MySQL

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MySQL Performance: Understanding & Tuning of CPU-Bound Workloads (part-1)

Overview 2026

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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

- **Standalone** MySQL Performance & Scalability
  - part-1 : Understanding & Tuning of CPU-Bound Workloads (aka In-Memory)
  - part-2 : Understanding & Tuning of IO-Bound Workloads

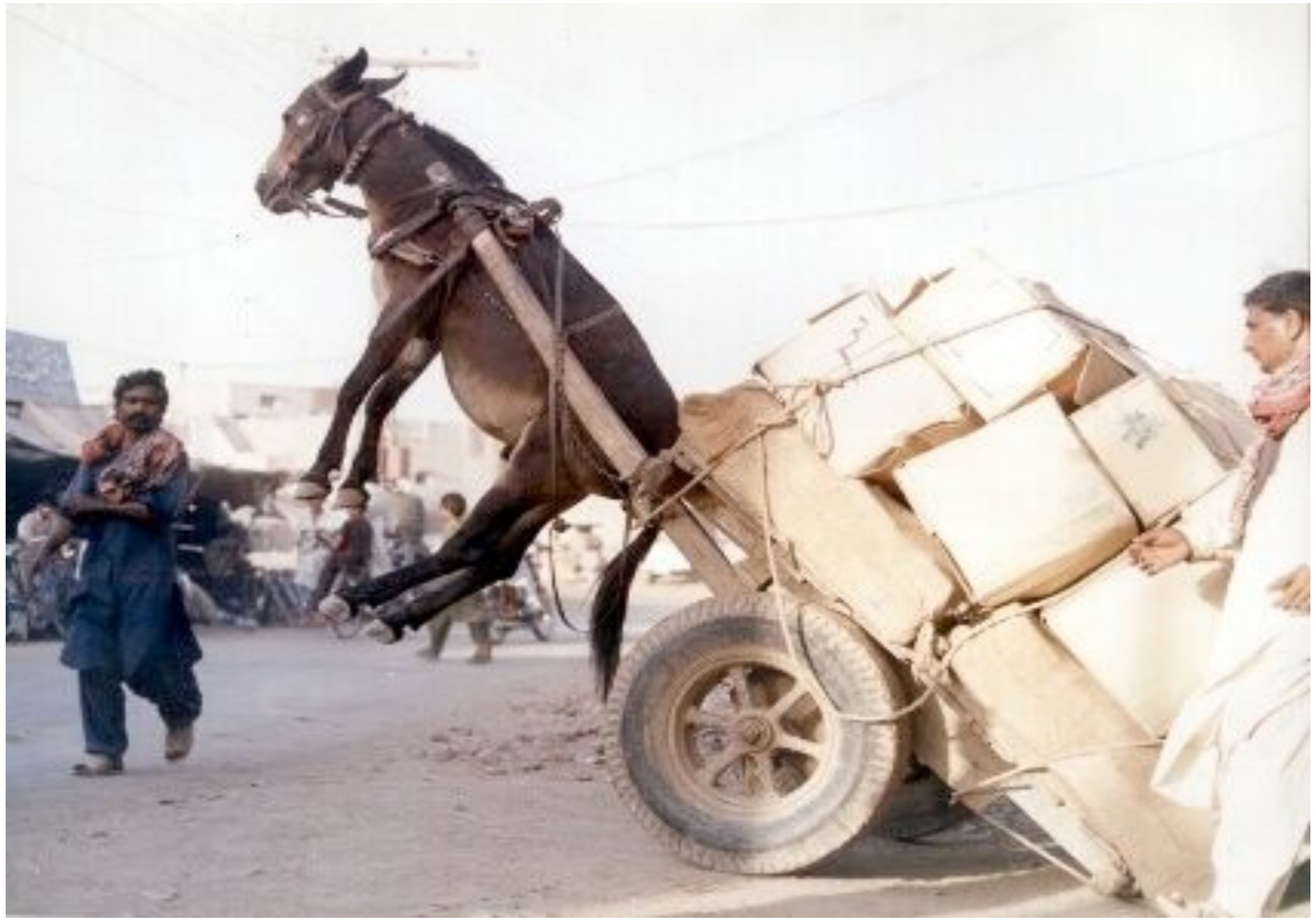
Why Performance & Scalability ?...

Why Performance & Scalability ?..

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

Why Performance & Scalability ?..

- Until it did not reach its limit..



Why Performance & Scalability ?..

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

Why Performance & Scalability ?..

- And reach a similar limit..

Why Performance & Scalability ?..

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

Why Performance & Scalability ?..

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

Why Performance & Scalability ?..

- World is changing constantly :
  - and what was considered rock solid yesterday, may become weak and smashable tomorrow..

But if you let “russian word” come to your Home..

- Final REMINDER :
  - Along with your WORK there is also REAL LIFE, don’t miss it..

MySQL Core Workload Target

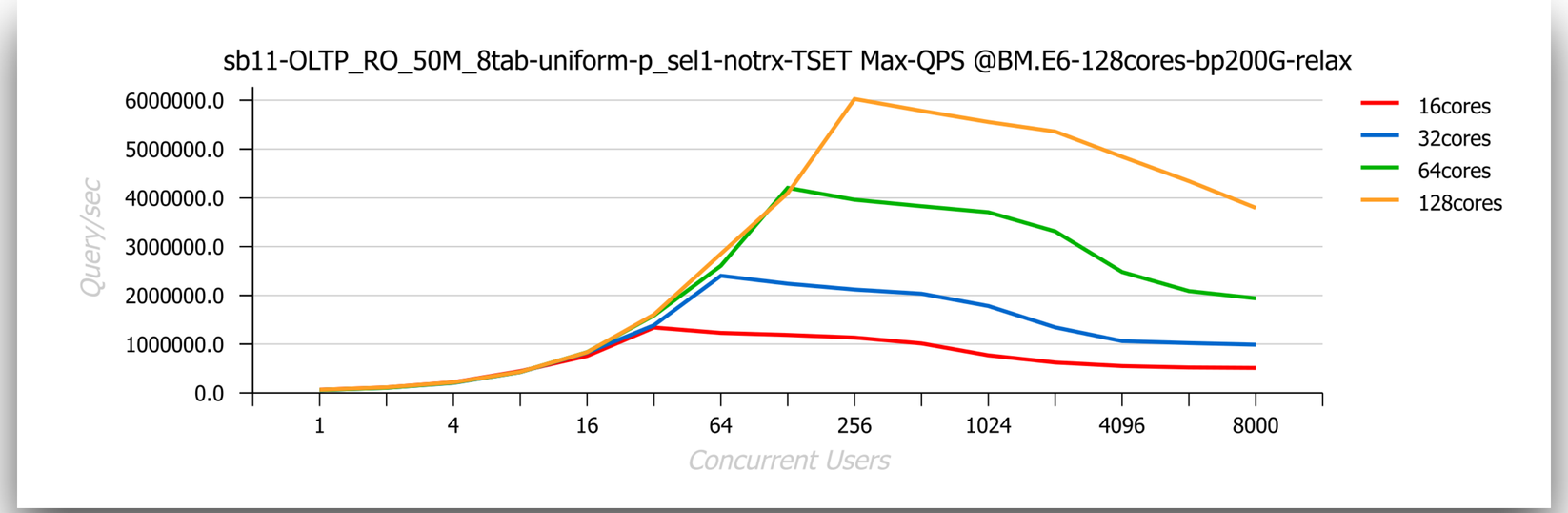
- Historically & Mainly => OLTP !
  - e.g. generally about fast short queries
  - do you recall LAMP ? Web ? Internet ? ;-))
- CPU-bound Workloads (aka In-Memory) :
  - no IO Reads from Storage
  - NOTE : except for TEMP tables (but not too much)
- IO-bound Workloads :
  - with IO Reads from Storage
  - generally active dataset is (much) bigger than RAM (or/and BP size)
- Side NOTE :
  - Hardware + Storage + Network + System setup choice = baseline for gains or pains !

CPU-bound : How Fast ?..

- **Q** : what is the fastest SQL Query ?
  - spoiler : please, don’t say “SELECT 1” ;-))

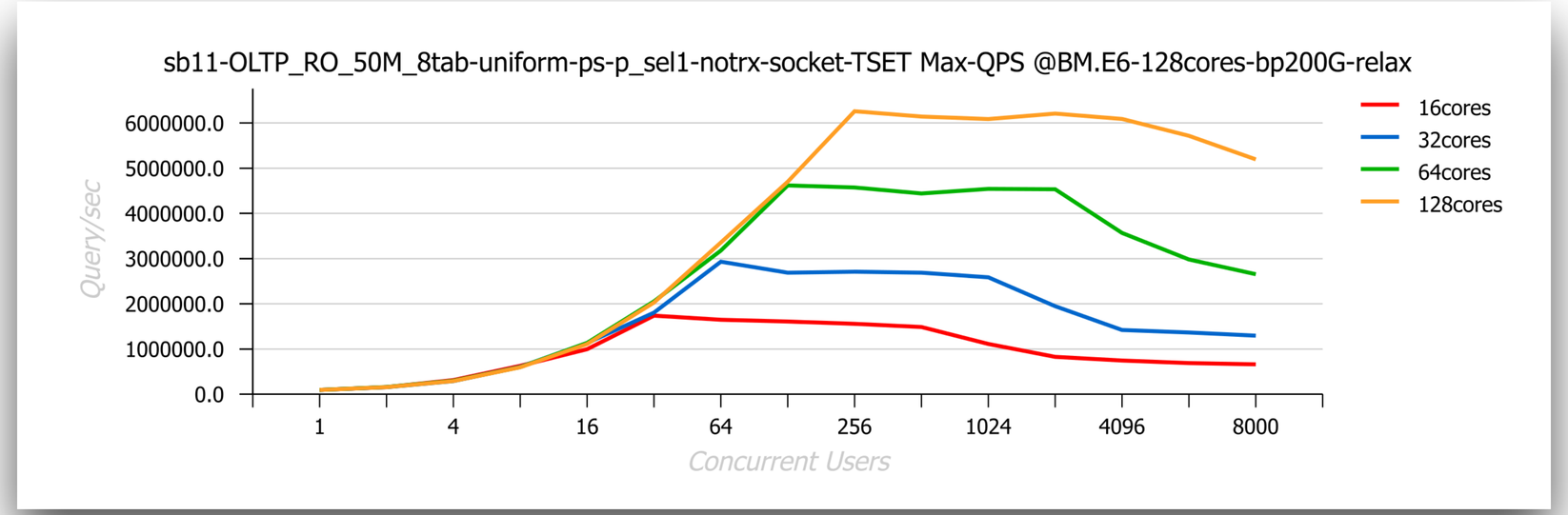
CPU-bound : How Fast ?..

- **A** : Lookup via Primary Key (aka PK-lookup)
  - ex.: “SELECT .. FROM table where ID = 1”
    - (where ID is PK)
    - Sysbench : point-selects workload
  - shorter PK => faster lookup
  - generally scales pretty well
  - NOTE : mind “clustered” nature of InnoDB tables



CPU-bound : Can Be Faster ?..

- PK-lookup Speed-Up :
  - using Prepared Statements => 10-20% boost
    - skipping Parser step, e.g. gain is only for short queries
  - connecting via UNIX-Socket => 10-100% boost (depends on the System)
  - enabling InnoDB Adaptive-Hash-Index (aka AHA) => helps, but it depends..
    - based on RW-locks
    - RW-locks are not scaling “by definition” (even for Read-Only)



Speed-UP with PGO

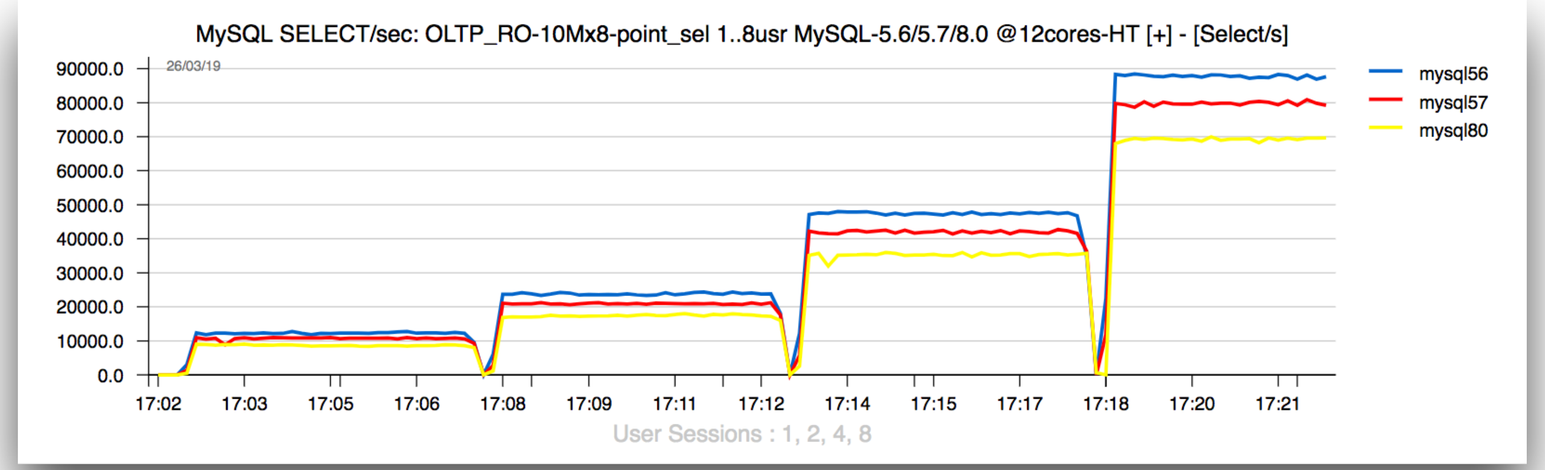
- 2019 : ready to deploy
- 2020 : …
- 2021 : …
- 2022 : …
- 2023 : …
- 2024 : …
- 2025 : …
- 2026 : finally OK to deploy !
  - expectation : to see all delivered MySQL binaries to be PGO-optimized since now

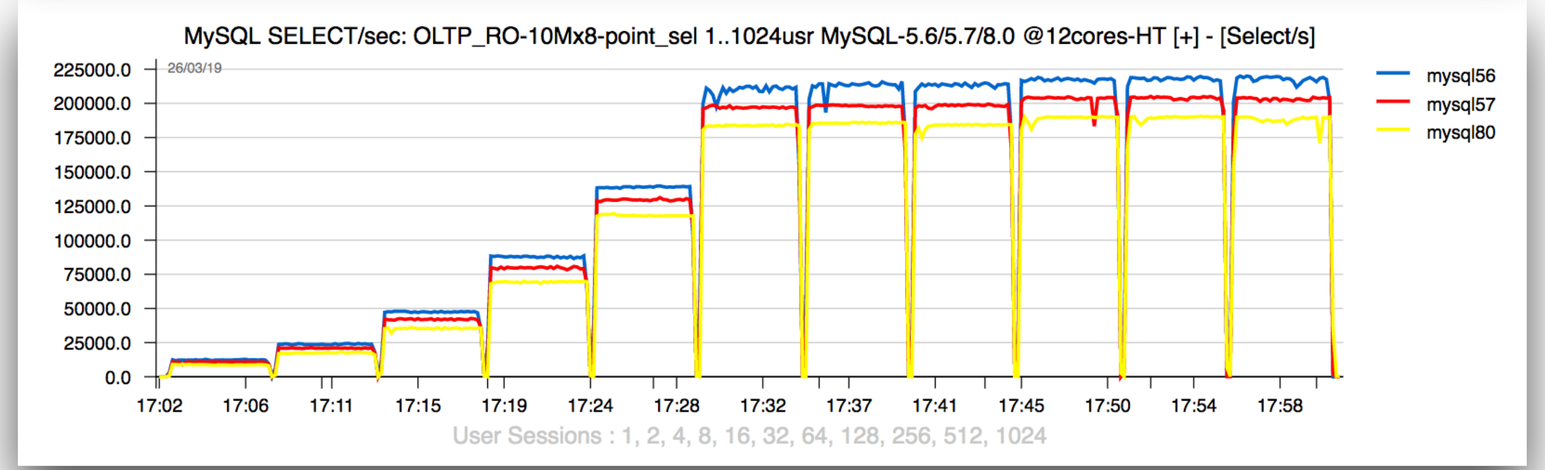
Small HW (May.2019 PLIVE Austin US)

- Unexpected Performance Regressions..
  - historically : single thread only (more new features => longer code path)
  - currently : **even on high load**..
- Looking closer :
  - Server : 12cores-HT Intel
  - Workloads (all in-memory) :
    - OLTP_RO
    - point-selects
    - OLTP_RW
    - Update_NoKEY
- So, **WHY** ???
  - the story is no more about longer code path..
  - the story is about bigger and bigger amount of instructions in binary (and icache miss) !
  - solution : optimize the MySQL 8.0 binary itself !
  - with strong collaboration with Oracle Linux Team ! (KUDOS Karsten !!! ;-))

Small HW (May.2019 PLIVE Austin US)

- OLTP_RO point-selects 10Mx8tab-uniform latin1 :





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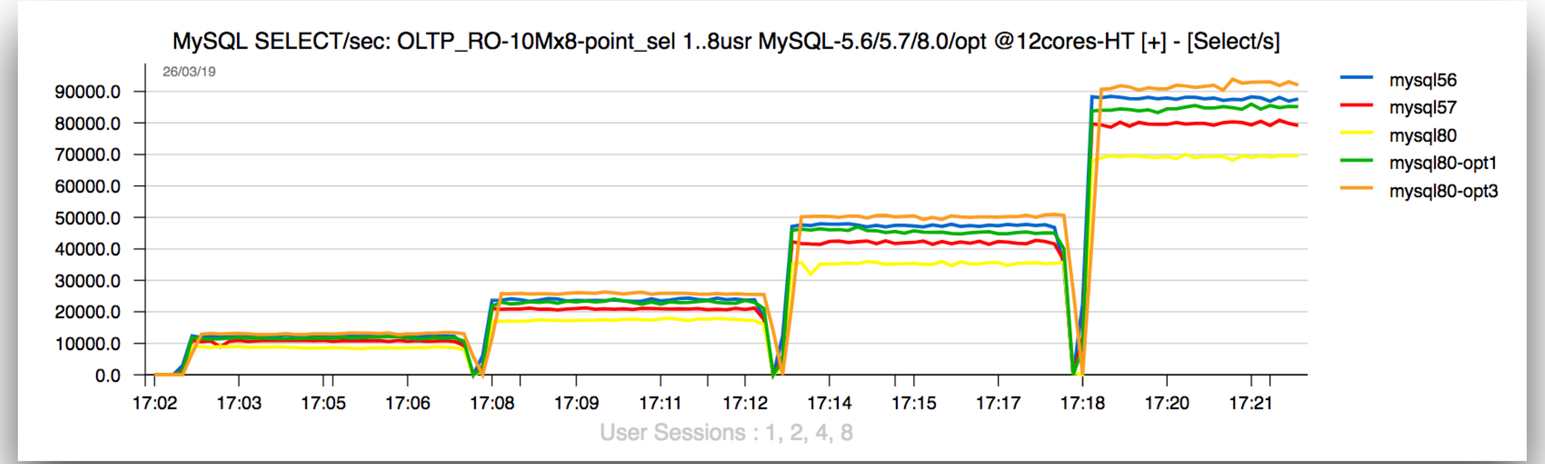
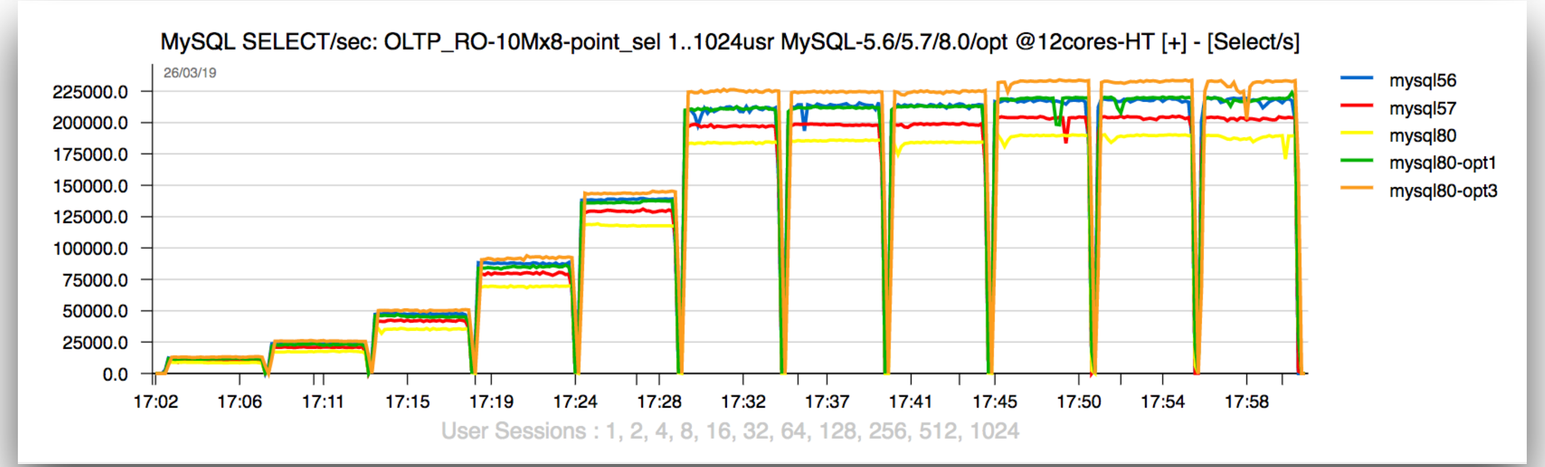
Small HW (May.2019 PLIVE Austin US)

- OLTP_RO point-selects 10Mx8tab-uniform latin1 + optimized :





PGO : Quick HOWTO (if you’re impatient)

- 3 steps :
  - compile
  - traine
  - re-compile

Compile with PGO enabled

```
$ cd mysql-sources
$ mkdir pgo-build
$ cd pgo-build
$ cmake3 .. -DFPROFILE_GENERATE=1 <other options as usual>
```

Run MTR tests

```
$ ./mysql-test/mtr --mem --force --max-test-fail=1000 --parallel=20
```

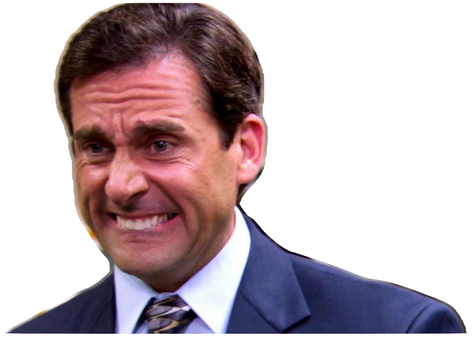
Compile final PGO optimized MySQL binary

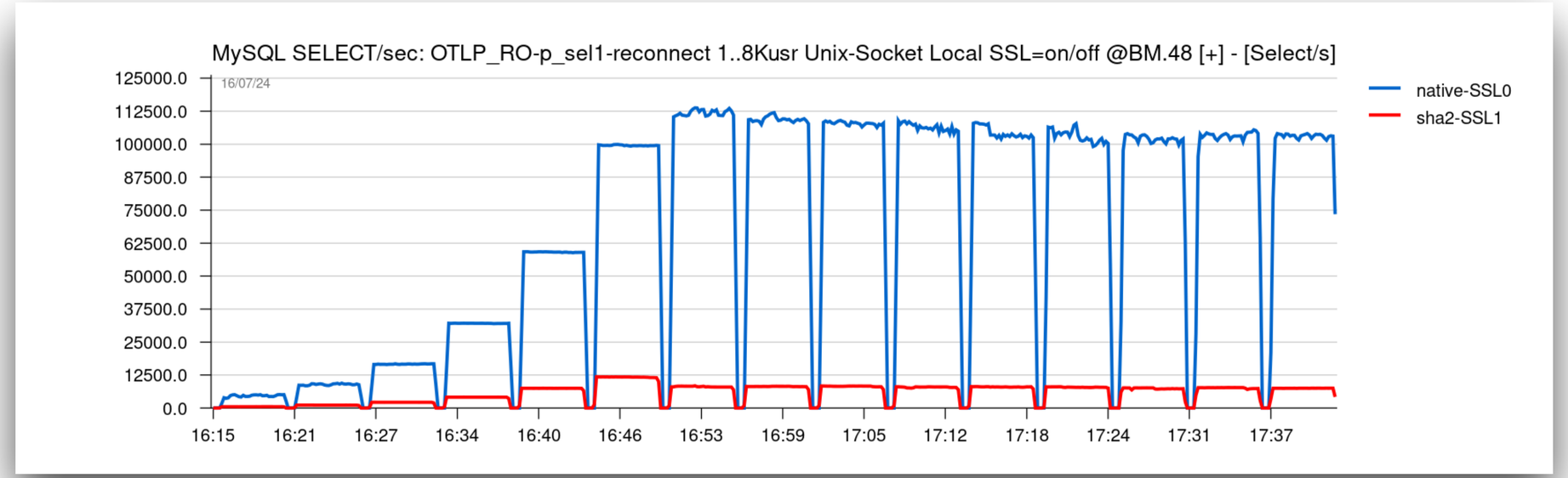
```
$ cd ..
$ mv pgo-build pgo-prepare
$ mkdir pgo-build
$ cd pgo-build
$ cmake3 .. -DFPROFILE_USE=1  <other options as usual>
$ cp runtime*/mysqld /path/to/mysqld-pgo
```

that's all ;-))

CPU-bound : Can be slower ?..

