MySQL 5.7 Performance: Scalability & Benchmarks

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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

- Overview of MySQL Performance
- Workload oriented tuning and MySQL Internals
- Performance improvements in MySQL 5.7 & Benchmark results
- Pending issues..
- Q & A

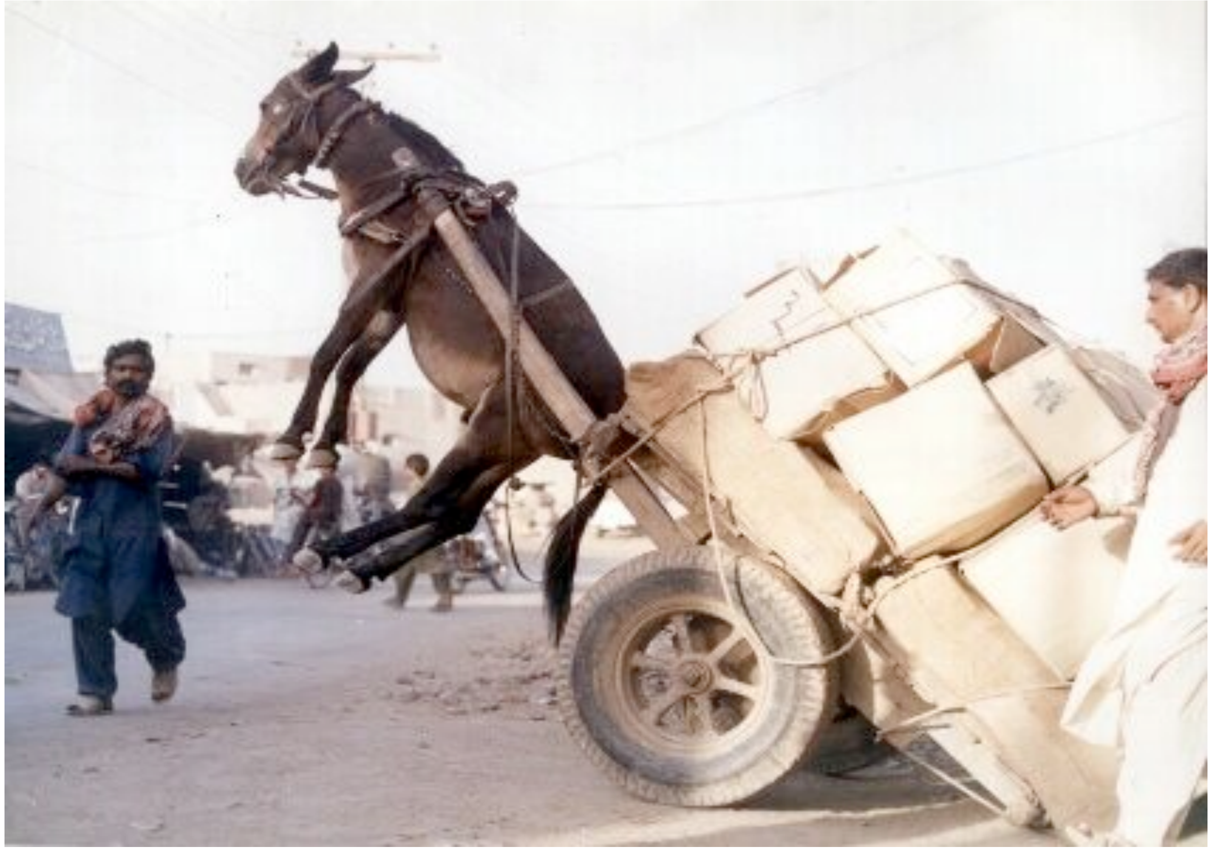
Why MySQL Performance ?...

Why benchmarking MySQL?..

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

Why benchmarking MySQL?..

- Until it did not reach its limit..



Why benchmarking MySQL?..

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

Why benchmarking MySQL?..

- And reach a similar limit..

Why benchmarking MySQL?..

- A good benchmark testing may help you to understand ahead the resistance of your solution to incoming potential problems ;-)

Why benchmarking MySQL?..

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

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

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

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

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

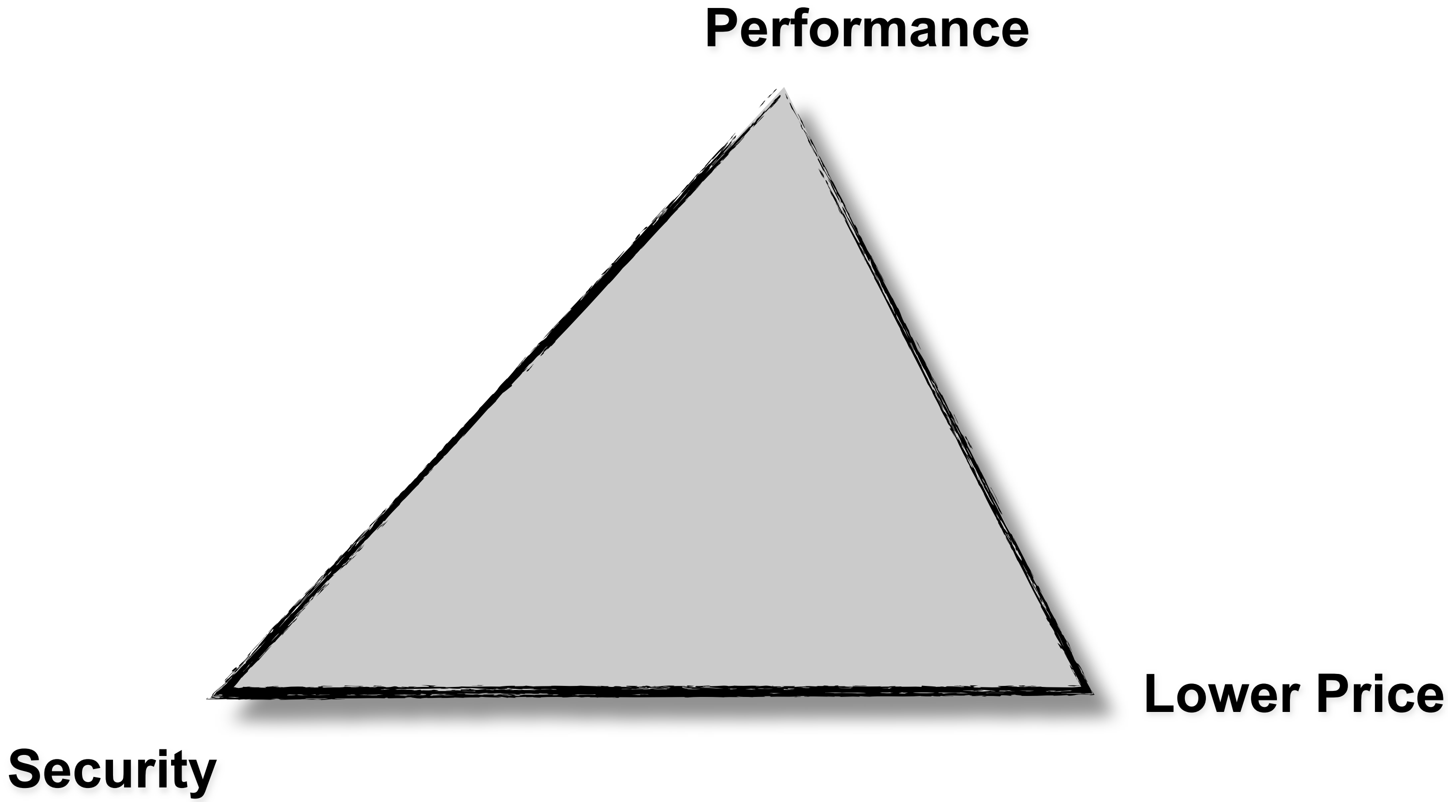
USE YOUR BRAIN !!!... ;-)

THE MAIN SLIDE! ;-))

Think “Database Performance” from the beginning!

- Server:
  - Having faster CPU is still better! 32 cores is good enough ;-)
  - OS is important! - Linux, Solaris, etc.. (and Windows too!)
  - Right malloc() lib!! (Linux: jemalloc, Solaris: libumem)
- Storage:
  - Don't use slow disks! (except if this is a test validation goal :-))
  - Flash helps when access is random! (reads are the most costly)
  - FS is important! - ZFS, UFS, QFS, VxFS, EXT3, EXT4, XFS, etc..
  - O_DIRECT or not O_DIRECT, AIO or not AIO, and be aware of bugs! ;-)
  - **Do some generic I/O tests first !!** (Sysbench, IObench, iozone, etc.)
- Don't forget network !! :-) (faster is better, 10Gbit is great!)

Seek for your best option..



Only a real test gives you a real answer...

- So, benchmark! ;-) -- And start with a clear goal!
  - Otherwise: I've obtained all these results, and now... so what?..
- Want to simulate your production workload?..
  - Then just simulate it! (many SW available, not always OSS/free)
  - Hard to simulate? - adapt some generic tests
- Want to know capacity limits of a given platform?
  - Still try to focus on the test which are most significant for you!
- Want just to validate config settings impacts?
  - Focus on tests which are potentially depending on these settings
  - Or any, if the goal is to prove there are not depending ;-)
- Well, just **keep thinking** about what you're doing ;-)

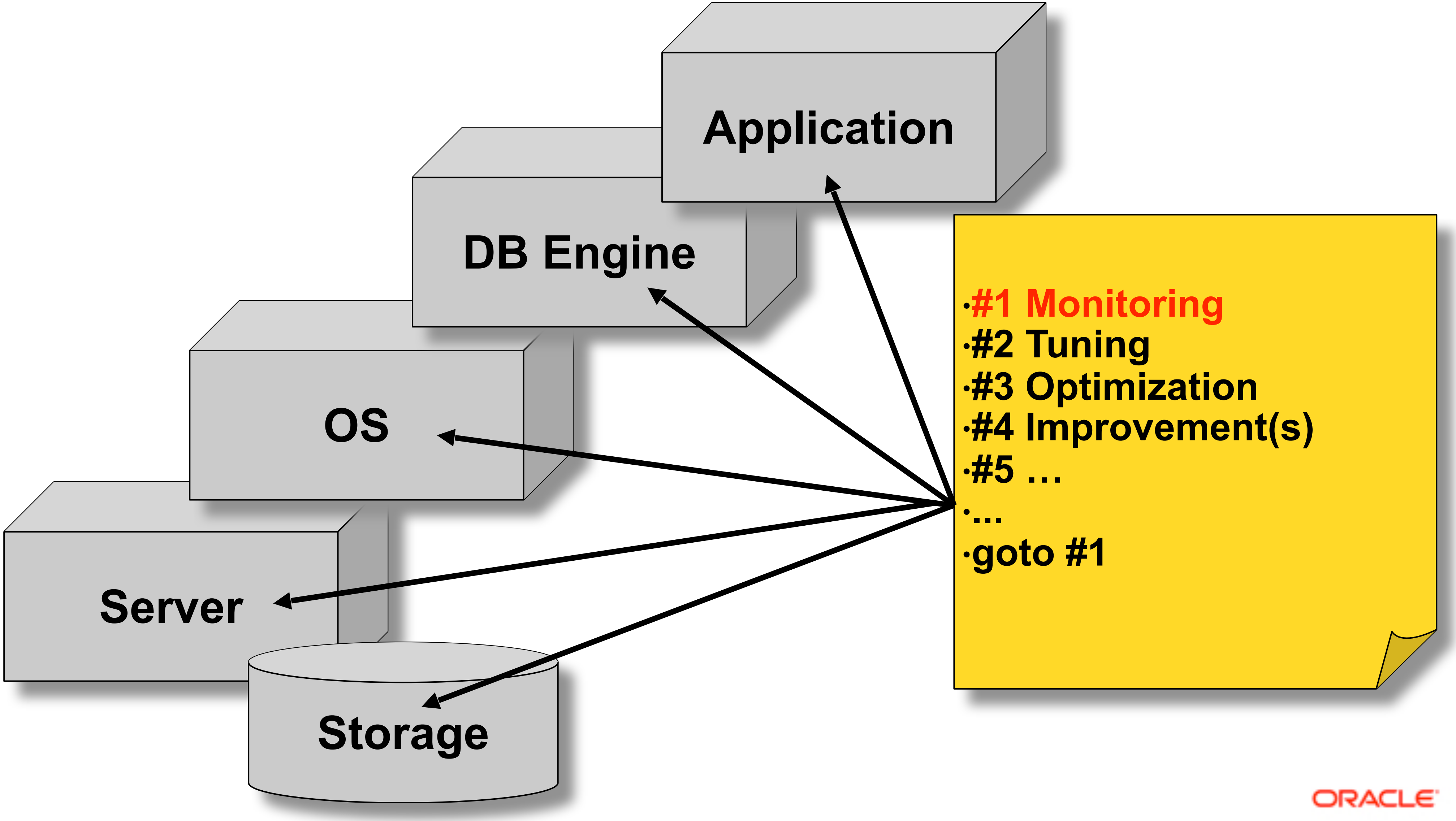
Test Workload

- Before to do 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..

“Generic” Test Workloads @MySQL

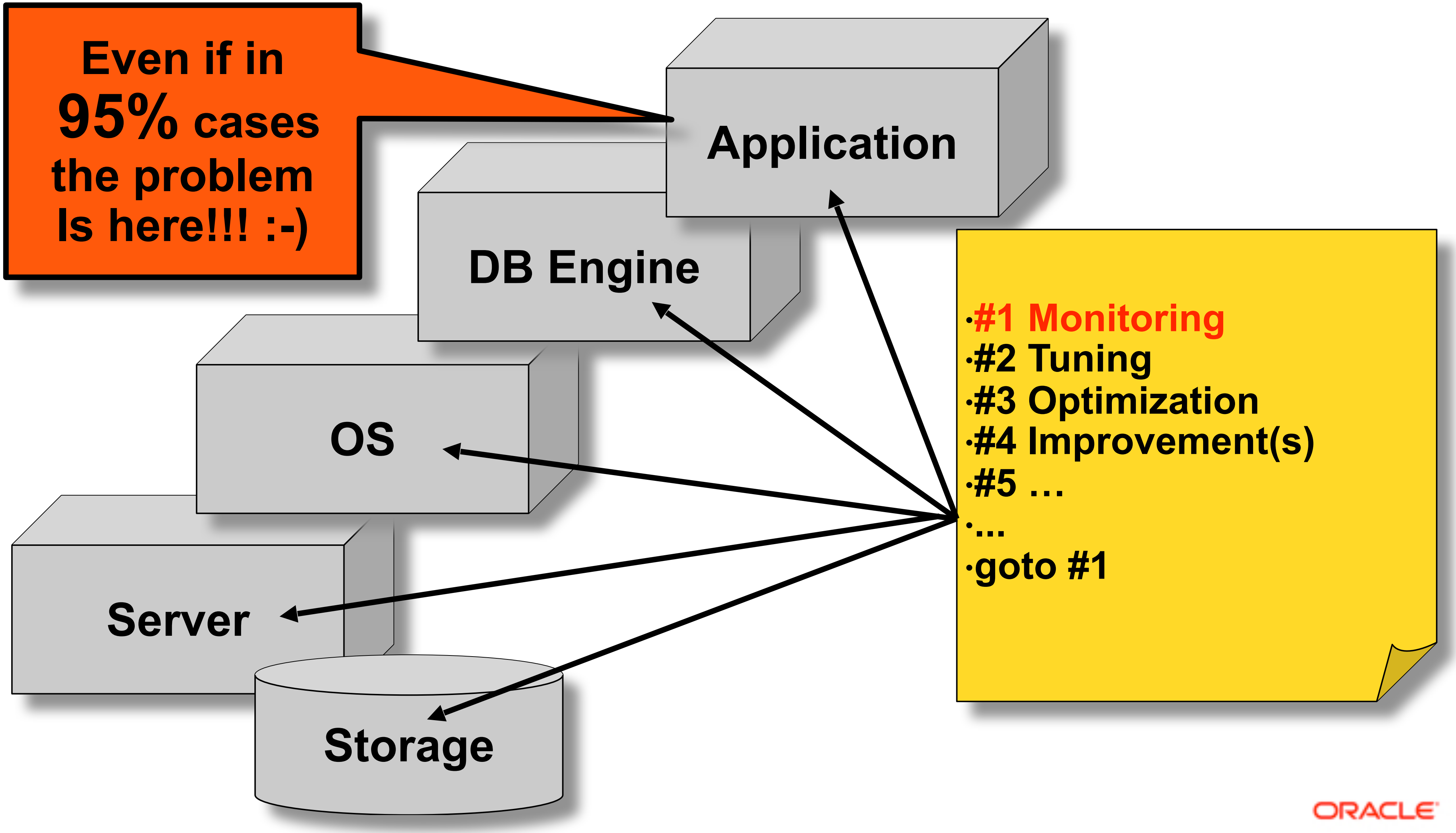
- Sysbench
  - OLTP, RO/RW, 1-table, since v0.5 N-table(s), lots load options, deadlocks
- DBT2 / TPCC-like
  - OLTP, RW, very complex, growing db, no options, deadlocks
  - In fact using mostly only 2 tables! (thanks Performance Schema ;-))
- dbSTRESS
  - OLTP, RO/RW, several tables, one most hot, configurable, no deadlocks
- linkbench (Facebook)
  - OLTP, RW, very intensive, IO-hungry..
- DBT3
  - DWH, RO, complex heavy query, loved by Optimizer Team ;-)

The Infinitive Loop of Database Tuning...



- #1 Monitoring
- #2 Tuning
- #3 Optimization
- #4 Improvement(s)
- #5 …
- …
- goto #1

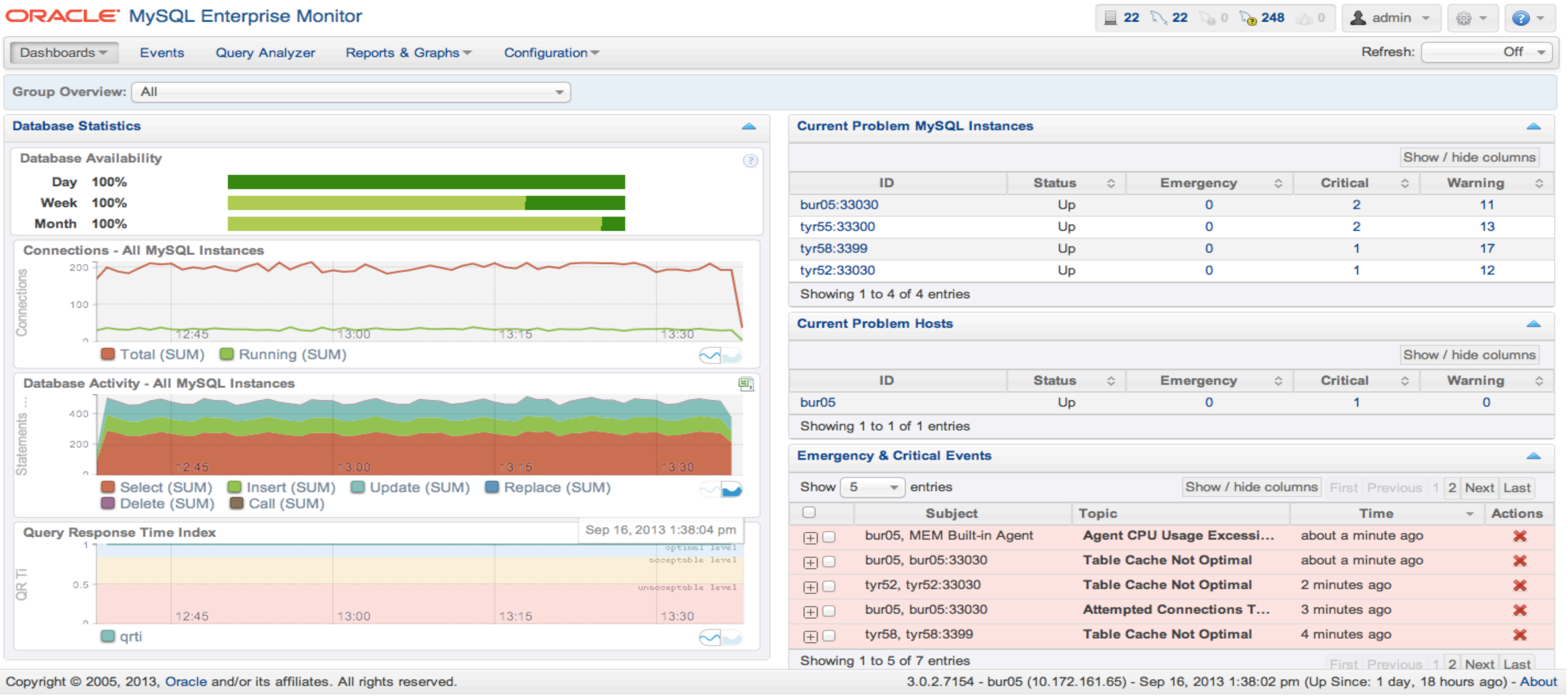
The Infinitive Loop of Database Tuning...



- #1 Monitoring
- #2 Tuning
- #3 Optimization
- #4 Improvement(s)
- #5 …
- …
- goto #1

MySQL Enterprise Monitor

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



ORACLE MySQL Enterprise Monitor

22 22 0 248 0 admin

Dashboards Events Query Analyzer Reports & Graphs Configuration

Refresh: Off

Group Overview: All

Database Statistics

Database Availability

Day	100%	
Week	100%	
Month	100%	

Connections - All MySQL Instances

Database Activity - All MySQL Instances

Query Response Time Index

Sep 16, 2013 1:38:04 pm

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 1:38:02 pm (Up Since: 1 day, 18 hours ago) - About

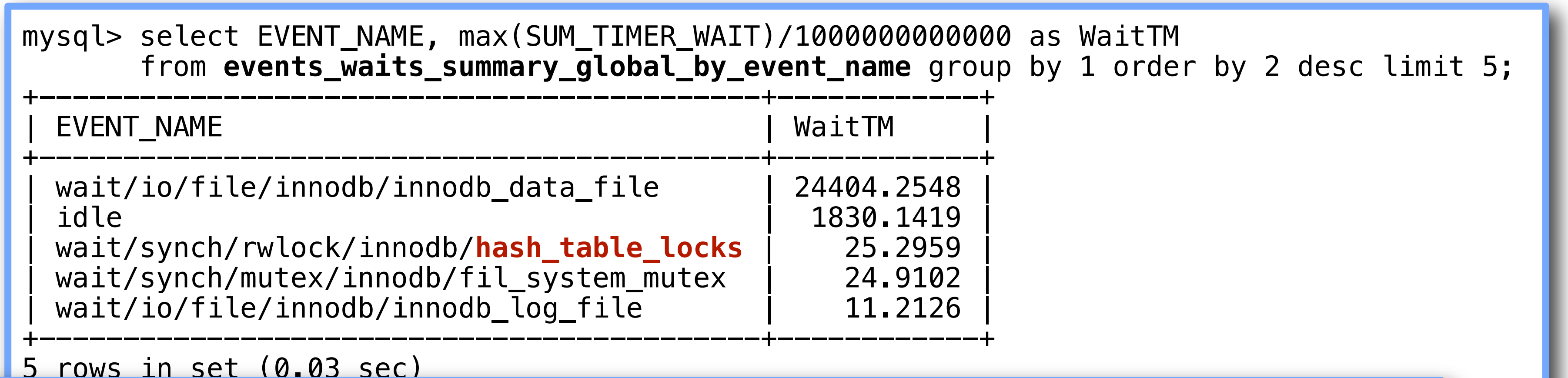
Other Monitoring Tools

- Cacti
- Zabbix
- Nagios
- Etc...

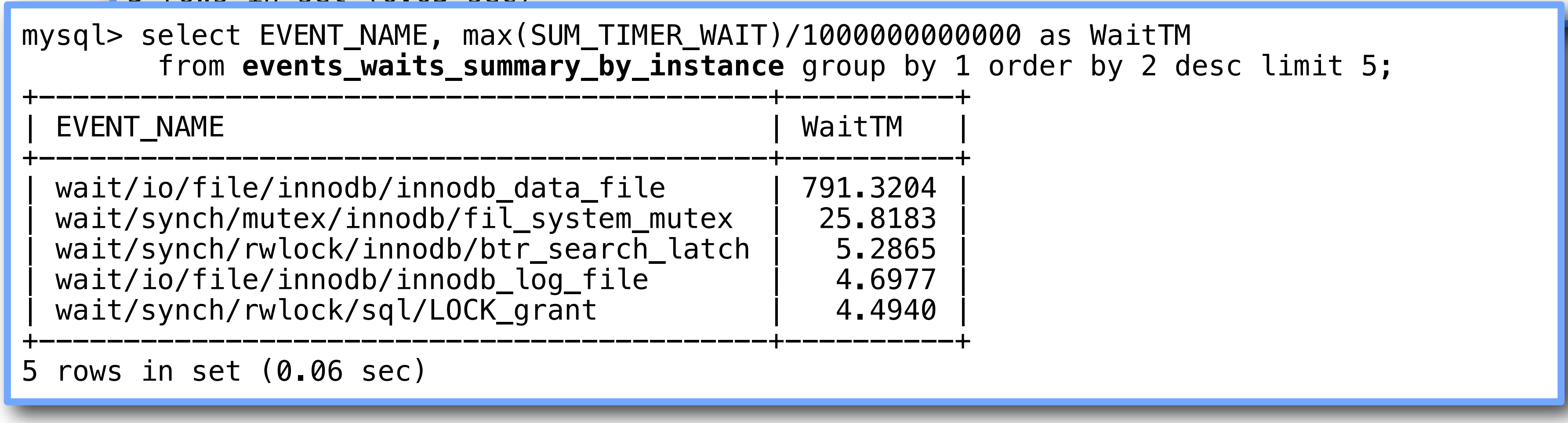
- dim_STAT
  - well, I'm using this one, sorry ;-)
  - all graphs within presentation were made with it
  - details are in the end of presentation..

Performance Schema: Gold Mine of Info!

- Just a point about how to analyze mutex lock **contentions**



```
mysql> select EVENT_NAME, max(SUM_TIMER_WAIT)/1000000000000 as WaitTM
       from events_waits_summary_global_by_event_name group by 1 order by 2 desc limit 5;
+-------------------------------------------+------------+
| EVENT_NAME                                | WaitTM     |
+-------------------------------------------+------------+
| wait/io/file/innodb/innodb_data_file      | 24404.2548 |
| idle                                      |  1830.1419 |
| wait/synch/rwlock/innodb/hash_table_locks |    25.2959 |
| wait/synch/mutex/innodb/fil_system_mutex  |    24.9102 |
| wait/io/file/innodb/innodb_log_file       |    11.2126 |
+-------------------------------------------+------------+
5 rows in set (0.03 sec)
```



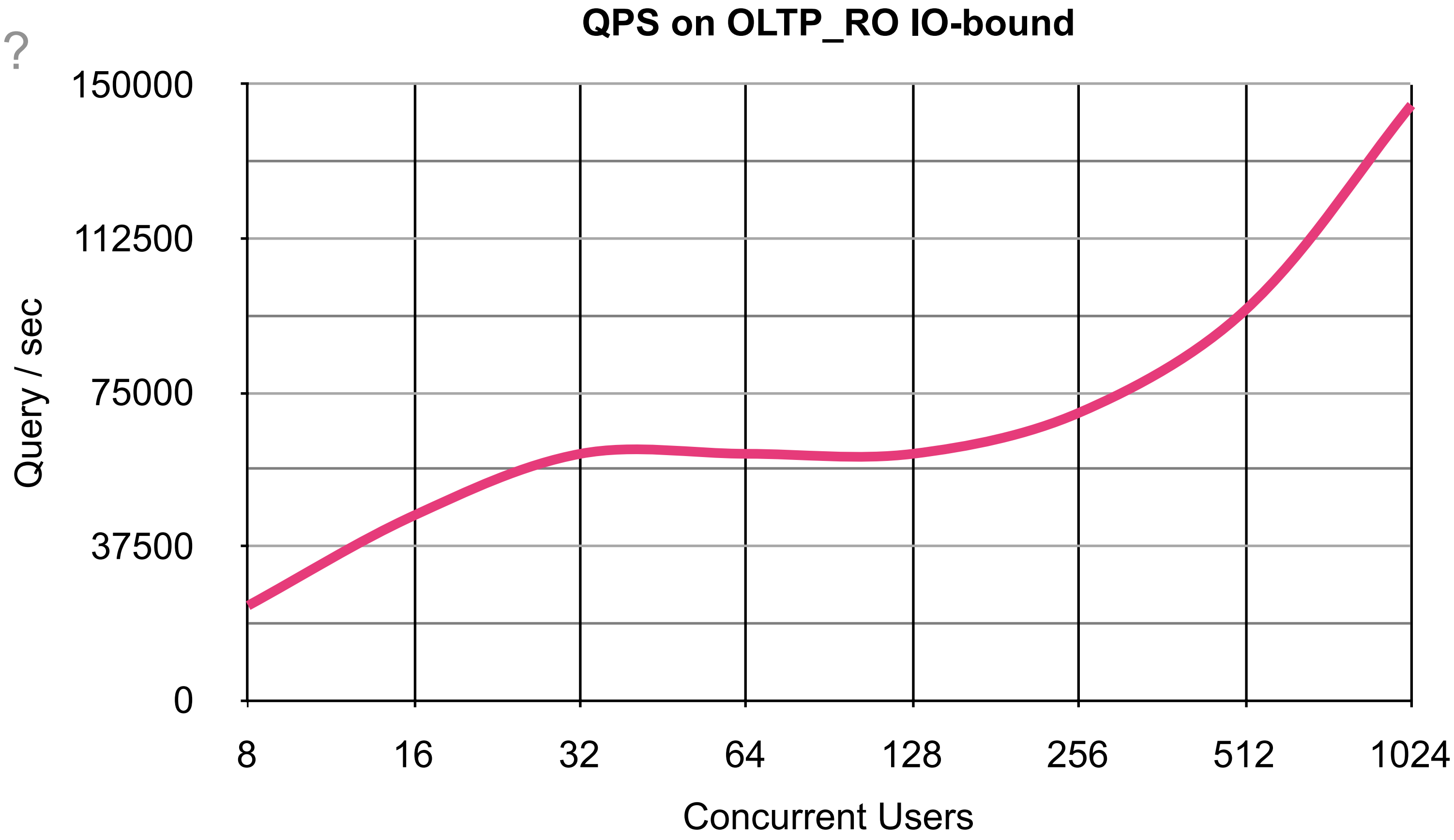
```
mysql> select EVENT_NAME, max(SUM_TIMER_WAIT)/1000000000000 as WaitTM
        from events_waits_summary_by_instance group by 1 order by 2 desc limit 5;
+-------------------------------------------+----------+
| EVENT_NAME                                | WaitTM   |
+-------------------------------------------+----------+
| wait/io/file/innodb/innodb_data_file      | 791.3204 |
| wait/synch/mutex/innodb/fil_system_mutex  |  25.8183 |
| wait/synch/rwlock/innodb/btr_search_latch |   5.2865 |
| wait/io/file/innodb/innodb_log_file       |   4.6977 |
| wait/synch/rwlock/sql/LOCK_grant          |   4.4940 |
+-------------------------------------------+----------+
5 rows in set (0.06 sec)
```

Basic Tuning

- Understanding HW platform **limits**
  - helps you to deploy your MySQL Server in the most optimal way..
- Understanding MySQL Server **internals**
  - helps you to configure your database settings in the most optimal way..
  - use the best adapted Storage Engine
- Understanding of your **Workload**
  - helps you to tune the whole solution in the most optimal way ;-)
  - 20% of known issues covering 80% of most common problems..
  - So, adapt some best practices from the beginning..
- There is **NO** “Silver Bullet” !!!
  - Think about the #1 MySQL Performance Best Practice ;-))

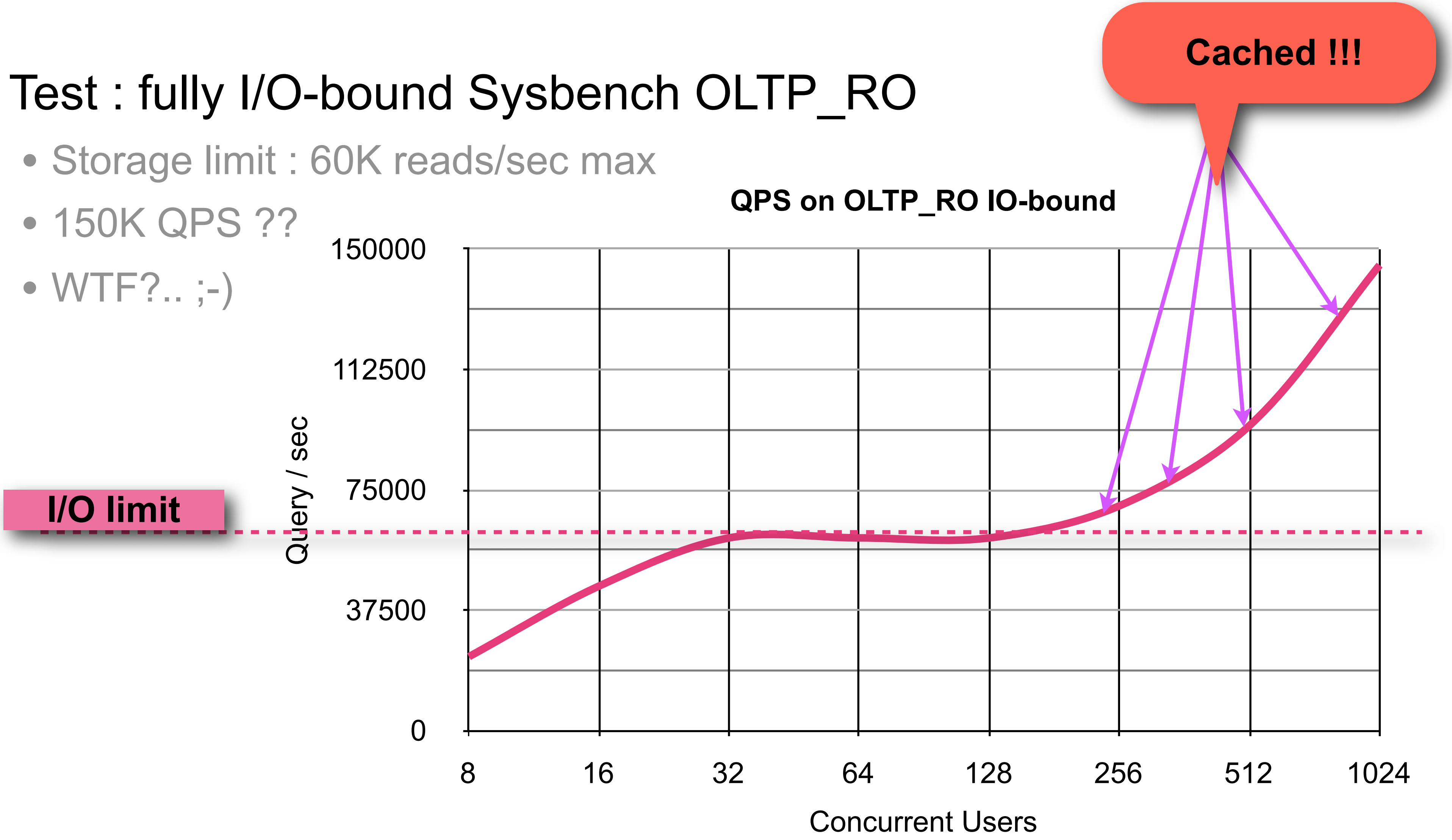
Let’s analyze the following benchmark result..

