MySQL Performance: Scalability & Systems Evaluation Overview 2025

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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 Overview @Linux
- Systems Evaluation by MySQL Benchmark Workloads
- Q & A

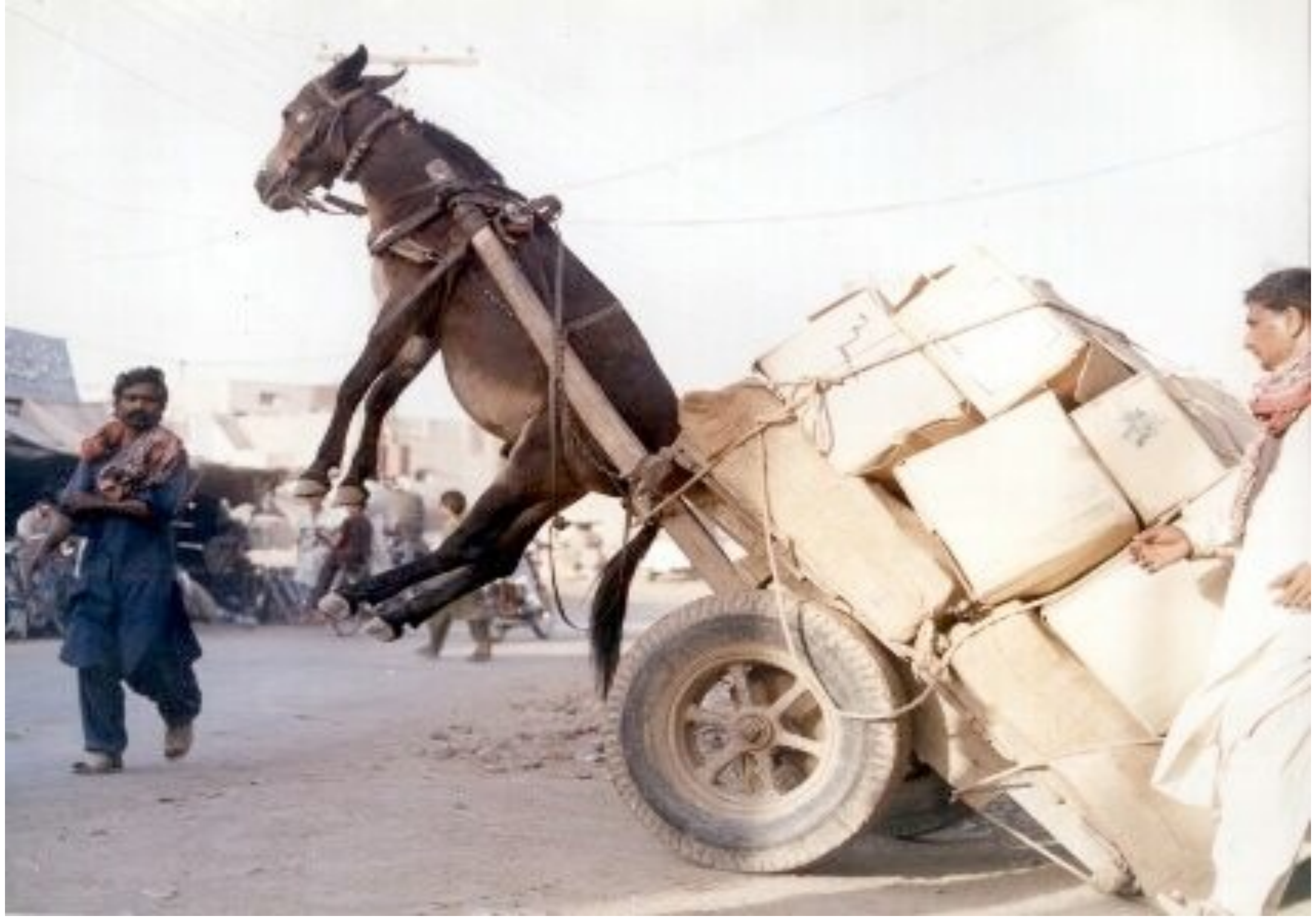
Why Scalability ?...

Why Scalability ?..

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

Why Scalability ?..

- Until it did not reach its limit..



Why Scalability ?..

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

Why Scalability ?..

- And reach a similar limit..

Why Scalability ?..

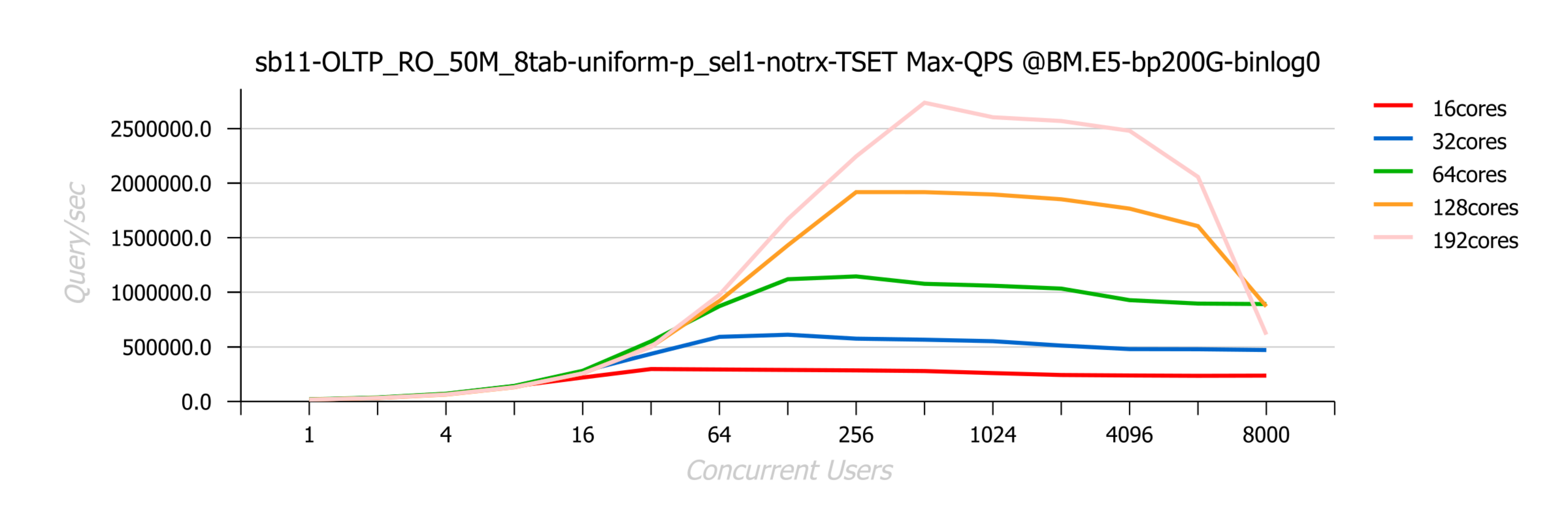
- Analyzing your workload performance and scalability by testing your limits may help you to understand ahead the resistance of your solution to incoming potential problems ;-)

Why Scalability ?..

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

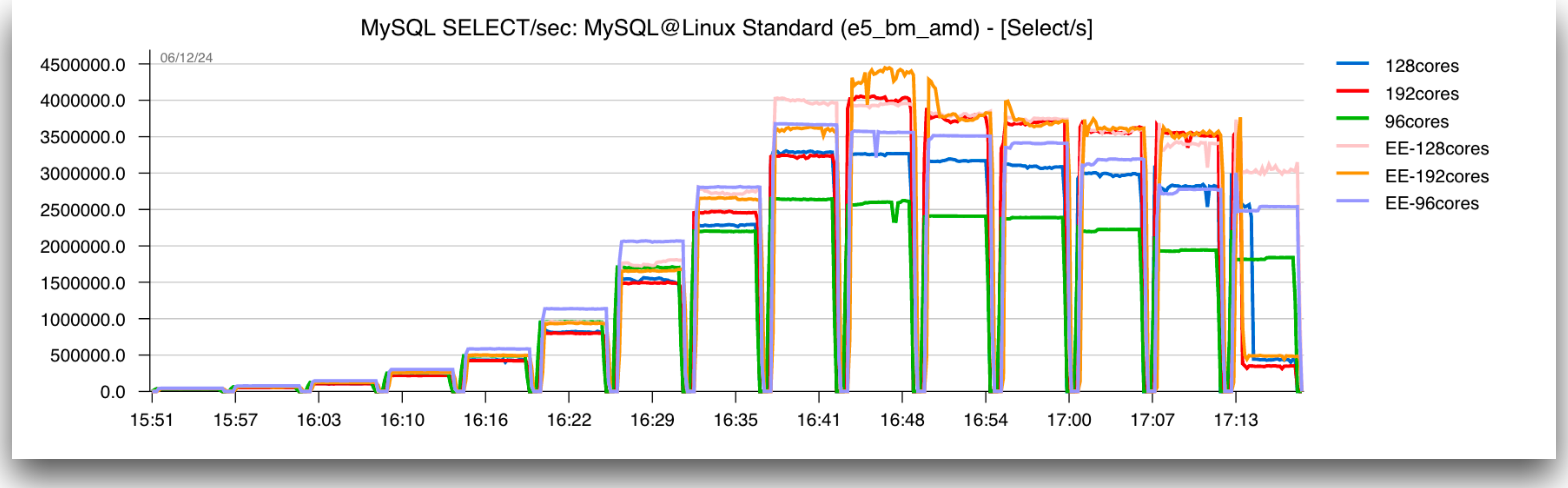
Scalability..

- what do we speak about ?
  - in short, scalability expectation : more resources => more work done
  - efficiency expectation : do more with less ;-))



Scalability.. (one more ;-))

- using prep.statements + UNIX socket :



MySQL Scalability Milestones over past 15 years..

- MySQL 5.5
  - delivered “already known” solutions (except BP instances and few other)..
- MySQL 5.6
  - first fundamental changes (kernel_mutex split, Adaptive Flushing, G5 patch, etc..)
  - but : RW workloads are faster than RO ! ;-))
- MySQL 5.7
  - finally fully unlocked Read-Only + no more contentions on the “Server” layer, etc..
  - and (finally) RO is faster than RW !! ;-))
- MySQL 8.0
  - main focus is on efficiency : do more on the same HW ;-))
  - main target HW : 2CPU Sockets systems (can be pretty big)
  - RW scalability.. & data security..
  - NOTE : Continuous Release Model ! => + new DBLWR, LOCK mgmt, REDO resize, etc..

MySQL Realities in 2025..

