Optimizing MySQL for Solid State Storage

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This talk

Flash technologies

- Server usage
  - not USB/digital camera flash cards

PCI-E and SATA cards

MySQL application

Revolutionary changes

- From spinning to solid state
- No mechanical moving parts
- Jump in performance
- Requires changes in applications
- In 5-10 years SSD will replace hard disks totally

Physics behind

“floating gate transistors”

- Non-volatile memory
- (more details)

One state – Single Level Cell (SLC)

- Faster, more reliable, more expensive

Many states – Multi Level Cell (MLC)

- Usually 4 states (2bits)
- 3bits (8 states)
- Slower, less reliable, cheaper

Types

NOR

- Random read access (bit granularity)
  - Speed compared with DRAM
- Slow write and erase
- Firmware storage

NAND (this talk)

- Faster writes
- Only block-level read access (4K)
- Idea is to compact many cells in limited space
  - Make competition with Hard Disk Drives

Erase (rewrite) challenges

Erase is to set all bits to “1111…”

- Erasing process is similar to “flash” in photocameras – there where name **FLASH** comes from
- Erase is slow, done in batch operation (up to 1MB)

Change “1”->”0” is fast

Change “0”->”1” is possible only by erasing

- 1st write: “1111” -> “1110” . Block marked as “written”
- 2nd write: even “1110” -> “1010” is not possible

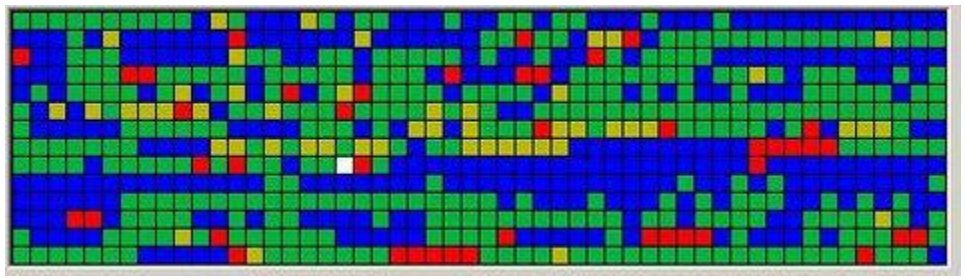
Erase challenges

Erase is slow

- You want to erase many blocks in single flash
- Block management

When you write – card never writes the same block

Background process to run garbage collector

- 

Erase lifetime

SLC

- 100.000 times per cell (may vary)
- ~20 years lifetime

MLC

- 10.000 times per cell (2cell)
- 5.000 times (3 cell)
- ~5 years lifetime

Big capacity and even distribution (wear leveling) prolongs lifetime

SSD types

SATA

- 200-500MB/sec
- Intel X25-M/E, OCZ, Unigen

PCI-E

- Over 1GB/sec, 70.000 req/sec, under 1ms response time
- FusionIO, Virident

SAN

- Violin memory

PCI-E cards

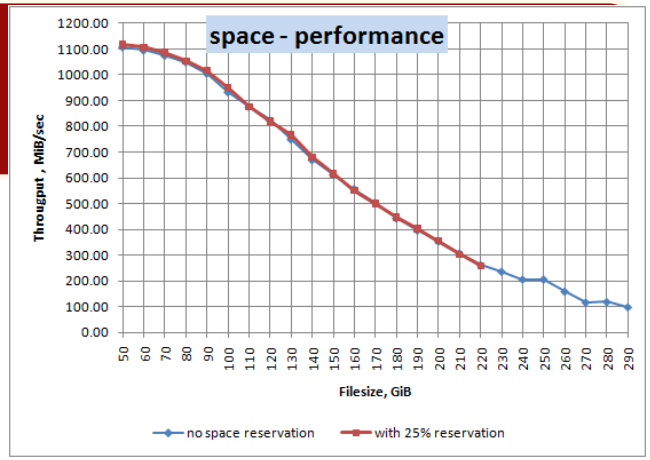
- Fast. Very fast.
- PCI-E, closest to CPU
- Shares host memory / CPU
- Most complex part – firmware
- Space reservation for heavy writes

PCI-E cards drawbacks

Expensive. Very expensive.