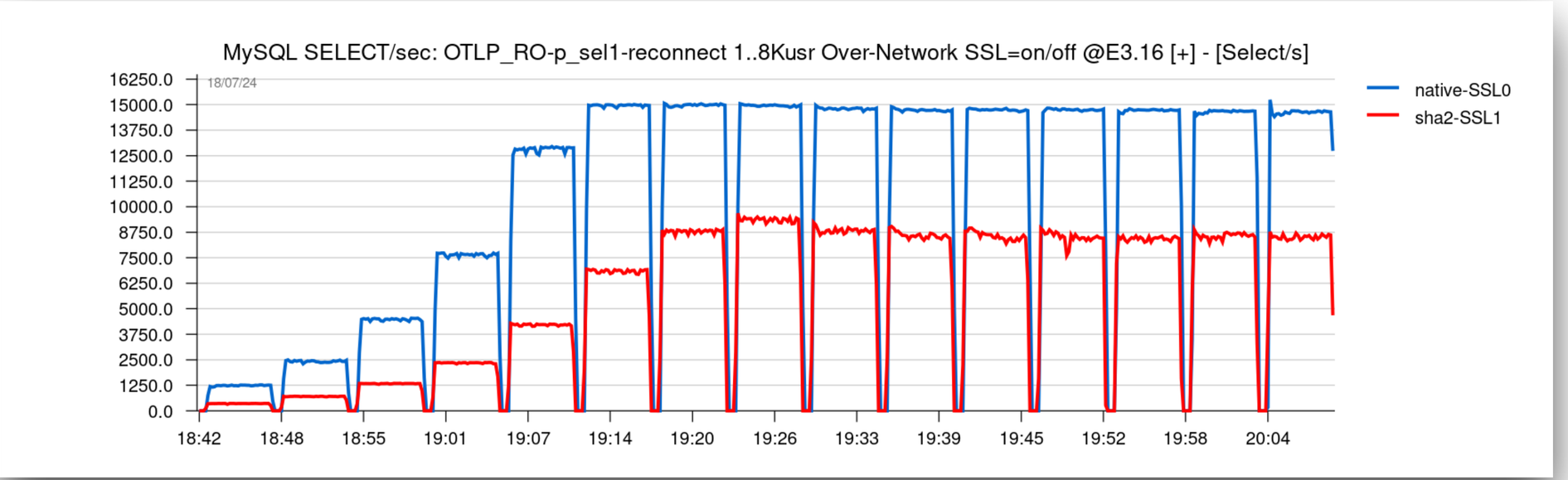
- Re-Connect on every query / transaction
  - aka PHP-based Web sites re-connecting on every Page refresh, etc..
  - BTW, “why” Oracle DB could not host PHP-based Web sites in 90’ ?..
- SSL = on
  - example of overhead with re-connect & SSL = 0/1 running on BM.48 server :
  - (with SSL = 0 and without re-connect it delivers 1M QPS)





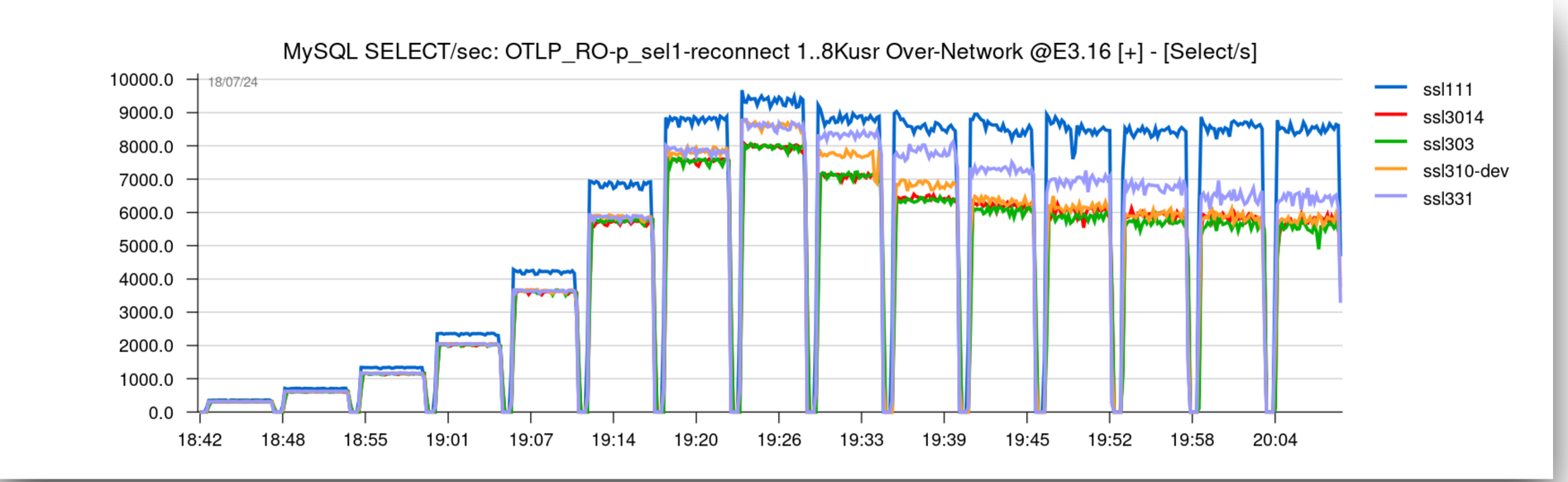
Re-Connect with SSL Over-Network

- Network is always adding latency
  - Network / NIC capacity is critical !
  - example from 16cores OCI VM with OpenSSL-1.1.1 :



Re-Connect with SSL Over-Network | OpenSSL versions

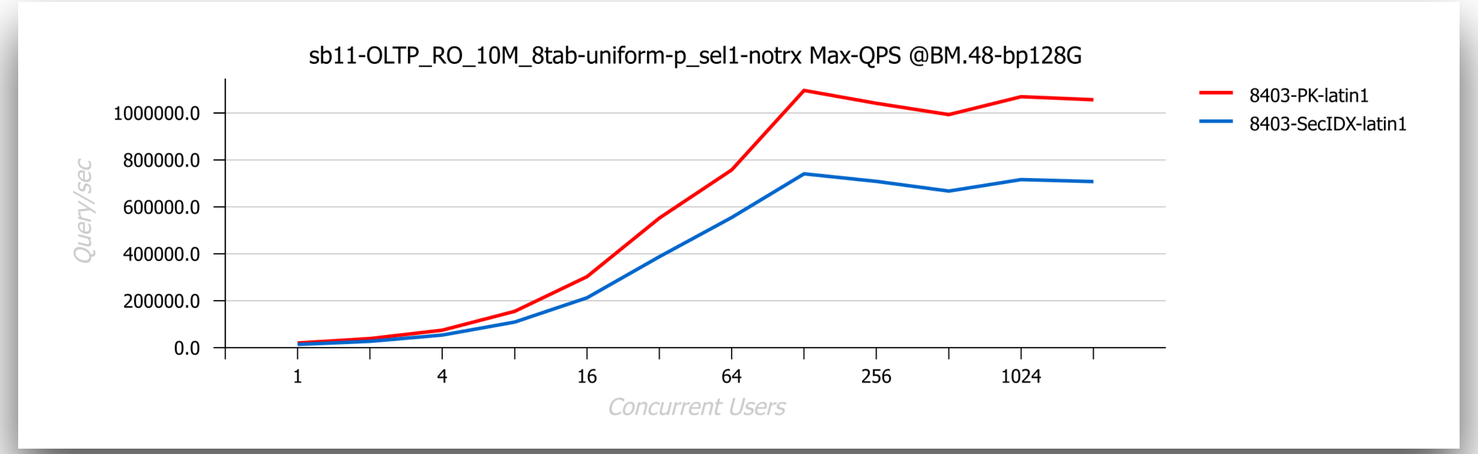
- OpenSSL regressions
  - OpenSSL-1.1.1 is still the best
  - example from 16cores OCI VM :



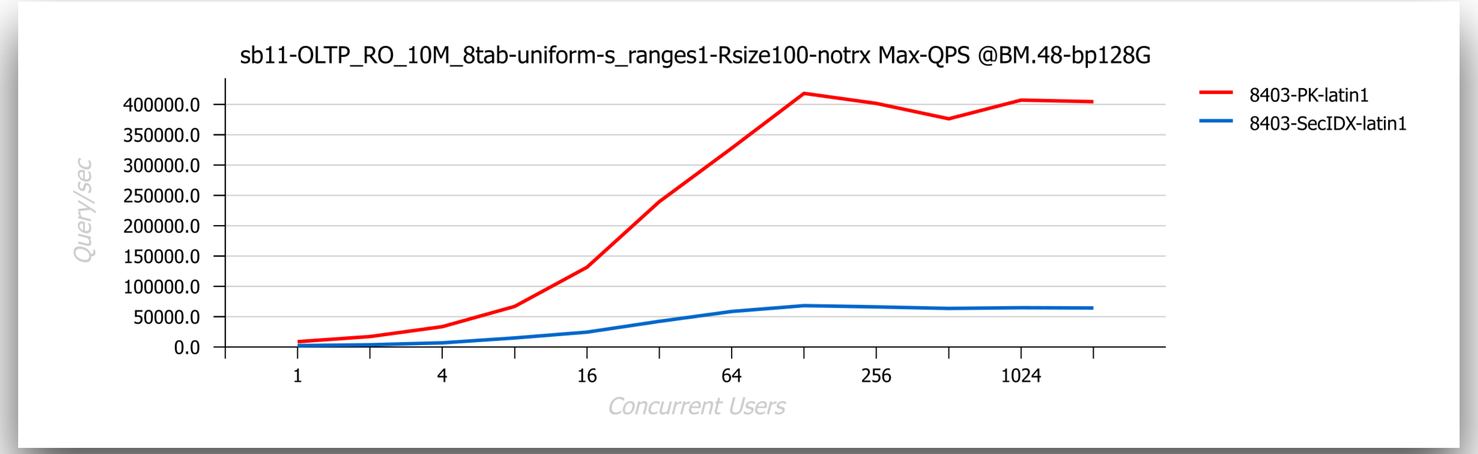
  - NOTE : evaluation of OpenSSL-3.5 is in my next TODO

Primary KEY or Secondary KEY ?..

- Point-SELECT
  - SELECT ..
    WHERE id = $v

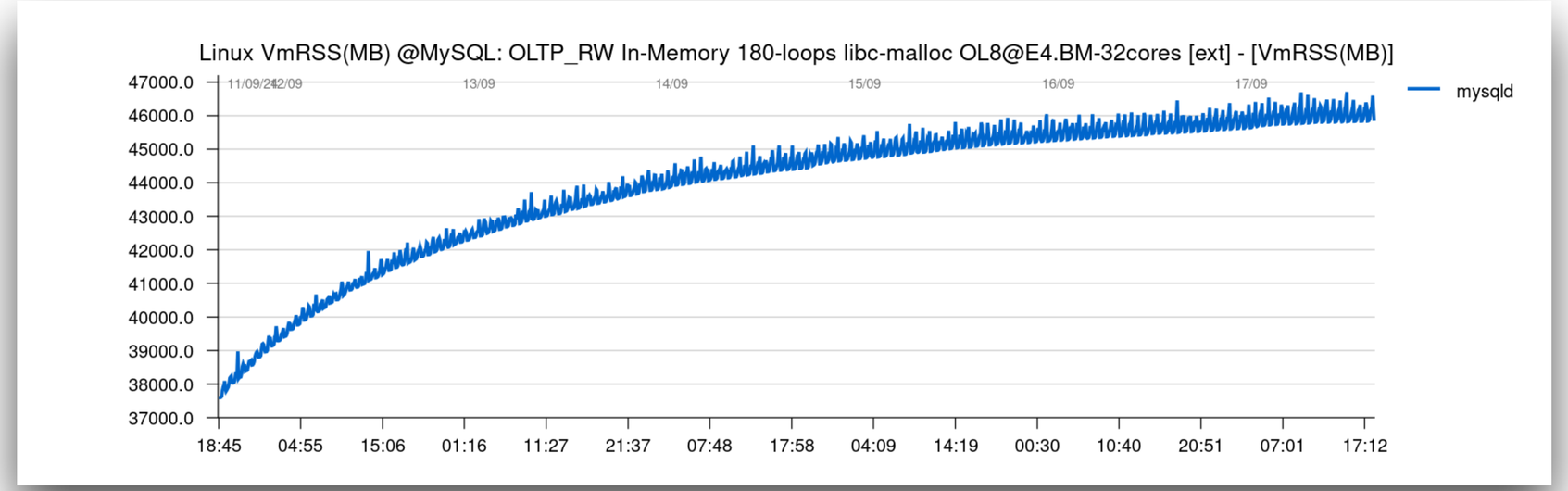


- Range-SELECT
  - SELECT ..
    WHERE id
    BETWEEN $v and $v + 100



Malloc Libs Today

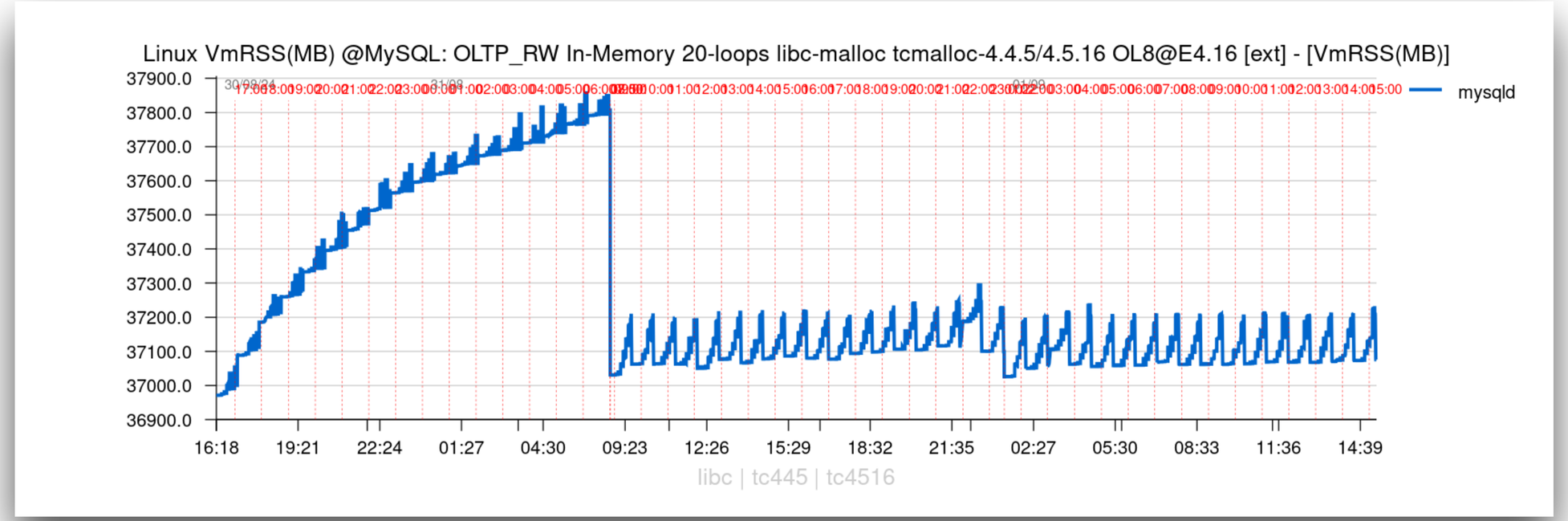
- glibc-malloc :
  - the latest glibc-malloc can be used with MT-apps today in most cases
  - but memory fragmentation !
- glibc-malloc : +10GB RSS usage over 1 week :



  - **NOTE** : Oracle Linux Team is pushing the fix to upstream !!!

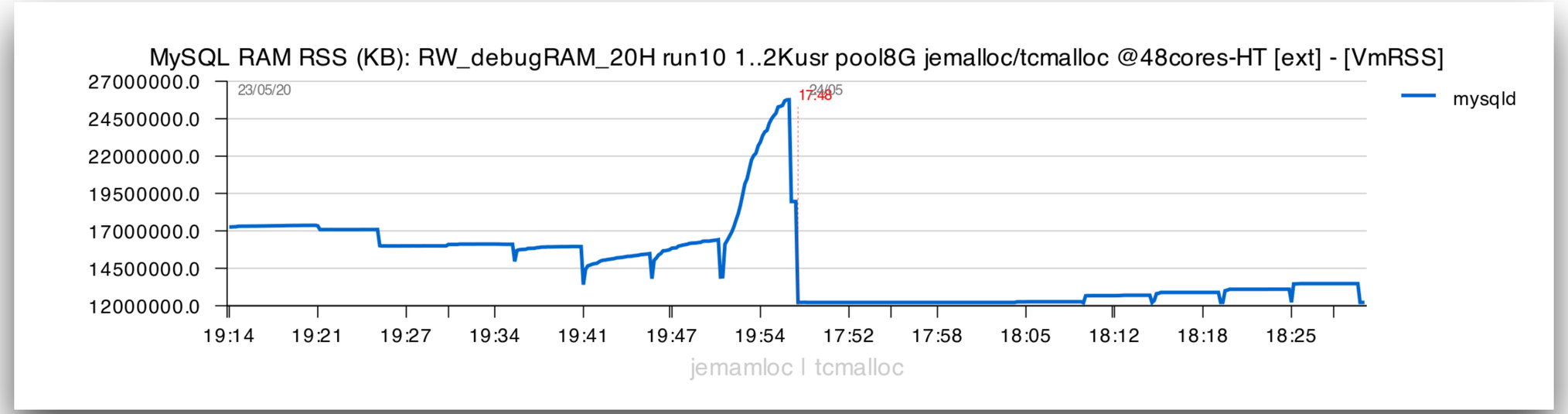
Malloc Libs Today

- glibc-malloc -vs- tcmalloc :



Malloc Libs Today

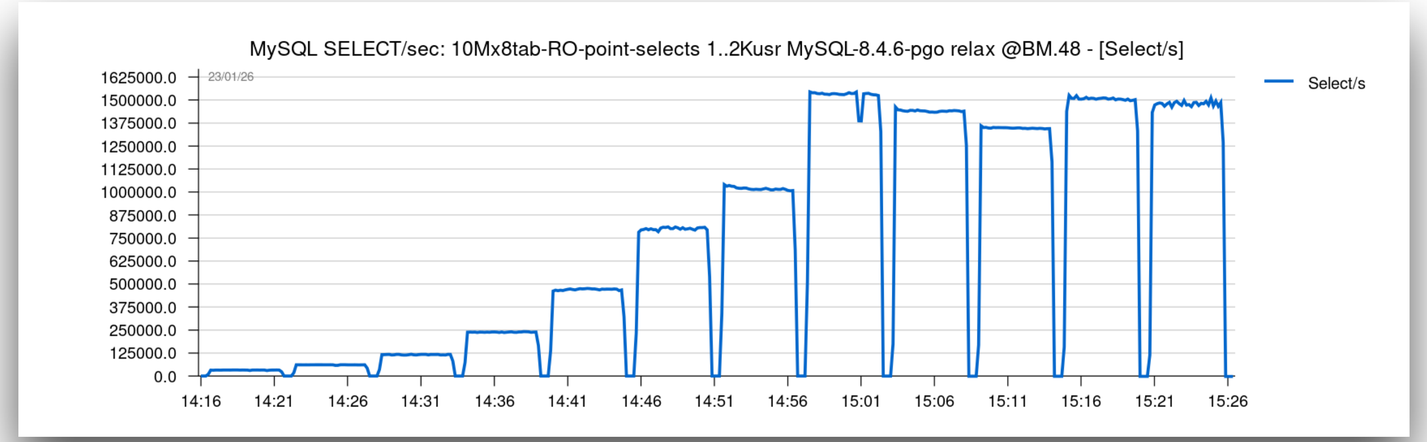
- jemalloc -vs- tcmalloc :



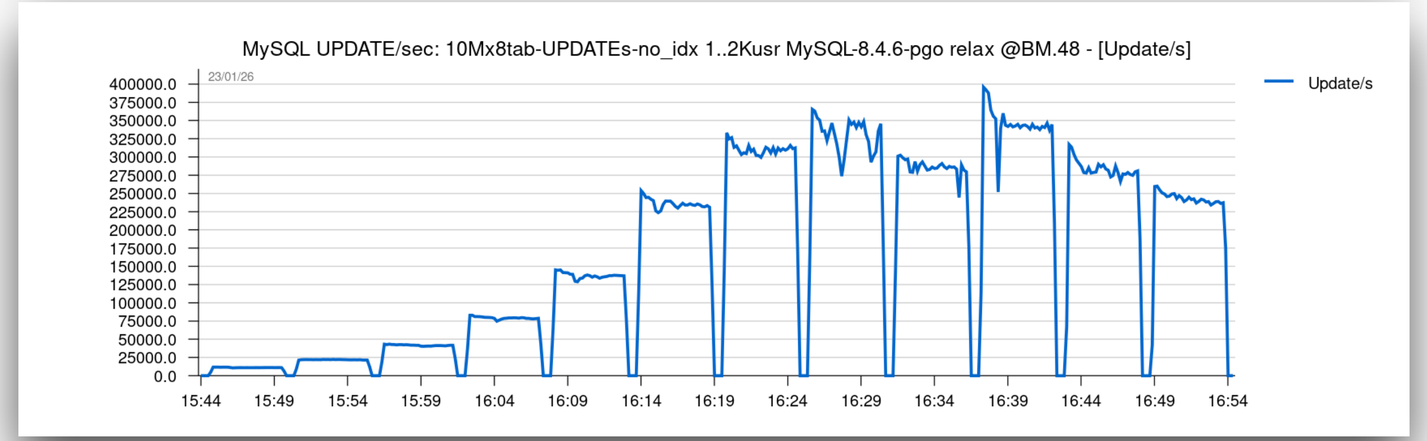
- NOTE :
  - **jemalloc** : EOL no more supported..
  - **tcmalloc** : latest evaluated stable version 4.5.16
    - (still supported within “gperftools” pkg, also shipped with MySQL source code)

CPU-bound : adding Writes

- SELECTs :
  - PK lookups
  - 1.5M QPS peak
  - 800K QPS on 32 users



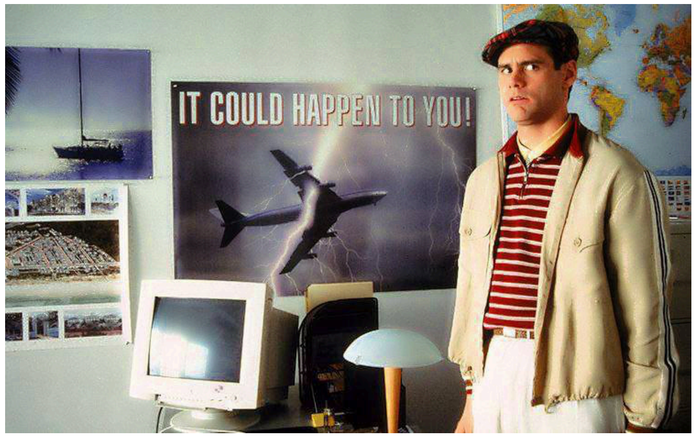
- UPDATEs :
  - non-index updates
  - over 350K QPS
  - over 225K QPS on 32 users

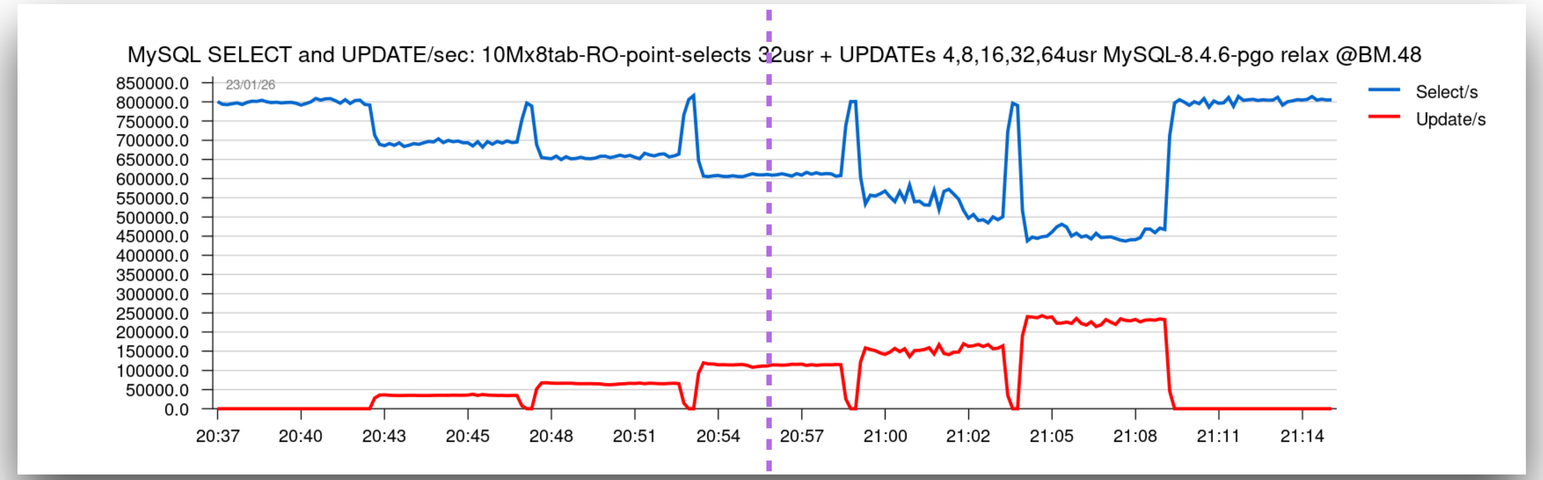


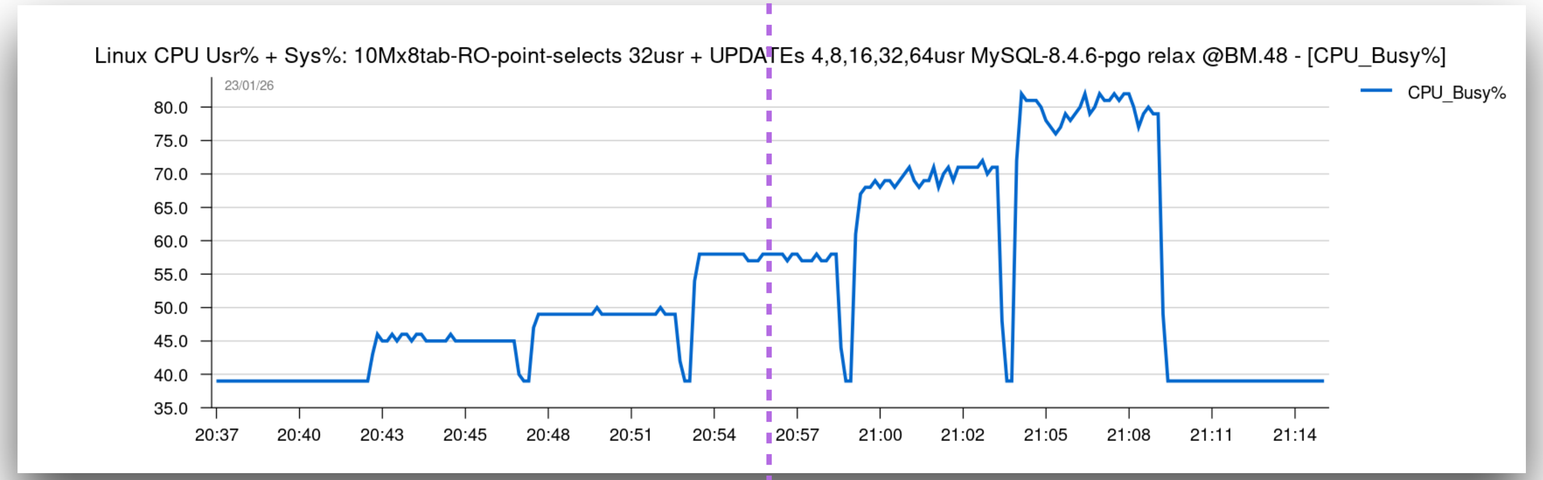
- Question :
  - what will happen if both will run on the same time ?..