- Test : fully IO-bound OLTP_RO
  - Storage limit : 60K reads/sec max
  - 150K QPS ??
  - WTF?.. ;-)

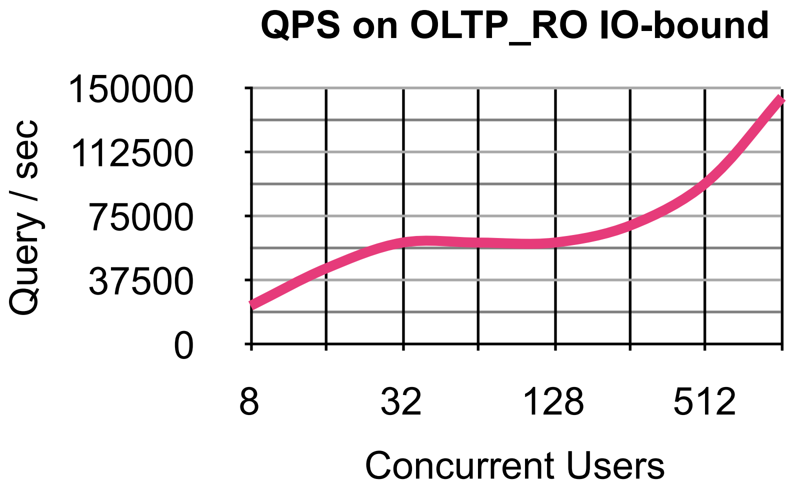


Let’s analyze the following benchmark result..

- Test : fully I/O-bound Sysbench OLTP_RO
  - Storage limit : 60K reads/sec max
  - 150K QPS ??
  - WTF?.. ;-)



Let’s analyze the following benchmark result..



- Test : fully IO-bound OLTP_RO
  - Storage limit : 60K reads/sec max
  - 150K QPS ??
  - WTF?.. ;-)
- The issue:
  - the random ID for a row acces is not that random as expected..
  - and with a higher workload the probability to get the same “random” row ID on the same time and by different threads only increasing..
  - workaround : for some of the tests started to use as many Sysbench processes as user threads (1 connection = 1 sysbench process)..

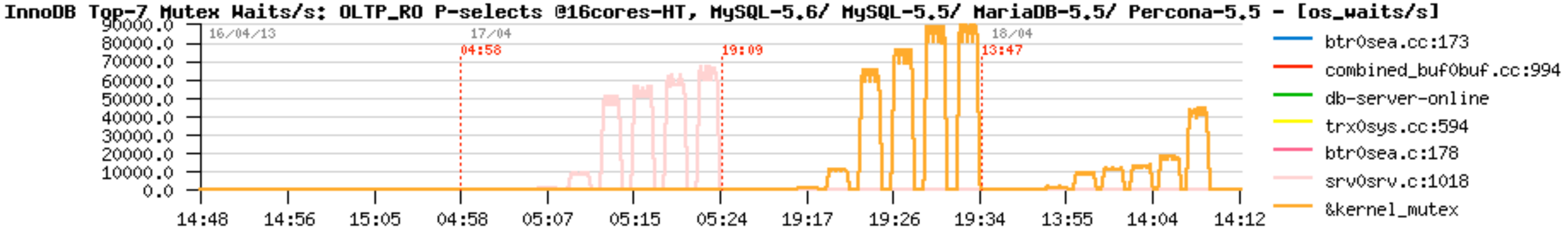
Analyzing Workloads...

- Read-Only (RO) :
  - Nothing more simple when comparing DB Engines, HW configs, etc..
  - RO In-Memory : data set fit in memory / BP / cache
  - RO IO-bound : data set out-passing a given memory / BP / cache
- Read+Write (RW) :
  - I/O is **ALWAYS** present ! - storage performance matters a lot !
  - may be considered as always IO-bound ;-)
  - RW In-Memory : same as RO, data set fit in memory, but :
    - small data set => small writes
    - big dataset => big writes ;-)
  - RW IO-bound : data set out-passing a memory
    - means there will be (a lot of?) reads !
    - don’t forget that I/O random reads = I/O killer !

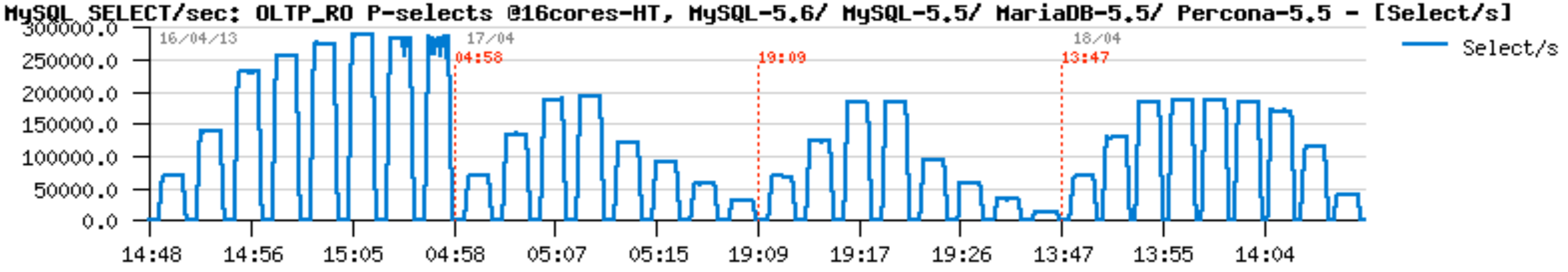
Workloads : Read-Only In-Memory

- Generally CPU / RAM bound + internal contentions ;-)
- 5.5 :
  - kernel_mutex
  - LOCK_open
  - + many other remane hidden ;-)
- 5.6 :
  - kernel_mutex => trx_sys + lock_sys
  - hot trx_sys : RO transactions, but can be impacted by RW
  - MDL : hash lock instances
  - LOCK_open : table cache instances
  - G5! (false cache sharing) ==> where Databases SW is hitting HPC ;-)
  - InnoDB spin lock delay
  - Adaptive hash index (AHI) : still unclear..
  - Memcached plugin

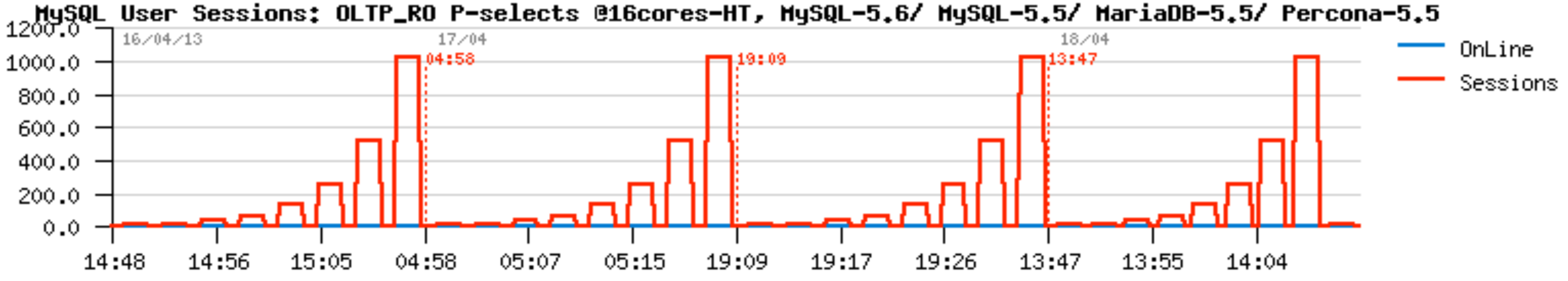
InnoDB: Read-Only Transactions in 5.6 (Apr.2013)



InnoDB Top-7 Mutex Waits/s: OLTP_RO P-selects @16cores-HT, MySQL-5.6/ MySQL-5.5/ MariaDB-5.5/ Percona-5.5 - [os_waits/s]



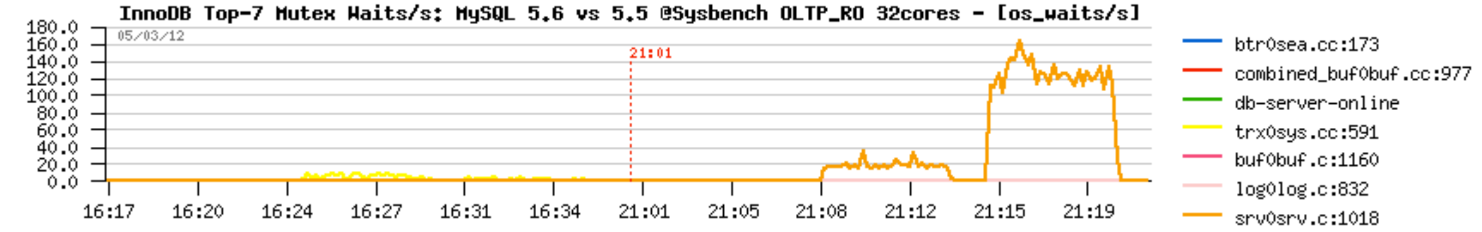
MySQL SELECT/sec: OLTP_RO P-selects @16cores-HT, MySQL-5.6/ MySQL-5.5/ MariaDB-5.5/ Percona-5.5 - [Select/s]

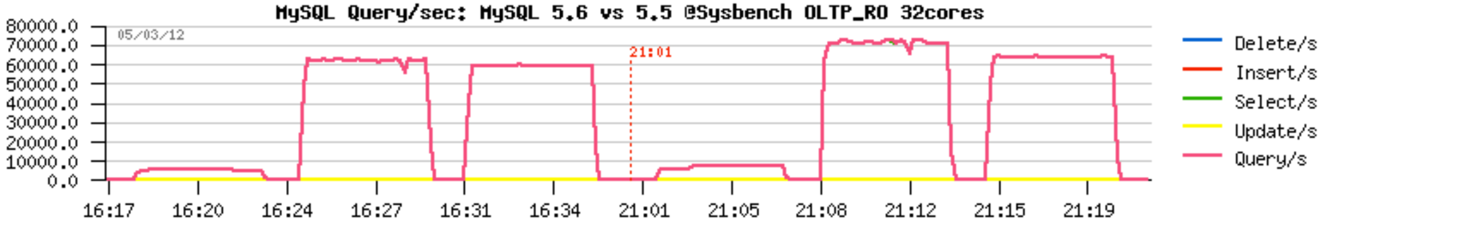


MySQL User Sessions: OLTP_RO P-selects @16cores-HT, MySQL-5.6/ MySQL-5.5/ MariaDB-5.5/ Percona-5.5

InnoDB : false sharing of cache-line = true killer

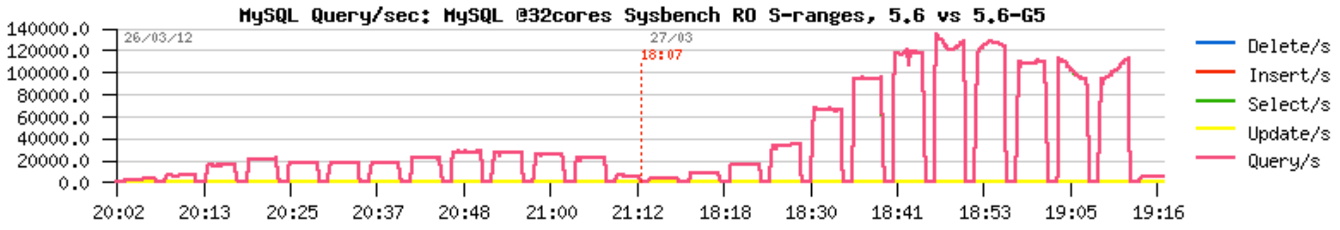
- RO or RW Workloads
  - Same symptoms in 5.5 & 5.6 : no QPS improvement between 16 and 32 user sessions:

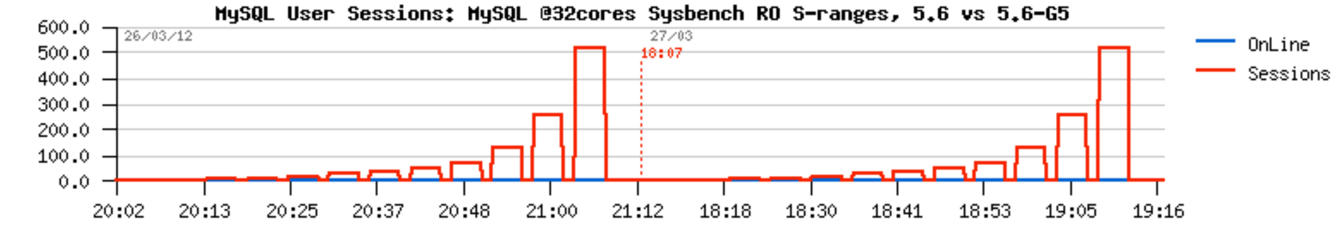




InnoDB : false sharing of cache-line fixed!

- RO or RW Workloads
  - “G5” patch! :-)
  - Over x2(!) times better on Sysbench OLTP_RO,
  - x6(!) times better on SIMPLE-Ranges!
  - NOTE: the fix is not applicable on 5.5..



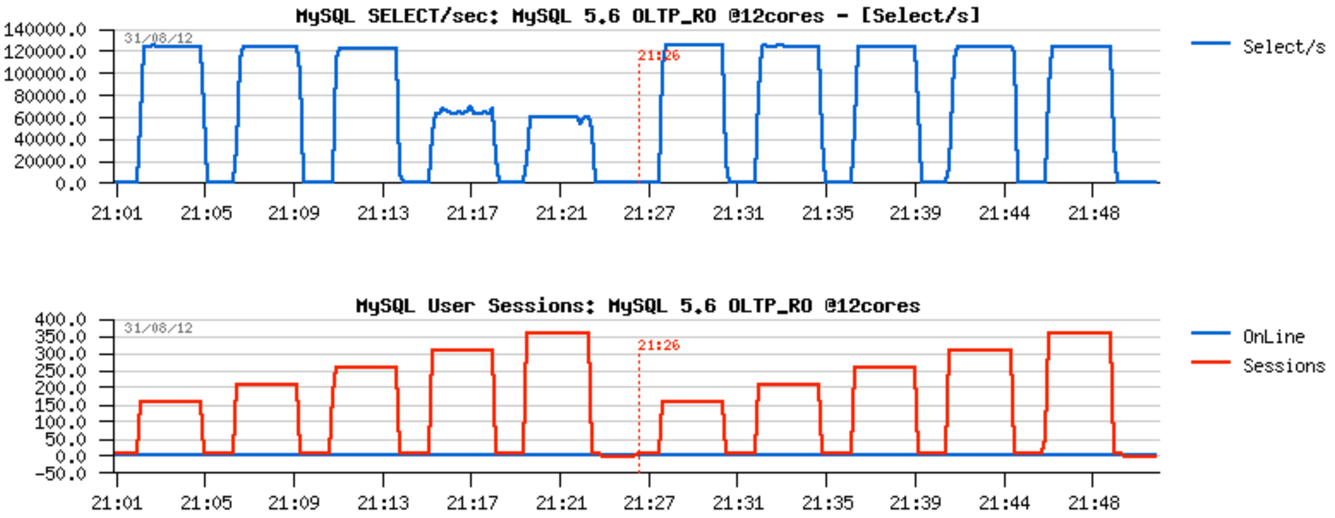


MySQL Internals: “killer” LOCK_open mutex

- MySQL 5.5 and before:
  - Keep “table_open_cache” setting big enough!
  - Monitor global status for '%opened%'
  - Once this contention become the most hot – well, time to upgrade to 5.6 ;-))
- Since MySQL 5.6:
  - Fixed: several table open cache instances
  - But it doesn't mean you can use a small “table_open_cache” either ;-)
  - Monitor PFS Waits!
  - Monitor “table_open_cache%” status variables!
  - Keep “table_open_cache_instances” at least bigger than 1

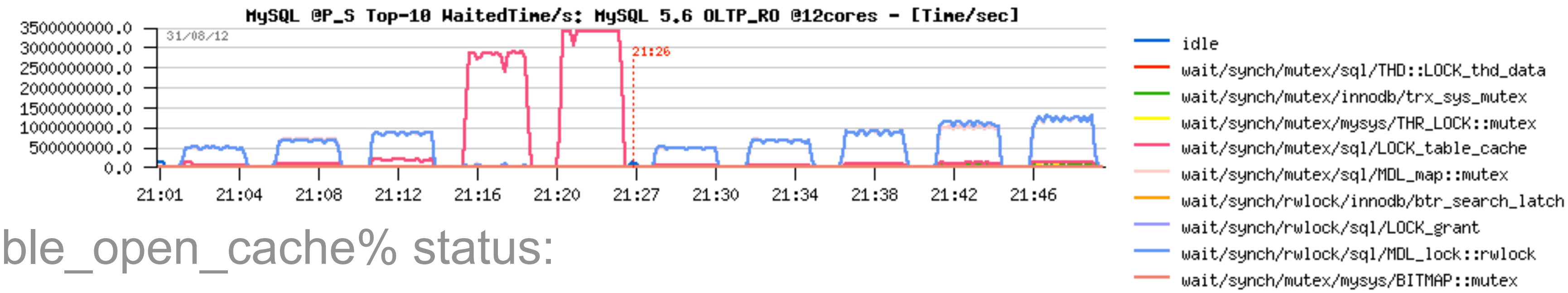
MySQL 5.6 Internals : low table_open_cache

- MySQL 5.6 :
  - Not big enough “table_open_cache” setting

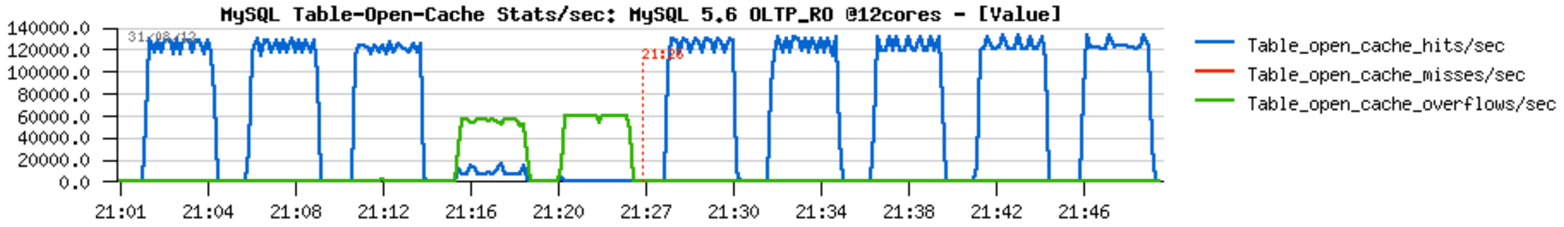


MySQL 5.6 Internals : low table_open_cache (2)

- MySQL 5.6 :
  - Not big enough “table_open_cache” setting
  - PFS Waits monitoring: LOCK_table_cache become the most hot:

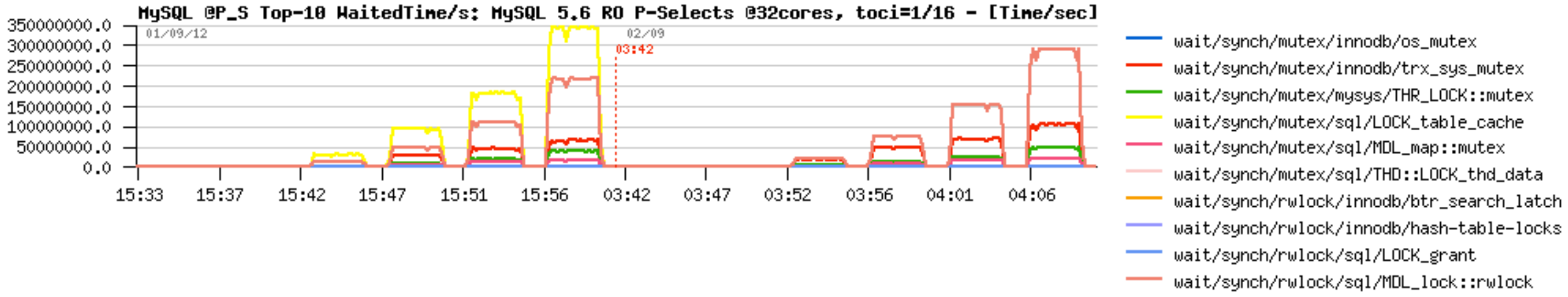


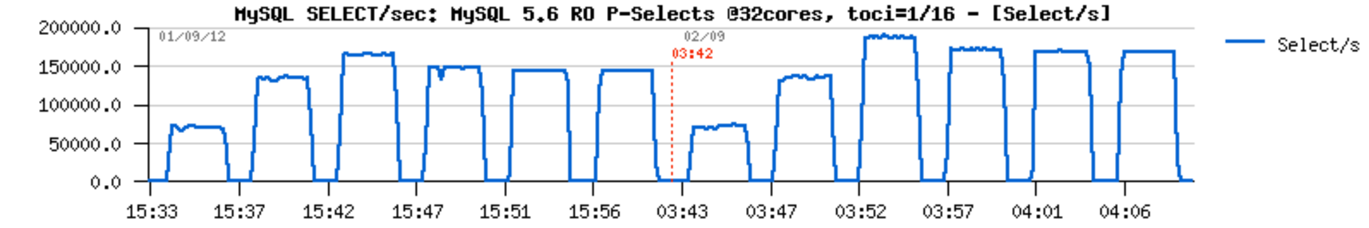
  - Table_open_cache% status:

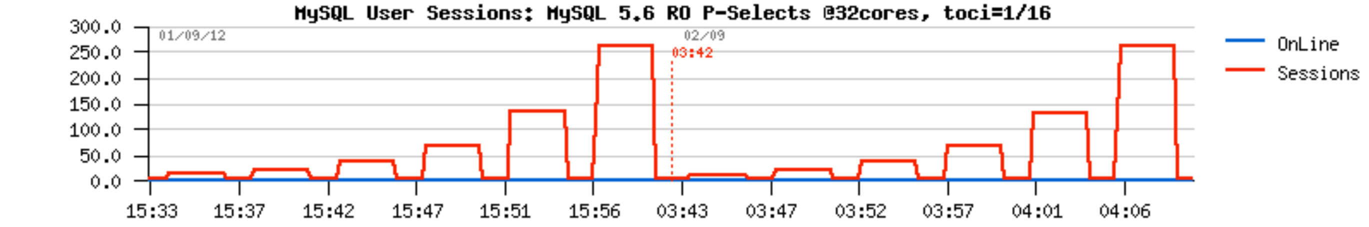


MySQL 5.6 Internals : table_open_cache_instances

- MySQL 5.6 :
  - When LOCK_table_cache wait is on top, the gain is usually well visible:





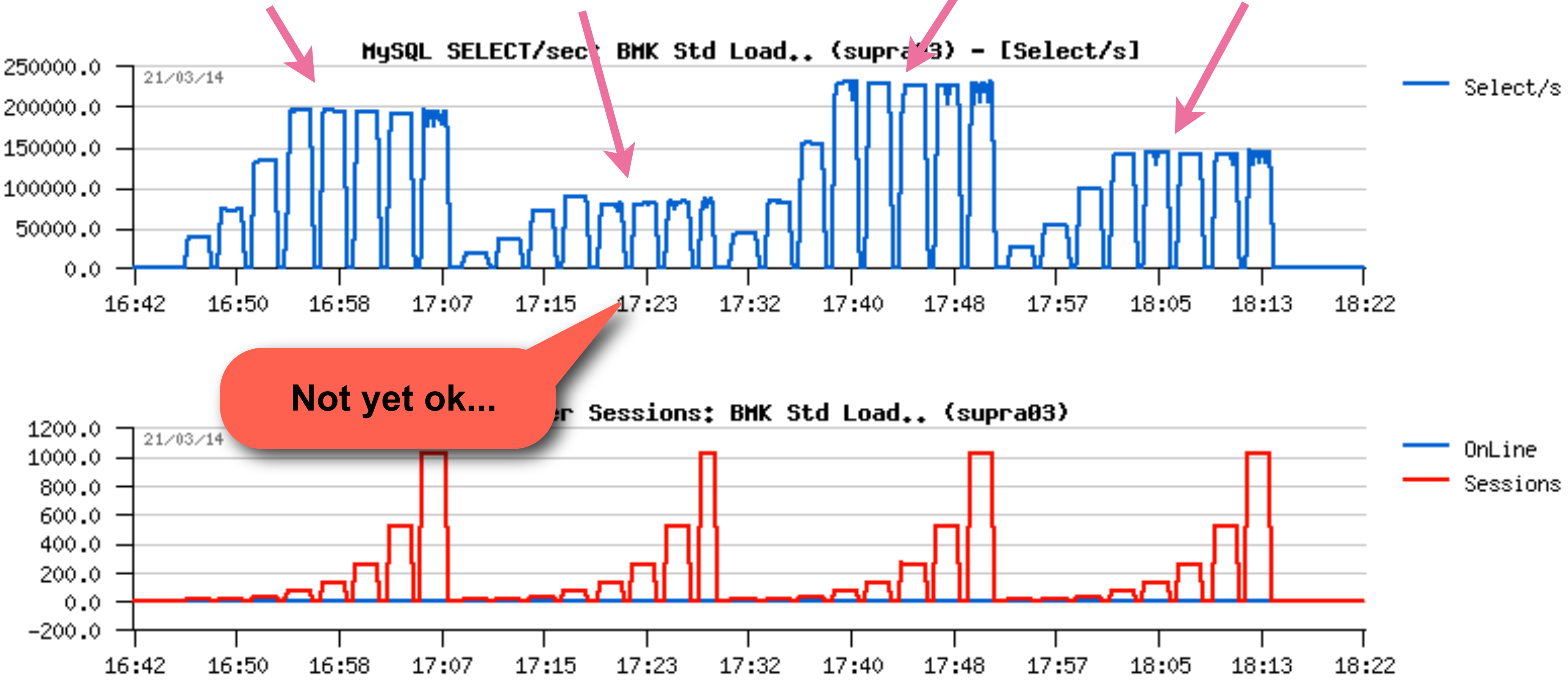


Workloads : Read-Only In-Memory @MySQL 5.7

- 5.7 :
  - trx_sys : redesigned TRX list! (yet better than RO transactions)
    - made MDL very hot !
  - MDL : lock free since DMR4 !!
    - made THR_lock very hot!! fix in pipe ;-)
  - Connect : remastered => 70K connect/disconnect/sec
  - QPS :
    - SQL : **over 500K (!) QPS** (SQL) on point-selects
    - Memcached plugin : **rocks over 1M (!)** QPS
  - InnoDB spin lock delay : still remains !
  - Scalability: very good, but RO Dranges remains..
  - AHI : remains

Sysbench OLTP_RO Workloads @MySQL 5.7

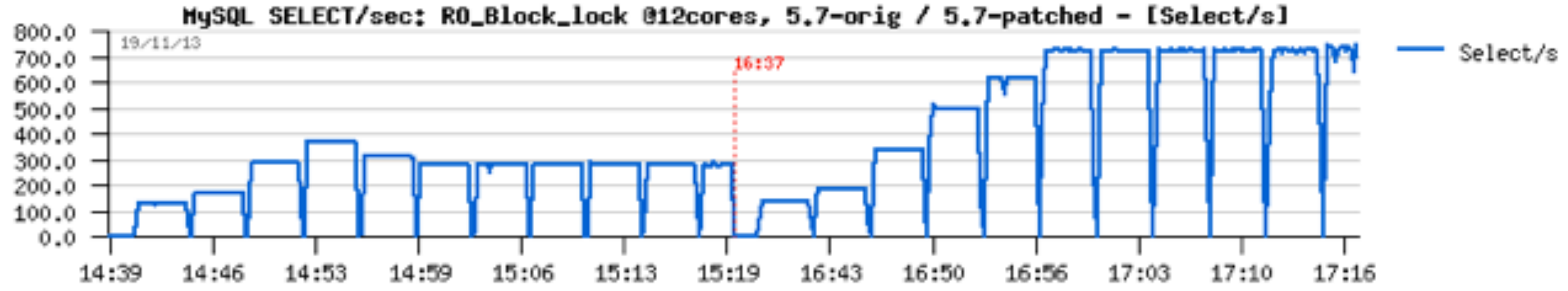
- Simple ranges, Distinct ranges, SUM ranges, Ordered ranges

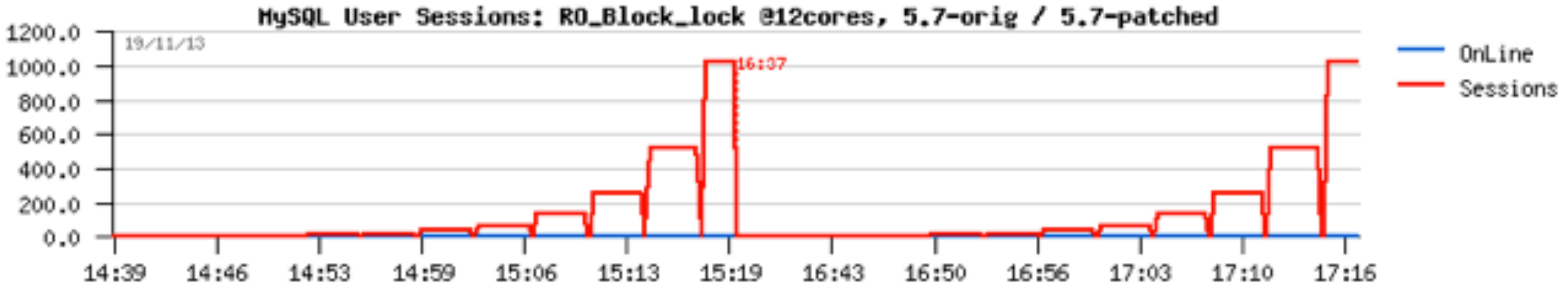


Not yet ok...

InnoDB block lock contentions...