- $18,999.00 / 640GB = 30$/GB
- On level with memory prices

Performance depends on space



Not hot-swap

SATA SSD

Good performance

Much cheaper, but

Requires engineering work

- How to attach
- What RAID controller
- Not all models are equal

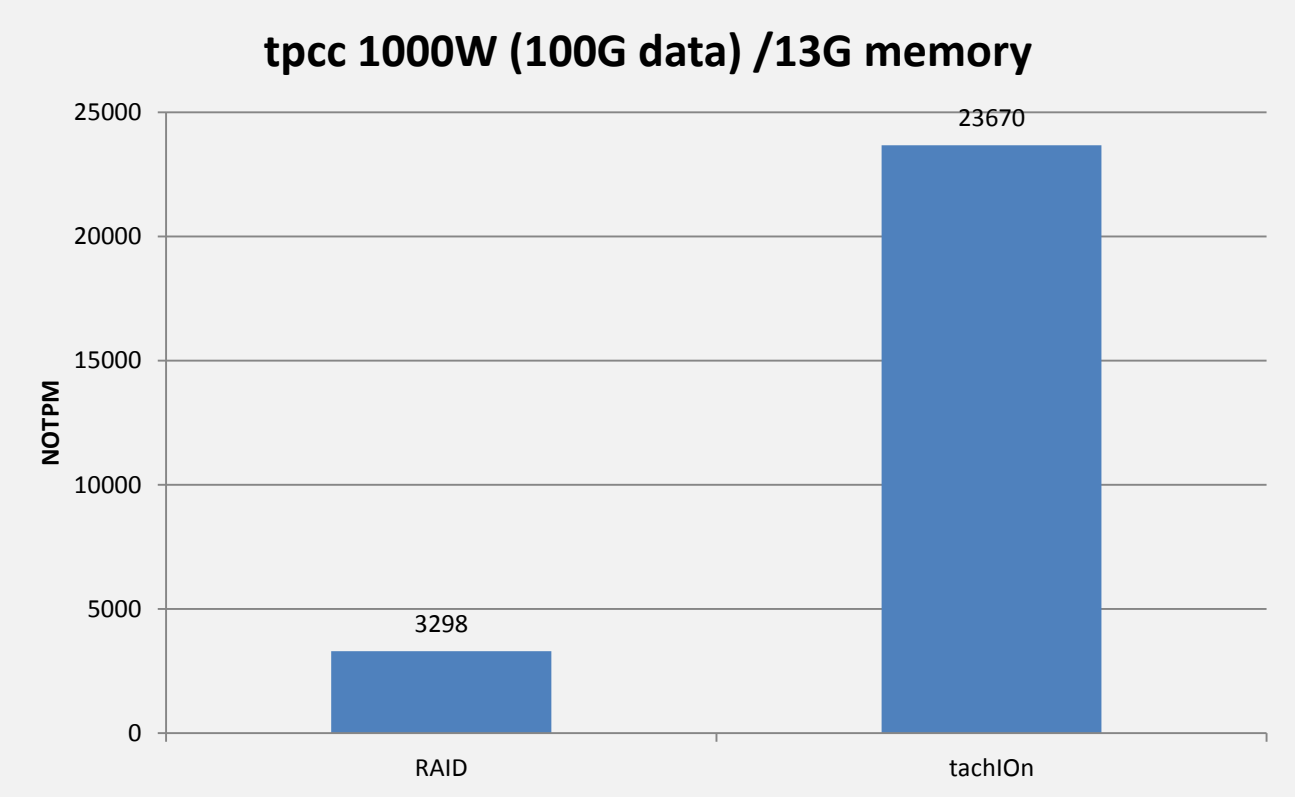
SSD for MySQL / Percona Server

IO performance: 1GB/sec – 70,000 req/sec

- A lot, but MySQL can't use that all

MySQL basic setups

- Everything on SSD (ibdata, ib_logfiles)
