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WHITE PAPER

Functional Testing of SQL Server on Kaminario K2 Storage

September 2016

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Executive Summary

Databases like Microsoft SQL Server are a critical data processing and storage infrastructure system in most organizations, supporting both revenue-generating customer transactions and internal business intelligence activities that drive insights and innovations. Because of their key role in an organizations IT infrastructure, much can be gained by virtualizing and consolidating these servers including reducing costs, improving resilience and simplifying management.

Along with processing transactions and analytic queries, databases like SQL Server need to perform regular maintenance activities such as making backup copies or switching to alternate databases in the event of a server failure. In the past, many IT operations designated windows when databases were inaccessible, allowing maintenance workloads like backups to run without conflicting with regular production workloads. This was possible because access to these databases was largely internal and maintenance could be synced up with local working hours.

However, many databases now support websites and trading systems that must be globally available around the clock, making it impractical to have even brief windows of downtime for maintenance. Instead, database servers and their supporting storage infrastructure must be able to handle backup and disaster recovery activities without significant downtime and with little or no impact on the performance of applications or the productivity of users.

This report documents a set of functional tests demonstrating the benefits of Kaminario K2's All-Flash Array storage for Microsoft SQL Server hosts, run as virtualized servers on VMware's vSphere 5.5. These tests cover two key areas of SQL Server operations – database backups and availability during server failures:

- **Backup via Microsoft Volume Shadow Copy Service** – Results showed that array throughput was not impacted by the creation of a database replica using K2's native snapshot capabilities. K2's writeable snapshots enable database backups – as well as creation of point-in-time database copies for analytics, development or test purposes – to complete more quickly and with no impact on production transaction and query processing.
- **Failover/Recovery using SQL Server Availability Groups** – Results showed that failover of SQL Server databases was efficiently handled by the K2 array. During the test, IOPS peaked at over 70,000 as the workload shifted to the secondary replica database, ensuring that high OLTP workloads could continue with minimal disruption immediately after the failover.

The results of these functional tests showed the ability of Kaminario's K2 All-Flash Arrays to support nonstop operations of virtualized SQL Server databases even during real-world backup, failover and recovery operations that would overwhelm legacy and hybrid storage arrays.

Introduction to Kaminario K2

Founded by storage experts, Kaminario has released its fifth-generation product with a design that is years ahead of other storage vendors. The new K2 enterprise-class All-Flash Array continues to leverage Kaminario's Scalable Performance and Resilience Architecture (SPEAR™) technologies. This ensures both data availability and the consistent level of high throughput and IOPS and low latencies needed to support the demanding blend of storage I/O generated by business-critical systems like virtualized SQL Server databases.

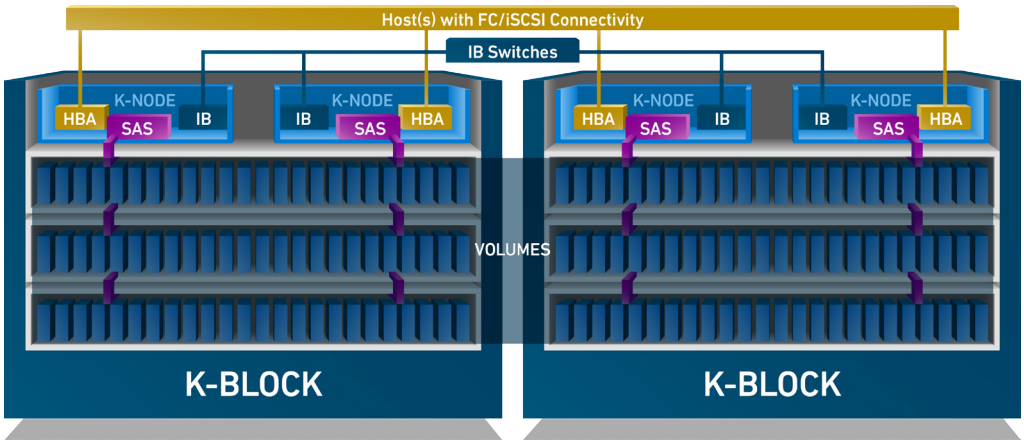

Figure 1: K2 Architecture Diagram

K2 has the only All-Flash Array architecture that lets you scale up, scale out or both. You can scale performance or capacity without impacting latency, with zero hot spots and no system tuning required. Each K-Block includes two K-Nodes (storage controllers), up to three shelves of 24 SSDs (scale-up), and Fibre Channel or iSCSI host connectivity. K-Blocks can be added (scale-out) as shown in Figure 1, above.