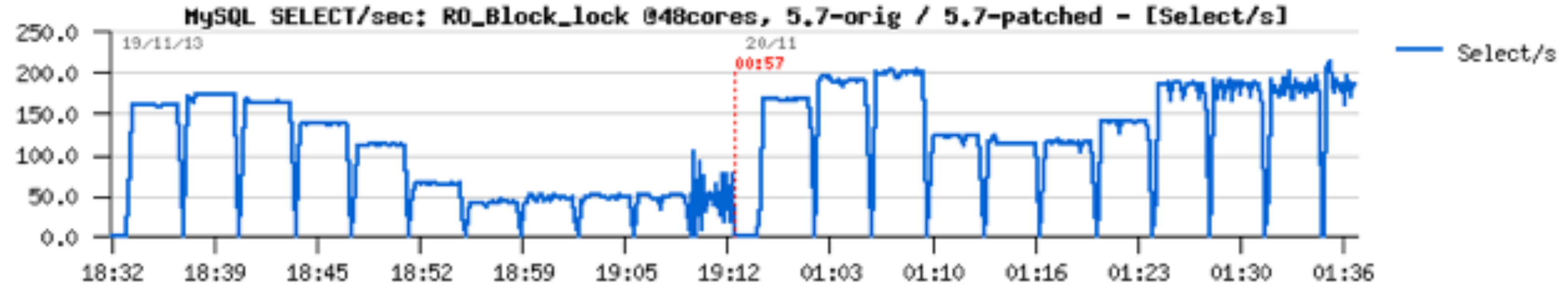
- Being here from a long long time (by design)..
- Improved in 2013, but not yet fully fixed..
- Can be seen as :

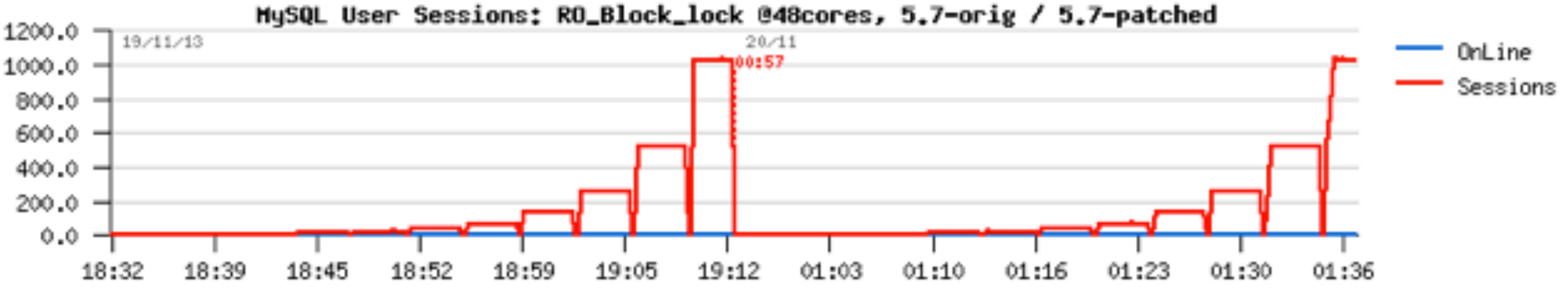




InnoDB block lock contentions... (cont.)

- Being here from a long long time (by design)..
- Improved in 2013, but not yet fully fixed..
- But also as :



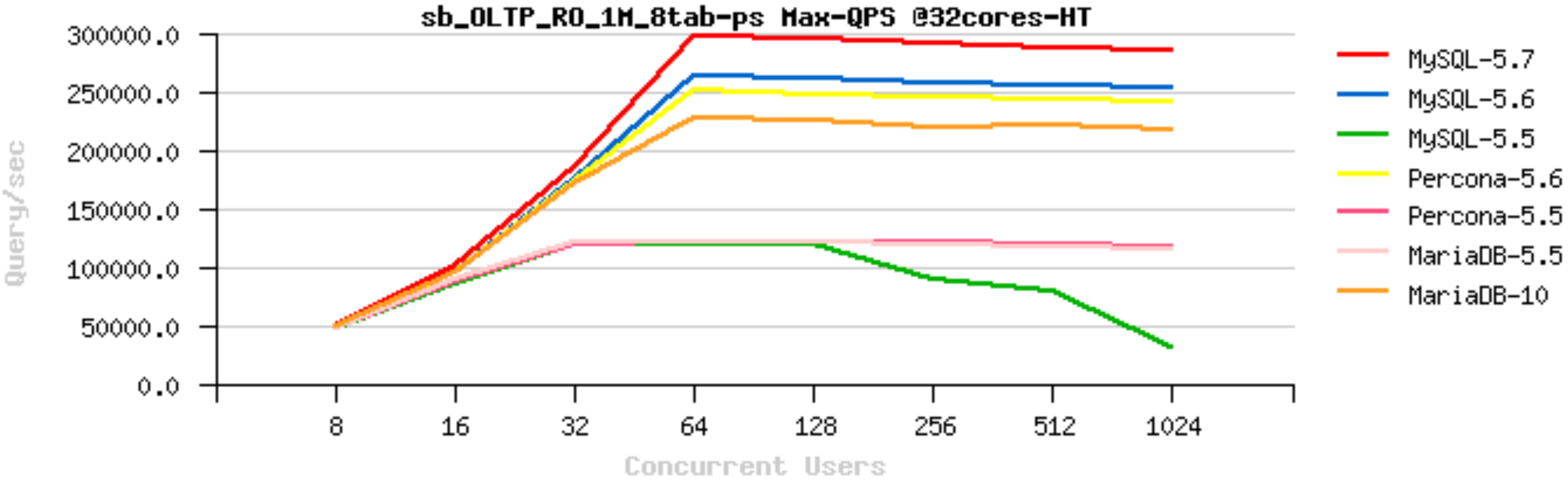


InnoDB block lock contentions... (cont.)

- Being here from a long long time (by design)..
- Improved in 2013, but not yet fully fixed..
- A true fix requires a full redesign of block related internals..
  - in TODO, but not for tomorrow ;-)
- Workarounds :
  - QueryCache ;-) well, any kind of cache ;-)
  - BTW, because of a widely used caching solutions around of MySQL servers in production made this issue “invisible” for so long time.. (that’s why)..

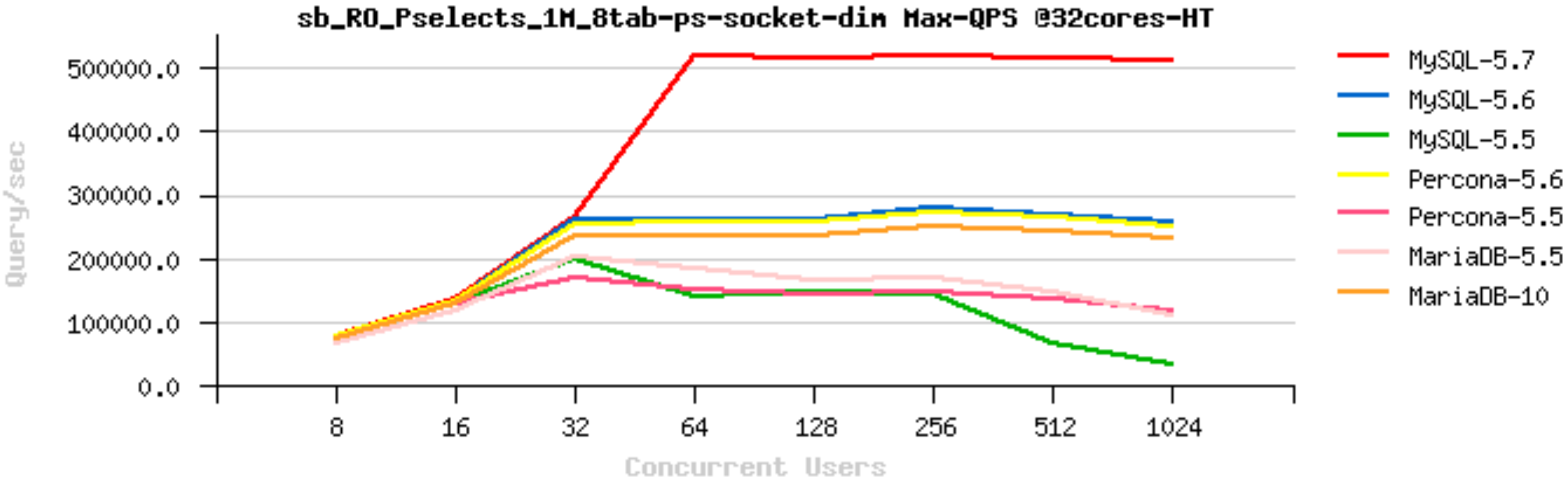
RO In-Memory @MySQL 5.7

- Sysbench OLTP_RO 8-tables, 32cores-HT :



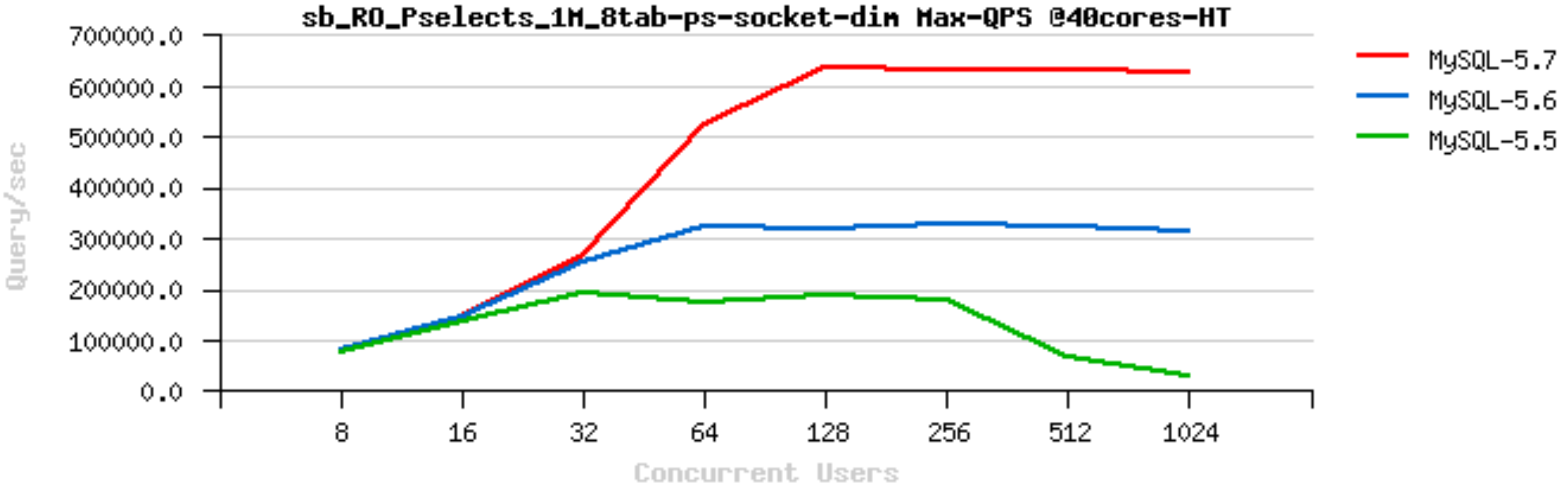
RO In-Memory @MySQL 5.7

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



RO In-Memory @MySQL 5.7

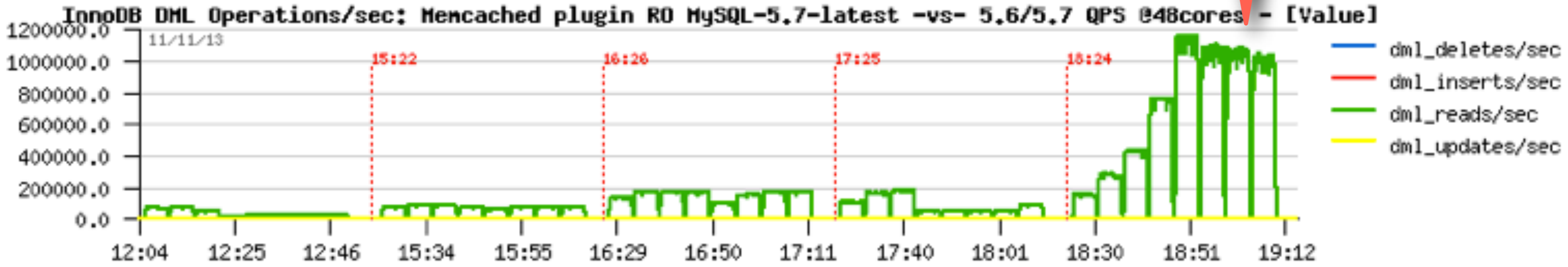
- **635K QPS** Sysbench Point-Selects 8-tab, 40cores-HT :

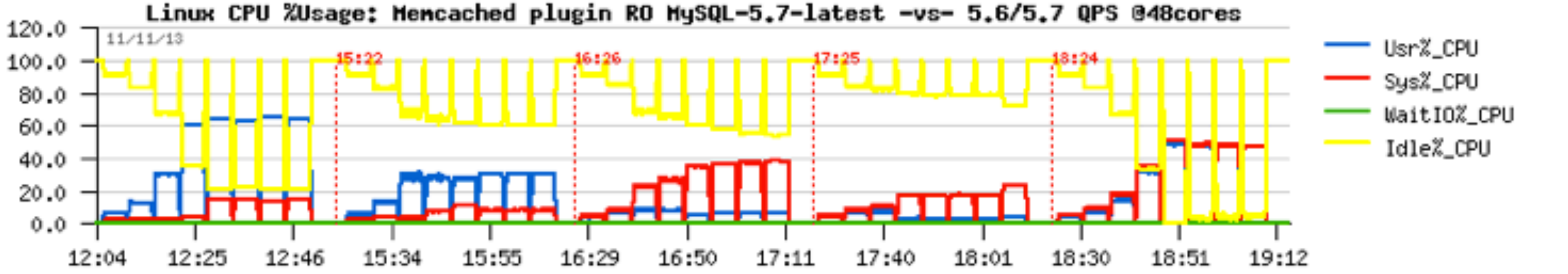


InnoDB Memcached @MySQL 5.7

- **Over 1M (!) QPS** on 48cores-HT :

That's it ;-)





Read-Only : IO-bound

- 5.5 : hmm..
- 5.6 / 5.7 :
  - LRU driven : just page eviction, see METRICS stats
  - HDD : limited by your I/O layer..
  - SDD : limited by your I/O layer..
  - Really Fast Flash (LSI, Fusion-io, etc.) :
    - avg load : follow I/O performance
    - high load: file_sys mutex contention...
  - also consider : innodb_old_blocks_time & innodb_old_blocks_pct
- 5.7 :
  - excessive page scan is fixed

Read+Write Workloads : In-Memory

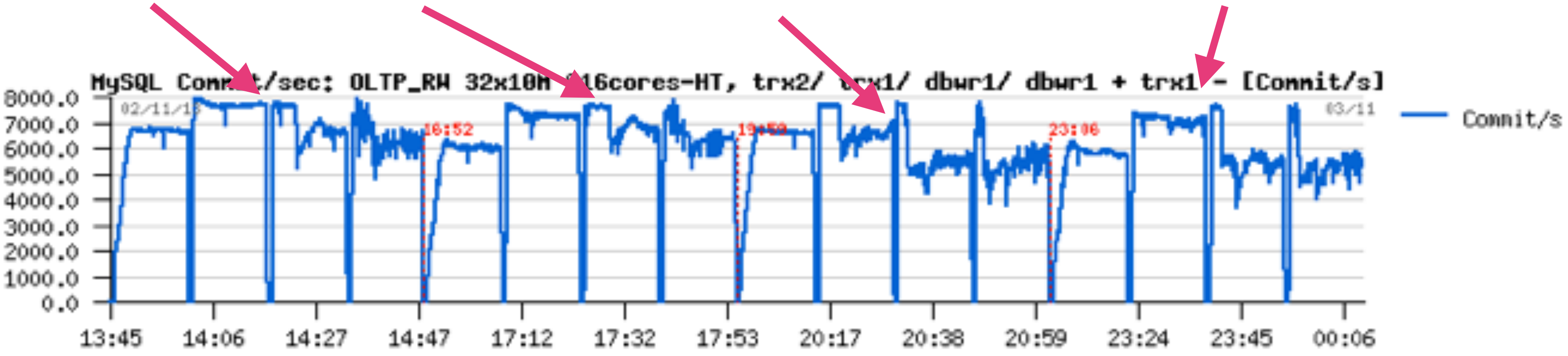
- Main points :
  - Processing itself / Data Safety
  - Internal contentions / Design limitations
  - Flushing / Checkpoint
  - Purge

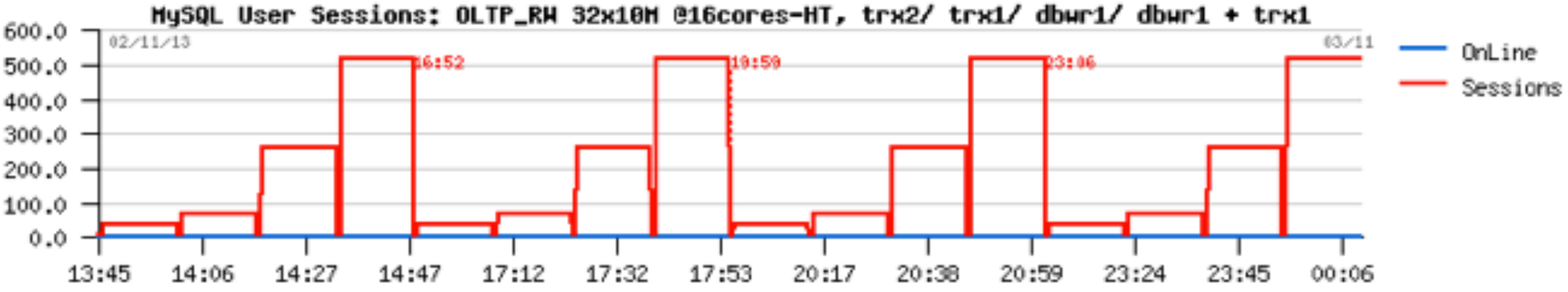
Read+Write Workloads : In-Memory

- Processing itself
  - your CPU-bound transactional processing defines your Max possible TPS
  - with a bigger volume / more IO / etc. => Max TPS will not increase ;-)
- Data Safety
  - binlog : overhead + bottleneck (be sure you have binlog group commit)
  - InnoDB checksums : overhead (reasonable since crc32 is used)
  - innodb_flush_log_at_trx_commit = 1 : overhead, low on “good” storage
  - InnoDB double write buffer : **KILLER** ! overhead + bottleneck..
    - need a fix / re-design / etc. in urgency ;-)
    - Fusion-io atomic writes is one of (**true** support in MySQL 5.7)
    - Facebook solution is very attractive too
    - but a true re-design is still preferable ;-)

Impact of “safety” options..

- OLTP_RW 32x10M-tables @Percona-5.6
  - (trx=2)(trx=1 + chksum=1)(dblwr=1)(trx=1 + chksum=1 + dblwr=1)





Impact of “safety” options..

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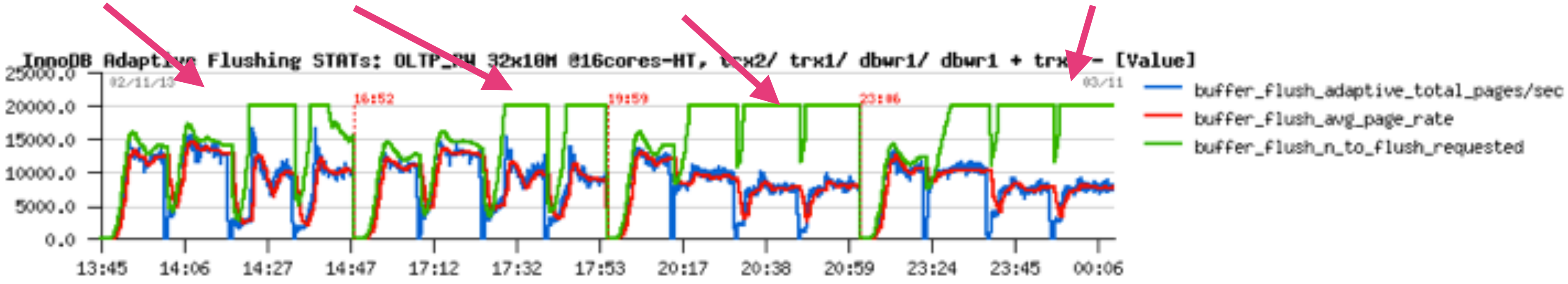
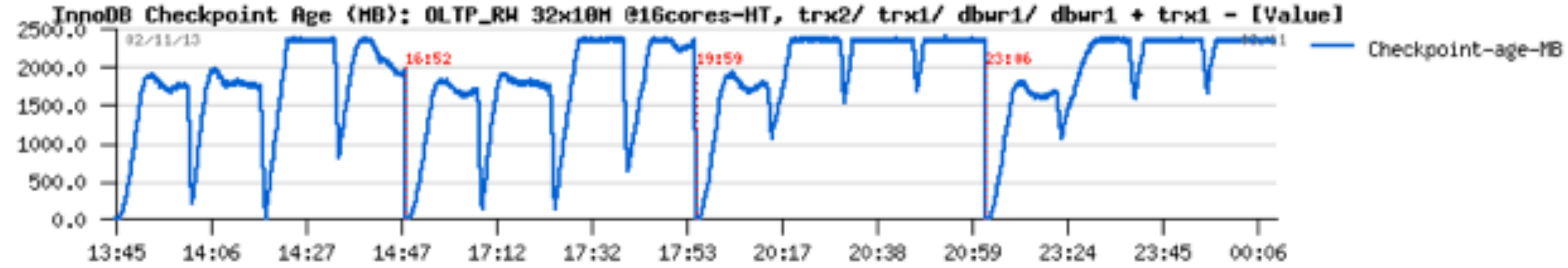


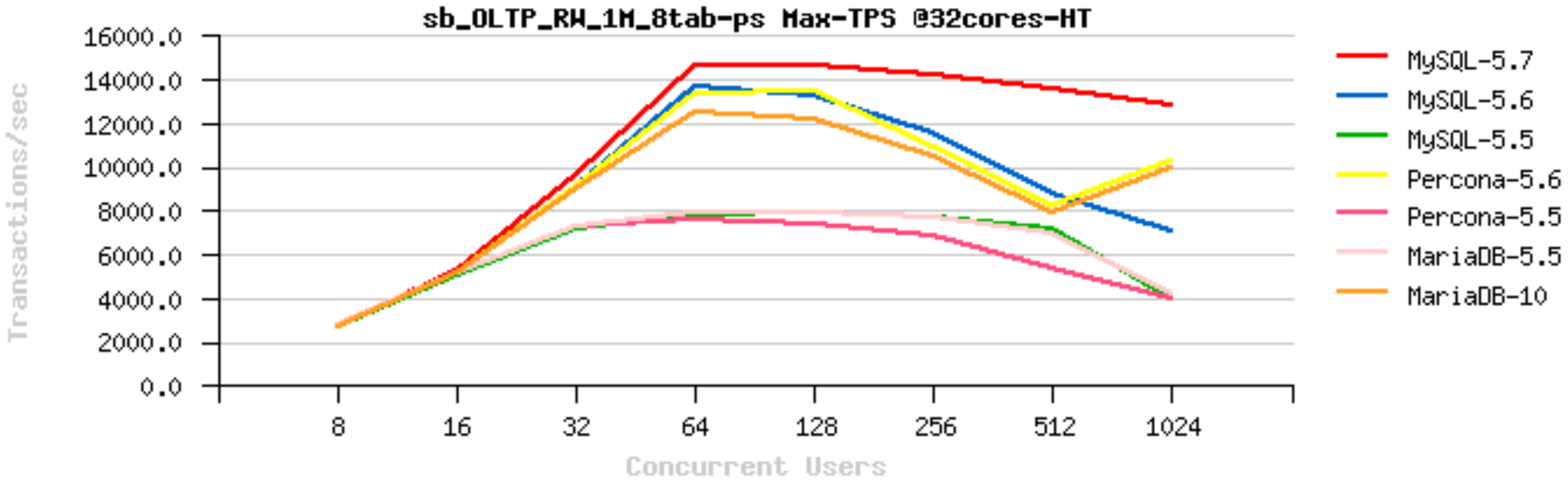


Read+Write Workloads : In-Memory

- Internal contentions / Design limitations
  - 5.5 : BP instances, RBS, etc..
  - 5.6 :
    - kernel_mutex => trx_sys & lock_sys
    - all already mentioned on RO + still many remaining ;-)
    - up to 2TB REDO, etc..
  - 5.7 :
    - lock free MDL !
    - index lock : fixed !
    - lock_sys : lowered
    - trx_sys : lowered + TRX list related re-design
    - **log_sys** : remains and killing ;-)
    - **fil_sys** : killing too, but on a high level storage only ;-)

RW In-Memory @MySQL 5.7

- Sysbench OLTP_RW 8-tables 32cores-HT :

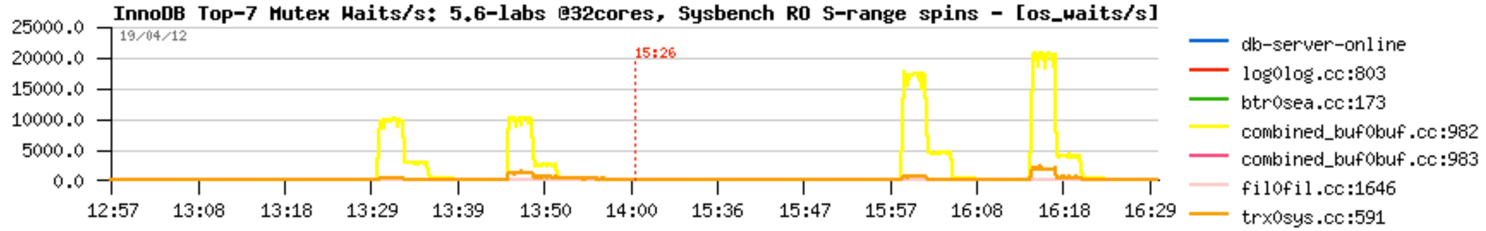


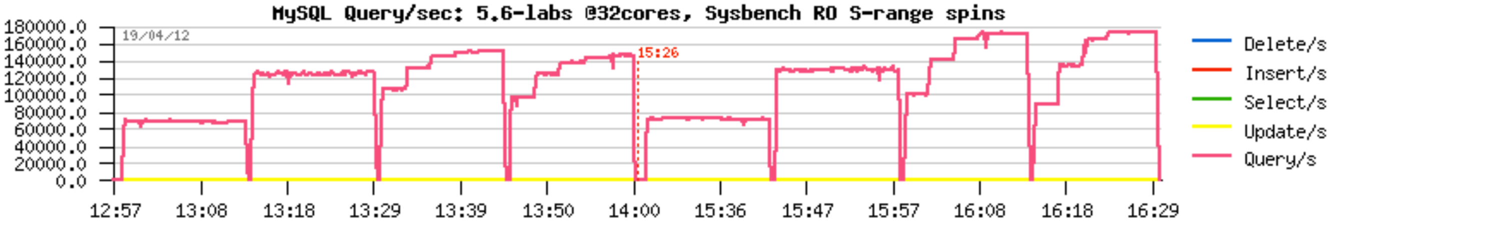
High Concurrency Tuning

- If bottleneck is due a concurrent access on the same data (due application design) – ask dev team to re-design ;-)
- If bottleneck is due MySQL/InnoDB internal contentions, then:
  - If you cannot avoid it, then at least don't let them grow ;-)
  - Try to increase InnoDB spin wait delay (dynamic)
  - Try innodb_thread_concurrency=N (dynamic)
  - CPU taskset / prcset (Linux / Solaris, both dynamic)
  - Thread Pool
  - NOTE:
    - things with contentions may radically change since 5.7, so stay tuned ;-)
    - InnoDB thread concurrency feature was **improved** in 5.6 and 5.7
    - the best working in 5.7, and using innodb_thread_concurrency=64 by default now makes sense..

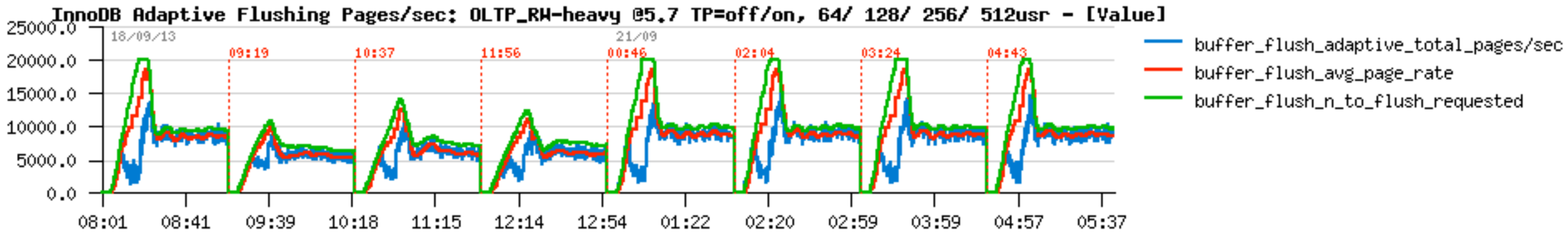
InnoDB Spin Wait Delay

- RO / RW Workloads:
  - With more CPU cores internal InnoDB contentions become more hot..
  - Bind mysqld to less cores helps, but the goal is to use more cores ;-)
  - Using innodb_thread_concurrency may not help here anymore..
  - So, innodb_spin_wait_delay is entering in the game:

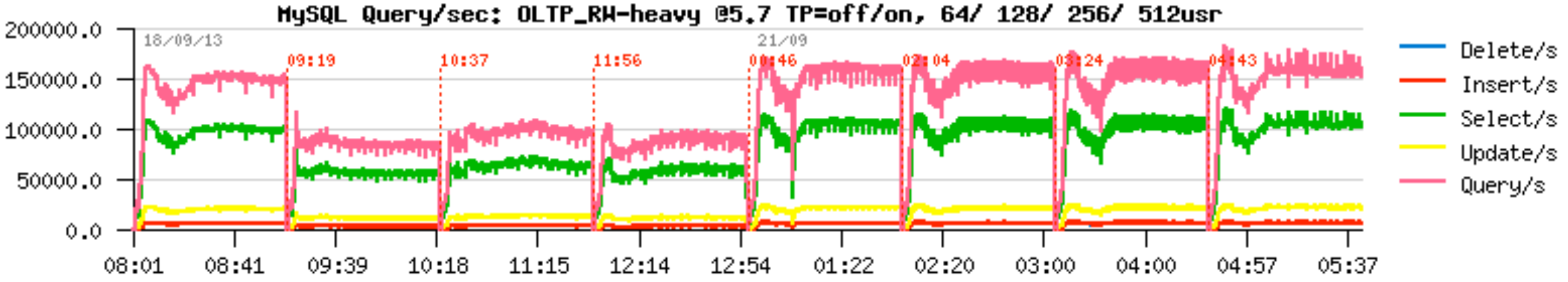




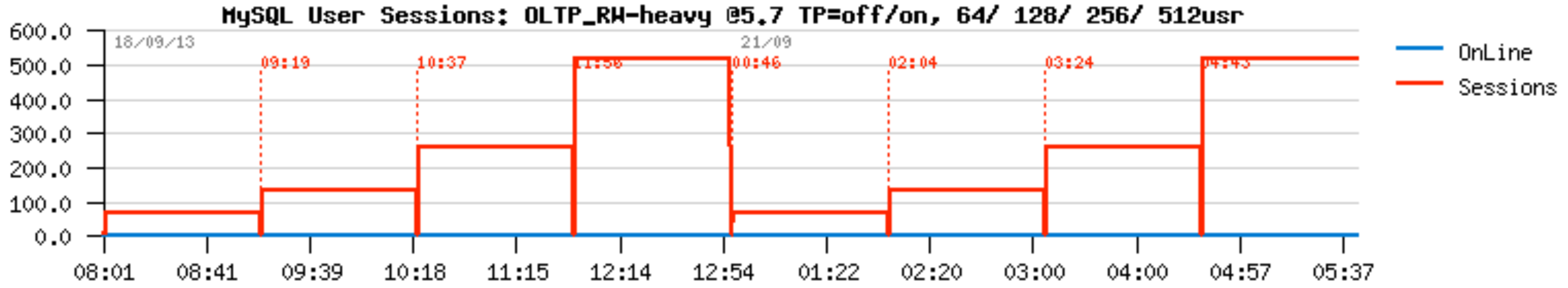
Thread Pool in old MySQL 5.7 @Heavy OLTP_RW



InnoDB Adaptive Flushing Pages/sec: OLTP_RW-heavy @5.7 TP=off/on, 64/ 128/ 256/ 512usr - [Value]



MySQL Query/sec: OLTP_RW-heavy @5.7 TP=off/on, 64/ 128/ 256/ 512usr



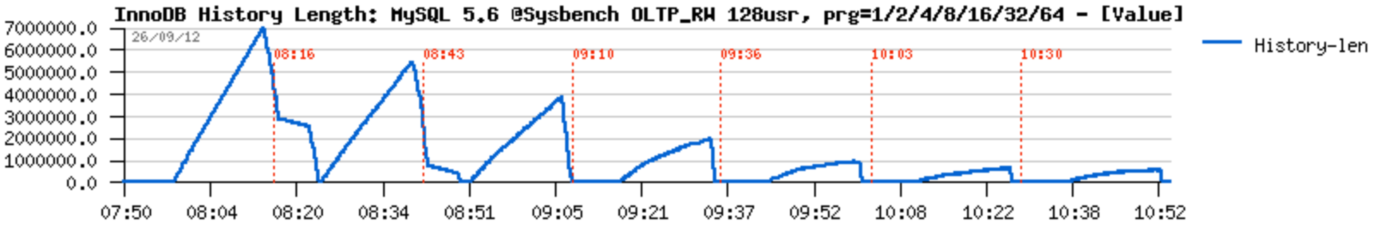
MySQL User Sessions: OLTP_RW-heavy @5.7 TP=off/on, 64/ 128/ 256/ 512usr

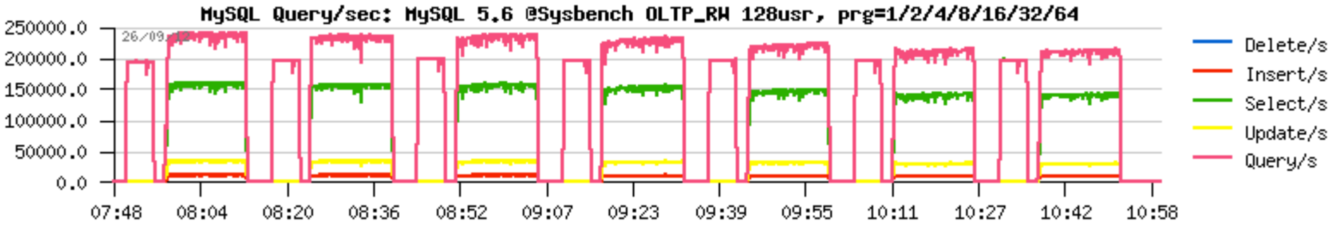
Read+Write Workloads : In-Memory

- InnoDB Purge...
  - 5.5 : Purge Thread !!! ;-)
  - 5.6 :
    - Multi-Threaded Purge !
    - fix for purge lag code !
  - 5.7 :
    - monitor InnoDB History Length **ALWAYS !** ;-)
    - if NO purge lagging : excellent! (& be happy! ;-))
    - if purge is lagging : use a purge lag config setting.. (& wait for fix)
  - example of config for 5.6 and 5.7 to avoid purge lagging:
    - innodb_max_purge_lag = 1000000 (1M max, ex.)
    - innodb_max_purge_lag_delay = 30000000
    - innodb_purge_threads = 4

InnoDB : Purge improvement since 5.6

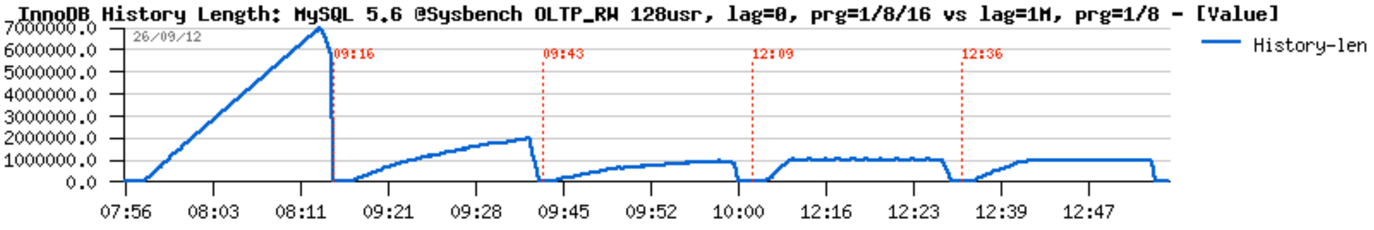
- Several Purge Threads :
  - NOTE #1 : activation is auto-magical (I'm serious ;-))
  - NOTE #2 : look well on the graphs - purge is not free !!!

