Samsung Key Value SSD enables High Performance Scaling

A Technology Brief by Samsung Memory Solutions Lab

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Introduction

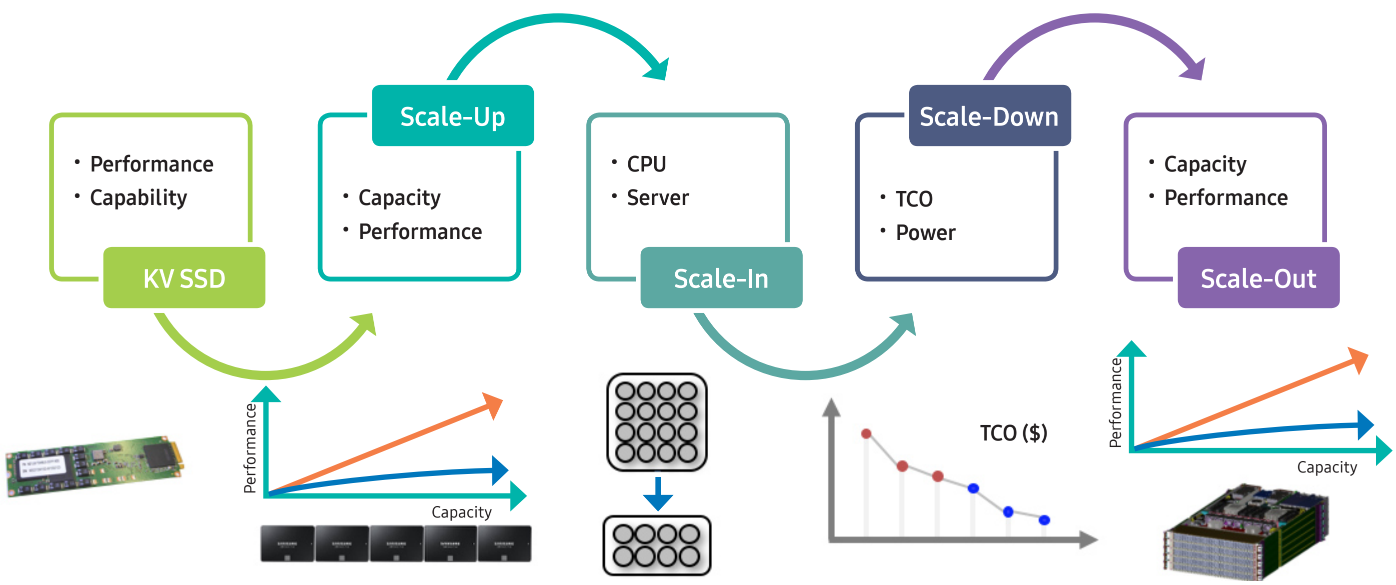
As global data continues to embrace object formats that are variable in size and unstructured, the quest for *effective* data conversion between object and block—level interfaces is becoming an urgent priority. Traditional Solid State Drives (SSDs) use only a block interface. Therefore data must be converted to allow applications to talk to virtually any solid state drive today.

Unfortunately, effective data conversion is costly from an operational standpoint and can often become a performance bottleneck in scale-out and scale-up infrastructures.

Samsung has developed a unique solution to this costly process that combines conventional SSD technology and the conversion layer into a single SSD. This solution—the Samsung Key Value (KV) SSD—not only simplifies the conversion process, but also significantly extends the drive's capabilities. By incorporating Key Value store logic within its firmware, Samsung KV SSDs can respond to direct data requests from an application with minimal involvement of the host software. The new process increases performance, and simplifies storage management, while providing the means for nearly unlimited system scaling. Surprisingly, the Samsung Key Value SSD needs only standard SSD hardware, which is augmented by special Flash Translation Layer (FTL) software that provides its processing capabilities.