  - 5-7x difference



MySQL basic recommendations

XFS, better with 4k blocks

- Mkfs.xfs -s size=4096
- Mount –o nobarrier

Multiple threads

- Percona Server or InnoDB-plugin or MySQL 5.5

Still uses about 5,000 req/sec, ~200MB/sec

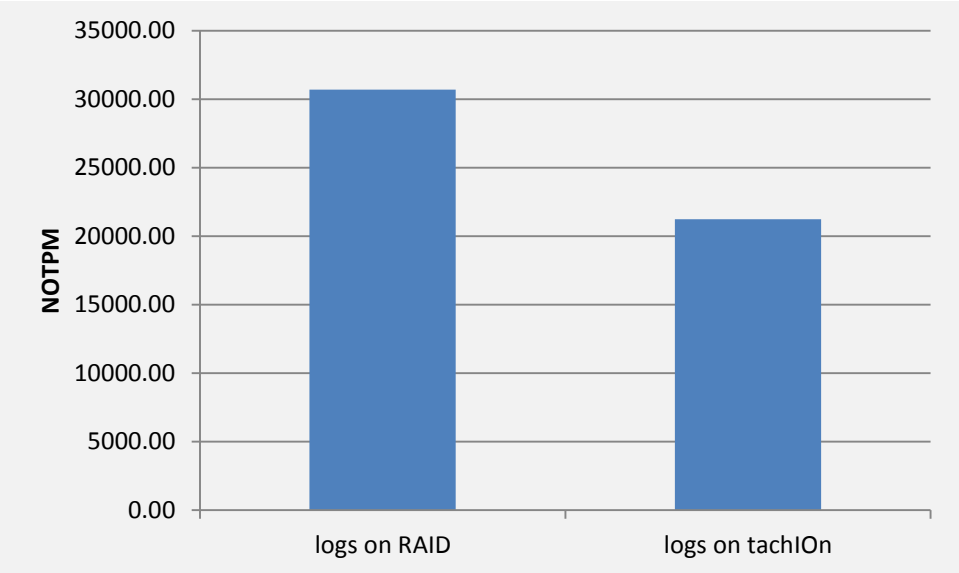
MySQL what can be improved

Single threaded sequential stuff

- InnoDB transactional logs with fsyncs
- Binary logs
- Doublewrite buffer (with whole ibdata)

