ZONE)
    - SEL2 : join of 2 tables by OBJECT REF (OBJECT => HISTORY)
    - WRITE: DELETE/ INSERT/ UPDATE of single HISTORY record by OBJECT REF

- The current "mystery" :
  - SEL1 : scaling well, QPS on 2S is higher than on 1S
  - SEL2 : not scaling ! QPS on 2S is worse than on 1S !!
    - NOTE: using PK instead of Sec.IDX is helping in efficiency, but not in scalability..

dbSTRESS-RO-SEL1

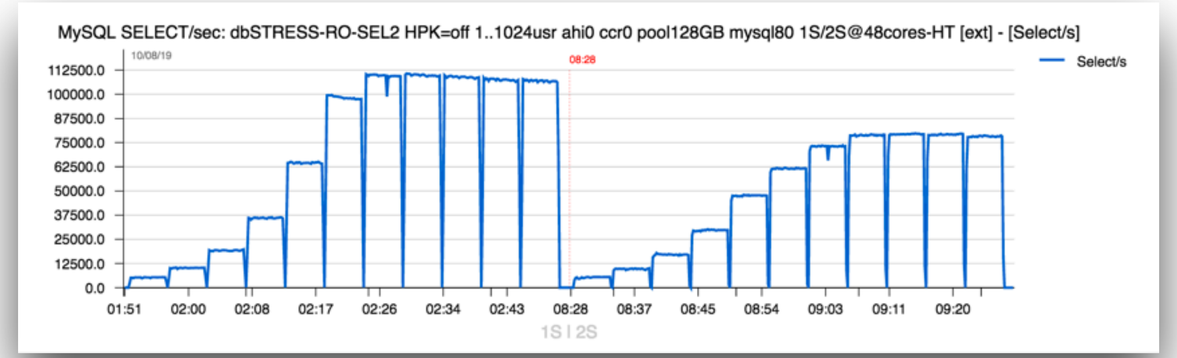
- SEL1 :
  - scaling from S1 to S2

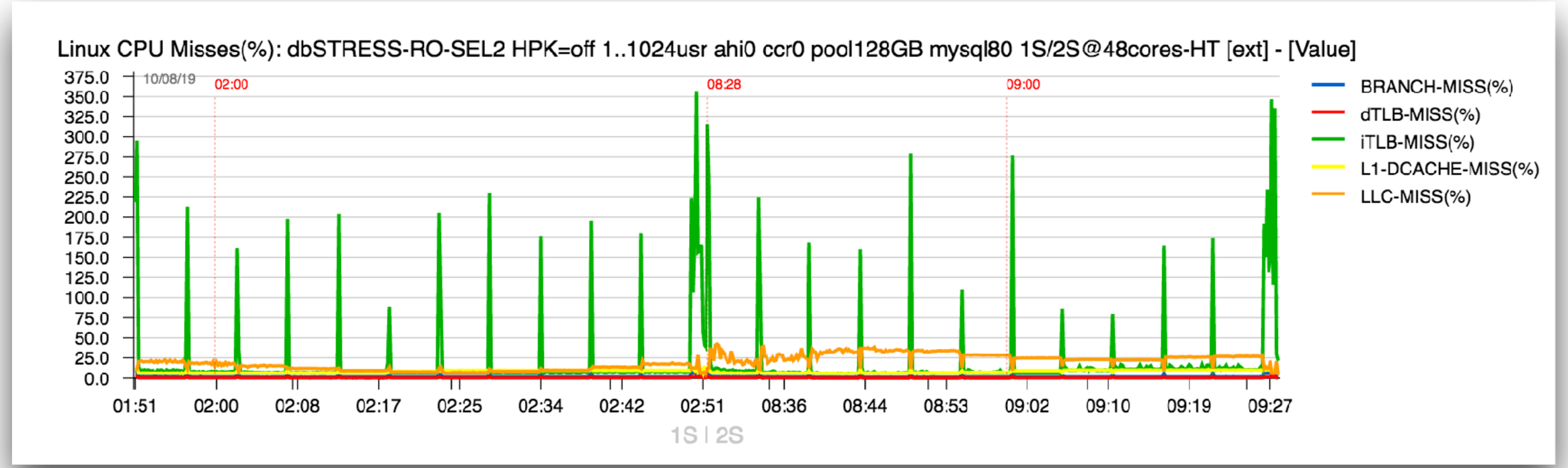




dbSTRESS-RO-SEL2

- SEL2 :
  - NOT scaling from S1 to S2





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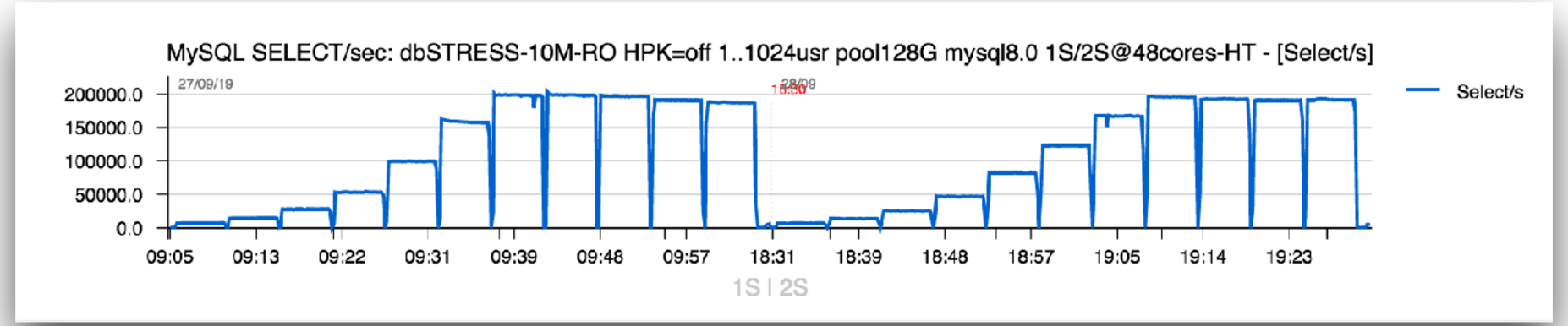
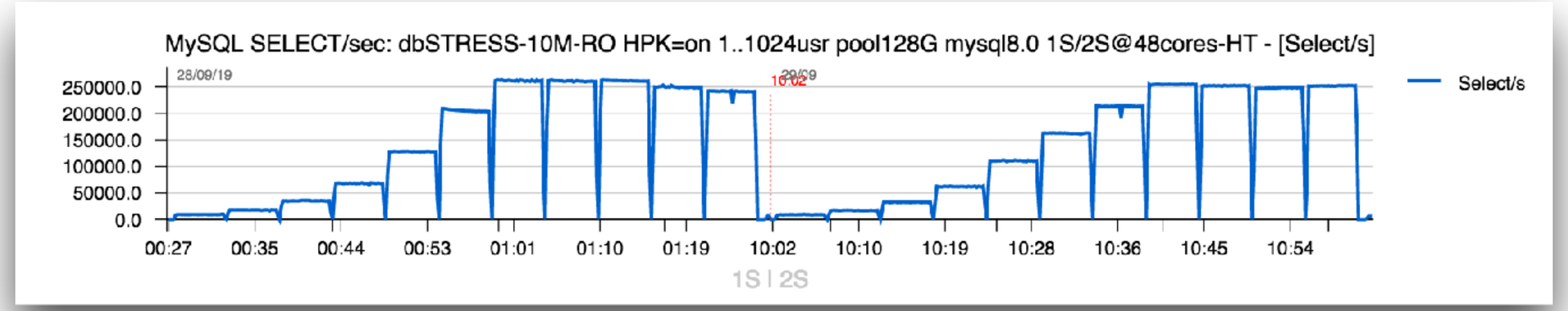
dbSTRESS-RO (SEL1 + SEL2)

- HISTORY table NOT using PK (HPK=off) :



- HISTORY table using PK (HPK=on) :