Highly Efficient Performance Scaling

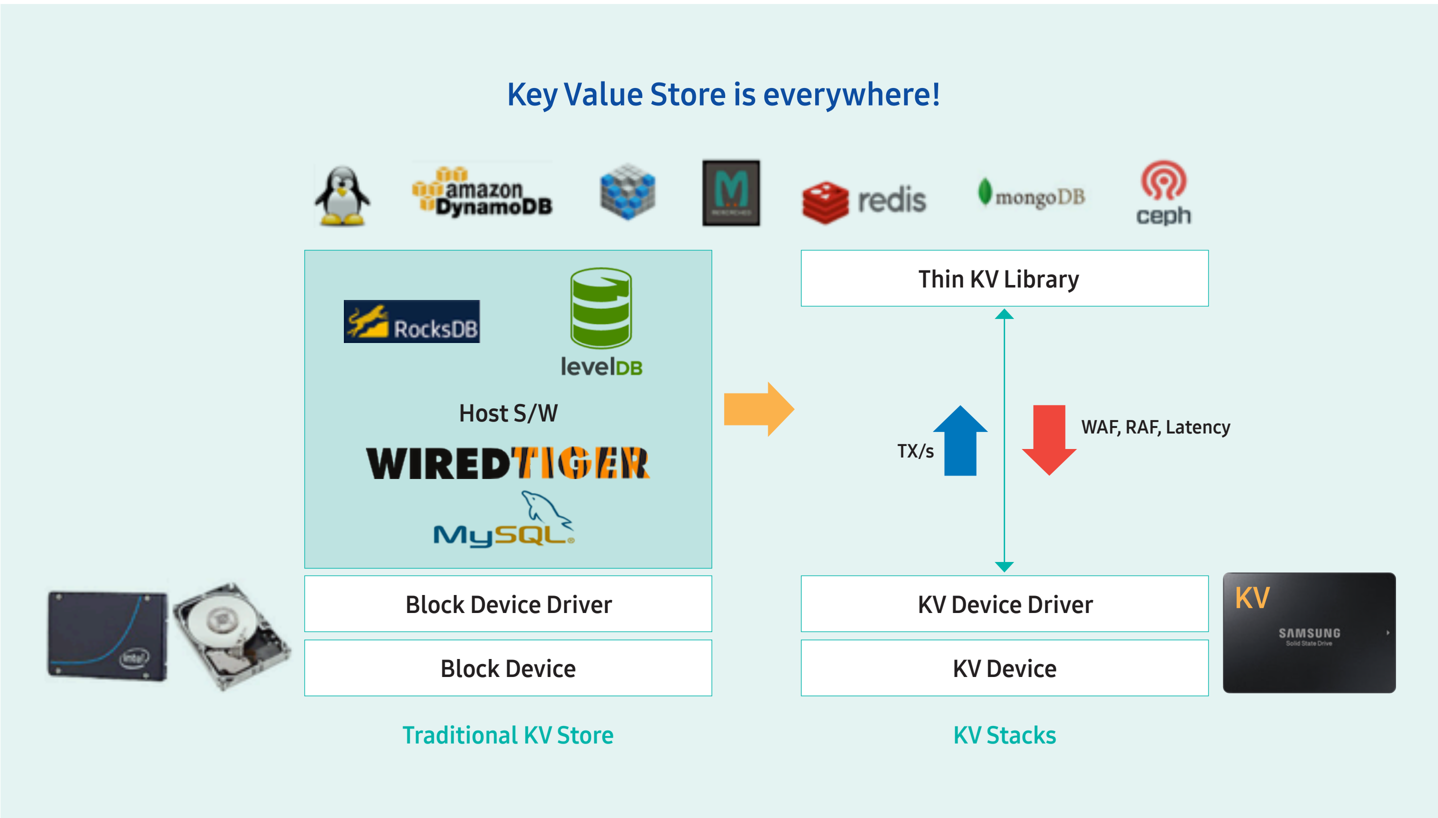
Up to now, performance scaling for SSDs has been addressed by raising the CPU's clock speed and increasing the number of cores. This approach sharply impacted the total cost of ownership (TCO) since it required more servers and considerably added to engineering overhead. In addition, compounding the cost spiral, power consumption and data center space requirements also rose. With the Samsung KV SSD's linear performance and capacity scaling, the need for added CPU functionality diminishes substantially, allowing extended use of existing resources and server infrastructure. In summary, Samsung KV SSD technology allows for an optimal scale-up in server performance, resulting in a more efficient TCO. For performance details and more information on leveraging this methodology, please refer to the information below.



