WiredTiger scalability (and RocksDB, too)

Benchmarks and observations

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Is performance important?

How the database can be more efficient

Getting more with less

In the end, it’s about money:

- Can we use less hardware/cloud instances?

Benchmark

Sysbench for MongoDB

https://github.com/Percona-Lab/sysbench/tree/dev-mongodb-support-1.0

What is sysbench?

Micro-synthetic benchmark

Primitive operations by primary key (collection _id)

Easy to setup and run

These operations are building blocks for more complex queries

Sysbench operations

Read-Only

- Point lookup
- Range select
- Range aggregation
- Distinct over range

Read-Write

- Read-only plus:
- Modify non-indexed field
- Modify indexed field
- Insert/delete row
  - Transactional for MySQL
  - Find-and-modify for MongoDB to guarantee atomic operation

Sysbench cons

Does not represent any real workload

But keep in mind:

It runs elementary operations that are building blocks for more complex operations

If there is problem in sysbench workload – most likely it will be a problem in real life

The reverse is not necessarily true…

Benchmark setup: hardware

Supermicro blade servers

CPU: Intel(R) Xeon(R) CPU E5-2683 v3 @ 2.00GHz

Total RAM: 256GB

Client and Server identical, connected via 10GB network

Storage, SSD:

- Samsung 850 Pro, SATA – consumer grade, $500/TB
- Samsung SM863, SATA – server grade, $600/TB
- Samsung PM1725, NVMe, – high end, $1,300/TB
  - Big progress from $10,000+/TB, ~5 years ago

Benchmark setup: configuration

8 collections x 60mln documents each (~100GB of uncompressed data)

Threads from 1 to 1000

Storage engines: WiredTiger and MongoRocks (RocksDB)

Cachesize: from 4GB to 200GB

- Cgroup limits mongod memory with 2x cachesize
- Both WiredTiger and MongoRocks keep cached data in OS cache
  - Need special attention, as otherwise all data (100GB) gets cached in OS

Engines specifics

WiredTiger

- B-Tree based
  - Fast reads
  - Slow random writes
- LSM engine is not documented

MongoRocks

- Based on RocksDB – LSM tree
  - Fast random writes
  - Slower reads

Ways to scale

- Multiple user threads
- Increase memory
- Storage with better performance
- Multiple servers (scale out) – not in this talk

Benchmark methodology

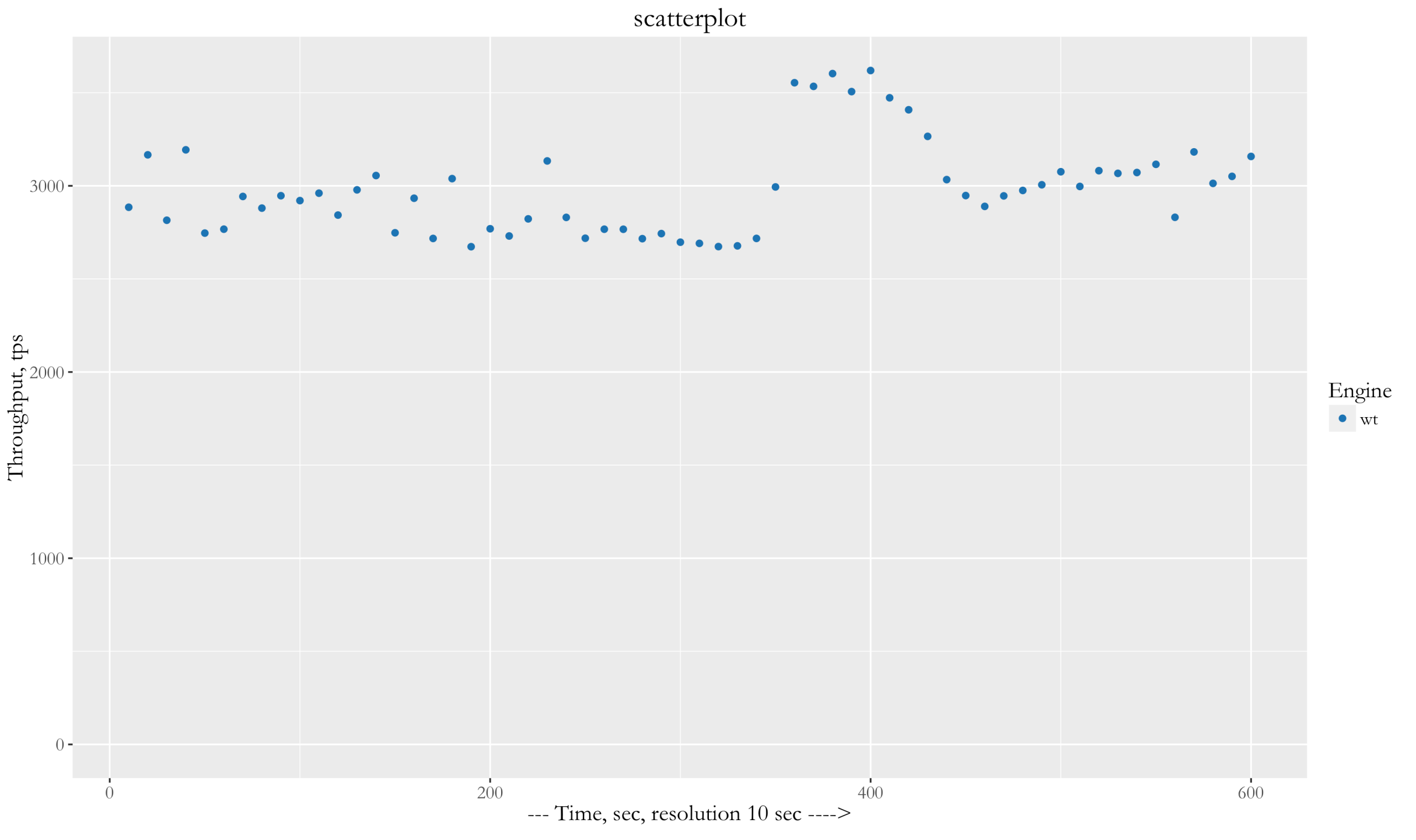
- Measurements with 10sec intervals
- Throughput and response time for the 10sec intervals
- It helps to see trends and stalls
- Benchmark length – 5-10 mins
- Threads in [1-1000] interval
- Cachesize in [4-200]GB interval
- A lot of data points