Key attributes of Kaminario's new fifth-generation K2 All-Flash Array are:

- **Low Deployment and Operating Costs** – K2's CAPEX and OPEX costs can be two-thirds of legacy or hybrid storage arrays. Optional Capacity on Demand pricing directly matches your investment to storage requirements.
- **No Single Point of Failure** – A shared-nothing architecture and automated recovery ensure that the array can keep running at peak performance even with hardware failures of up to two SSDs at once in a single shelf.
- **Consistent High Performance** – Intelligent hardware and software ensure the array delivers low latency even under peak workloads.

- **Non-Disruptive Everything** – Software or hardware upgrades and expansion of the array can be performed with no downtime and require no manual tuning.
- **Simple Deployment and Management** – No disk groups to plan, configure or manage; everything is managed via a simple browser-based GUI. VMware integration simplifies management of K2 arrays as part of your virtualized server infrastructure, with a vCenter plugin and support for the VMware VAAI hardware offload/acceleration API.
- **High-Efficiency RAID** – K2's dual-protected K-RAID™ is highly efficient, with 87.5% of the physical capacity available for data storage and consistent high performance even during rebuilds.
- **Advanced Data Reduction** – K2's native inline compression provides the ability to save over two-thirds of database capacity, matching the best-case SQL Server compression without any extra overhead on the host server's CPUs or RAM.

More information oon the features and cost effectiveness of the fifth generation of Kaminario's K2 All-Flash Arrays can be found on the **Kaminario website.**

Functionality Tests for SQL Server

Backup – Microsoft Volume Shadow Copy Service:

Challenge: Databases play a crucial support role for most applications and store most of an organization's data. Frequent backups of databases as well as a means to reliably perform a database recovery are essential. Backups are needed both to recover from data loss and to archive point-in-time copies of databases for record-keeping, often due to regulatory mandates. Although SQL Server provides a very simple backup capability, creating a backup can have an adverse impact on ongoing production use of the database.

Besides the obvious need for traditional database backup and recovery, there are other scenarios where having an earlier point-in-time backup of a production database is very useful:

- Test databases for application development or QA testing that need to exactly match a real production database.
- Long running business intelligence processes like analytics or data mining that need access to the data in the production database, but which might hurt the performance of production applications if directly run on the same database.

Using K2's native snapshots allows you to quickly create a writable point-in-time copy of the database (what Kaminario calls a "replica") with no impact on production use. K2 snapshots or replicas have the benefit of being very fast to create as well as providing the same performance as production databases while consuming very little additional capacity on the K2 array. When database replicas are created, they can be mounted by other SQL Server hosts and will only consume capacity in the K2 array for any new writes. This capability creates significant opportunity to collapse the reporting infrastructure and/or to deploy database schema changes with zero risk and with minimal additional capacity required. K2's snapshots can radically lower the storage costs for backups by up to 95%.

In order to create a K2 snapshot of a SQL Server database, Microsoft Volume Shadow Copy Service (VSS) is needed. A very simple and intuitive K2 provider for VSS is available and should be installed in order to create a point-in-time application-consistent snapshot of a database. In addition to the K2 VSS Provider that was installed on the SQL Server VM, the VM was configured with RDM disks. VSS, which was introduced by Microsoft in Windows Server 2003, facilitates the interchange between K2 arrays, the Kaminario Management Service and other database and server components to allow them to work together.

Results: The test starts by running an Online Transaction Processing (OLTP) workload on the SQL Server database. During the OLTP workload, VSS is triggered to create a snapshot of the SQL Server volumes, shown in Figure 2 below.