SELECTs impacted by UPDATEs..

- SELECTs :
  - 32 users
  - running non-stop
- UPDATEs :
  - growing load
  - starting with 4 users
  - then 8, 16, 32, 64







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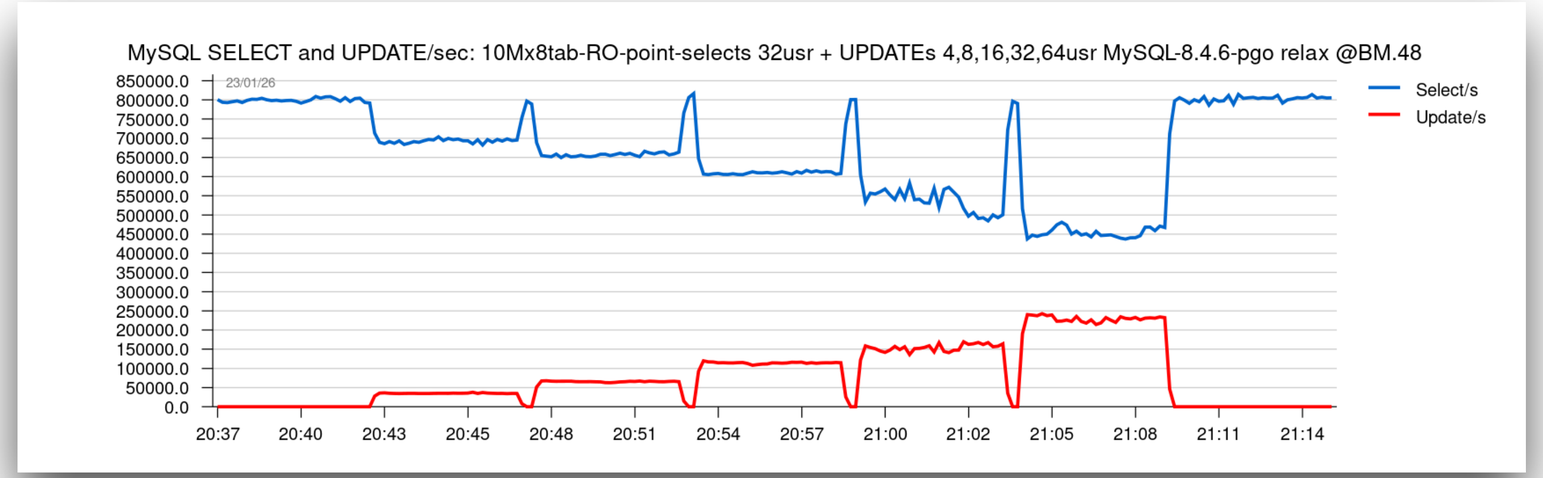
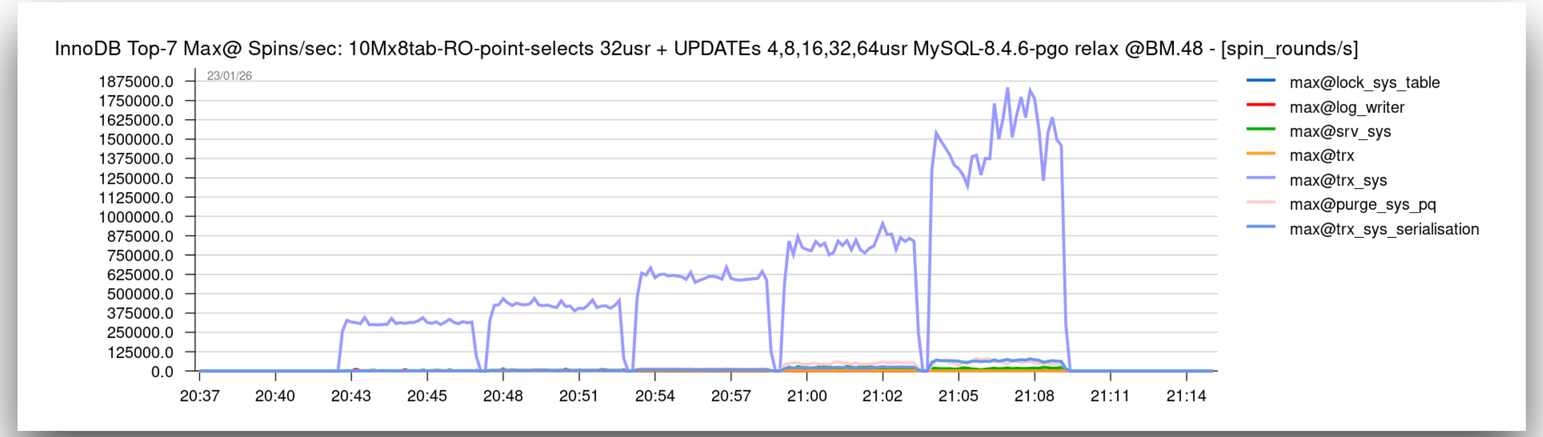
SELECTs impacted by UPDATEs..

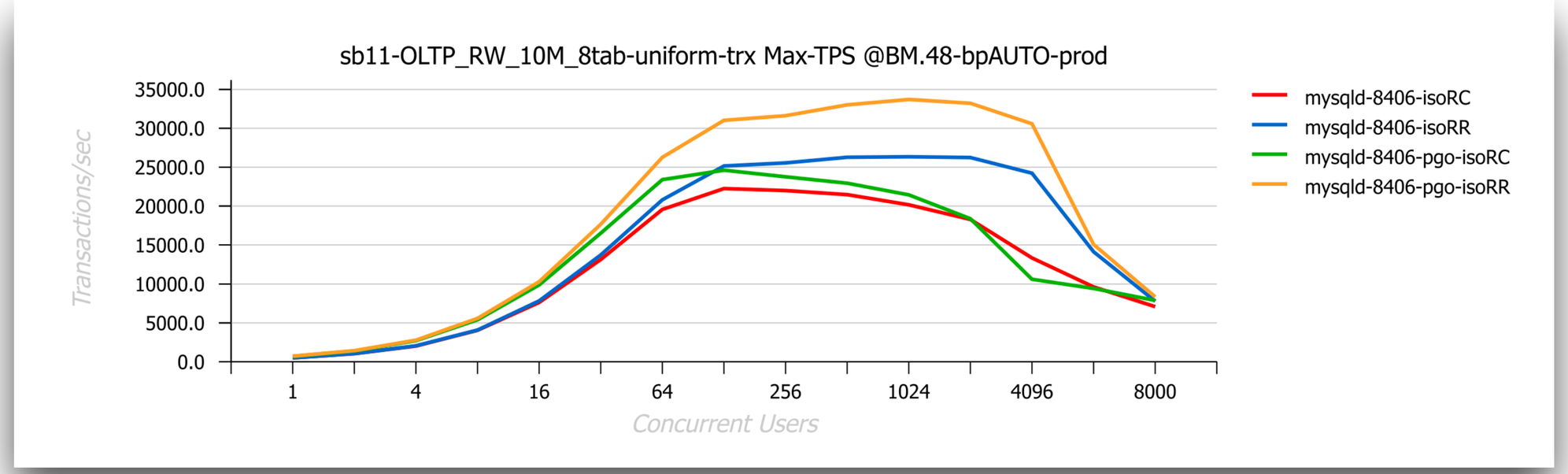
- SELECTs :
  - 32 users
  - running non-stop
- UPDATEs :
  - growing load
  - starting with 4 users
  - then 8, 16, 32, 64
- ReadView overhead
  - absent on RO (since 5.7)
  - present on RW
  - spin-rounds on trx_sys





ReadView & Transaction Isolation : RR or RC ?..

- REPEATABLE-READ (RR) used by default
  - ReadView is created **only** on BEGIN of transaction
- COMMITTED-READ (RC)
  - ReadView is created for **every** query !



- **NOTE** : work in progress to make RC as good as RR !

MySQL Config

- since MySQL 8.4 : **auto-adaptive** default config !!
- e.g. just use default config + InnoDB dedicated = ON
  - auto-adaptive : BP size, BP instances, Page Cleaners, REDO size, etc..
  - by default : AHI = off, IBUF = 5, DBLWR = 2x128, O_DIRECT, etc..
- example of your new my.conf :

```
[mysqld]
 innodb_dedicated_server = on
 max_connections = 4000
```

- data safety & security first !!!
  - trx_commit = 1, sync_binlog = 1
  - **NOTE** : and this is **mandatory** !! even if you use multi-nodes GR/Replication !!
  - (except if you don't care about your data and ok to loose them..)

NOTE to PeterZ :
please,
update your slides !!

REDO Log

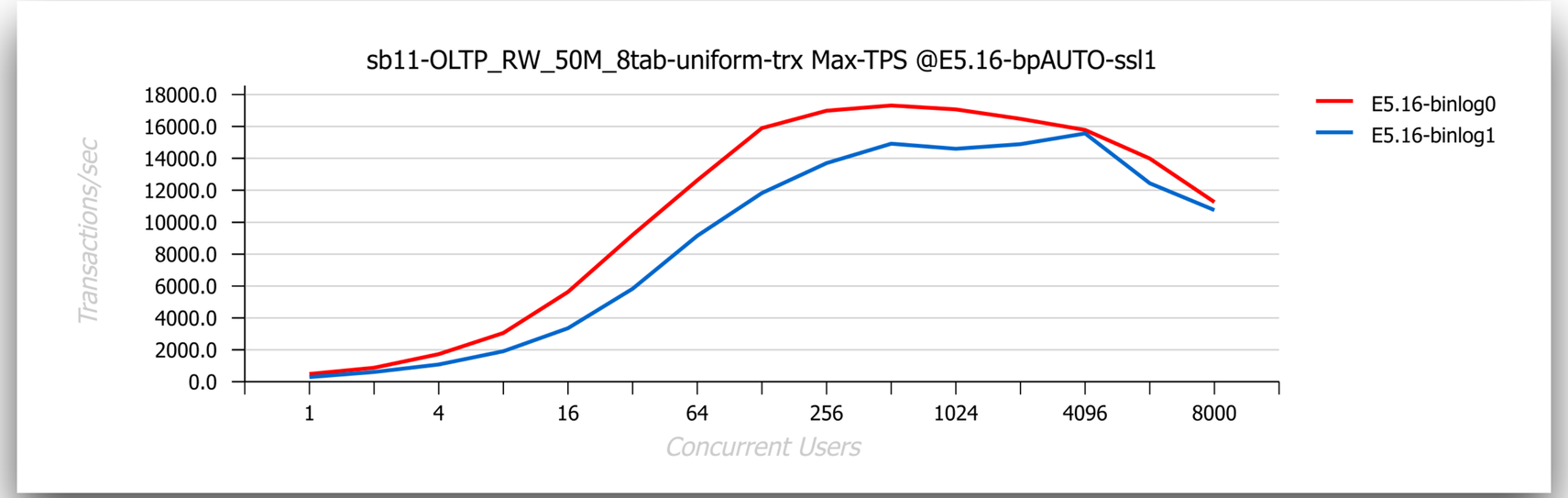
- Storage fsync latency
  - COMMIT => fsync
  - ex. : 1ms fsync latency = 1K COMMIT/s for single-user
  - InnoDB METRICS : log_flush_avg_time, log_flush_max_time (us)
  - check Storage :

```
$ fio --ioengine=psync --blocksize=512 --fsync=1 –rw=write \
 --numjobs=1 --iodepth=1 --name=TEST --filename=/path/to/file \
 --size=256m --runtime=60
```

- REDO log size
  - auto-defined according to your VCPUs number
  - online resize on-demand !
- REDO log threads
  - if Binlog=on : disable for less 16vcpu, enable if more
  - if Binlog=off : disable for less 4vcpu, enable if more
  - NOTE : auto-tuned since MySQL 9.x

Binlog Overhead

- “By design” :
  - keeping only “**committed**” data !
  - do nothing until InnoDB COMMIT (e.g. no any parallel work)
  - so, every WRITE request is **twice** longer (“in theory”)
  - impact : directly depends on the READs / WRITEs ratio in your transaction
  - ex. : 14 SELECTs : 4 WRITEs => up to **30% lower** TPS :



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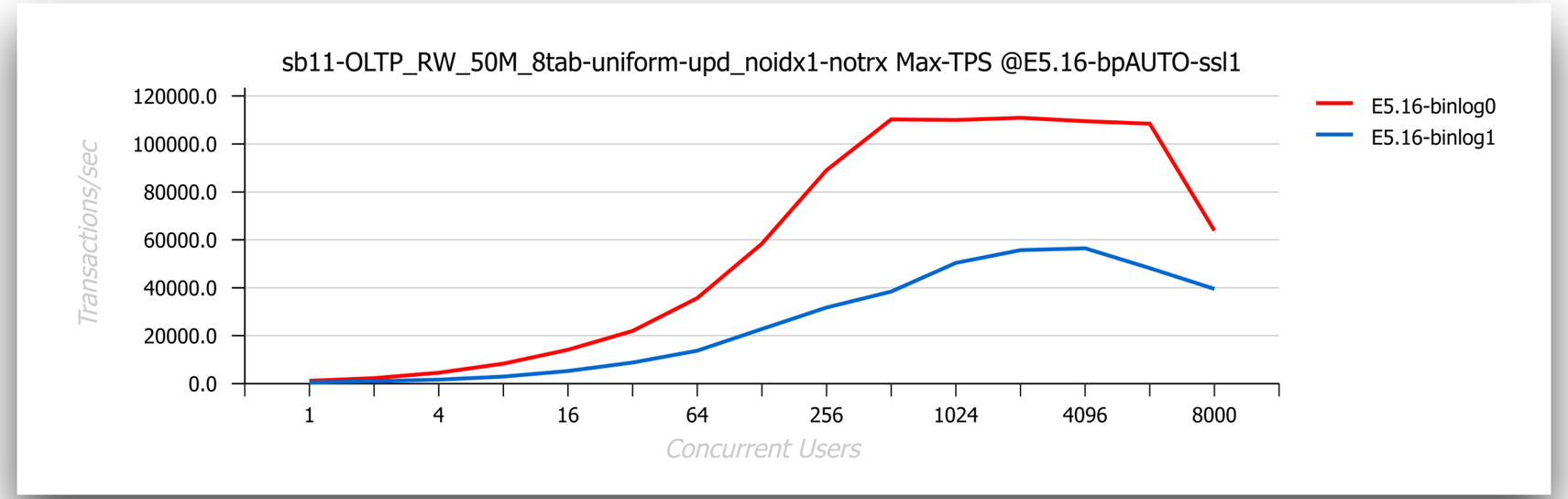
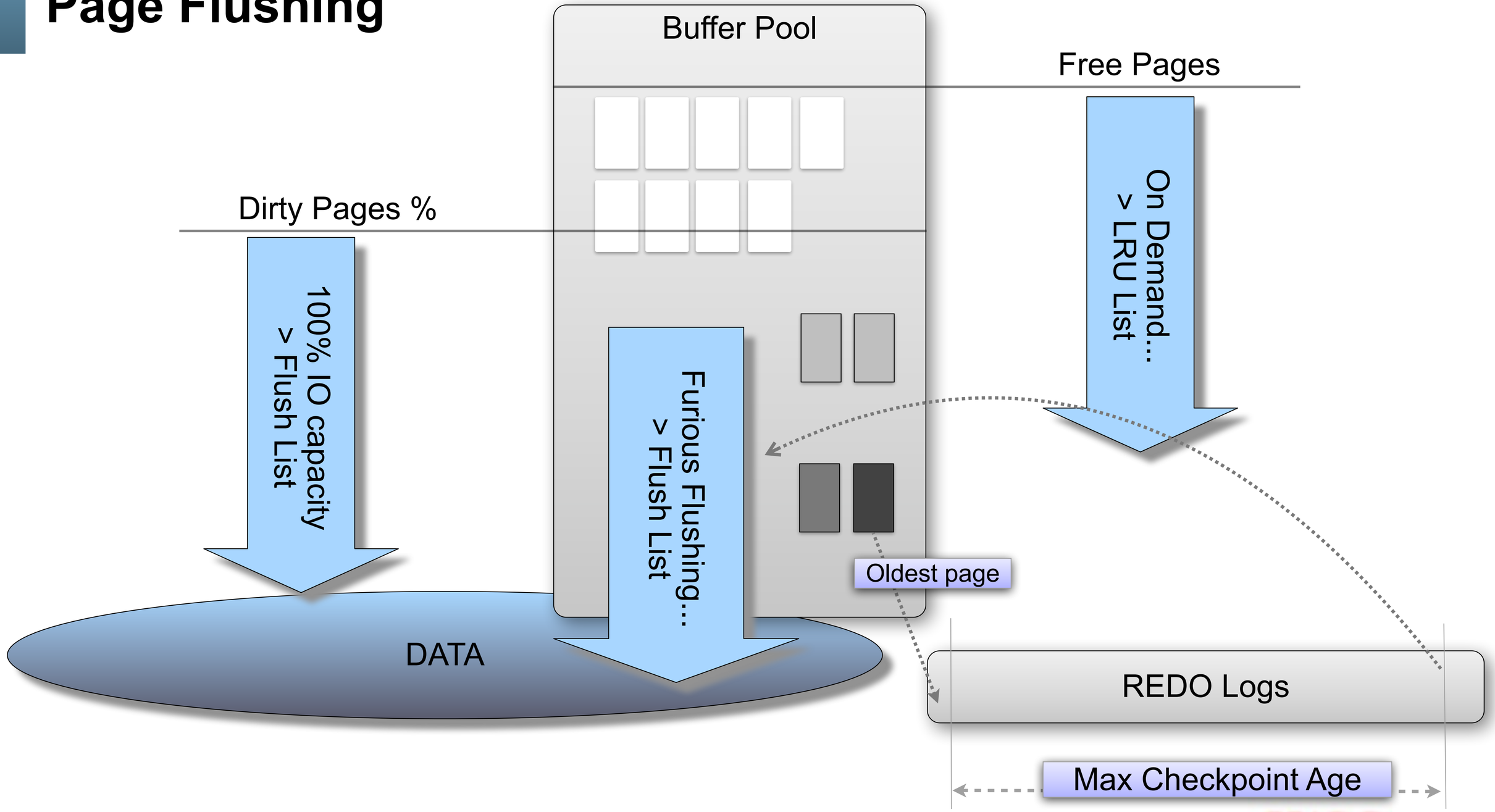
  - so, every WRITE request is **twice** longer (“in theory”)
  - impact : directly depends on the READs / WRITEs ratio in your transaction
  - ex. : WRITEs only (UPDATEs) => up to **x3 times lower** TPS :



Page Flushing



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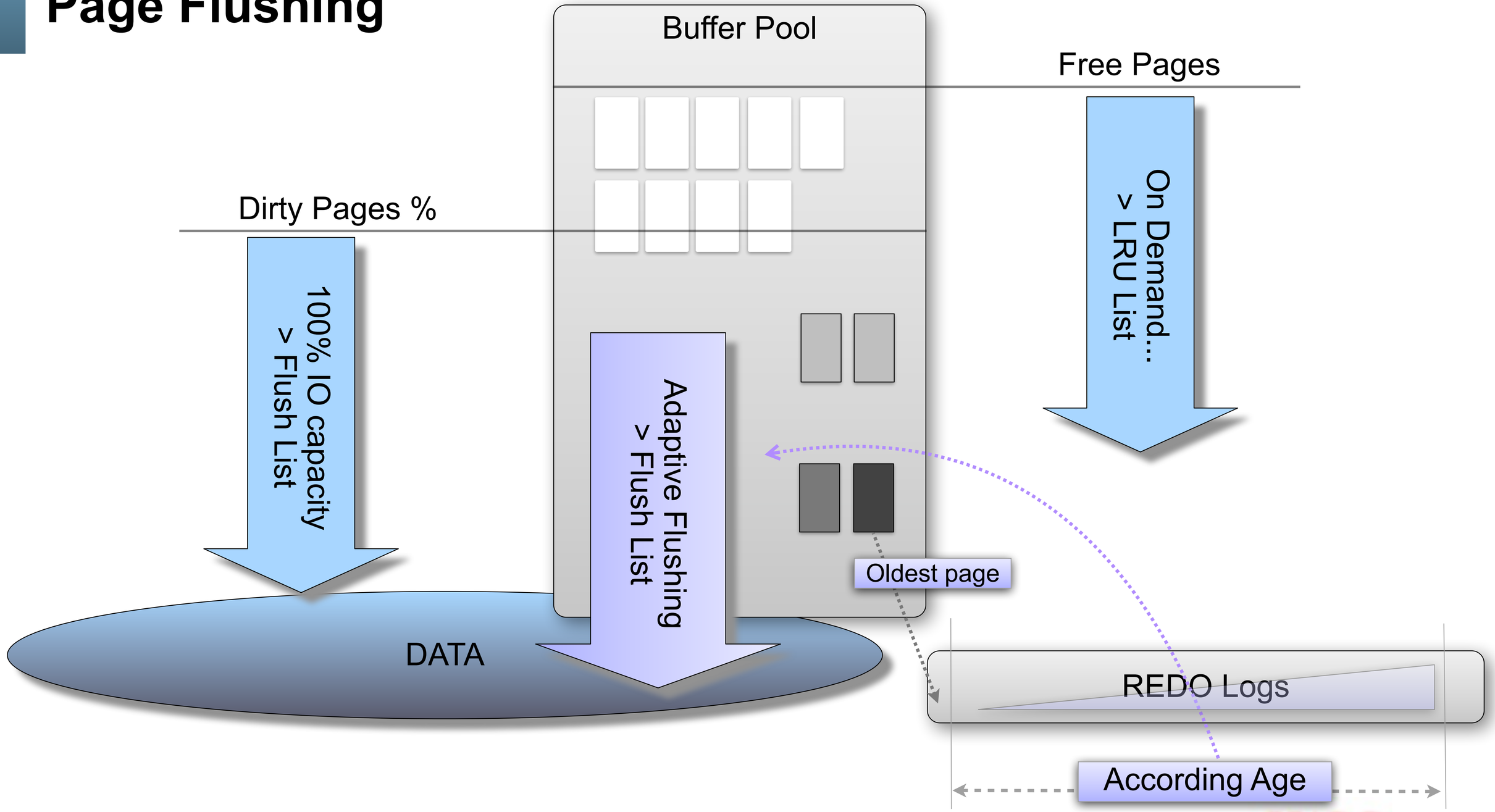

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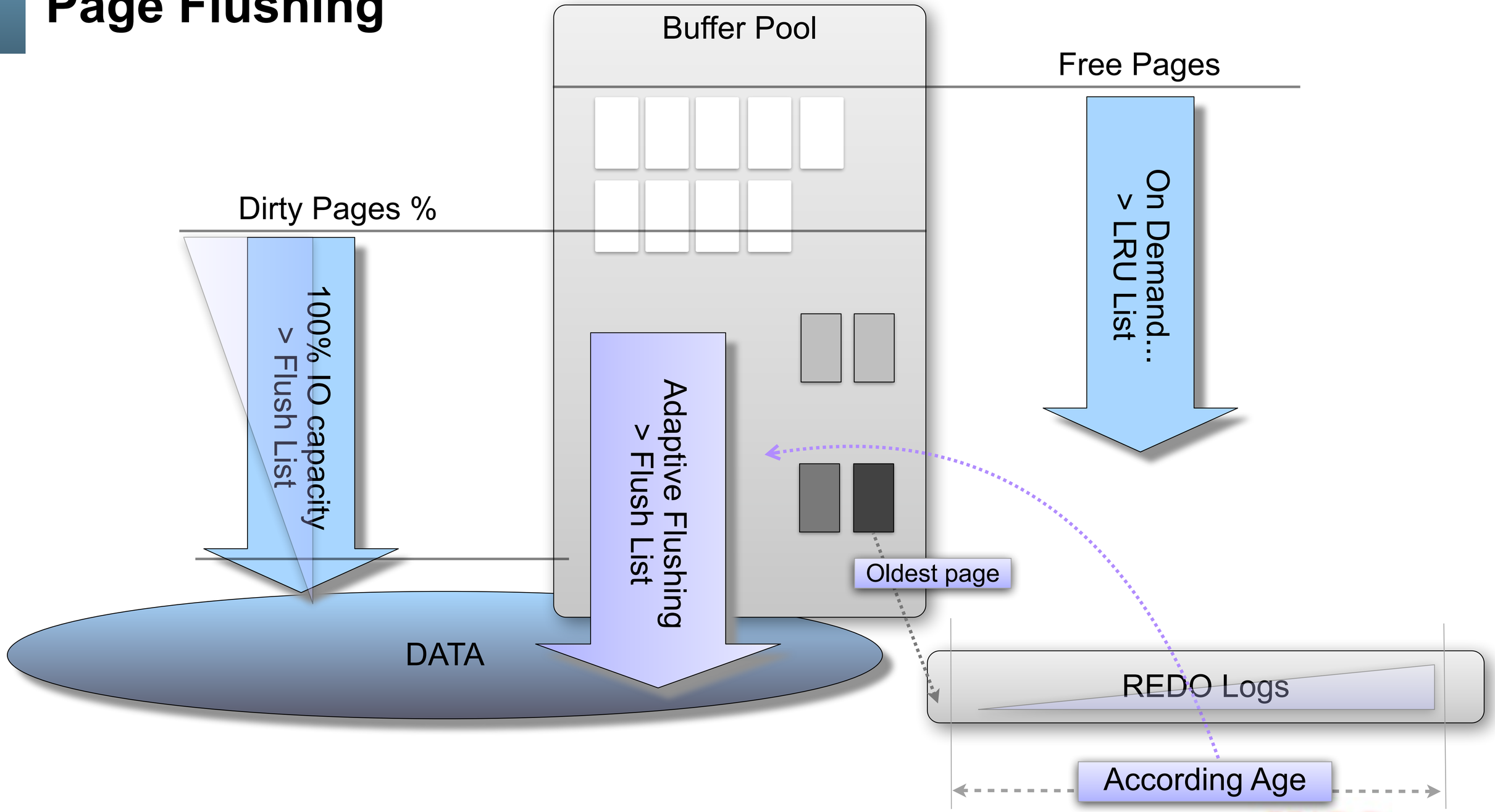