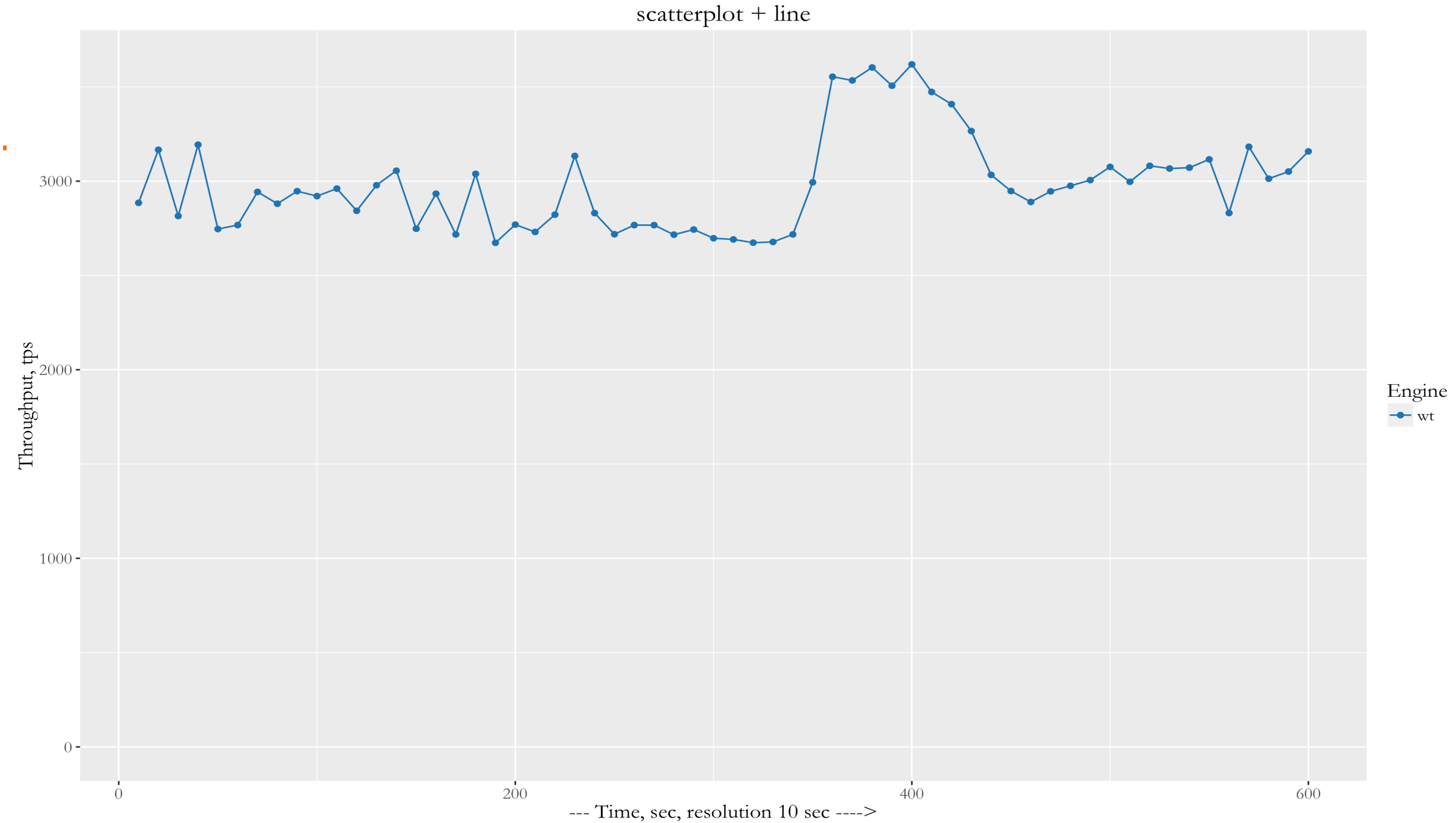
A single number is not interesting

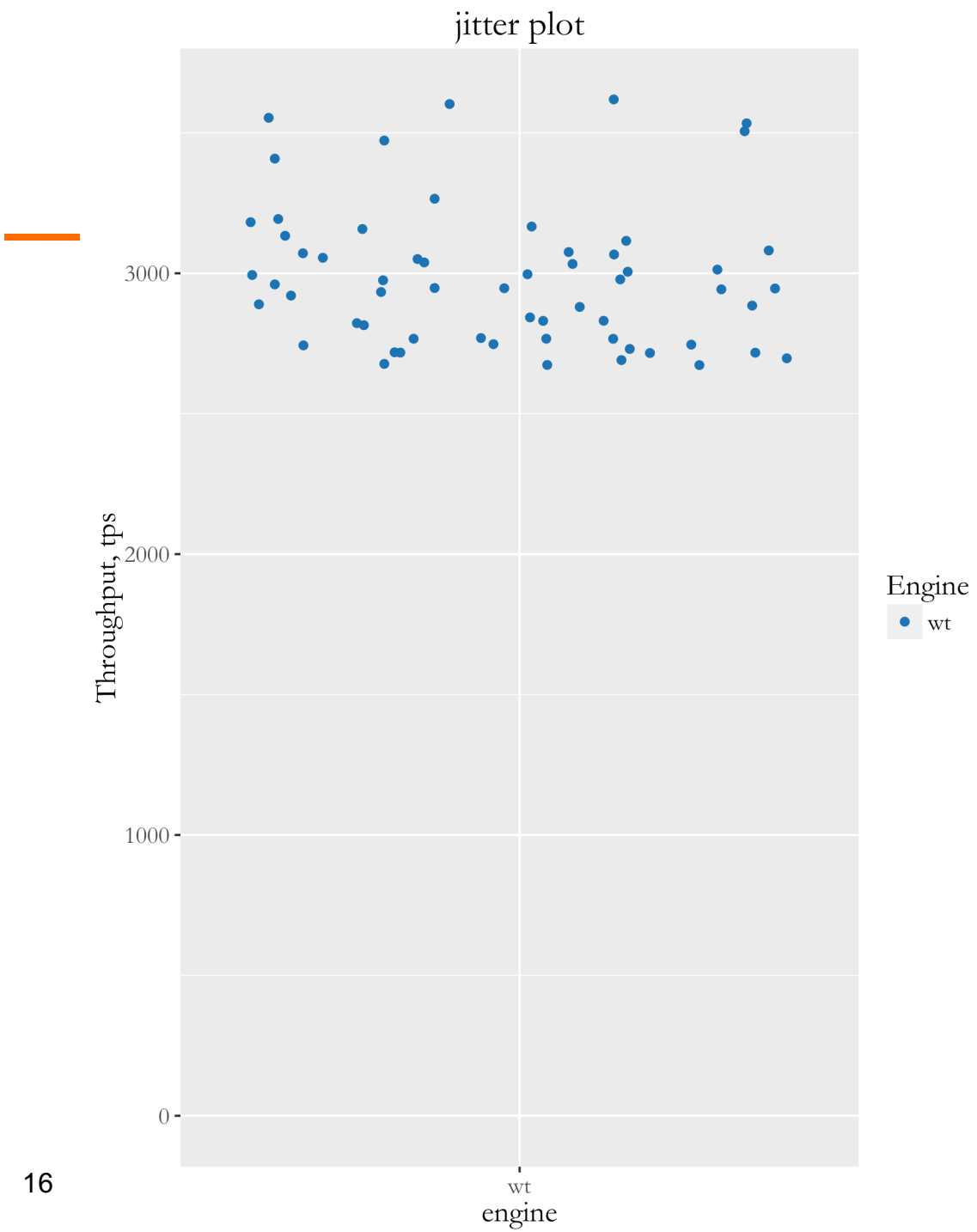
The trend is interesting

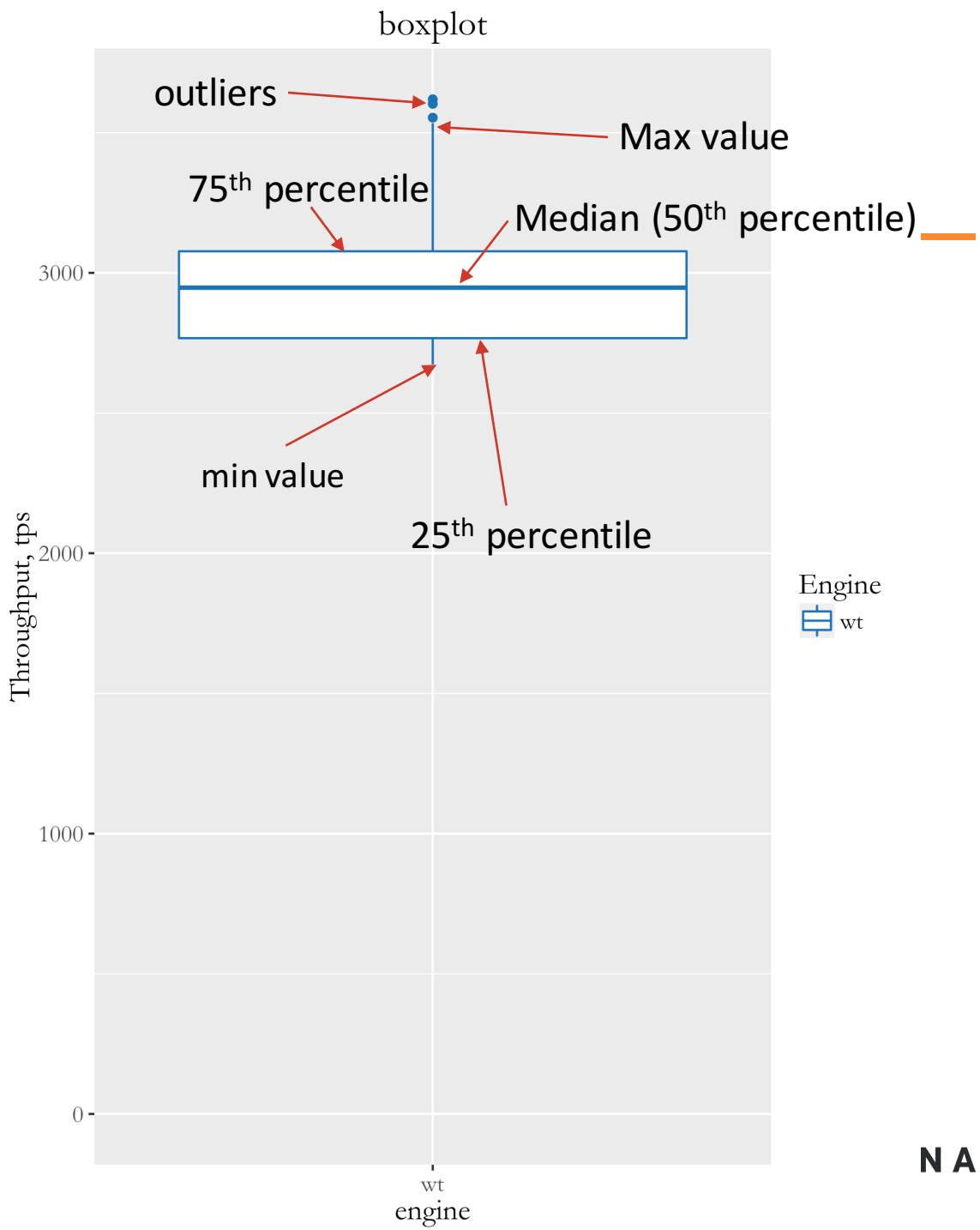
Ways to represent data

- Scatterplots
- Trend lines
- Jitters
- Boxplots


scatterplot
Throughput, tps
3000
2000
1000
0
0
200
400
600
--- Time, sec, resolution 10 sec ---->
Engine
wt


scatterplot + line
Throughput, tps
3000
2000
1000
0
0
200
400
600
--- Time, sec, resolution 10 sec ---->
Engine
wt


jitter plot
3000
2000
1000
0
Throughput, tps
wt
engine
Engine
wt


boxplot
outliers
Max value
75th percentile
Median (50th percentile)
min value
25th percentile
3000
2000
1000
0
Throughput, tps
wt
engine
Engine
wt

Results

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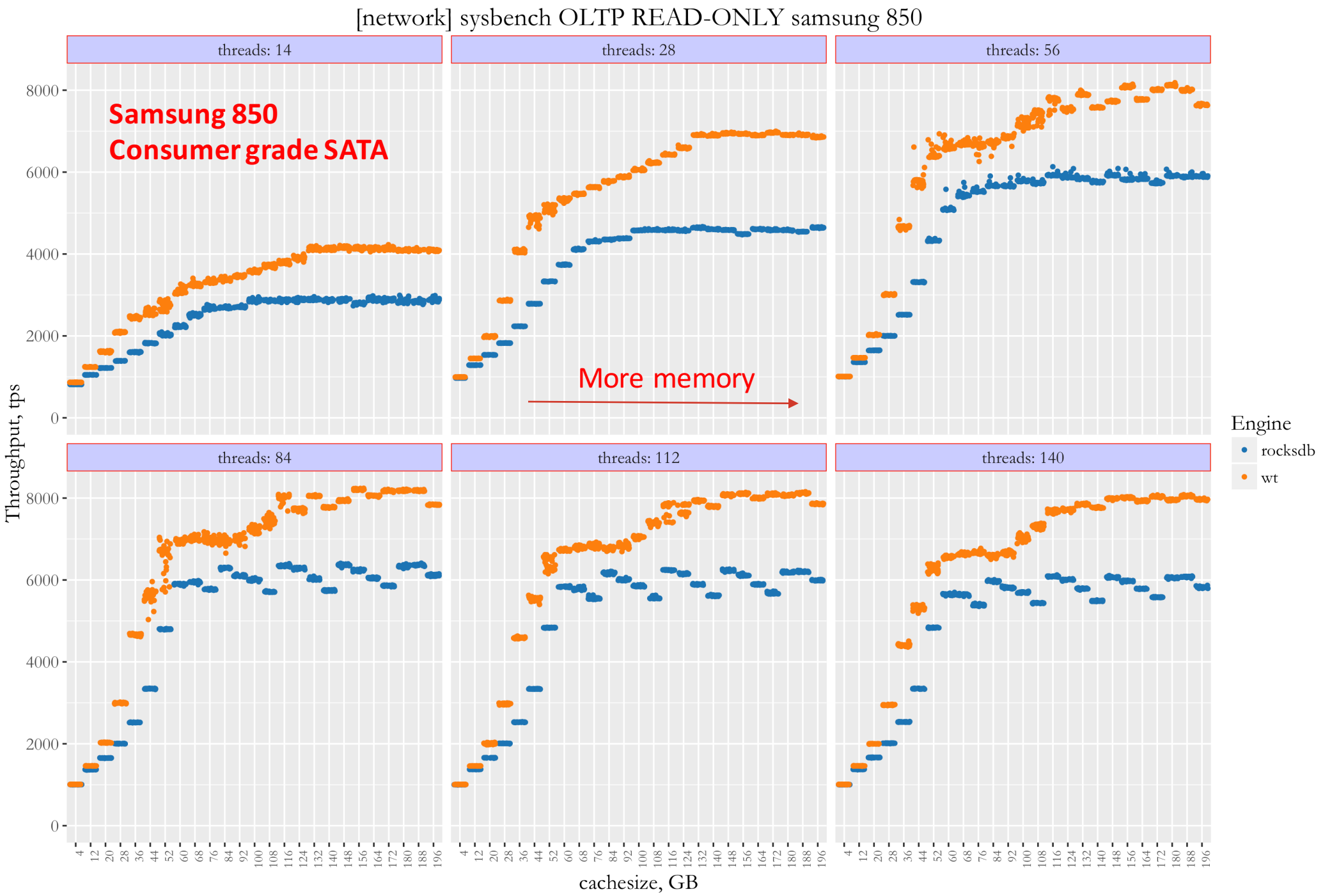
Read-only

- Different cachesizes
  - Small cachesize shows ability to handle growing data
    - Pressure on IO-reads
  - Big cachesize shows the efficiency of internal structures
- Read-only use cases:
  - Reporting
  - Read-intensive components (blog, wiki etc)
- Problems in read-only scalability signal design problems
  - e.g., mutex abuse to access a shared structure


[network] sysbench OLTP READ-ONLY samsung 850
threads: 14
threads: 28
threads: 56
threads: 84
threads: 112
threads: 140
Samsung 850
Consumer grade SATA
More memory
Throughput, tps
cachesize, GB
Engine
rocksdb
wt

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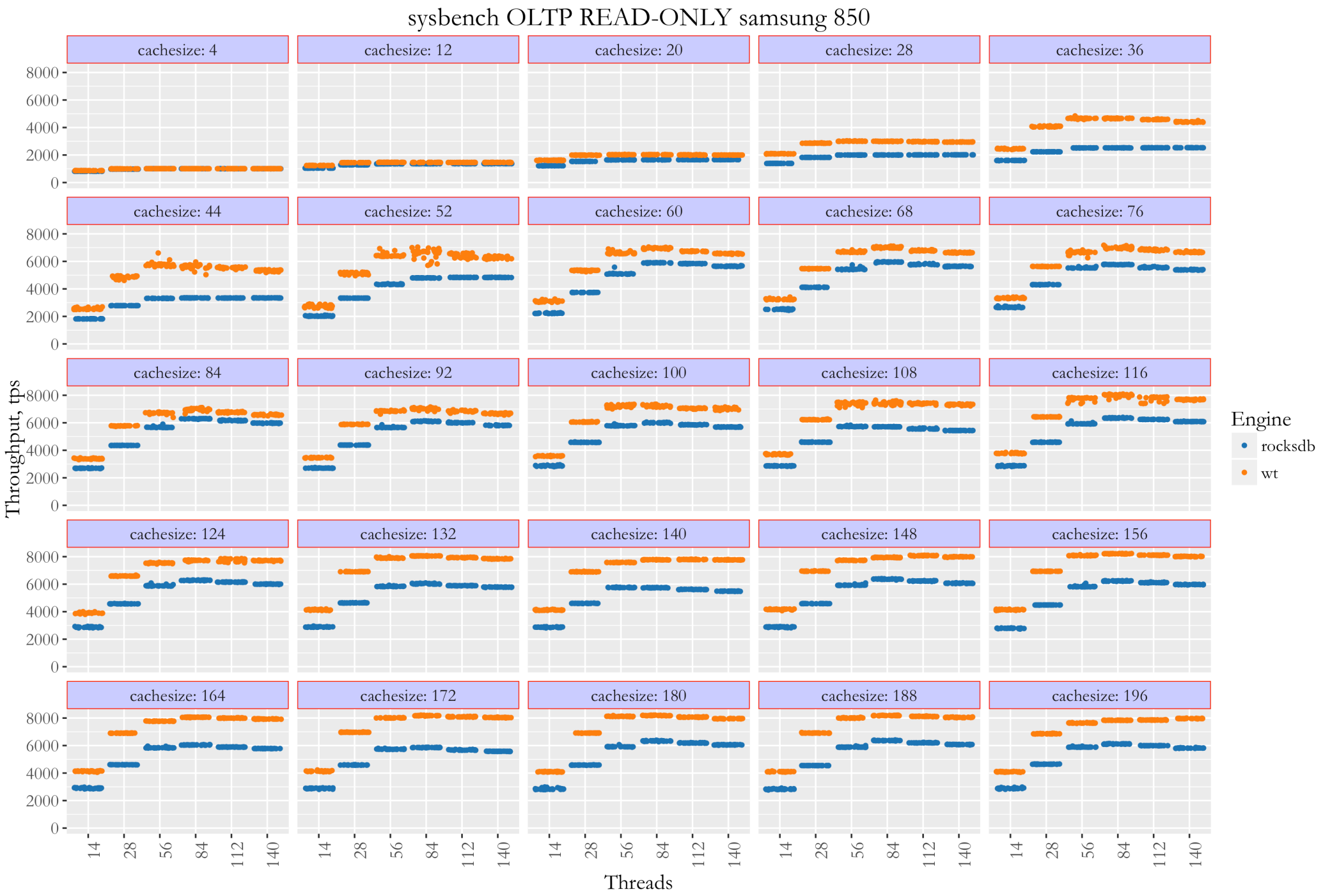
sysbench OLTP READ-ONLY samsung 850
cachesize: 4
cachesize: 12
cachesize: 20
cachesize: 28
cachesize: 36
cachesize: 44
cachesize: 52
cachesize: 60
cachesize: 68
cachesize: 76
cachesize: 84
cachesize: 92
cachesize: 100
cachesize: 108
cachesize: 116
cachesize: 124
cachesize: 132
cachesize: 140
cachesize: 148
cachesize: 156
cachesize: 164
cachesize: 172
cachesize: 180
cachesize: 188
cachesize: 196
Throughput, tps
0
2000
4000
6000
8000
14
28
56
84
112
140
Threads
Engine
rocksdb
wt