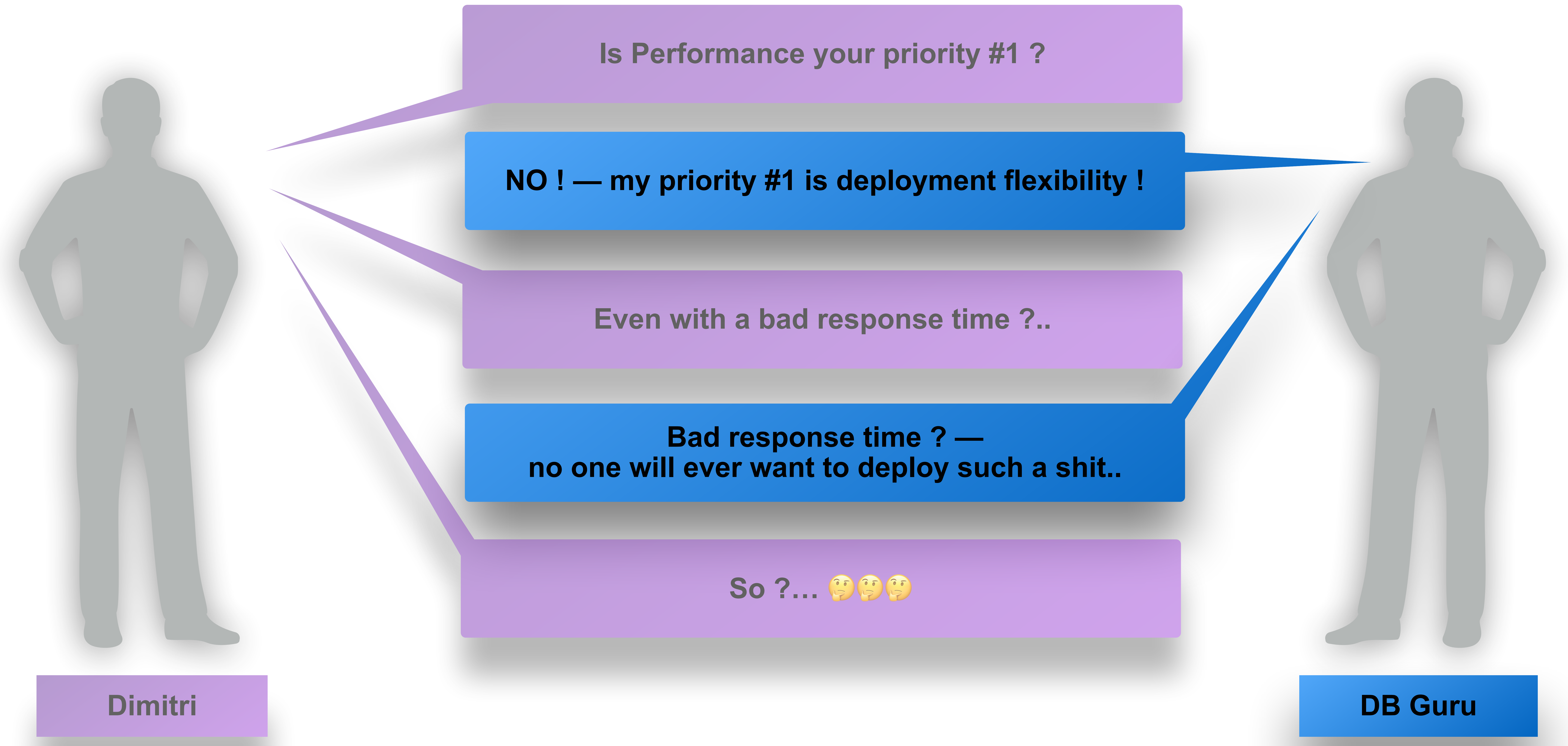
- Users before => “too long to wait for new features in new release !”
  - MySQL => here is MySQL 8.0 Continuous Release !

- Users => “too new many features every 3 months, we cannot follow !”
  - MySQL => OK, here is MySQL 8.4 LTS ;-))

- Users before => “I have 96cores systems, MySQL don’t scale !”
  - MySQL => OK, let’s work hard to improve overall scalability !

- Users today => “How I can speedup MySQL on my 2cores VM ?”..
  - MySQL => what ?.. ;-))
  - (hm.. maybe we should reconsider support for MySQL 5.1 ??.. ;-))

Why MySQL Performance ? => entry ticket



Is Performance your priority #1 ?

NO ! — my priority #1 is deployment flexibility !

Even with a bad response time ?..

Bad response time ? —
no one will ever want to deploy such a shit..

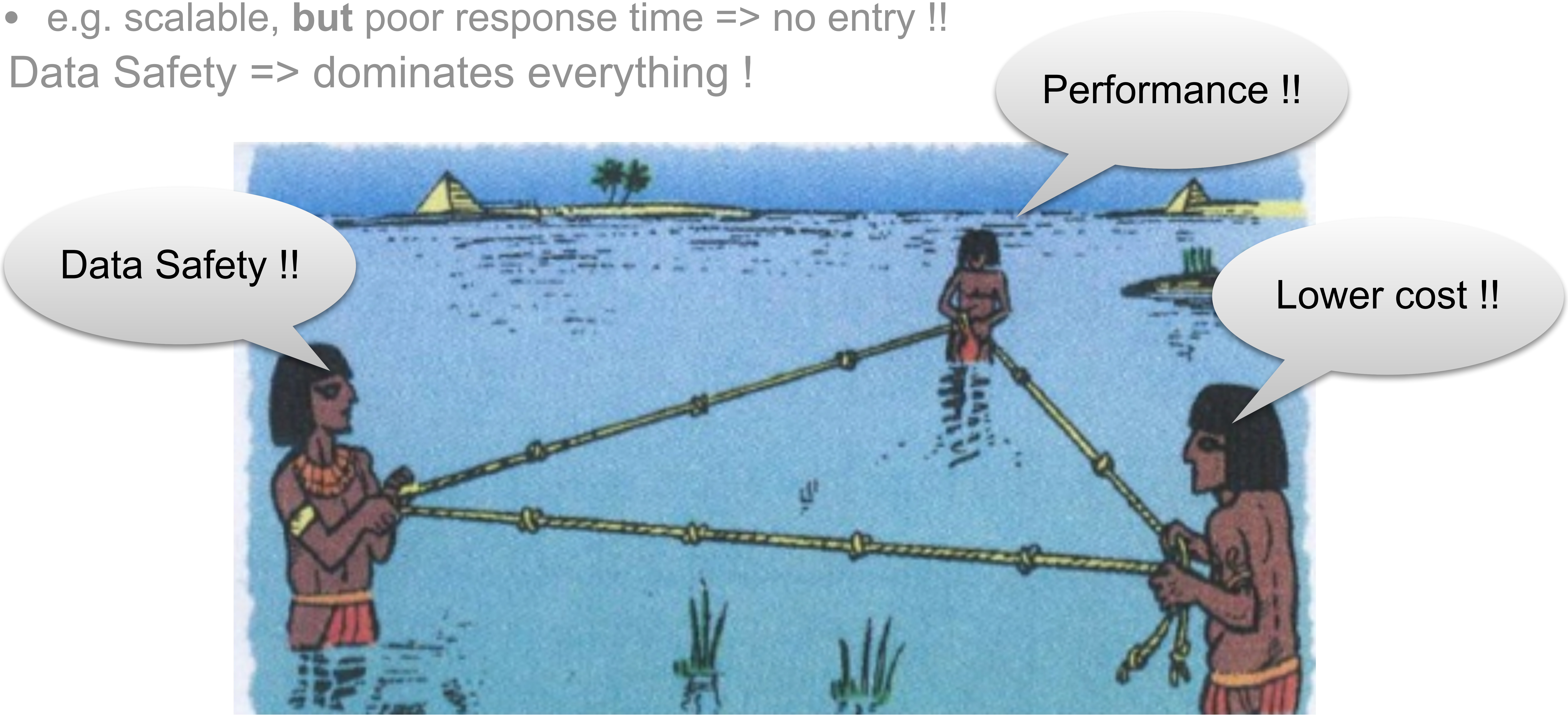
So ?… 🤔🤔🤔

Dimitri

DB Guru

About Priority Balance

- Performance -vs- Data Safety -vs- Lower Cost…
  - Performance => entry ticket
    - e.g. scalable, **but** poor response time => no entry !!
  - Data Safety => dominates everything !

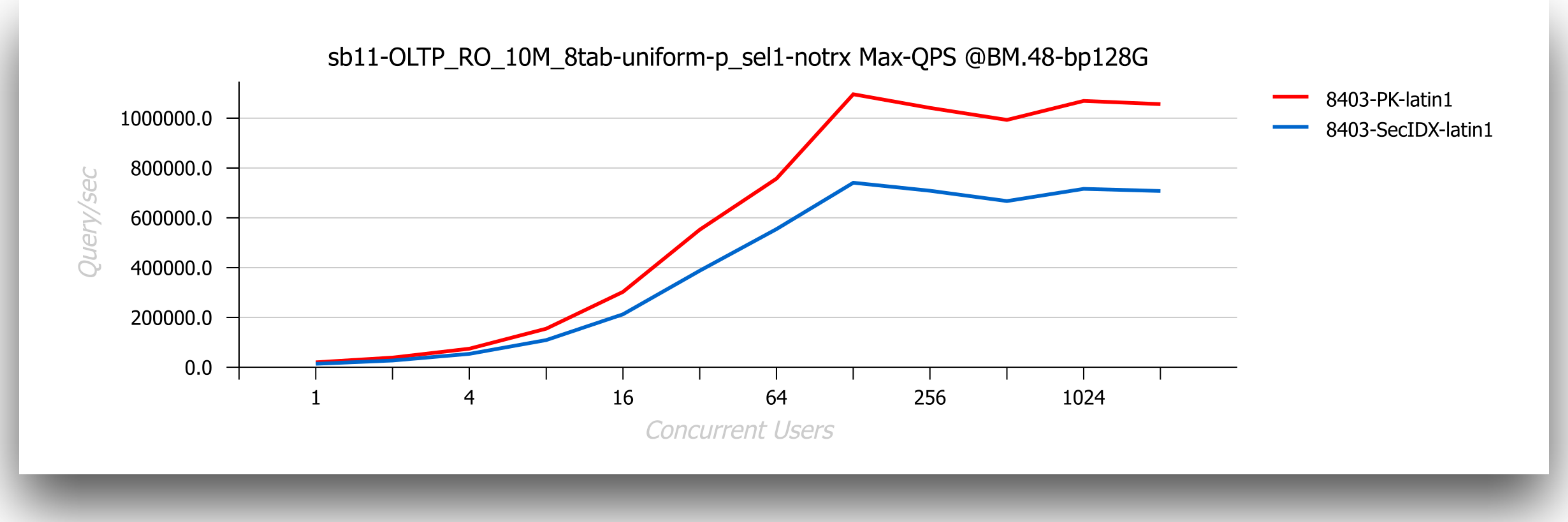


RO Scalability Limits

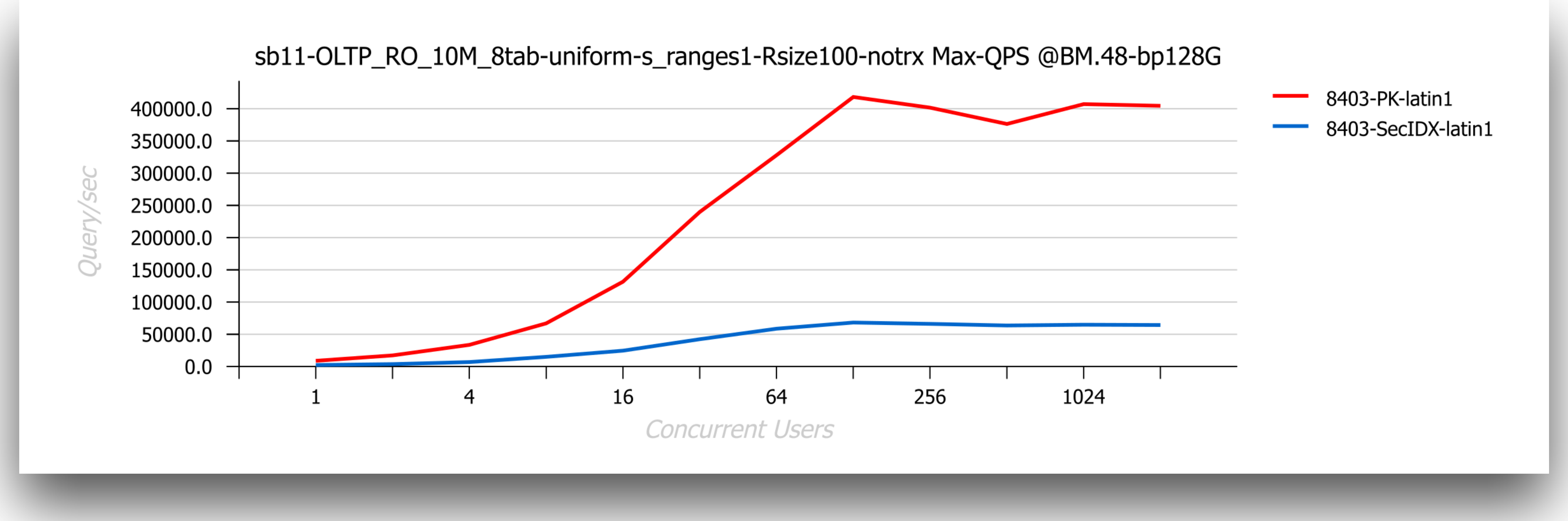
- simple & fast queries ? query execution plan ?
- malloc ! => consider tcmalloc or jemalloc
- re-connect or persistent connections ??
- SSL overhead
- AHI : on / off ? (since 8.4 def: off)
  - speed-up on low load
  - bottleneck on high load
- RW-lock contention on CPU cache
- PK in table is mandatory !
- PK vs SK lookups
- ...