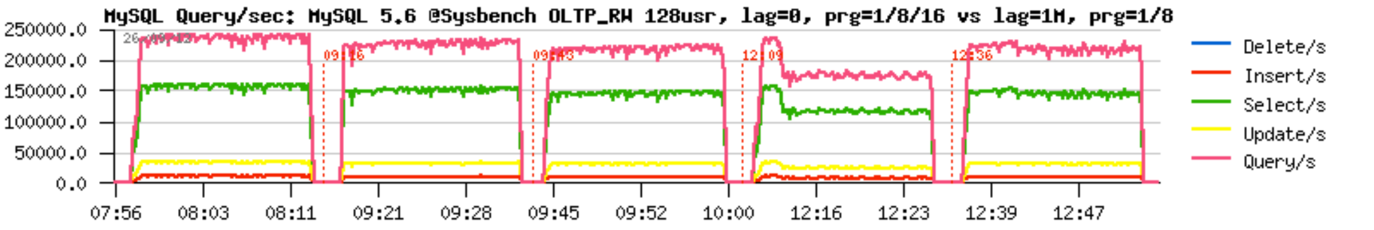




InnoDB : Purge improvement since 5.6

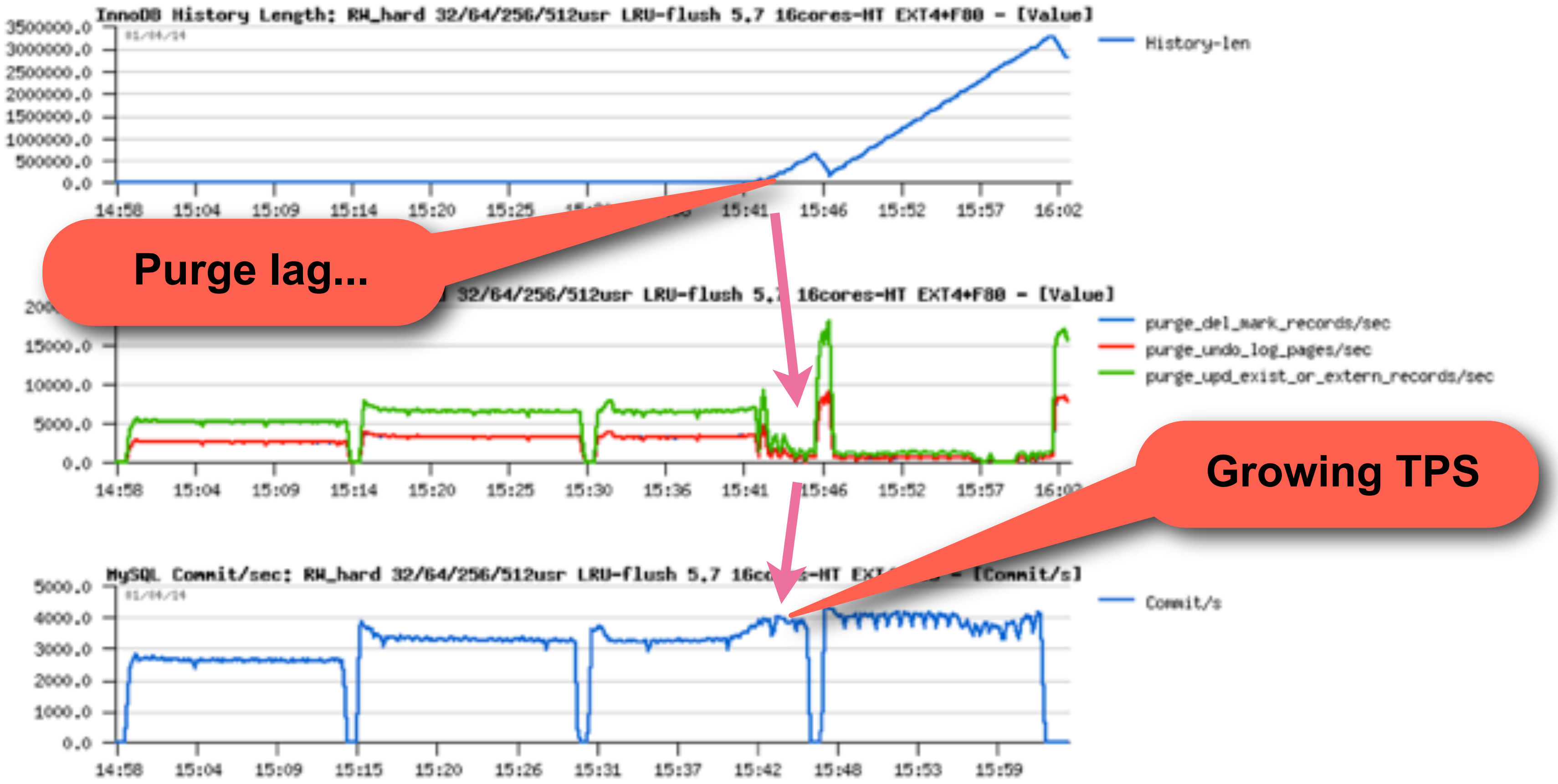
- Fixed max purge lag code!
  - innodb_max_purge_lag
  - innodb_max_purge_lag_delay <= configurable!
- Setting innodb_max_purge_lag=1M:





InnoDB : be sure your TPS is fair ;-)

- Purge lagging impact on IO-bound OLTP_RW 10Mx32-tab:
  - moving from 3200 to 4000 TPS... - cool, right? ;-) but not fair...



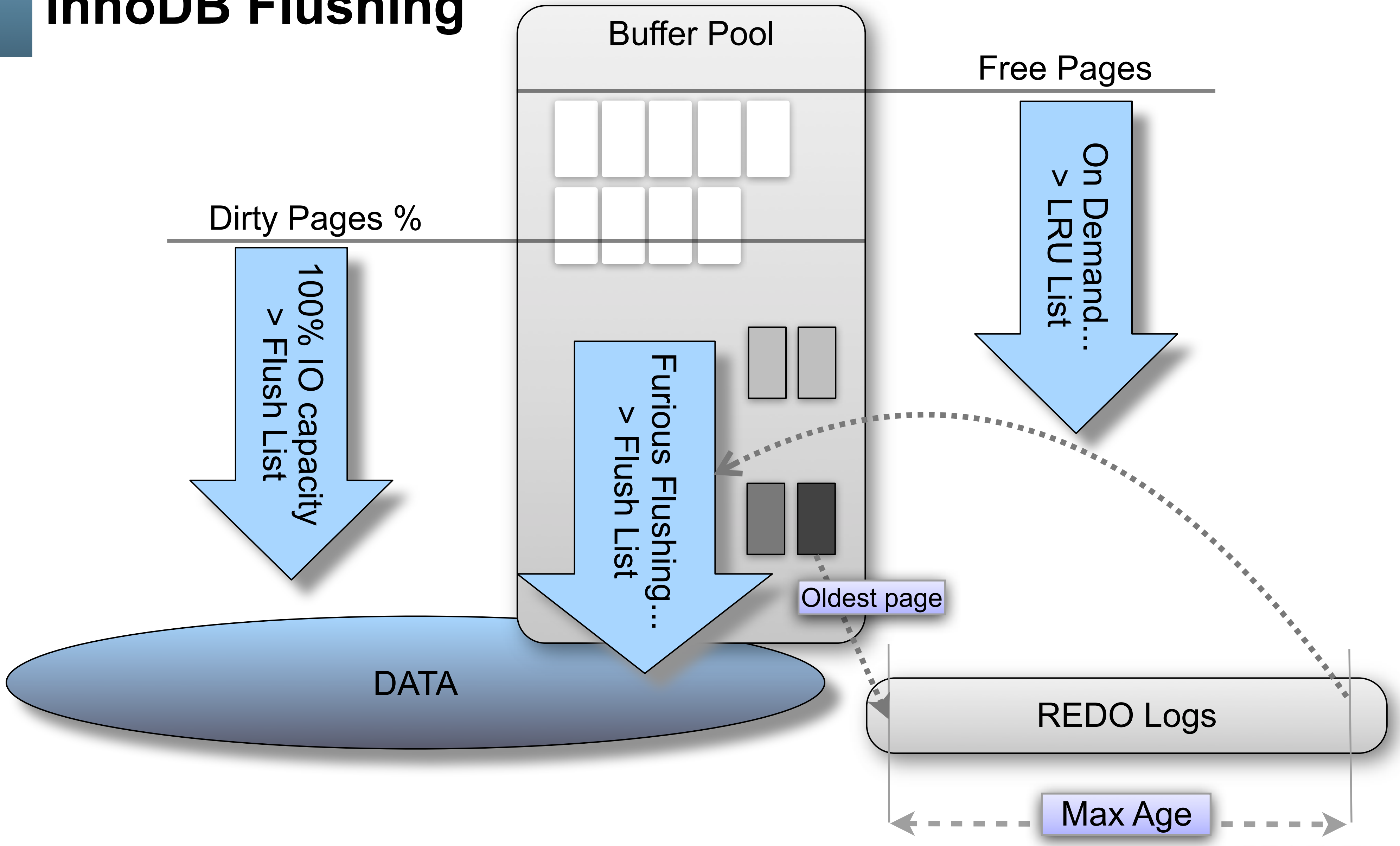
Purge lag...

Growing TPS

Read+Write Workloads : In-Memory

- InnoDB Flushing...
  - 5.5 : no comments.. ;-)
  - 5.6 :
    - Improved Adaptive Flushing (step 1)
    - Cleaner Thread
  - 5.7 :
    - multiple Cleaner Threads
    - improved LRU flushing
    - improved Adaptive Flushing Design (step 2)

InnoDB Flushing



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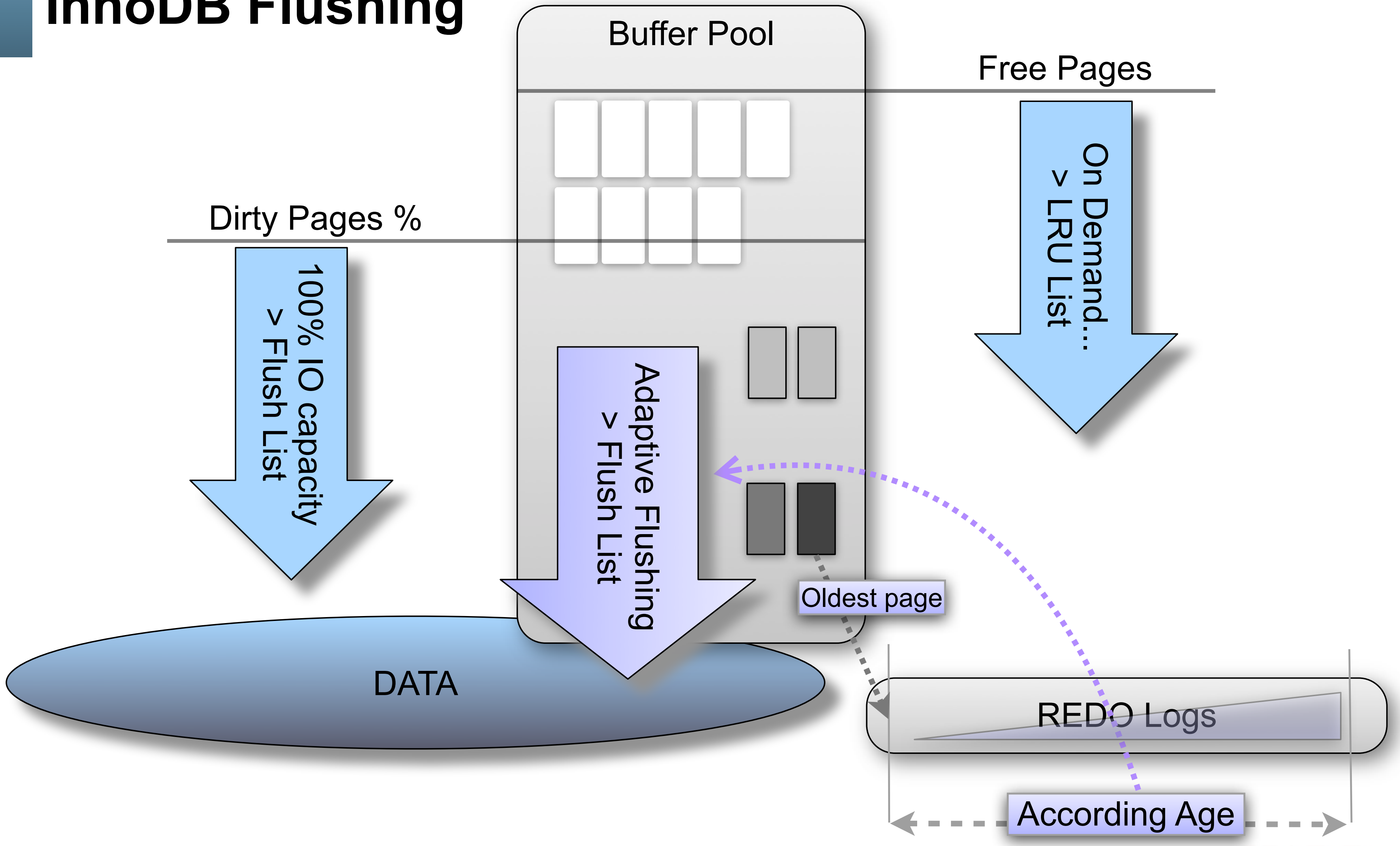
InnoDB Flushing



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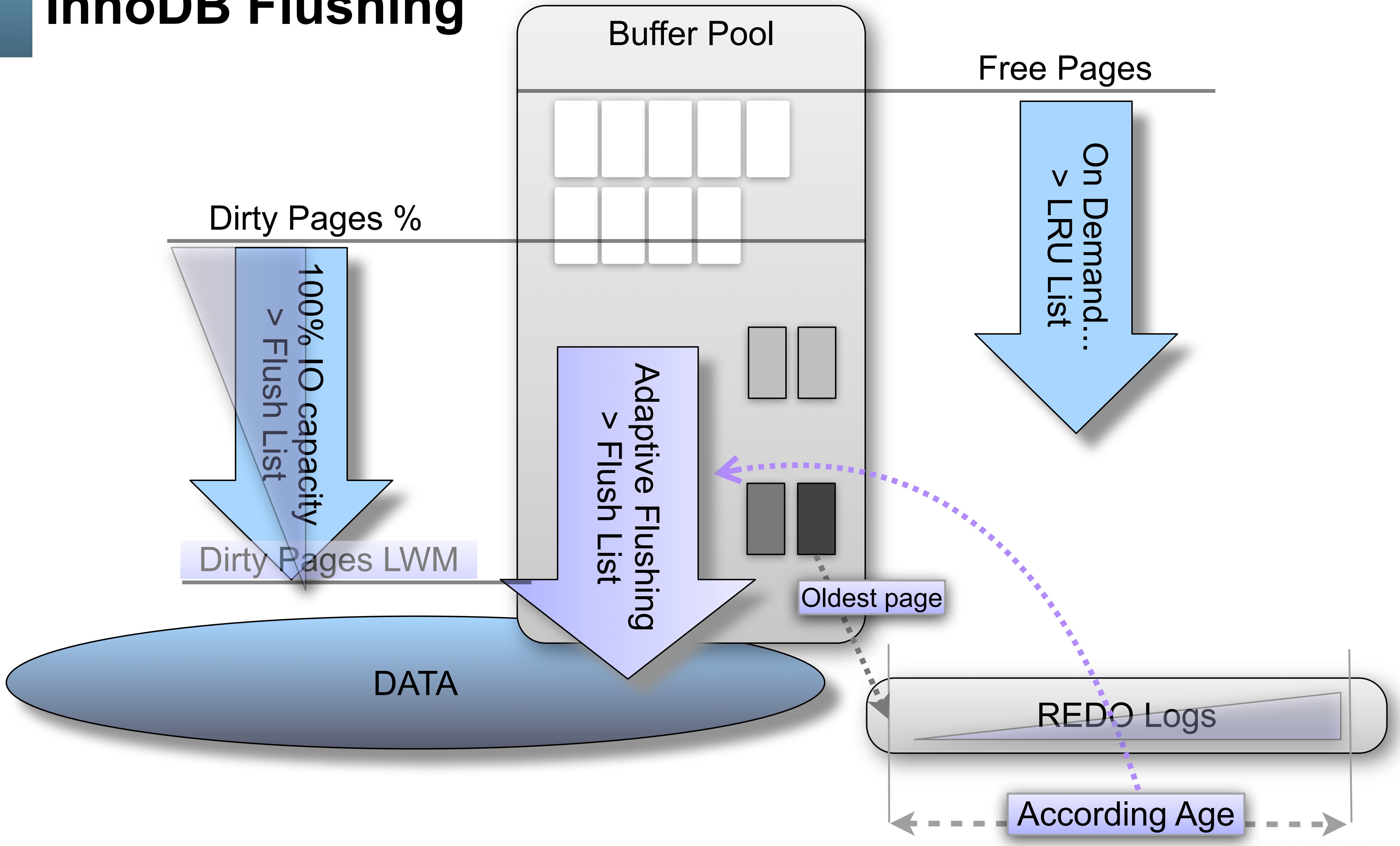

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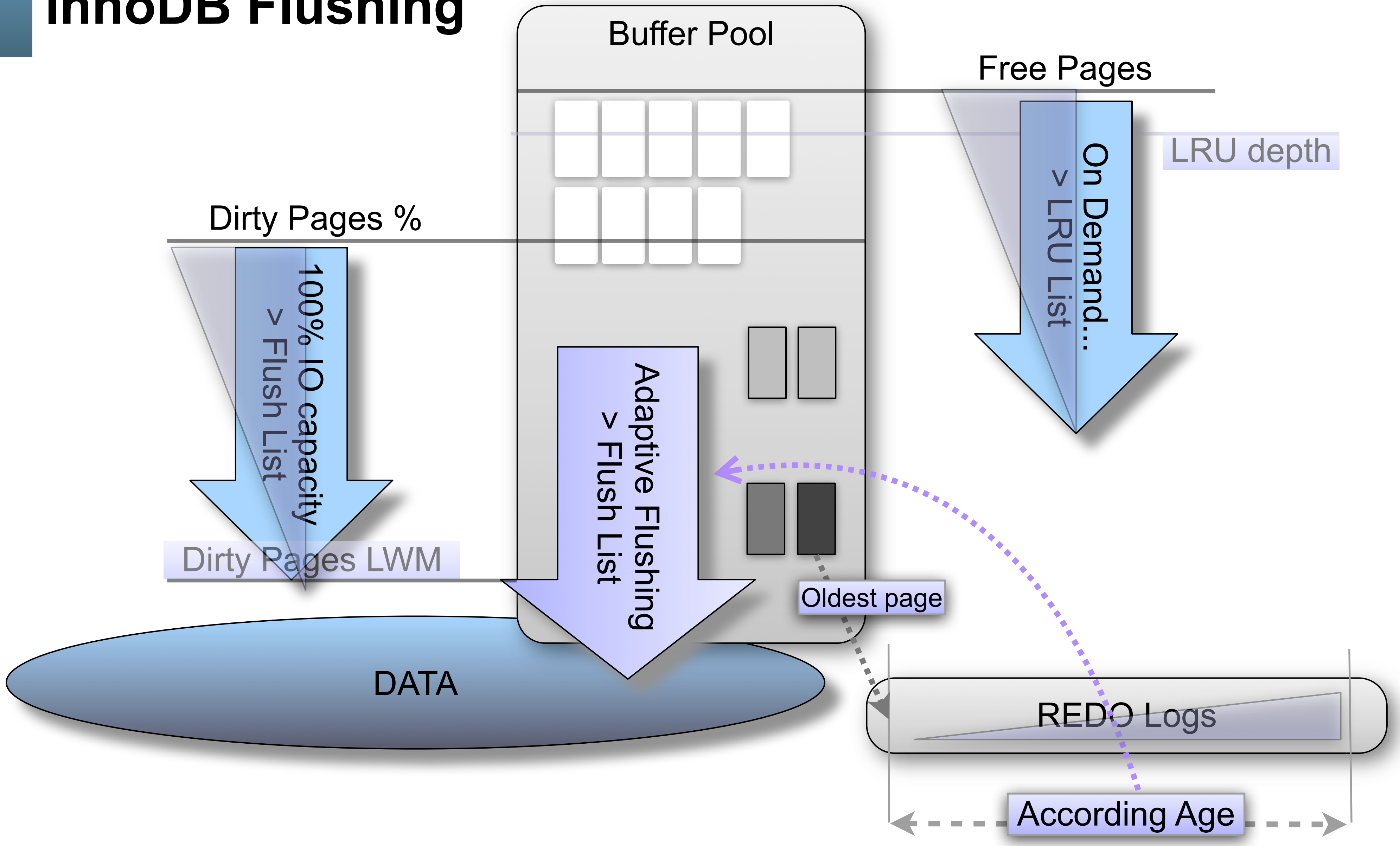
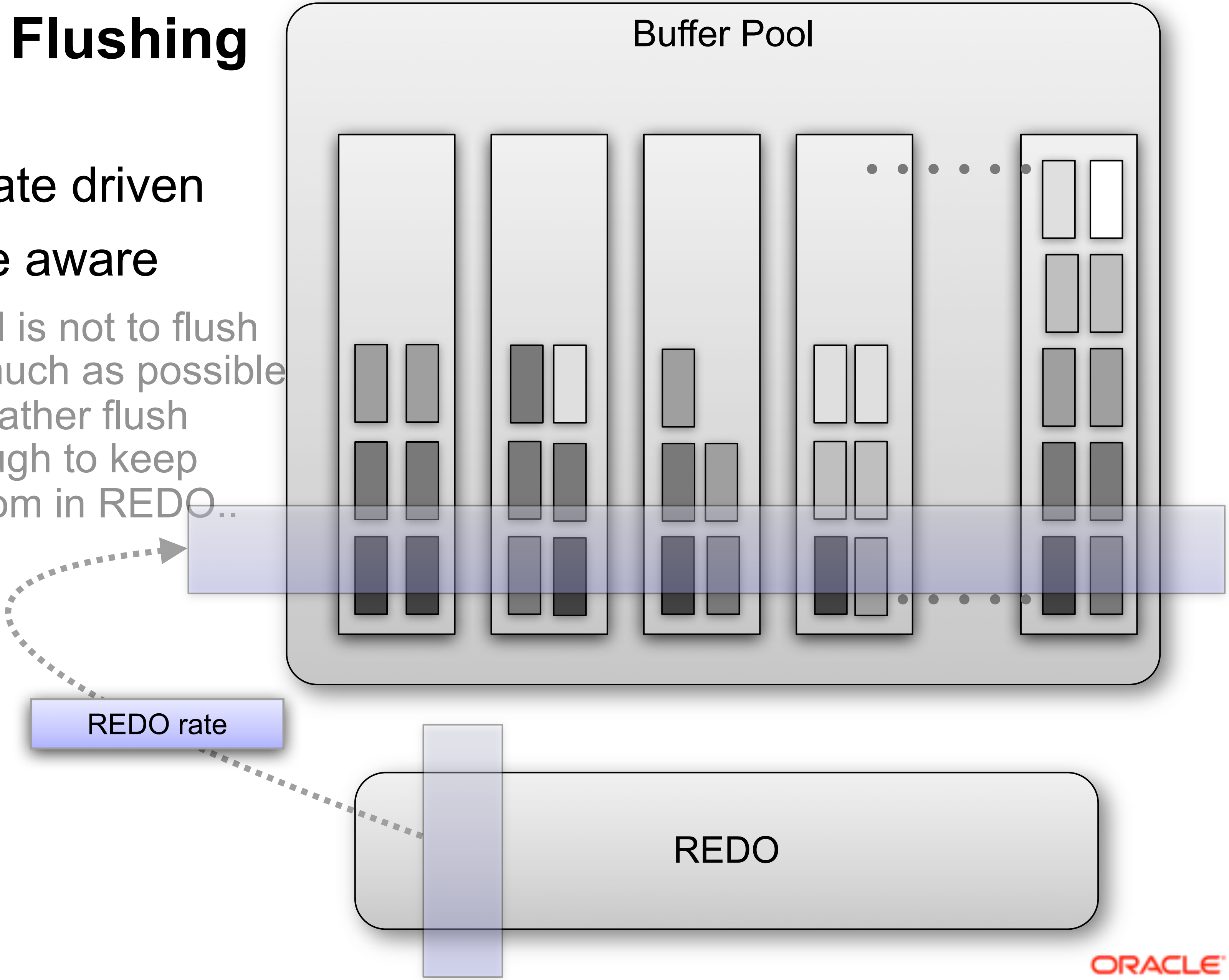
InnoDB Flushing



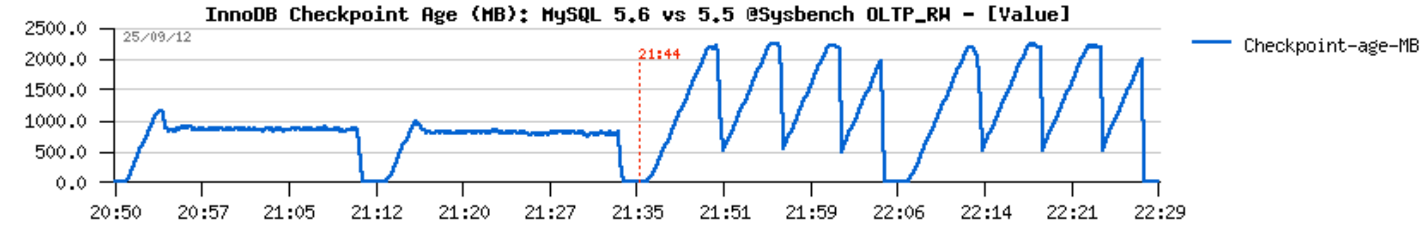
InnoDB Flushing

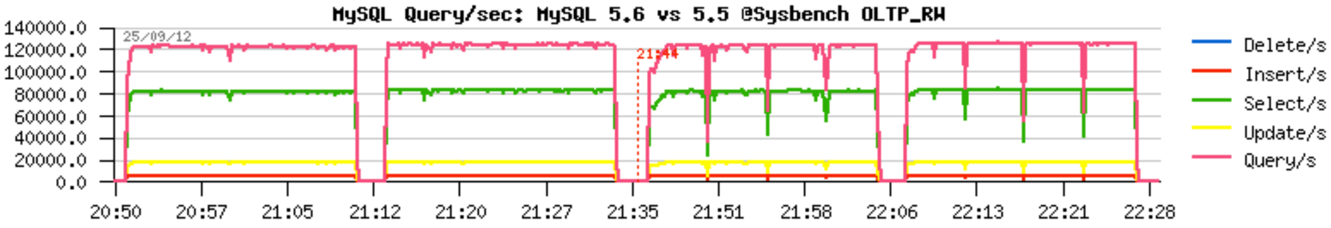
- REDO rate driven
- LSN Age aware
  - the goal is not to flush as much as possible but rather flush enough to keep a room in REDO..



Adaptive Flushing: MySQL 5.6 vs 5.5

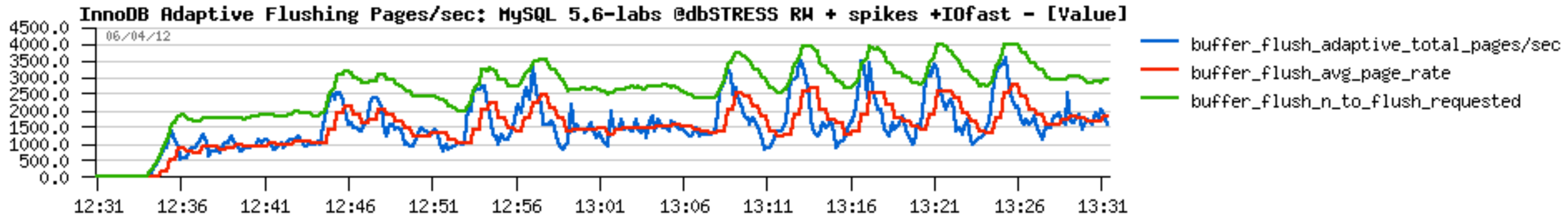
- OLTP_RW Workload:
  - Same IO capacity
  - Different logic..