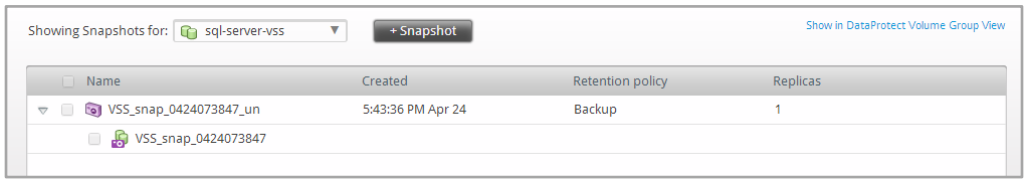

Figure 2: SQL Server Snapshot and Replica on K2 GUI

As seen below in Figure 3, there is no significant impact on performance or throughput during the snapshot creation.

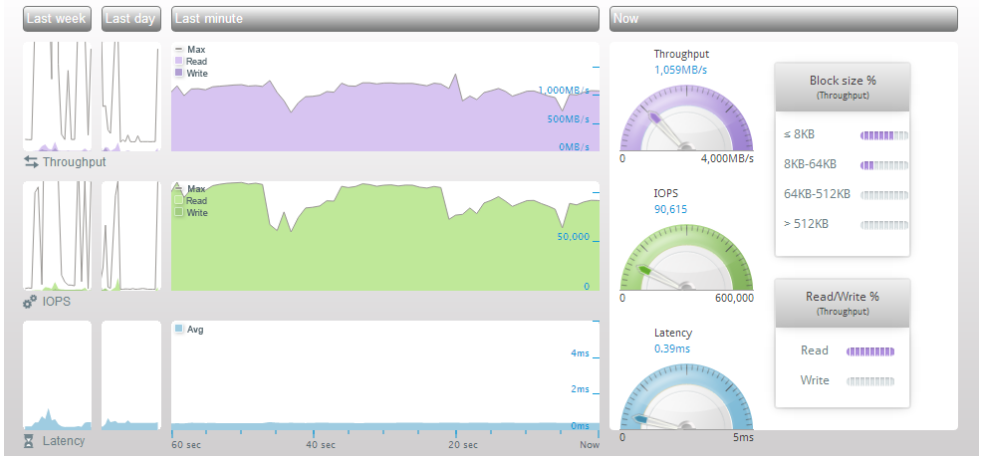

Figure 3: K2 GUI during VSS backup

Recovery Using SQL Server Availability Groups

Challenge: SQL Server's AlwaysOn Availability Groups provides by SQL Server, a continued database availability via a failover environment using a discrete set of databases that fail over together, known as availability groups. These availability groups include a primary database and one to four corresponding secondary databases, all hosed within a set of availability replicas.

To test the performance of the K2 array, during a SQL Server failover, an availability group of three SQL Servers connected to two Kaminario K2 arrays was created. This configuration simulates what happens in real-world scenarios when the primary database, located in the main data center of an organization, is replicated to a secondary failover database in the same site. The secondary database was configured to be fully synchronized with the primary database and act as the backup database server with automatic failover if the primary database fails. A third database located in a remote site was configured to be replicated with an asynchronous method and act as a backup for a disaster recovery scenario.

In our test, the remote secondary database is connected to a different Kaminario K2 array. This added replicated secondary database was set up to act as a read-only database and served as the main server for an OLTP query workload. As shown in the Availability Group dashboard in Figure 4 SQLSERVER2012_A was the primary database while SQLSERVER2012_B was acting as the synchronous secondary database within the automatic failover group. SQLSERVER-PERF4 served the remote site database that was replicated asynchronously.