RO Limits : PK -vs- SK lookups

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



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



ORACLE

RO Limits : PK -vs- SK lookups

- Point-SELECT
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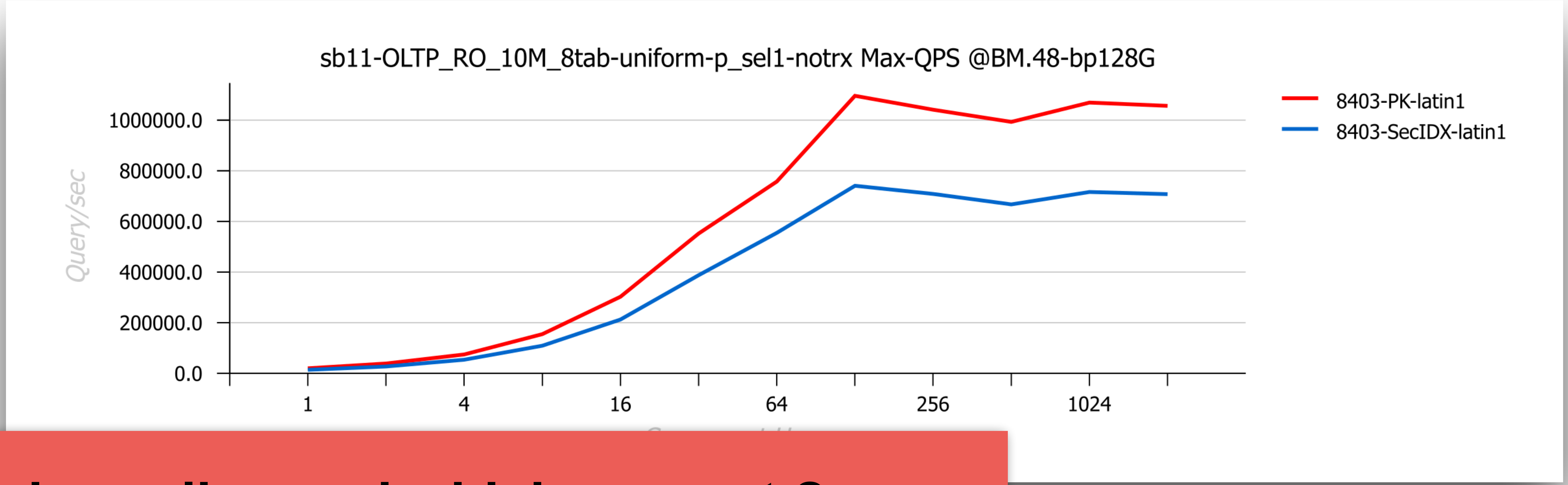
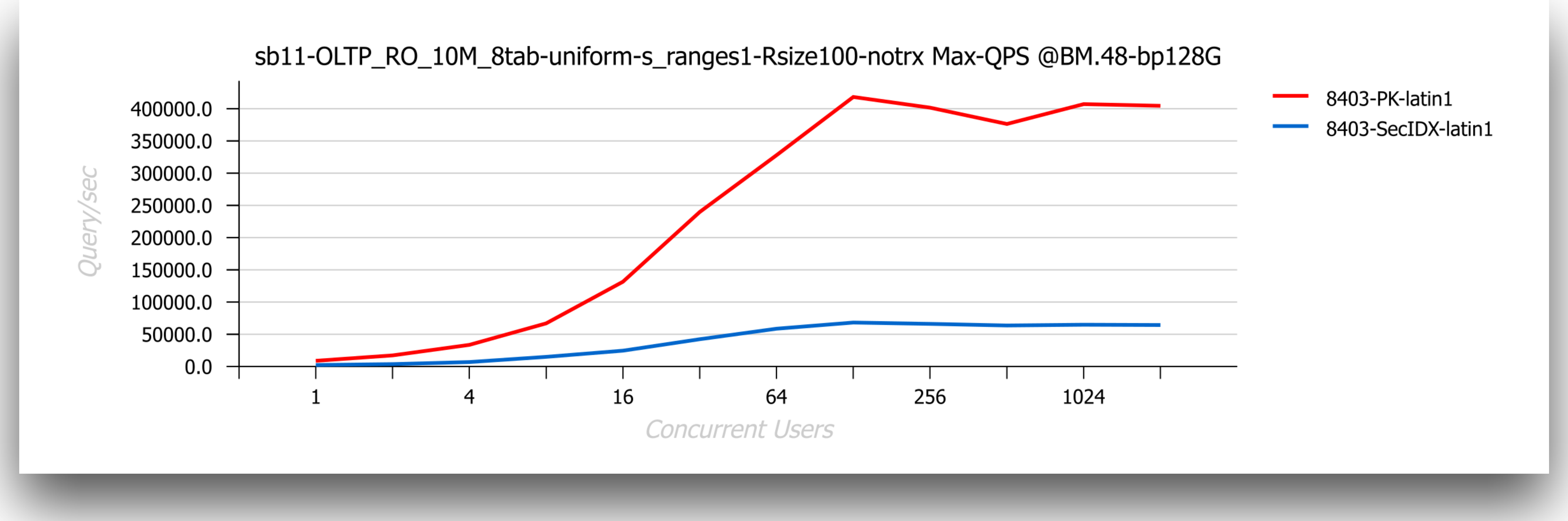


sb11-OLTP_RO_10M_8tab-uniform-p_sel1-notrx Max-QPS @BM.48-bp128G

Q : which one is scaling and which one not ?

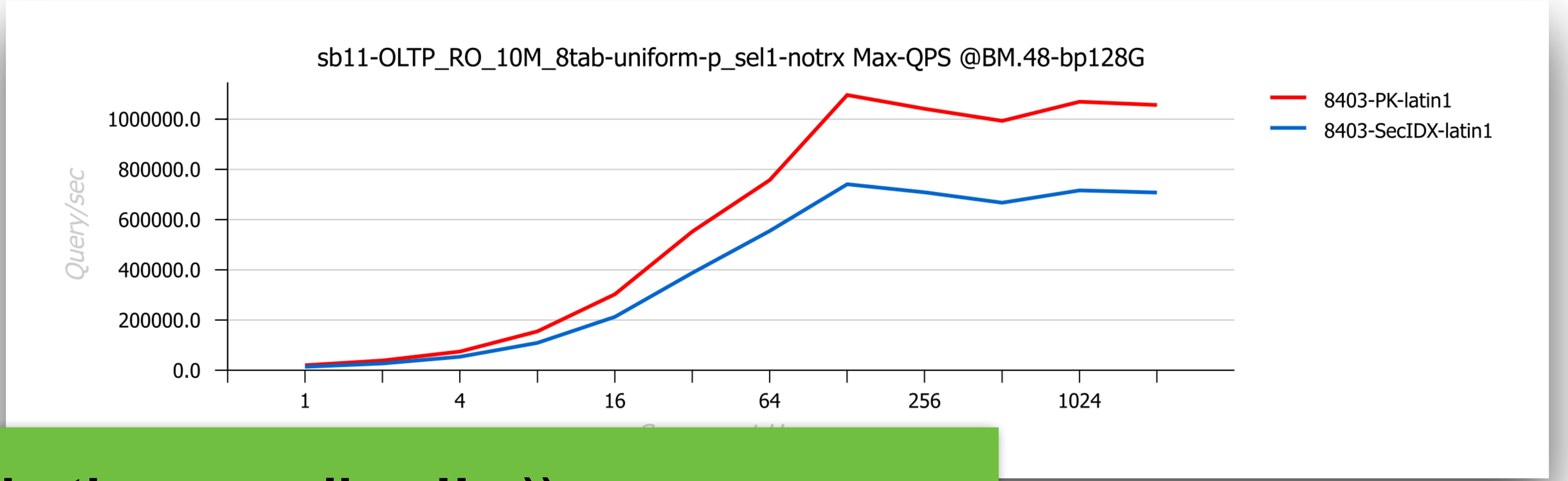
- Range-SELECT
  - SELECT ..
    WHERE id
    BETWEEN $v and $v + 100



sb11-OLTP_RO_10M_8tab-uniform-s_ranges1-Rsize100-notrx Max-QPS @BM.48-bp128G

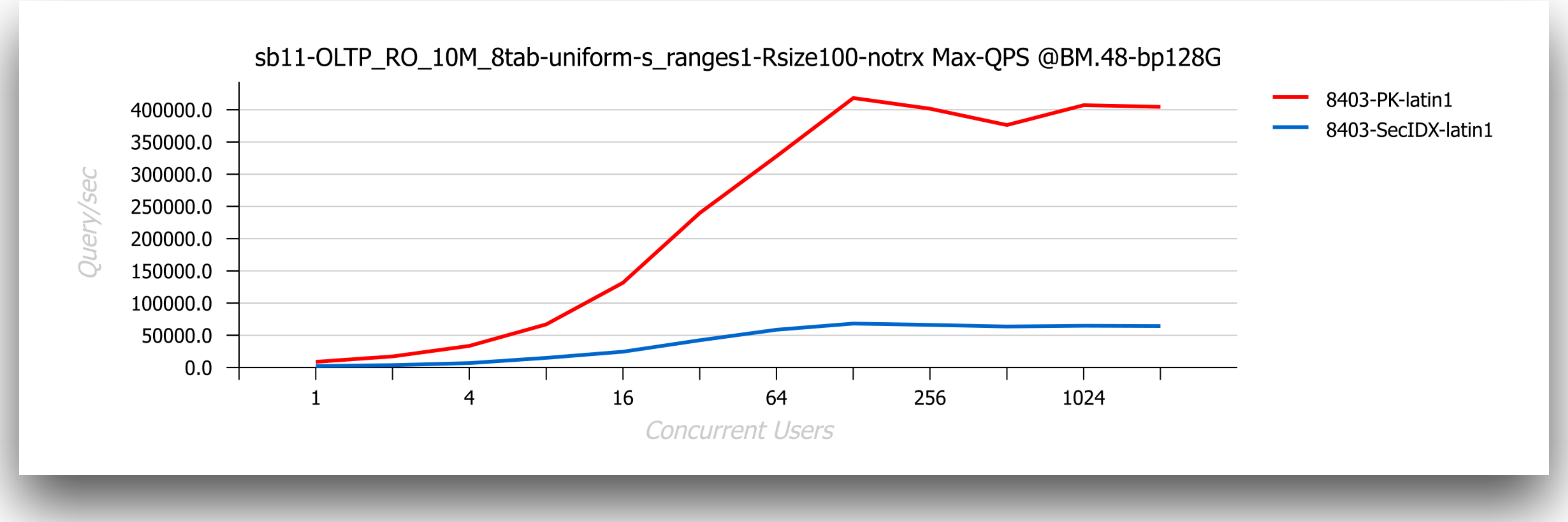
RO Limits : PK -vs- SK lookups

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



A : both are scaling !! ;-))