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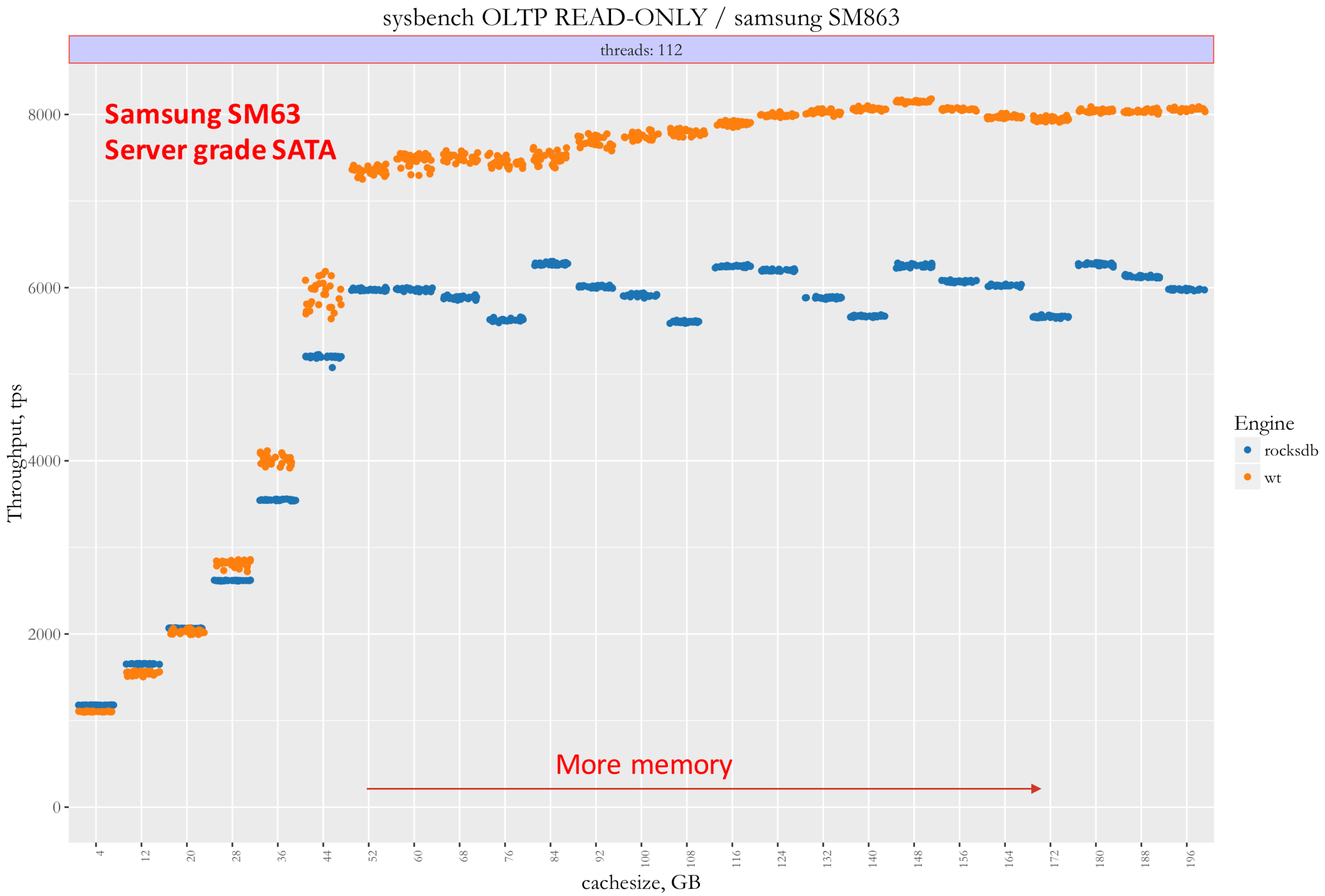
sysbench OLTP READ-ONLY / samsung SM863
threads: 112
Samsung SM63
Server grade SATA
More memory
Throughput, tps
cachesize, GB
Engine
rocksdb
wt

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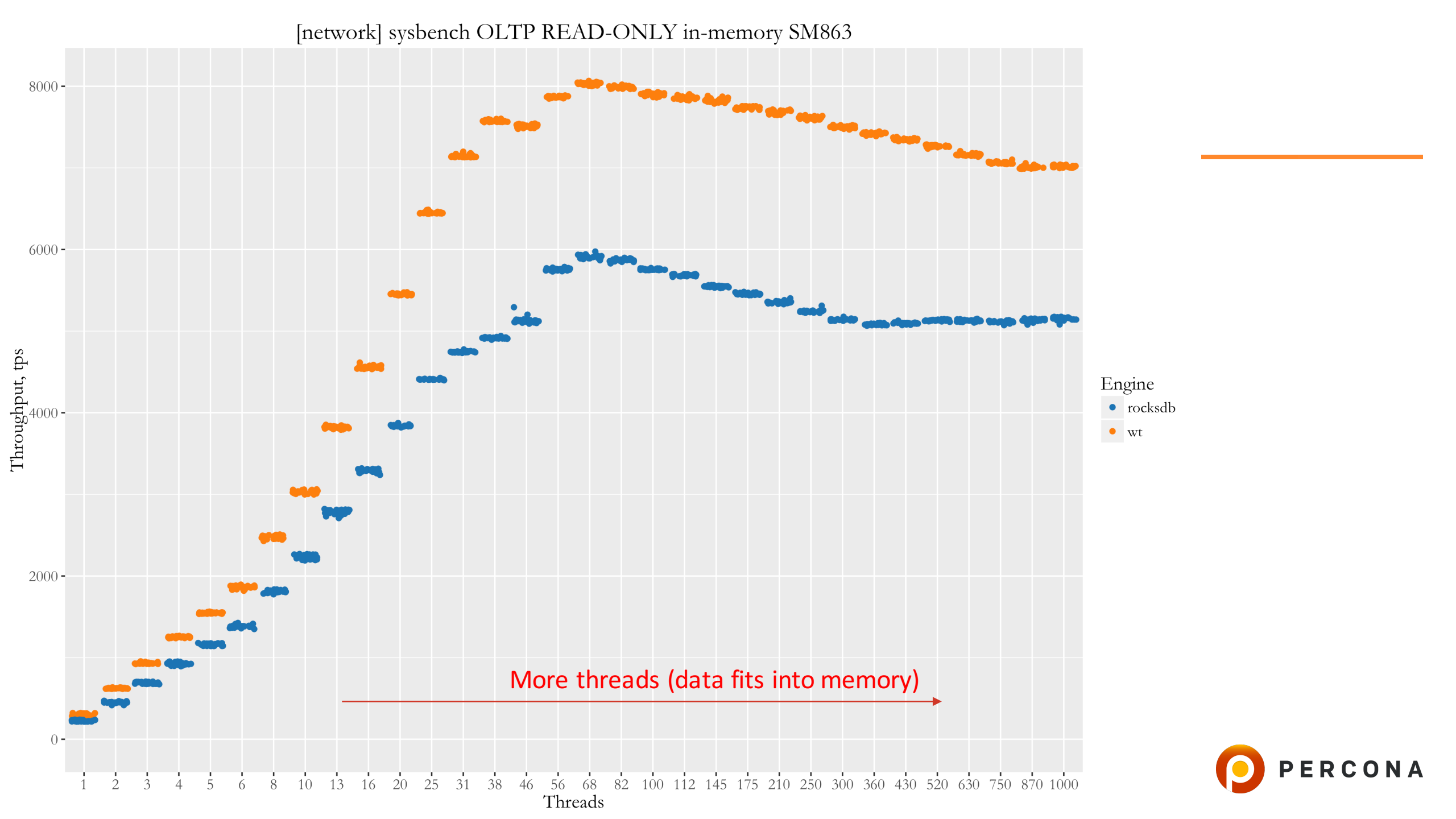
Multi-threaded scalability Read-Only

- Data fits into memory (200GB cachesize)


[network] sysbench OLTP READ-ONLY in-memory SM863
Throughput, tps
8000
6000
4000
2000
0
1 2 3 4 5 6 8 10 13 16 20 25 31 38 46 56 68 82 100 112 145 175 210 250 300 360 430 520 630 750 870 1000
Threads
More threads (data fits into memory)
Engine
rocksdb
wt

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Read-only observation

- Both engines scale reasonable on read-only
- WiredTiger benefits from more memory, scales better with increasing threads
- WiredTiger seems suitable for read-intensive workloads, a lot of cached data

Read-Write results

Memory varies

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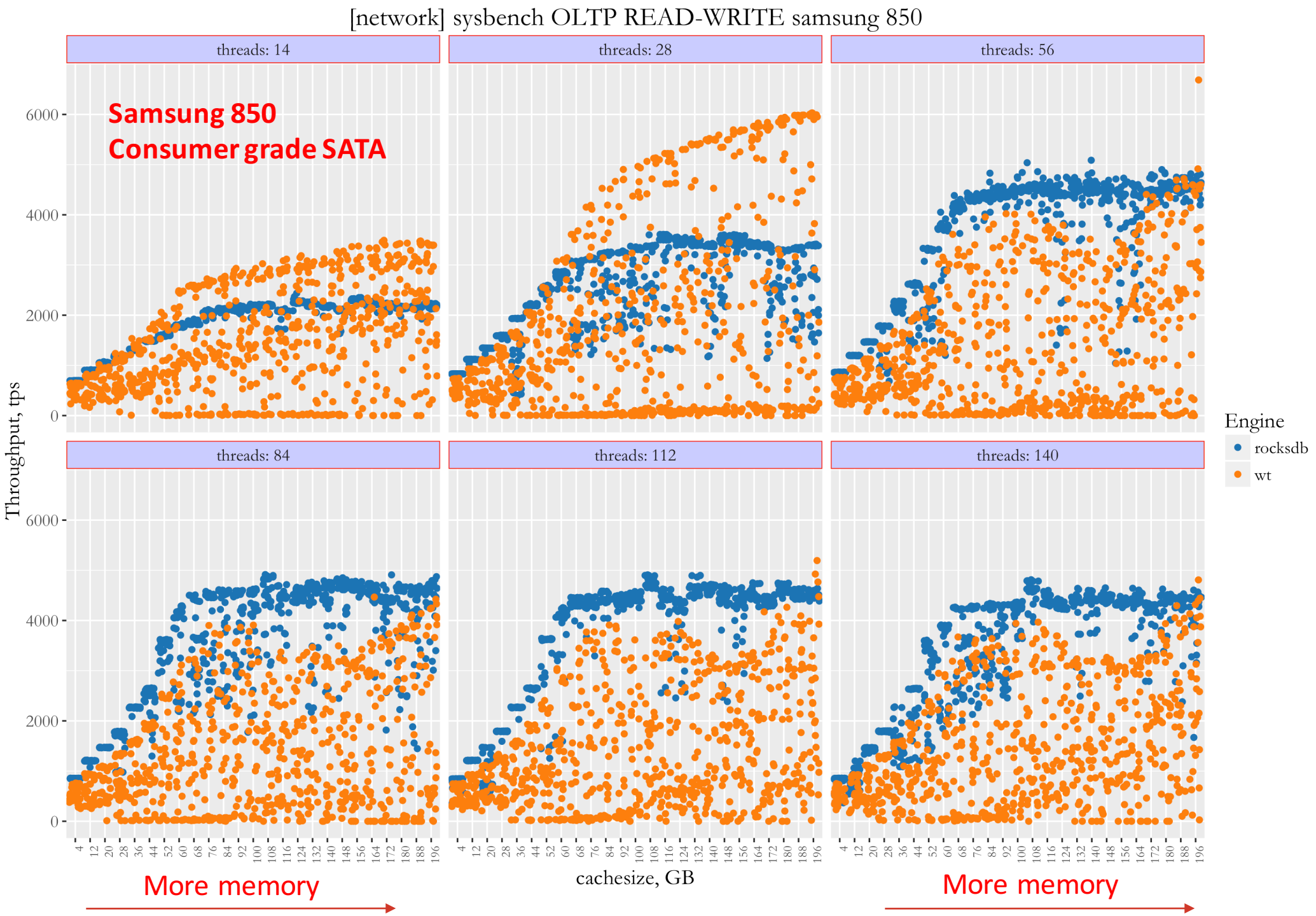
[network] sysbench OLTP READ-WRITE samsung 850
threads: 14
threads: 28
threads: 56
threads: 84
threads: 112
threads: 140
Samsung 850
Consumer grade SATA
Throughput, tps
0
2000
4000
6000
4
12
20
28
36
44
52
60
68
76
84
92
100
108
116
124
132
140
148
156
164
172
180
188
196
cachesize, GB
More memory
More memory
Engine
rocksdb
wt