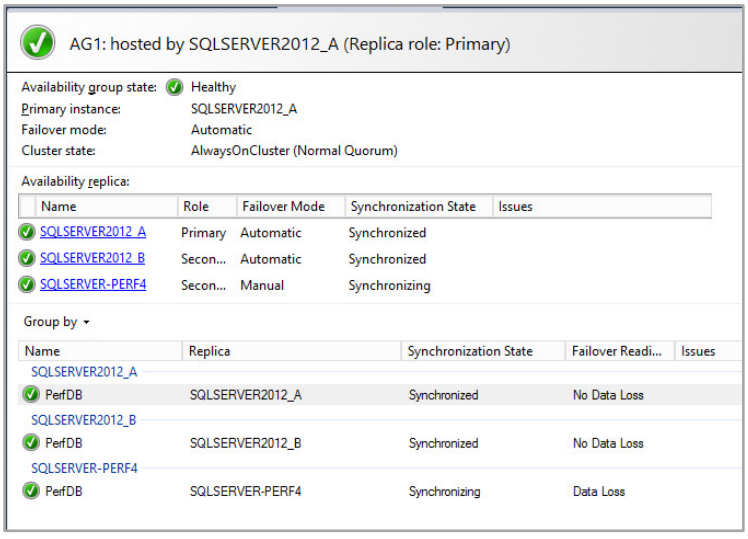

Figure 4: SQL Server Availability Group Dashboard

Table 1, below, shows the goals for RPO and RTO periods for SQL Server Availability Groups according to Microsoft's SQL Server AlwaysOn Solutions Guide for High Availability and Disaster Recovery on SQL Server 2012.

Table 1: Test Results for SQL Server Availability Groups

High Availability and Disaster Recovery SQL Server Solution	Potential Data Loss (RPO)	Potential Recovery Time (RTO)
AlwaysOn Availability Group - synchronous-commit	Zero	Seconds
AlwaysOn Availability Group - asynchronous-commit	Seconds	Minutes

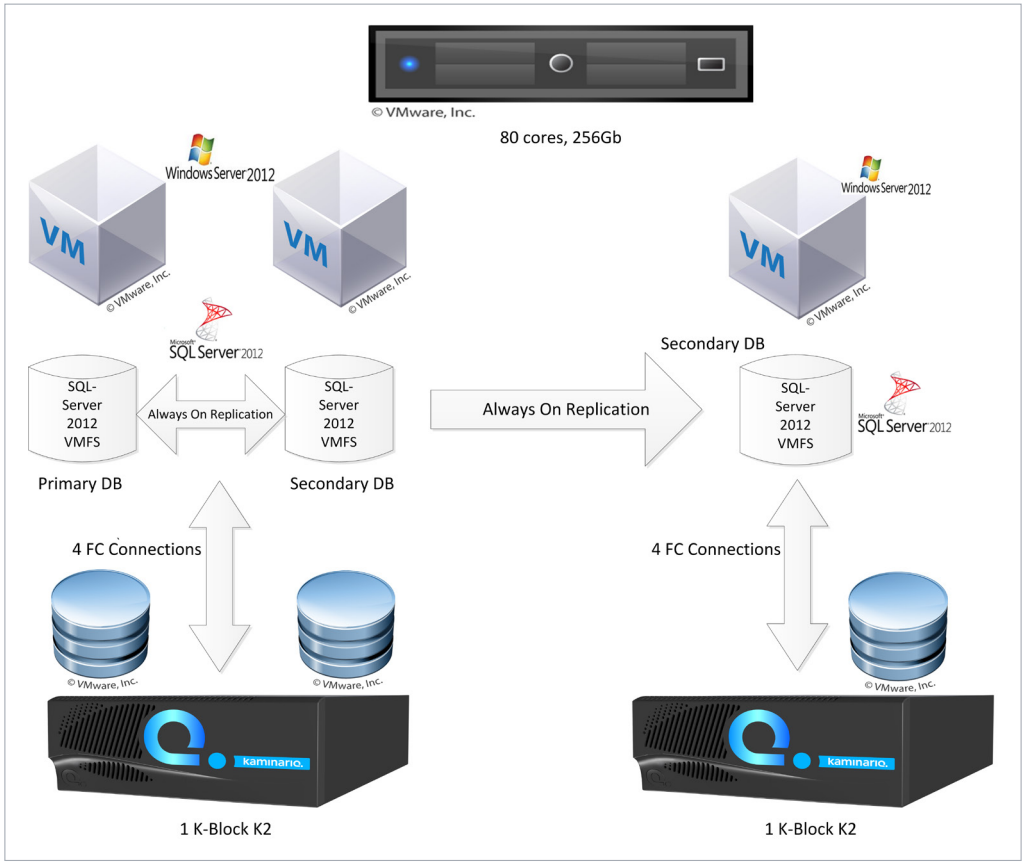

Figure 5: Configuration used for AlwaysOn Testing

Results: The test The test process and results for SQL Server Availability Groups were as follows:

A constant workload stream of read/write database I/O was routed through the Availability Group listener to the primary SQL Server database in order to enable SQL automatic failover facilities. When the primary database (SQLSERVER2012_A) failed, the secondary database (SQLSERVER2012_B) became the primary and began serving the read/write queries. The primary database was then connected to the first K2 as shown in Figure 5 on the prior page.