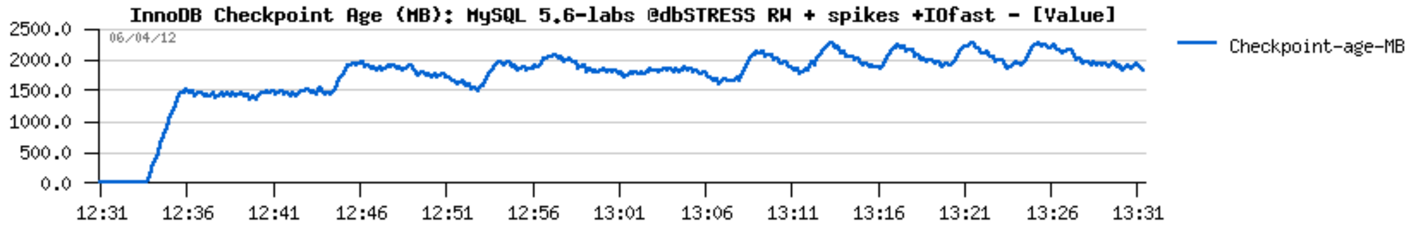


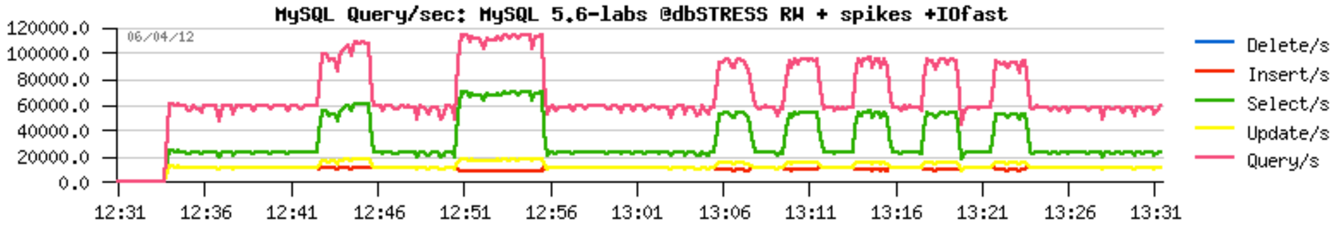


InnoDB : Resisting to activity spikes in 5.6

- dbSTRESS R+W with spikes

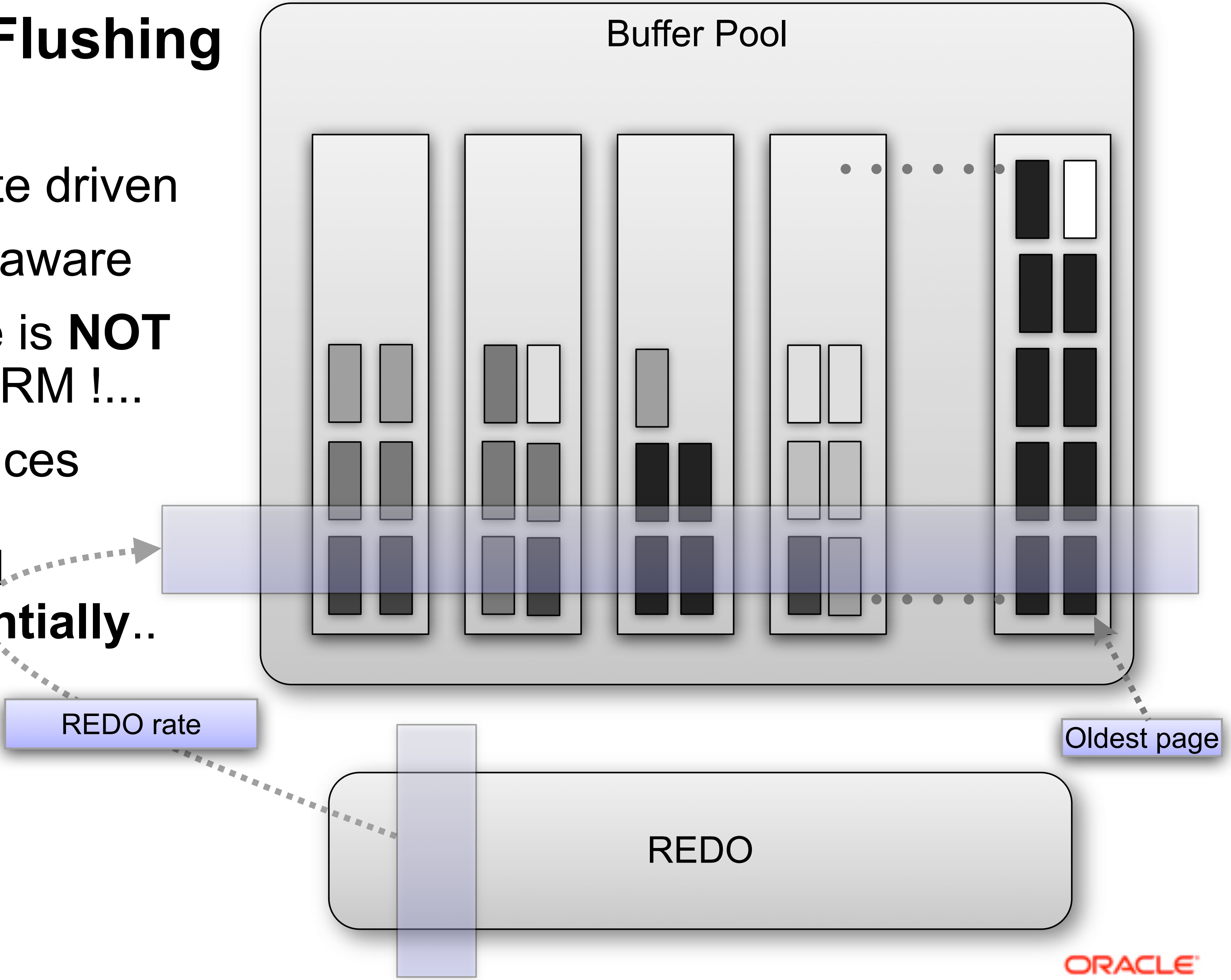






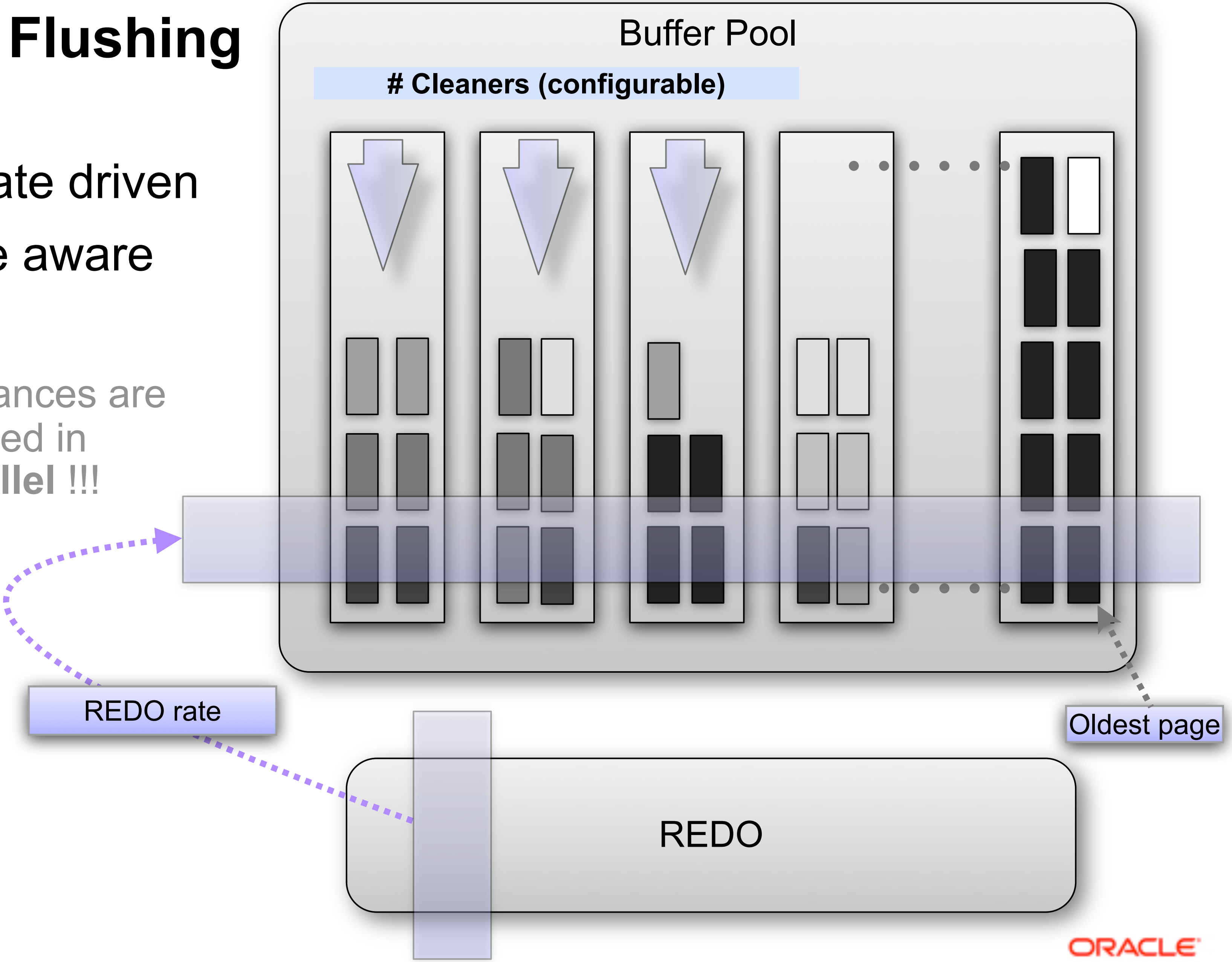
InnoDB Flushing

- REDO rate driven
- LSN Age aware
- Page Age is **NOT** UNIFORM !...
- BP Instances are flushed **sequentially**..



InnoDB Flushing

- REDO rate driven
- LSN Age aware
- 5.7 :
  - BP Instances are flushed in **parallel** !!!



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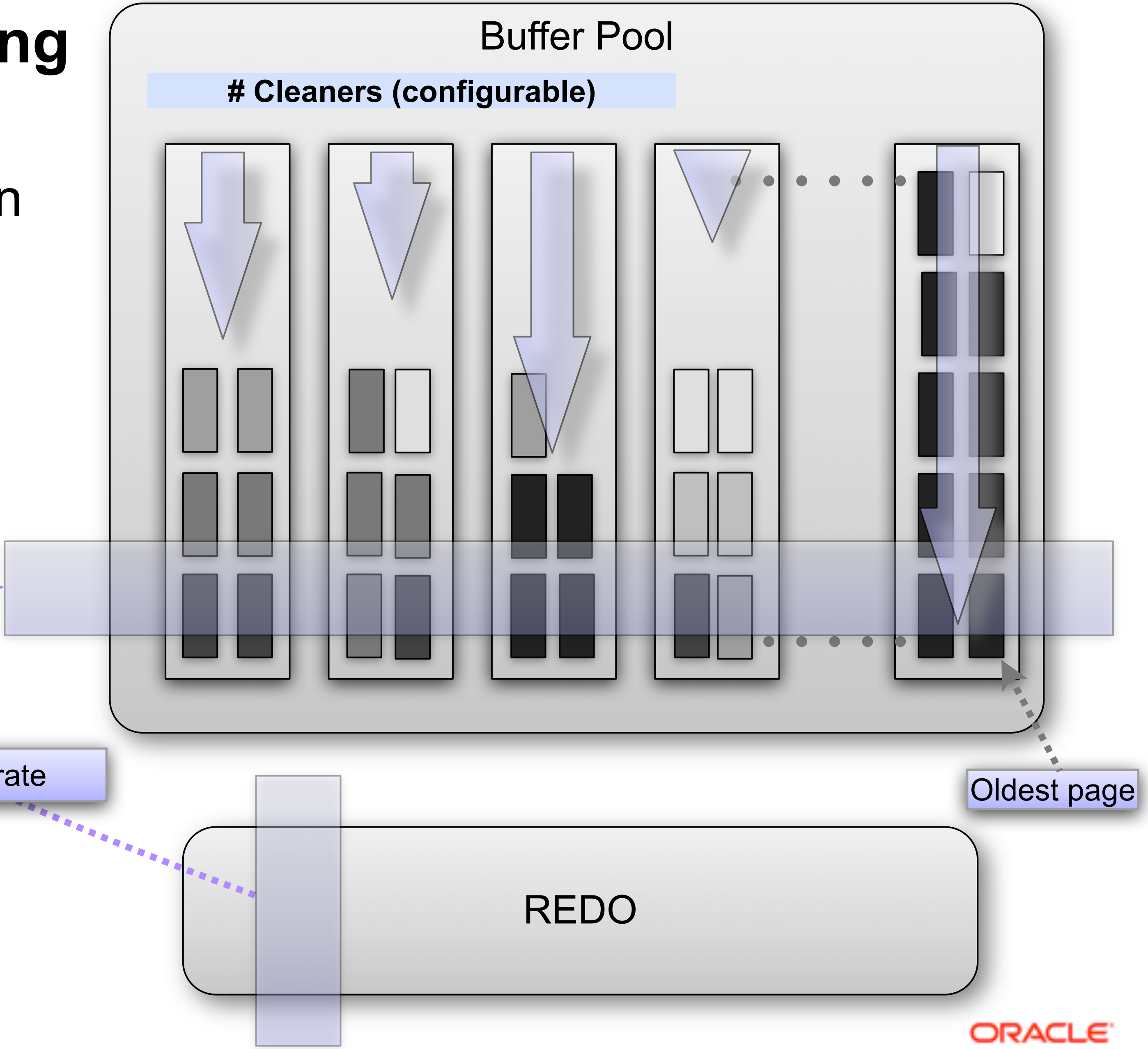
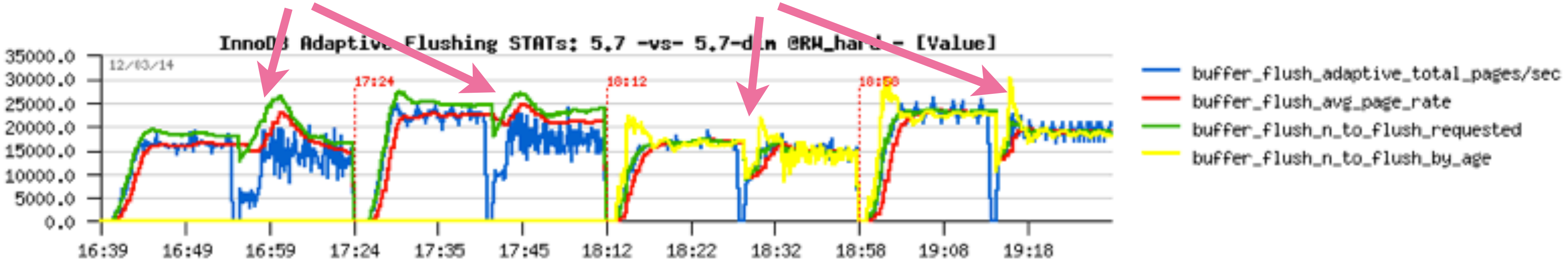
InnoDB Flushing

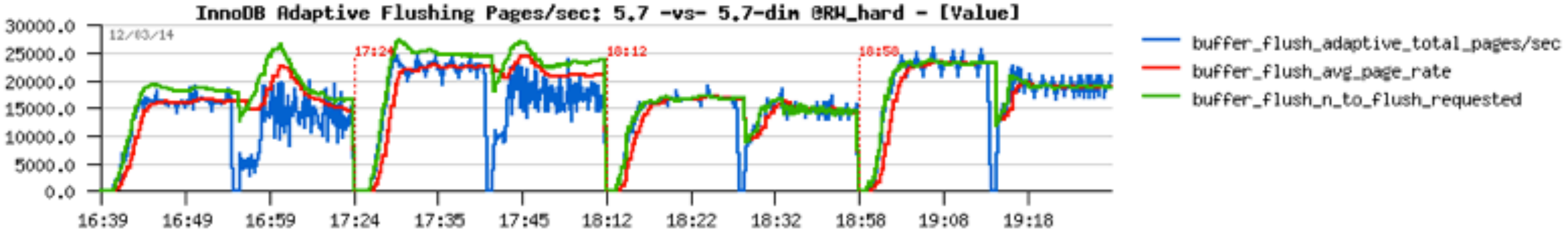
- REDO rate driven
- LSN Age aware
- 5.7 :
  - BP Instances are flushed in **parallel** !!!
  - Flushing rate is **adapted to Age distribution** within each BP instance !!!



InnoDB Flushing in 5.7

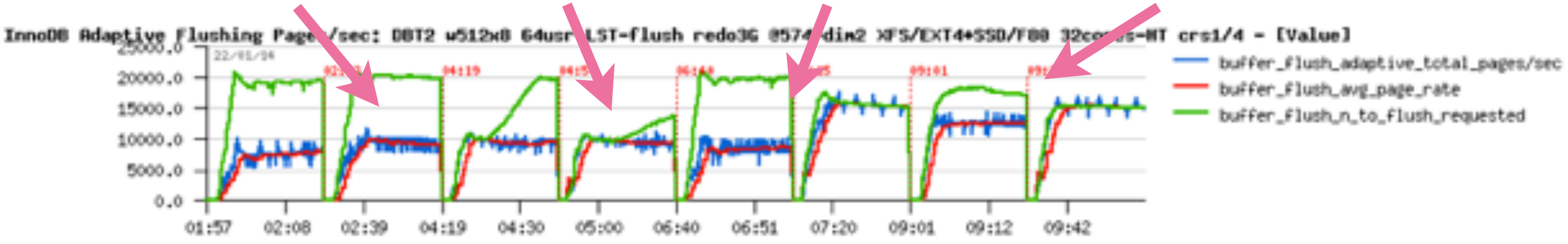
- Considering Age distribution :
  - Parallel Only -vs- Parallel + Age aware

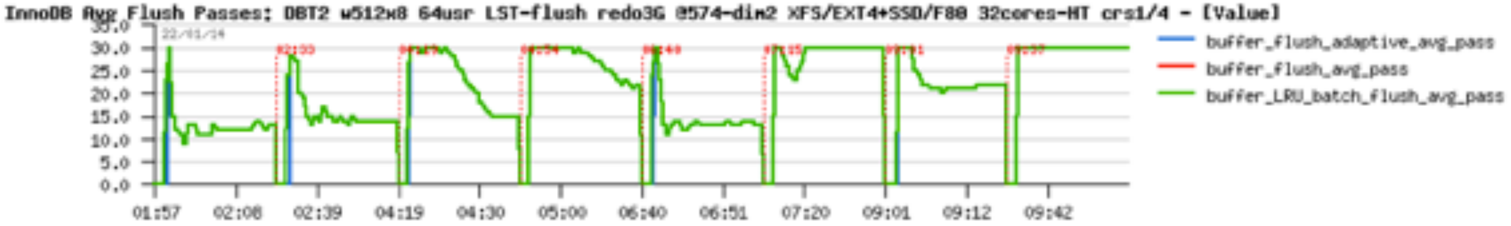


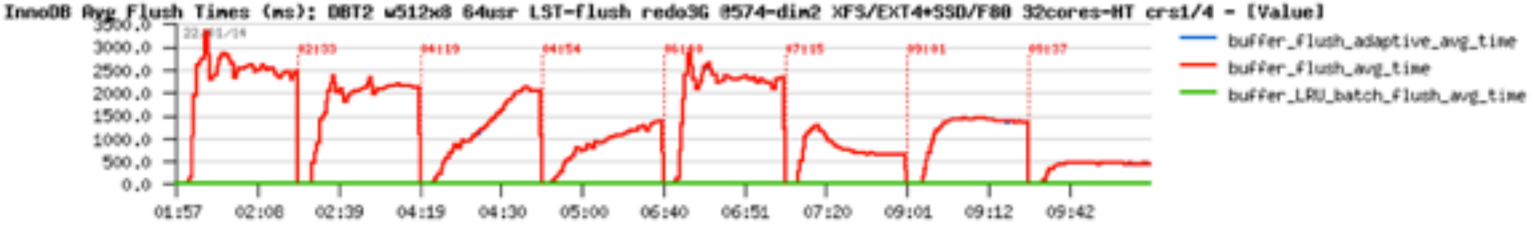


InnoDB Flushing in 5.7

- Considering fast storage :
  - DBT2 512Wx8, 64usr, each test first with 1 then with 4 cleaners
  - XFS@SSD | EXT4@SSD | XFS@LSI-F80 | EXT4@LSI-F80







InnoDB Flushing in 5.7

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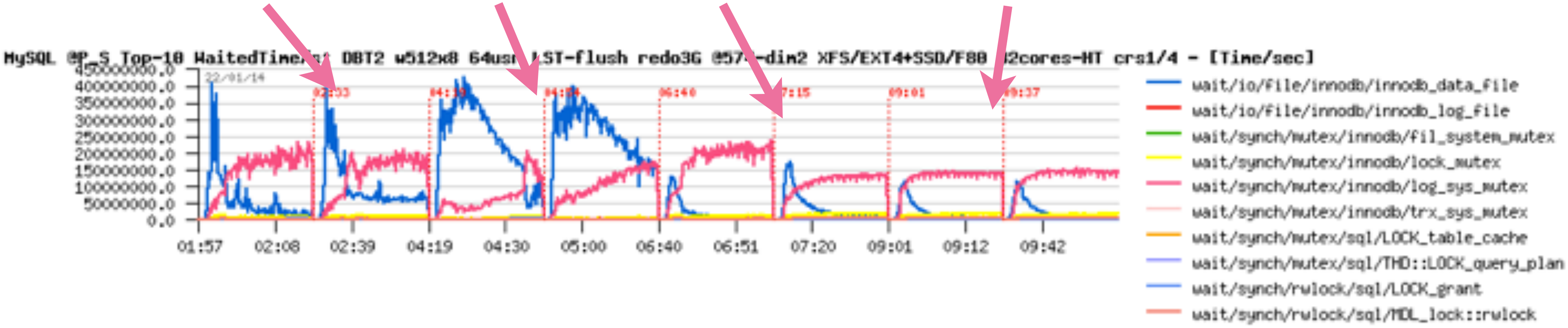
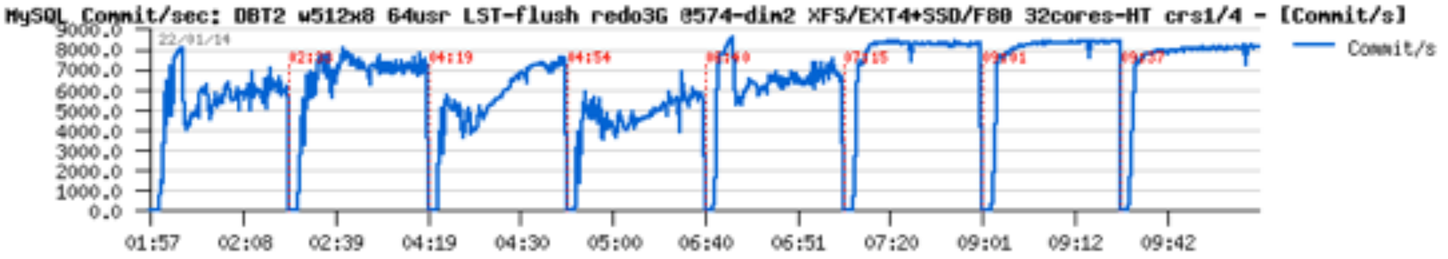


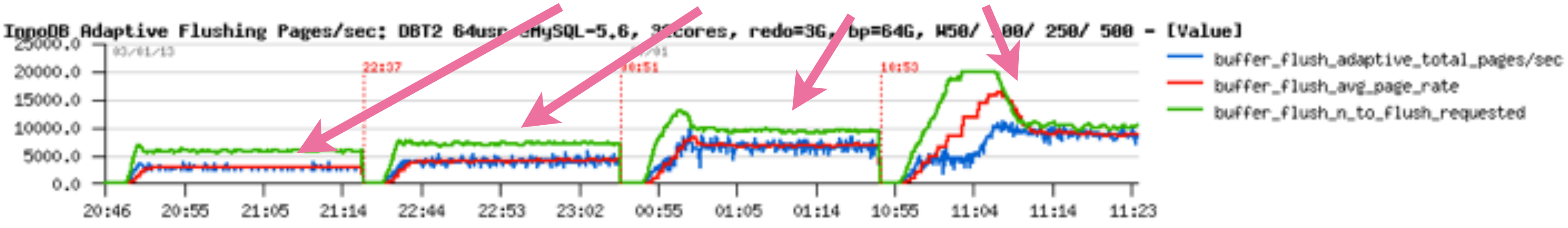


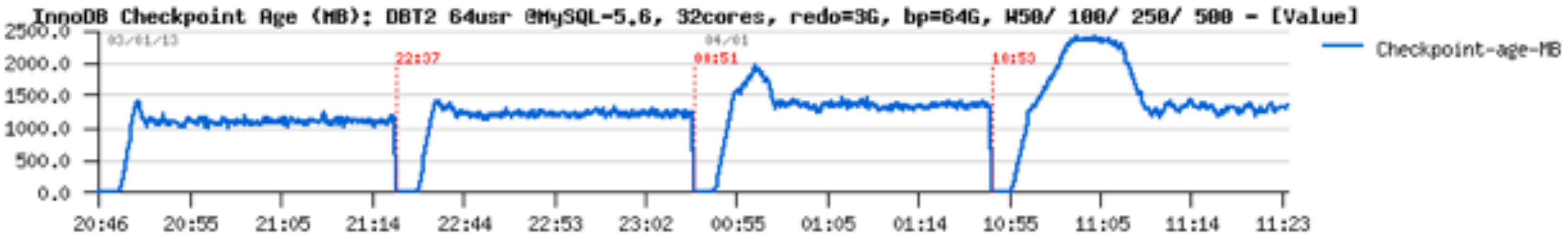
RW IO-bound

- Still data In-Memory, but much bigger volume :
  - more pages to flush for the **same** TPS rate
- Data bigger or much bigger than Memory / cache / BP :
  - the amount of free pages becomes short very quickly..
  - and instead of mostly IO writes only you’re starting to have IO reads too
  - these reads usually mostly random reads
  - if your storage is slow - reads will simply kill your TPS ;-)
  - if your storage can follow - then things become much more interesting
  - ..until you’re hitting fil_sys mutex contention and reach your Max TPS within a given conditions...
- NOTE:
  - using **AIO + O_DIRECT** is the must for RW IO-bound !..

RW IO-bound “In-Memory”

- Impact of the database size
  - with a growing db size the TPS rate may be only the same or worse ;-)
  - and required Flushing rate may only increase..
- DBT2 workload :
  - 64 users, db volume: 50W, 100W, 250W, 500W



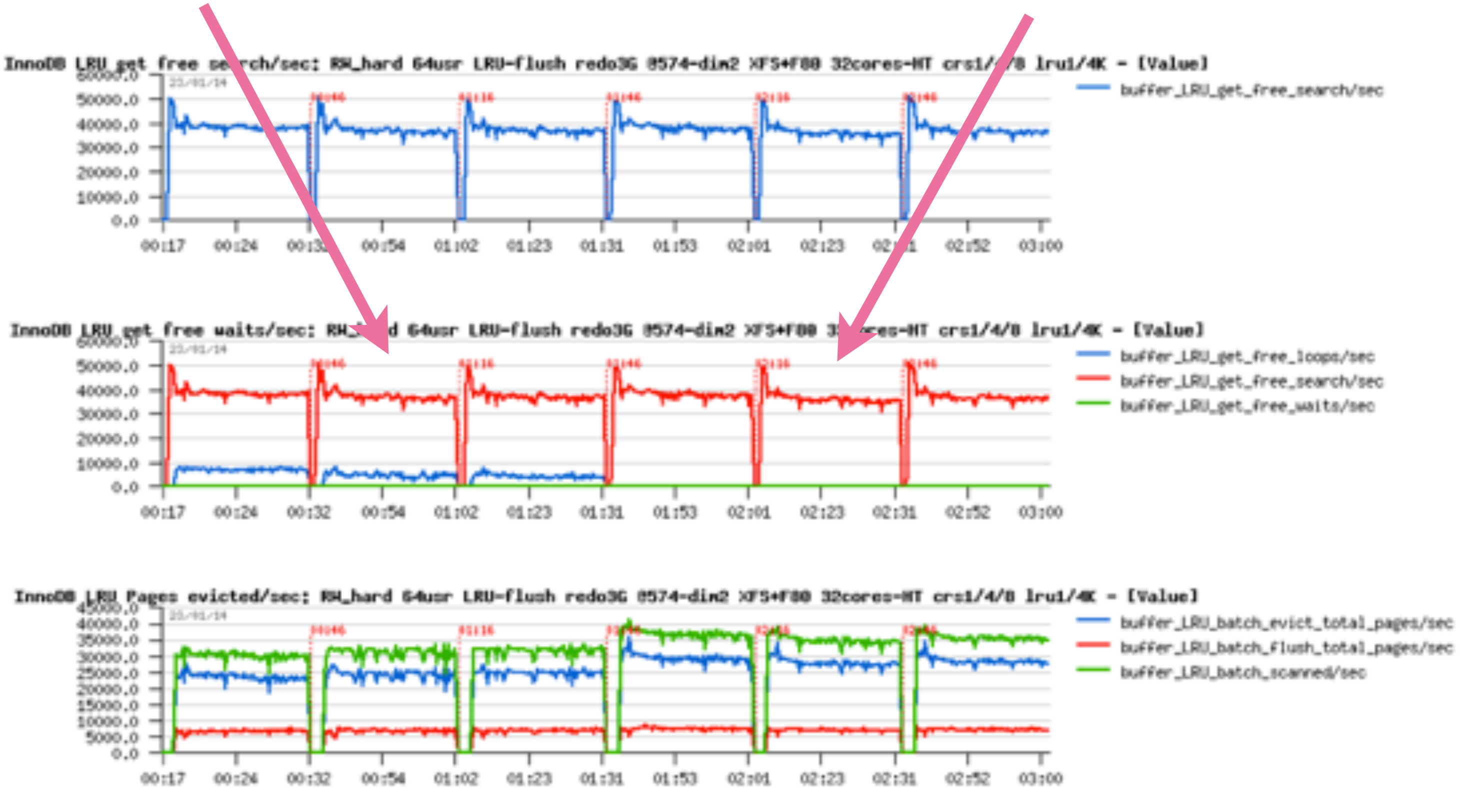


RW IO-bound “Out-of-Memory”

- LRU Flushing in 5.6 (broadly speaking) :
  - **Cleaner thread for each BP instance :**
    - check if free list contains at least N (LRU depth) pages : yes => return();
    - scan BP instance LRU list up to N (LRU depth) pages :
      - page is “dirty” : place it on flush, then clear & move to a free list
      - page is “not dirty” : clear & move it to a free list
      - free list reached N (LRU depth) pages: return()
  - **User thread :**
    - want a free page : get a one ? yes => return();
    - scan LRU list to see if can find one “not dirty” quickly..
      - found : clear & move it to a free list; goto begin..
      - not found : try to flush one; signal “flush event”; goto begin..
    - doing a second loop and there is still no free pages : sleep; then goto begin..
- Better that Cleaner is always keeping free lists non-empty ;-))

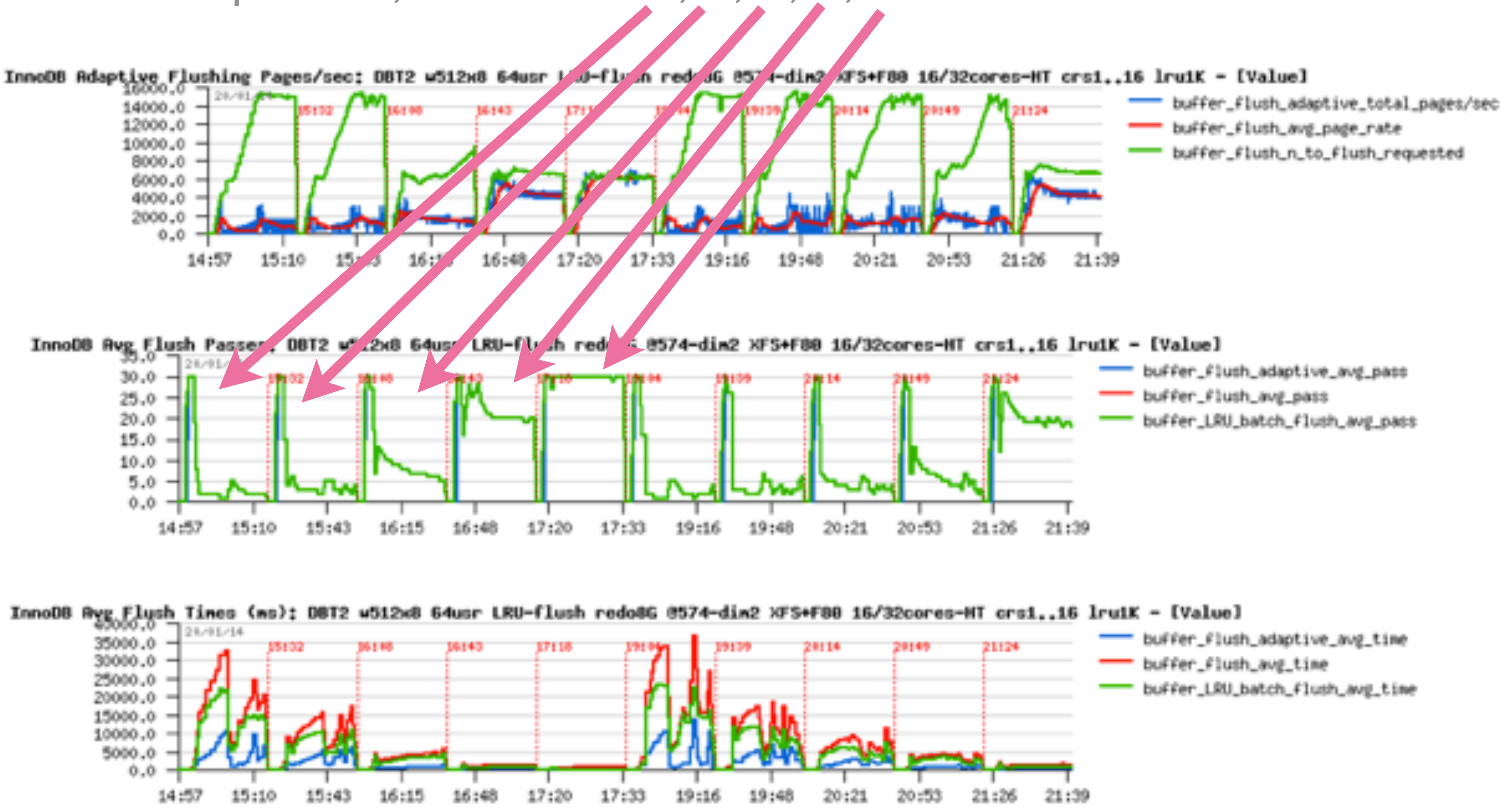
RW IO-bound “Out-of-Memory”

- LRU Flushing in 5.7 (broadly speaking) :
  - similar to 5.6 but with parallel Cleaners (but this is not always important ;-))
  - look: LRU depth=1K, cleaners=1/4/8 | LRU depth=4K, cleaners=1/4/8



RW LRU-bound : FS impact..