Conventional Key Value (KV) store versus Samsung KV Stacks solution

Many applications now use RocksDB or MySQL as a Key Value store to store unstructured data. However, attempting to manage and improve the performance of such systems *at scale* has proven increasingly difficult, if not impossible. For example, changing storage media from hard disk drives (HDDs) to solid state drives (SSDs) often yields only modest improvement in application performance. Clearly, a technologically disruptive solution that bypasses the database performance and scaling challenge is warranted. Samsung's KV Stacks is such a solution.

Samsung's KV Stacks is a combination of KV SSD and the corresponding host software such as device drivers and associated libraries.



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Conventional Key Value (KV) store versus Samsung KV Stacks solution (continued)

Specifically, Samsung's KV SSD implements minimal core features of host-based Key Value stores like RocksDB or LevelDB at the FTL level. This approach provides acceleration that linearly scales with available KV SSDs which are designed to operate independently and concurrently. This also introduces numerous immediate benefits:

- **Cost Efficiency** – Samsung's KV SSD significantly reduces the amount of data transferred between a host and a system's storage devices because KV Stacks reduces or eliminates host database processing – as processing occurs in the KV SSD itself. This conserves substantial host processing power and allows host systems to use less powerful processors and reduced core counts to achieve the same effect.

- **IO Efficiency** – Because applications can now communicate directly with KV SSD instead of through a thick stack of host software, application performance can increase as bottlenecks have been removed from the processing path. Hence, applications enjoy significantly higher data access bandwidth and are able to share the bandwidth with the application's users. Thus, data centers can provide higher performance to existing end users or support more end users with the same infrastructure, again saving operational costs.

- **Linear Scaling and Seamless Expansion** – As processing requirements increase, unlike today's database processing that uses block storage devices, adding more Key Value SSDs provides systems with linear performance increases. Unlike traditional device-density scaling approaches, Key Value SSDs are easily managed by an intuitive, *single-pane-of-glass* management process embedded in the drive. Though Key Value SSDs operate independently, their intelligence and high performance enables them to provide additional services. For example, it is easy to organize groups of Key Value SSDs and enable them to provide real-time data replication and recovery capabilities with performance that also scales linearly.

- **Incorporates Metadata** – The keys in each Key Value SSD can store metadata, as well as object identity data, further accelerating applications requiring metadata access.

For these reasons, and many more, Samsung's Key Value SSD represents a breakthrough advancement that addresses performance and "density increase" challenges, while enabling simple management procedures.

KV Stacks Performance

As a case study, we compared the performance of our KV Stacks to that of the popular RocksDBs database. RocksDB relies on a log-structured merge tree to improve the write performance issue in traditional B-tree-based technology. In addition, RocksDB's "get" performance greatly depends on DRAM size due to its block and page cache methods. For this reason, we focused on write performance.

RocksDB performance can vary by H/W system, configuration, and workload. This experiment uses the following configurations:

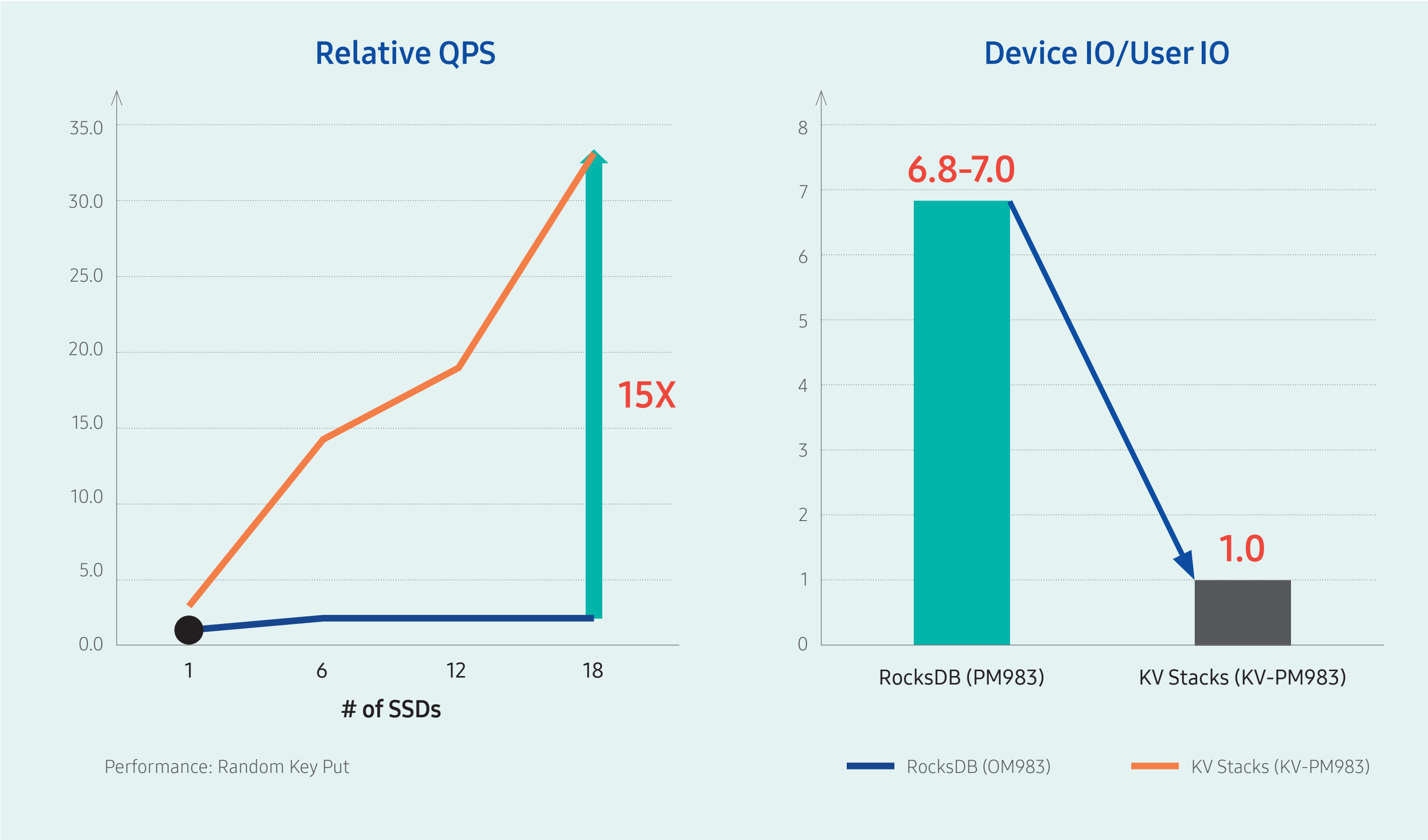
Experiment Setup

Server H/W (1U Mission Peak)	• Dual 2.1Ghz Intel Xeon E5 Skylake CPUs • 24 cores (48 virtual cores) per CPU (96 virtual cores in total) • 384G DRAM per CPU (768GB in total) • 18 NGSFF PM983 SSDs for CPU 0 and 18 NGSFF KV-PM983 SSDs for CPU 1 (36 SSDs in total) • 1 x 100G Ethernet and 1 x 50G Ethernet per CPU (2 x 100G, 2 x 50G in total)
Host OS	• Ubuntu 16.04.2 LTS • Ext4 filesystem
RocksDB	• RAID0 over 18 block SSDs for single address space • RocksDB 5.0.2
KV Stacks	• Simple hash over 18 KV SSDs for single address space
Workload (RocksDB)	• dbbench 5.0.2 • 24 instances per CPU • 4 threads per instance • 50GB data per instance • Default RocksDB configuration • Keys prepopulated in DRAM
Workload (KV Stacks)	• KVBench • 1 instance with 6 threads per CPU • 1.2TB data per CPU • Keys prepopulated in DRAM

KV Stacks Performance (continued)

We partitioned the storage server through the CPUs: one CPU for KV Stacks with KV SSDs, and the other CPU for RocksDB with block SSDs. We focused on the relative performance of Samsung's Mission Peak reference server with one socket. Base maximum performance is what the default configuration for RocksDB can achieve with a random "put" workload for a single PM983 SSD. Specifically, we used 1.2TB of data over 24 RocksDB instances to saturate the devices.