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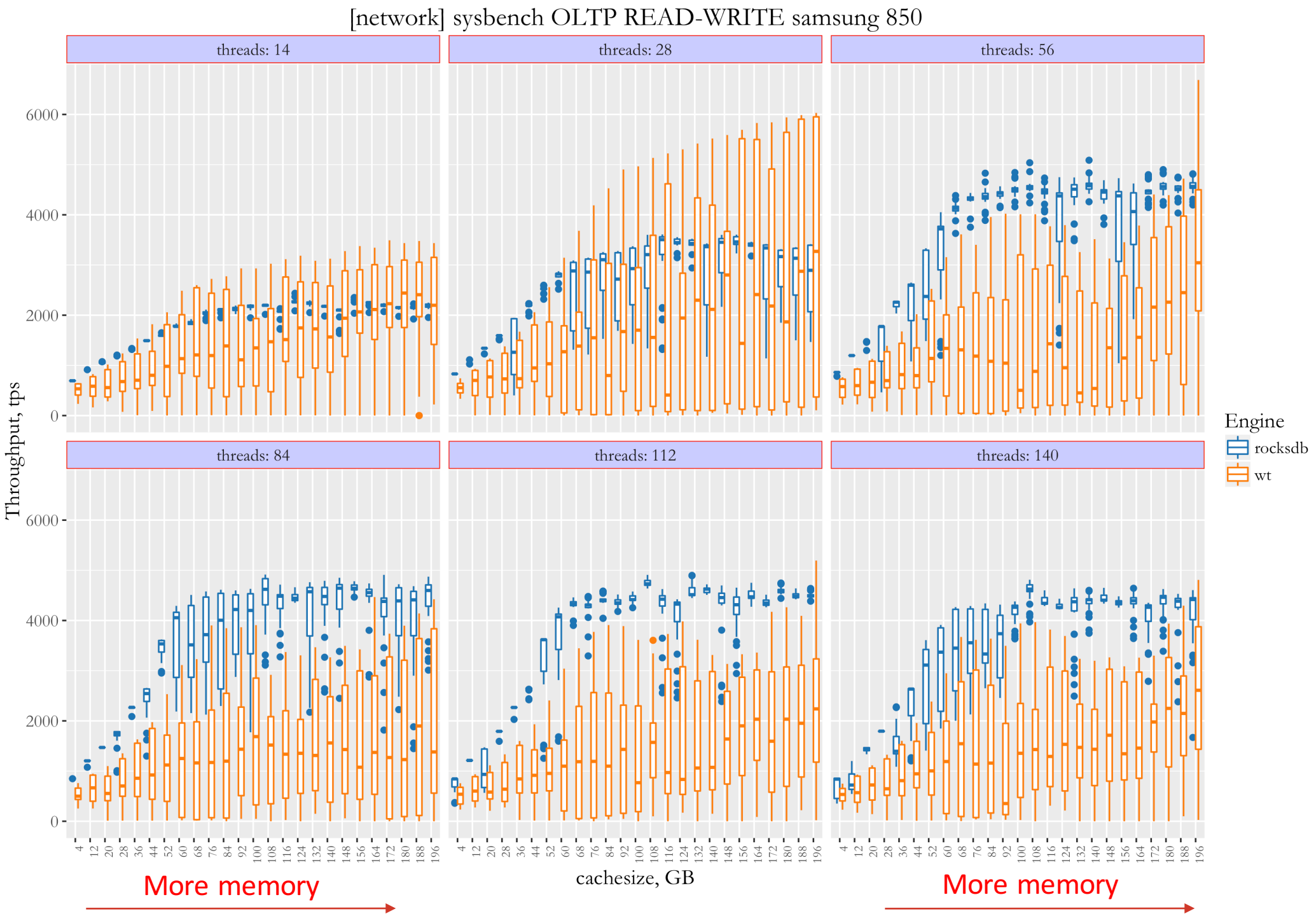
[network] sysbench OLTP READ-WRITE samsung 850
threads: 14
threads: 28
threads: 56
threads: 84
threads: 112
threads: 140
Throughput, tps
0
2000
4000
6000
4
12
20
28
36
44
52
60
68
76
84
92
100
108
116
124
132
140
148
156
164
172
180
188
196
cachesize, GB
More memory
More memory
Engine
rocksdb
wt

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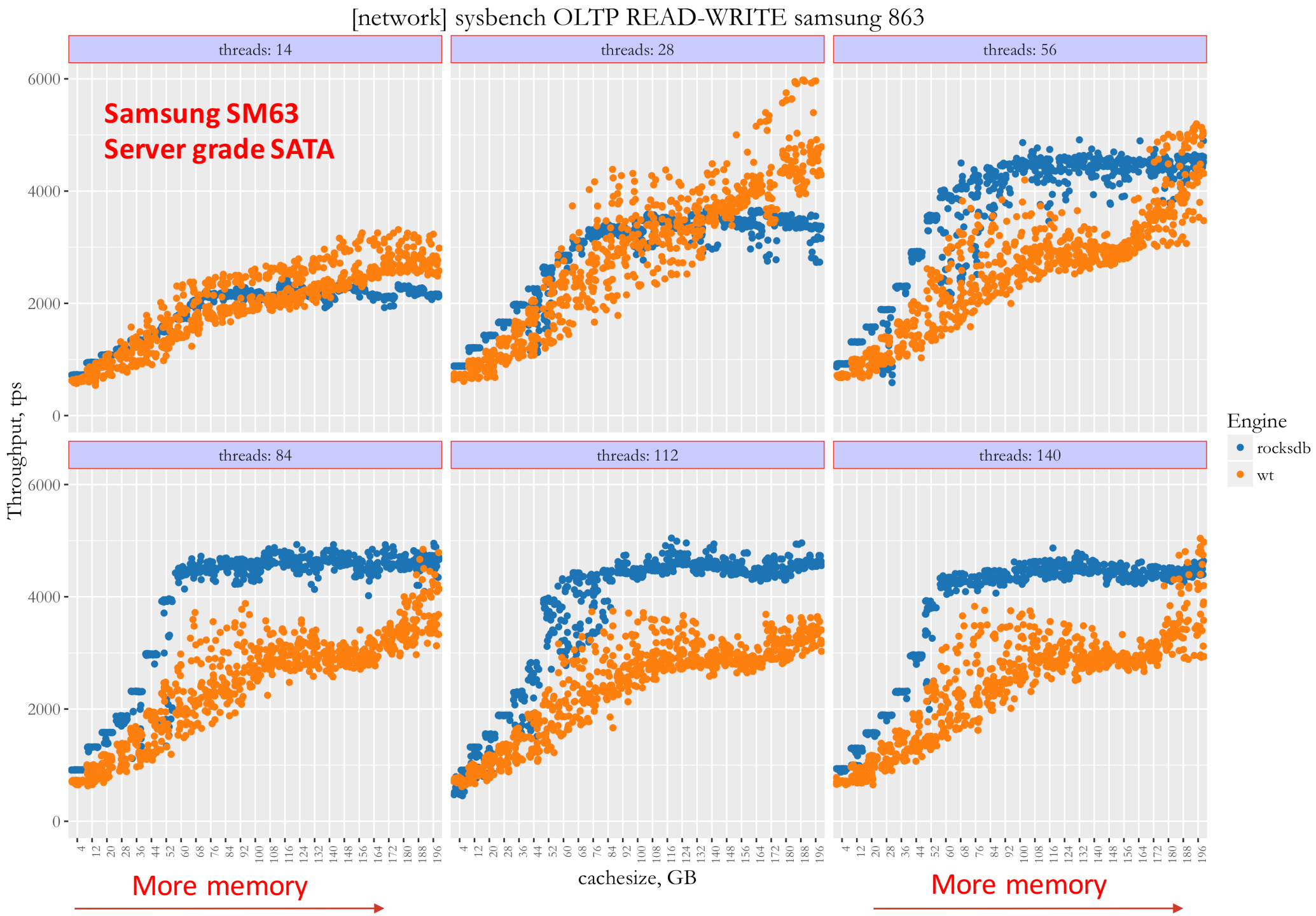
[network] sysbench OLTP READ-WRITE samsung 863
threads: 14
threads: 28
threads: 56
threads: 84
threads: 112
threads: 140
Samsung SM63
Server grade SATA
Throughput, tps
0
2000
4000
6000
4
12
20
28
36
44
52
60
68
76
84
92
100
108
116
124
132
140
148
156
164
172
180
188
196
cachesize, GB
More memory
More memory
Engine
rocksdb
wt

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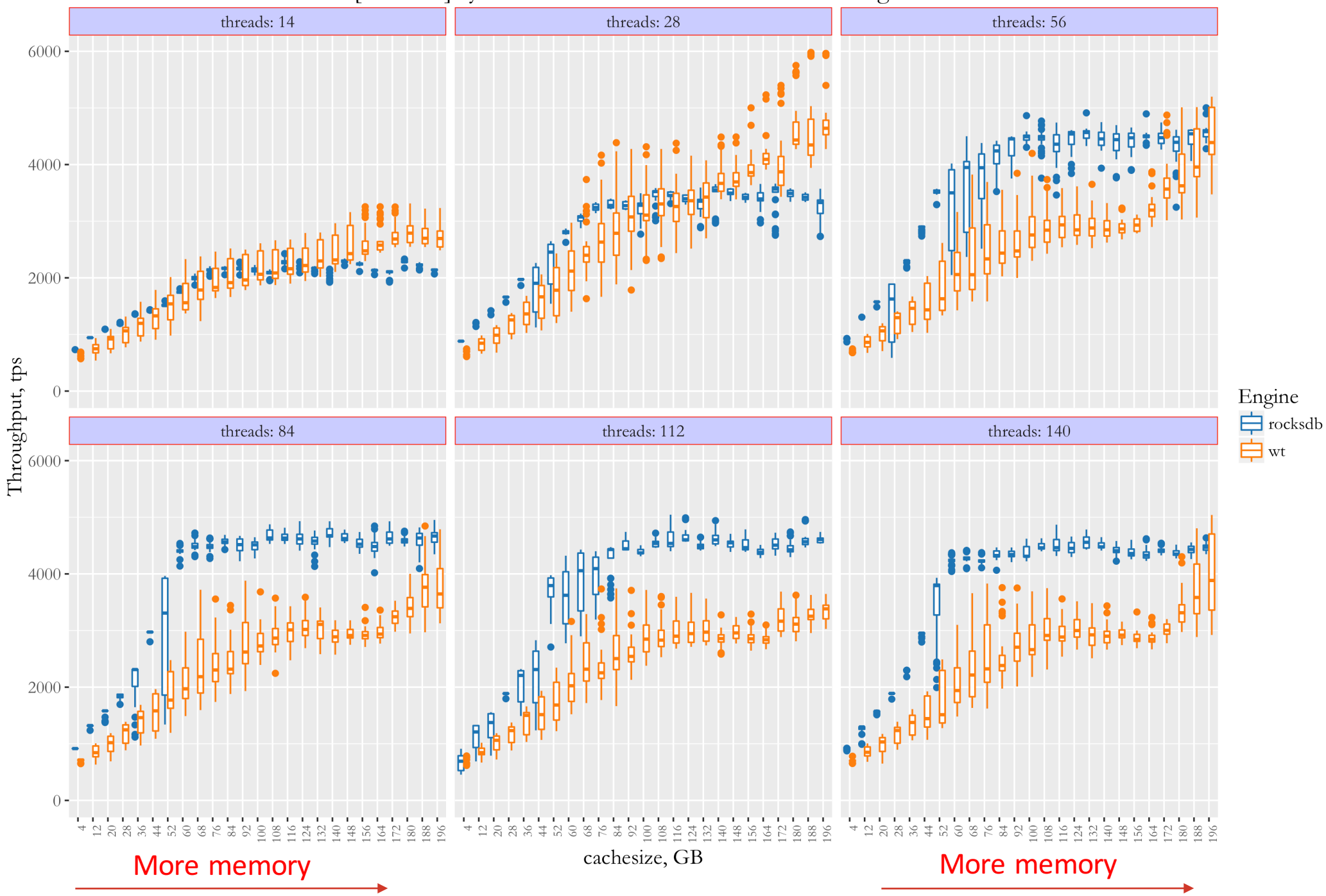
[network] sysbench OLTP READ-WRITE samsung 863
threads: 14
threads: 28
threads: 56
threads: 84
threads: 112
threads: 140
Throughput, tps
0
2000
4000
6000
4
12
20
28
36
44
52
60
68
76
84
92
100
108
116
124
132
140
148
156
164
172
180
188
196
cachesize, GB
More memory
More memory
Engine
rocksdb
wt