Figure 6: K2 GUI during Failover of Availability Group

OLTP read workload was done on the remote secondary asynchronous replica (SQLSERVER-PERF4), as shown in Figure 7, below.

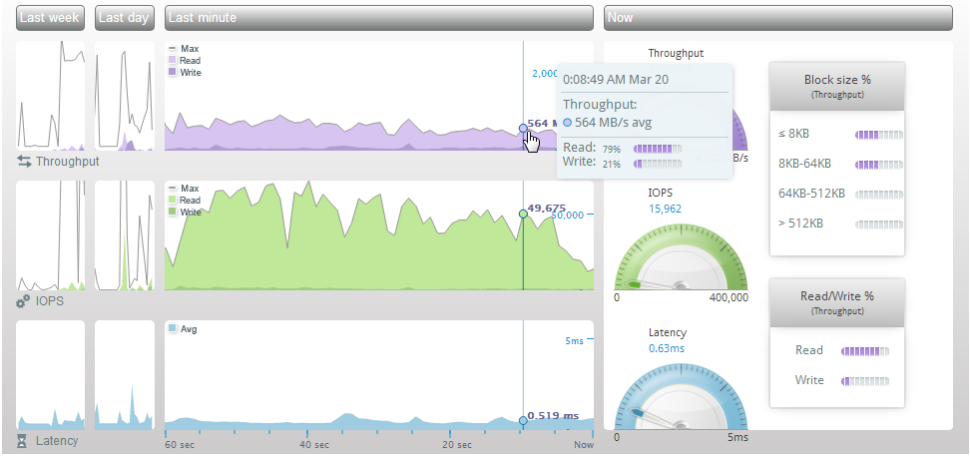

Figure 7: K2 GUI during OLTP Read Workload on Secondary Replica

A sudden failure on the primary database (SQLSERVER2012_A) occurred. The read/write activity I/O on the primary database stopped and there was no I/O on the system until the automatic failover occurred, as shown in Figure 8 .on the next page.

Figure 8: K2 GUI during Primary Fail-over as Queries Stop

The secondary database (SQLSERVER2012_B) became the primary database as shown in Figure 9, below.

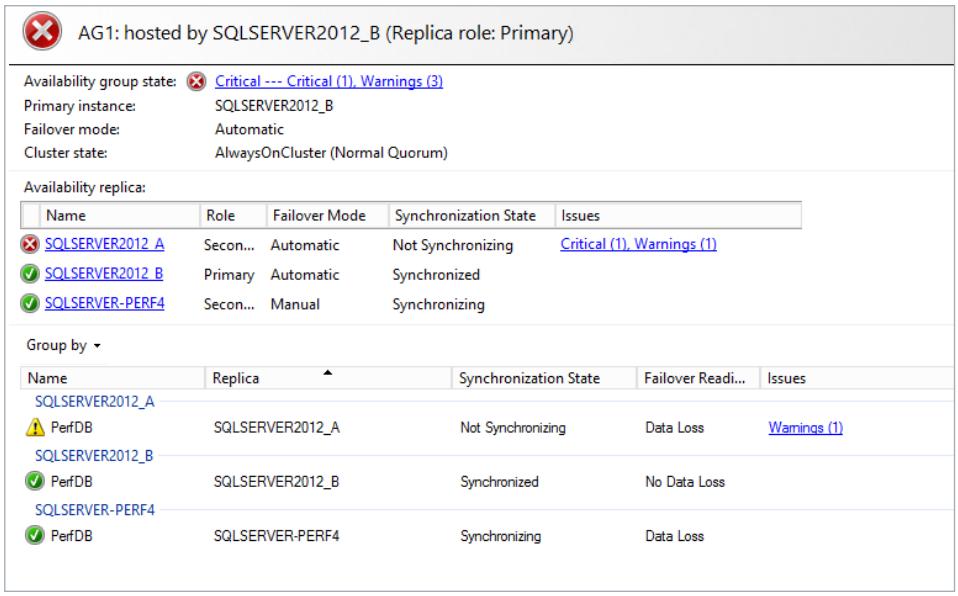

Figure 9: SQL Server Dashboard as Secondary Database becomes Primary

The After the secondary database became the primary, the databases continued to process read/write I/O normally as shown in Figure 10.