RAID with BBU good place for them

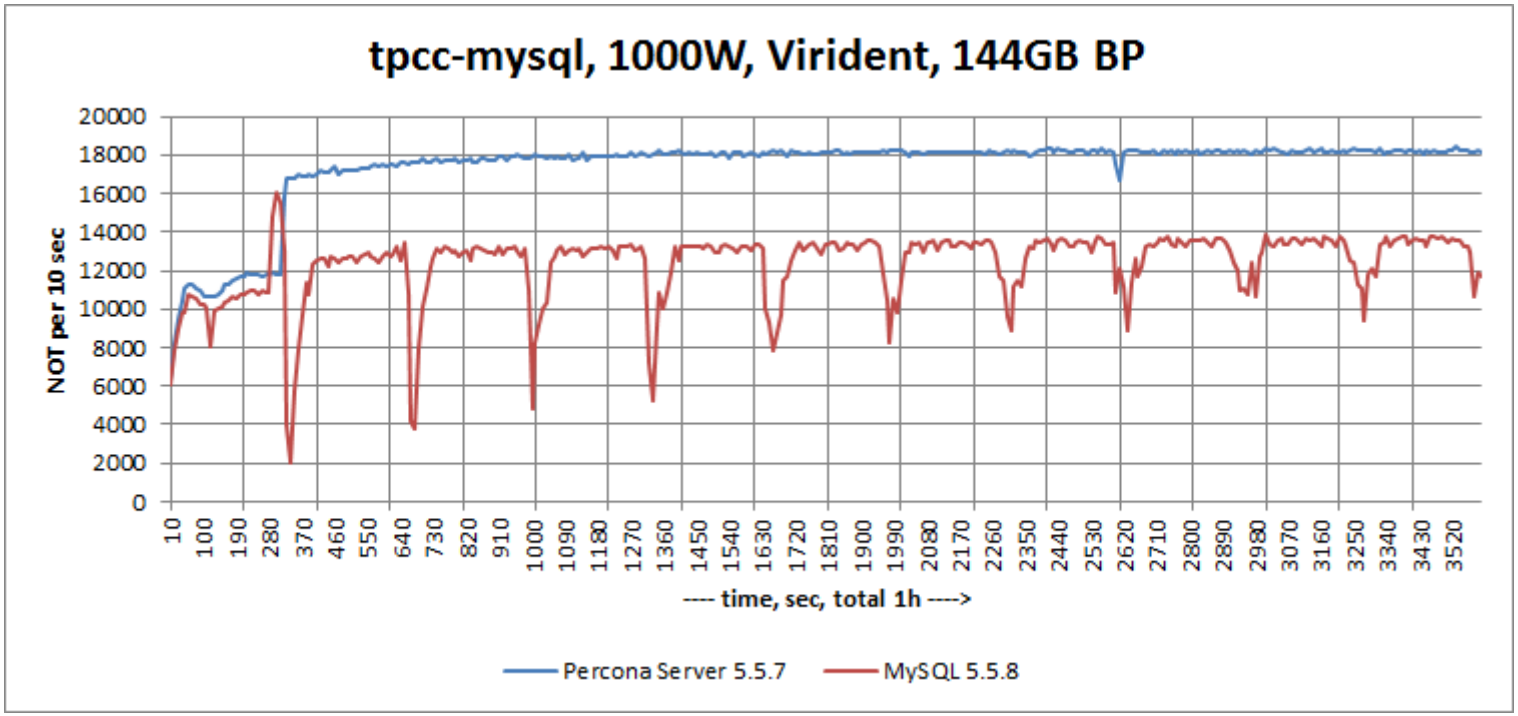
- Up to 45% improvement



Percona Server tunings

- innodb_flush_neighbor_pages= ON | OFF
- innodb_log_block_size = 512 | 4096
- innodb_page_size = 4K | 8K | 16K
  - Use carefully
- innodb_doublewrite_file
- Innodb_adaptive_checkpoint=keep_average
- innodb_log_file_size > 4GB