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Read-Write

Threads scalability – in-memory workload

Cachesize 200GB

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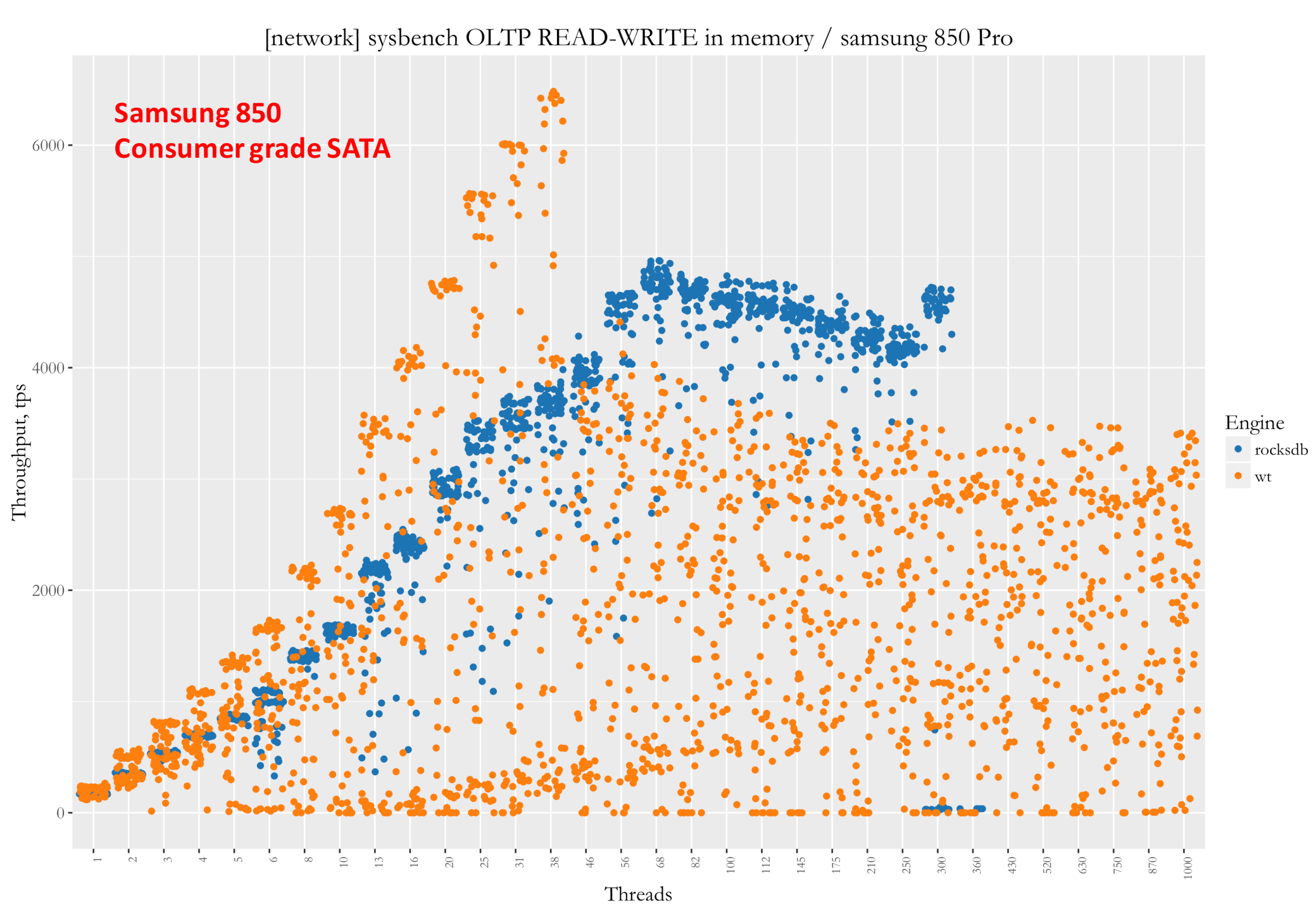
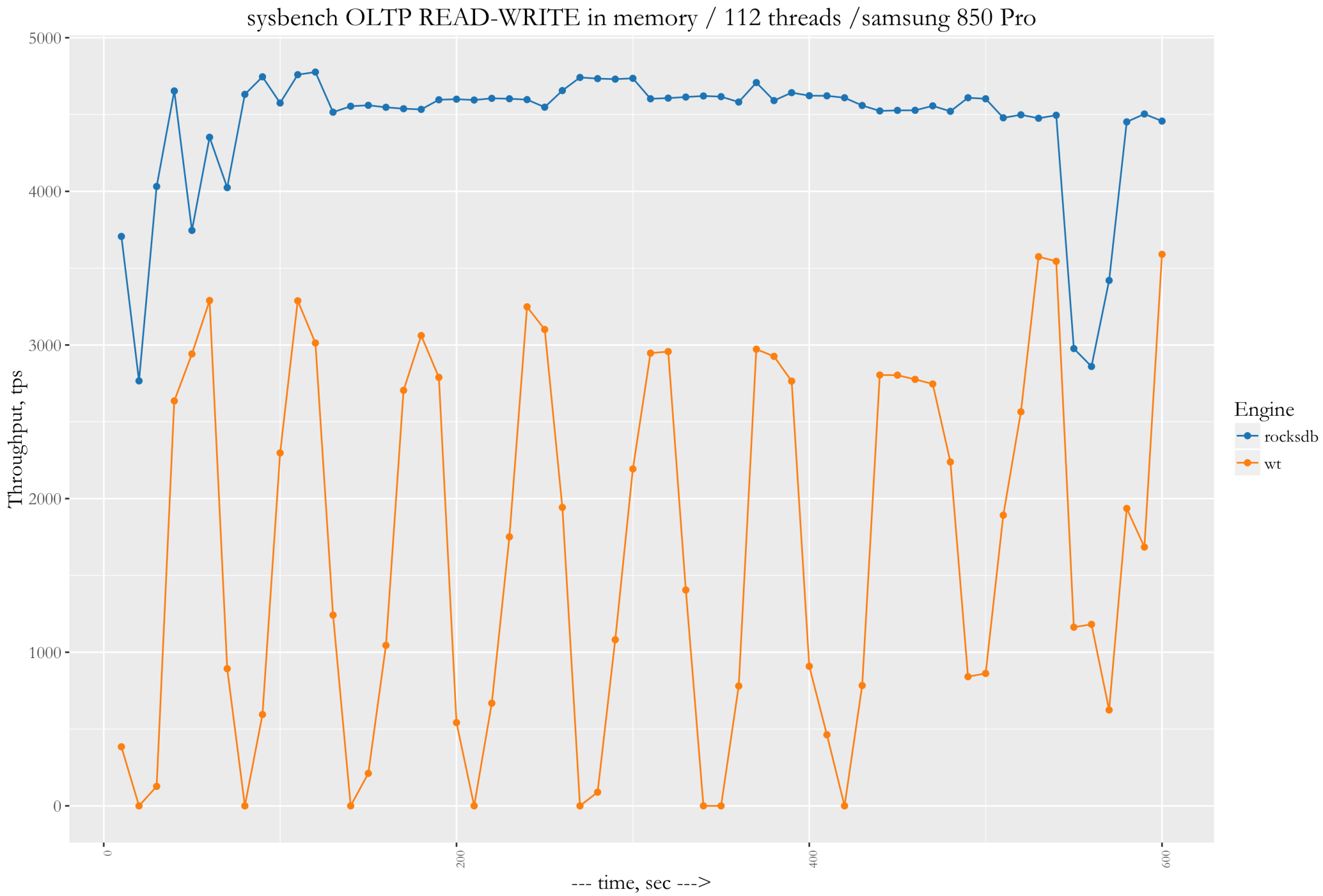

[network] sysbench OLTP READ-WRITE in memory / samsung 850 Pro
Samsung 850
Consumer grade SATA
Throughput, tps
6000
4000
2000
0
Threads
1
2
3
4
5
6
8
10
13
16
20
25
31
38
46
56
68
82
100
112
145
175
210
250
300
360
430
520
630
750
870
1000
Engine
rocksdb
wt

PERCONA


sysbench OLTP READ-WRITE in memory / 112 threads /samsung 850 Pro
Throughput, tps
5000
4000
3000
2000
1000
0
0
200
400
600
--- time, sec --->
Engine
rocksdb
wt

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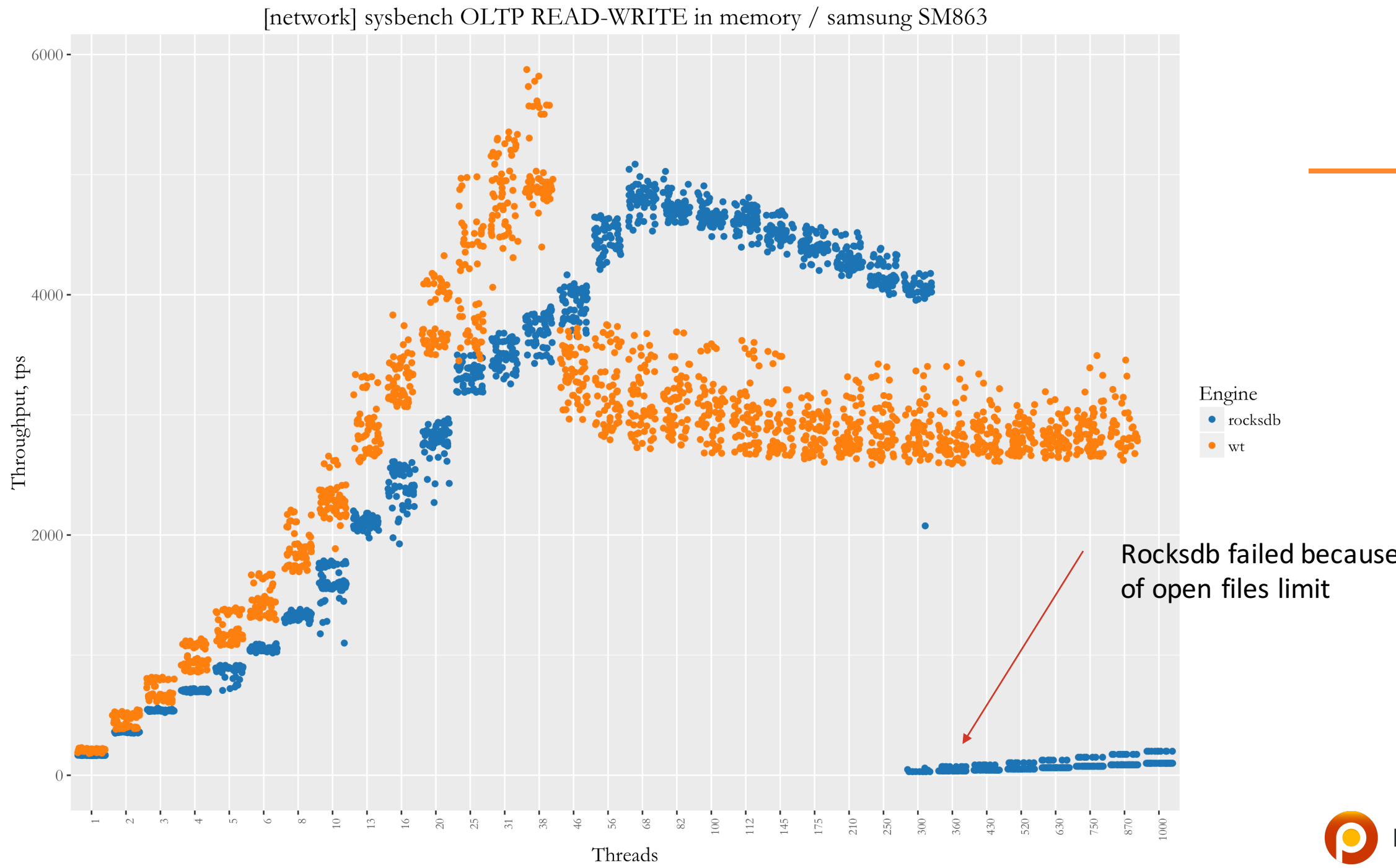
Let’s talk about checkpointing

- Writes buffered in memory (not immediately landed on storage)
- To deal with crashes:
  - Write-Ahead-Log (WAL)
  - Redo-logs
  - Journals
- To limit size of log files in WiredTiger:
  - Time-based checkpointing (60 sec default)
  - syncdelay option
  - Or 2GB of log files (journals), whatever happens sooner
    - I am not sure if 2GB if configurable


[network] sysbench OLTP READ-WRITE in memory / samsung SM863
Throughput, tps
6000
4000
2000
0
Threads
1
2
3
4
5
6
8
10
13
16
20
25
31
38
46
56
68
82
100
112
145
175
210
250
300
360
430
520
630
750
870
1000
Engine
rocksdb
wt
Rocksdb failed because
of open files limit