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

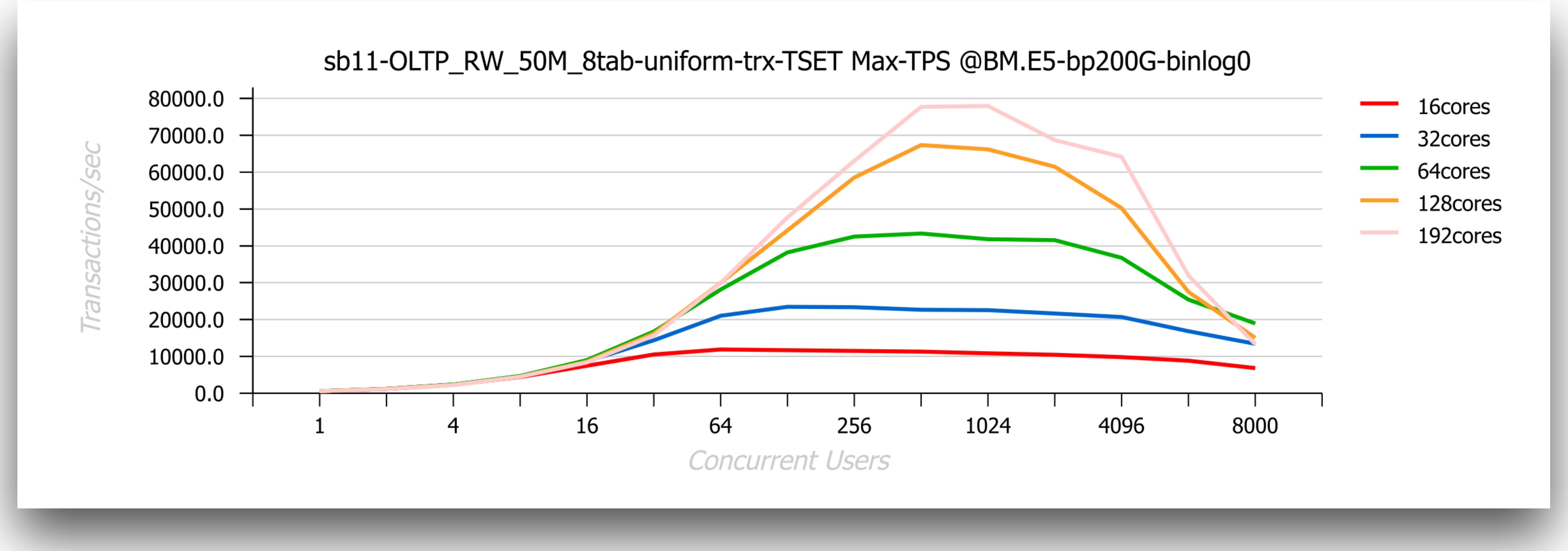


RW Scalability Limits (RO + more)

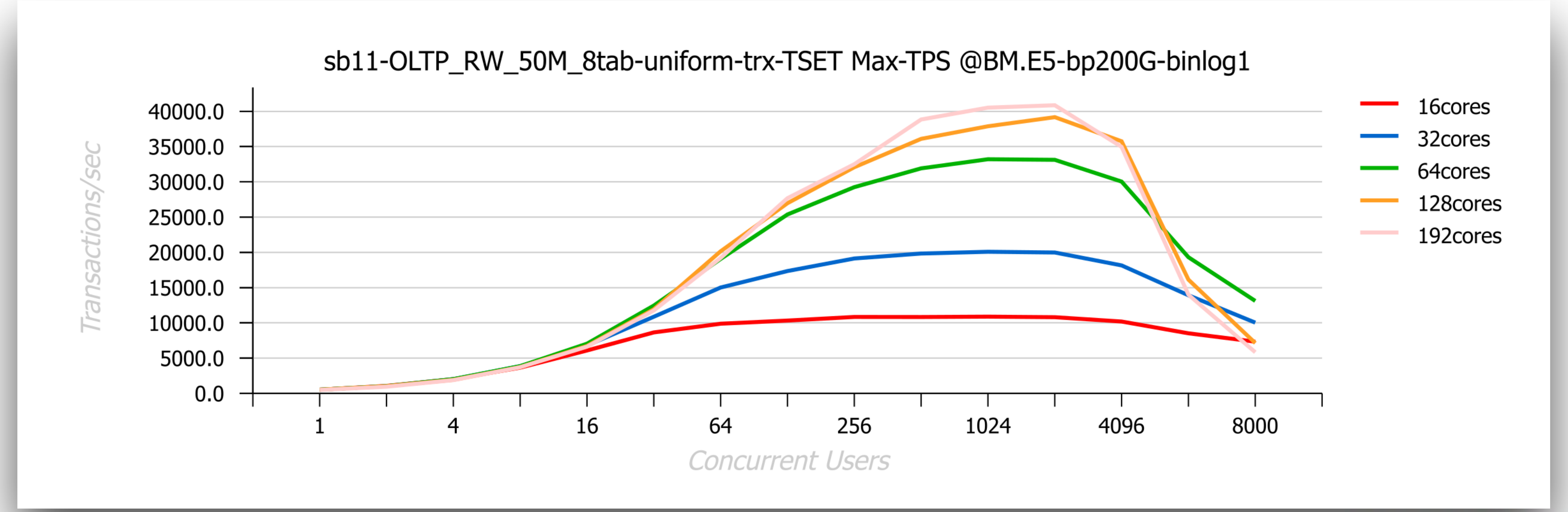
- REDO write+fsync latency
  - ex. 1ms = 1000 TPS max for single-thread
  - e.g. single-thread apps is not a right design ! ;-))
- REDO efficiency
  - small systems up to 8cores => REDO threads = OFF
- ReadView lock contentions (part of "trx_sys")
- LOCK mgmt contentions (“lock_sys”, largely improved since 8.0)
- data contention ! => new ThreadPool to solve this !
- Binlog impact
  - (post-REDO activity design)