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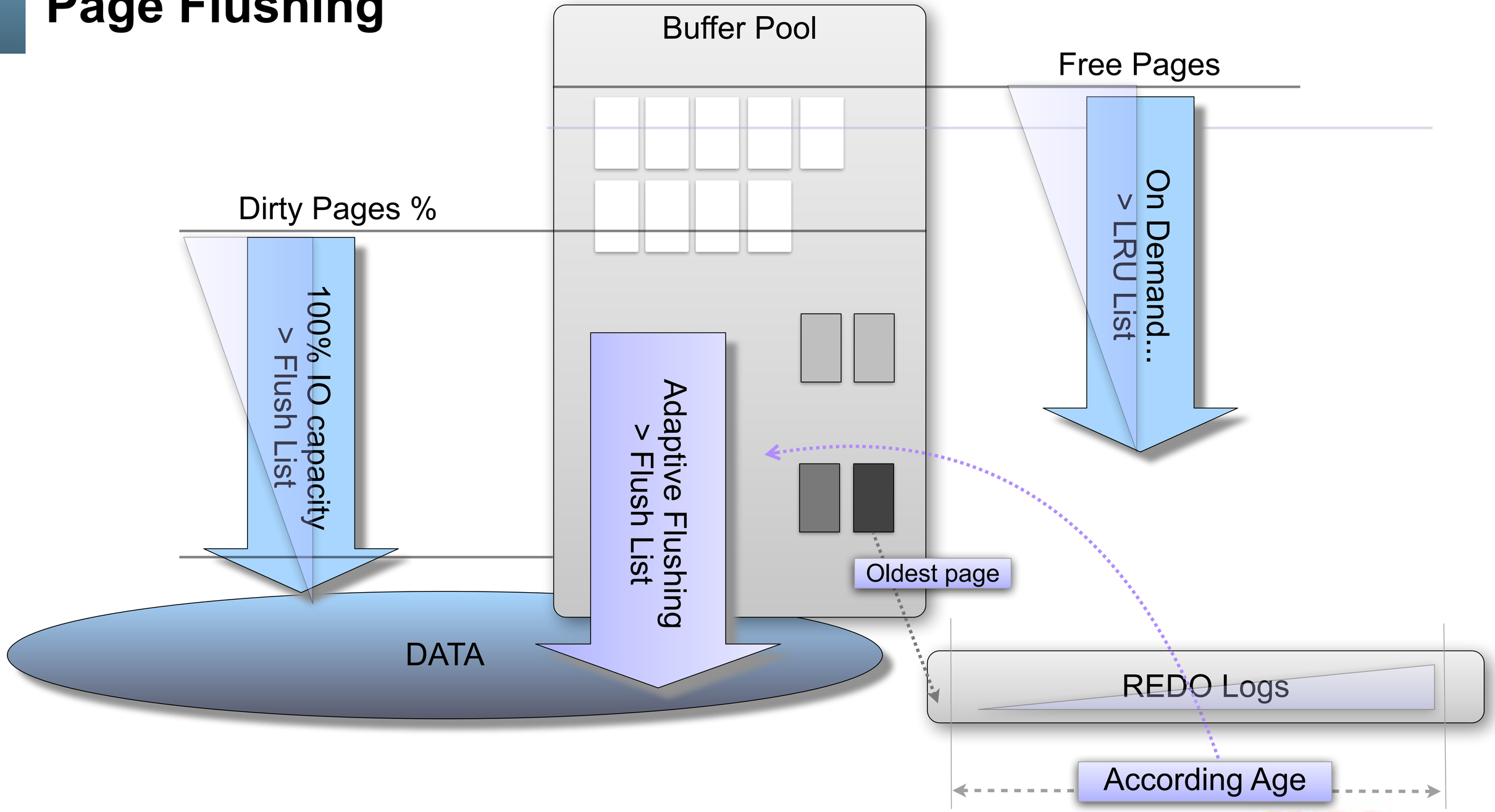
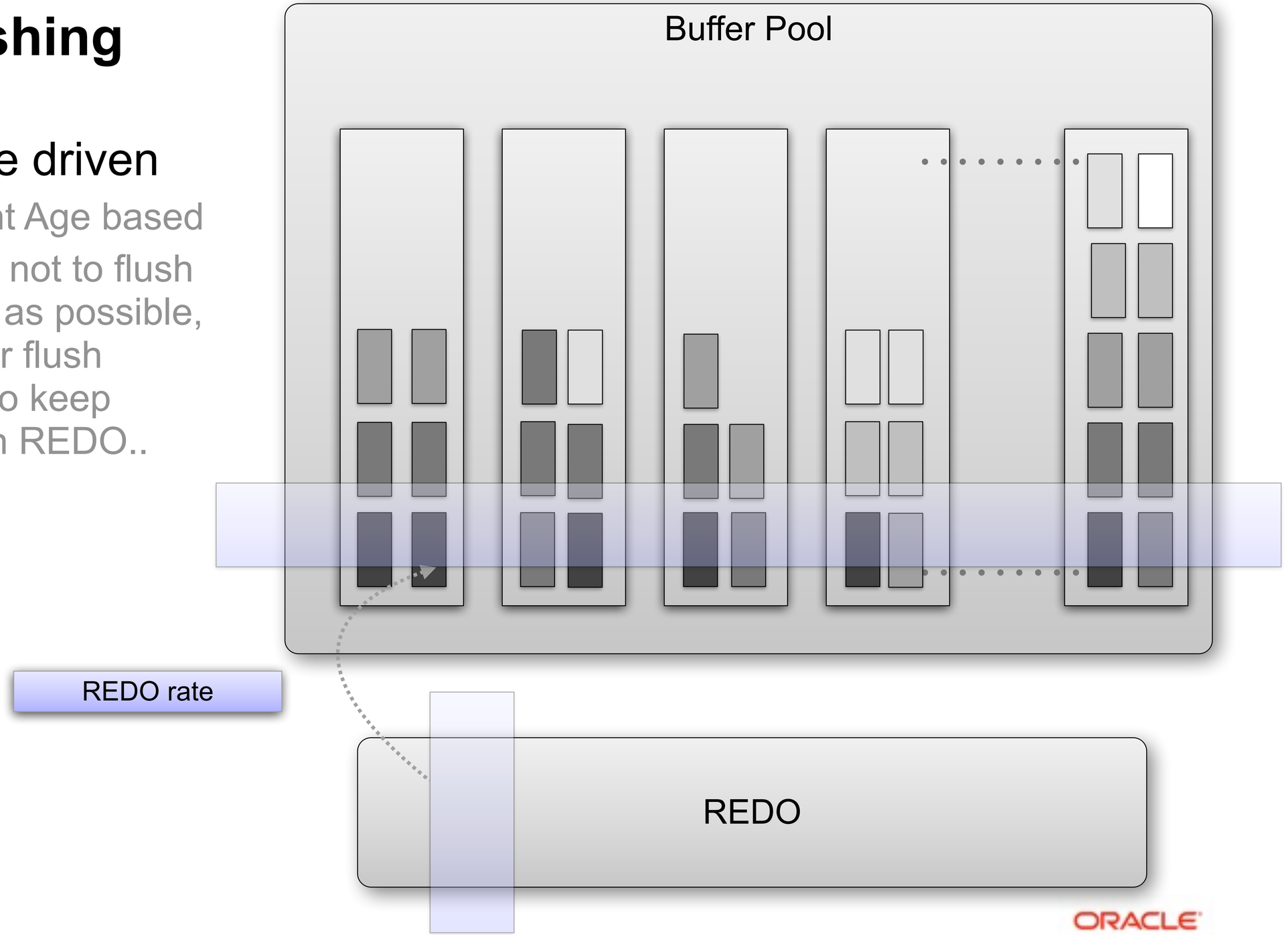


Page Flushing

- REDO rate driven
  - Checkpoint Age based
  - the goal is not to flush as much as possible, but rather flush enough to keep a room in REDO..



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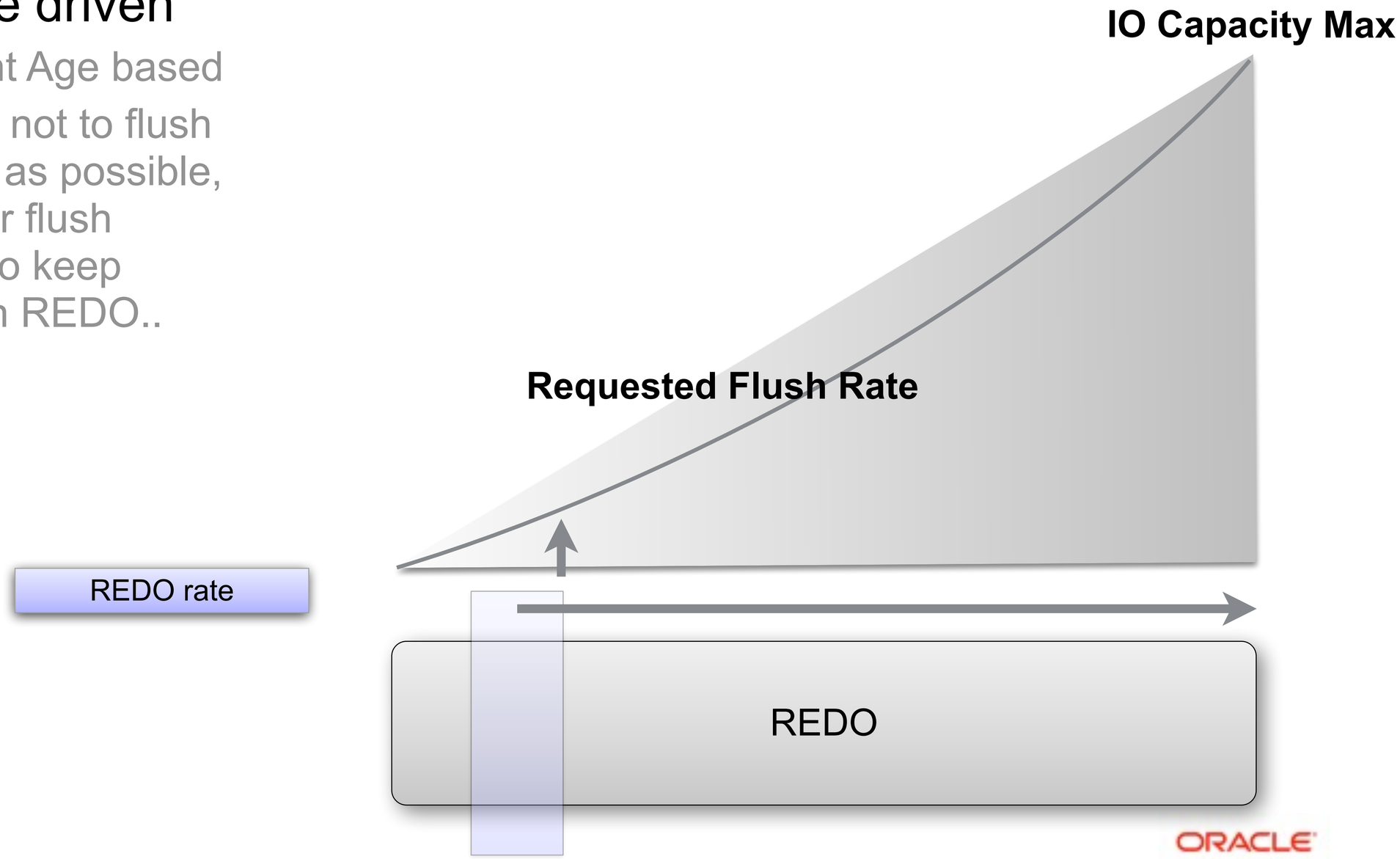

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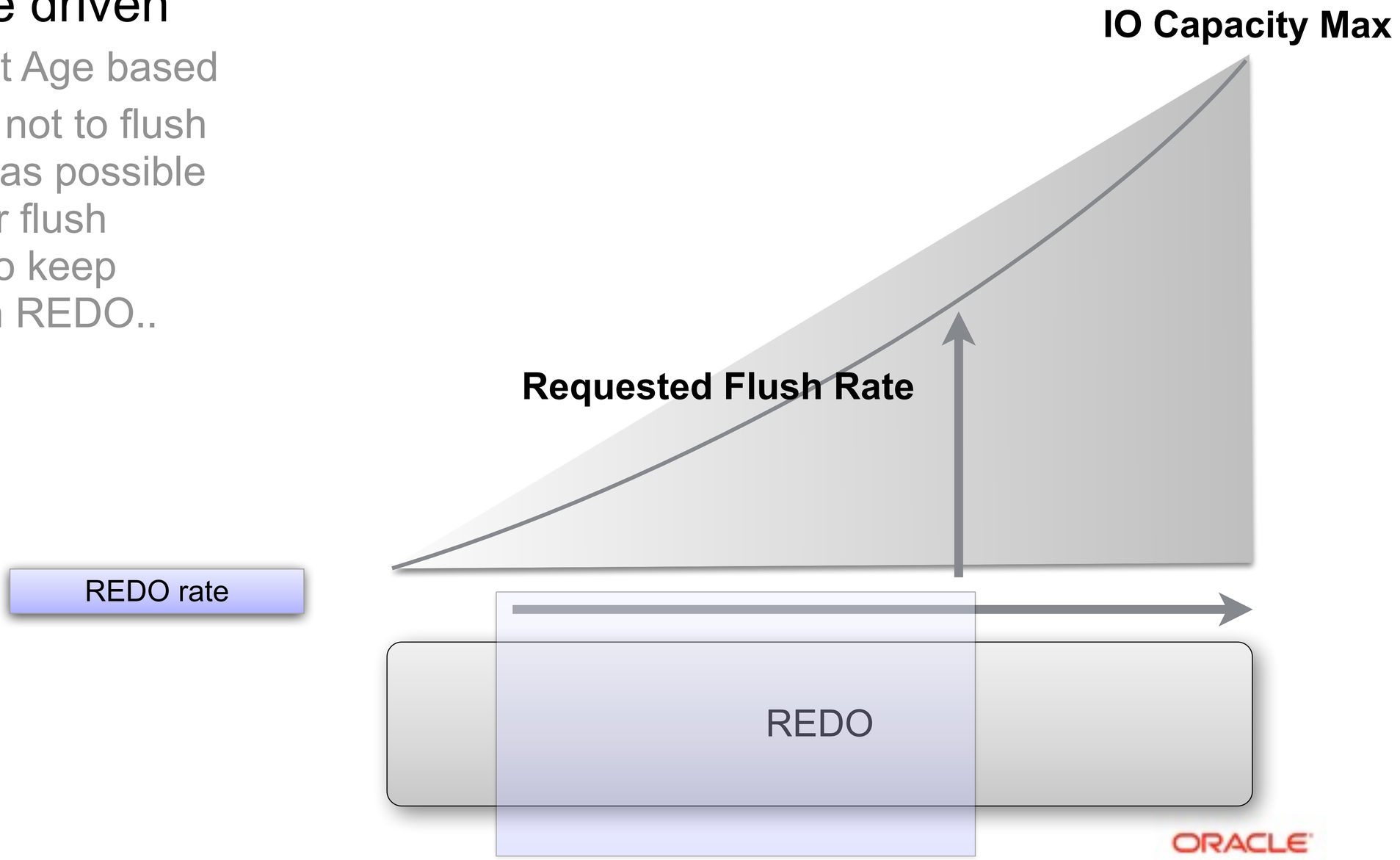
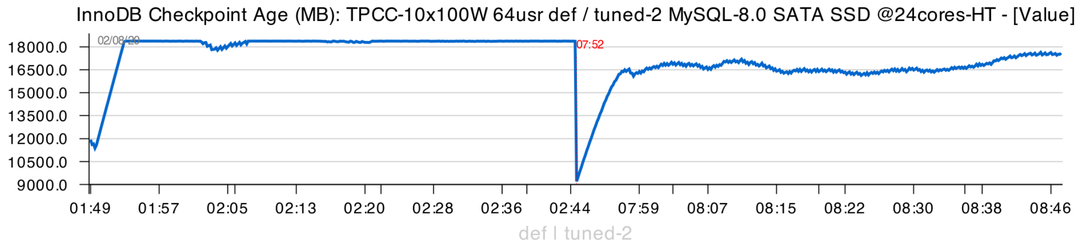


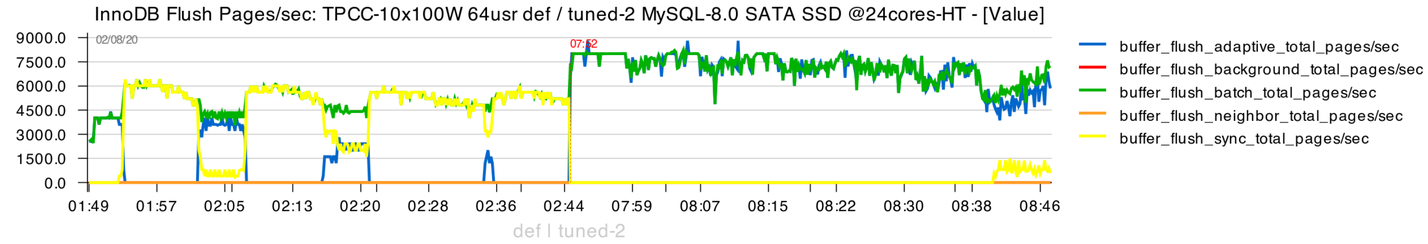
InnoDB Page Flushing : Tuning via Monitoring

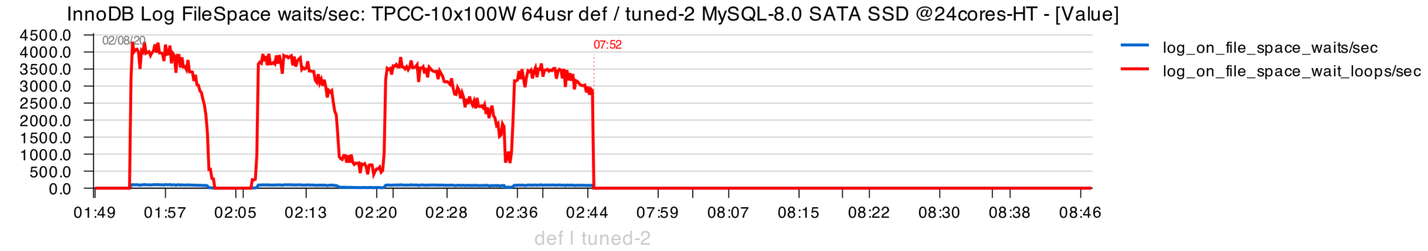
- Monitoring InnoDB METRICS :
  - Checkpoint Age < REDO total size
  - log_on_file_space_wait_loops/sec == 0
  - buffer_flush_sync_waits && buffer_flush_sync_pages == 0
  - buffer_flush_avg_time < 1sec
  - buffer_flush_adaptive_avg_pass == 30 (def. avg loops)
  - buffer_flush_adaptive_total_pages/sec ~= buffer_flush_n_to_flush_requested
    - this will tell if “IO capacity max” should be increased or not
- If Page Flushing is still lagging :
  - check your IO capacity max setting (can be changed **online**)
  - you can try higher number of BP Instances & Page Cleaners (need restart)
  - finally, increase REDO log size (can be changed **online** now)

InnoDB Page Flushing : Tuning via Monitoring

- Monitoring InnoDB METRICS :







InnoDB Page Flushing : Other Impacts

- DBLWR :
  - every Page is written twice => twice higher Page Write times !
  - if your Storage is saturated => may require additional tuning
    - since 8.4 default is : 2 files x 128 pages
    - if you use RAID on top of your Storage : use stripe size 128K or 256K
  - Oracle Linux Team => Atomic IO !!! (already pushed to upstream)
    - MySQL code : mostly ready
- Compression :
  - table compression : “in theory” may help
  - “transparent” compression (using punch holes) : DON’T USE ! (more later ;-))

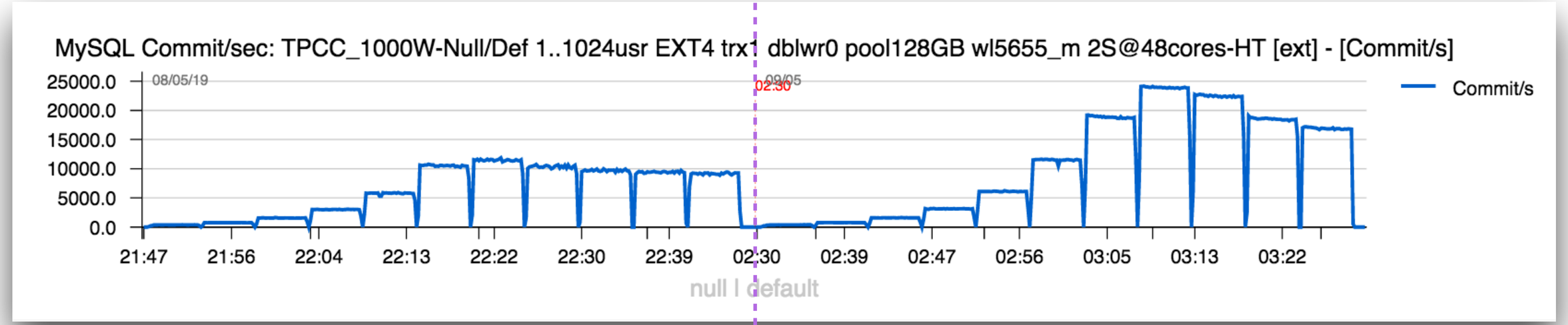
Using NULL -vs- DEFAULT

- When you use NULL as default value :
  - UPDATE NULL to real Value => Row size increase => Page split..
  - Page split => Lock contentions => slow down processing..
  - Page split => cascade increase of Dirty Pages => higher Page Flushing => stalls ?..

- More efficient approach :
  - instead of NULL use DEFAULT (and assign a “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 not NULL */
  - and so on.. => no more Page split (or very minimal)

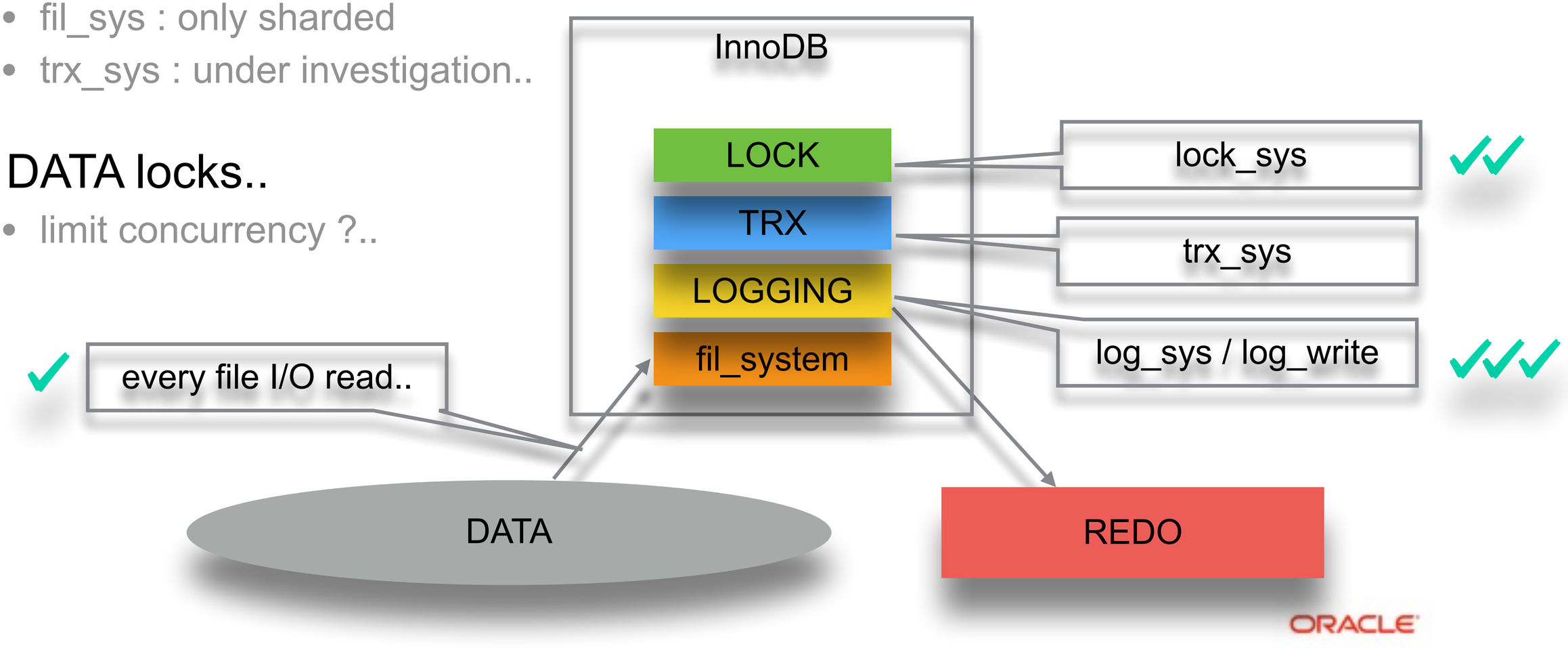
TPCC “mystery” : test results

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



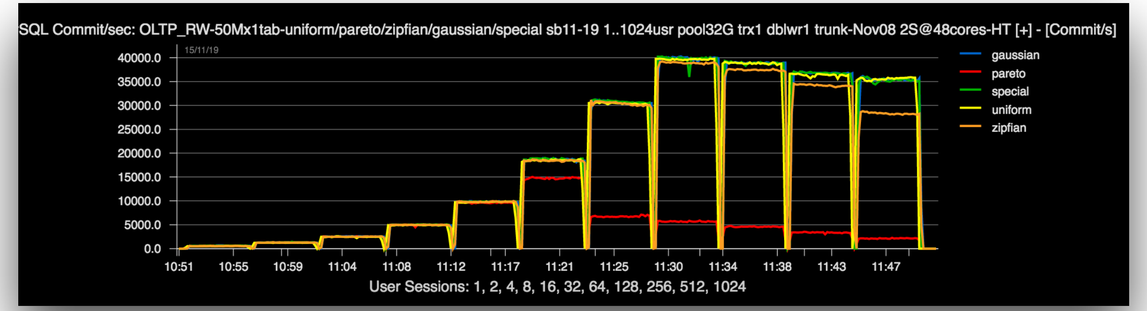
LOCK Contentions

- Many improvements since 8.0
  - log_sys : gone !!!
  - lock_sys : largely improved !!
  - fil_sys : only sharded
  - trx_sys : under investigation..
- DATA locks..
  - limit concurrency ?..