- DBT2 Workload, 64 users, **XFS**
  - LRU depth=1K, cleaners= 1, 2, 4, 8, 16 16cores-HT / 32cores-HT



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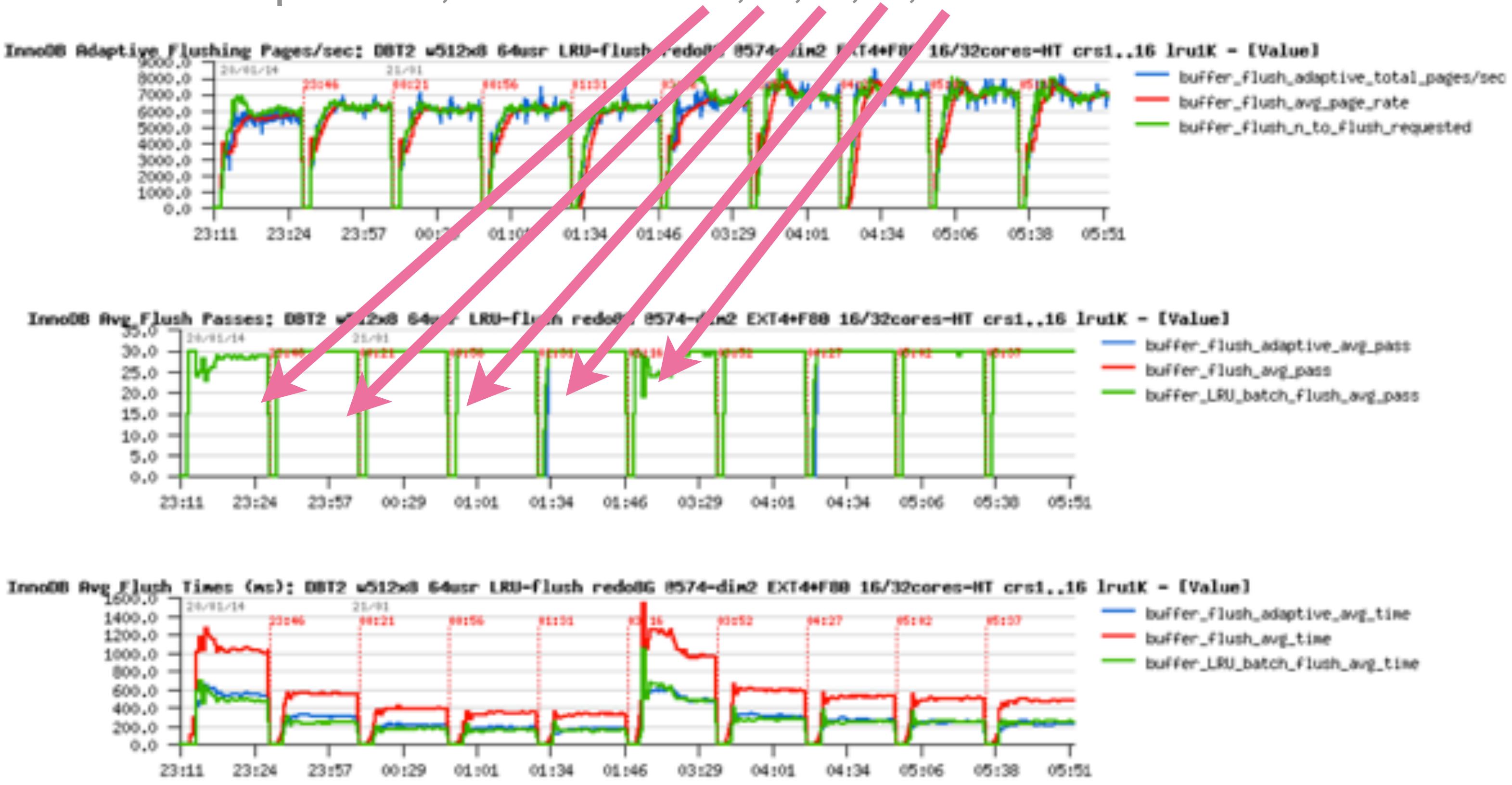
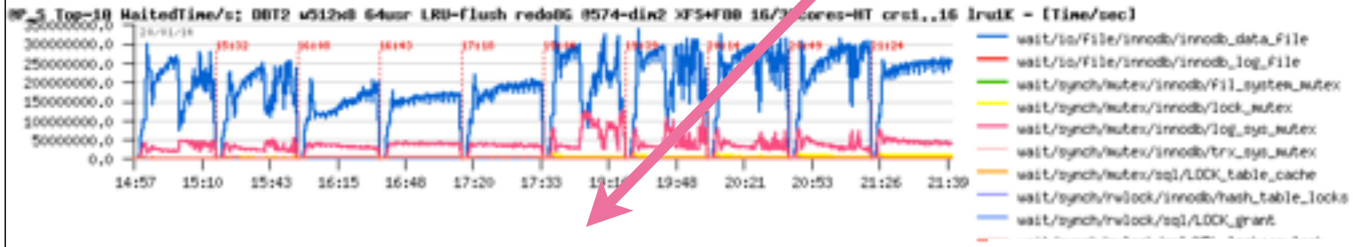
RW LRU-bound : FS impact..

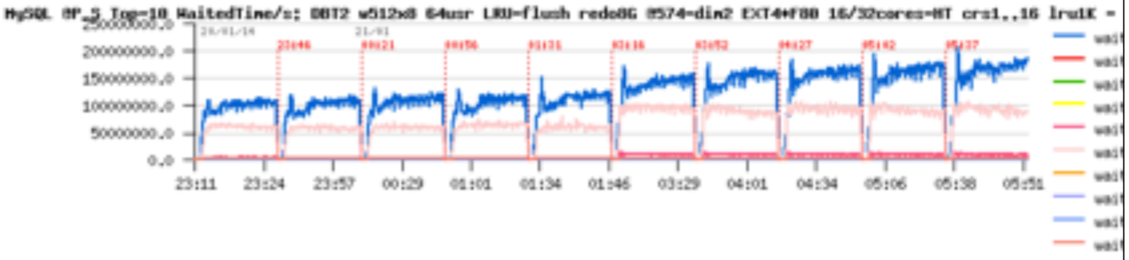
- DBT2 Workload, 64 users, **EXT4**
  - LRU depth=1K, cleaners= 1, 2, 4, 8, 16 16cores-HT / 32cores-HT

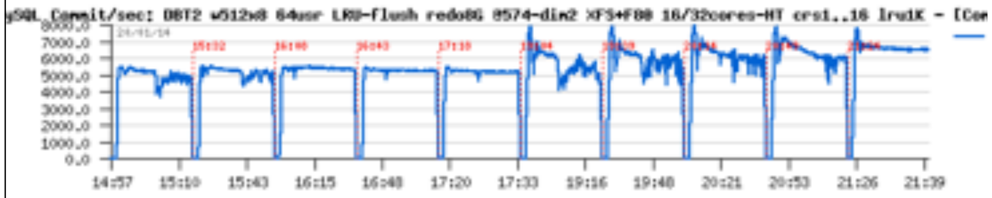


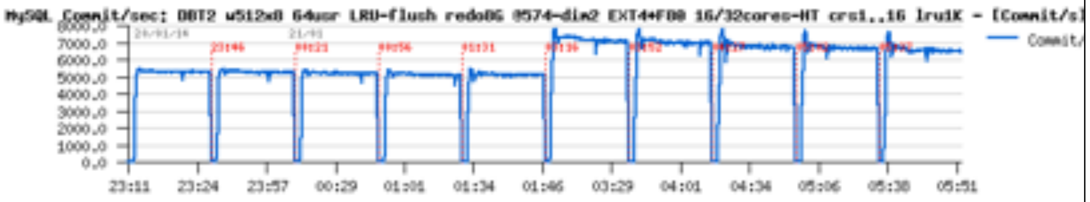
RW LRU-bound : FS impact..

- DBT2 Workload, 64 users, **XFS -vs- EXT4**
  - LRU depth=1K, cleaners= 1, 2, 4, 8, 16 16cores-HT / 32cores-HT
  - More IO data wait on XFS...









RW LRU-bound : “tuning” by elimination

- Filesystem : let’s go with EXT4 ;-)
  - TODO : understand what is wrong with XFS...
- # Cleaner threads :
  - 2 or 4 should be enough.. - let’s go with 4
- LRU depth :
  - the SUM setting should be bigger than a free page/sec demand
  - so for 40K get free page/sec setting LRU depth=2K with 32 BP instances should be more than enough..
  - but a free page demand may grow.. - let’s go with LRU depth=**4K** and see ;-)
- Purge :
  - innodb_max_purge_lag = 1000000
  - innodb_max_purge_lag_delay = 30000000
  - innodb_purge_threads = 4

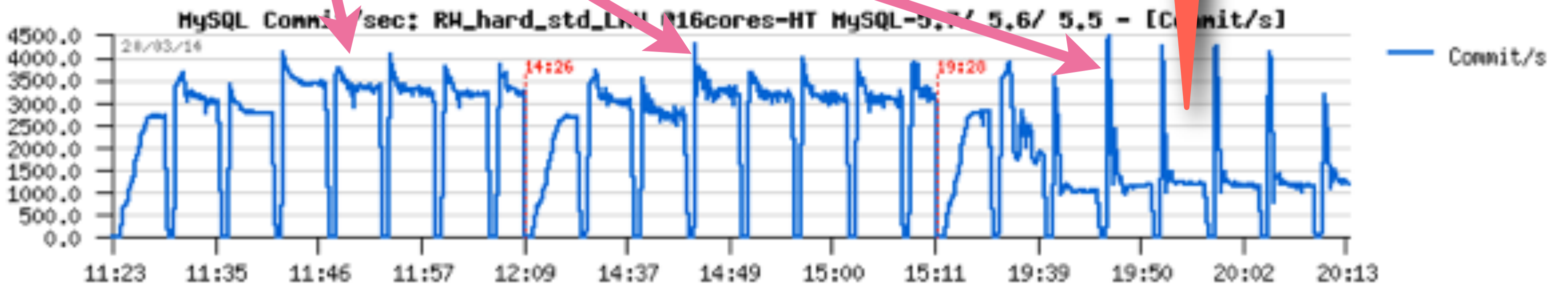
RW IO-bound Workloads

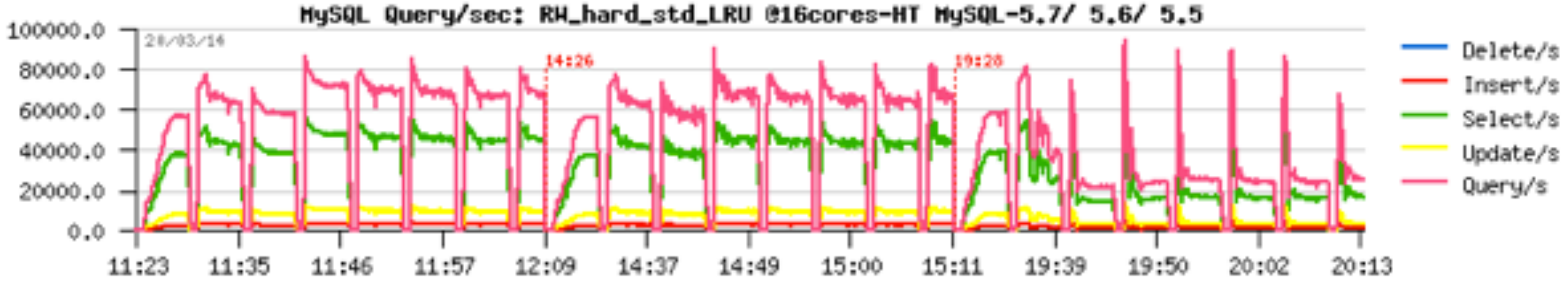
- Workloads :
  - Sysbench OLTP_RW 10Mx32-tables UNIFORM / PARETO
  - DBT2 512W x8 databases
  - LinkBench 150G data (150M ids)
- User Concurrency :
  - 32, 64, 256, 512 users
  - 15-20 min for each test level
- Test Conditions :
  - LRU-bound (BP size is less than 1/4 or 1/3 of db size)
  - LIST-bound (BP size is big enough to fit the whole db set)
- Engines:
  - MySQL 5.7 latest, 5.7.3, 5.6, 5.5 (Percona 5.6 just for PARETO)

RW LRU-bound : 5.5 is out of the game..

- Sysbench OLTP_RW 10M x32-tables
  - Users: 8, 16, 32 .. 1024
  - MySQL : 5.7 / 5.6 / 5.5

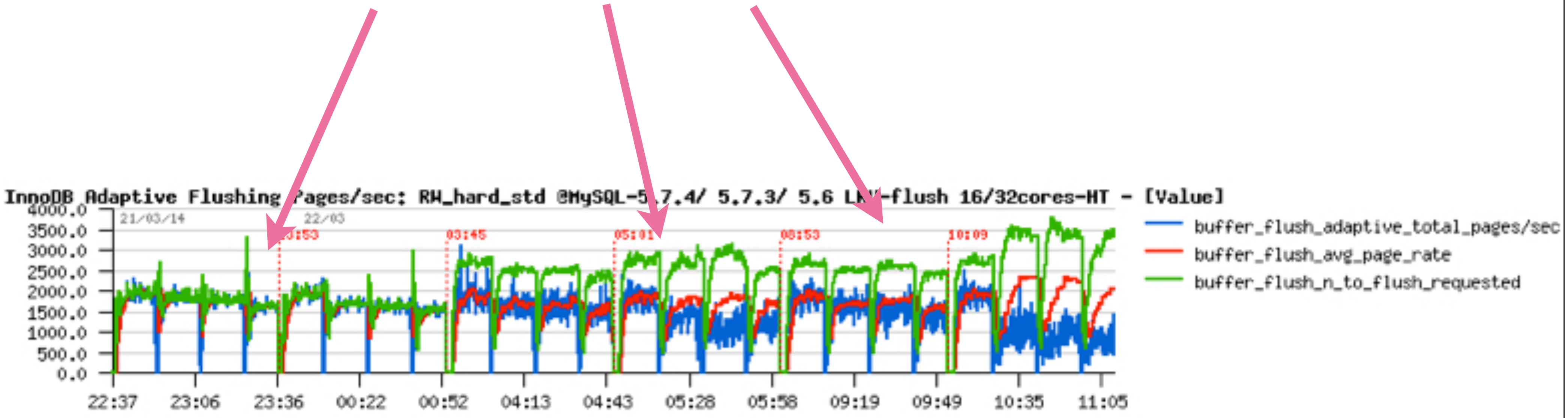
Please, upgrade me to 5.6 !!!





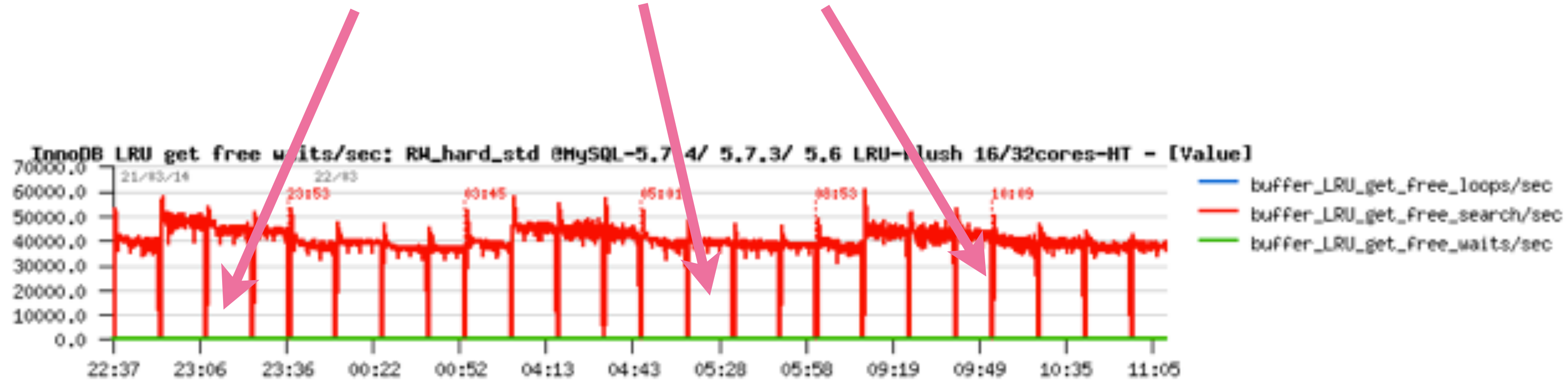
OLTP_RW 10Mx32-tab Uniform : LRU-bound

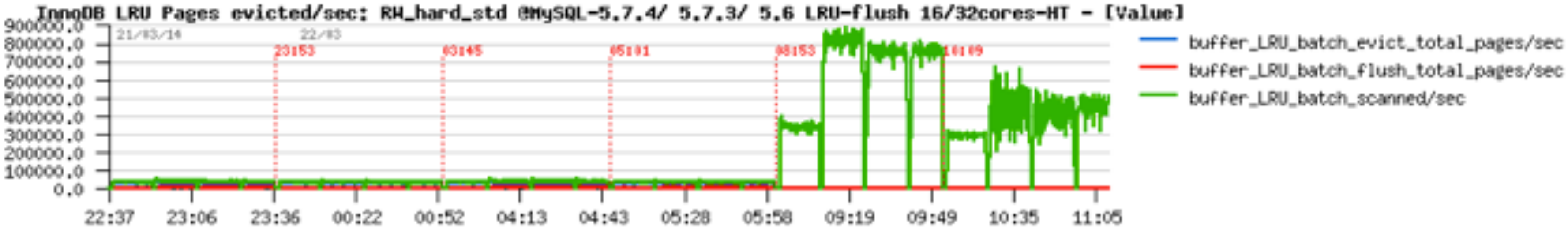
- Focus on : flush list
- Engines: 5.7 latest, 5.7.3, 5.6



OLTP_RW 10Mx32-tab Uniform : LRU-bound

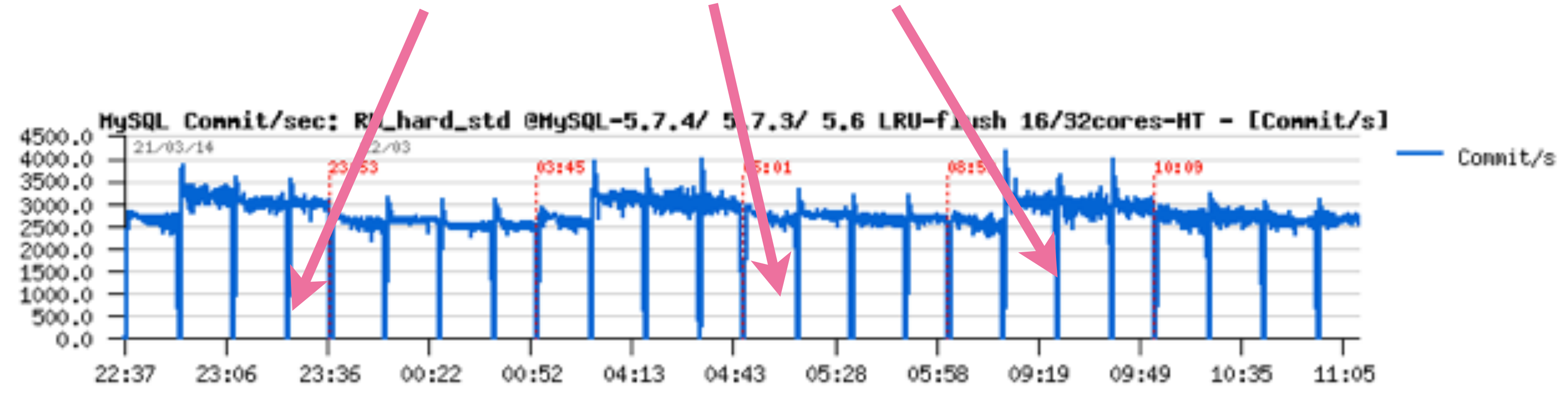
- Focus on : page scan & LRU flushing
- Engines: 5.7 latest, 5.7.3, 5.6

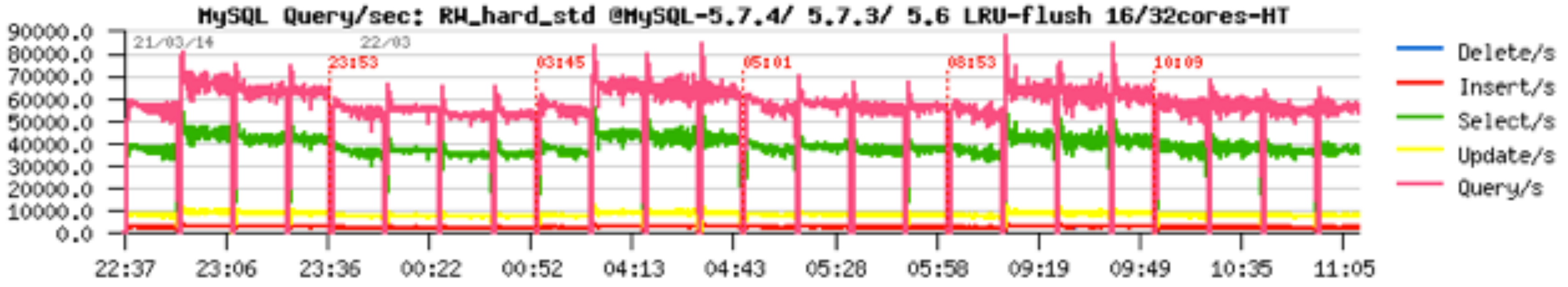




OLTP_RW 10Mx32-tab Uniform : LRU-bound

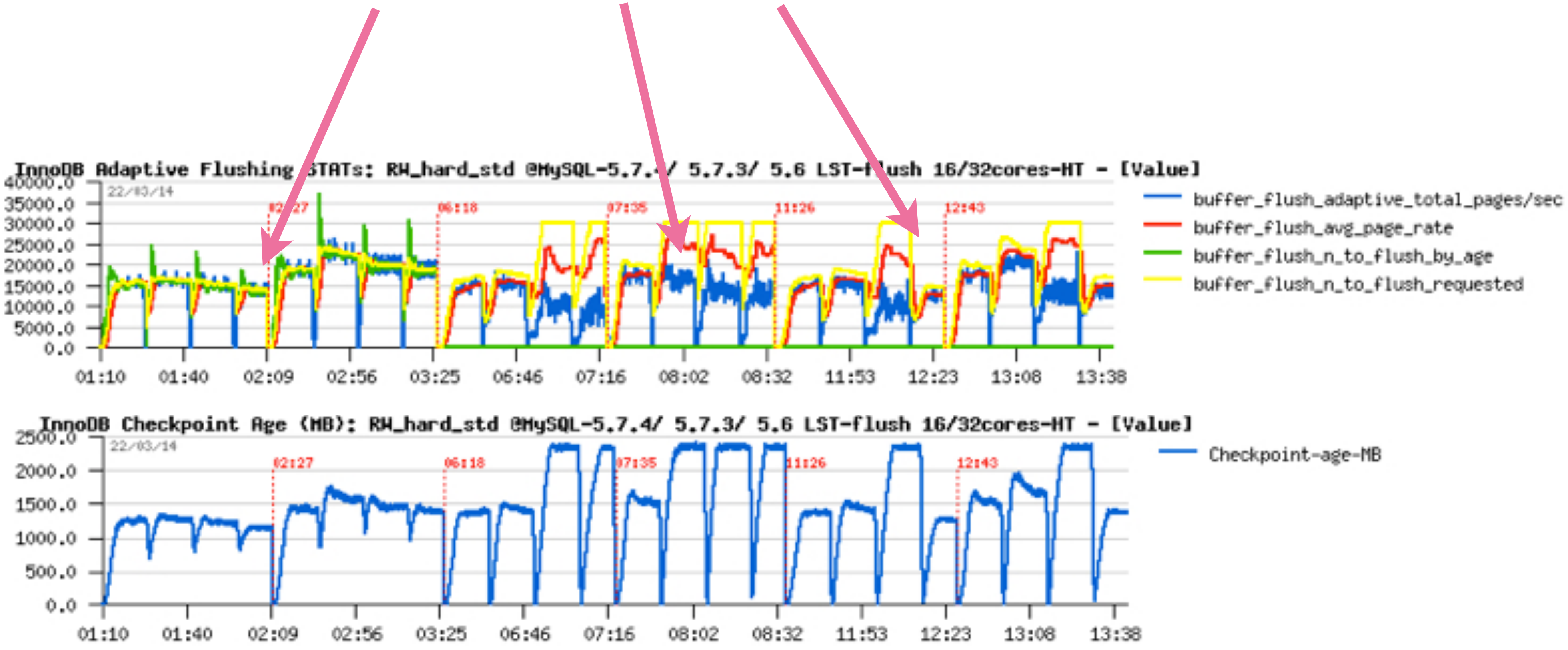
- Focus on : TPS & QPS... (hmm.. : near the same?? ;-))
- Engines: 5.7 latest, 5.7.3, 5.6





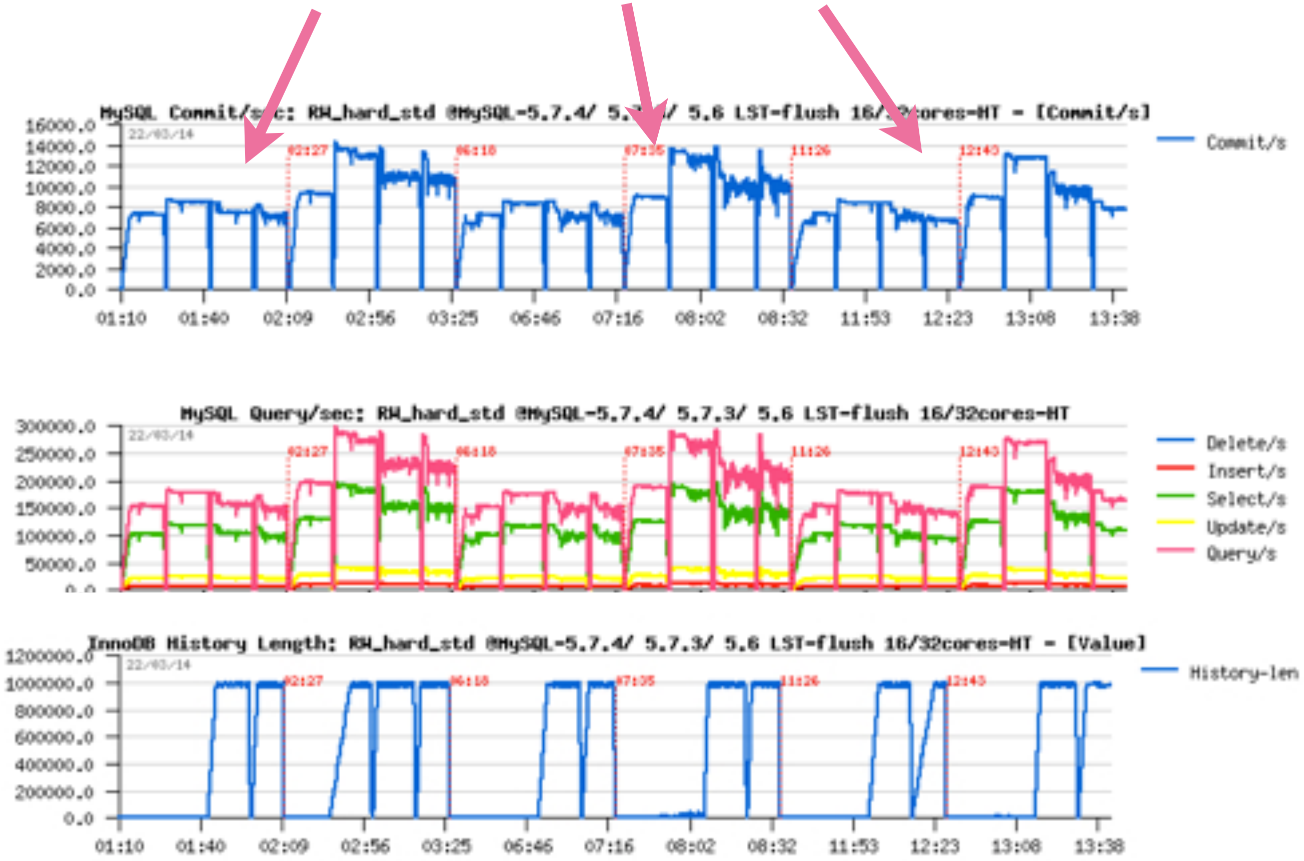
OLTP_RW 10Mx32-tab Uniform : LIST-bound

- Focus on : flush list (note: reaching 25K pages/sec on 5.7 now!)
- Engines: 5.7 latest, 5.7.3, 5.6



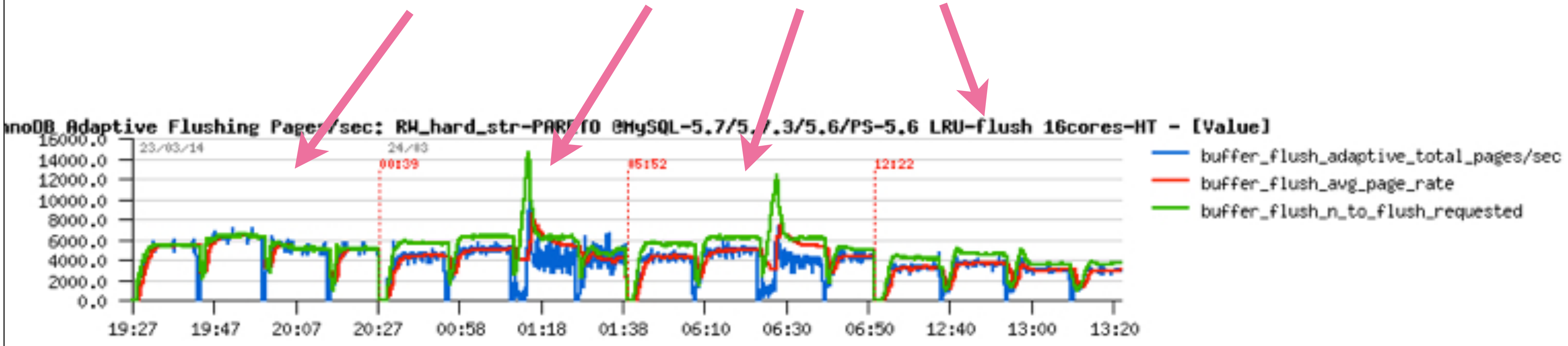
OLTP_RW 10Mx32-tab Uniform : LIST-bound

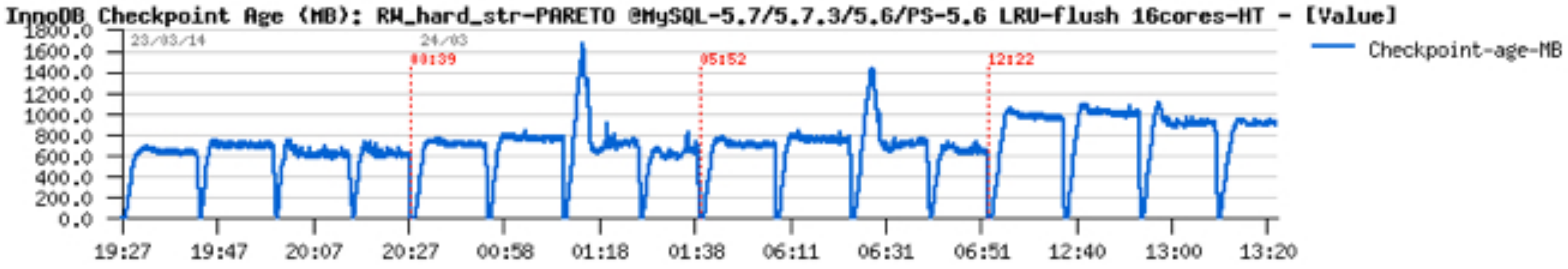
- Focus on : TPS / QPS / History Length impact
- Engines: 5.7 latest, 5.7.3, 5.6