Binlog Impact on Scalability | OLTP_RW

- Binlog = ON

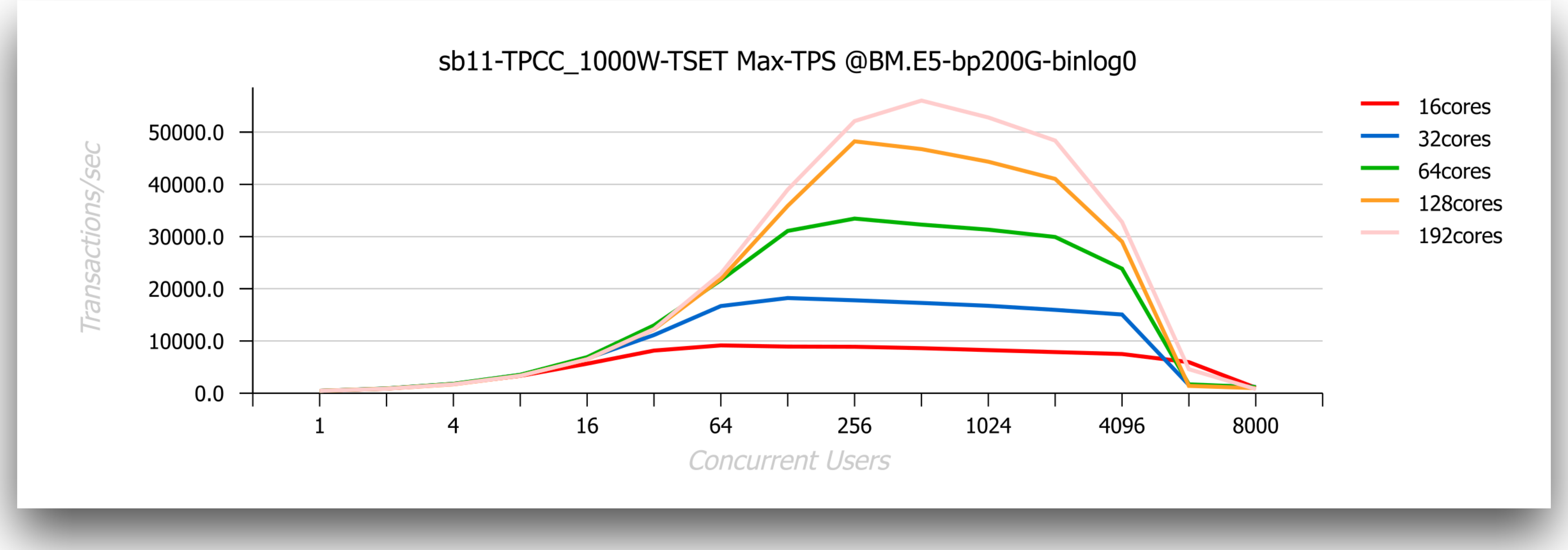


- Binlog = OFF

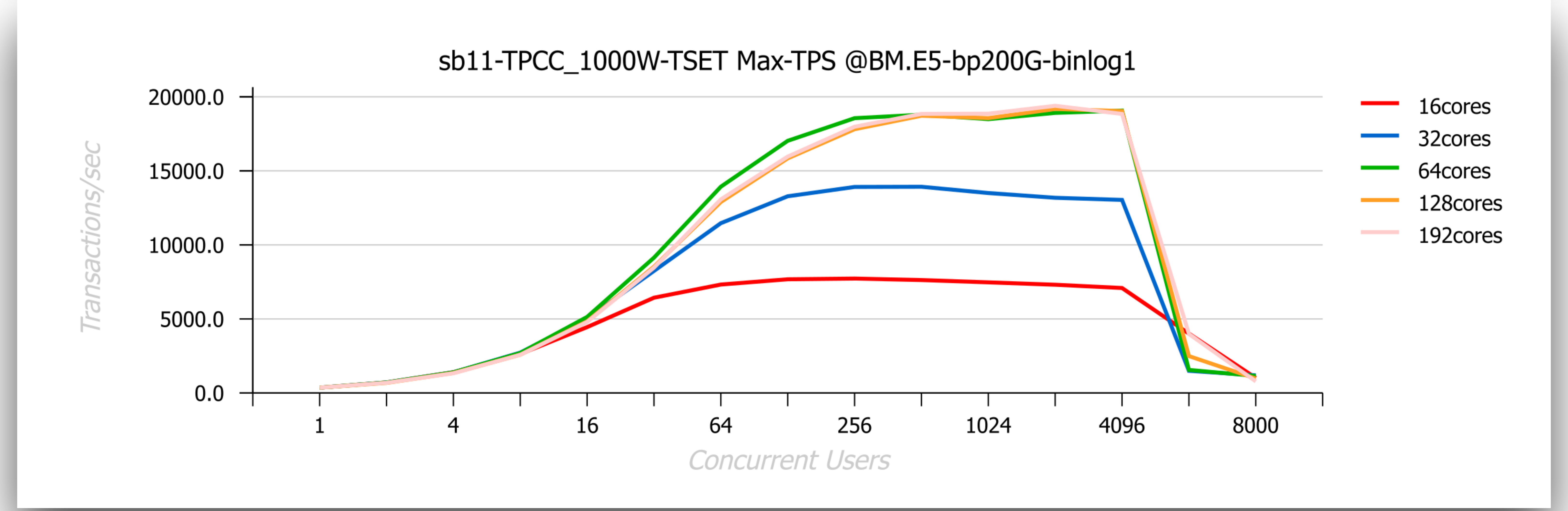


Binlog Impact on Scalability | TPCC-1000W

- Binlog = ON



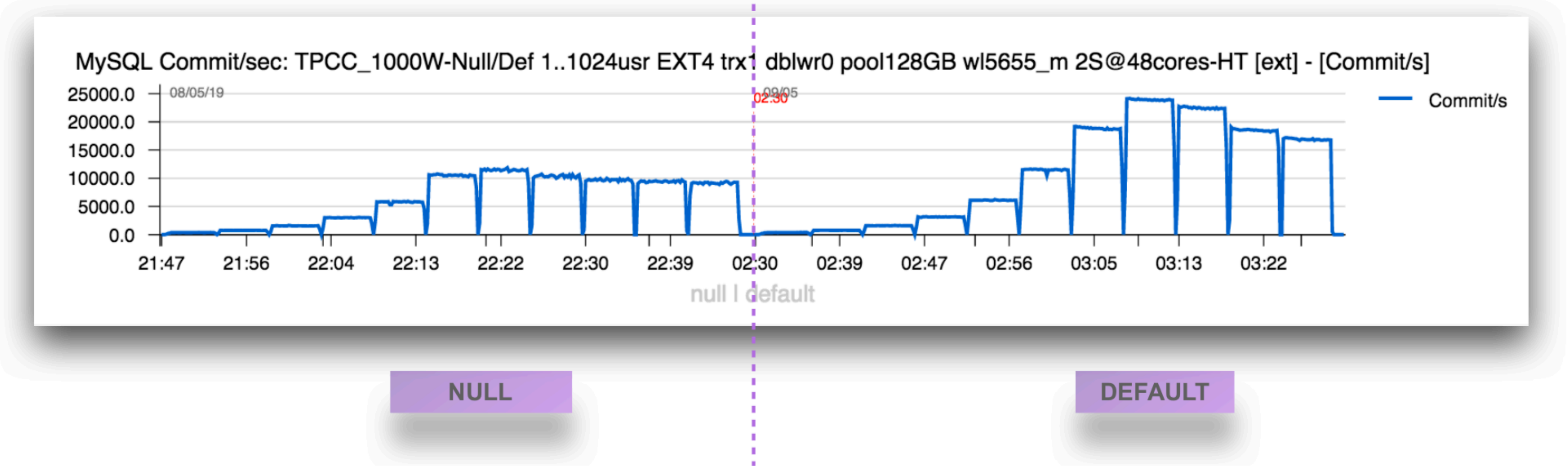
- Binlog = OFF



RW : In-Memory (e.g. no I/O Reads)

- REDO write latency & REDO space
- Page Flushing / IO capacity / REDO size
- Purge lagging / UNDO / History Length
- auto-truncate UNDO ?
- IBUF : no help, but merges may impact !
- NULL -vs- DEFAULT :
  - use DEFAULT to avoid massive page split / merges spikes !

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



RW : IO-bound (all previous + more)

- Storage IOPS capacity
- LRU Flushing driven
- BP instances / Page Cleaners
- Single Page Flushing
- DBLWR => if using RAID-n, then mind Storage stripe size !
- Oracle Linux Team => Atomic IO !
- IBUF : helps ! but beware side effects
  - ex. : on BP resize (reduce)
  - ex. : on recovery process (fixed since MySQL 9.2)
- fil_sys mutex contention (sharded since 8.0, but still problematic)
- partitions ?
- compression ?

Evaluating Systems for MySQL Performance

MySQL Config

NOTE to PeterZ :
please,
update your slides !!

- use 8.4+ version : **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 = off, O_DIRECT
- data safety & security first !!!
  - trx_commit=1, sync_binlog=1 (don't expect HA will solve you)

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

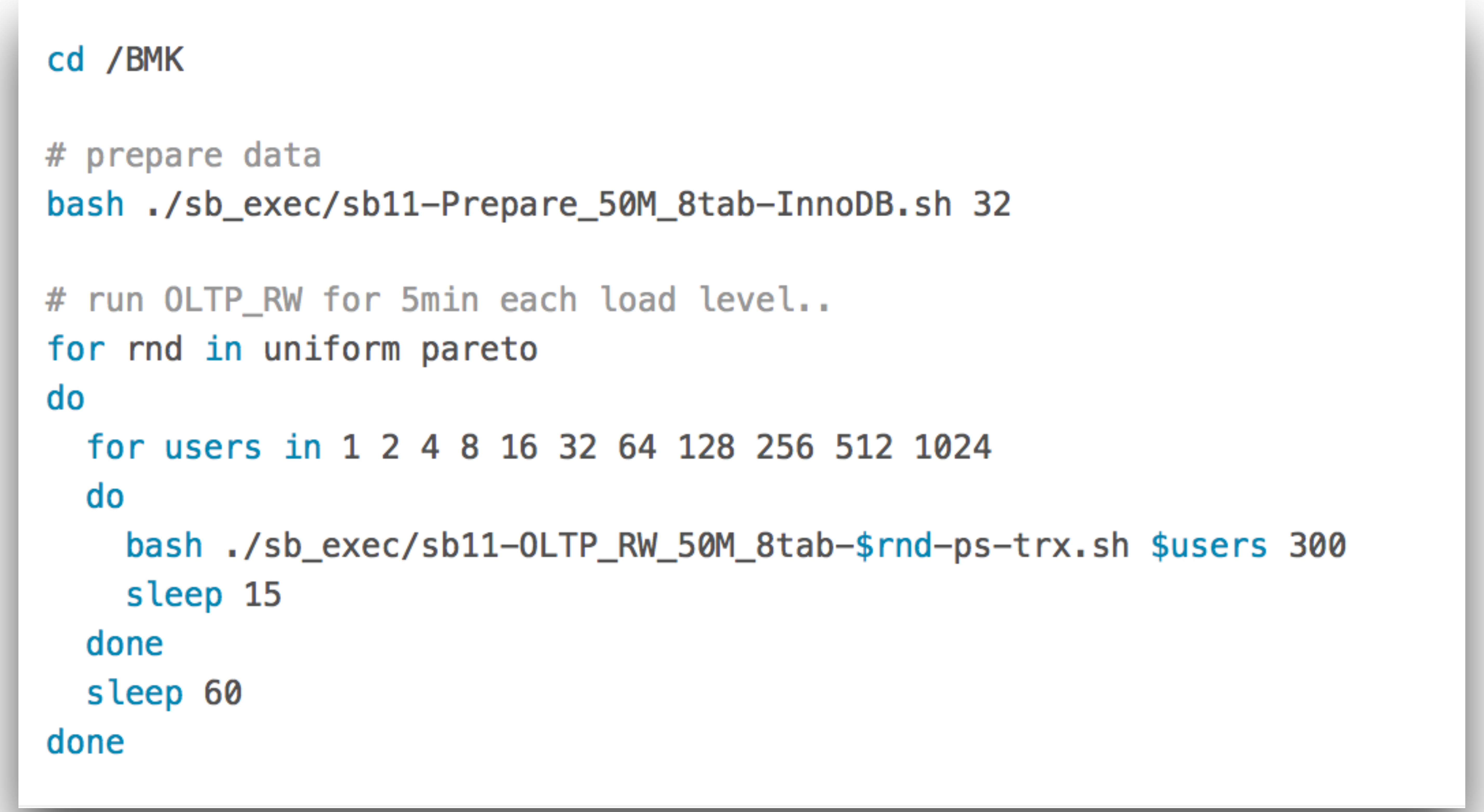
- NOTE : consider also to test with MySQL EE !!

Test Workloads

- start with generic workloads
  - more easy to compare with “expectations”
  - more easy to report problems and reproduce it by others
- understand what you're ~~doing~~ testing !!
  - go from the most simple to more complex
  - have a clear target from the beginning ! (except if you have unlimited time ;-))
  - when Network is poor => you’re not testing the System, but Network !
  - using Java-based load-generator ? => be sure you’re not just testing JVM itself !
  - using too small data set ? => you’re probably just testing CPU cache ;-))
  - using not-scaling test workload => you’re not testing the System, but bottleneck !
  - e.g. avoid to have useless results..
- finish with your's **Production** workload
  - if not possible, then with what is **the most representative** for your Production !
  - **Sysbench Lua** : simple & efficient **platform** to develop test workloads for MySQL !

To Simplify Your Life : Benchmark Kit (BMK-kit)