DATA Locking

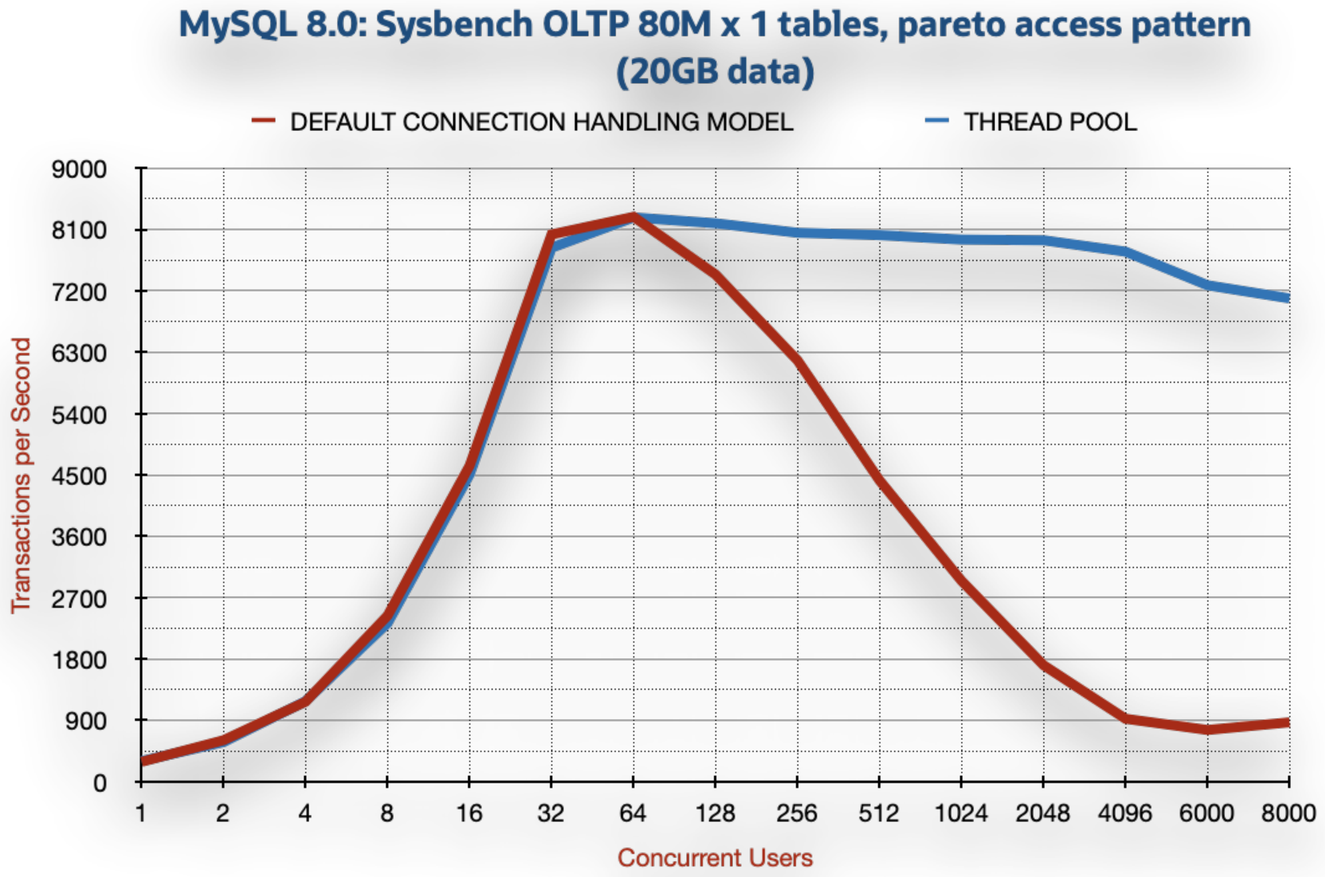
- DATA concurrent X-locking overload => TPS decrease
- InnoDB Thread Concurrency :
  - (+) historically most commonly advised solution
  - (+) limits number of concurrent user threads
  - (-) not considering thread's IO waits
  - (-) not considering transaction locking
  - (-) amplifies lock waits
  - (-) amplifies "deadlocks feeling" states..



- Most safe solution : Limit ~~Thread~~ **Transaction** Concurrency !
  - complicate to implement on InnoDB level
  - currently working solution : **New** MySQL ThreadPool

New MySQL ThreadPool

- Max Transaction Limit (MTL)
  - can be adapted online according to your workload



ref : https://blogs.oracle.com/mysql/the-new-mysql-thread-pool

InnoDB UNDO Logs & Purge

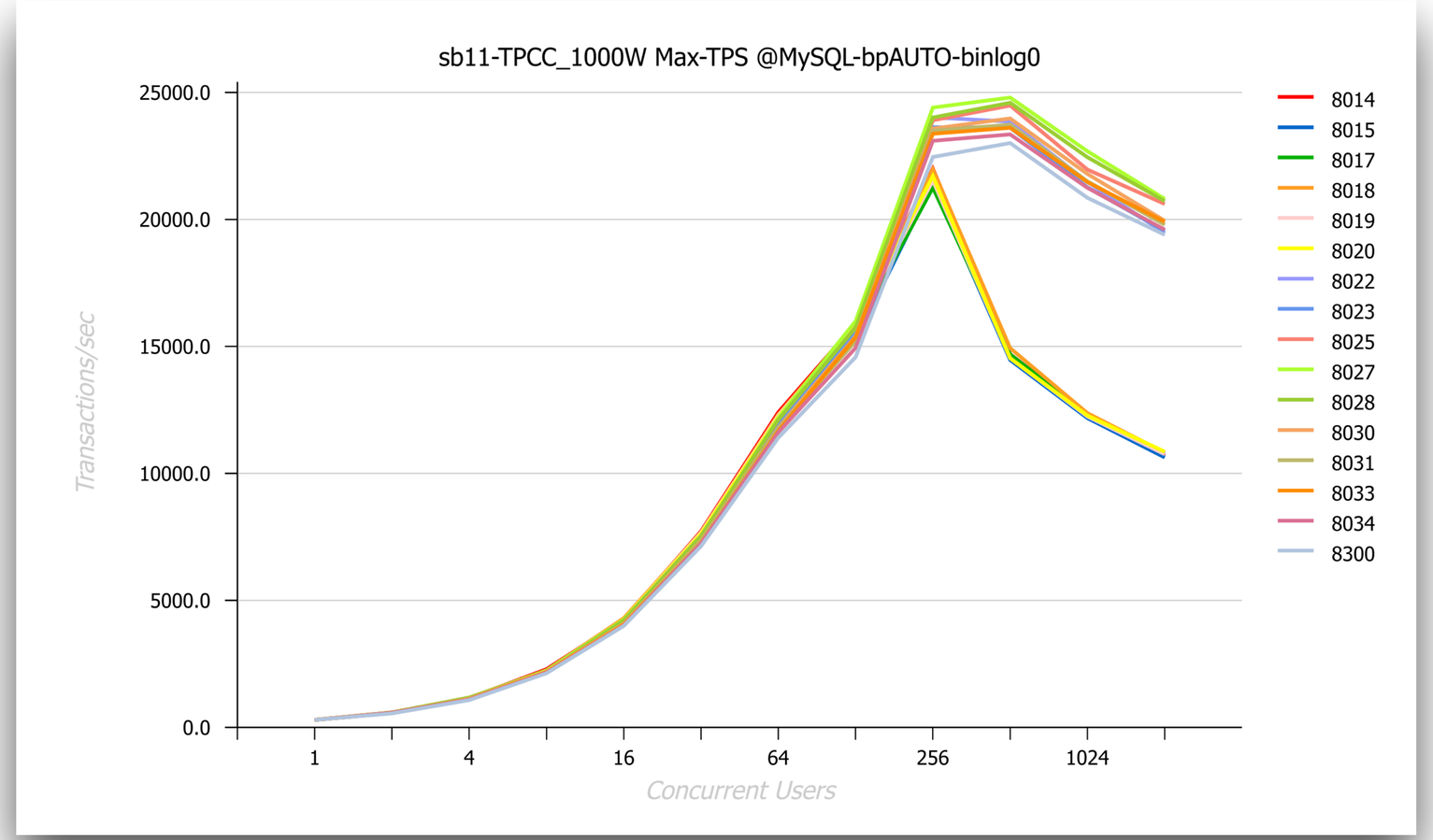
- InnoDB UNDO :
  - also using BP, can grow very quickly ! (performance / disk space / overall impact)
  - can be dropped manually / automatically (do with caution)

- InnoDB Purge :
  - cleaning-up UNDO records, but can be lagging
  - monitor InnoDB History Length **ALWAYS !**
    - if NO purge lagging : excellent! (& be happy! ;-))
    - if purge is lagging : use a purge lag config setting.. (write throttling)

  - **Example of config settings to avoid purge lagging :**
    - innodb_max_purge_lag = 1000000 (1M max for ex.)
    - innodb_max_purge_lag_delay = 30000 (30ms max for ex.)
    - innodb_purge_threads = 4 (check yourself if using more threads is helping)

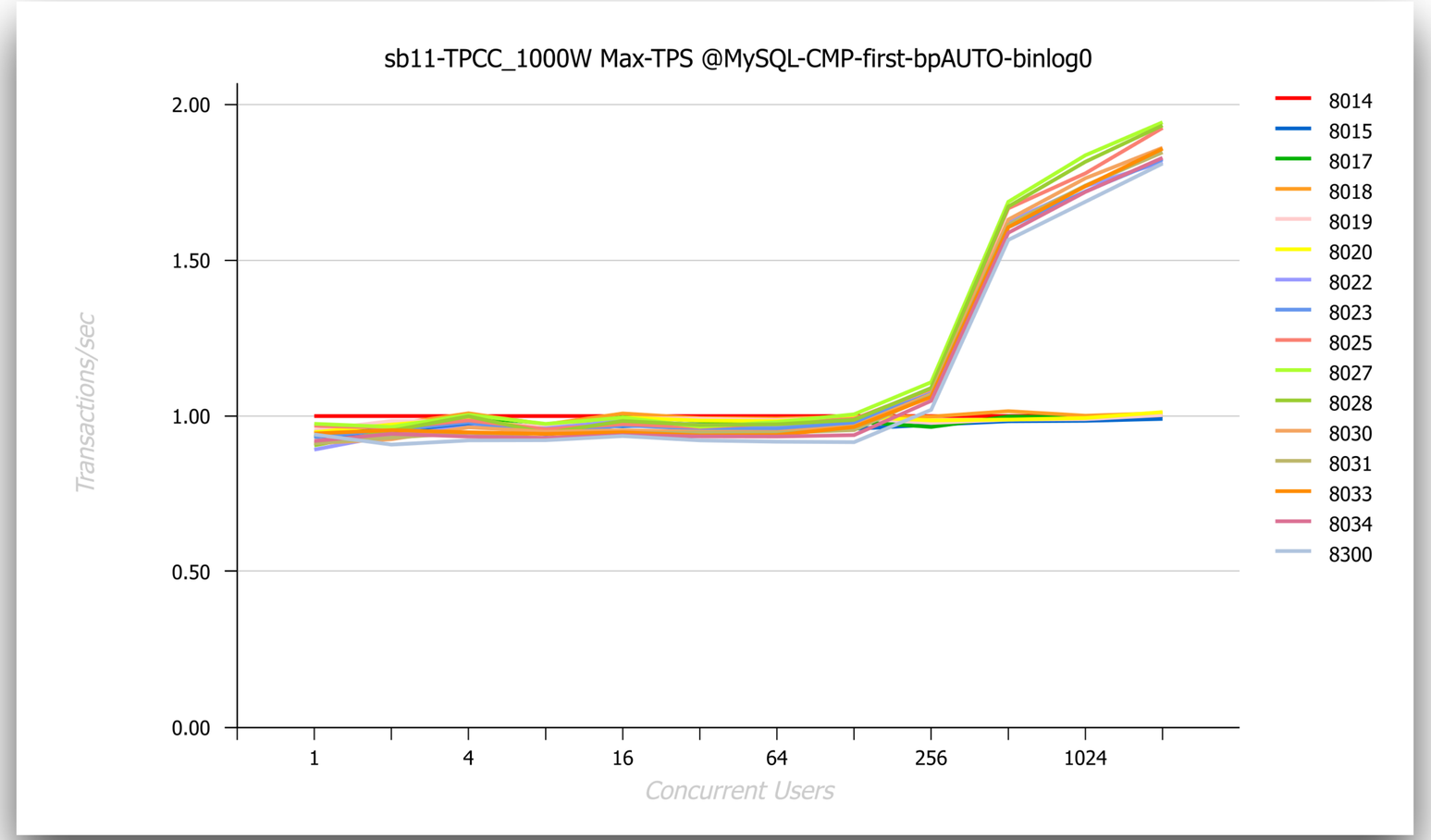
MySQL Regressions.. (in case you could think we don't care)

- TPCC example..
  - comparing TPS between 5 years back releases : clear regression on 8.3



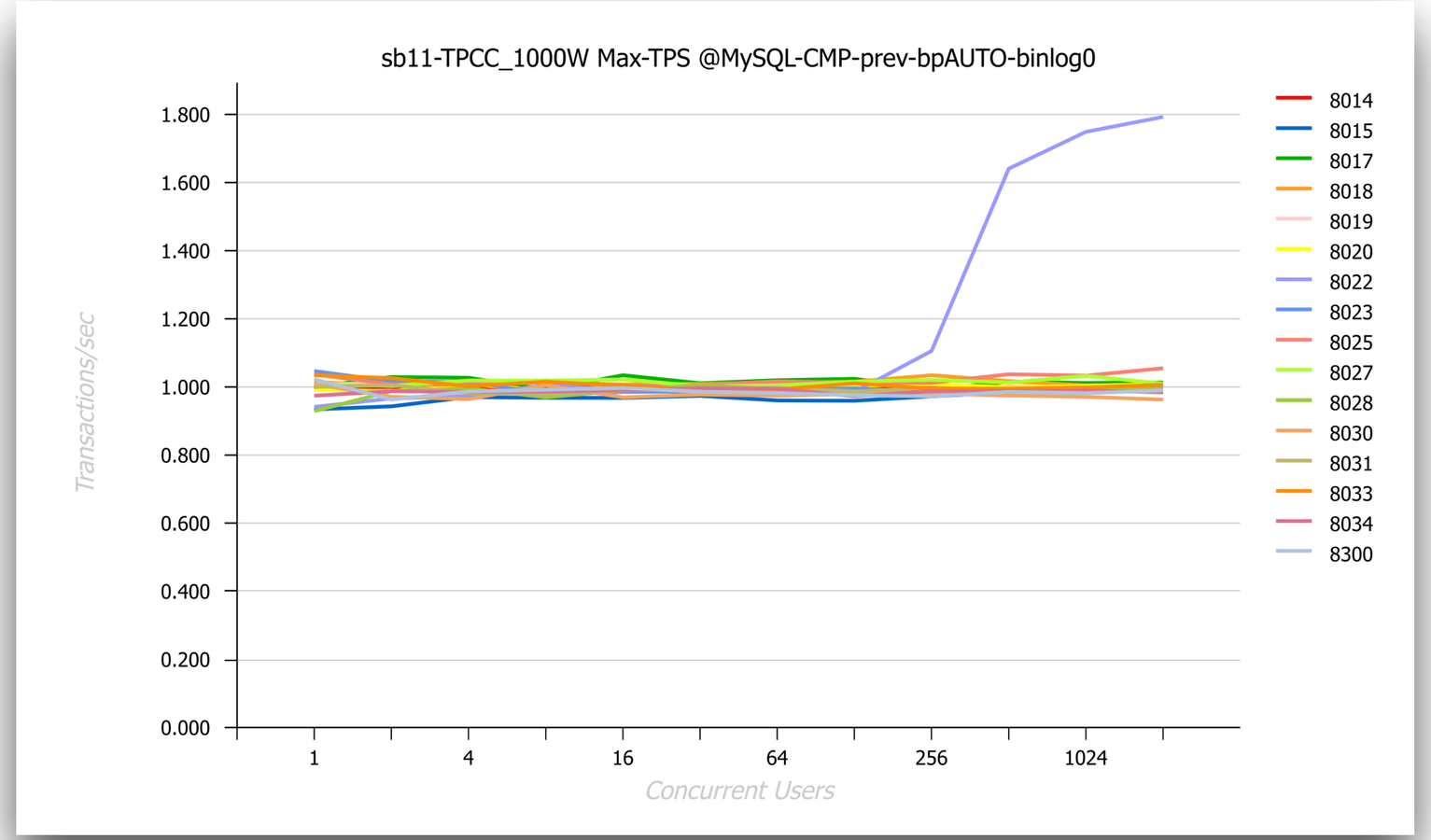
MySQL Regressions.. (in case you could think we don't care)

- TPCC example..
  - comparing relative ratio with 8.0.14 : up to 10% difference..



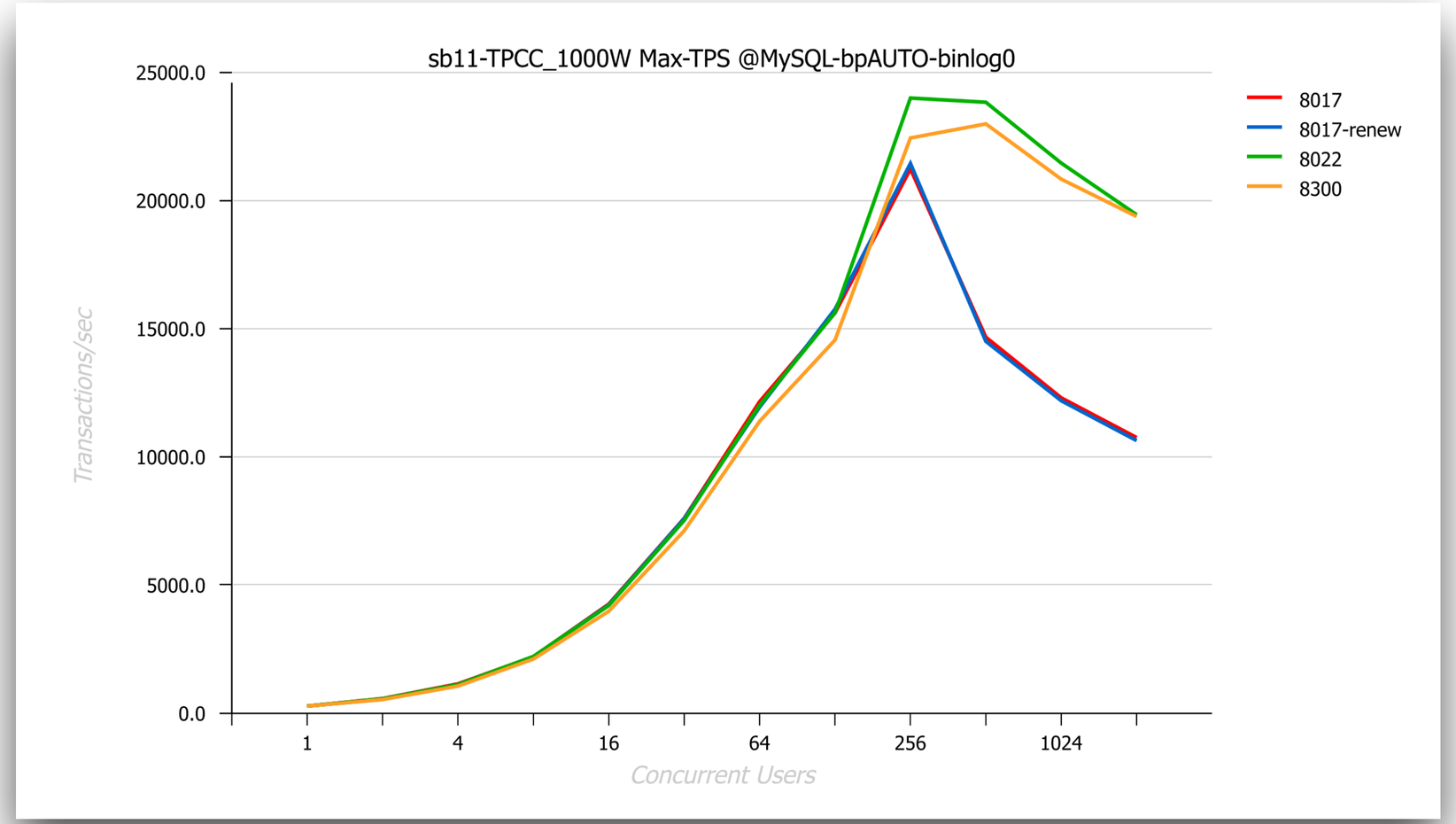
MySQL Regressions.. (in case you could think we don't care)

- TPCC example..
  - relative ratio for given release to its previous release : **less** 3% difference..



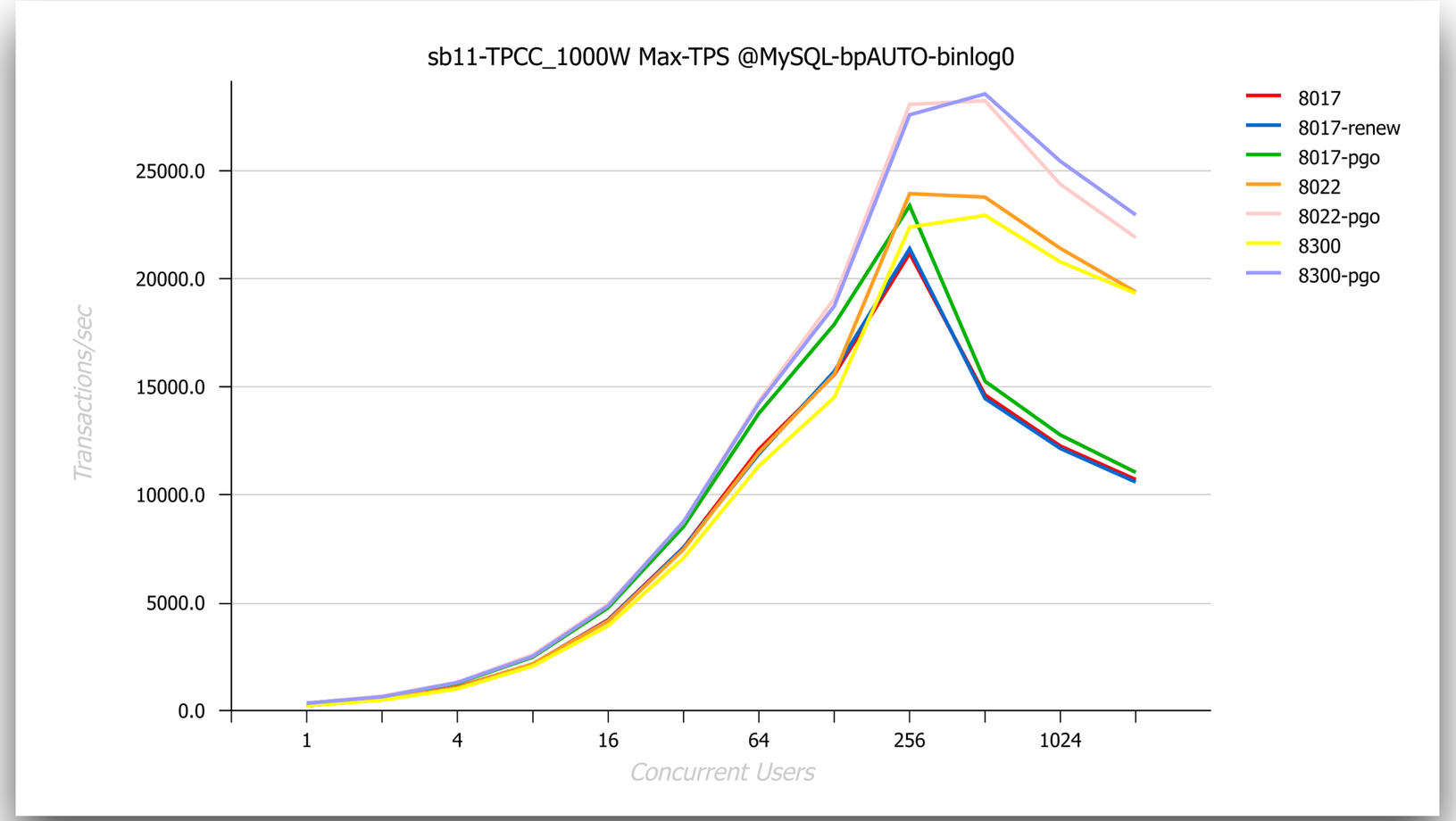
MySQL Regressions.. (in case you could think we don't care)

- TPCC example..
  - comparing main "milestone" releases : regression on 8.3



MySQL Regressions.. (in case you could think we don't care)

- TPCC example..
  - comparing main "milestone" releases + **all** PGO-optimized : no regression on 8.3 ?..