Figure 10: K2 GUI after Secondary Database became Primary

When the problem in the faulty database was resolved, the AlwaysOn group returned to normal state (with the new primary).

In most cases, an organization would like to get back to the original state before the failover, as the original primary database might be monitored more closely than the other replicas and might be running on a stronger server in terms of CPU or memory. If that is the case, the organization would perform a manual failback of the AlwaysOn environment to make the original server the primary again.

SQL Server then failed back the AlwaysOn environment to the original state as shown in Figure 11 below.

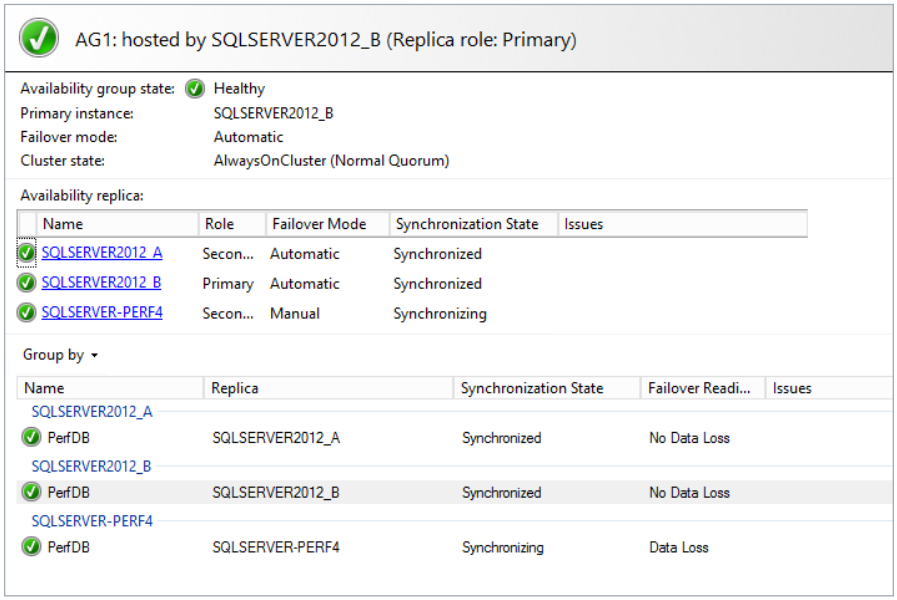

Figure 11: SQL Server Availability Dashboard after Failover

Summary

Virtualizing database servers provides IT groups with easier management and better resource utilization. However, combining multiple virtual servers to shared servers may generate a very demanding blend of I/O requests that can swamp traditional HDD or hybrid storage. Backup and data recovery operations after database failures are especially demanding. Using an All-Flash Array can meet these demands for performance, but only if it is also cost-effective, robust and simple to operate.

This set of tests demonstrates the ability of Kaminario's new fifth-generation All-Flash Array to support complex SQL Server management operations including volume backups, failovers/recoveries and recoveries within SQL Server's native Availability Groups. K2 is easily managed via a user-friendly GUI and provides robust availability with a shared-nothing architecture and highly efficient RAID implementation. In addition, the K2 is uniquely cost-effective, with costs below $3 per effective GB after database capacity requirements are reduced by its highly efficient native compression.

For more information please visit **www.kaminario.com**

Appendix: Test System Configuration

Hardware Configurations – Arrays, Servers, Connectivity

For both of the functional tests, a K2 array with a single K-Block with 45 TB of available storage was configured with different sets of VMware virtual disks. In all cases, an out-of-box configuration was used and no tuning was done for any of the specific tests.

The ESX host server hardware used was one Dell PowerEdge R810 with 40 1.994 GHz Intel® Xeon® CPU E7-4850 and 256 GB of memory.