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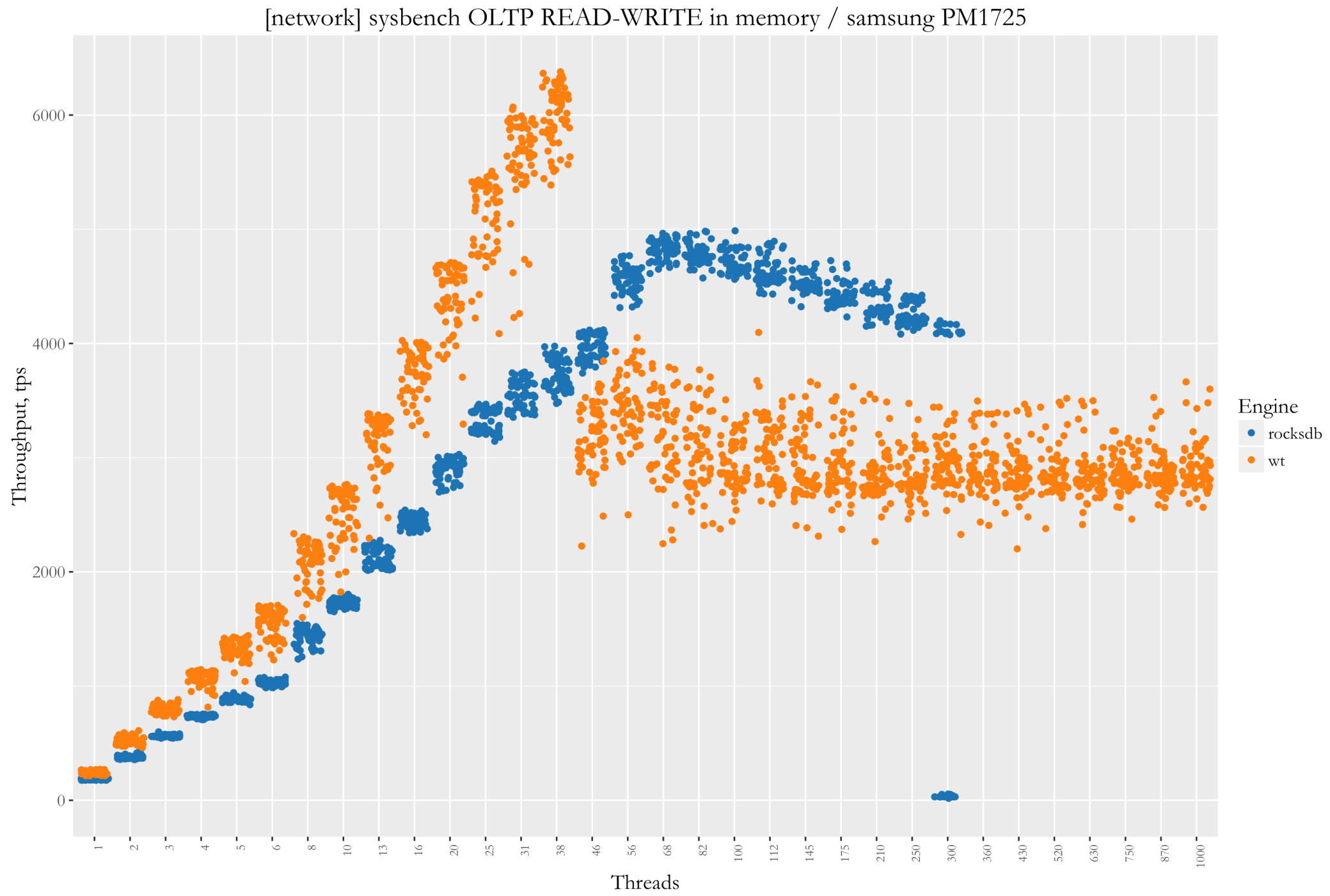
Let’s talk about open files in RocksDB

- RocksDB stores data in chunk files, fixed sizes
- It can result in large number of open files at give point of time
  - Be sure to increase the limit of open files `ulimit -n`
  - Not quite predictable how much will be required


[network] sysbench OLTP READ-WRITE in memory / samsung PM1725
Throughput, tps
0
2000
4000
6000
Threads
1
2
3
4
5
6
8
10
13
16
20
25
31
38
46
56
68
82
100
112
145
175
210
250
300
360
430
520
630
750
870
1000
Engine
rocksdb
wt

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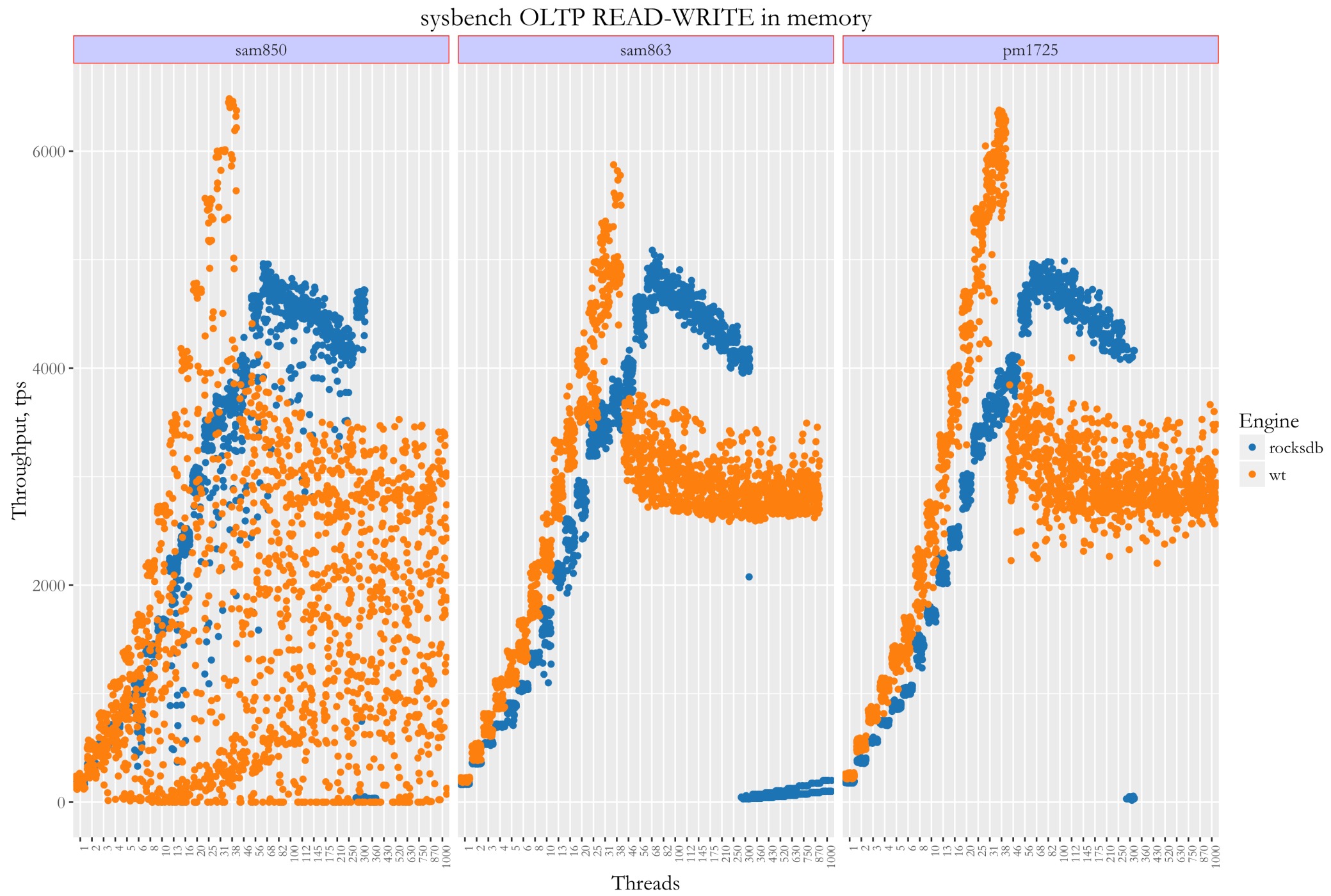
sysbench OLTP READ-WRITE in memory
sam850
sam863
pm1725
Throughput, tps
0
2000
4000
6000
Threads
1 2 3 4 5 6 8 10 13 16 20 25 31 38 46 56 68 82 100 112 145 175 210 250 300 360 430 520 630 750 870 1000
Engine
rocksdb
wt

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Conclusions

- When data fits into memory:
  - RocksDB works well even on cheap storage
  - WiredTiger still requires storage that handles big volume writes well

Read-Write

Threads scalability – IO-bound workload

Cachesize **20GB**

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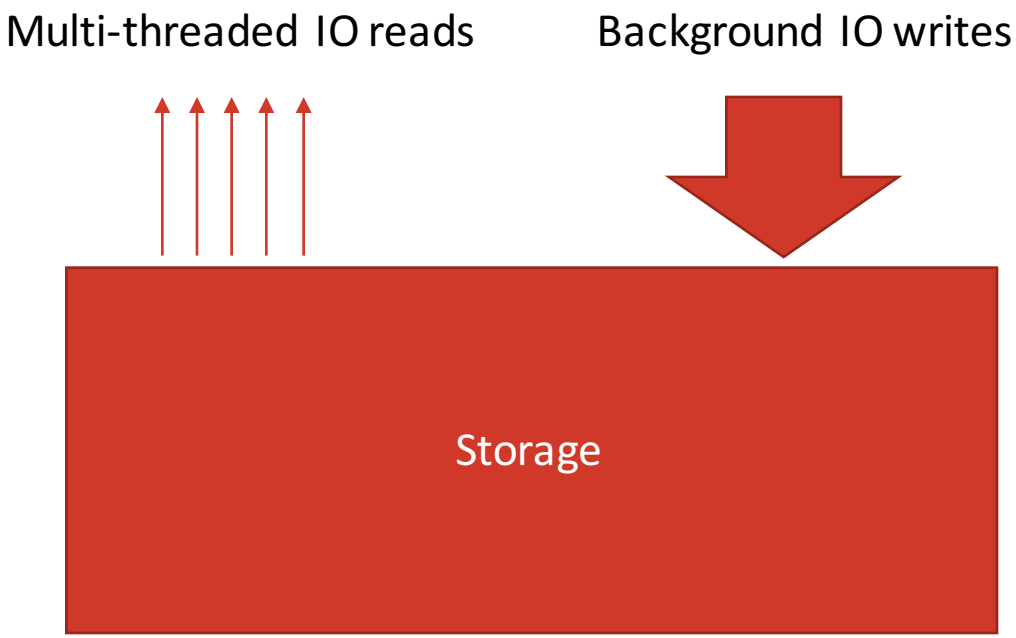
What to expect from this workload

- Intensive background writes
- Response time to user query depends on IO read response time



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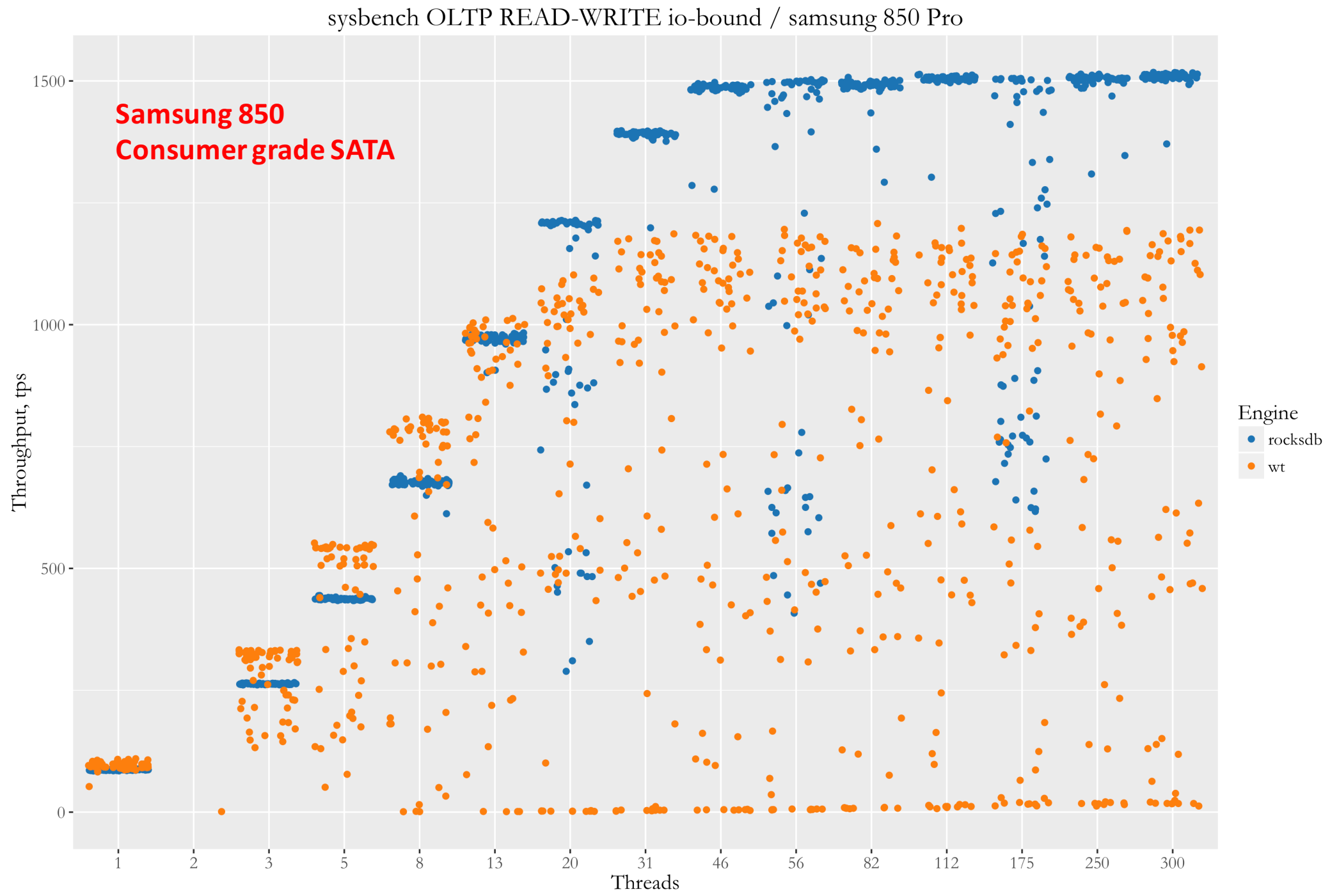
sysbench OLTP READ-WRITE io-bound / samsung 850 Pro
Samsung 850
Consumer grade SATA
Throughput, tps
1500
1000
500
0
1
2
3
5
8
13
20
31
46
56
82
112
175
250
300
Threads
Engine
rocksdb
wt