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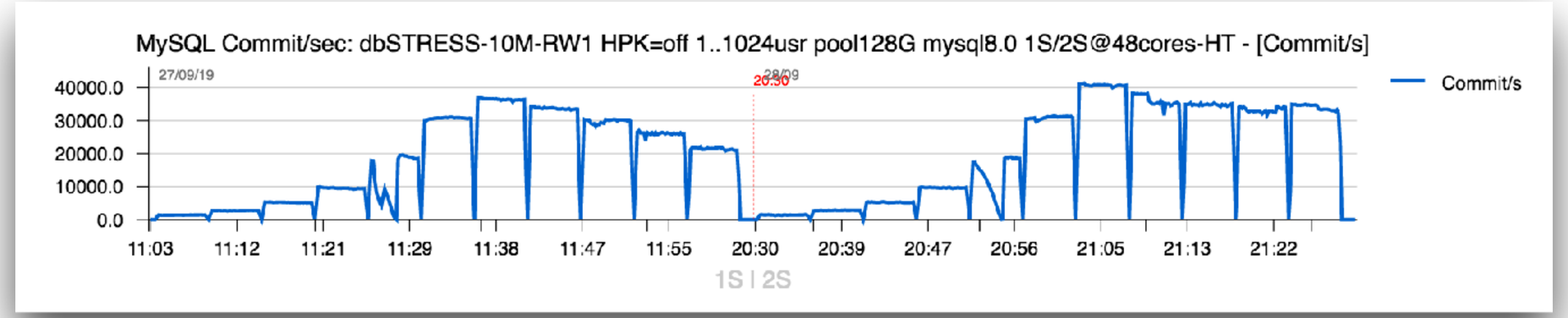
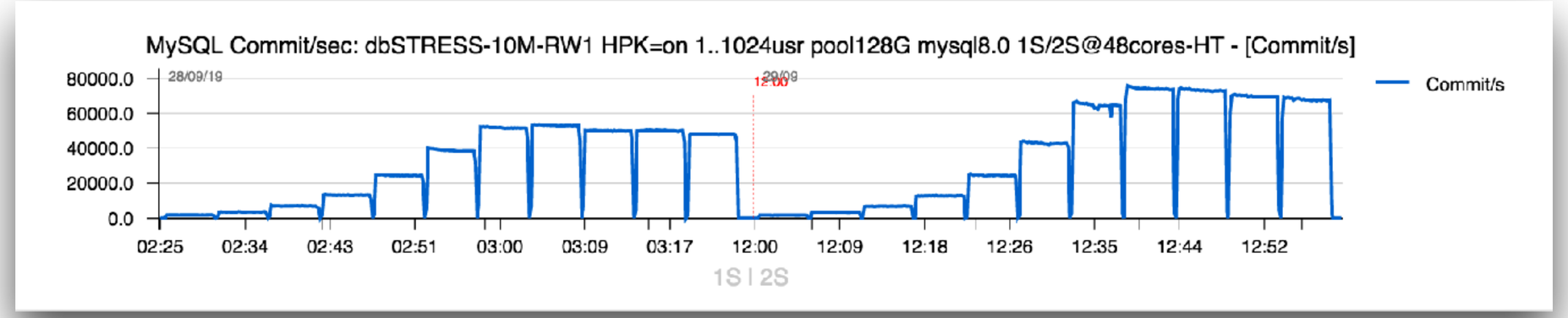
dbSTRESS-RW1 (R/W ratio= 1:1)

- HISTORY table NOT using PK (HPK=off) :



- HISTORY table using PK (HPK=on) :