Thank you !

- Hope it was not boring ;-))

MySQL

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MySQL Performance: Understanding & Tuning of IO-Bound Workloads (part-2)

Overview 2026

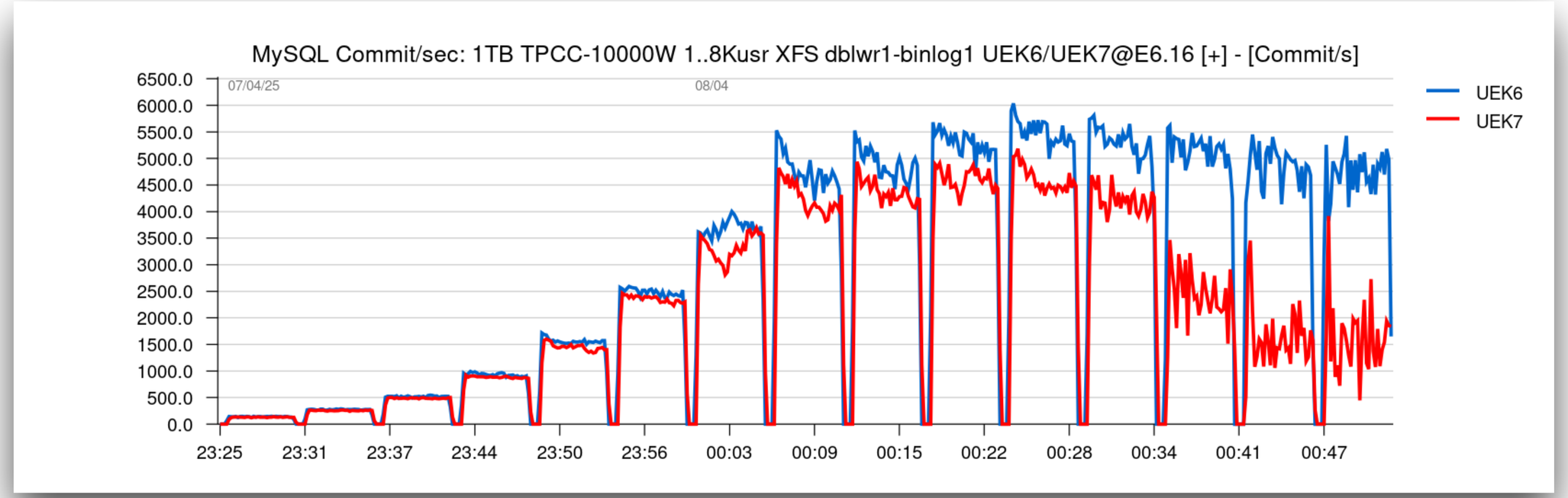
Dimitri KRAVTCHUK
MySQL Performance Architect @Oracle

IO-bound Workloads

- have IO Reads
- e.g. all complexity of CPU-bound + IO Reads !
- Storage = master piece !
  - both IOPS & MB/s capacities are critical !
  - fsync latency is **always** critical for REDO Writes ;-))
  - if you use RAID on top of Storage => use stripe size 128K/256K (for DBLWR)
- bigger RAM size always helps
- Linux kernel (see later)
- Filesystem choice :
  - XFS : most advanced
  - EXT4 : limited, but ok
  - ZFS : if you're ZFS expert
  - BTRFS : if you want to slowdown everything ;-))

Linux Kernel : Regression..

- Kernel 5.4 -vs- 5.15 (and any newer kernel) on 1TB TPCC :



- Oracle Linux Team has a potential fix with improved Scheduler !

Linux Kernel : Filesystem Cache

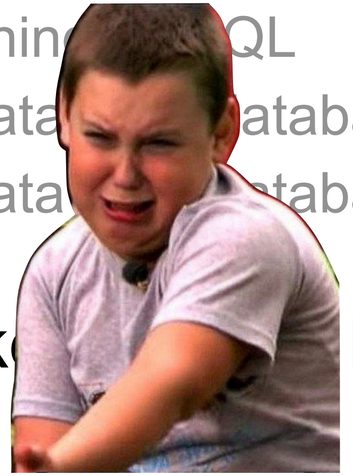
- No way to limit FS cache !
- Linux Kernel may give priority to FS cache
- e.g. for some strange reasons it’ll decide to make FS cache bigger !
- and then.. move MySQL process to SWAP ! ;-))
- currently the only workaround : switch SWAP = off
- **SR** : could we push Linux Kernel devs to implement FS cache limit ?..

IO-bound Read-Only

- Dilemma :
  - 256GB RAM on the server running MySQL
  - big batch-1 scanning all 1TB data from database-1 when runs alone = takes 1H
  - big batch-2 scanning another 1TB data from database-2 when runs alone = takes 1H
- Question : how long it’ll take if we run both batches on the same time ?..

IO-bound Read-Only

- Dilemma :
  - 256GB RAM on the server runnin QL
  - big batch-1 scanning all 1TB data atabase-1 when runs alone = takes 1H
  - big batch-2 scanning all 1TB data tabase-2 when runs alone = takes 1H



- Question : how long it'll tak both batches on the same time ?..
- Answer : **3H** (or more) !!
- Why ?…..

IO-bound Read-Only

- Dilemma :
  - 256GB RAM on the server running MySQL
  - big batch-1 scanning all 1TB data from database-1 when runs alone = takes 1H
  - big batch-2 scanning all 1TB data from database-2 when runs alone = takes 1H
- Question : how long it'll take if we run both batches on the same time ?..
- Answer : **3H** (or more) !!
- Why ?…..
  - batch-1 : brings its data to BP, removes data of batch-2 from BP..
  - batch-2 : brings its data to BP, removes data of batch-1 from BP..
  - e.g. run one-by-one = 2H total time ;-))

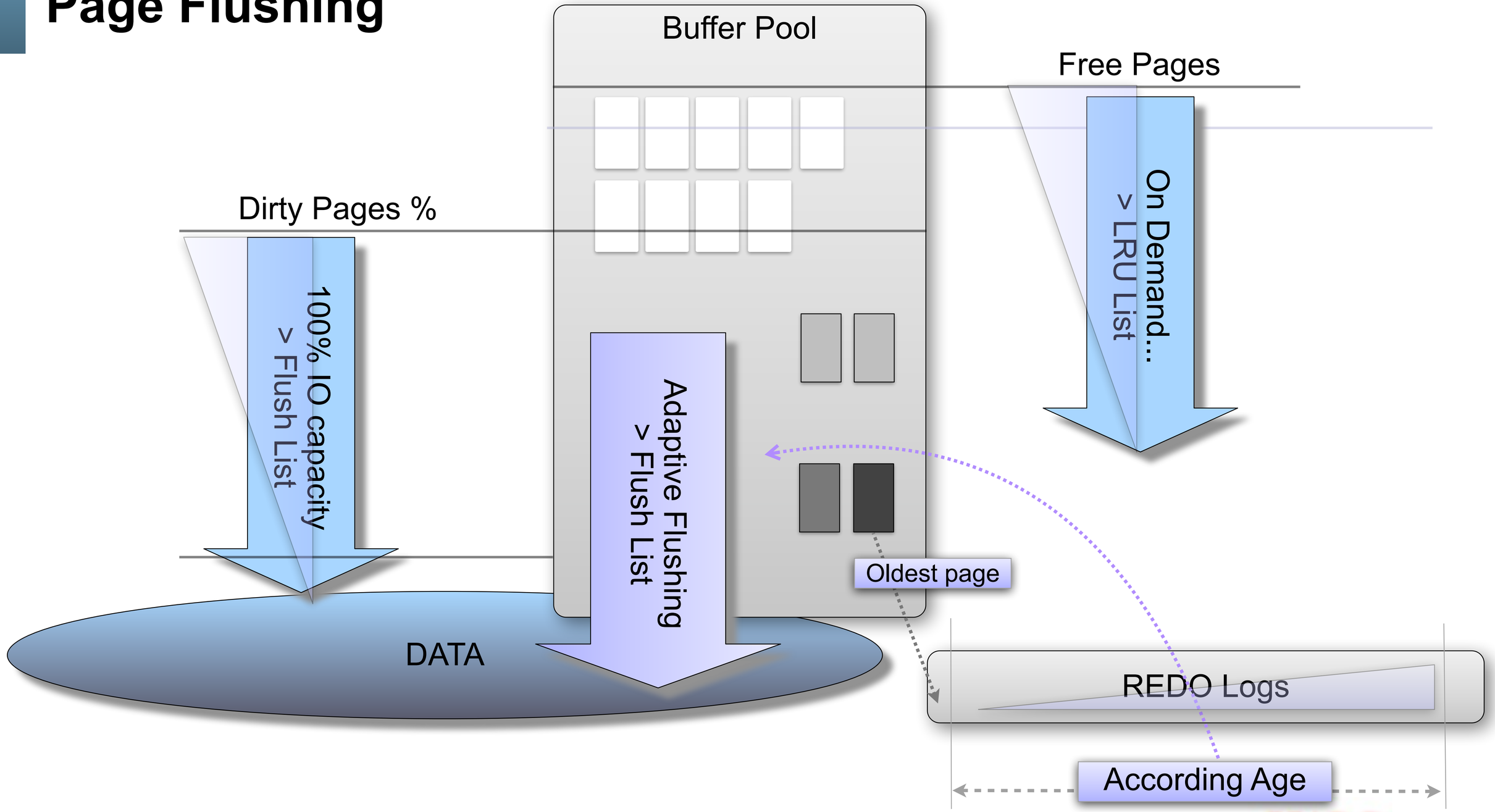
IO-bound Read-Only

- One of possible “tricks” to speed-up a single RO batch :
  - stop MySQL Server
  - drop FS cache (sync ; echo 3 > /proc/sys/vm/drop_caches)
  - start MySQL Server with “fsync” (instead of O_DIRECT)
  - run your batch-1 and leave Filesystem to do pre-fetch (read-ahead) for you !
  - drop FS cache again
  - run your batch-2
  - ….
  - restart MySQL Server with O_DIRECT => ready for RW OLTP ;-))

IO-bound Read-Write Overall Complexity

- To be able to Read a Page from Storage you need a Free Page in BP
- To get a Free Page in BP you need to Flush a Dirty Page from BP
- e.g. you need to do IO Write to be able to do IO Read
- but your Storage's IOPS capacity is limited
- if you do too many IO Reads => you have no more capacity for IO Writes
- if you do too many IO Writes => no more capacity for IO Reads..
- so, it's all about a right balance between IO Reads & Writes !
  - and this is the reason "why" InnoDB IO-Reads are not using AIO (will be disaster)
- NOTE :
  - Page Writes are most efficient with AIO + O_DIRECT (default since 8.4)
  - we don't use AIO for Page Reads (just O_DIRECT IO-Reads only)
  - same for DBLWR, but doing IO-Writes (O_DIRECT without AIO)
  - this all may add complexity to your Filesystem (ex.: EXT4 and 4.14 - 5.0 kernels)

Page Flushing

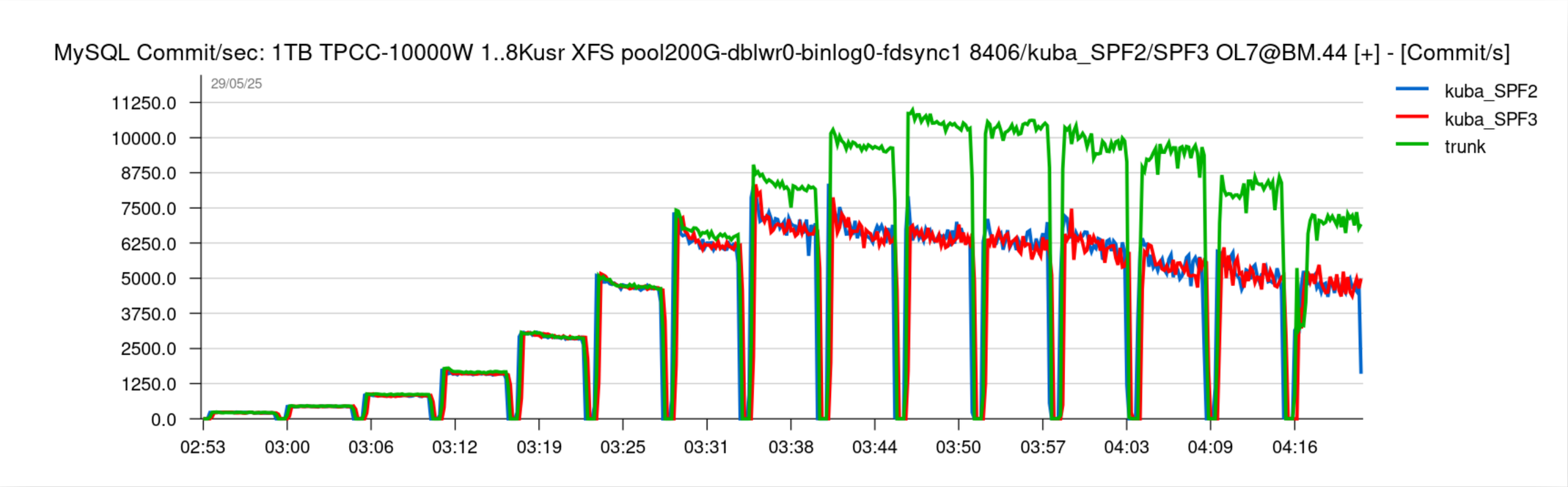


LRU Page Flushing

- Page Cleaners : Driven by Free Pages demand
  - involved when there is no more Free Pages
  - theory : scanning LRU up to “LRU depth” level
  - reality : LRU depth = amount of Free Pages to deliver ;-))
  - found not-Dirty Page => evict and move to Free Pages list
  - found Dirty Page => Page Flush first, then evict and move to Free Pages list
- User Thread :
  - 1) tries to get a Free Page => if ok, return
  - 2) if did not get => send signal to Page Cleaners and do a short wait loop
  - 3) if still did not get => involve Single Page Flush and goto 1)
- Single Page Flush :
  - user thread will scan LRU itself, and then evict or flush one Page
  - still better than do nothing !

Single Page Flush

- Historically often blamed
  - reality : blame is not really justified ;-))
  - tentatives to disable Single Page Flush -vs- enabled (green) on 1TB TPCC :

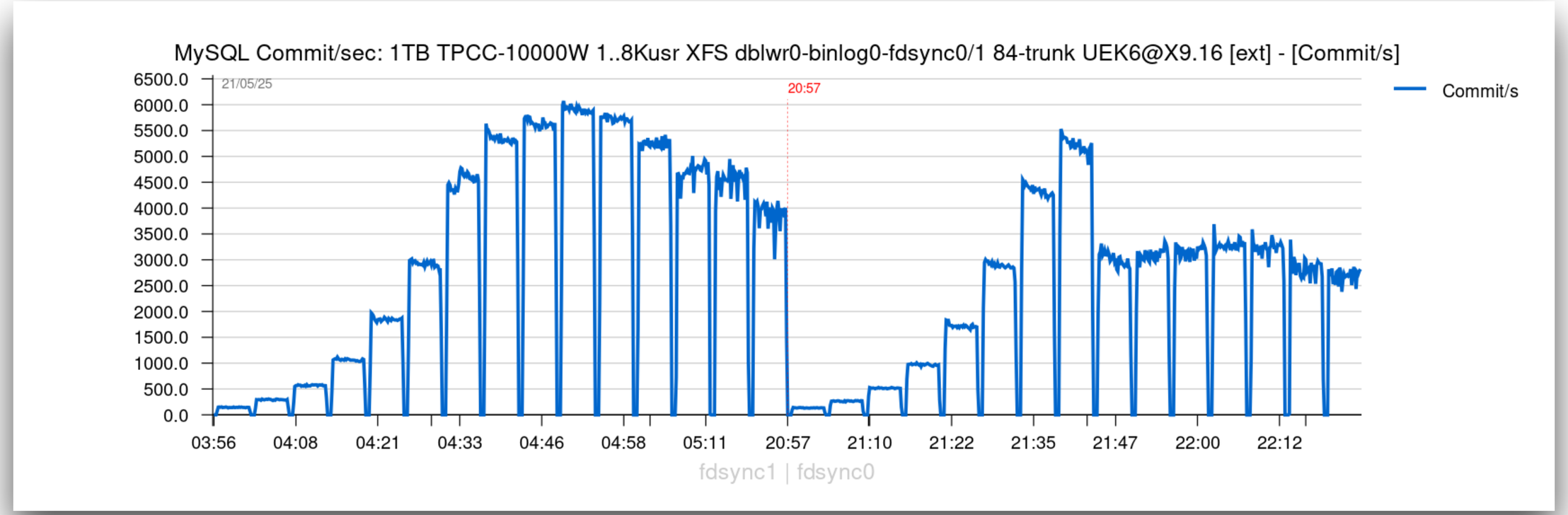


IO-bound Workloads : Tuning

- Config :
  - innodb_lru_scan_depth = 1K (default)
    - generally you don’t need a bigger value since Page Cleaners are waked-up on-demand
  - AIO + O_DIRECT : mandatory ! (O_DIRECT_NO_FSYNC : banned !!)
  - innodb_use_fdatasync = 1 : mandatory ! (new default)
  - IBUF : innodb_change_buffering = all, innodb_change_buffer_max_size = 5
  - DBLWR : try **default** settings first, tune further if Storage is saturated
- Monitoring :
  - buffer_LRU_get_free_search/sec <= Free Pages demand by Users
  - buffer_LRU_get_free_loops/sec <= User’s loop waits on Free Pages..
  - buffer_LRU_get_free_waits/sec <= User’s sleep waits on Free Pages..
  - buffer_LRU_single_flush_num_scan/sec <= Single Page Flush by User
  - buffer_LRU_batch_evict_total_pages/sec <= Pages Evicted by Cleaners
  - buffer_LRU_batch_flush_total_pages/sec <= Pages Flushed by Cleaners
  - buffer_LRU_batch_scanned/sec <= Pages Scanned by Cleaners

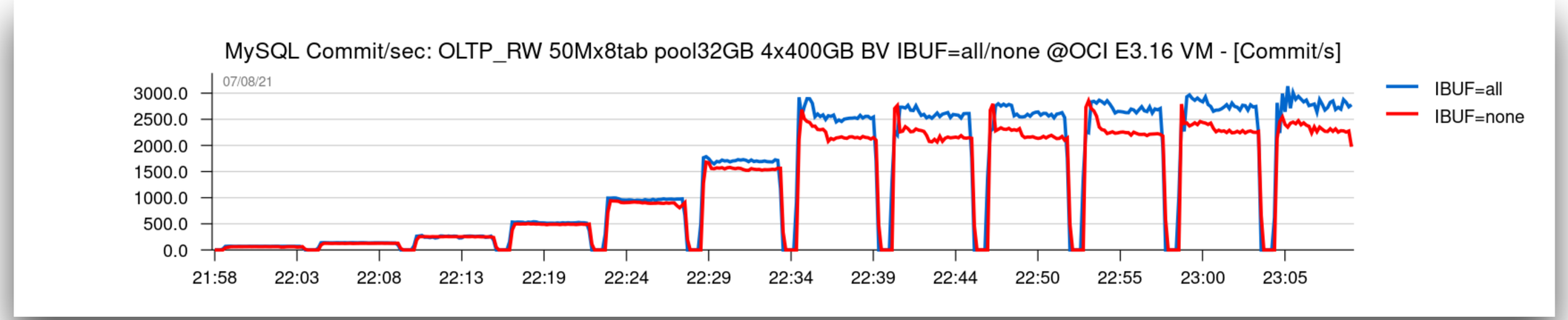
IO-bound : fdatasync Impact

- 1TB TPCC : innodb_use_fdatasync = 1/0

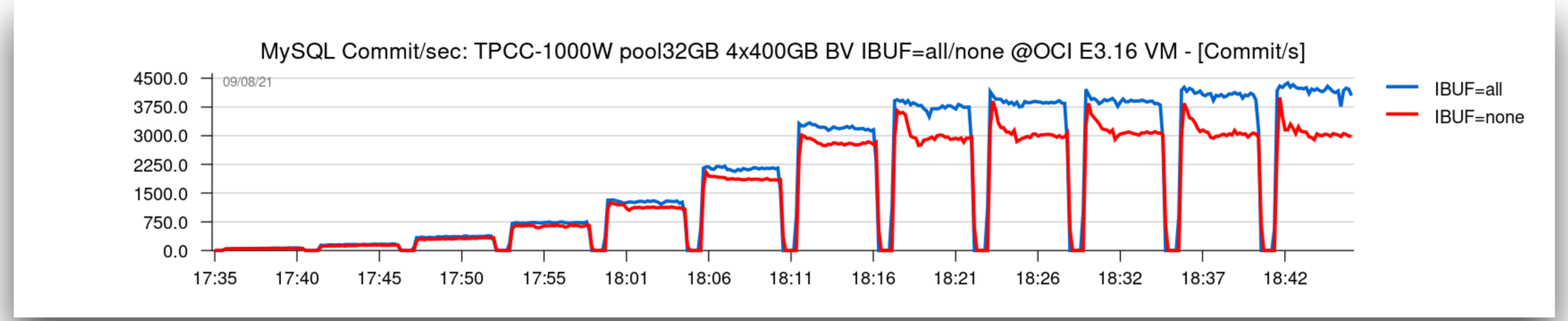


IO-bound : IBUF Impact (Change Buffer)

- IO-bound OLTP_RW :



- IO-bound TPCC :



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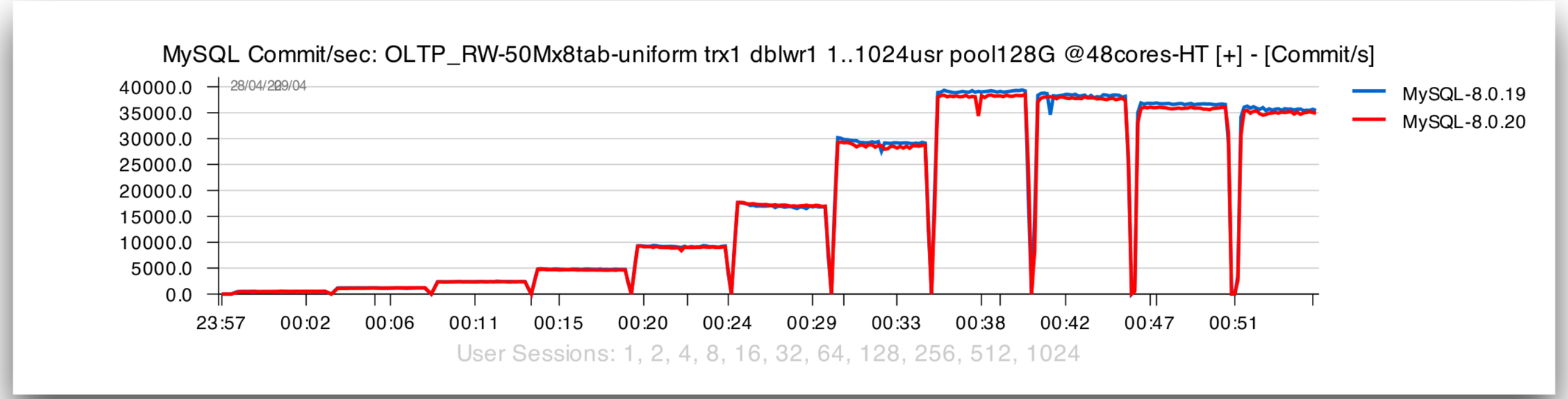
IO-bound : DBLWR Impact

- New DBLWR since MySQL 8.0.20 !!
  - just in case you forgot about innovations in 8.0 ;-))

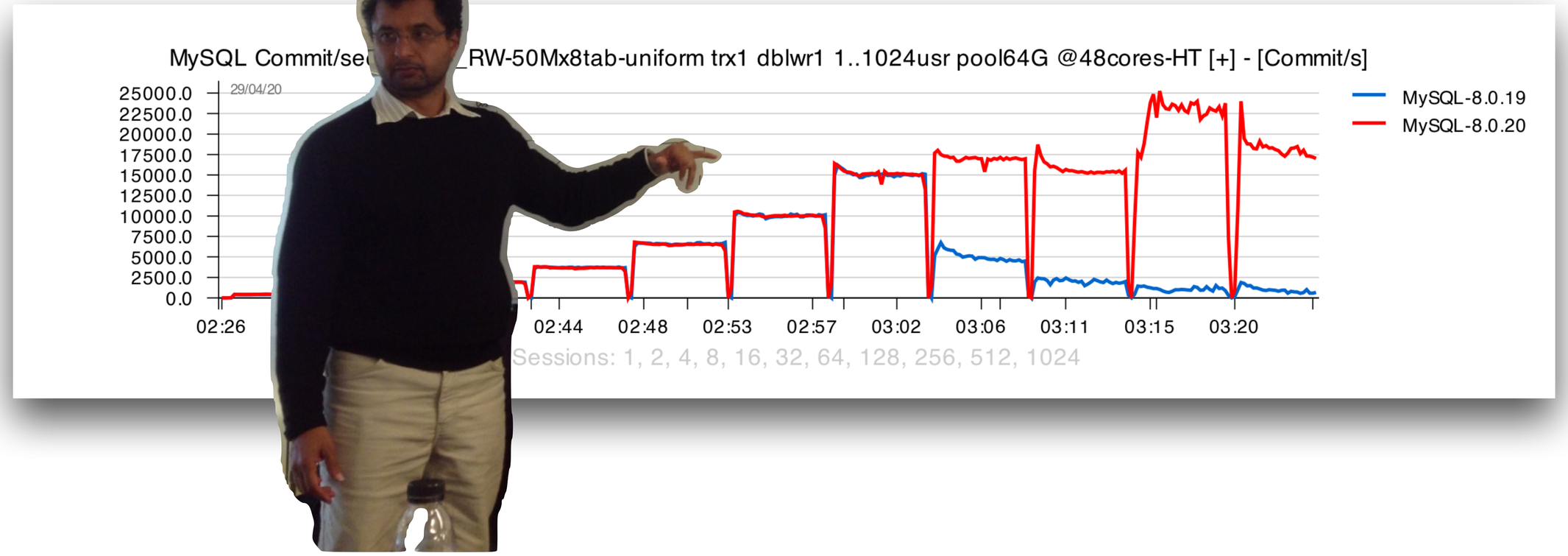
- CPU-bound :