OLTP_RW 10Mx32-tab Pareto : LRU-bound

- Focus on : flush list
- Engines: 5.7 latest, 5.7.3, 5.6, Percona 5.6

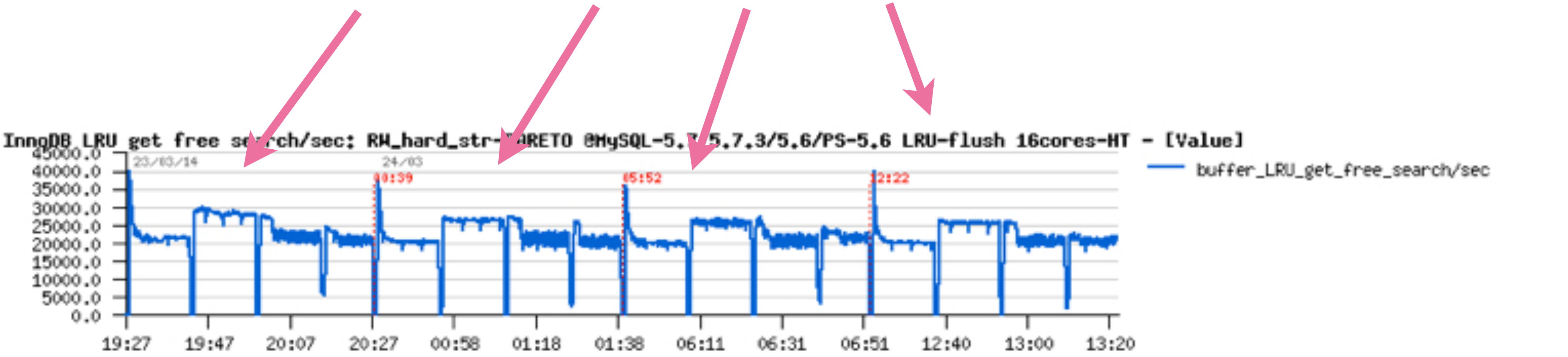


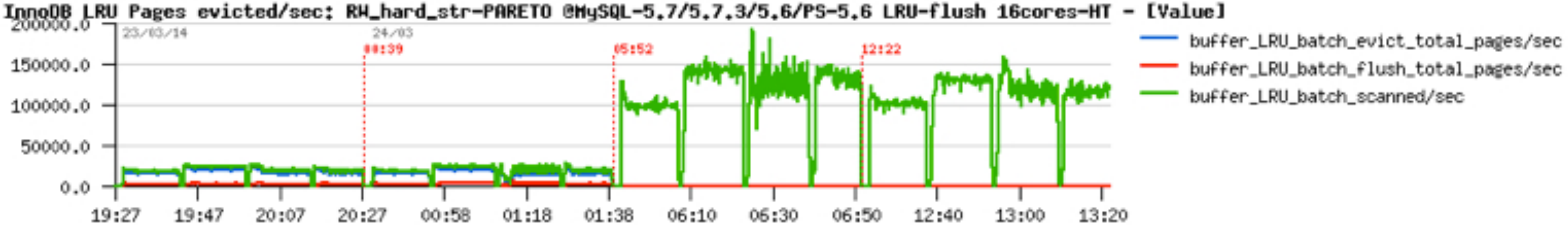


ORACLE

OLTP_RW 10Mx32-tab Pareto : LRU-bound

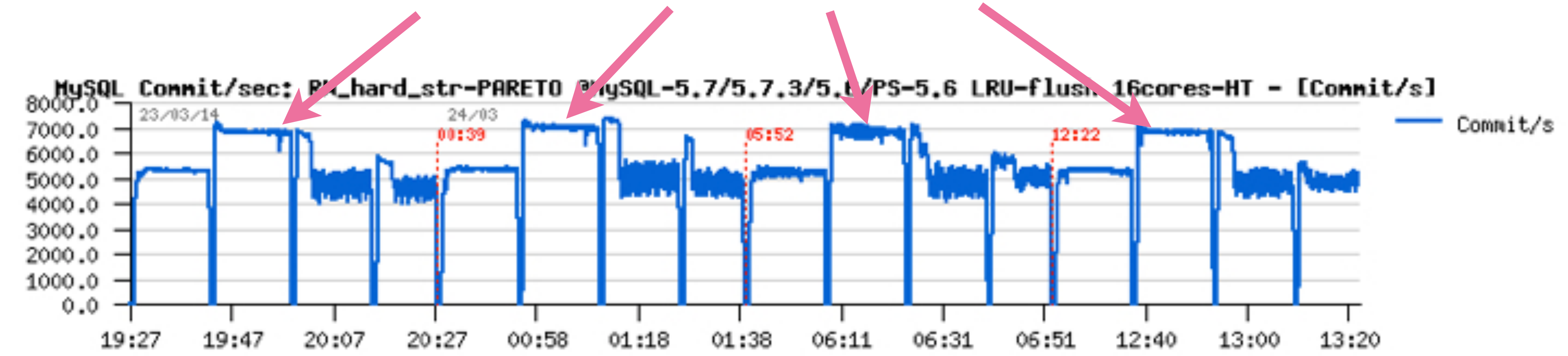
- Focus on : get free / LRU flushing
- Engines: 5.7 latest, 5.7.3, 5.6, Percona 5.6

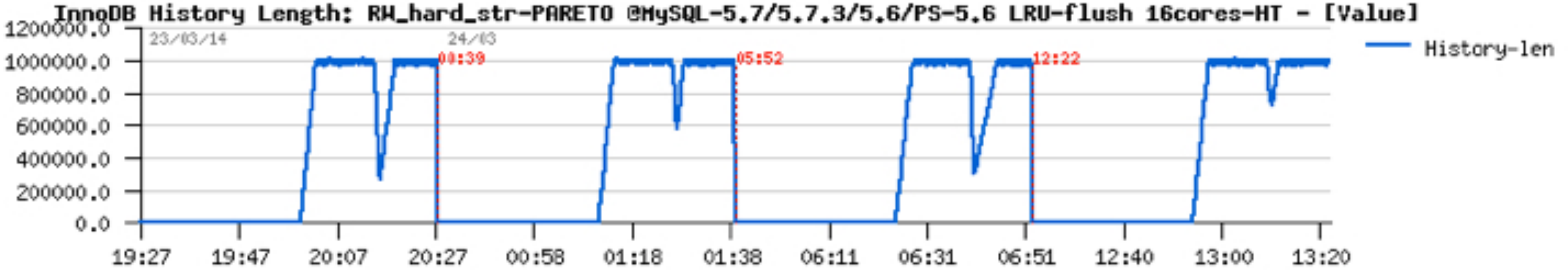




OLTP_RW 10Mx32-tab Pareto : LRU-bound

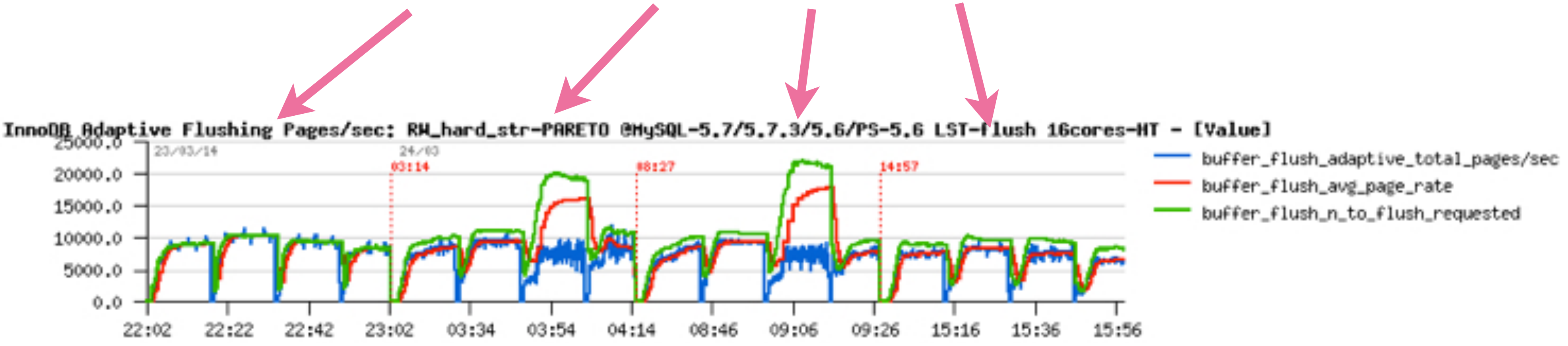
- Focus on : TPS / Purge lag
- Engines: 5.7 latest, 5.7.3, 5.6, Percona 5.6

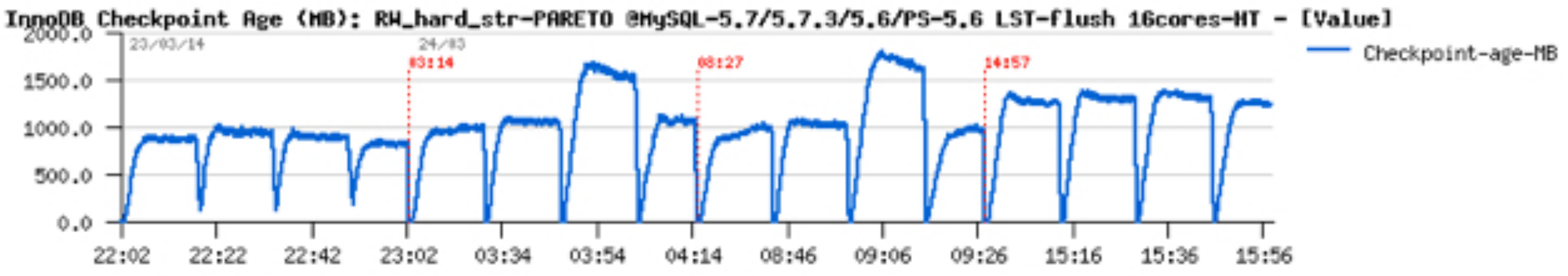




OLTP_RW 10Mx32-tab Pareto : LIST-bound

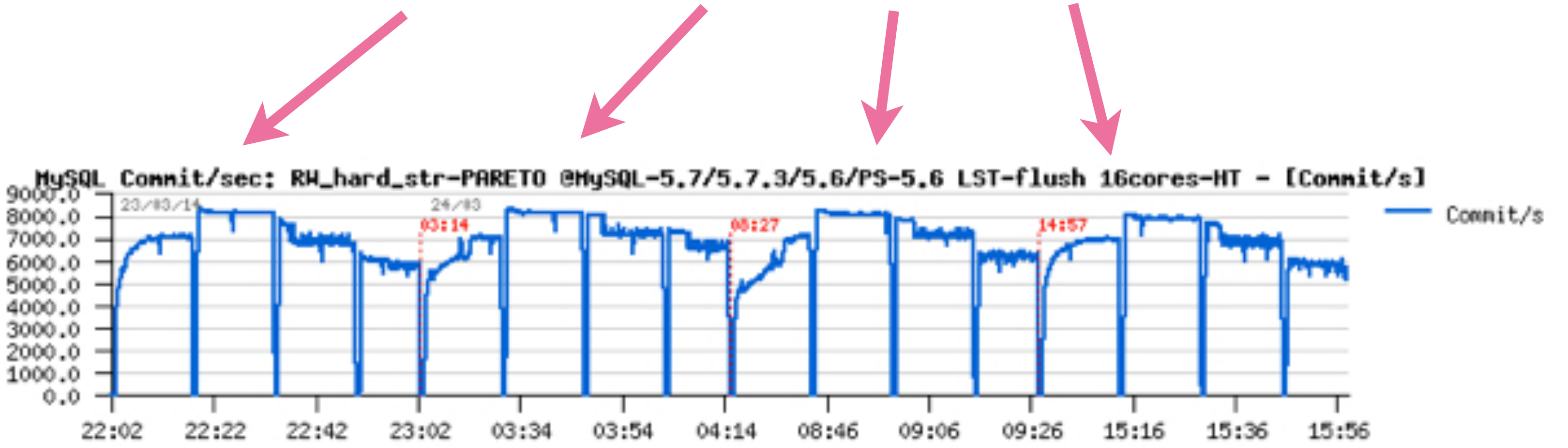
- Focus on : flush list
- Engines: 5.7 latest, 5.7.3, 5.6, Percona 5.6

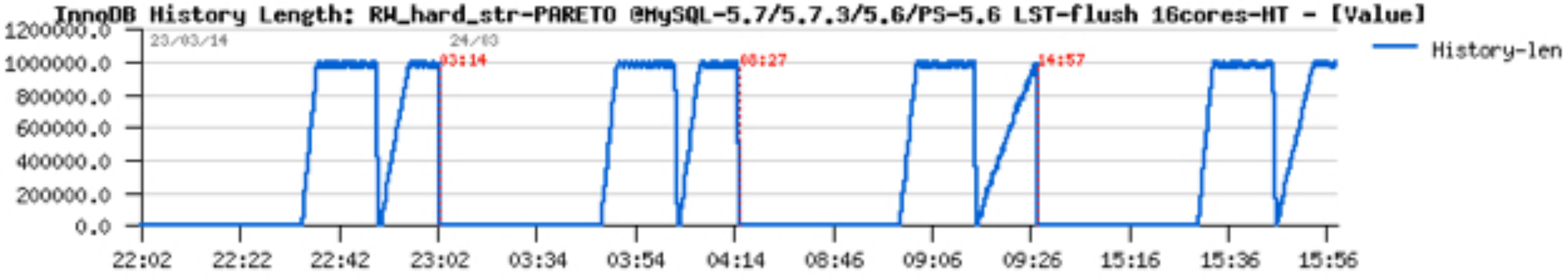




OLTP_RW 10Mx32-tab Pareto : LIST-bound

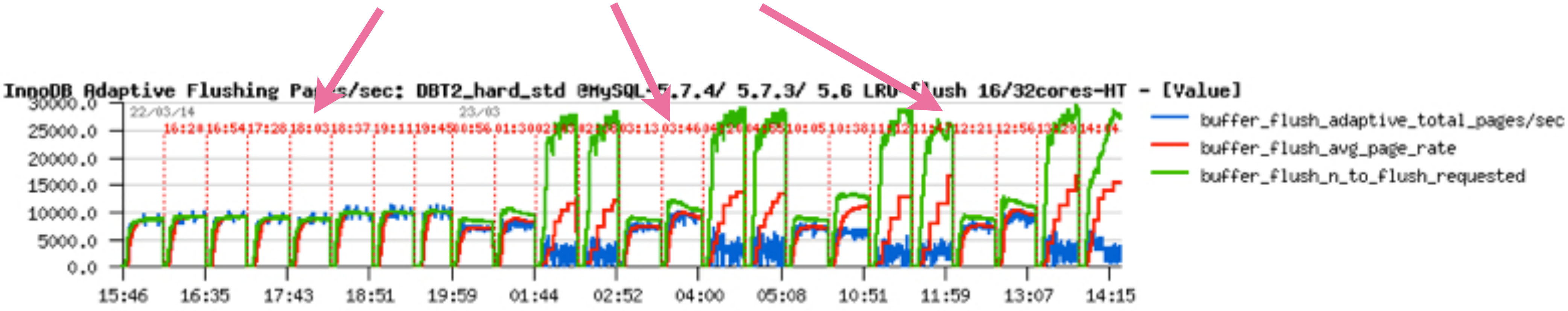
- Focus on : TPS / Purge lag
- Engines: 5.7 latest, 5.7.3, 5.6, Percona 5.6

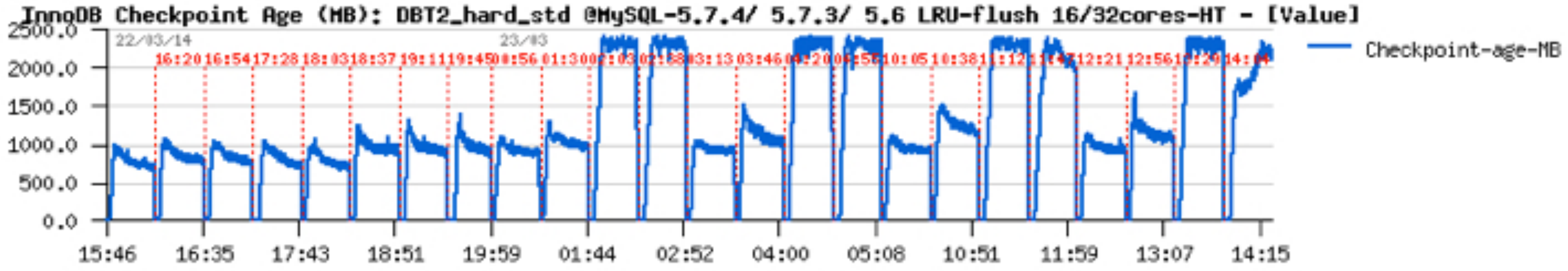




DBT2 512Wx8-db : LRU-bound

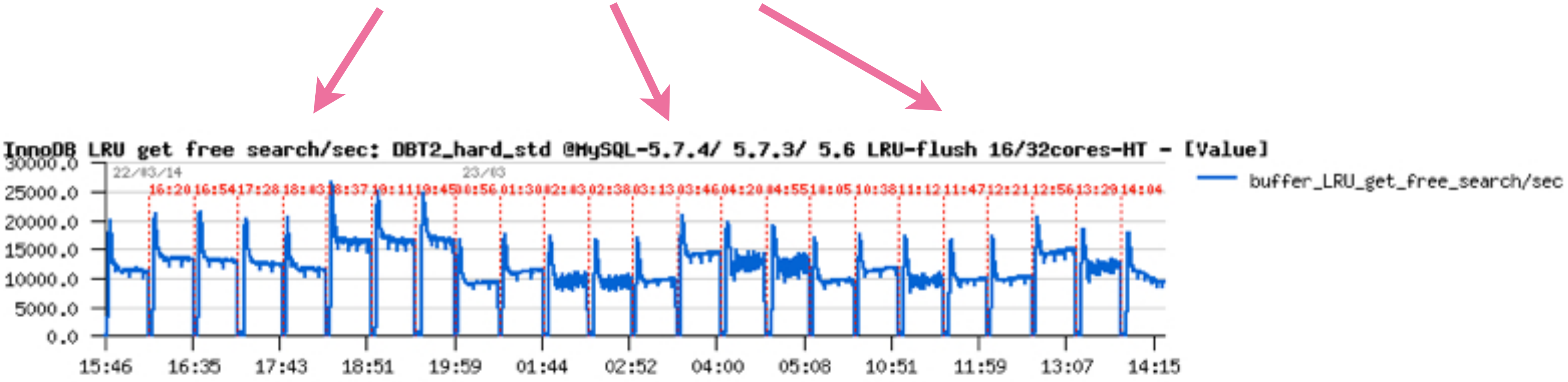
- Focus on : flush list
- Engines: 5.7 latest, 5.7.3, 5.6

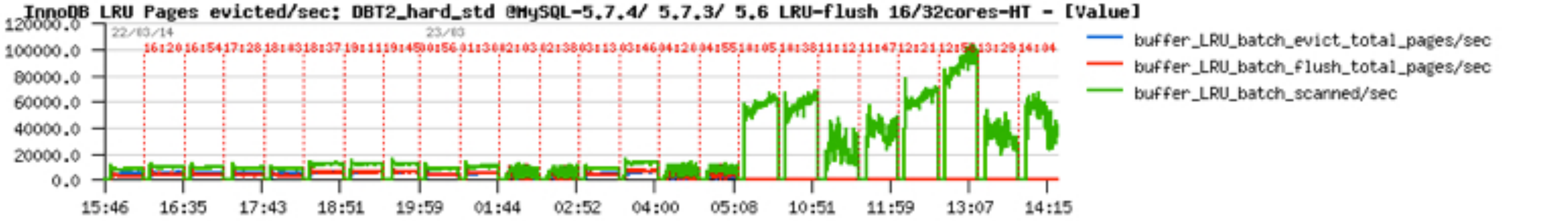




DBT2 512Wx8-db : LRU-bound

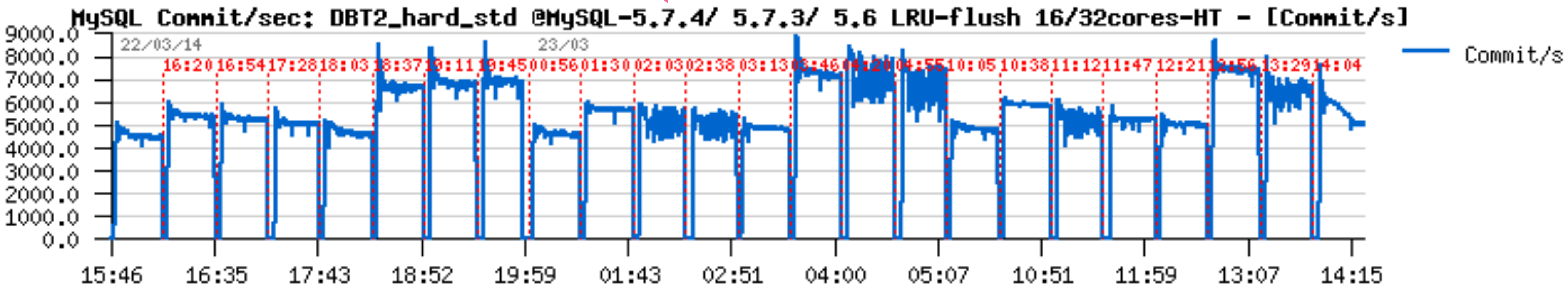
- Focus on : get free / page scan
- Engines: 5.7 latest, 5.7.3, 5.6





DBT2 512Wx8-db : LRU-bound

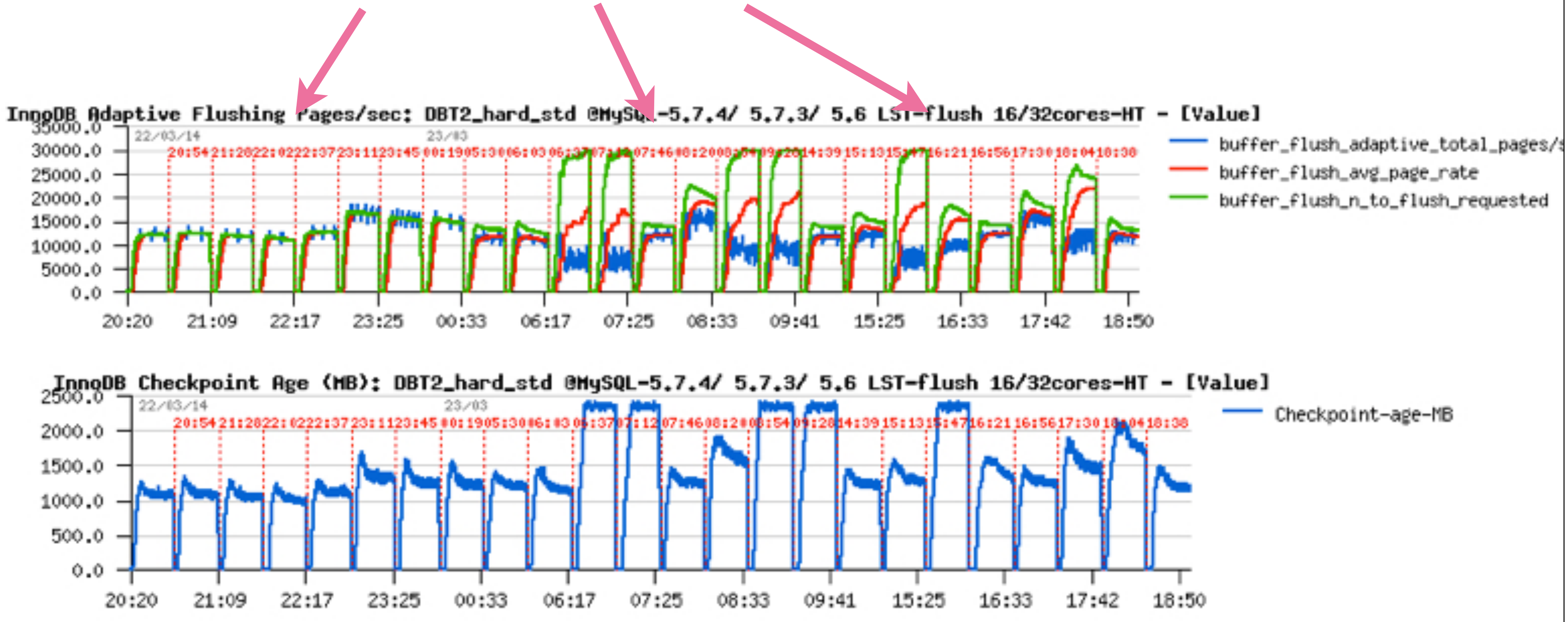
- Focus on : TPS
- Engines: 5.7 latest, 5.7.3, 5.6



- **Notes**:
  - no Purge lag = no TPS drop on 256 and 512 users..
  - innodb_thread_concurrency=64 is doing very well! ;-)

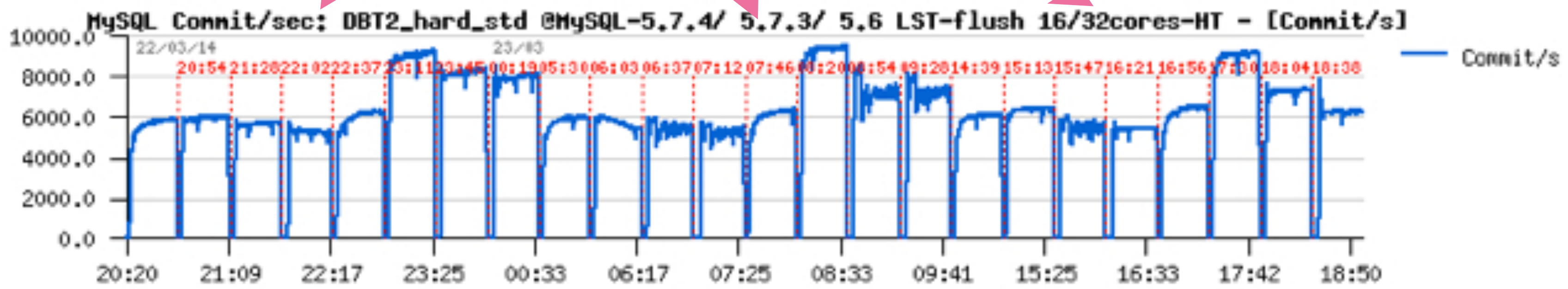
DBT2 512Wx8-db : LIST-bound

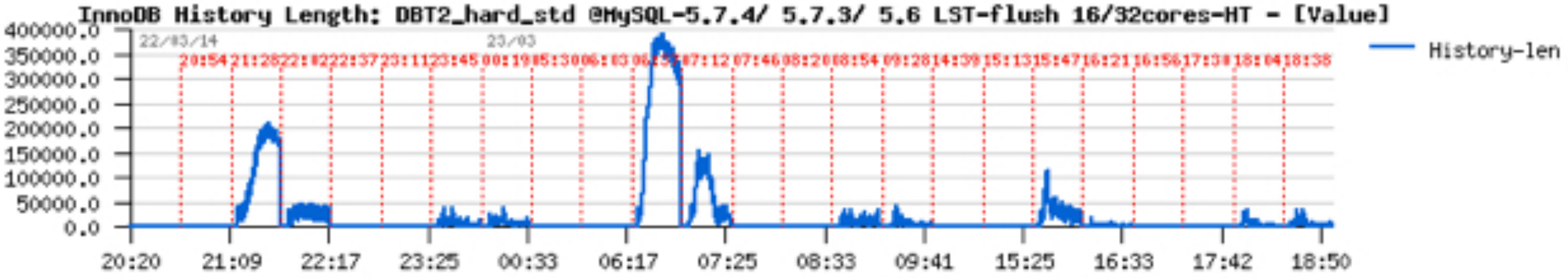
- Focus on : flush list
- Engines: 5.7 latest, 5.7.3, 5.6



DBT2 512Wx8-db : LIST-bound

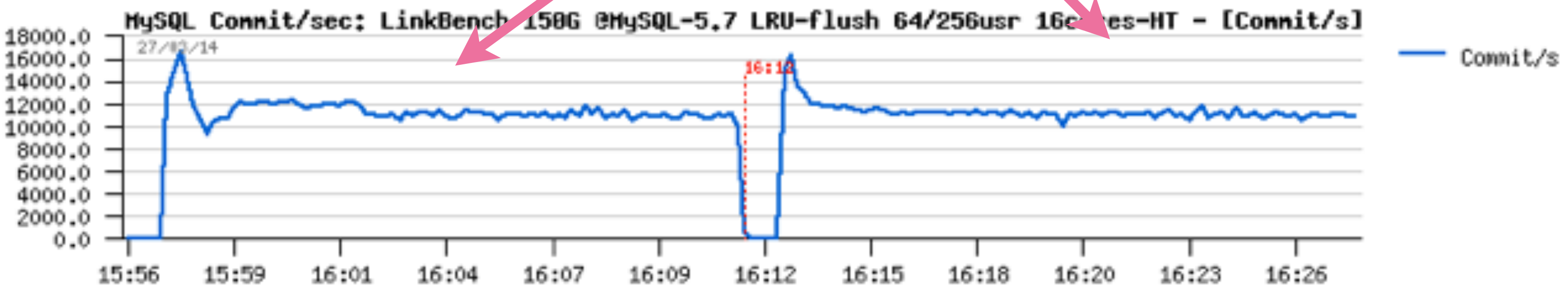
- Focus on : TPS (drops: see Checkpoint Age! not Purge Lag..)
- Engines: 5.7 latest, 5.7.3, 5.6

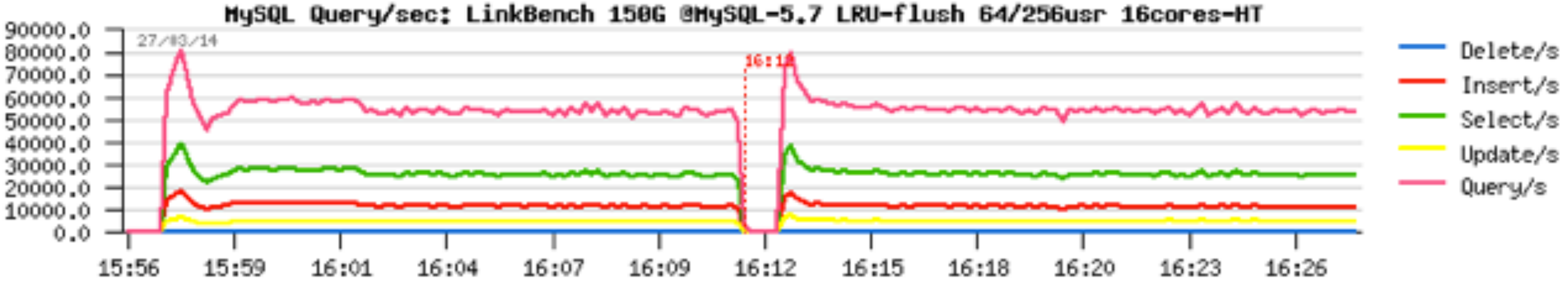




LinkBench 150G: LRU-bound

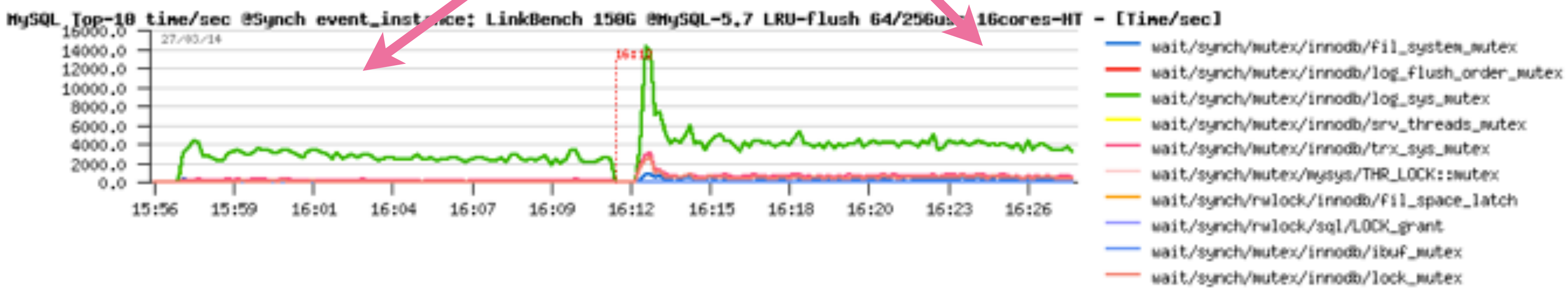
- Focus on : TPS
- Engines: 5.7 latest, 64 users / 256 users