- Ready out-of-the-box :
  - shipped with Sysbench binaries for Linux x64 / arm64
  - pre-generated scripts for all workloads
  - script name = test & options
  - all standard Sysbench tests
  - many additional extensions
  - includes TPCC-like
  - includes dbSTRESS
  - frequent updates



```
cd /BMK

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

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

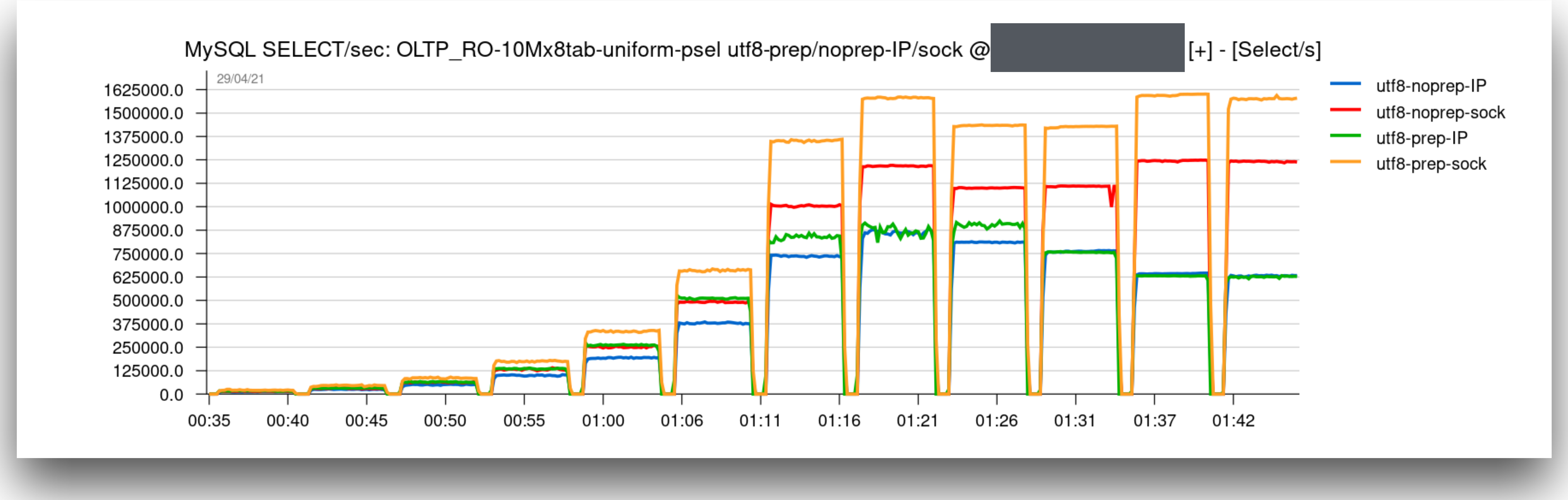
Complete detailed HOWTO : http://dimitrik.free.fr/blog/posts/mysql-perf-bmk-kit.html

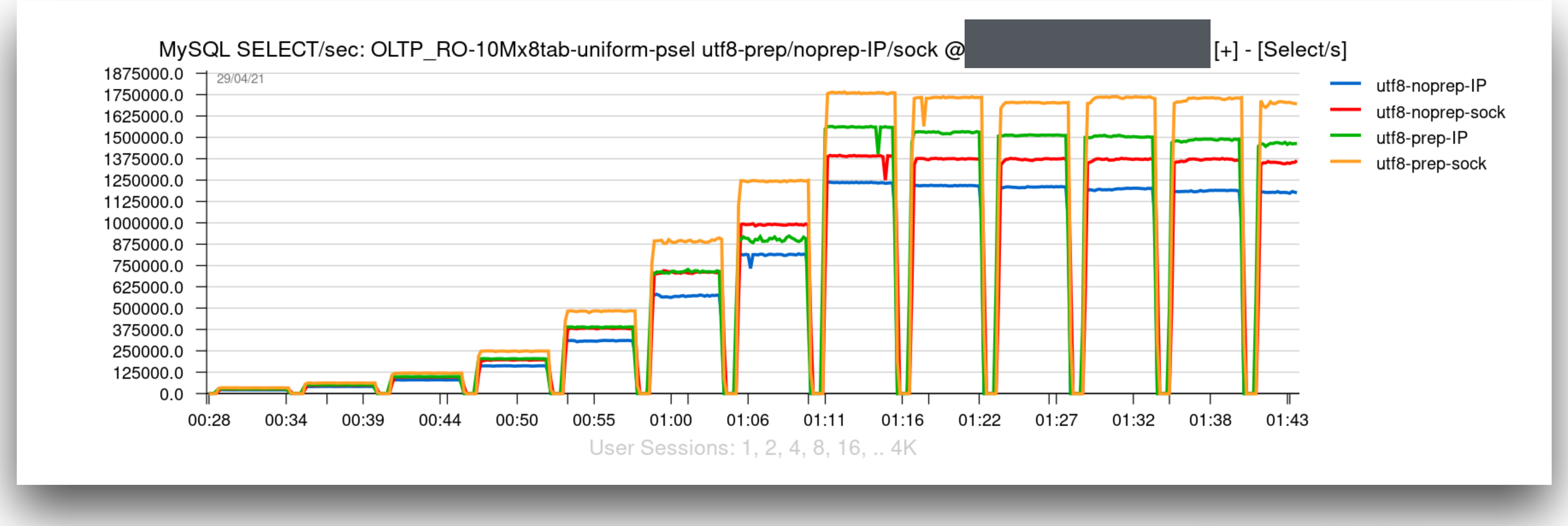
Starting Point : RO In-Memory

- start with Point-Selects
  - 10Mx8tab = 20GB, or 50Mx8tab = 100GB — according to available RAM
- BP size big enough to keep your data cached
- prepared statements = on / off ??
- first use connections via UNIX-socket to see the impact
- then IP-port
- then real Network
- finish with OLTP_RO

UNIX Socket -vs- IP port

- point-selects
- prep. stmt = on/off





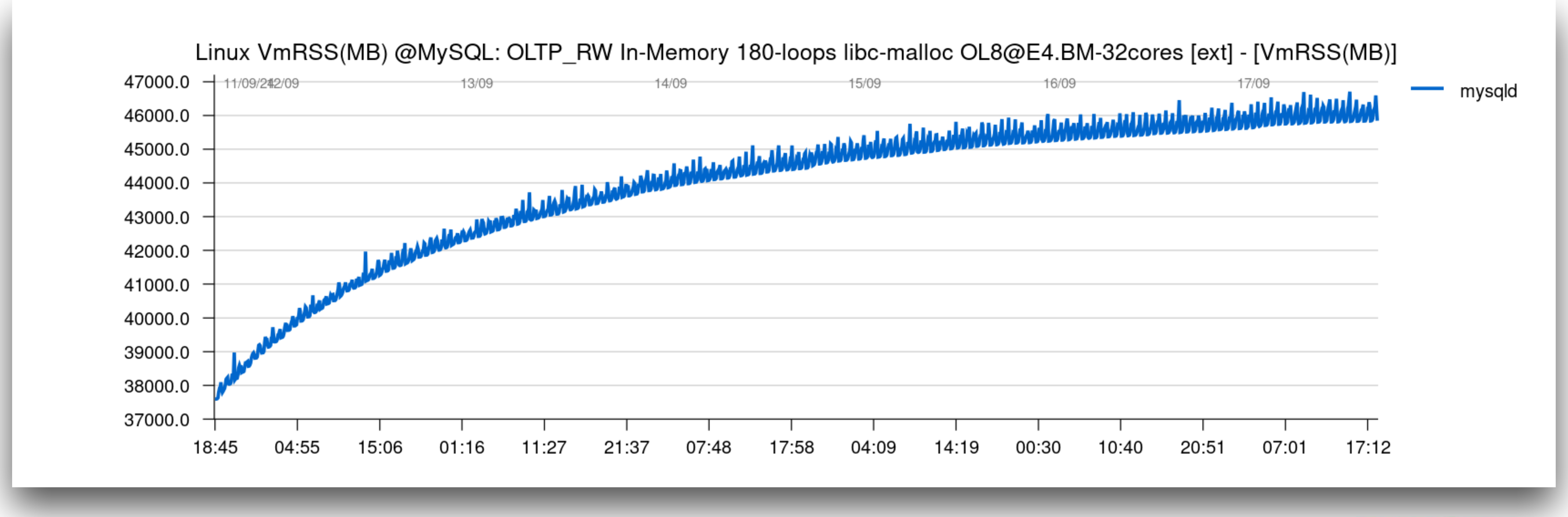
User Sessions: 1, 2, 4, 8, 16, .. 4K

RO In-Memory

- BM : NUMA & CPU affinity ??
- VM : always check CPU Steal% !!
- single-thread matters !!
  - base line for response time !
  - (e.g. can be only higher with growing load levels)
- malloc lib ! => critical !
  - glibc-malloc => **DANGER** !!
  - jemalloc => better, but may have allocation spikes