Percona Server results



Still not enough utilization

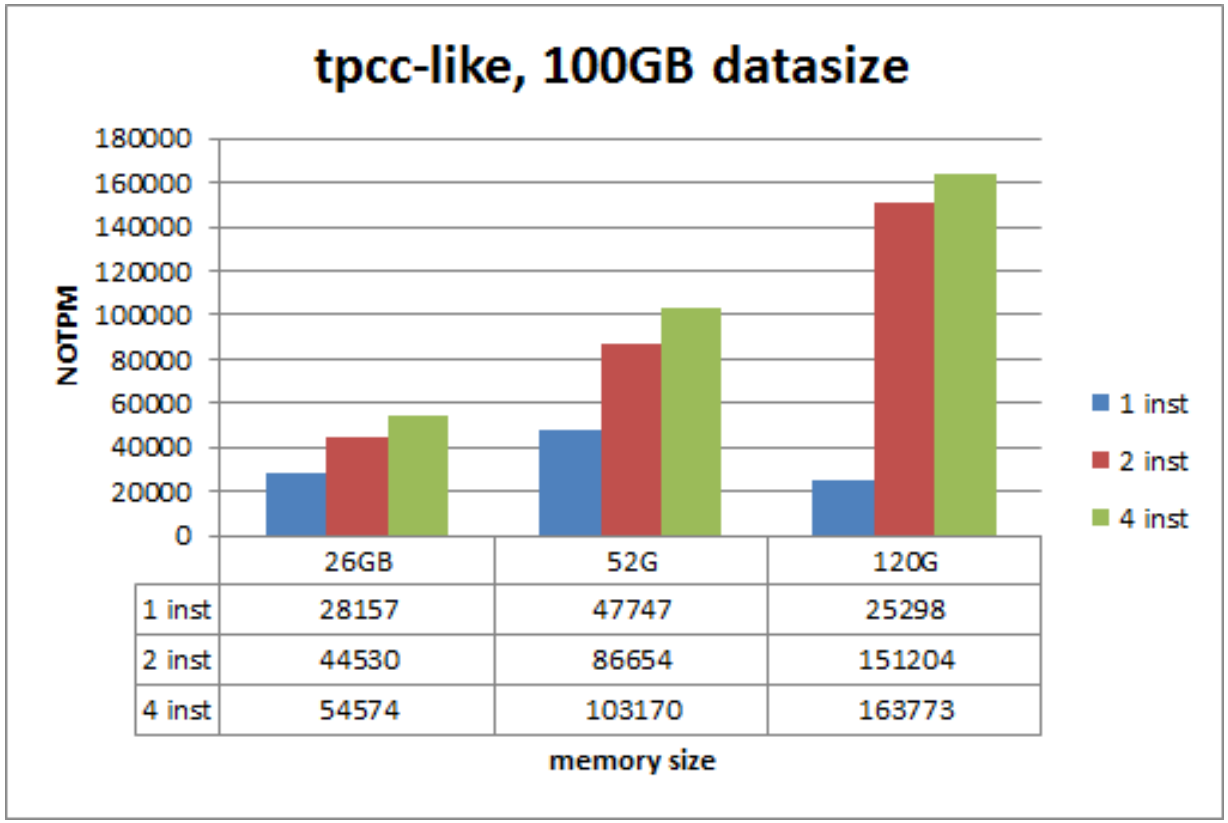
Single MySQL instance not able to utilize all IO

- Solution: several MySQL instances

Experiment

- Dell PowerEdge R815
- 4 physical AMD CPUs / 48 cores
- 144GB of RAM
- Virident tachIOn 200GB card
- Tpcc-mysql workload
  - 48 user connections
- Whitepaper “Scaling MySQL With Virident Flash Drives and Multiple Instances of Percona Server” on percona.com/about-us/mysql-white-papers/

Results



	26GB	52G	120G
1 inst	28157	47747	25298
2 inst	44530	86654	151204
4 inst	54574	103170	163773

Results conclusions

With 120GB memory single instance result worse then with 26GB

- InnoDB contentions problems again

Two instances allows to improve 1.5x-6x times

I do not like multi-instance, but

- Management complexity
- Good scripts solve it
- 2-3 instances seems reasonable

Dealing with space problems

Hot tables on SSD / Cold tables on disks

- MySQL does not have proper tablespace management
- Symlinks are pain to maintain

Use SSD as cache

- ZFS
- FlashCache

FlashCache

Developed and maintained in production by Facebook

OpenSource

Shows good/stable results in production

Drawbacks

- Not user friendly
- Kernel module – manual compilation

FlashCache details

- Write-through and write-back modes
- FIFO and LRU block management
- Configurable % of dirty pages
- Cache survive server reboot
- You need to compile kernel module by yourself
- ibdata1/ib_logs layout
  - Keep on non-FlashCache partition

Why you may want Flash

Performance

Scale up instead of scale out

Expensive one time investment, but saving on

- Amount of server
- Power consumption
- Datacenter space

More talks

Today 4:15pm

- “Tuning For Speed: Percona Server and Fusion-io” by Torben Mathiasen from FusionIO

Thank you!

Flash technologies are evolving

- A lot of research ahead

We can discuss more today

- Mickey Mantle open bar 6-8pm

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