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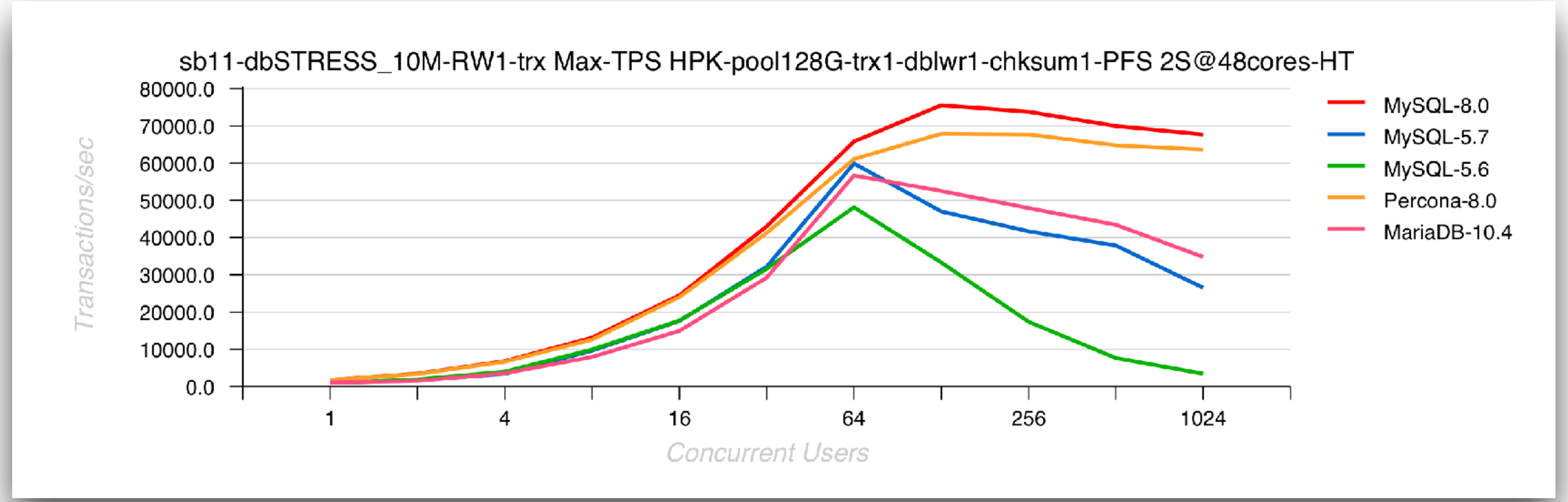
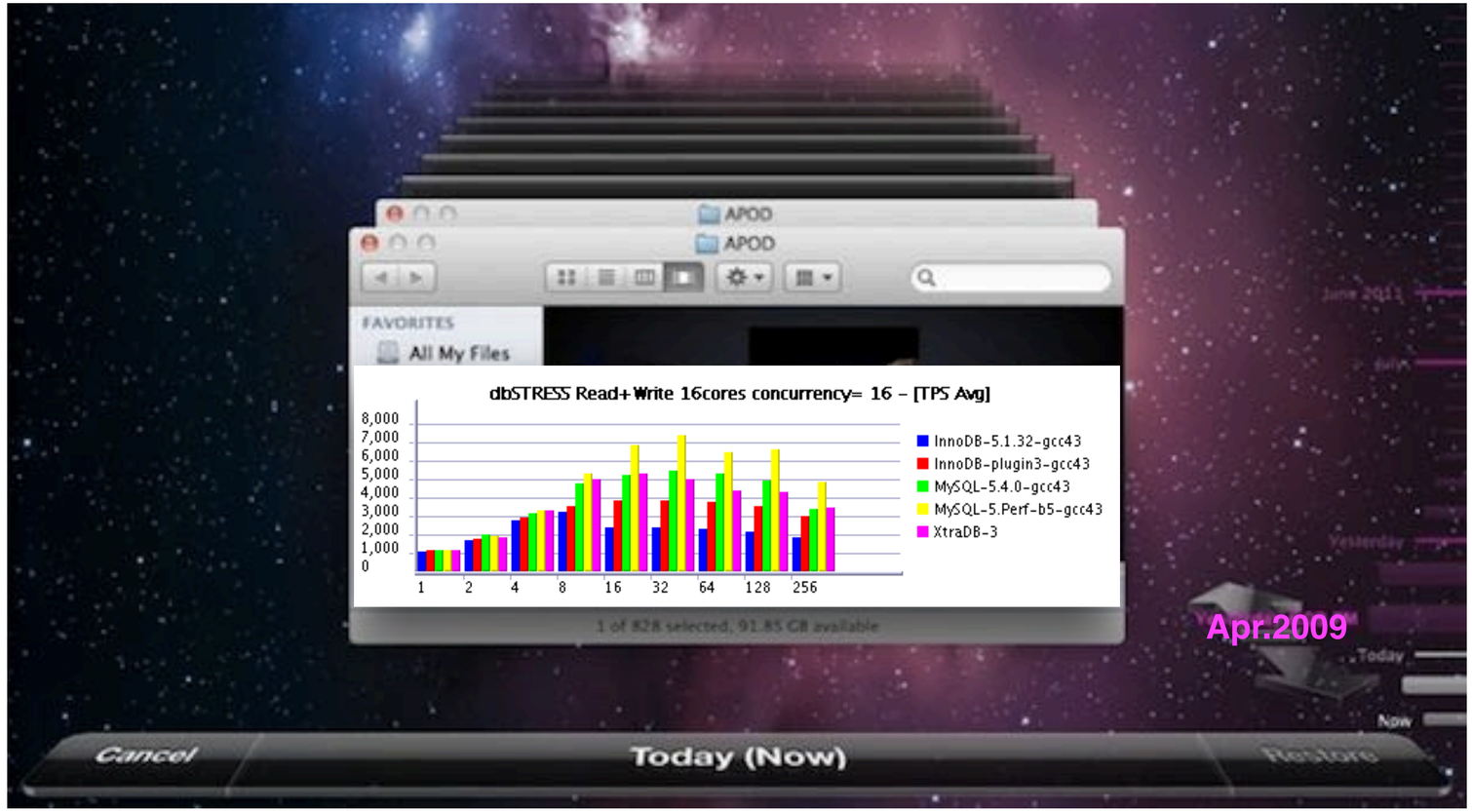
dbSTRESS 10M RW1 Test + HPK=on

- Dataset : 10M (200M HISTORY+PK (HPK)) @48cores-HT Cascade Lake
  - as usual, “everything is relative”..
  - while we blame MySQL 8.0 for scalability limits, it’s still doing better than all we have ;-))



dbSTRESS RW1 Test & Time Machine..

- Looking back with Time Machine :
  - even more once again — “everything is relative”..
  - **Apr.2009** : dbSTRESS 10M RW1 => **7.5K** TPS **only** as the best ever possible result !!
  - 10 years => and so huge jump in SW/HW + MySQL 8.0 !!! => x10 times diff..



Thank You !!! 🍾🍾🍾

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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 profiler stats), 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.