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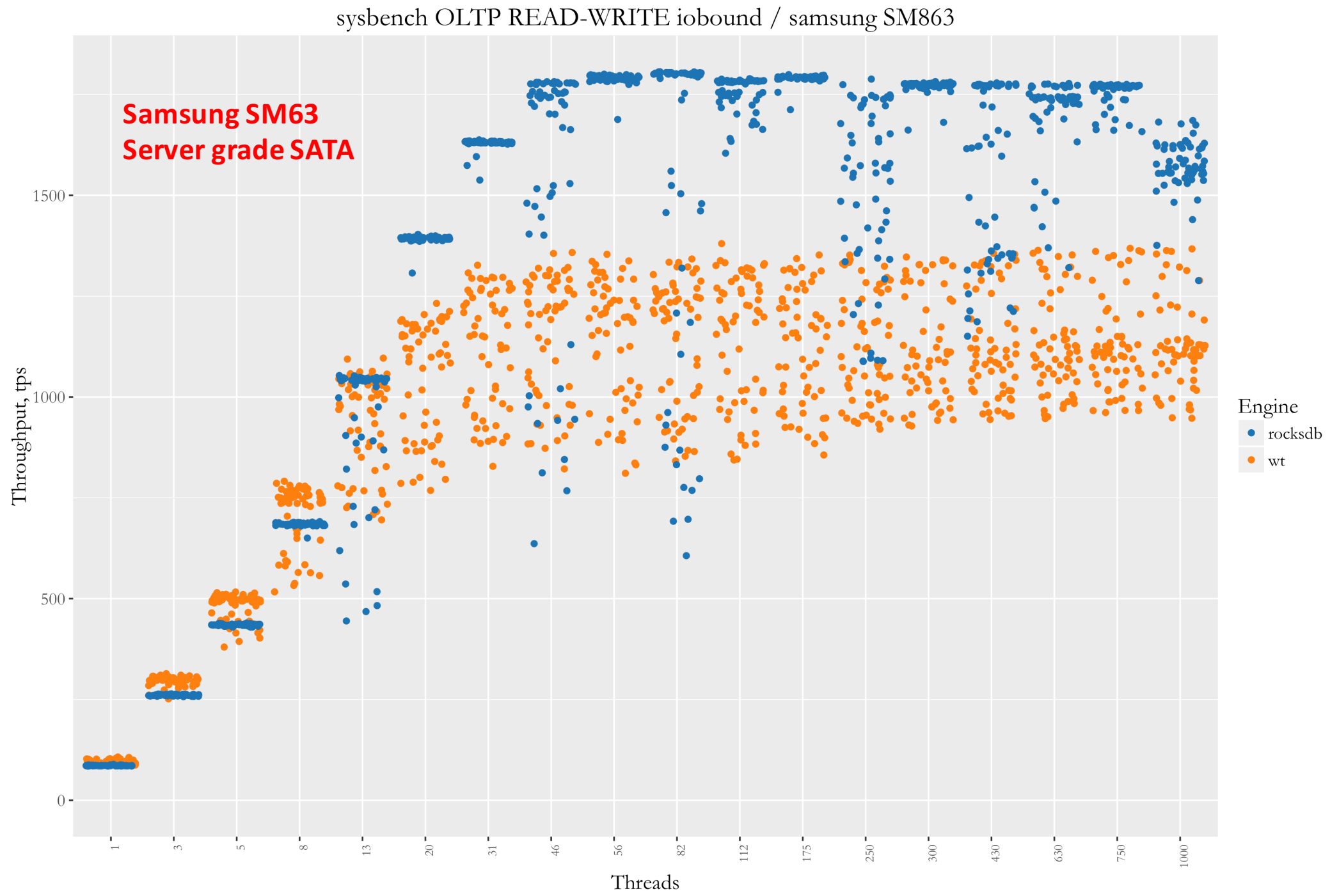
sysbench OLTP READ-WRITE iobound / samsung SM863
Samsung SM63
Server grade SATA
Throughput, tps
0
500
1000
1500
Threads
1
3
5
8
13
20
31
46
56
82
112
175
250
300
430
630
750
1000
Engine
rocksdb
wt

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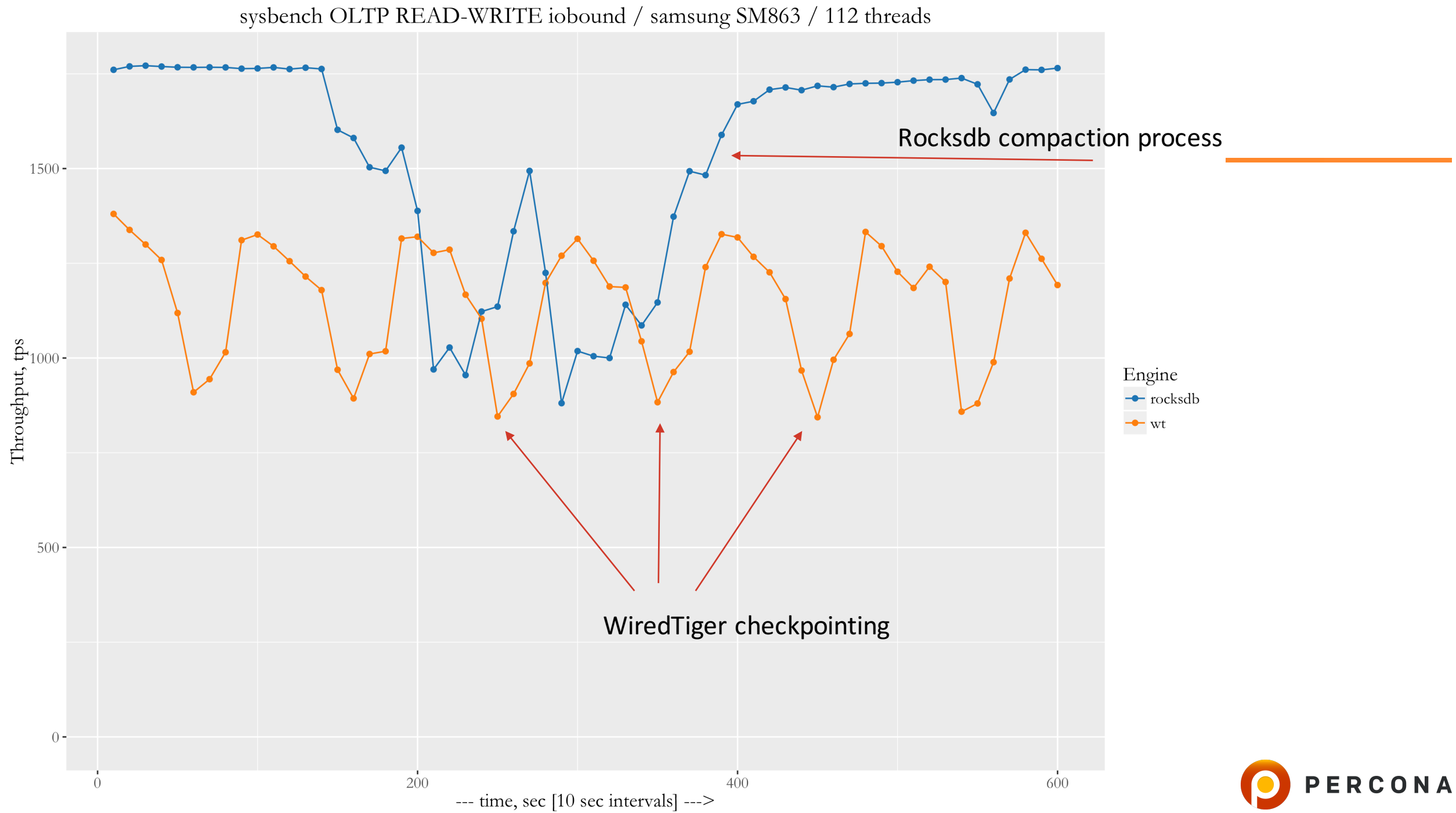
sysbench OLTP READ-WRITE iobound / samsung SM863 / 112 threads
Rocksdb compaction process
WiredTiger checkpointing
Throughput, tps
1500
1000
500
0
0
200
400
600
--- time, sec [10 sec intervals] --->
Engine
rocksdb
wt

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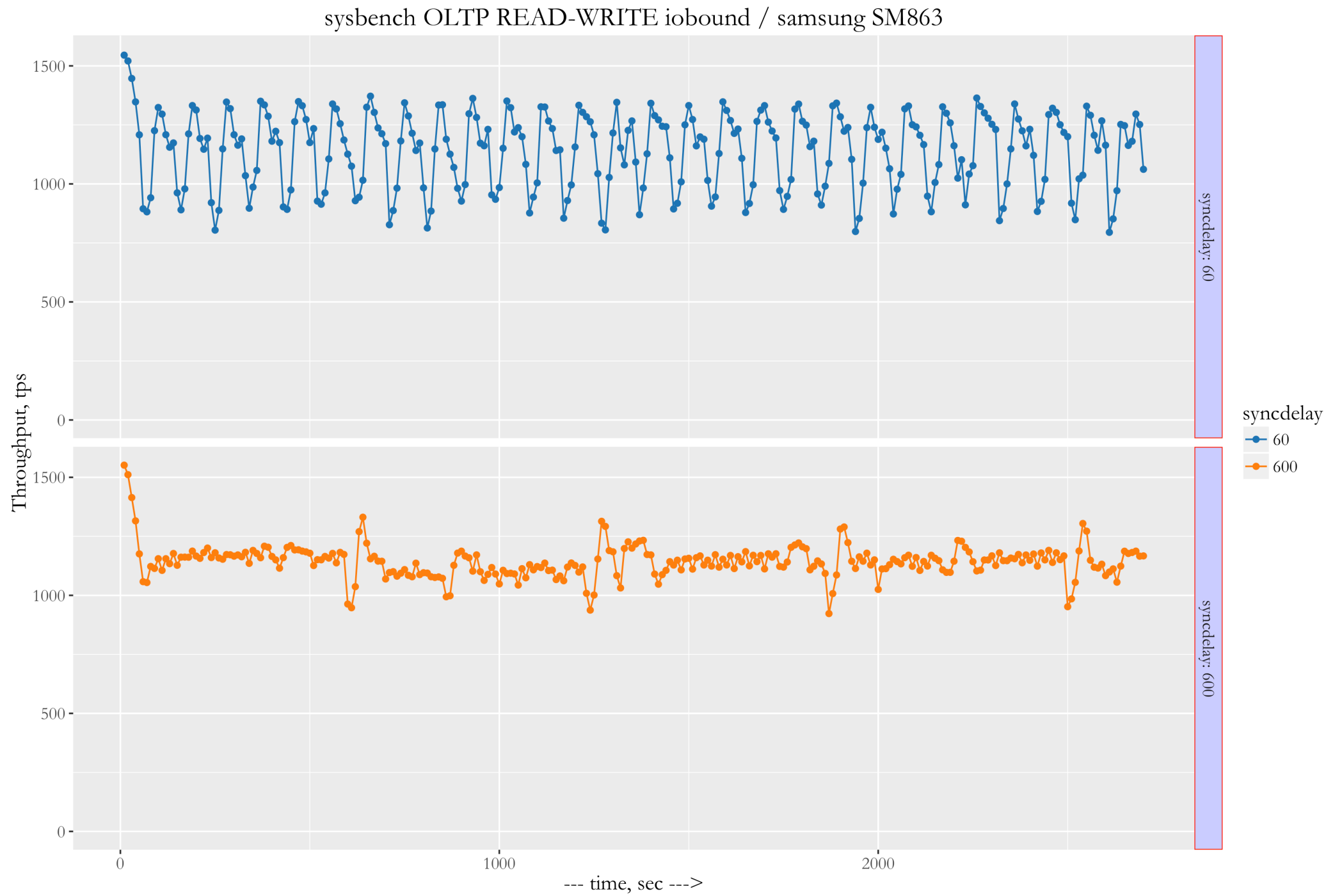
sysbench OLTP READ-WRITE iobound / samsung SM863
Throughput, tps
1500
1000
500
0
syncdelay: 60
syncdelay: 600
0
1000
2000
--- time, sec --->
syncdelay
60
600