  - gpertools tcmalloc => currently the most efficient !

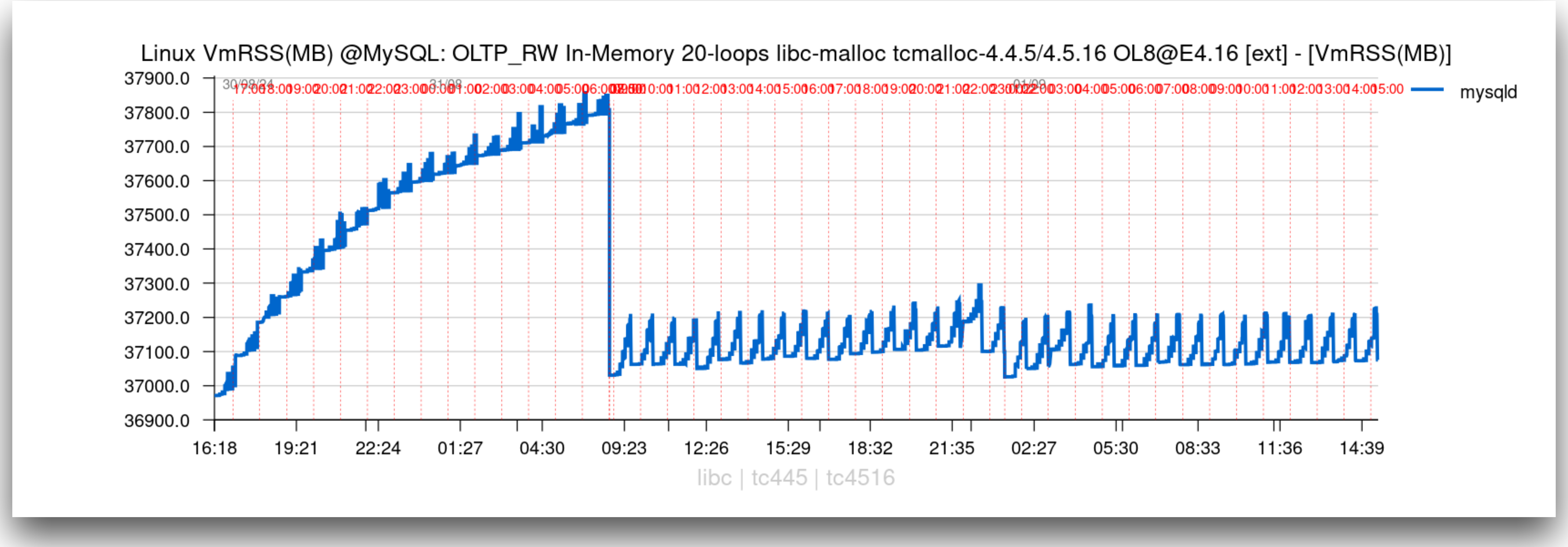
Malloc Libs Today

- 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..



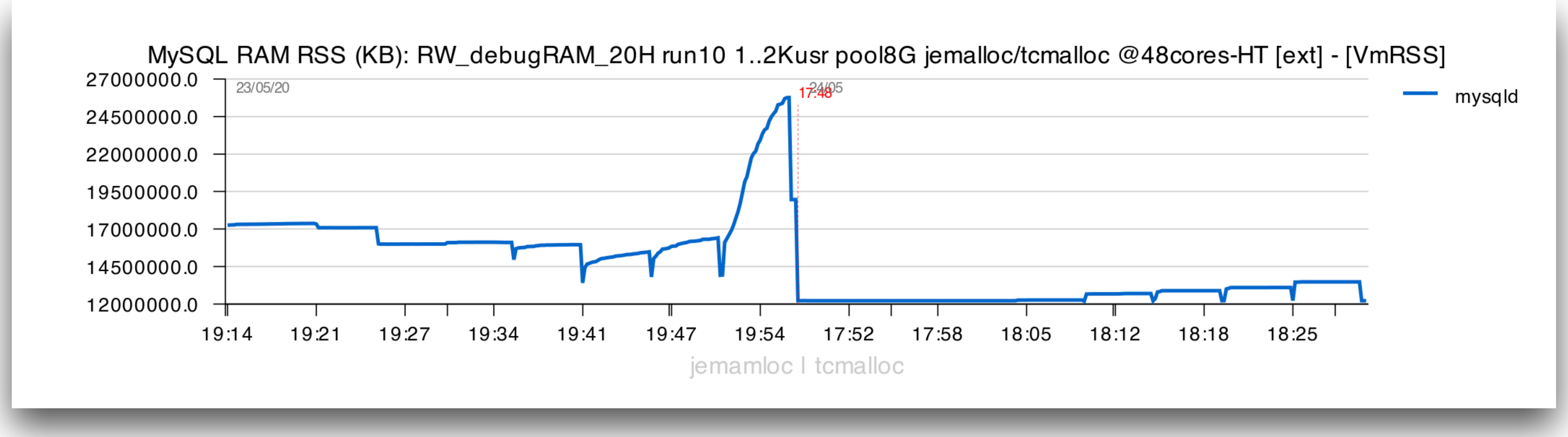
Malloc Libs Today

- glibc-malloc -vs- tcmalloc :



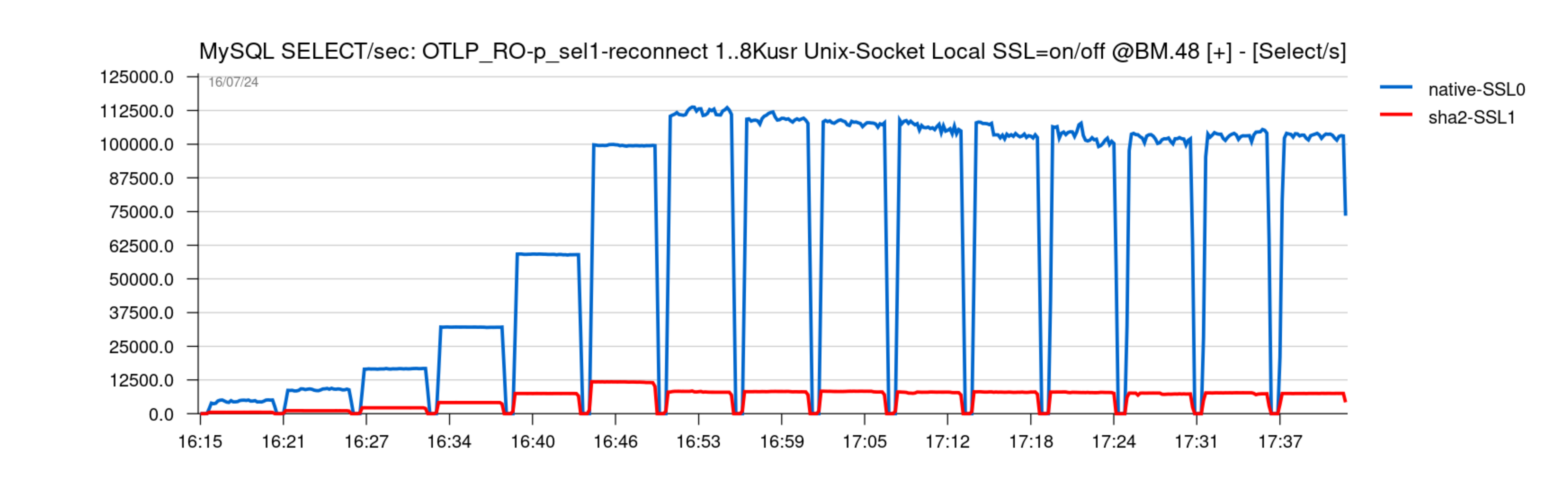
Malloc Libs Today

- jemalloc -vs- tcmalloc :



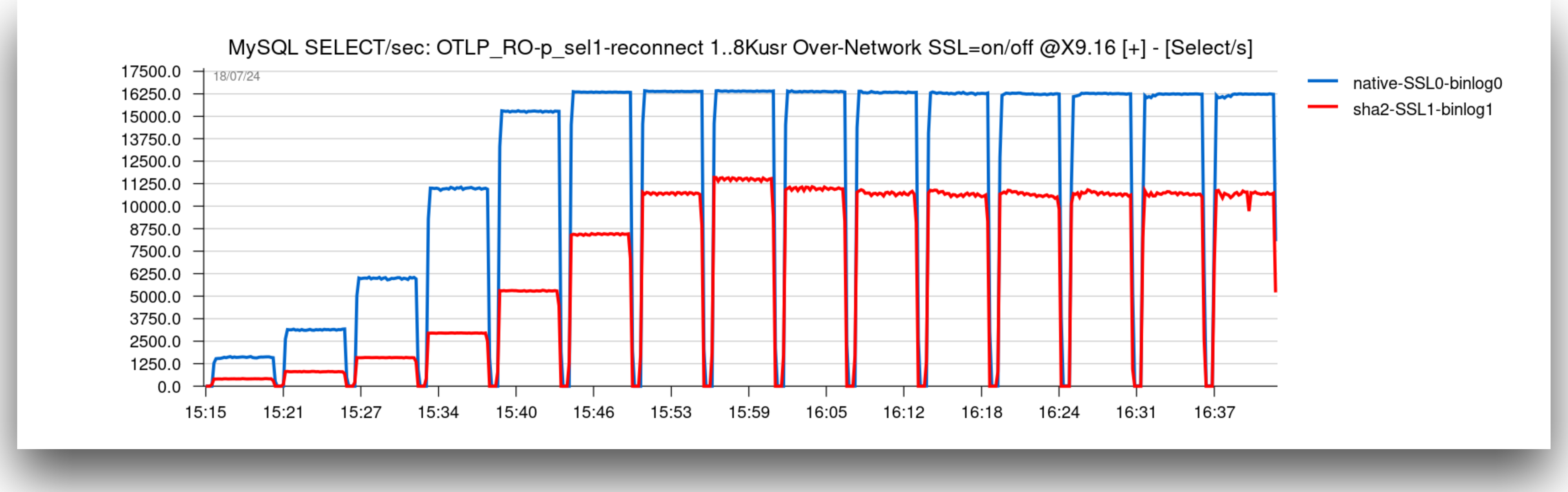
SSL Impact

- OpenSSL versions :
  - avoid OpenSSL-1.0 !! => bottleneck itself !
  - OpenSSL-1.1.1 => the most efficient as of today
  - OpenSSL-3.x => loosing 15-20% comparing to 1.1.1
- Re-Connect ?
  - SSL connection initialization has a very high cost !!

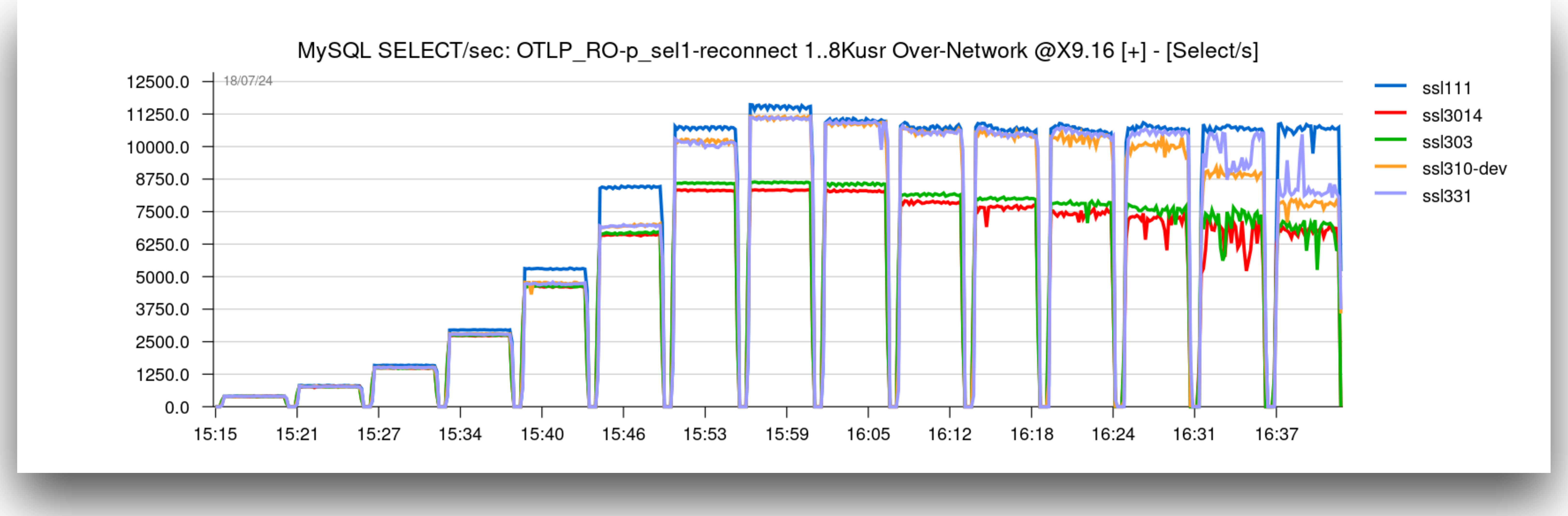


SSL Impact | Re-Connect Over Network

- SSL = on / off
  - x3 times on low/mid load
  - 30% on high load



- OpenSSL versions :
  - OpenSSL-1.1.1 => best
  - OpenSSL-3.0 => bad
  - OpenSSL-3.1+ => better



RW In-Memory

- XFS or EXT4 ?
- REDO latency : single thread write+fsync for single file !
  - NOTE : latency is not always directly related to IOPS !!

- simple test for REDO latency :

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

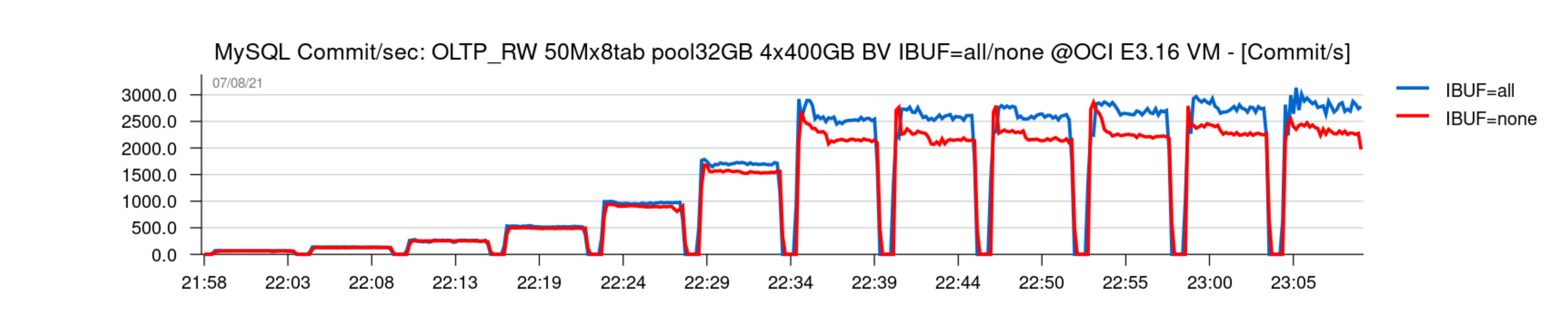
- Binlog = ON/OFF

RW IO-bound

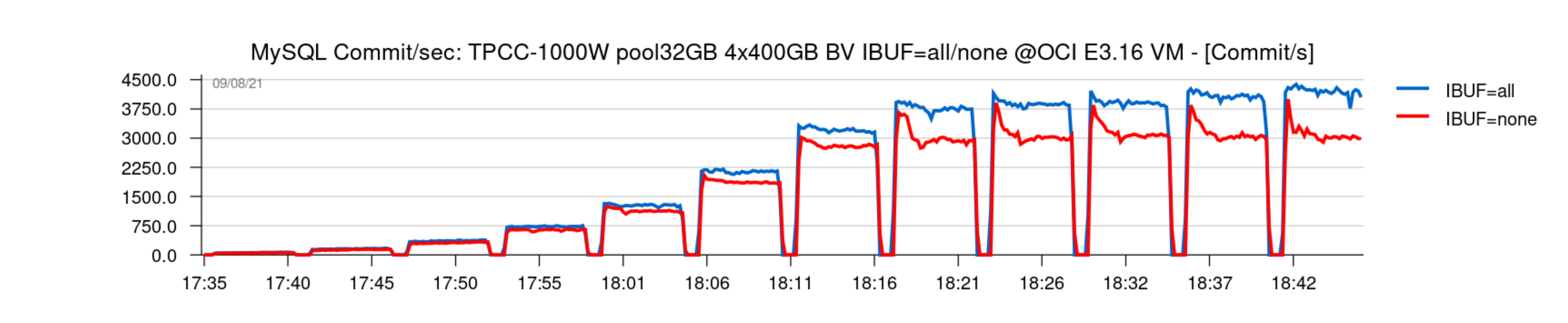
- use 1TB of data (or more) to make it more realistic !!