IO-bound : DBLWR Impact

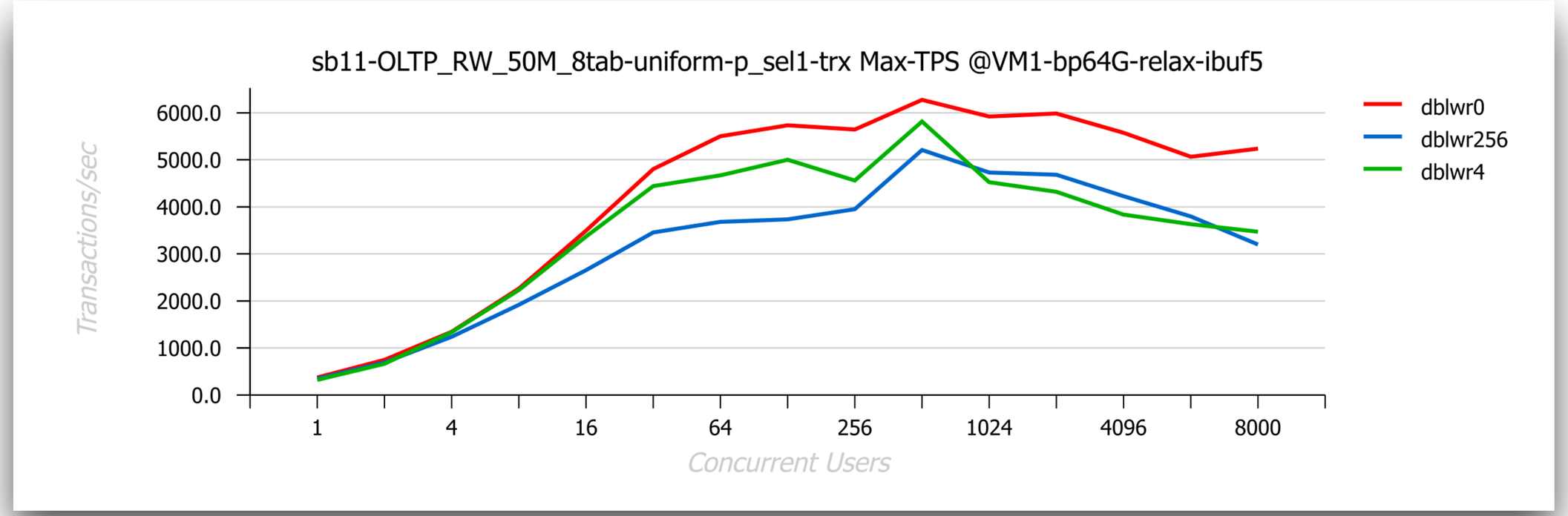
- New DBLWR since MySQL 8.0.20 !!
  - just in case you forgot about innovations in 8.0 ;-))

- IO-bound :



IO-bound : DBLWR Impact

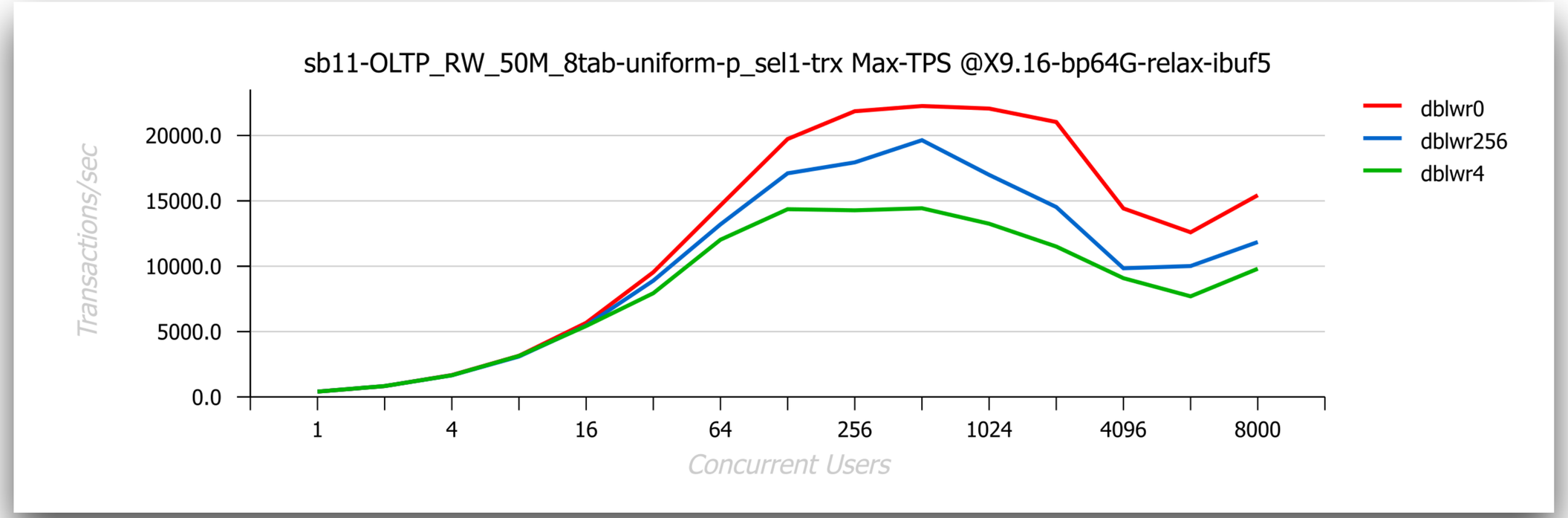
- OLTP_RW++ : Saturated Storage
  - dblwr0 : DBLWR=off (expectation for Atomic IO)
  - dblwr4 : DBLWR=on, 2 files x 2 pages (old default)
  - dblwr256 : DBLWR=on, 2 files x 128 pages (default since 8.4)



- Oracle Linux Team => Atomic IO !!! (already pushed to upstream)

IO-bound : DBLWR Impact

- OLTP_RW++ : Higher Capacity Storage
  - dblwr0 : DBLWR=off (expectation for Atomic IO)
  - dblwr4 : DBLWR=on, 2 files x 2 pages (old default)
  - dblwr256 : DBLWR=on, 2 files x 128 pages (default since 8.4)



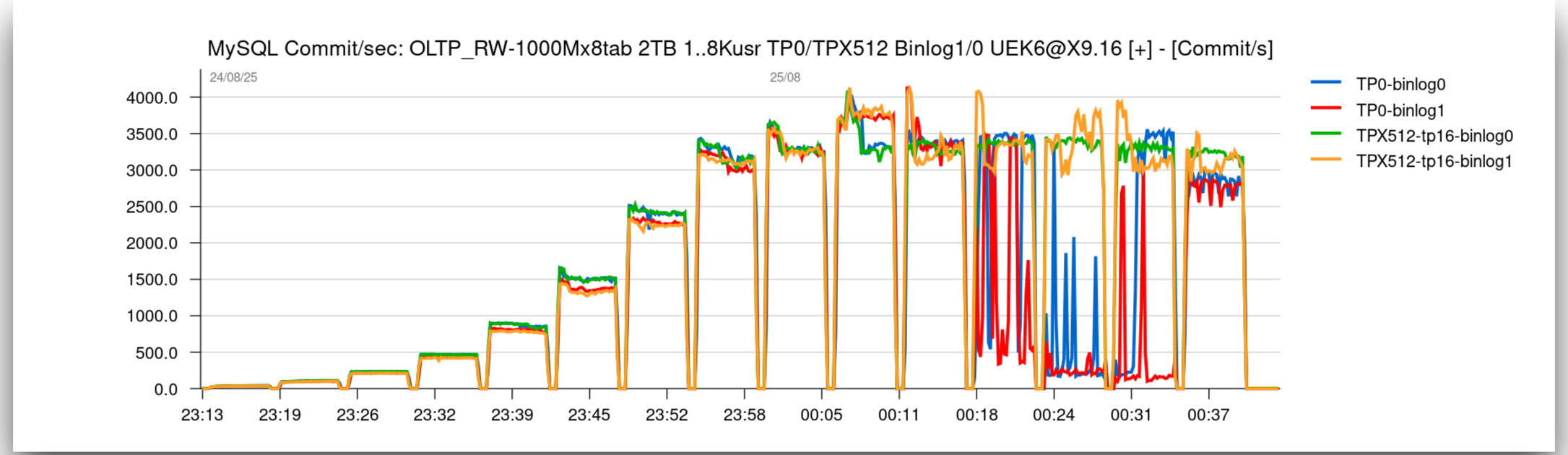
- Oracle Linux Team => Atomic IO !!! (already pushed to upstream)

Evaluation : 2TB OLTP_RW IO-bound Workload

- System :
  - 16cores VM, 256GB RAM, 8TB HighPerf OCI BV Storage, OL8, XFS
- MySQL Config :
  - BP size = auto (200GB) / 64GB
  - Binlog = 1 / 0
  - IBUF = 0 / 5
  - ThreadPool = on / off
- Test Workload :
  - OLTP_RW-uniform, 8 tables x 1000M rows each
  - growing load level : 1, 2, 4, 8, … 4K, 6000, 8000 users
  - InnoDB transparent compression : OFF / ON

2TB OLTP_RW : First Results

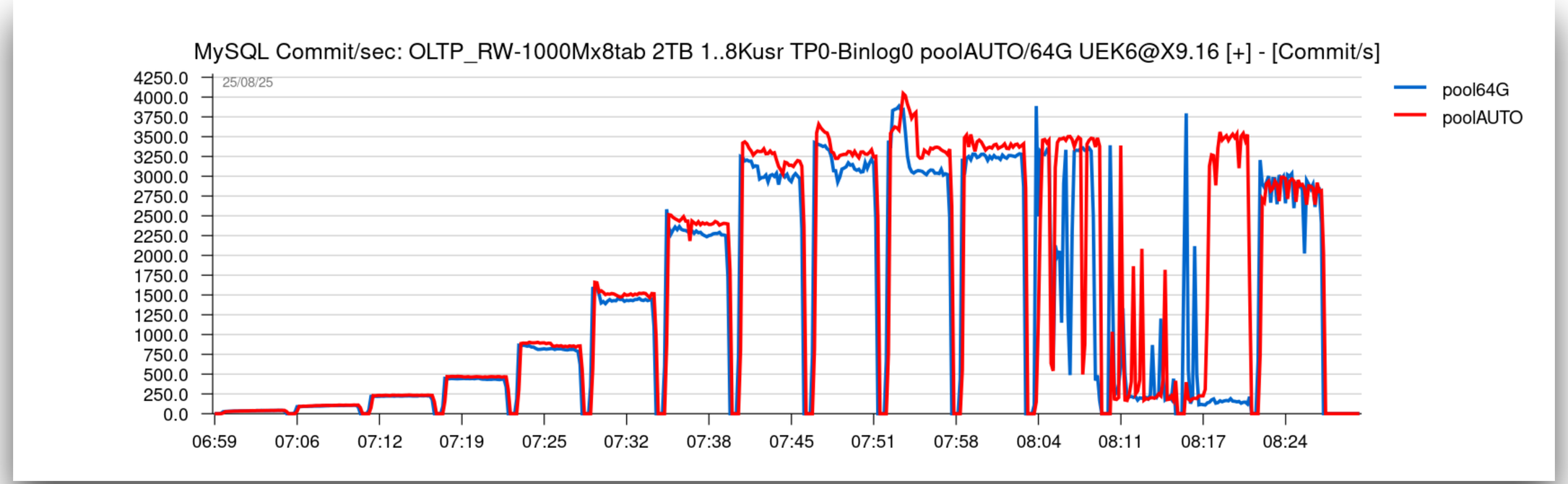
- Comparing :
  - Binlog = ON / OFF
  - ThreadPool = ON / OFF



- Binlog = ON / OFF => no difference
- TPS disaster since 2K users, but ThreadPool is able to solve this !

2TB OLTP_RW : First Results

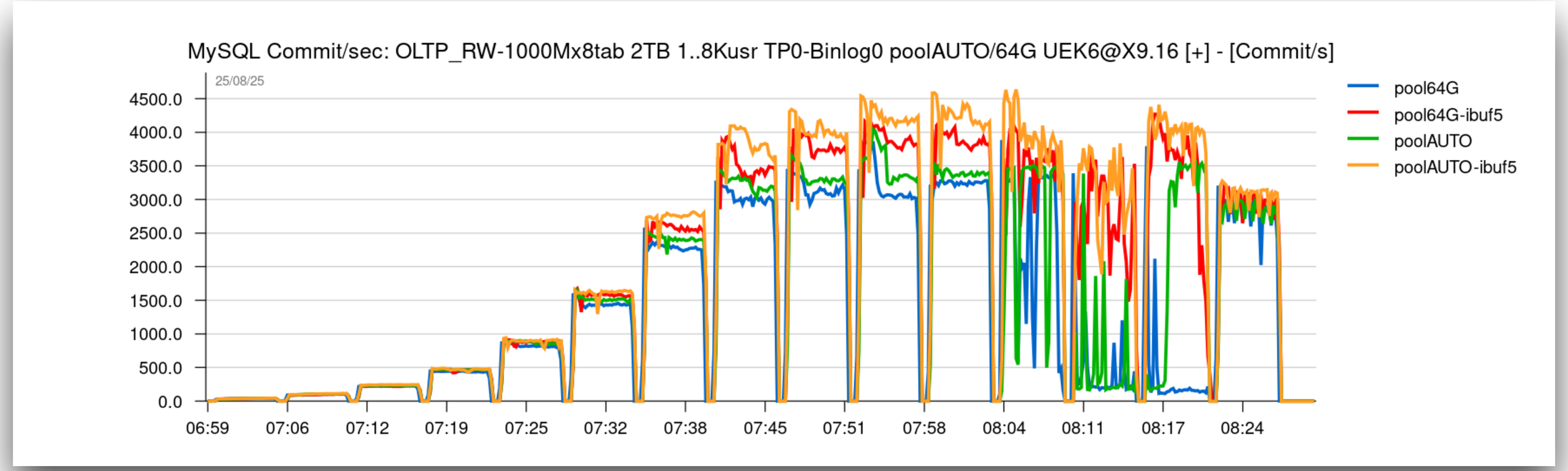
- Comparing :
  - BP size = auto (200G) / 64G
  - ThreadPool = OFF, Binlog = OFF



- small or bigger BP => no much difference, Storage capacity drives the results

2TB OLTP_RW : First Results

- Comparing :
  - BP size = auto (200G) / 64G
  - IBUF = 0 / 5



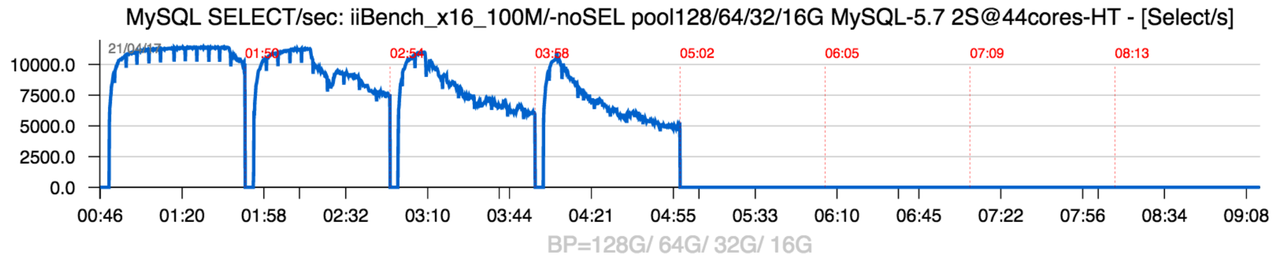
- IBUF helps (as expected), more help with a bigger BP (as expected)

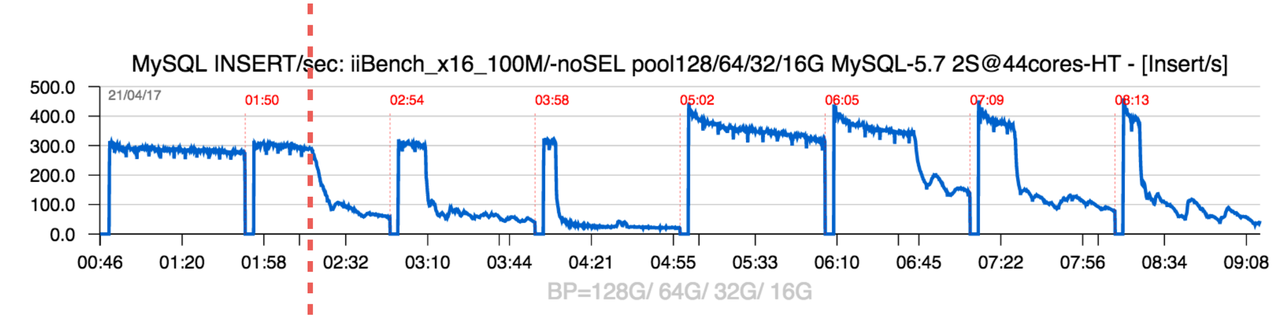
History from 2019 : iiBench (Index INSERT Benchmark)

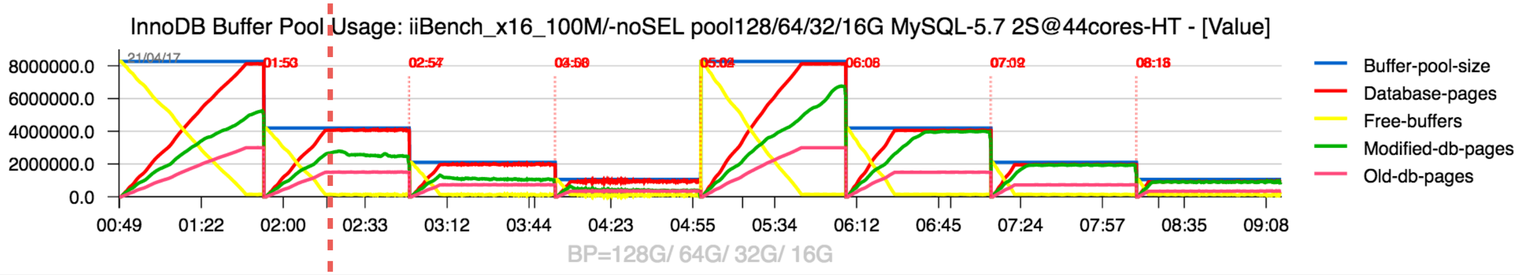
- Main claim :
  - InnoDB is xN times slower vs Write-oriented Engine XXX
  - so, use XXX, as it’s better
- Test Scenario :
  - x16 parallel iiBench processes running together during 1H
  - each process is using its own table
  - one test with SELECTs, another without..
- Key point :
  - during INSERT activity, B-Tree Index in InnoDB grows 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)

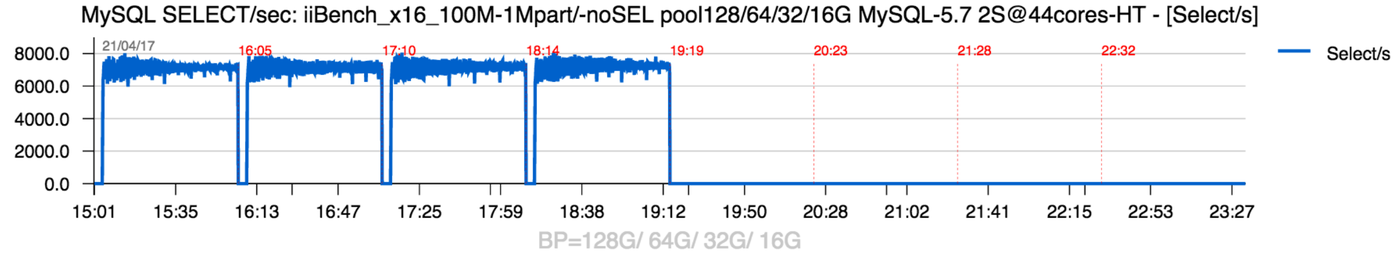


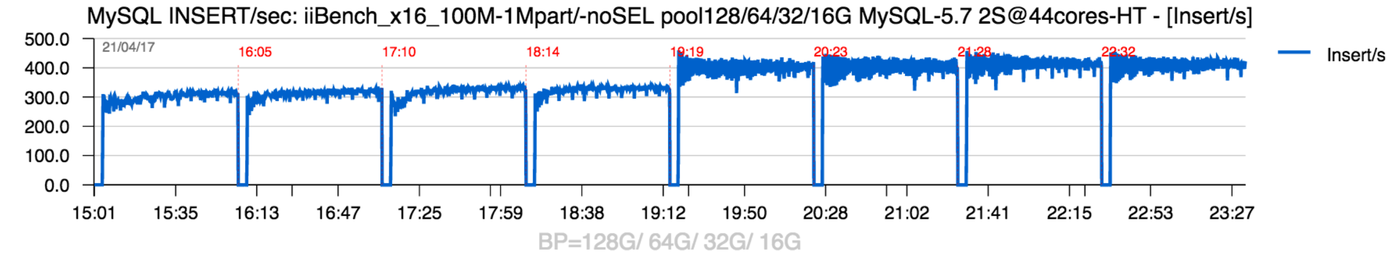


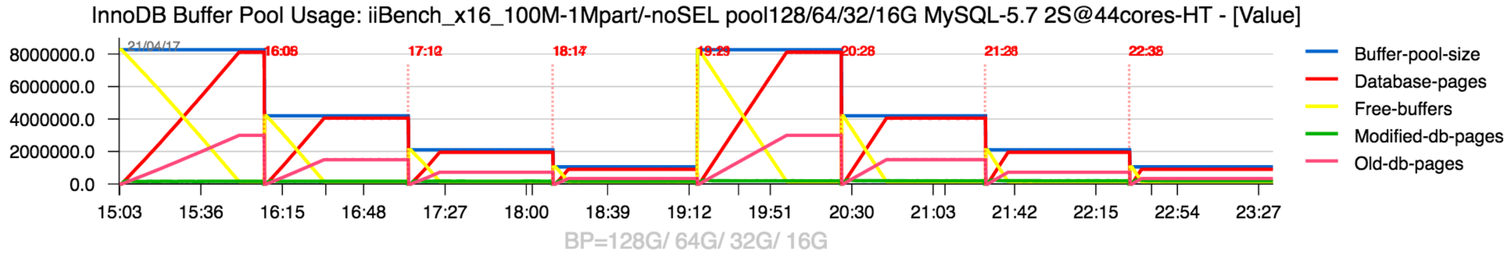


iiBench 100M x16 & 1M-parts : BP= 128G/ 64G/ 32G/ 16G

- Observations :
  - workaround : keep index cached in BP (via table partitions or other)

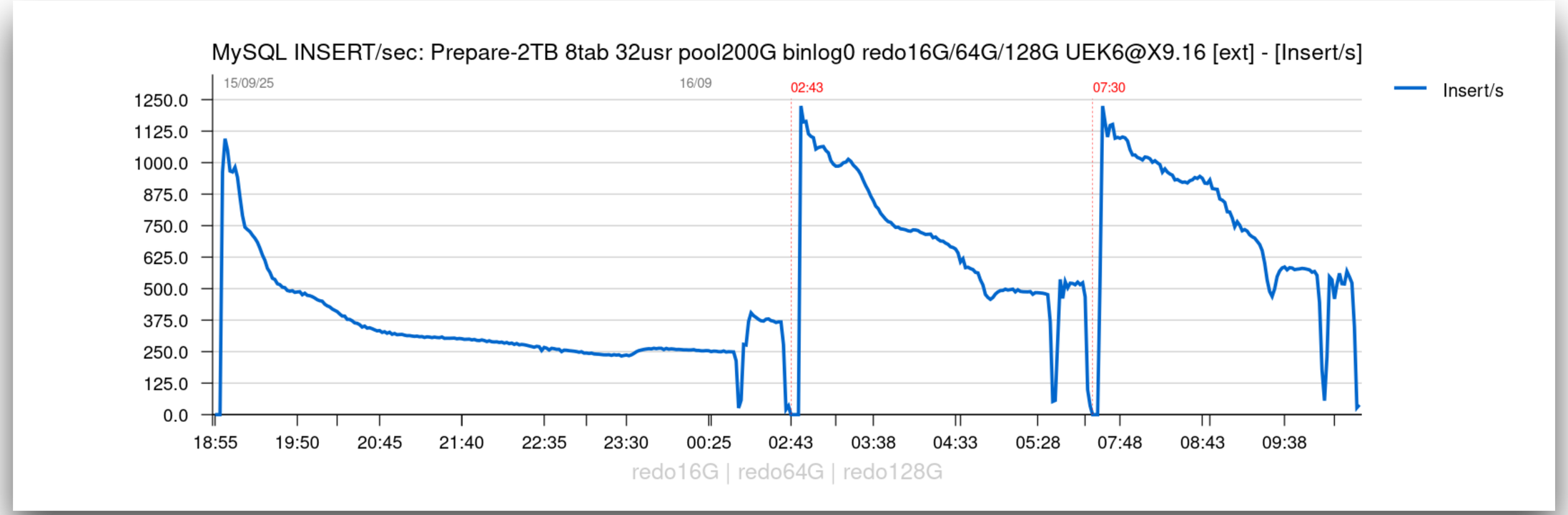






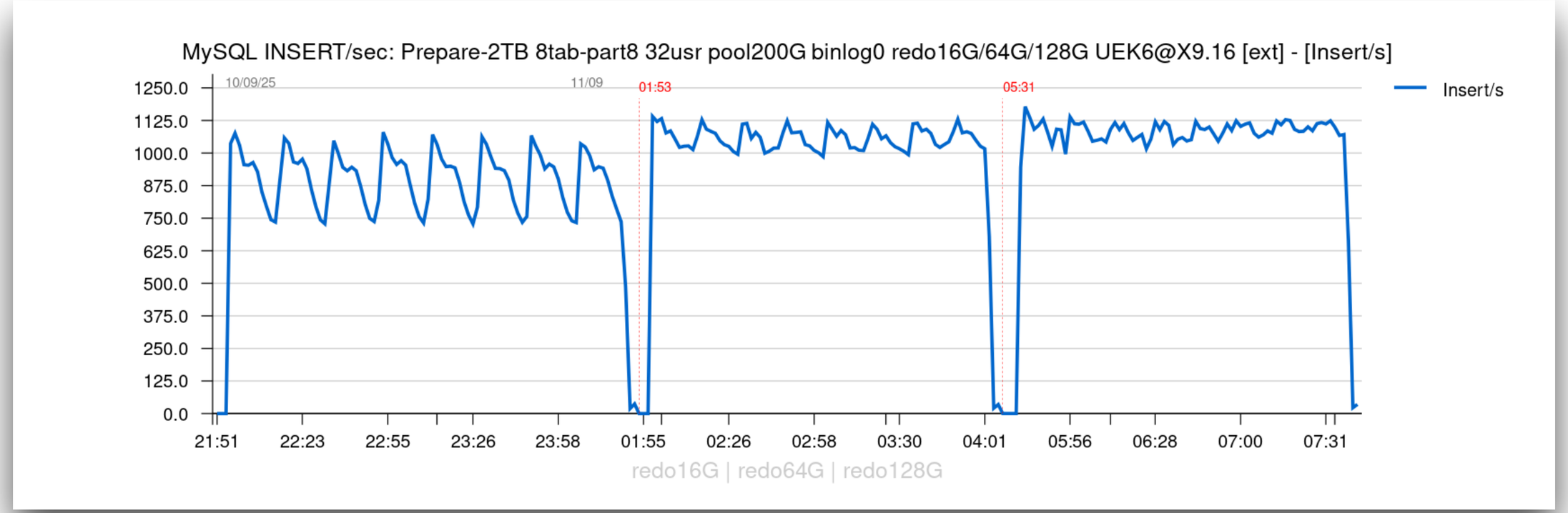
2TB OLTP_RW : Data Load with 32 connections

- Problem : progressive decrease of INSERT/sec rate
- Workaround #1 : increase REDO size
  - REDO = 16GB / 64GB / 128GB



2TB OLTP_RW : Data Load with 32 connections

- Problem : progressive decrease of INSERT/sec rate
- Workaround #2 : use Partitions
  - 8 Partitions + REDO = 16GB / 64GB / 128GB



2TB OLTP_RW : InnoDB Transparent Page Compression

- History background :
  - delivered since MySQL 5.7
  - based on Filesystem “punch holes” feature
  - **main problem** :
    - it takes a long time for FS to drop a big “sparse” file
    - InnoDB gets a signal on a long wait timeout and aborts..