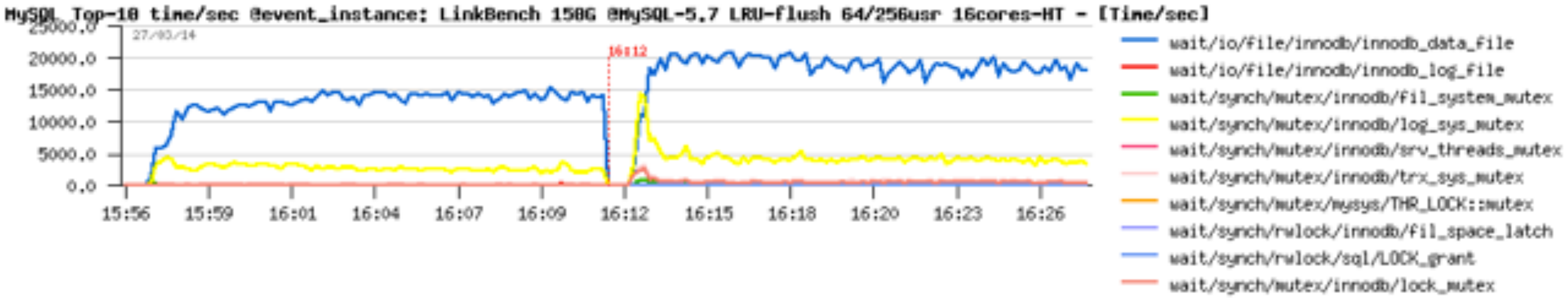




LinkBench 150G: LRU-bound

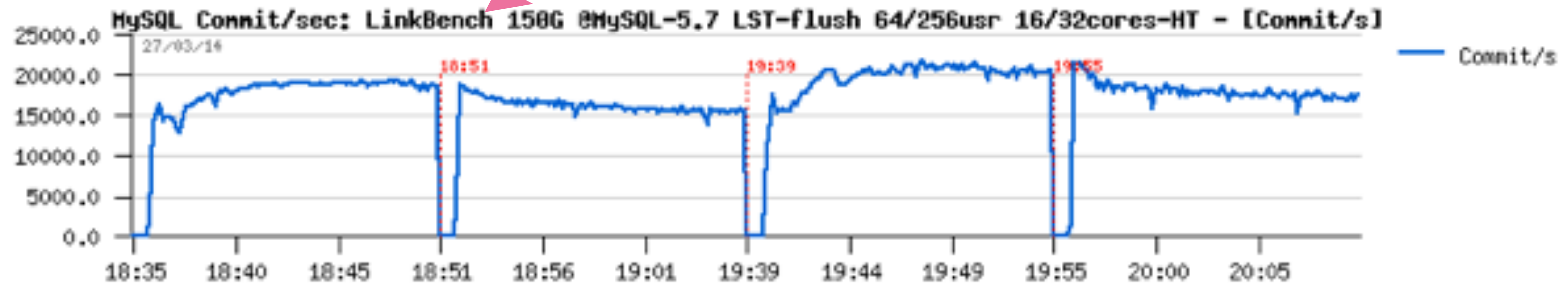
- Focus on : Lock contentions...
- Engines: 5.7 latest, 64 users / 256 users

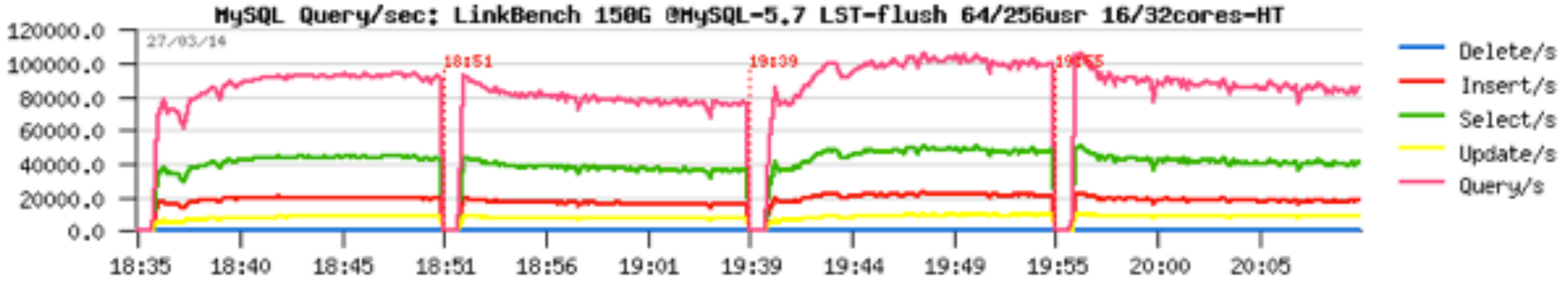




LinkBench 150G: Less LRU-bound (BP=96G)

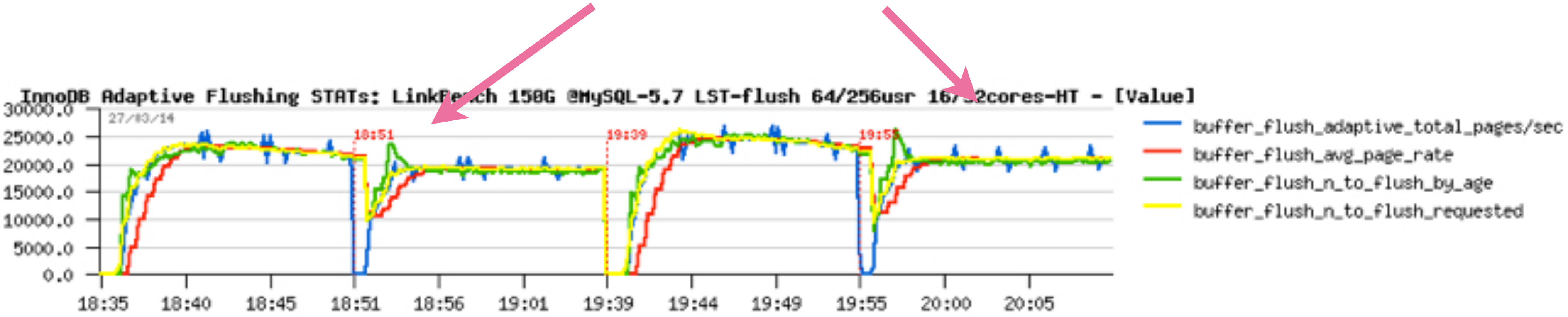
- Focus on : TPS / QPS
- Engines: 5.7 latest, 64 users / 256 users on 16/32cores-HT

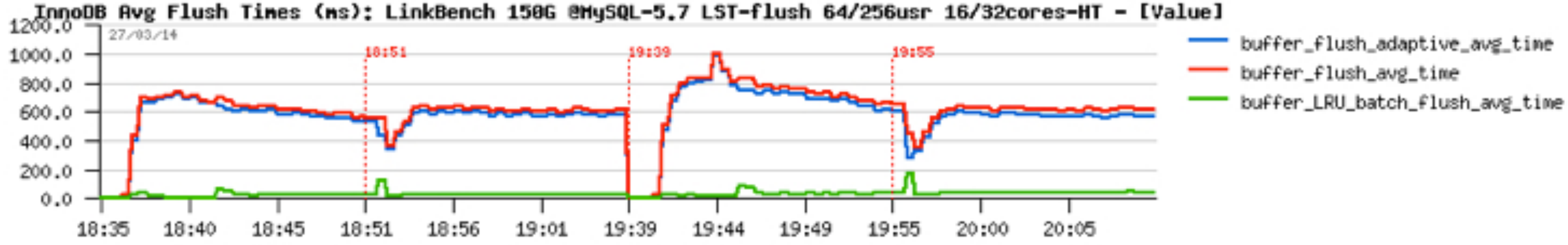




LinkBench 150G: Less LRU-bound (BP=96G)

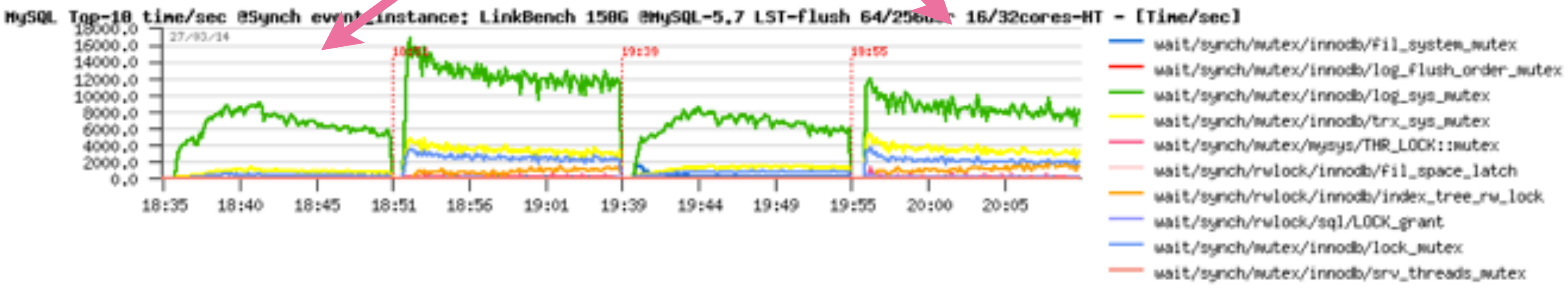
- Focus on : flush list rate / time
- Engines: 5.7 latest, 64 users / 256 users on 16/32cores-HT



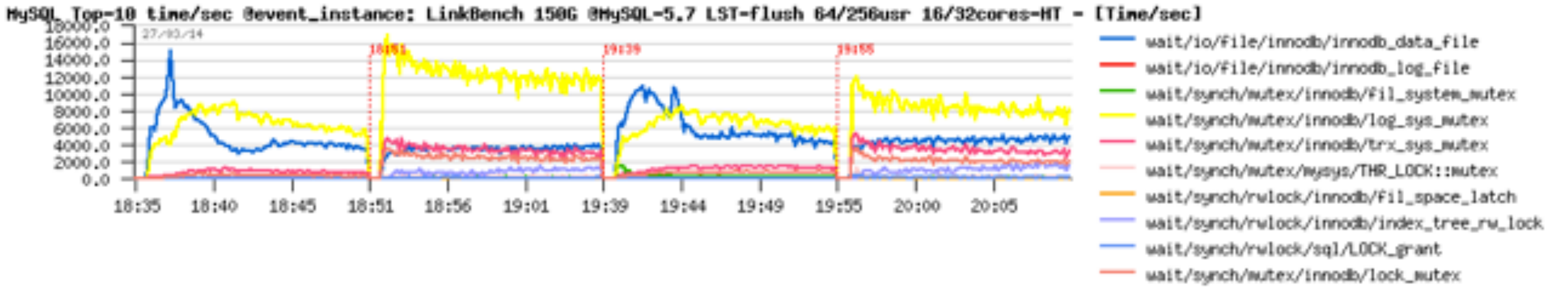


LinkBench 150G: Less LRU-bound (BP=96G)

- Focus on : Lock contentions
- Engines: 5.7 latest, 64 users / 256 users on 16/32cores-HT



MySQL Top-10 time/sec @Synch event_instance: LinkBench 150G @MySQL-5.7 LST-flush 64/256usr 16/32cores-HT - [Time/sec]



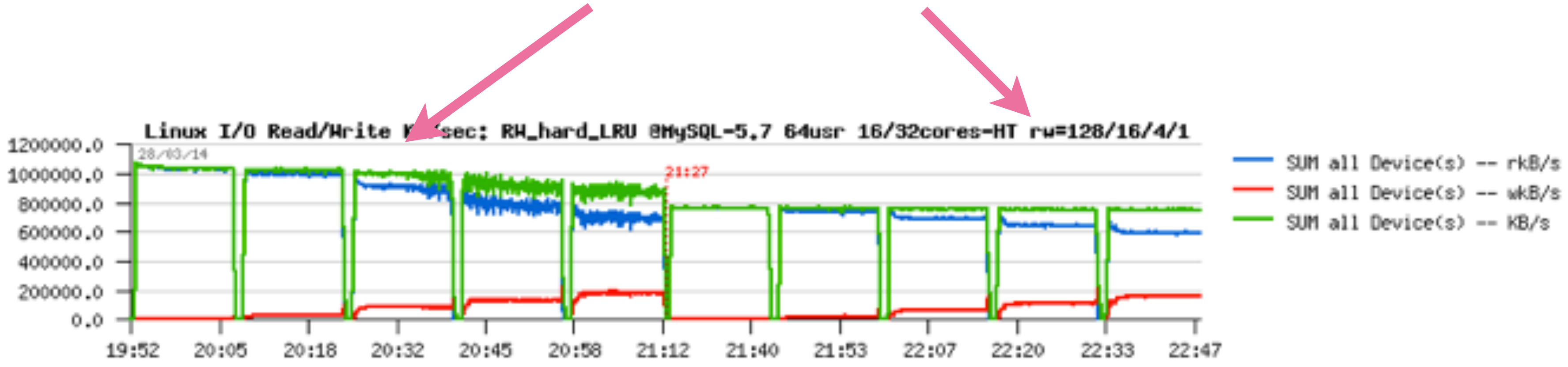
MySQL Top-10 time/sec @event_instance: LinkBench 150G @MySQL-5.7 LST-flush 64/256usr 16/32cores-HT - [Time/sec]

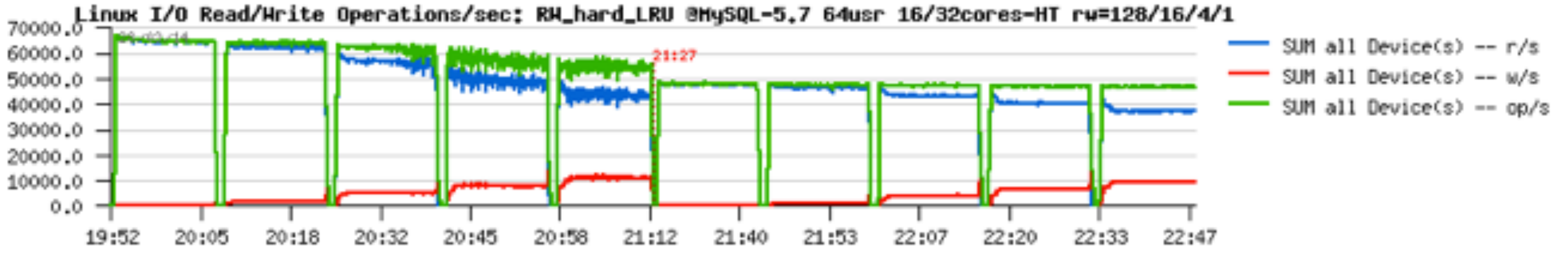
The RW IO-bound “mystery”..

- Test Case :
  - Workload: OLTP_RW 10Mx32-tab Uniform
  - CPU config : 16cores-HT / 32cores-HT
  - IO subsystem : EXT4 on F80
  - Users : 64
  - R/W ratio : 128, 16, 4, 1

The RW IO-bound “mystery”

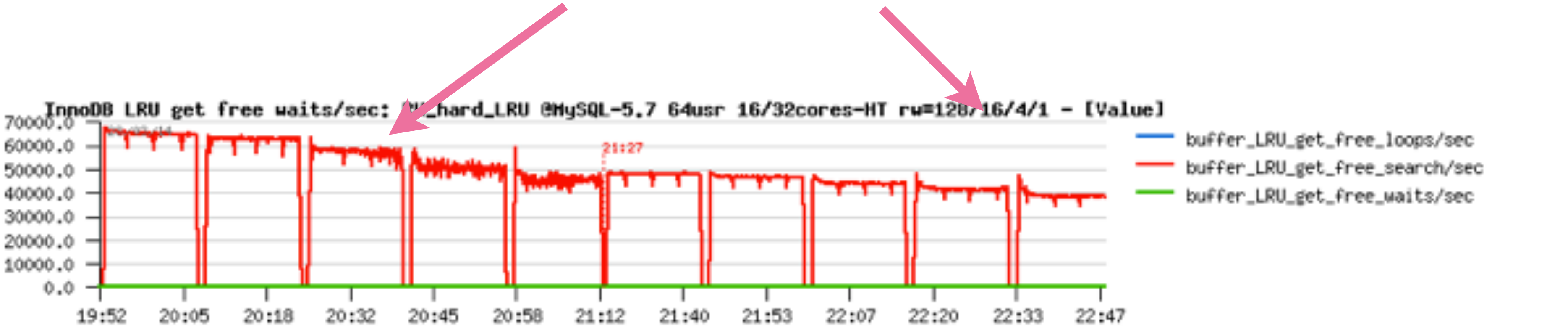
- Focus on : I/O stats
- Engines: 5.7 latest, 16cores-HT / 32cores-HT

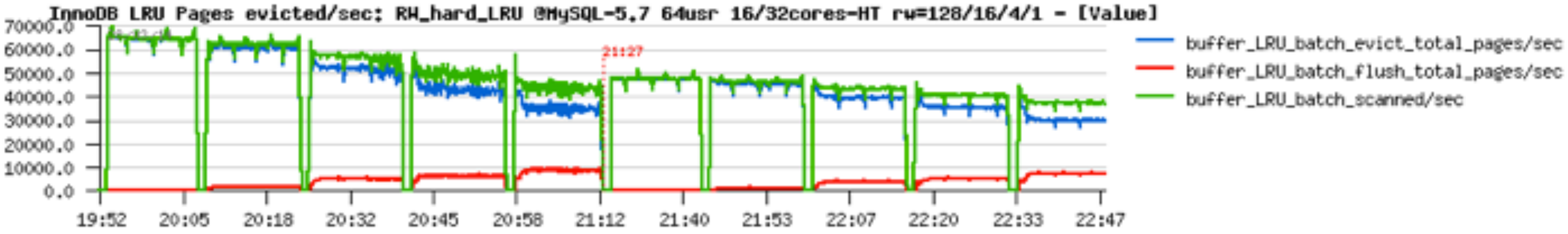




The RW IO-bound “mystery”

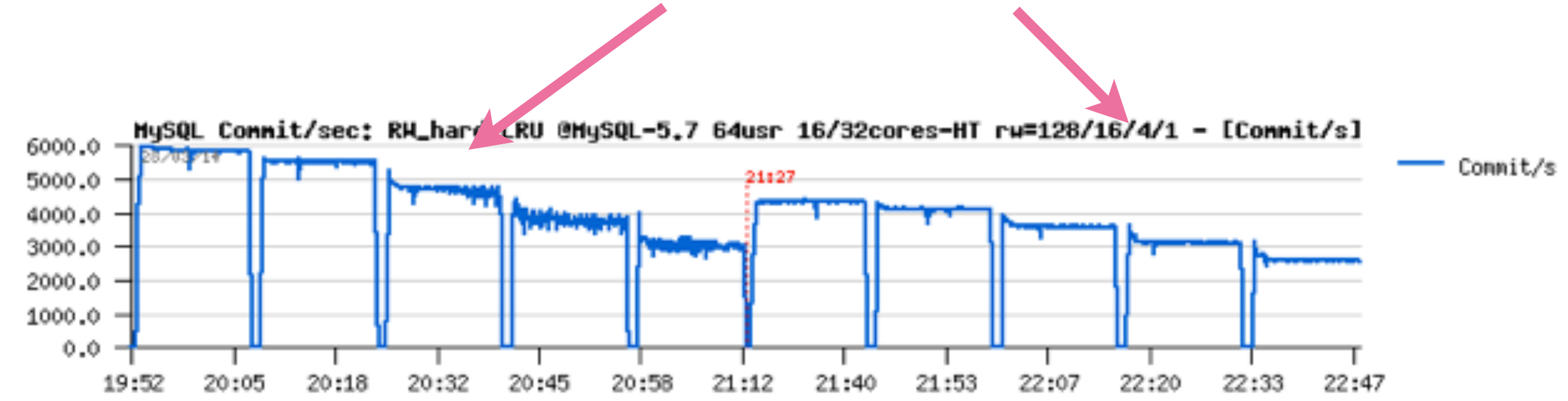
- Focus on : LRU stats
- Engines: 5.7 latest, 16cores-HT / 32cores-HT

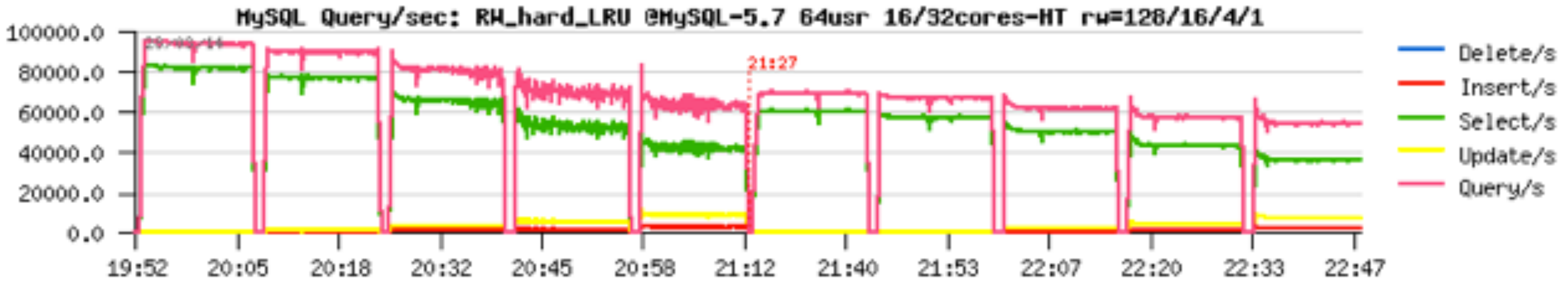




The RW IO-bound “mystery”

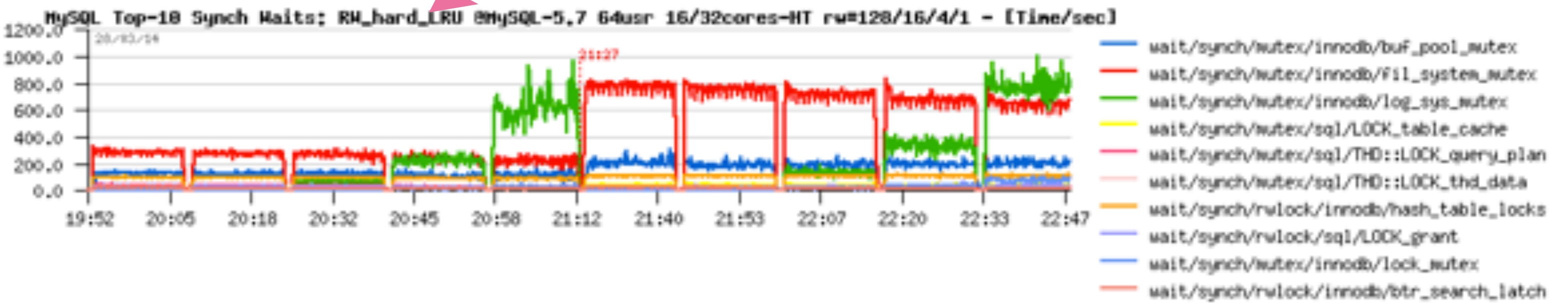
- Focus on : TPS / QPS (note: x2 times worse at the end!!)
- Engines: 5.7 latest, 16cores-HT / 32cores-HT

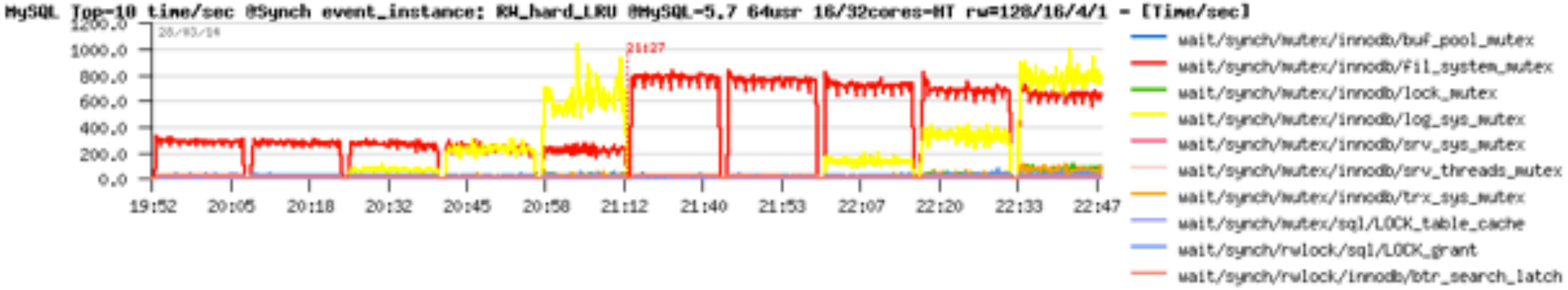




The RW IO-bound “mystery”

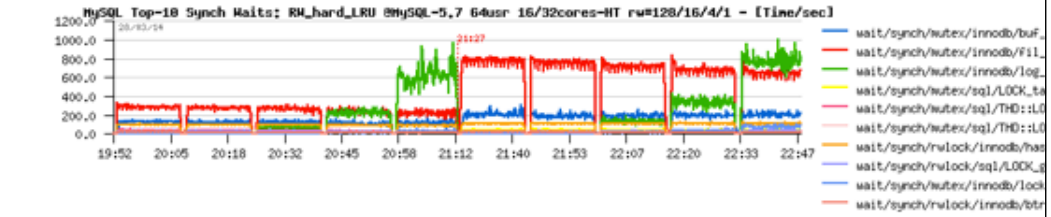
- Focus on : Lock contentions... (note: killing fil_sys + log_sys)
- Engines: 5.7 latest, 16cores-HT / 32cores-HT

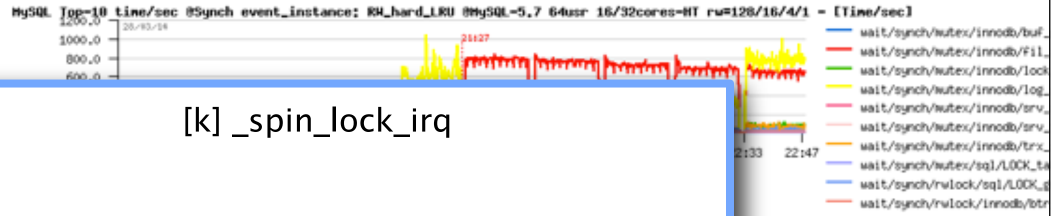




The RW IO-bound “mystery”

- Why not scaling?
  - InnoDB : killing fil_sys + log_sys
  - I/O : kernel contention !!!





```
17.80%      mysqld  [kernel.kallsyms]          [k] _spin_lock_irq
         |
         --- _spin_lock_irq
           |
           |--51.26%-- scsi_request_fn
           |     |
           |     |--89.93%-- __generic_unplug_device
           |     |     |
           |     |     |--65.42%-- __make_request
           |     |     |     generic_make_request
           |     |     |     submit_bio
           |     |     |     |
           |     |     |     |--99.83%-- dio_bio_submit
           |     |     |     |     __blockdev_direct_IO
           |     |     |     |     |
           |     |     |     |     |--97.28%-- ext4_ind_direct_IO
           |     |     |     |     |     ext4_direct_IO
           |     |     |     |     |     generic_file_aio_read
```

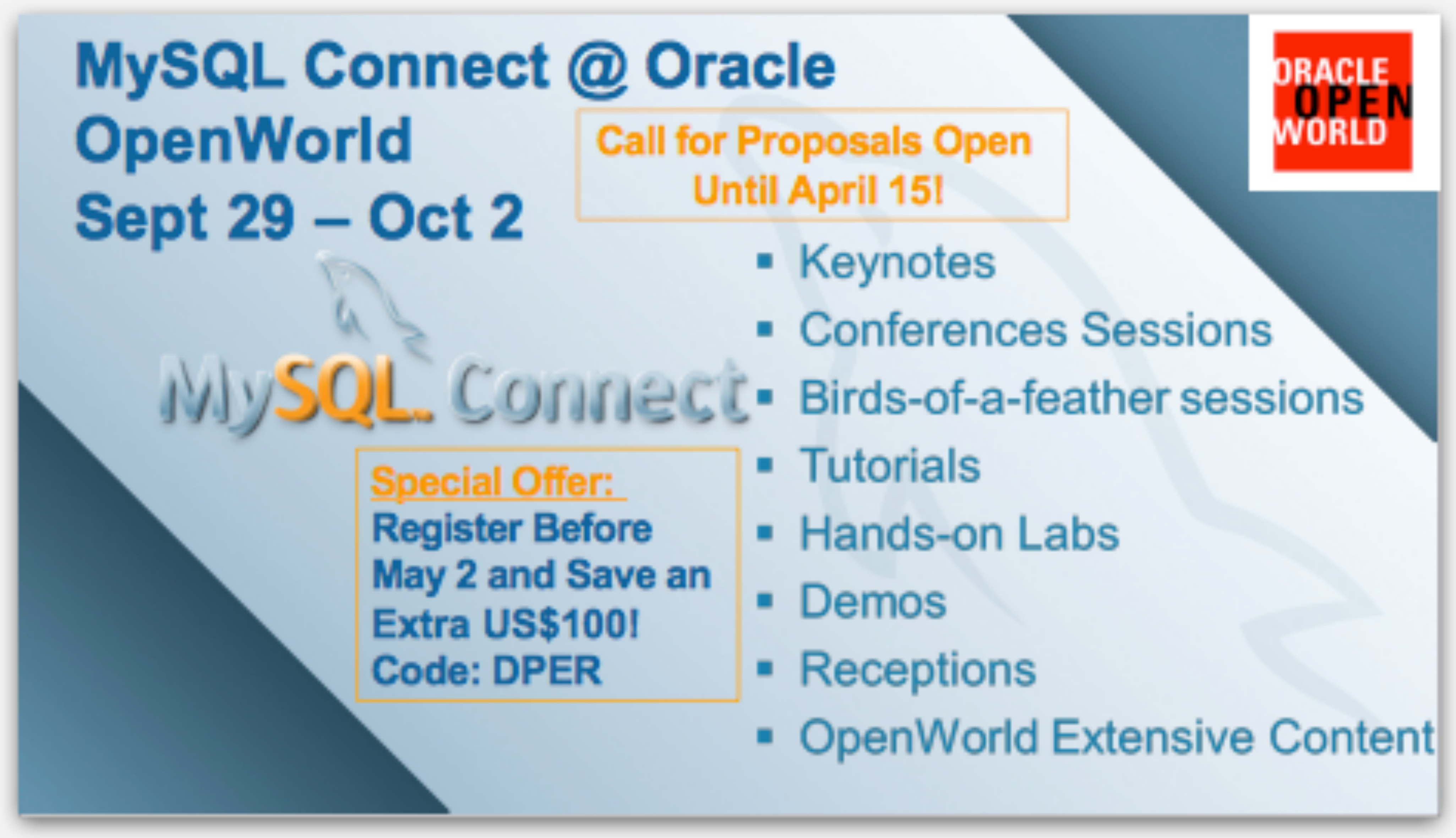
So, work continues..
stay tuned... ;-)

Few words about dim_STAT (if you're asking ;-))

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

THANK YOU !!!

- All details about presented materials you may find on:
  - http://dimitrik.free.fr - dim_STAT, dbSTRESS, Benchmark Reports, etc.
  - http://dimitrik.free.fr/blog - Articles about MySQL Performance, etc.



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