- IBUF helps ! but beware trade-offs !
- monitoring !
  - e.g. don't look only on final numbers !!
- beware of fake results !
- compression ?
- partitions ?

InnoDB IBUF (Change Buffer)

- IO-bound OLTP_RW :

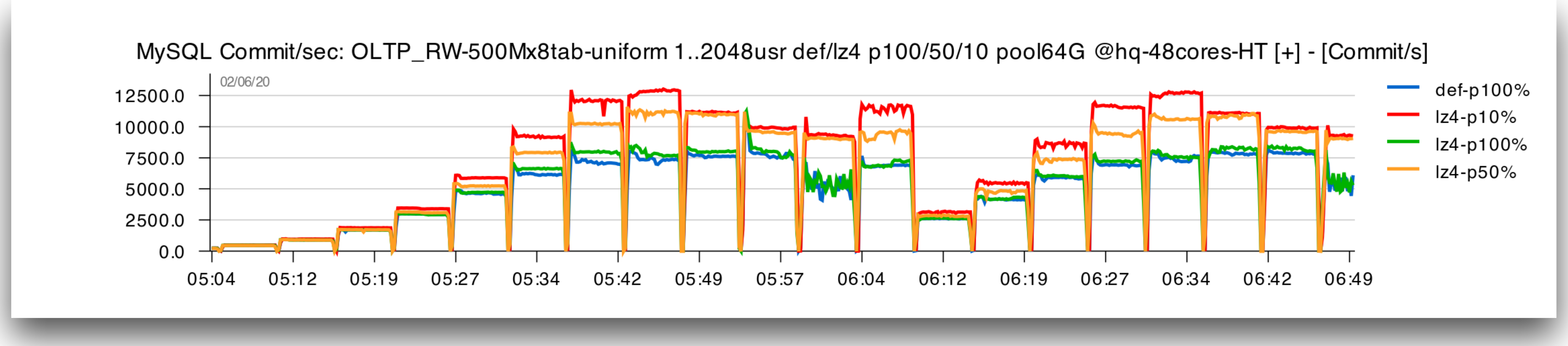


- IO-bound TPCC :



InnoDB Transparent Compression

- IO-bound OLTP_RW
- different level of data “randomness” : 10% / 50% / 100%
- transparent compression LZ4, data size = 1TB :
  - **up to 50% gain** when data are **favorable** for compression !!



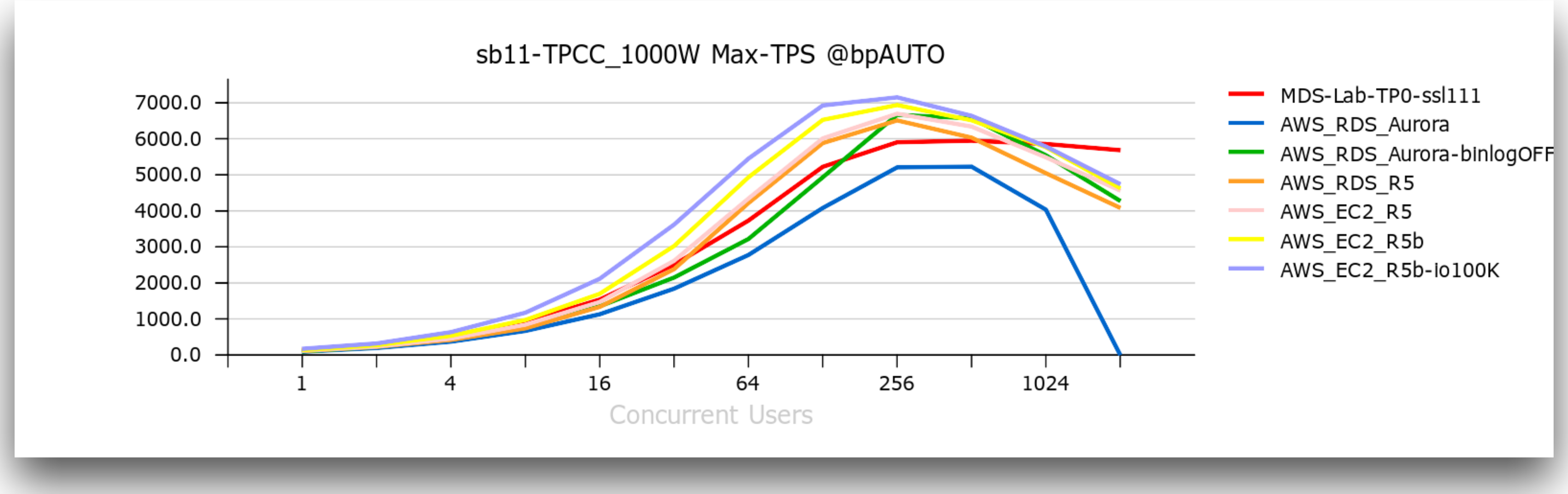
Shortlist Scenario “by Dimitri”

- In-Memory : 100GB
  - (50Mx8tab / 100W / 1000W)
- IO-bound : 1TB
  - (500Mx8tab / 10000W)
- OLTP_RO point-selects
- OLTP_RO
- OLTP_RW
- UPDATEs bombarding
- INSERTs bombarding
- TPCC-100W/ 1000W/ 10000W
- ... more tests if time permits ...

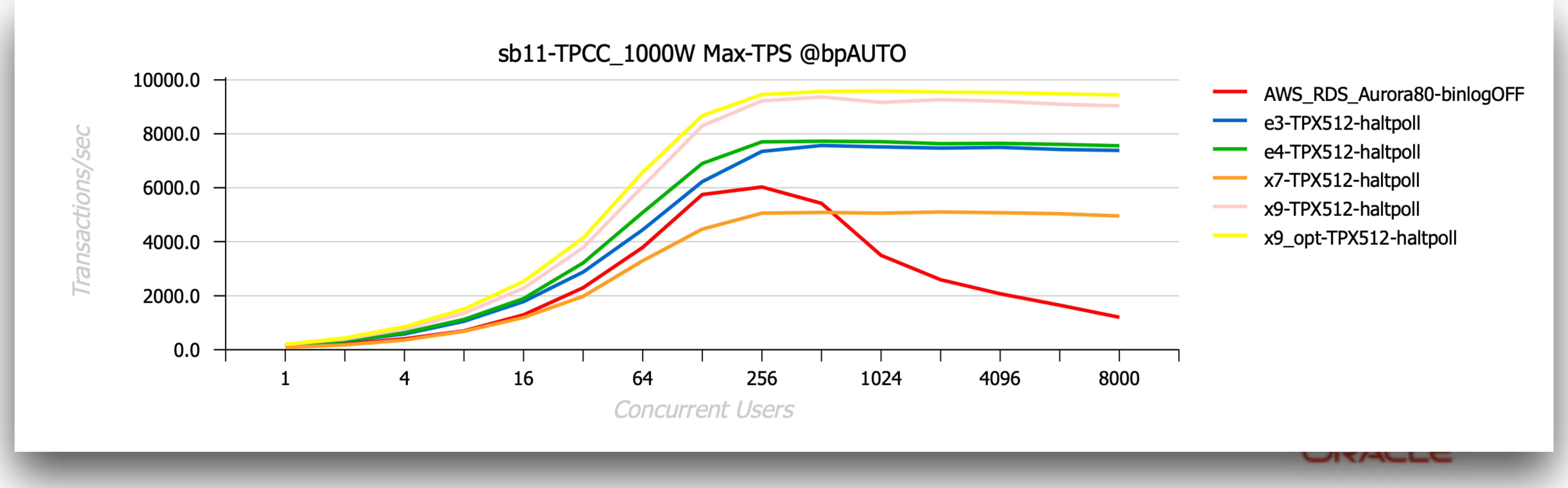
- **NOTE** : just to remind, the target is about "system evaluation" !!

Few TPCC Results | 1000W (100GB), RAM 256G, 16cores

- Amazon
  - RDS
  - EC2
  - Aurora



- MDS
  - E3
  - E4
  - X9



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

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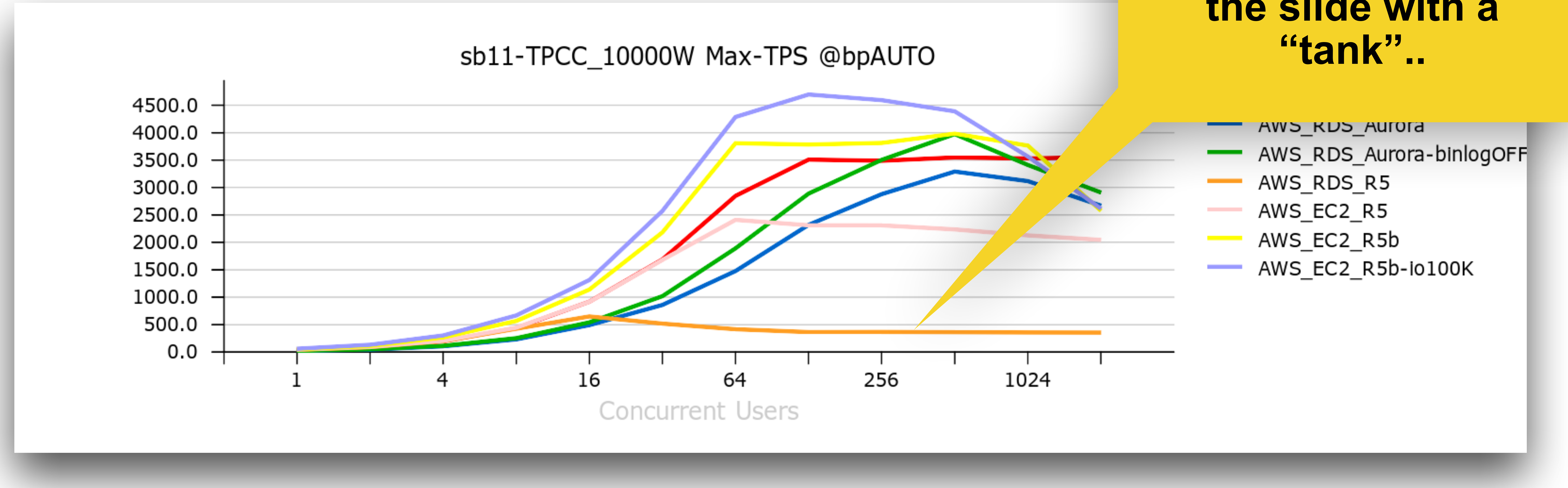
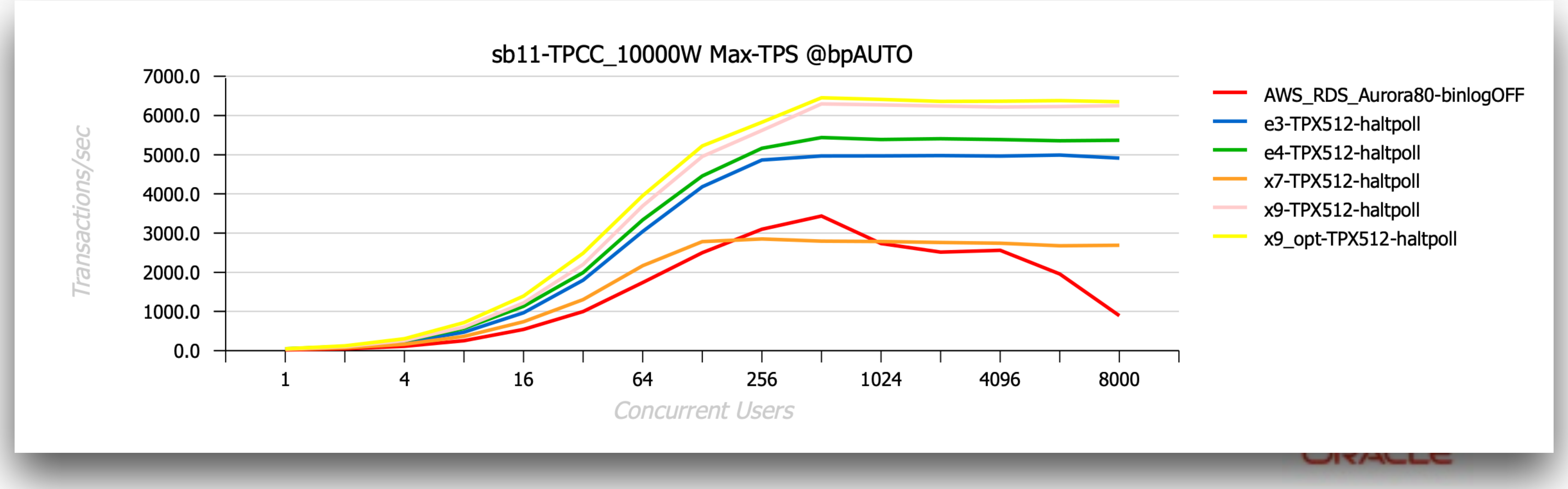


If you recall the slide with a "tank"..

- 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 !!!