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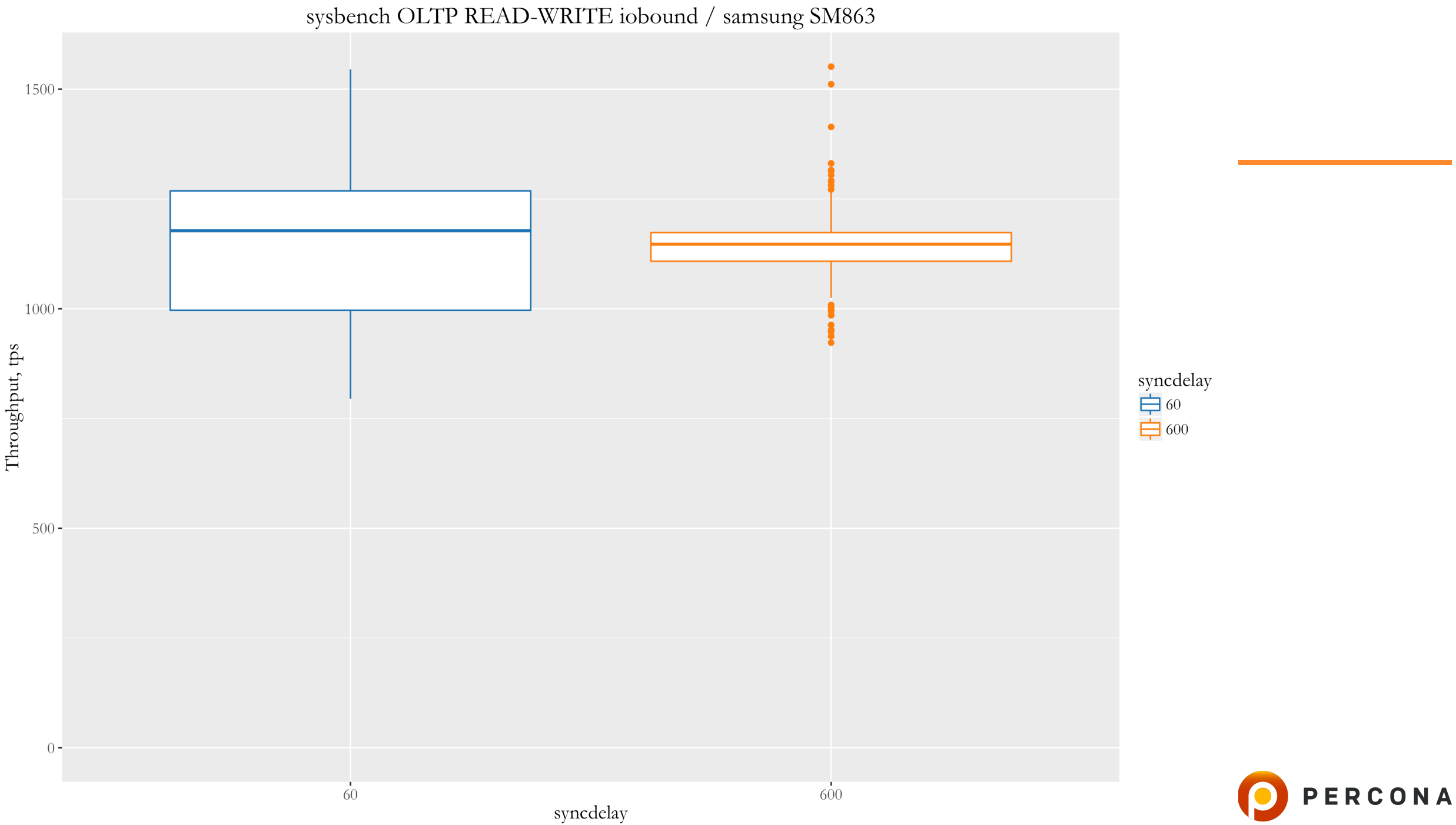
sysbench OLTP READ-WRITE iobound / samsung SM863
Throughput, tps
1500
1000
500
0
60
600
syncdelay
syncdelay
60
600

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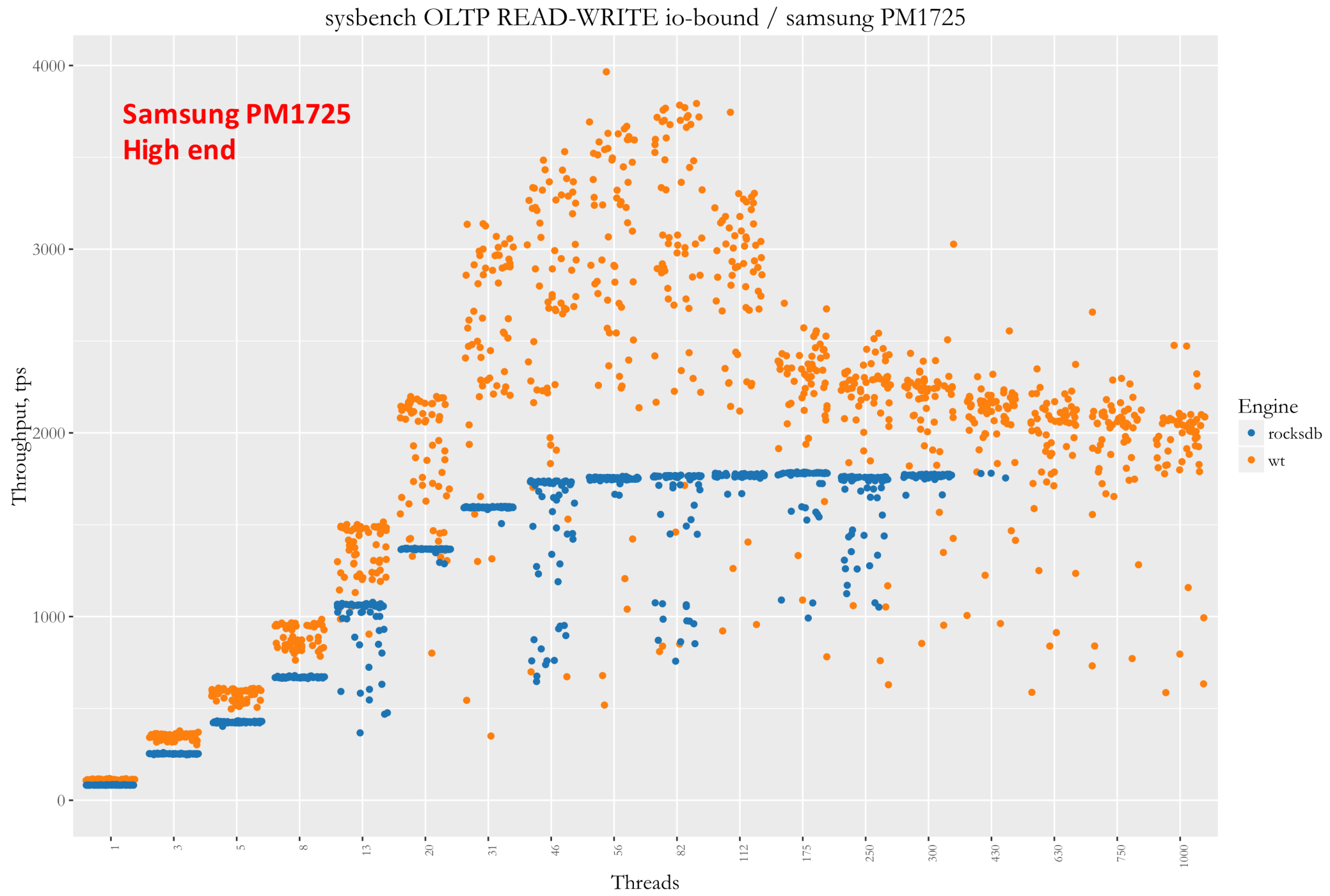
Crash Recovery time

- Syncdelay=60
  - To start mongod after a crash: ~25 mins
- Syncdelay=600
  - ~40 mins


sysbench OLTP READ-WRITE io-bound / samsung PM1725
Samsung PM1725
High end
Throughput, tps
4000
3000
2000
1000
0
Threads
1
3
5
8
13
20
31
46
56
82
112
175
250
300
430
630
750
1000
Engine
rocksdb
wt

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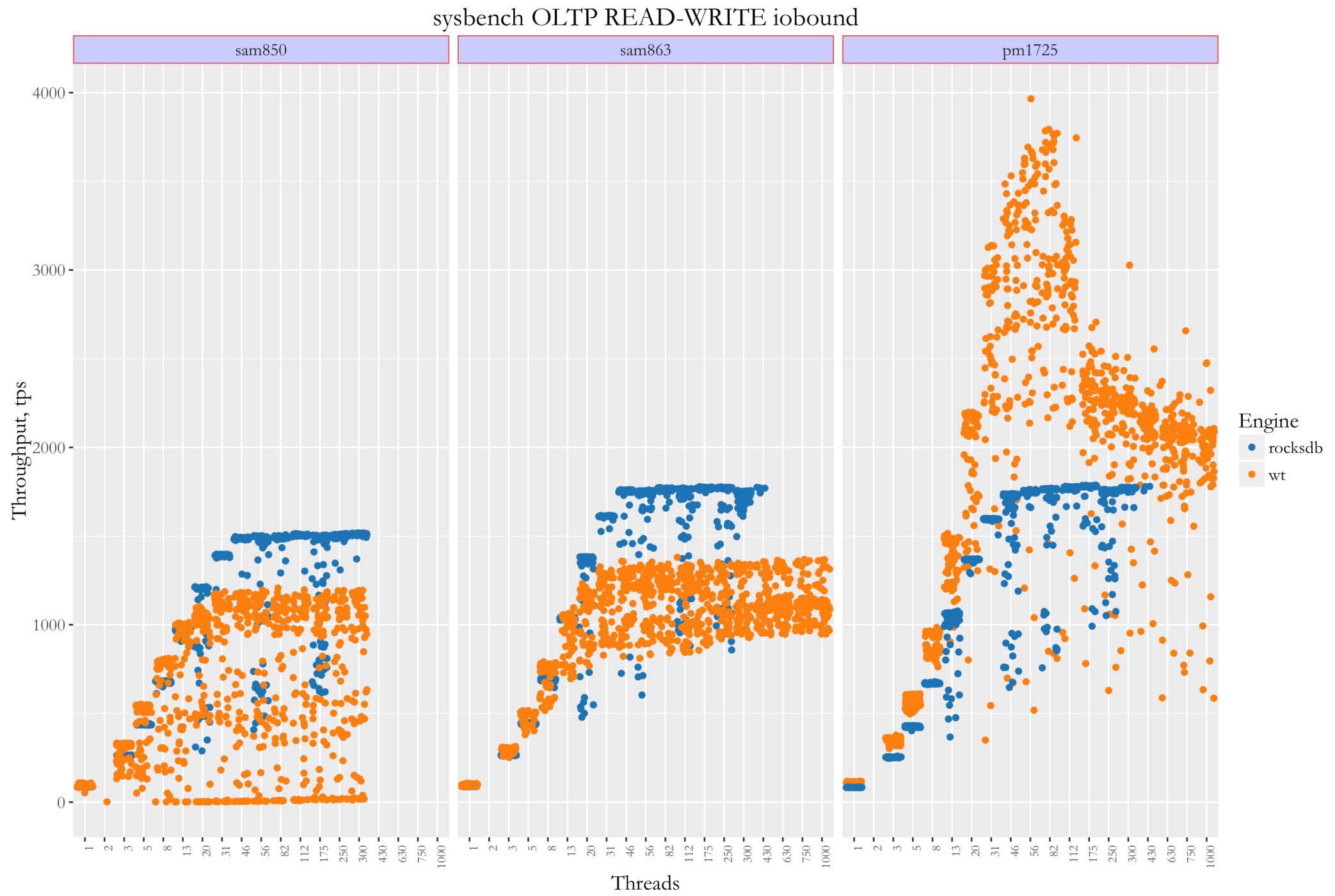
sysbench OLTP READ-WRITE iobound
sam850
sam863
pm1725
Throughput, tps
4000
3000
2000
1000
0
1
2
3
5
8
13
20
31
46
56
82
112
175
250
300
430
630
750
1000
Threads
Engine
rocksdb
wt

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Conclusions

- RocksDB works well with cheap storage
- WiredTiger benefits from faster storage
- To improve WiredTiger performance:
  - Typical recommendations for B-Tree based engines
    - More memory if data does not fit into memory
    - Storage with better response times
  - Playing with checkpoint intervals may help with variability, but keep in mind crash recovery times
- Send questions/feedback: @VadimTk, vadim@percona.com