The ESX host server was connected via eight 8 Gb Fibre Channel connections to the SAN fabric. Each K2 array was connected via four 8 Gb Qlogic Fibre Channel HBAs to the SAN fabric. In the scale-out tests, the two-K-Block array was connected via eight 8 Gb Qlogic Fibre Channel HBAs to the SAN fabric. During the AlwaysOn tests, the network connection to the remote secondary server was via a virtual 10Gig link as shown in Figure 12 below.

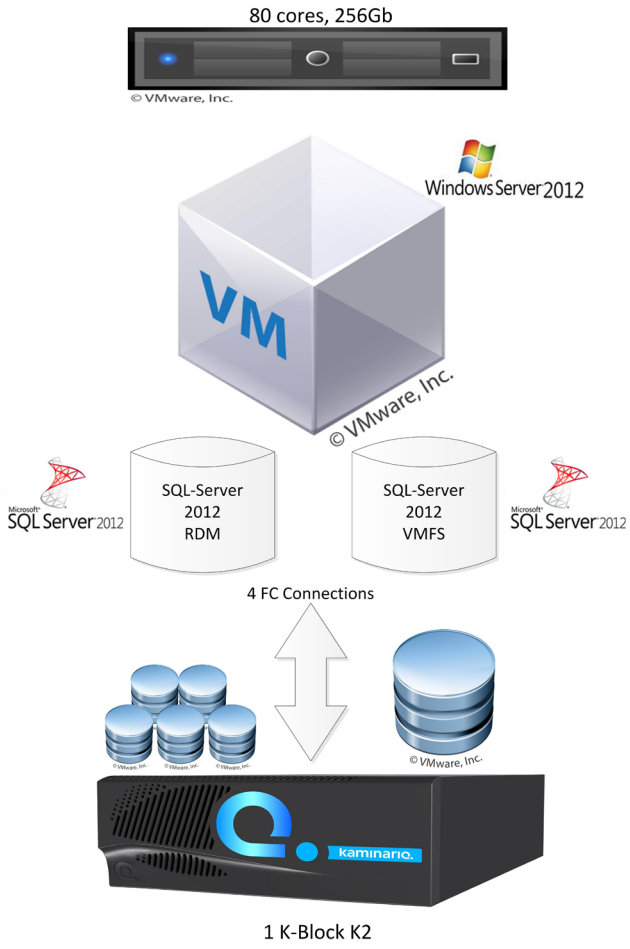

Figure 12: Array Configuration used in Testing

Software Configurations – Microsoft SQL Server

The configuration of the Microsoft SQL Server 2012 software was as follows:

1. Maximum server memory: 1500 MB
2. Startup parameters and trace flags:
    a. –E - Increases number of extents allocated for each file in a filegroup.
    b. –T1118 - Helps reduce contention across the SQL Server instances by removing almost all single page allocations.
    c. –T610 - Controls minimally logged inserts into indexed tables.

VMware Configuration – vSphere Virtual Machines

The virtual machine was created with VMware vSphere ESXi 5.5 software and was configured with eight vCPUs (two sockets with four cores for each socket), and 16 GB of memory.

All of the server VMs were running Windows Server 2012 R2 Standard and SQL Server 2012 SP1 Enterprise Edition. For the VSS tests, RDM disks were used, while for the AlwaysOn tests, the disks were VMFS. All the disks were formatted with a 64K NTFS filesystem, as is typical in SQL Server best practices. The SCSI controllers of these virtual disks were configured as VMware Paravirtual SCSI (PVSCSI) adapters.

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Contact a business development representative to answer any questions you may have.

Schedule a Demo

Schedule a demo with an engineer and learn if Kaminario's solution works for you.

Request a Quote

Request a quote for your application from our business development team.

About Kaminario

Kaminario, the leading all-flash storage company, is redefining the future of modern data centers. Its unique solution enables organizations to succeed in today's on-demand world and prepares them to seamlessly handle tomorrow's innovations. Only Kaminario K2 delivers the agility, scalability, performance and economics a data center requires to deal with today's cloud-first, dynamic world and provide real-time data access -- anywhere, anytime. Hundreds of customers rely on the Kaminario K2 all-flash array to power their mission critical applications and safeguard their digital ecosystem. Headquartered in Needham, MA, Kaminario works with an extensive network of resellers and distributors, globally.

For more information, visit www.kaminario.com