- Today :
  - InnoDB has capability to drop data files in background (no abort anymore)
  - XFS is now dropping “sparse” files in background, mostly immediate ACK on unlink()
  - **main problem is gone !** sounds good ? — not really :
    - still some unexpected slowdowns in IO activity
    - side effects : IO activity on “sparse” file impacts IO on “normal” files, etc..
    - e.g. still not ready for Production

2TB OLTP_RW : Data Load Times & Transparent Compression

- Data Load :
  - 32 threads in parallel
  - using bulk INSERTs
  - 1K rows per INSERT

No Partitions

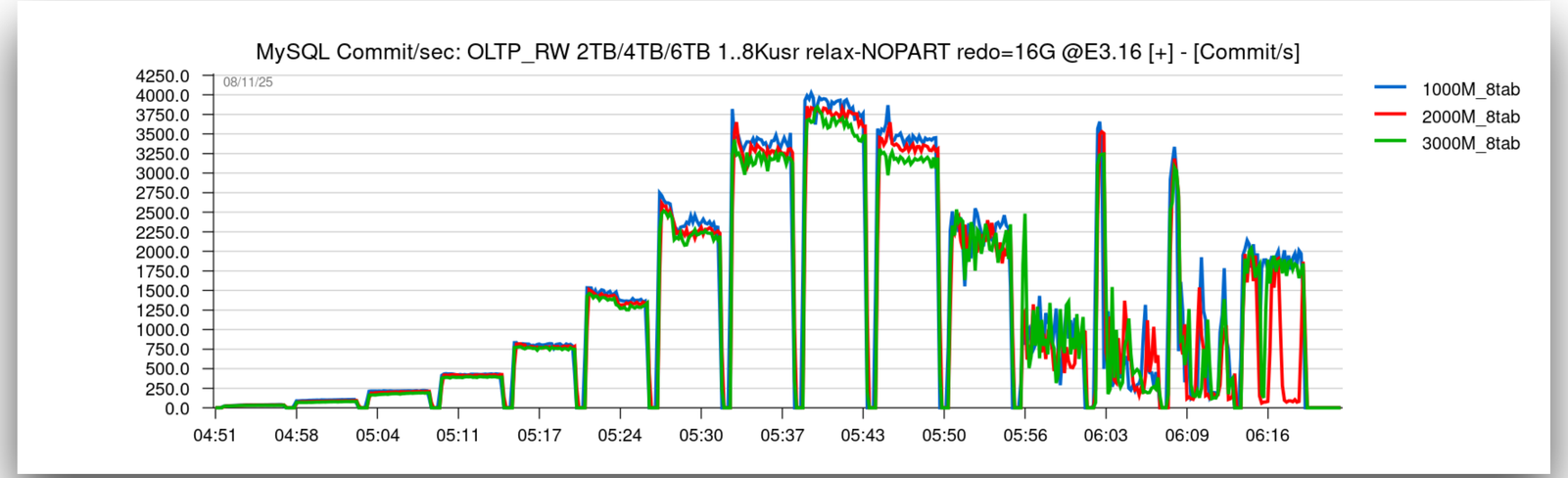
REDO size	compression=OFF	compression=ON
16G	6H20	15H15
64G	3H15	10H25
128G	2H54	9H52

8 Partitions

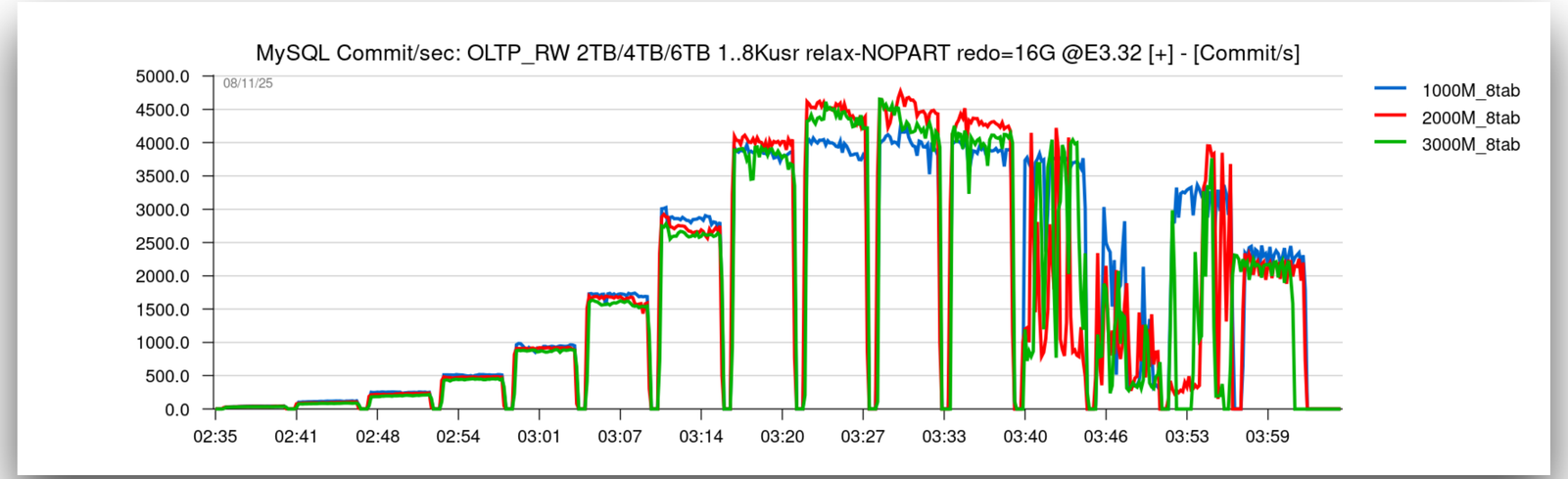
REDO size	compression=OFF	compression=ON
16G	2H30	5H42
64G	2H02	5H20
128G	2H08	5H00

IO-bound OLTP_RW : 2TB / 4TB / 6TB | REDO = 16GB

- E3.16 :
  - 16cores VM
  - 256GB RAM
  - 8TB BV Storage

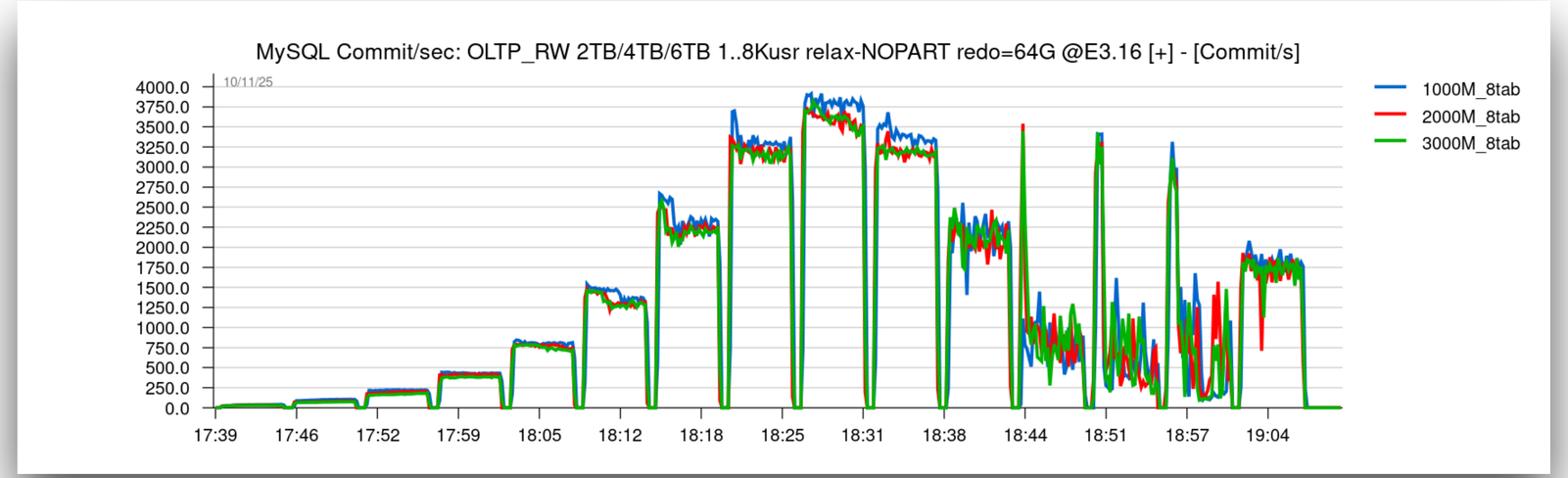


- E3.32 :
  - 32cores VM
  - 512GB RAM
  - 8TB BV Storage

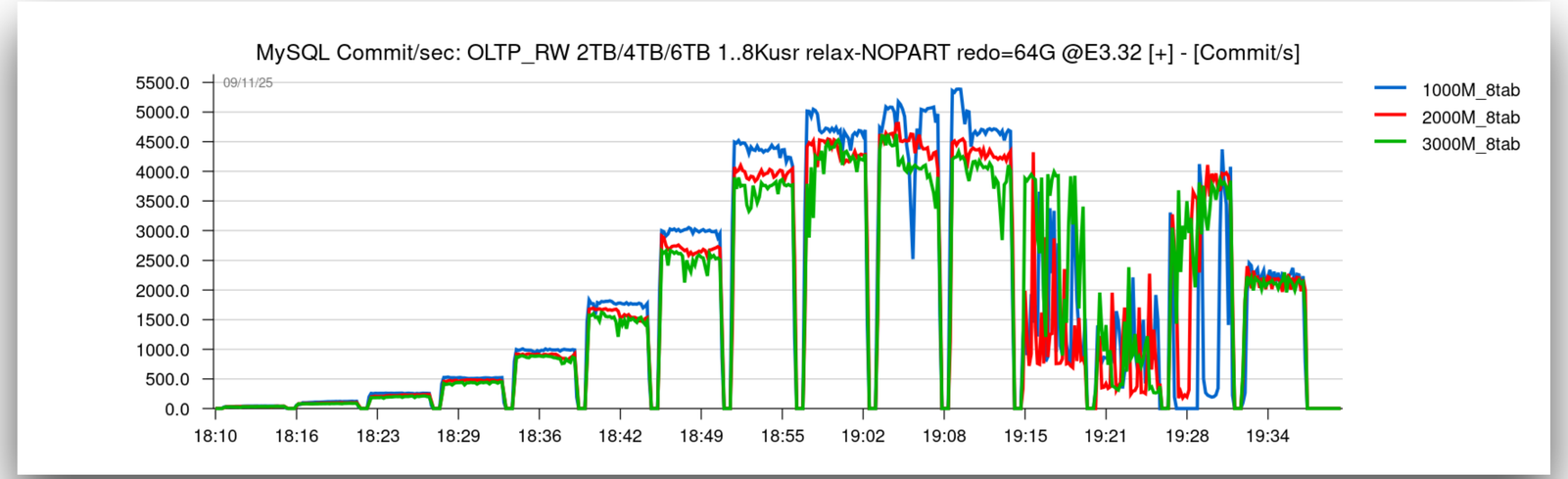


IO-bound OLTP_RW : 2TB / 4TB / 6TB | REDO = 64GB

- E3.16 :
  - 16cores VM
  - 256GB RAM
  - 8TB BV Storage

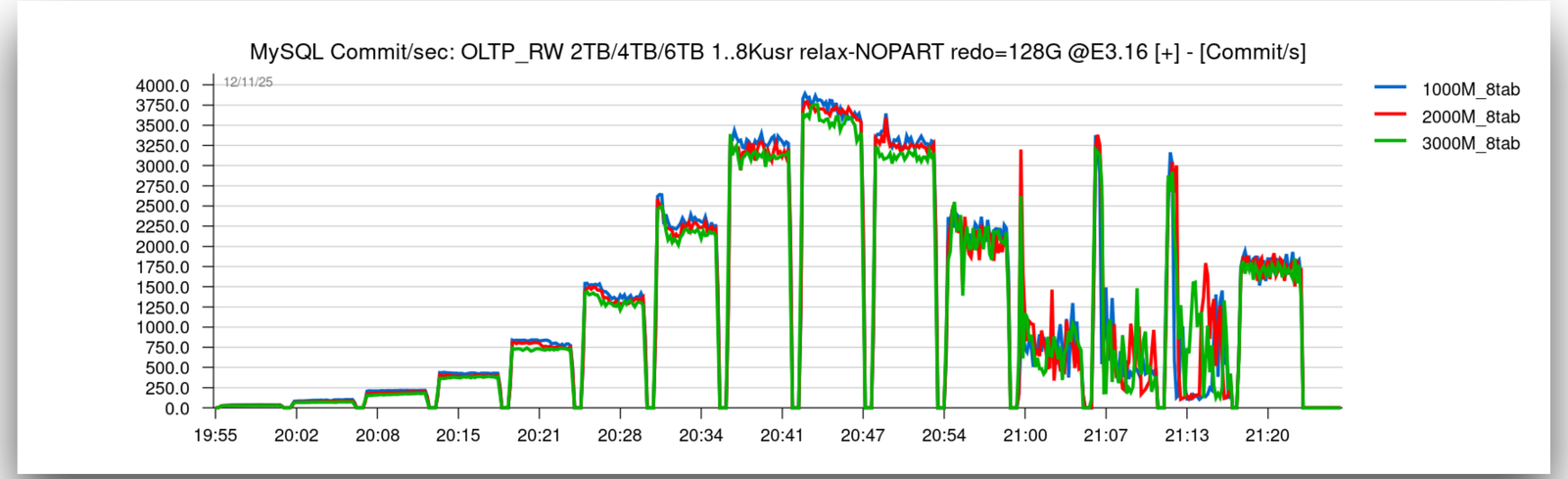


- E3.32 :
  - 32cores VM
  - 512GB RAM
  - 8TB BV Storage

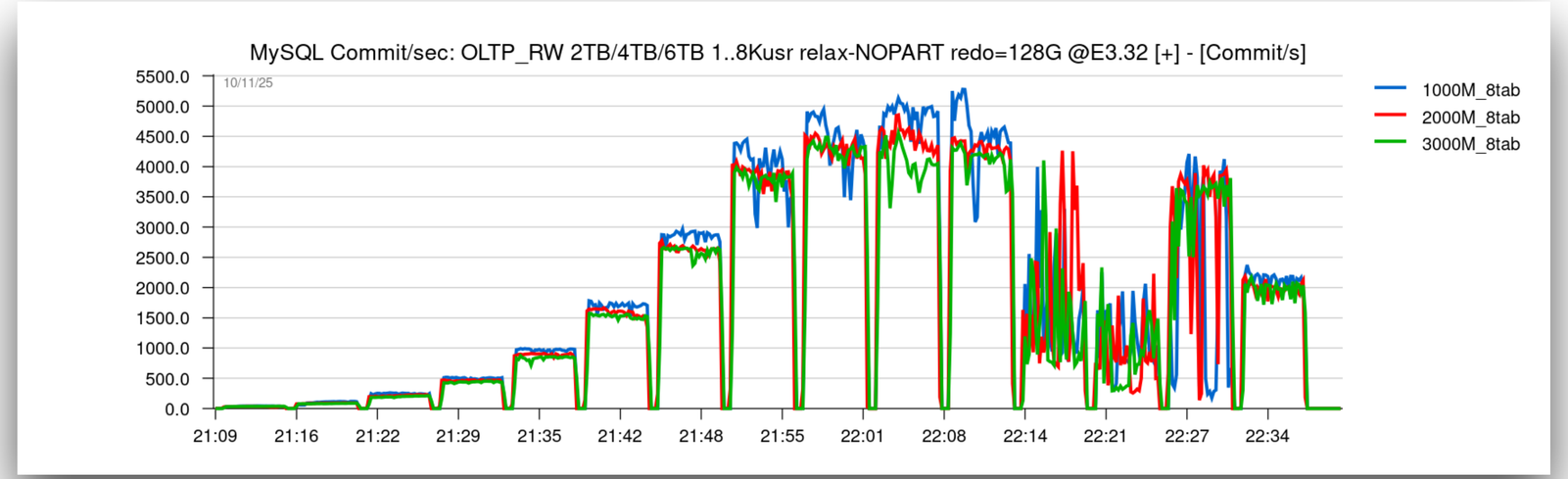


IO-bound OLTP_RW : 2TB / 4TB / 6TB | REDO = 128GB

- E3.16 :
  - 16cores VM
  - 256GB RAM
  - 8TB BV Storage



- E3.32 :
  - 32cores VM
  - 512GB RAM
  - 8TB BV Storage



IO-bound OLTP_RW : Data Load Times

- E3.16 :
  - 16cores VM
  - 256GB RAM
  - 8TB BV Storage

2TB data

REDO	NOPART	8-PART	NOPART-ibuf5	8-PART-ibuf5
16G	06H46	03H09	06H57	03H10
64G	03H59	02H45	04H03	02H47
128G	03H35	02H41	03H42	02H42

4TB data

REDO	NOPART	8-PART	NOPART-ibuf5	8-PART-ibuf5
16G	17H11	07H17	18H18	07H18
64G	12H24	05H48	13H41	05H52
128G	11H59	05H34	12H57	05H38

6TB data

REDO	NOPART	8-PART	NOPART-ibuf5	8-PART-ibuf5
16G	35H00	12H32	33H05	12H37
64G	29H36	09H02	26H38	09H10
128G	28H49	08H37	25H53	08H42

IO-bound OLTP_RW : Data Load Times

- E3.32 :
  - 32cores VM
  - 512GB RAM
  - 8TB BV Storage

2TB data

REDO	NOPART	8-PART	NOPART-ibuf5	8-PART-ibuf5
16G	04H30	02H43	04H20	02H44
64G	02H42	02H26	02H41	02H26
128G	02H39	02H23	02H35	02H23

4TB data

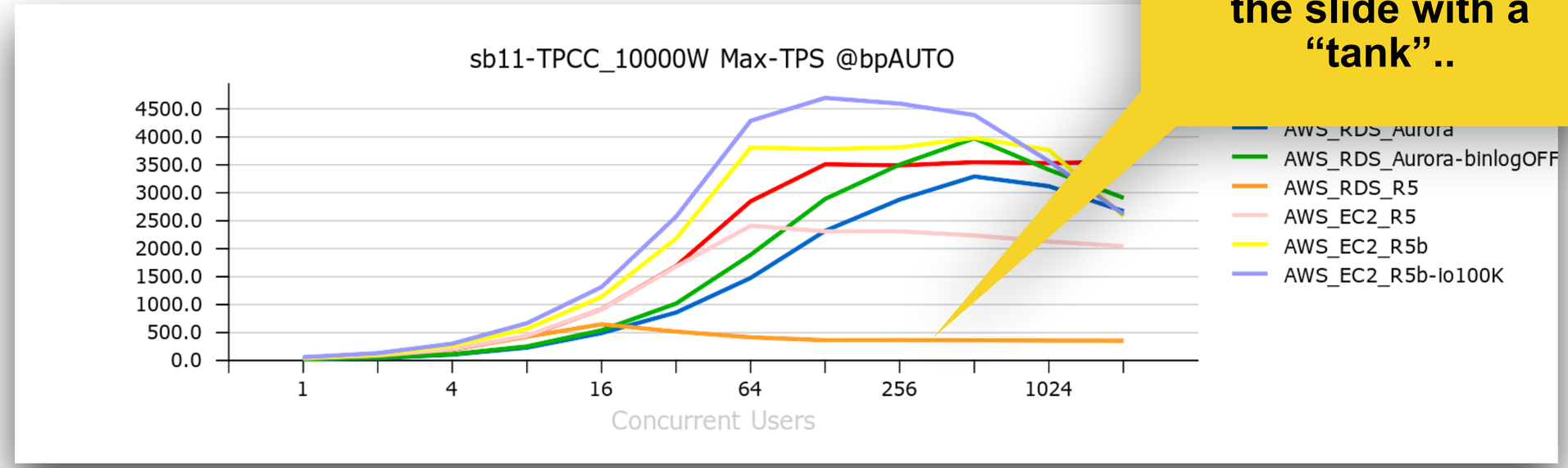
REDO	NOPART	8-PART	NOPART-ibuf5	8-PART-ibuf5
16G	11H58	05H47	12H19	05H50
64G	06H45	05H04	07H19	05H01
128G	06H43	04H57	06H59	04H55

6TB data

REDO	NOPART	8-PART	NOPART-ibuf5	8-PART-ibuf5
16G	20H14	09H10	22H57	09H16
64G	12H56	07H43	16H46	07H46
128G	12H07	07H35	16H09	07H41

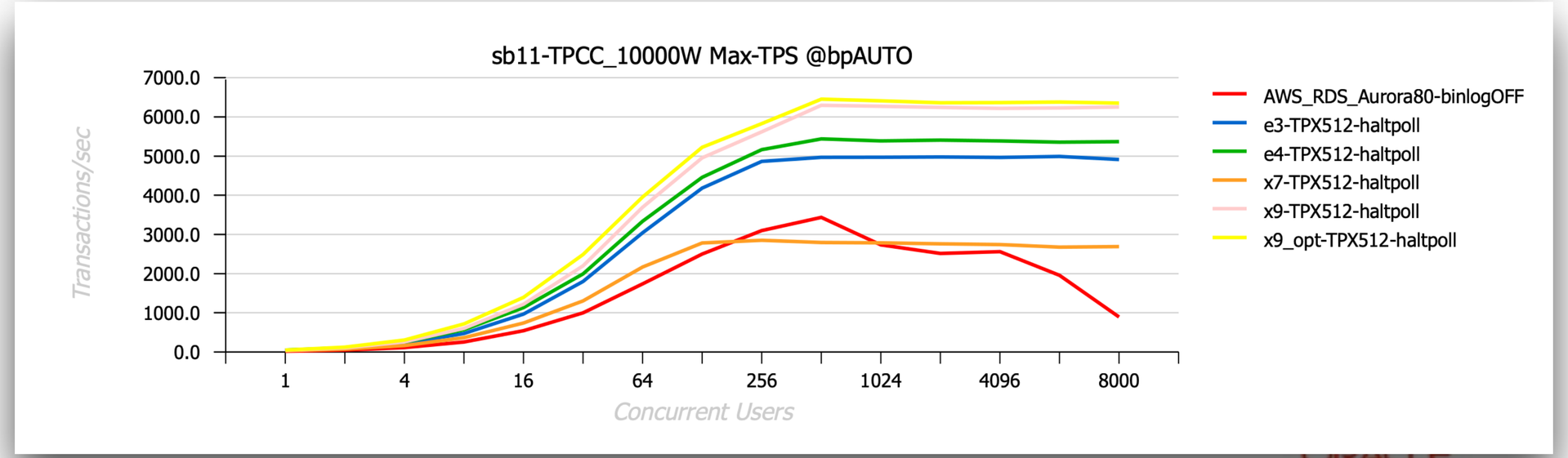
Few TPCC Results | 10000W (1TB), RAM 256G, 16cores

- Amazon
  - RDS
  - EC2
  - Aurora



If you recall the slide with a "tank"..

- MDS
  - E3
  - E4
  - X9



Hope everything is more clear now for you !

One more thing.. ;-))

- All graphs are built with ***dim_STAT*** (http://dimitrik.free.fr)
  - All System load stats (CPU, I/O, Network, RAM, Processes, etc..)
    - Mainly for Linux x64 / arm64 / MacOS (but can be any other UNIX too :-))
    - Add-Ons for MySQL, Oracle DB, PostgreSQL, Java, etc.
  - MySQL Add-Ons:
    - mysqlLOAD : compact stats data, multi-host monitoring oriented
    - mysqlWAITS : top wait events from Performance SCHEMA
    - InnodbSTAT : most important data from InnoDB status
    - innodbMUTEX : monitoring InnoDB mutex waits
    - innodbMETRICS : all counters from the METRICS table
    - Perf Profiling / DTrace call-stacks / etc..

- Links
  - http://dimitrik.free.fr - dim_STAT
  - http://dimitrik.free.fr/blog/posts/mysql-perf-bmk-kit.html - BMK-kit
  - http://dimitrik.free.fr/blog - Articles about MySQL Performance, etc.

Thank You !!!

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