RocksDB performance saturates with six SSDs due to Amdahl's law, IO amplification and CPU saturation. Meanwhile, KV Stacks' performance is close to linear. For a given random put workload, RocksDB experienced about 7xIO amplification due to its mild compaction overhead. Using the same number of cores (i.e., 24 virtual cores), widens the performance gap in terms of Query Per Second (QPS) to 15x in terms of query per second (QPS).



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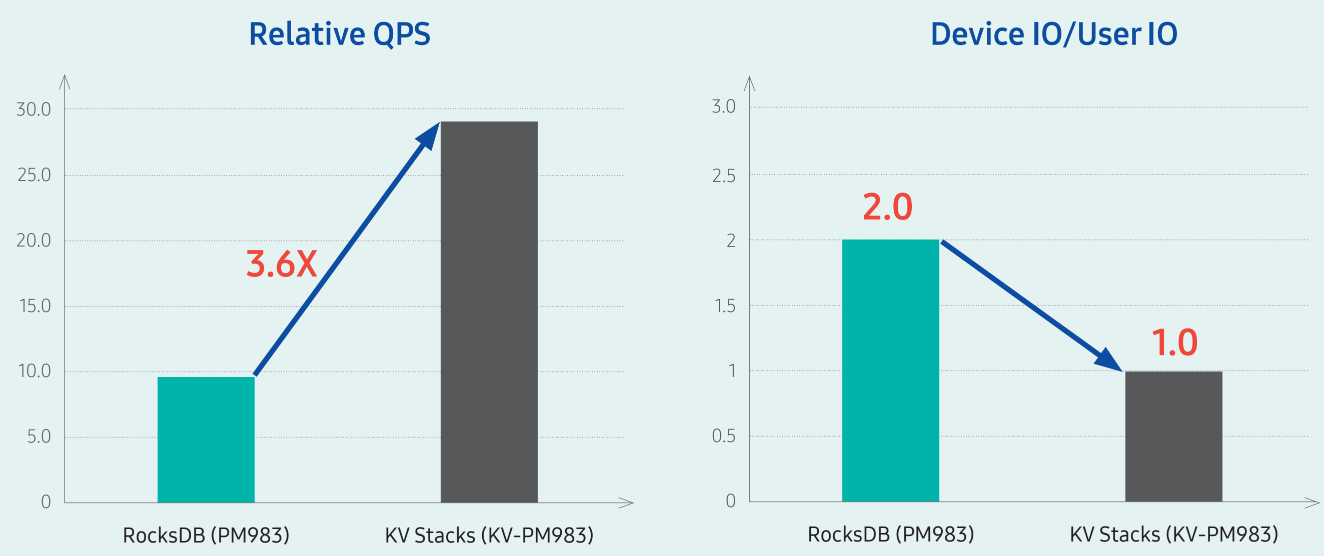
KV Stacks Performance (continued)

RocksDB shows better write performance with a sequential key workload because it does not have to contend with compaction overhead. RocksDB experienced around 2xIO amplification because of its WAL (Write Ahead Log), and registered a performance difference of 3.6x.



Performance: Sequential Key Put

Our results conclusively demonstrate the substantial value of Samsung Key Value SSDs in maximizing performance scaling for new server architectures and KV Stacks.

Conclusion

Samsung Key Value SSD is an explosive new foundation for unstructured object data, which eliminates the need for massive data conversion of block interfaces to support native key value commands. It simplifies host software stacks and lessens engineering resource requirements by eliminating heavyweight software KV stores. Furthermore, it provides linear performance and capacity scaling, in addition to offering significant TCO improvement with more efficient IOs. Finally, it enables seamless expansion and more intelligent data management in data center.

For More Information

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